6

CONSTRUCTION

6.1 INTRODUCTION

Construction carries important place in human civilization. It shows us the progress made by man from time to time. The first buildings made by human were simple huts, tents. Wood, stones and sands were the only material used.

The first bridges made by humans were probably wooden logs placed across a stream.

In the ancient time architects put all their skill in building the roof of the construction. They construct walls and roofs using stones. Still we can see the stony beam on the stony column in old temples.

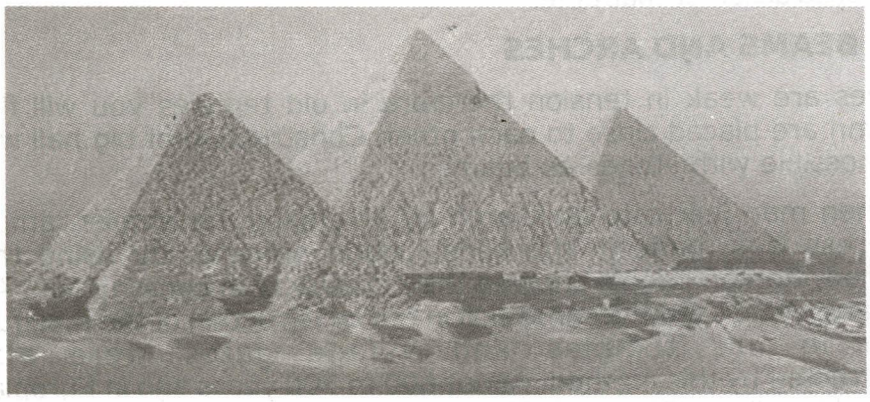


Fig 6.1 Pyramids

The knowledge gained over 5000 years ago is still used in the construction of every building in the world. Ancient architects were constructing large buildings with the help of limestone, stones, and earthen materials etc. Today Steel, cement etc. material is available for architects to construct big buildings and large bridges. We will study common types of construction method in following section.

6.2 OBJECTIVES

After reading this lesson, you will be able to:

- learn about history of construction, different types of structures.
- know about different tools used in construction.

6.3 HISTORY OF CONSTRUCTION

Construction has a long tradition of thousands of years. To become immortal in history, Kings asked their architect to construct huge buildings. Pyramids were build to bury Faroha king around 5000 years ago. Height of the pyramid is approximately 300 feet and was built with 5-6 feet rectangular stones. Those architects showed their skill of building such huge, accurate construction. Pyramids are one of the Seven Wonders of the World.

In India, Kailash temple at Ellora (Dist Aurangabad) is built from huge stones in 7^{th} – 13^{th} centuries.

It is the largest and most magnificent rock-cut temple in the world and is considered one of the wonders of India. 3 million cubic feet of rock was chiseled away to complete the temple buildings, life-size elephants, and sculptures. It is estimated that to carve the Kailash Temple, 200,000 tons of rock had to be removed by thousands of workers for over 150 years.

Archaeologists estimate it took thousands of skilled stone cutters seven to eight generations to construct this temple. Kailash temple is 81m long, 47m wide, and 33m high.

In recent history, Tajmahal was built by Shahjahan in the memory of his wife. Human being always expresses his creativity and skill through the construction of that time.

6.4 BEAMS AND ARCHES

Stones are weak in tension therefore in old temples you will find column are placed close to each other. Construction of big hall was not possible with stones as beam.

When man learnt to built arch by arranging the stones, ample progress was made in the construction process. By using this method, Roman people showed their creativity in construction. Afterwards Arab used the same skill in the construction of the mosque. Arch in our temples and village gates were also constructed by this method. About 600 to 700 years ago in Europian started building elliptical arches instead of rounded one.

In stony roof and beams, pressure comes on the beam due to the weight of the roof and it bends at the center. Therefore, limited distances were kept between the two beams. In case of circular arches, pressure is equally distributed and hence, we can keep more distance between the columns. In elliptical arches we can increase this distance further and can construct the stony concave roof.

