Structure and mechanical properties of matter

Mechanical properties of matter are the behaviour of matter under the action of an external force. Materials are things used in the construction of structures like buildings, bridges, dams, etc.

Before a material is put to use the following mechanical properties should be considered; strength, stiffness, ductility, brittleness and elasticity.

Strength: Is the ability of a material to resist the application of forces without rapture. The strength depends on

(i) Diameter of the material in that a large force is applied in order to bend a material of large diameter.

(ii) Nature of the substance

Materials of same size but of different substance require different forces to be broken, e.g a large force is applied to a steel rod compared to a piece of wood of the same size.

Stiffness (toughness):

Is the ability of a material to resist forces which try to change its shape or size. A material which is more stiff always needs a larger force in order to deform e.g. wood is more stiff than rubber.

Elasticity: Is the ability of a material to recover its original shape or size after the force deforming it has been removed. The material stretches due to the particles being pulled further apart from one another. A material which does not recover its original shape and size but is deformed permanently is plastic.

Hooke's law

Hook's law states that the extension of a material is proportional to the force provided by the elastic limit is not exceeded.

Intension, e $\propto$ stretching force provide elastic limit is not exceed i.e.,the material returns to its original length when the force is removed.in short F = ke

where k is the constant of the material in N/m
F is the stretching force e is the extension in metres.
extension e - new length - original length

Example 1

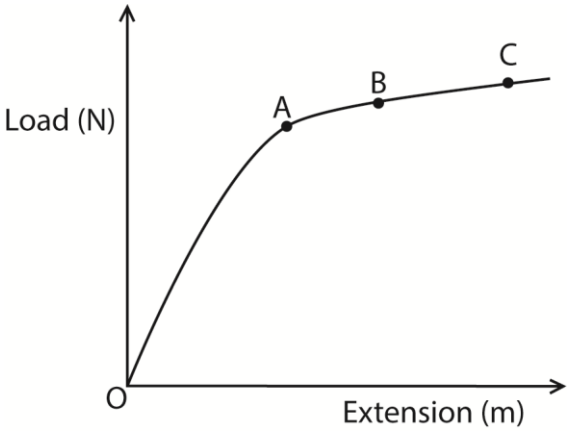
A spring increases its length from 20cm to 25cm when a force is applied. If the spring is constant is 100N/m. Calculate the force

L_0 = 20cm = 0.2m ,L_n= 25 = 0.25m

e =L_n- L_0 = 0.25 - 0.2 =0.05m

k= 100N/m

F=ke
=100x0.05
=50N



Explanation
OA mean that the load is proportion to extension in that the extension increases as the load increases.

Point "A" is called elastic limit
Beyond A (elastic limit) the graph is not straight line meaning that extension is no longer proportional to the load.

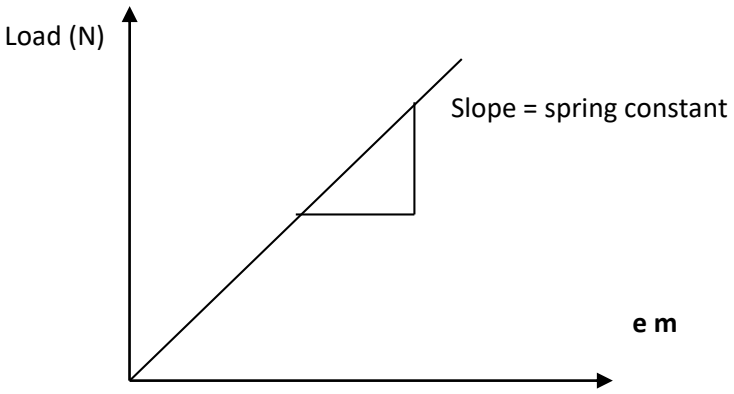
Beyond A the material become plastic. This is indicated by akink at B which is called yield point.

Beyond B the material behaves plastically ie. does not regain its shape and size. So it undergoes plastic deformation. This goes on tothis breaking point D.

Experiment to verify Hook's law
The original length of the spring is noted. Then various loads are suspended on the spring and the corresponding new length L_n of spring for each is noted. The readings are noted in a table as below

Load 'N'	L_nm	$L_n - L_0 = e$ (m)

Then load is plotted against extension ("e'' = L_n–L_0)



A straight line graph is obtained whose slope is spring constant.

Thus load is proportional to extension "e"

Young's Modulus = $\frac{Stress}{Strain}$

Tensile strain $\frac{\text{extension}}{\text{original length}} = \frac{e}{L_0}$

It has no units

Example 2

A wire increases in length from 20cm to 25cm when a force is applied. Calculate the tensile strain.

L_0 =20cm

L_n =25cm

$e = L_n - L_0$

25-20

5cm

Stain $= \frac{e}{L_0} = \frac{5}{20} = 0.25$

Tensile stress = $\frac{Stressing\ force\ (F)}{Cross\ section\ area\ (A)} = \frac{F}{A}$

The SI unit is N/m^2

Example: Calculate the tensile stress when a force of 25N act on a wire of cross sectional area $5m^2$.

$A = 5m^2$

F=25N

Tensile stess = F/A

= 25/5

$=5N/m^2$

Young's modulus = $\frac{Stress}{Strain}$

$= \frac{F}{A} \div \frac{e}{L}$

$= \frac{F}{A} \times \frac{L}{e}$

Young's modulus = $\frac{FL}{Ae}$

Note: This holds only when the elastic limit of a material is not exceeded.

It is also important to note that

$\frac{F_1}{e_1} = \frac{F_2}{e_2}$

where F, is stretching force producing extension e, F_2 is stretching force producing extension e_2 on the same material

Example A spring is stretched 0.05m by weight of 5N hung from one end. What weight will stretch by 0.03m

$F_1 = 5N$

$e_1 = 0.05$

F_2 = ?

e_2 = 0.03m

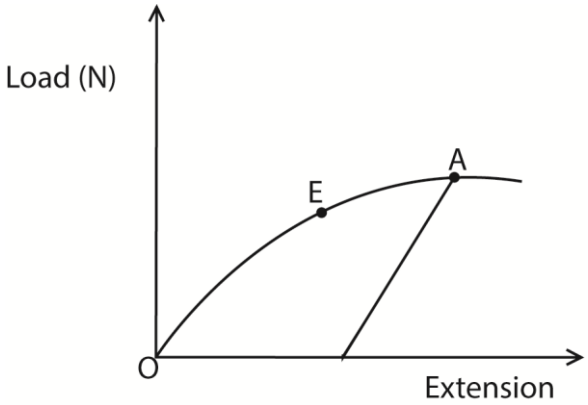
$\frac{F_1}{e_1} = \frac{F_2}{e_2}$

$\frac{5}{0.05} = \frac{F_2}{0.03}$

$\frac{5 \times 0.03}{0.05} = F_2$

$3N = F_2$

Explanation of sketch of load against extension according to kinetic theory



OE the molecules are pulled slightly farther apart but can move back to original position when stretching force is removed. The deformation is called elastic.