TRUSSES

People realized that wood and steel can bear the tension & pressure easily. Therefore, use of Wood and steel started in construction.

Architects recognized importance of triangular frames in construction. Triangular frames are stronger than square or pentagon frames.Therefore, architects started making the truss for the roof by joining different sized triangles for small houses. People started using roof tiles on this truss with the support of vertical and horizontal planks. Afterwards method of putting steel or cement sheets on the roof got developed.

INTEXT QUESTIONS 6.1

State True or false:

i) Stone is strong therefore, always preferred material for beams. ( )

ii) Man started constructing big halls after he learnt to build arches. ( )

iii) Modern construction is far advanced and do not use any of the old construction techniques. ( )

iv) Triangular frames are stronger than square frames. ( )

6.5 TYPES OF CONSTRUCTION

Following two are the most commonly used construction methods :

1. Wall bearing structures
2. RCC structures

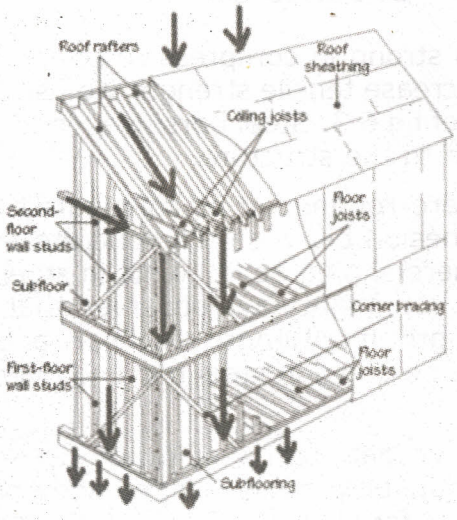


Fig: 6.2 Wall bearing construction

(1) Wall bearing construction

In wall or load bearing construction, all load of roof and structure is carried by walls down to its foundation ref. fig.6.2. This type of construction may not use supporting column or wood pillar. The size of walls needs to be bigger to carry all the loads. Further, there is limitation to construct long walls at a stretch. This is typically used in residential or 1–2 storied buildings. This is economical than RCC structure or steel frame structures.

(2) Reinforced cement concrete (RCC)

Most of the high rises building uses RCC techniques.

In an RCC framed structure, the load is transferred from a slab to the beams then to the columns and further to lower columns and finally to the foundation which in turn transfers it to the soil.

The walls in such structures are constructed after the frame is ready.

Fig: 6.3 Image showing laying process of cement concrete with steel bars in rcc coloum

Cement concrete is strong in compressive strength but weak in tensile strength. To increase tensile strength we use mild steel bars in cement concrete. Ref.fig 6.3. Steel bars used in cement concrete provide good strength to the structure.

Usually steel bars are roughened or corrugated to further improve the bond or cohesion between the concrete and steel. Care must be taken that there should be no joints in steel bars used for RCC work. Therefore, you might have observed that steel used for RCC work is long in length. If full length steel bars are not available, proper overlap should be given in steel bar and overlap should be staggered.

A care must be taken that steel should not disturb during concreting. Steel rods should be properly binded and proper planks or plates must be provided for walking. Curing of all concrete is done at least for 20 days.

Following are the different names of the structural elements in a building as shown in the figure

Slab: A The flat ceiling of a story is called a 'Slab'.

Beam: The peripheral horizontal members supporting the slab are called 'Beams'.

Plinth Beams: The beams at ground level or plinth level (the lowermost habitable level) are called 'Plinth Beams'.

Columns: The vertical members supporting the beams are called 'Columns'.

Foundation: The system below ground transferring the entire load of the structure to the soil is called 'Foundation'.

Cantilever: A slab or a beam supported only on one side and projecting horizontally on the other side is called a 'Cantilever' slab or beam e.g. balconies, lofts and canopies.

6.6 STEEL FRAME STRUCTURES

In big buildings, a steel frame is constructed as a skeleton of building. All loads of roof and floor are transmitted to beams and girders. Walls in these structures do not carry load of the structures.