Beyond A layers of atoms slip over each other, the molecule move farther apart but cannot move back to original position when stretching force is removed.

Partıculate nature of matter crystal

Crystals have hard, flat sides and straight edges. Crystals of the same substance have the same shape. This will be observed when salt crystals grow as water evaporates from the salt solution on glass slice as seen through a microscope.

This fact suggest that crystals are made of small panicles called atoms or molecules arranged in an orderly way in plates. Metals consist of tiny crystals.

Ductility

A Ductile material is one which stretches elastically then plastically before it breaks when tensile force acts on it.

Properties of ductile material

(i) Can be moulded into any shape.
(ii) Can be bent without breaking.

Because of the aboveproperties of ductile materials, they can be rolled into sheet, wires or worked into other useful shapes without breaking,

Example is metals, Plasticine

Ductility is the ability of a material to be hammered, pressed, bent,rolled or stretched into useful shapes without breaking.

Brittle material
Is a material which bends very little, then suddenly cracks withoutundergoing plastic deformation.

Properties of Brittle material
(i) Can bend very little and suddenly break without undergoing plastic deformation.

Cannot be moulded into any shape.

Examples are glass, chalk, stone concrete, cast iron, bricks. When a brittle material breaks its pieces together almost exactly and can be glued back. Alloy like brass bronze are brittle material.

Tensile, shear and compression forces

Compression force

Compressions is when the force acts as in the diagram above. The particles pushed to each other. So the Length of the material decreases but the thickness of the material increase.

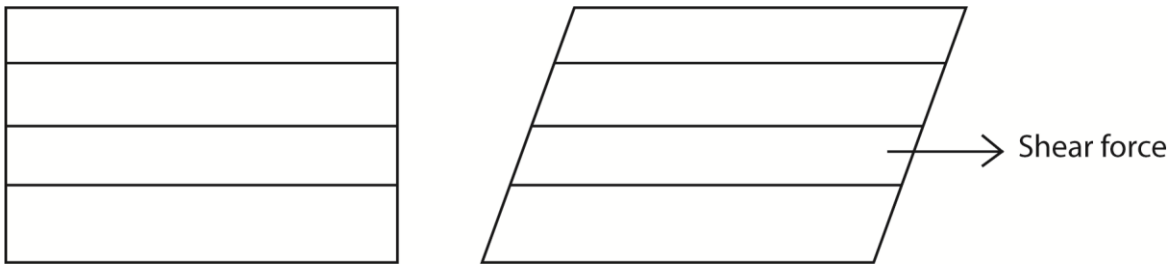
Tensile force

Tensile force is when the forces act in the diagram be above. This result in the particles of the material to be pulled further apart from one another. So tensile forces increases the length of the material but thickness decreases.

Differences between tensile and compression force

Tensile	**Compression**
i) particles are pulled further	(i) particles are pushed close to each other
(ii) length of the material increases	(ii) length of the material decreases
iii) thickness of the material reduces	(iii) Thickness of the material increase

Shear force
Shear force is the force needed to fracture the material in a direction parallel to the applied force in that one section of the material slides over its neighbour. A shear is produced when two equal but opposite forces are applied to an object at a distance from one another so that they twist the body. The effect depends on the turning effect or movement of the force.



Metals
Large variety of metals are available from which different alloys or combinations of these metals are made into various shapes. Metal can be rolled, pressed, and drawn, and are usually strong, rigid and elastic.

Some of the common metals are copper, iron, zinc, lead etc.

Alloys
Alloys are made by mixing one metal with one or more other metals and in some cases non metals.

Steel alloys
Iron is alloyed with a variety of the other materials like:-

Examples of steel
Mild steel used in making cars, ships etc.
Stainless steel, has high corrosion resistance due to its composition of chromium and nickel. It is used in making knives, watch casing etc.
Lead and sulphur steel. It is used in the making of screws because it is easy to cut.

Other alloys

Doralium is an alloy of aluminium and is used in the making of air crafts because of its lightness and strength.

Nickel-Chromium alloy

i) have good resistance to corrosion
ii) the electrical conductivity is fairly independent of temperature.
iii) have a high melting- point.

For these properties nickel- chromium alloys are useful for making elements for electrical heaters.

Invar: Is a nickel -iron alloy with low expansivity. It can be used to make accurate measuring tapes and parts of watches.

Brass: Is a copper-zinc alloy. It is ductile and with high tensile strength. It is used in stamping, pressing or drawing. It is used in the making plumbing fitting.

Bronze: Is an alloy of copper and tin is harder and stronger than brass. It is useful in ornamental work.

Stony materials
Bricks: Are made by moulding a mixture of clay and water and heating the mixture strongly.

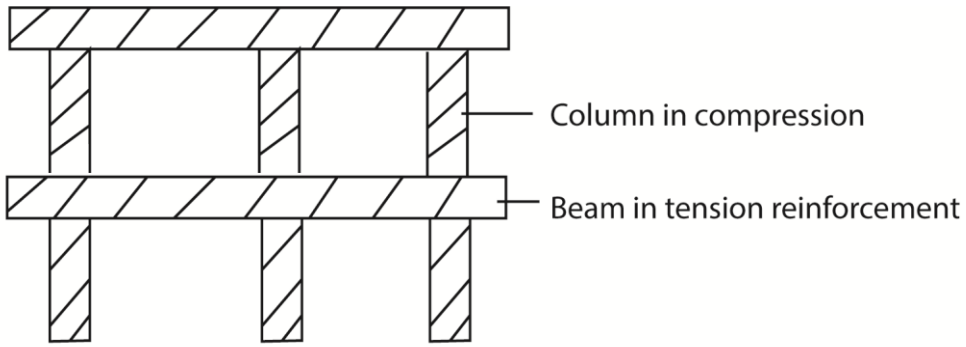
Concrete: A concrete is a stony material which is a mixture of cement, sand, gravel and water. This is left to harden into desired form.