6.7 FOUNDATION

Foundation is in direct contact with soil and transmits load of complete structure to soil. If foundation is weak then there is danger that walls will collapse or tilt due to load of the structure.

Generally, foundation is below the ground level. Depth of foundation depends on type of soil and its bearing capacity, depth of ground water table and the size of structure.

To allow removal of top loose soil and variation in ground level, the best recommended depth of foundation is from 1.00 meter to 1.5 meter from original ground level.

Following are the different steps in Foundation Work:

1. Excavation of soil for foundation.
2. Laying out cement concrete.
3. Laying Brick work up to plinth level.
4. Refilling of earth around the walls
5. Refilling of earth in the building portion to the required height.

INTEXT QUESTIONS 6.2

Fill in the blanks:

i) Long form of RCC is _____.

ii) Two common types of construction methods are _____ and _____.

iii) _____ transmits load of entire structure to soil.

iv) The beam at ground level is called _____.

v) A slab supported only on one side is called _____.

BRICK WORK

When laying bricks, the manner in which the bricks overlap is called the bond.

1) **Stretcher bond** (also known as running bond) is the most common bond. Ref Fig 6.4 (a) It is easy to lay. It is entirely composed of stretcher bricks, set in rows that are offset by half a brick as shown in the figure.

   Stretcher bond is generally used to build a single-brick wall.

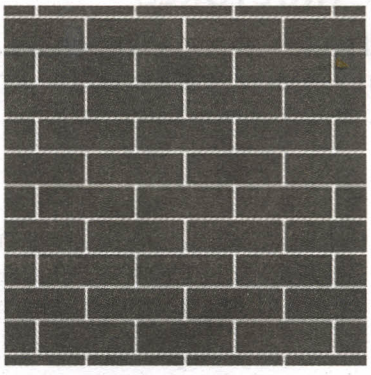


Fig: 6.4(a)

2) **English bond** is shown in the figure 6.4(b). This produces a solid wall that is a full brick in depth. English bond is fairly easy to lay and is the strongest bond for a one-brick-thick wall.

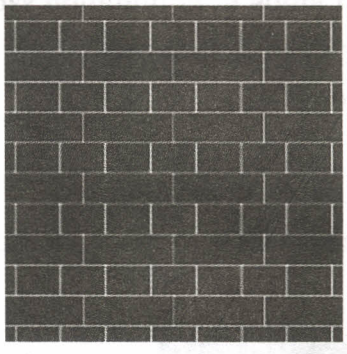


Fig: 6.4 (b)

3) **Header bond** (also known as Spanish bond) was a very common bond for bearing walls Ref fig 6.4(c).

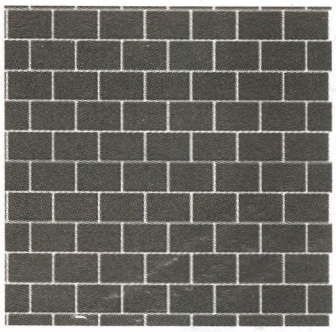


Fig: 6.4(c)

4) Flemish bond-Flemish bond, also known as Dutch bond, has historically always been considered the most decorative bond. Ref Fig 6.4(d)

Fig: 6.4(d)

5) **Rat-trap bond**, also known as Chinese bond.

The air cavity gets created between the bricks hence the name 'Rat – trap bond'. It shown in fig 6.4(e). It requires less number of bricks than a solid wall. Air cavity helps in keeping the building cool.

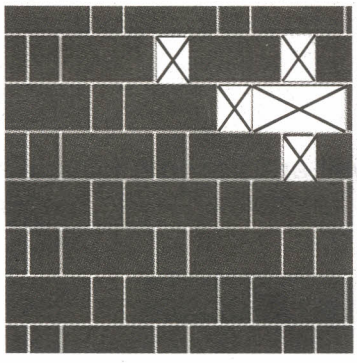


Fig: 6.4(e)

6.9 USE OF PLUMB, LEVEL TUBE AND SPIRIT LEVEL

In any type of construction, accurate measurement of construction is most importance. It is necessary to maintain the right angle direction. Tools used in construction are discussed here.