Properties of concrete which makes It a suitable building material
(i) whether resistance,
(ii) high compressive strength
(iii) durability
(iv) fire safety

Concrete can be primarily subjected to compression like column and arches because its compression strength is high. However, concrete is relatively brittle material whose tensile strength is small compared to Its compression strength. This makes concrete unsuitable for use in structural members which are subjected to tension like tie rods, beam. In order to overcome the limitation of low tensile strength, steel (with high tensile strength) is interlocked and completely surrounded by hardened concrete mass to form an integral part of the members. The resulting combination of the two materials called reinforced concrete.

Reinforced concrete is a combination of steel rod, cement, sand, gravel and water.

Concrete is reinforced by interlocking and completely surrounding the steel rods with the hardened concrete mass.
Advantages of the reinforced concrete
(i) high compressive strength
(i) high tensile strength
(ii) much greater ductility
(iii) toughness
(iv) Good whether and fire resistance



However, the disadvantage of concrete is its volume instabilitycaused by shrinkage of concrete which results in cracks.

The cracks can be filled with fresh mixture of special tar, sand,cement and water.

Cement Mortar: Cement mortar is composed of sand, cement,mixed with water and left to harden.

Reinforcement Sisal-fibre, bamboo stripes, woodstrand are also used in reinforcing concrete and cement mortars. The reinforcing improves on tensile strength and whether resistance of the materials.
Glass Glass can be melted and formed into various shapes.

Advantages of glass **which makes it useful as construction material**

(i) It is transparent
(ii) Its surface is quite harder
(iii) Very few chemicals react with glass.
(iv) Can be melted and formed into various desired shapes.

Safety glass

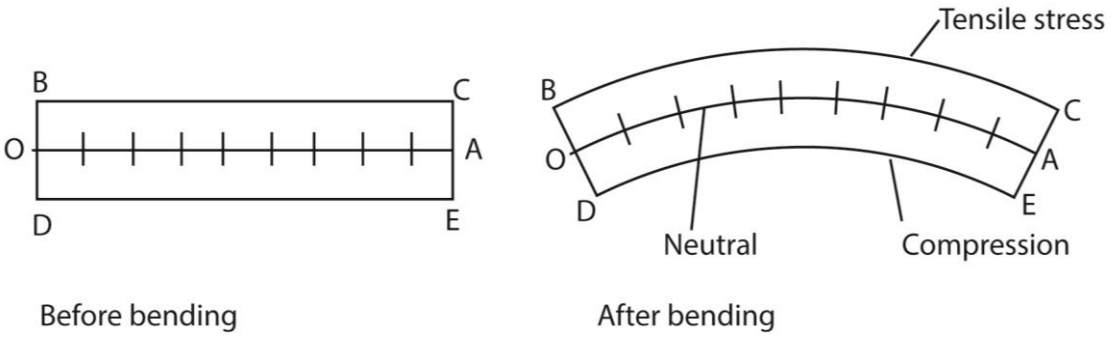
Is used for motor vehicle wind screen. safety glass ismade by heating plate glass cooling the two surfaces in a stream of air. These contract and compress the glass in the middle resulting avery strong glass which when hit hard enough breaks into small fragments that are less dangerous than larger pieces.

Wood:

Wood is a poor conductor of both heat and electricity.
The hardness and strength of wood varies from one sample to another.
Thin sheets of woods are glued together to form a laminate(plywood) which is stronger than solid wood of the same thickness,

Beam and structure.

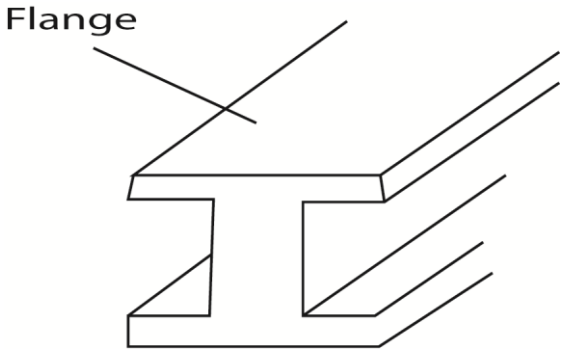
A beam is the simplest but one the most important structures. When a beam bends, one side is compressed, the other is stretched (tensile) and the centre is unstretched neutral plane.



Before bending After bending

Above is a diagram of rubber marked with lines as shown;

- The lines above OA move further apart showing that the above parts,are in tension.
- The lines below OA move closer showing that the below parts are incompression.
- Along OA the lines are at the same distance apart as before implyingthat they are not in tension or compression. This region is called neutral axis.
- From above it can be noted that materials from neutral plane can withstand compression and tensile forces due to loading.



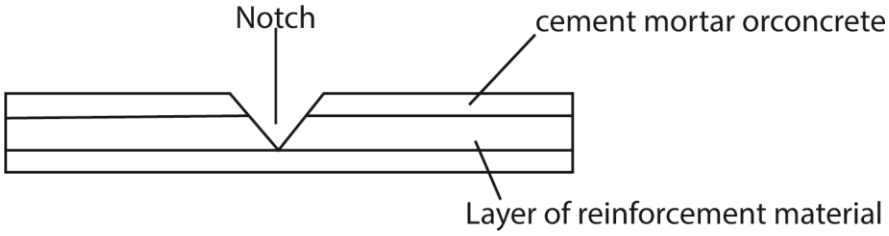
The top and bottom flanges have the shape shown.
Because they are beams that have had material removed from theneutral plane so can withstand compression and tensile forces due to loading.

In general pipes for construction of structures like bicycles, bridges are made hollow for the following advantages.

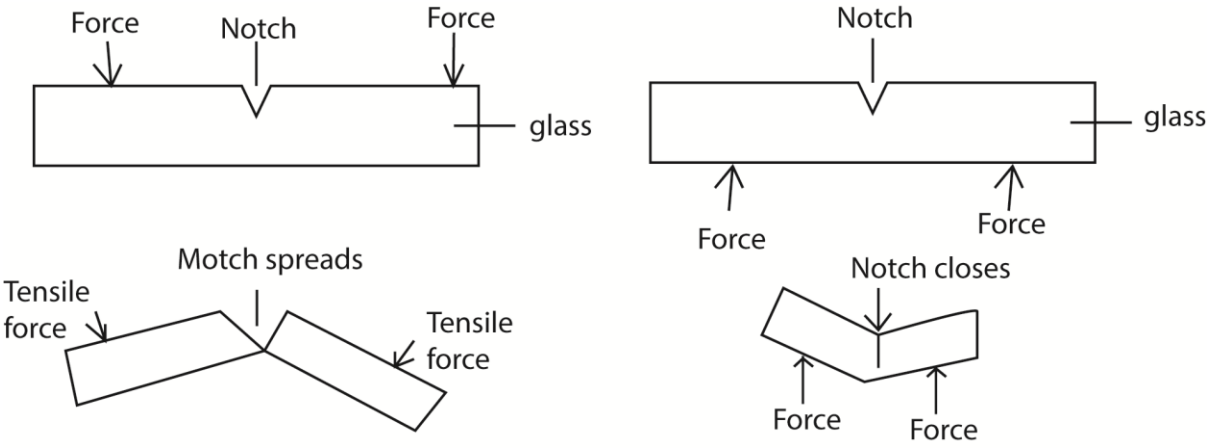
(i) They are beams that have had materials removed from theneutral plane so can withstand tensile and compression forces.
(ii) Notches cannot spread easily so less risk of breaking
(iii) Less material is used for construction
(iv) the finished structure is lighter
(v) Expansion and contraction

Cracks and fracture; A notch is a cut or weak point in a given material

Notch effect: when a notch is made in the reinforcing material, the fibres, stripes and strands in the length of concrete or mortar are broken down. This result in such materials to fail to withstand Impression or tensile force.



Glass tube are easily broken after a notch is made on the side.



A notch, crack or scratch on the surface of brittle material like concrete and glass, spreads more readily under tensile force than under compression.

Reducing notch effect:

For concrete and cement mortar notch effect can be reduced by: pre-stressed concrete containing steel rod that are in tension because they were stretched while the concrete was poured on them. This is advantageous in that as well as resisting tension forces they keep the concrete in compression even if the whole structure is not.

For Glass: Notches can be removed from glass

(i) By making the surface of glass as smooth as possible. So glass is usually made smooth to reduce the breaking due to notches.

(ii) For safety glass used in motor vehicle screens is made by heating plate glass and cooling the two surfaces in a stream of air where they contract and compress the glass in the middle.

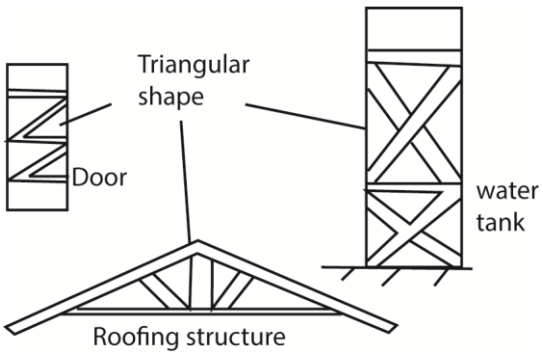
For wood

Thin sheet of wood are glued together to form a laminated structure which is able to resist notches more than solid because for solid structure the crack or a notch goes right through while in a laminated structure it may be stopped by one of the layers.

Structures

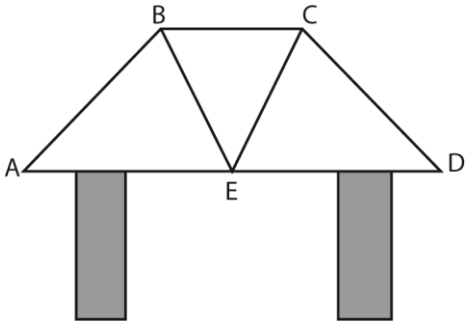
Structure is rigid meaning that it can support weight

Triangular structures are more rigid than other. So rectangular stracture can be made rigid by adding a diagonal piece so that the rectangular change into two a triangular structures which are more rigid. This is why door, water tank, roofing tops.



Struts and ties

Ties are girders which are under tension. This occurs when a girder it in the points it joins to move further apart on the removal of such girder in a tie.
Struts are girder which are under compression. This occurs when a glider result in the point to move closer together on removal girder in struts.

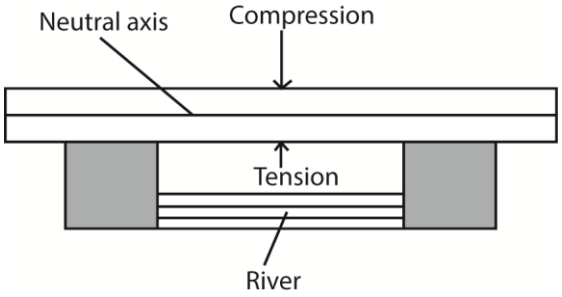


In order to determine each of the girder whether its in tie or in strut each of the girder is removed and the effect is noted in that if the points move further apart then the girder is tie and if the points moved closer together then the girder is strut.

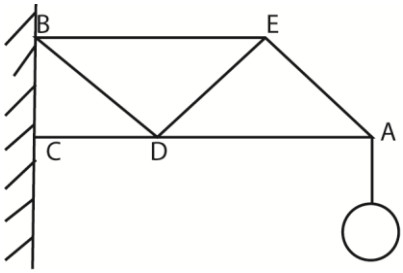
When BC is removed point B move close to point C showing that girder BC is strut.
When AB is removed point A move close to B so girder AB is strut.

When AE is removed point A move further apart from E meaning girder AE is tie. Even girder ED is tie.

For a Bridge



For Structure
When BE is removed point B move further apart from E meaning the girder BE is tie



AE is a tie
ED is a strut
AC is a strut
CD is a strut
DA is a strut
BE s tie

Exercise

1. The diagram below shows a structure of wooden beams P, Q, R, S and T supporting a heavy rod L

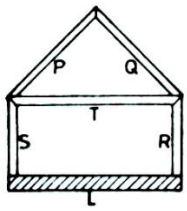


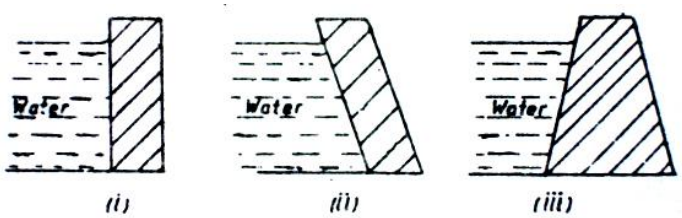
Fig. 7

Which of the beams can be replaced by ropes if the same shape is to be maintained

A. P, R, S and T
B. P ,Q,S and T
C. Q,R,S and T
D. P,Q,R and S

2. Which of the following are brittle substances?
   A. Dry clay, steel, chalk, wood
   B. Chalk, steel, plastic, glass
   C. Glass, chalk, concrete and steel
   D. Dry clay, glass, chalk and concrete.