1) Plumb – bob

A **plumb** is a weight, usually with a pointed tip on the bottom that is suspended from a string. It is used as a reference line for leveling vertical length. Ref fig 6.5(a)

Mesons used this method to ensure that their constructions are perfectly upright

Fig. 6.5 (a) Plumb

2) String Line

You must have seen meson using string for laying bricks of foundation. A line is described by two points, the start point and the end point, and the shortest distance between two points is a straight line. A mason uses a string line between two points (nails or line blocks etc.) and he pulls the line tight to get it the shortest distance, to make it straight, with no sag. He takes this string as a reference to complete his work.

3) Spirit level

It is used to check the horizontal level of construction. The bubble in the tube should be at the center to make the level horizontal. Ref. fig 6.5(b)

Fig:6.5(b) Spirit Level

4) Water tube

To check all points of wall are at same level, a simple water tube is used. It uses the simple principle of 'water remains at the same level'.

INTEXT QUESTIONS 6.3

Match the following:

	A	B
i)	Spirit level	leveling horizontal level
ii)	Plumb	Cooler houses
iii)	Rat trap bonds	Single brick wall

iv) Spanish bond	Leveling vertical length
v) Stretcher bond	bearing wall

6.10 FERRO CEMENT CONSTRUCTION

In Ferro cement construction a frame of chicken wire mesh is made. A mixture of cement, sand, and water is spread over the frame. Then the Ferro cement structure is allowed to cure for 28days. Advantages of Ferro cement structures are as follows: i) Despite the small thickness, Ferro cement structures are strong ii) Economical iii) It requires less skill to manufacture iv) Safe in earthquakes. Now a days other materials viz fiber, bamboo etc are used in place of chicken mesh to reduce the cost.

Structures for strength

In this section, we will discuss commonly used arrangements to get the proper strength for construction. In nature, all animals have skeleton. They are able to take up their own weight and do movement due to skeleton. In tree trunks fibers are connected to each other using lignin. This makes wood strong. Man has learnt from nature and made use of this structure in imaginative way for their benefit.

There are two different kinds of structure:

1 Skeleton type

Flexible limbs and parts of animal body are supported by a bony skeleton (frame). Similarly man has learnt to construct frame-work to support weak substances. Viz. Man has constructed trusses,

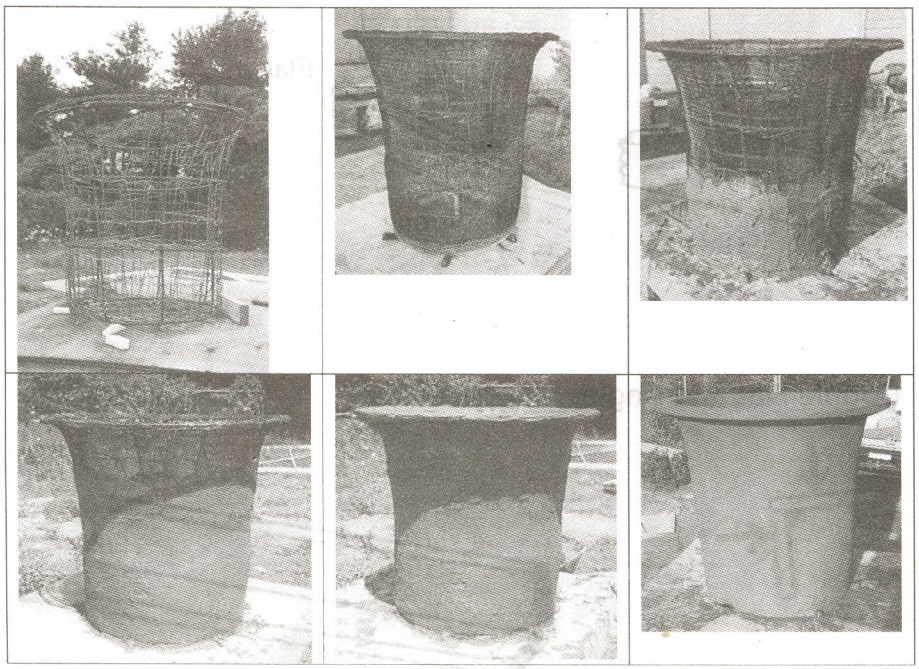


Fig:6.6

beams, and columns of steel or wood, to support roof made of grass or mud-tiles. Similarly steel frames filled with concrete become stronger than either.