3. The diagrams below show the possible shapes of water dams.

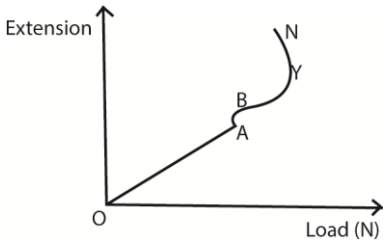


Which shape(s) is /are preferable?

A. (i) and (ii) only
B. (ii) and (iii) only
C. (i) and (iii) only
D. (iii) only

4. Which of the following substances is not elastic?
   A. Glass B. Rubber C. Plastic D. Copper

5.

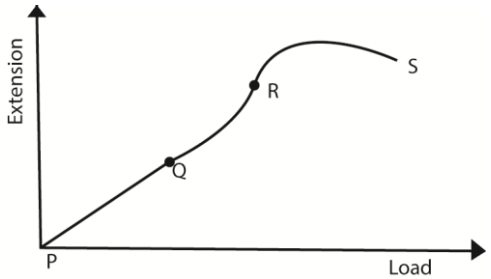


The graph above shows extensions of a wire against load added to the wire. Hooke's law is obeyed between

A. OY B. AN C. AB D. OA

6. Concrete is a mixture obtained by carefully proportioned mixture of
   A. cement, sisal , wood and water B. sand, gravel, bamboo and water
   C. cement, sand, gravel and water D. gravel, sand, sisal and water

7. A notch on a material spreads more rapidly when the metal is
   A. in tension B. in compression C. prestressed D. Reinforced

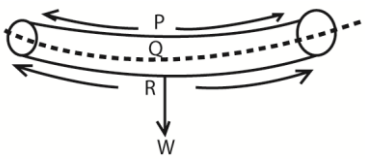


8. The graph above represents the extension of a wire with increasing load. Where does the yield point occur?
   A. between points P and Q B. between points Q and R
   C. between points R and S D. at point S

9. Which of the following are all brittle materials?
   A. Leather, rubber, thread. B. Clay, glass, wood.
   C. Glass, cast iron, stone. D. Rubber, polyester, copper wire.

10. In a write supporting a load, stress is given by
   A. $\frac{\text{Strain}}{\text{Area}}$ B. Force x Area
   C. $\frac{\text{Area}}{\text{Force}}$ D. $\frac{\text{Force}}{\text{Area}}$

11. the beam in the figure below is being acted on by the weight W.



The regions P, Q and R are respectively,
A. tension, compression, neutral axis
B. neutral axis, compression, tension
C. compression, neutral axis, tension
D. tension, neutral axis, compression.

12. An object is said to be behave elastically when
    A. its elastic limit is exceeded
    B. its breaking point is reached
    C. equal increases in the force applied to it produce equal changes in length
    D. the potential energy stored in it is used to permanently deform the object.

13. A ductile material is that which
    A. Is fragile
    B. Is not elastic
    C.Can be molded into any shape
    D.Easily breaks under compression.

14. The strength of a material is its ability to resist
    (i) compression.
    (ii) shearing forces.
    (iii) change in size or shape.

    A. (i) only. B. (ii) only.
    C. (i) and (ii) only. D. (i), (ii) and (iii).

15. A concrete bridge develops a notch when overloaded because it is,
    A. stiff B. brittle C. elastic. D. ductile.

16. A beam may be designed with much of its central part removed in order to improve on its
    A. brittleness B. stiffness C. ductility D. stability

17.

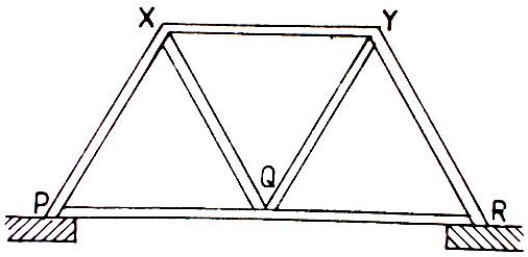


Fig.6

The diagram in figure 6 shows a framework of a bridge. Which of the girders are *ties*?
    A. XQ, QY, PX, YR B. PQ, QR, XY
    C. XQ, QY D. PX, YR

Ties are girders under tension e.g. PQ, QR, XY. Strut are girders under compression e.g. XP, XQ, YQ

18.

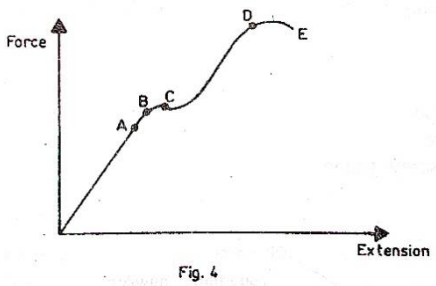


Fig. 4

The above figure shows how the extension of a wire varies with the forces applied. Point B represents

A. proportional limit B. elastic limit C. breaking stress D. yield point

19. (a) What is a ductile material ? *(01 mark]*

(b) Give two examples of ductile materials. *(01 mark)*

(c) A load of 12N stretches a spring by 80 mm. Find the weight which produces an extension of 60 mm on the same spring. *(02 marks)*

20. (a) State Hooke's law of elasticity.

(b) Different loads, W, are applied to the ends of an elastic wire and corresponding extension, e, of the load is recorded.

(i) Sketch a labelled graph of e against W

(ii) Describe the features of the graph

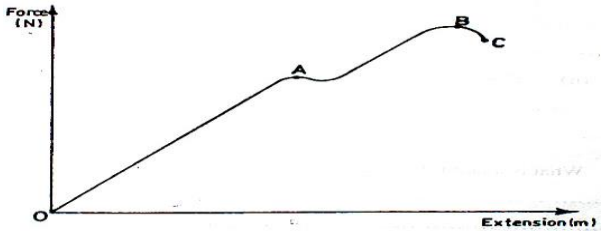
(c) A spring of natural length 5.0×10^{-2}m extends by 2.0×10^{-3}m when a force of 1.8N acts on it. Calculate the extension when a force of 10N is applied on the spring.

21. (a) Define the following terms

(i) Strain

(ii) Stress

(b)



The curve in the figure shows the force versus extension graph for a copper wire. Describe what is happening between points A and B.

22. (a) Use a dragram to describe the effect of a shearforce on a body.

A shear force is a force which causes layers of a material to slide overone another, in the direction parallel to the applied force.

(b) (i) What is meant by the term strength as applied to a material

(ii) What factors affect the strength of a material

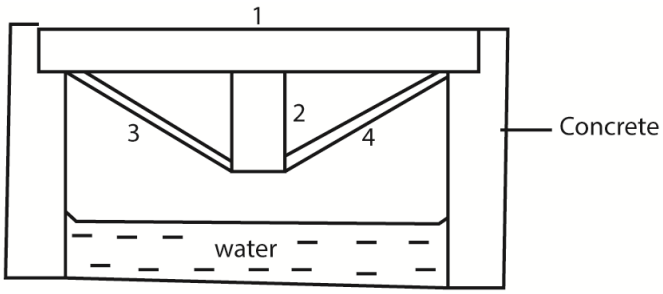
(c) (i) State Hooke's law

(ii) Describe an experiment to verify this law

(d) (i) What is concrete

(ii) State three characteristics of concrete that makes it a desirable building material

23. The diagram in the figure below shows the structure of a bridge



(a) Name the type pf force that acts along the side 1,2,3 and 4 when the bridge has a load at the centre

Side force

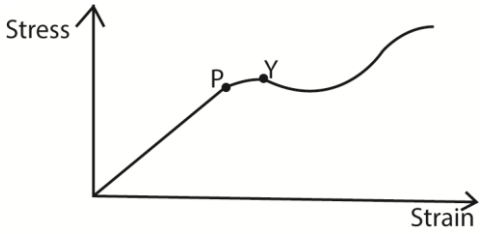
1……..

2……..

3……..

4 ……..

(b) Name one material in each case that can be used to construct parts 2 and 4. Give one reason for your answer in each case



The diagram above shows the variation of the stress against strain for a ductile material

(a) What is meant by the terms stress and strain

(b) What is the significance of points P and Y

24. (a) Name three constituents of concrete materials

(b) State any two characteristics of concrete which make it a desirable building material

(c) State any three ways in which concrete may be reinforced

25. (a) State Hooke's law.

(b)

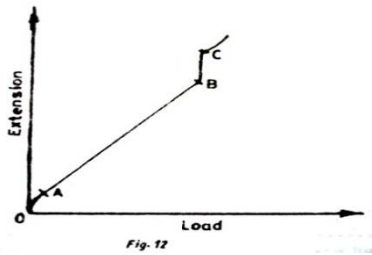


Fig. 12

The figure above shows a graph of extension against load for a copper wire.

(i) Name points B and C

(ii) Explain what happens to the wire between O and A (iii) What happens to the wire just after point C.

26. (a) Explain with the aid of a sketch diagram, how a notch weakens a beam of a brittle material

(b) Sate two ways in which concrete may be made stronger.

27.

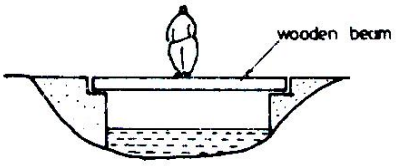


Fig. 9

The diagram in the above figure shows a simple bridge on a stream.

(i) Mark the neutral axis

(ii) label the part that will be in tension

(ii) Indicate on the diagram how the brigde can be strengthened.

28. (a)

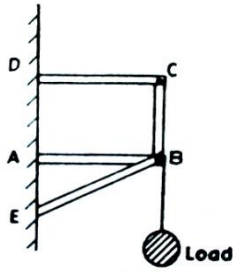


Fig.9

The above diagram shows a structure fixed on a wall so that it stands in the vertical plane and supports a load as indicated. Identify one strut and one tie from the structure

(b)

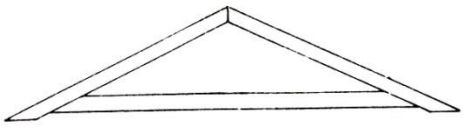


Fig. 10

The above figure shows a diagram of a roof structure. Show on the diagram one way of strengthening the structure by using two additional girders

Suggested answers

1. The diagram below shows a structure of wooden beams P, Q, R, S and T supporting a heavy rod L

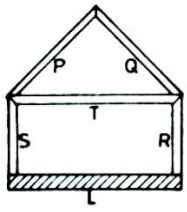


Fig. 7

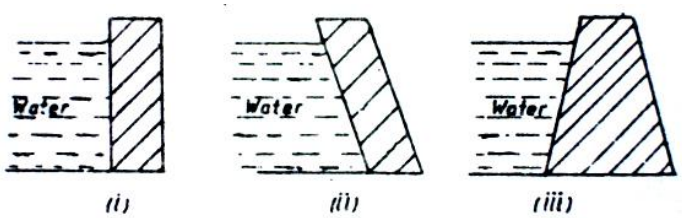
Which of the beams can be replaced by ropes if the same shape is to be maintained

A. P, R, S and T
B. P ,Q,S and T
C. Q,R,S and T
D. P,Q,R and S

2. Which of the following are brittle substances?

A. Dry clay, steel, chalk, wood
B. Chalk, steel, plastic, glass
C. Glass, chalk, concrete and steel
D. Dry clay, glass, chalk and concrete.

3. The diagrams below show the possible shapes of water dams.



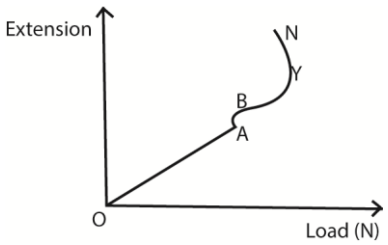
Which shape(s) is /are preferable?

A. (i) and (ii) only
B. (ii) and (iii) only
C. (i) and (iii) only
D. (iii) only

4. Which of the following substances is not elastic?

A. Glass B. Rubber C. Plastic D. Copper

5.

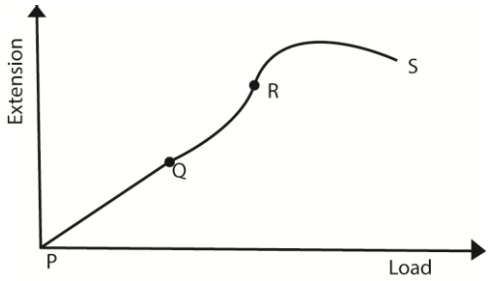


The graph above shows extensions of a wire against load added to the wire. Hooke's law is obeyed between

B. OY B. AN C. AB D. OA

6. Concrete is a mixture obtained by carefully proportioned mixture of
   A. cement, sisal , wood and water B. sand, gravel, bamboo and water
   C. cement, sand, gravel and water D. gravel, sand, sisal and water

7. A notch on a material spreads more rapidly when the metal is
   A. in tension B. in compression C. prestressed D. Reinforced

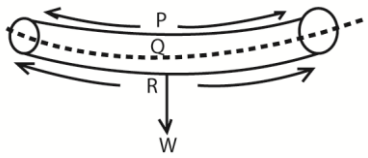


8. The graph above represents the extension of a wire with increasing load. Where does the yield point occur?
   A. between points P and Q B. between points Q and R
   C. between points R and S D. at point S

9. Which of the following are all brittle materials?
   A. Leather, rubber, thread. B. Clay, glass, wood.
   C. Glass, cast iron, stone. D. Rubber, polyester, copper wire.

10. In a write supporting a load, stress is given by
   A. $\frac{\text{Strain}}{\text{Area}}$ B. Force x Area
   C. $\frac{\text{Area}}{\text{Force}}$ D. $\frac{\text{Force}}{\text{Area}}$

11. the beam in the figure below is being acted on by the weight W.



The regions P, Q and R are respectively,
A. tension, compression, neutral axis
B. neutral axis, compression, tension
C. compression, neutral axis, tension
D. tension, neutral axis, compression.

12. An object is said to be behave elastically when

E. its elastic limit is exceeded
F. its breaking point is reached
G. e**qual increases in the force applied to it produce equal changes in length**
H. the potential energy stored in it is used to permanently deform the object.

13. A ductile material is that which
A. Is fragile
B. Is not elastic
C.Can be molded into any shape
D.Easily breaks under compression.

14. The strength of a material is its ability to resist
(i) compression.
(ii) shearing forces.
(iii) change in size or shape.

A. (i) only. B. (ii) only.
C. (i) and (ii) only. **D.** (i), (ii) and (iii).

15. A concrete bridge develops a notch when overloaded because it is,
A. stiff **B.** brittle C. elastic. D. ductile.

16. A beam may be designed with much of its central part removed in order to improve on its
A. brittleness **B.** stiffness C. ductility D. stability

17.

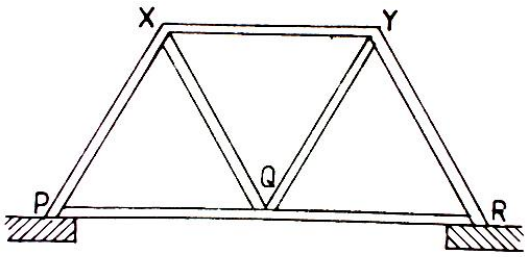


Fig.6

The diagram in figure 6 shows a framework of a bridge. Which of the girders are *ties*?
A. XQ, QY, PX, YR **B.** PQ, QR, XY
C. XQ, QY D. PX, YR

Ties are girders under tension e.g. PQ, QR, XY. Strut are girders under compression e.g. XP, XQ, YQ

18.

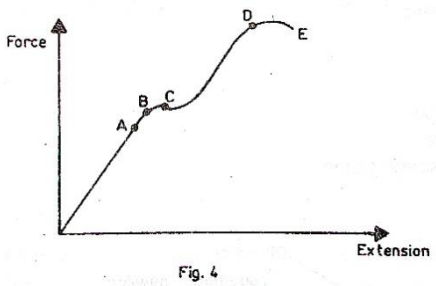


Fig. 4

The above figure shows how the extension of a wire varies with the forces applied. Point B represents

A. proportional limit **B.** elastic limit C. breaking stress D. yield point

19. (a) What is a ductile material ? *(01 mark]*

İt is a material that can be hammered, bent, rolled or pressed into different shapes

(b) Give two examples of ductile materials. *(01 mark)*

Steel, copper, iron, silver

(c) A load of 12N stretches a spring by 80 mm. Find the weight which produces an extension of 60 mm on the same spring. *(02 marks)*

80mm done by 12N

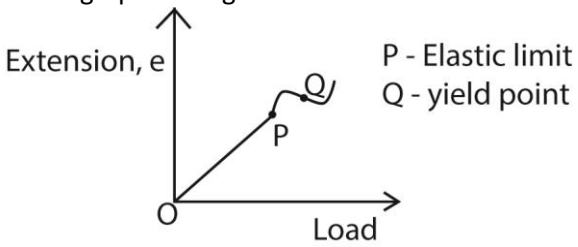
60mm done by $\frac{12\ x\ 60}{80}$ = 9N

20. (a) State Hooke's law of elasticity.

Hooke's lawstates thatthe extension of a material is directly proportional to the load provided the elastic limit is not exceeded.

(d) Different loads, W, are applied to the ends of an elastic wire and corresponding extension, e, of the load is recorded.

(iii) Sketch a labelled graph of e against W



(iv) Describe the features of the graph

- OP the graph is linear becauseextension is proportional to the load
- Beyond P the graph is not straight because extnsion is not proportional tothe load, W

(e) A spring of natural length 5.0 x 10^{-2}m extends by 2.0 x 10^{-3}m when a force of 1.8N acts on it. Calculate the extension when a force of 10N is applied on the spring.

F = ke

k = $\frac{F}{e} = \frac{1.8}{2.0\ x\ 10^{-3}} = \frac{10}{e}$

e = 0.01m

21. (a) Define the following terms

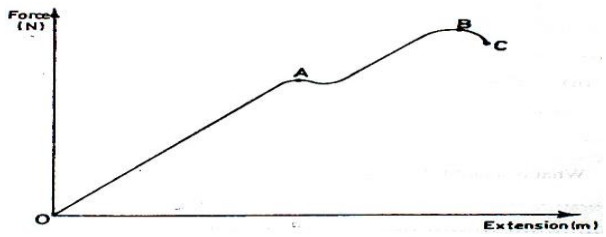
(i) Strain

This is extension per unit length

(ii) Stress

This is the stretching force per unit cross sectional area.

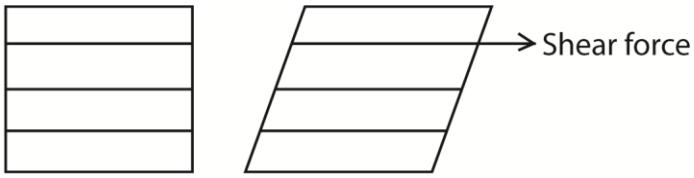
(b)



The curve in the figure shows the force versus extension graph for a copper wire. Describe what is happening between points A and B.

- A is the eleastic limit, beyond A extension is not proportional to the load. Beyond A the wire does not regain its original shape and size.
- B is called the yield point; beyond B the wire undergoes plastic deformation

22. (a) Use a dragram to describe the effect of a shearforce on a body.
A shear force is a force which causes layers of a material to slide overone another, in the direction parallel to the applied force.



(e) (i) What is meant by the term strength as applied to a material
Strength is the ability of a material to resist the application of forces on it without breaking or raptuure

(ii) What factors affect the strength of a material
- Temprature
- Size/diameter
- Nature

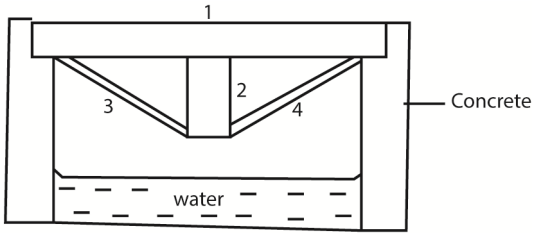
(f) (i) State Hooke's law
Hooke's lawstates thatthe extension of a material is directly proportional to the load provided the elastic limit is not exceeded.

(ii) Describe an experiment to verify this law
- A spring with a pointer is clampedvertically and a ruler is placedby the side
- The initial position of the pointer is noted
- A known mass is suspended from the spring
- A new position of the pointer is noted and extension determined.
- The procedure is repeated for various masses
- A graph of extension against the load is a straight line showing that extension is proportional to the load.

(g) (i) What is concrete
Concrete is a mixture of cement, samd, gravel and water
(ii) State three characteristics of concrete that makes it a desirable building material
- Durable
- Weather resistant
- Resistant to fire

- Strong under compression
- economical

23. The diagram in the figure below shows the structure of a bridge

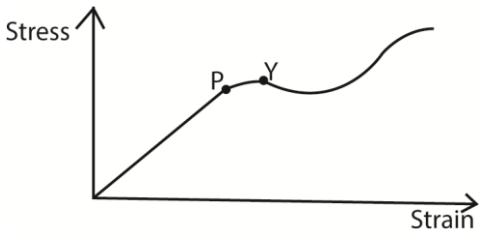


(a) Name the type pf force that acts along the side 1,2,3 and 4 when the bridge has a load at the centre

Side	Force
1	Compression
2	Compression
3	Tensile
4	Tensile

(b) Name one material in each case that can be used to construct parts 2 and 4.
Give one reason for your answer in each case
Reinforced concrete it withstands compression

24.



The diagram above shows the variation of the stress against strain for a ductile material

(a) What is meant by the terms stress and strain
Stress is the ratio of force over area
Strain is is the ratio extension over original leangth

(b) What is the significance of points P and Y
P – proportional limit
Y – elastic limit

25. (a) Name three constituents of concrete materials
Sand, gravel, cement and water

(b) State any two characteristics of concrete which make it a desirable building material
(i) whether resistance,
(ii) high compressive strength
(iii) durability
(iv) fire safety

(c) State any three ways in which concrete may be reinforced
-using iron bars
- using woos
- using fibres

26. (a) State Hooke's law.

Hooke's lawstates thatthe extension of a material is directly proportional to the load provided the elastic limit is not exceeded.

(b)

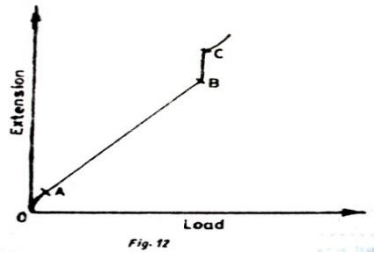


Fig. 12

The figure above shows a graph of extension against load for a copper wire.

(i) Name points B and C

B. proportional limit

C. Eleatic limit

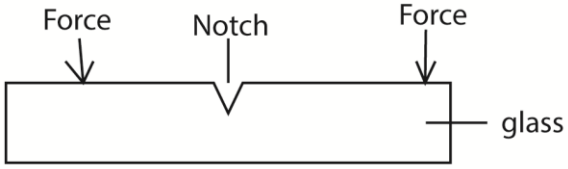
(ii) Explain what happens to the wire between O and A

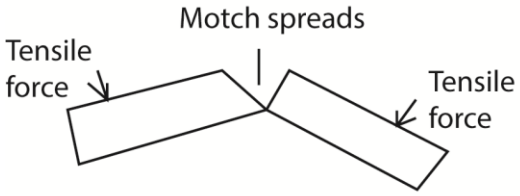
İt straightens

(iii) What happens to the wire just after point C.

Wire undergoes plastic deformation

27. (a) Explain with the aid of a sketch diagram, how a notch weakens a beam of a brittle material





Under tension the notch spread and the beam breaks

(b) Sate two ways in which concrete may be made stronger.

- by reinforcing it with steel bars
- by reinforcing it with fibres

28.

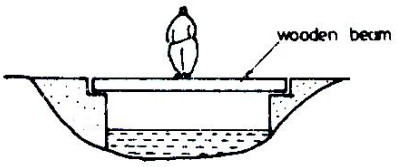


Fig. 9

The diagram in the above figure shows a simple bridge on a stream.

(iii) Mark the neutral axis

(ii) label the part that will be in tension

(iv) Indicate on the diagram how the brigde can be strengthened.

29. (a)

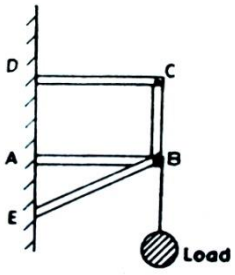


Fig.9

The above diagram shows a structure fixed on a wall so that it stands in the vertical plane and supports a load as indicated. Identify one strut and one tie from the structure

(b)

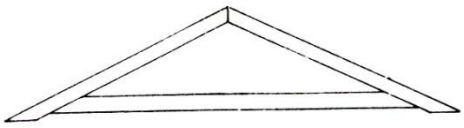


Fig. 10

The above figure shows a diagram of a roof structure. Show on the diagram one way of strengthening the structure by using two additional girders