2 Fiber method

Fiber's are often flexible but they are strong in tension. If the fibers are combined together by an adhesive substance then it can produce strong material.

If fiber is added to brittle substances then its brittleness decreases. For example :

i) Cement is brittle; to overcome that weakness asbestos is added to cement to make strong asbestos- cement sheets.

ii) Plastic is breakable. If glass fiber is added to it then it turns into strong FRP.

iii) Cement Mortar is easily breakable. But if thin chicken-mesh is put into mortar that makes it a strong Ferro cement.

iv) Similarly, fiber is added to tar to make it into durable roof-sheet.

It is not always necessary to use two or different materials to create strong objects. Strength can be obtained by arranging the same material in different ways. We can learn this from following comparisons:

1) Flat and Rod – Judge Strength of flat from all direction.

Rod is strong in all direction but flat is stronger in only one direction.

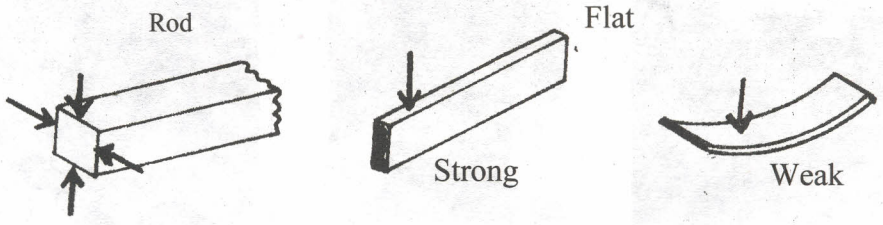


Fig: 6.7(a)

2) Double Flat and Angle.

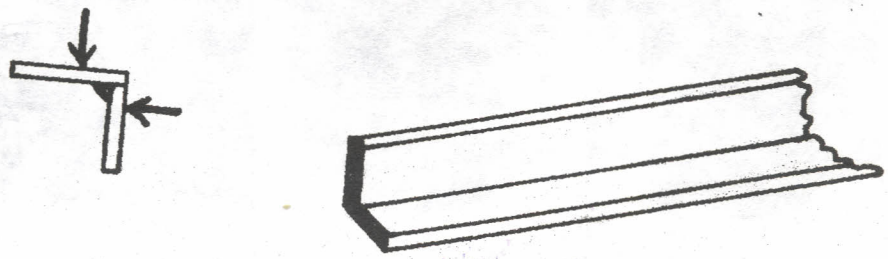


Fig: 6.7(b)

3) Twisted Flat

Fig: 6.7(c)

4) Rod and hollow Tube

If the diameter of cross section is same, Hollow tube is stronger than the rod.

Fig. 6.7 (d)

5) Triangle and Rectangle: Between the same size of triangle and rectangle, triangle is stronger. Under load triangle will not change its shape.

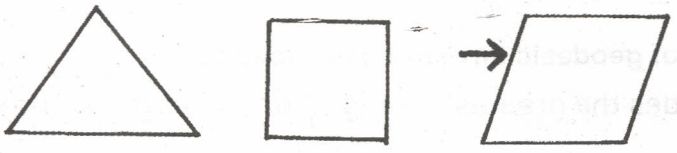
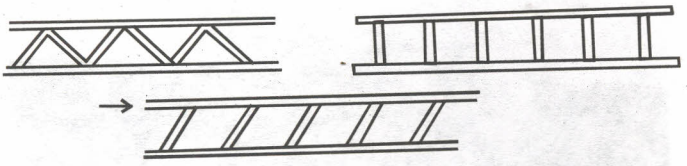


Fig: 6.7(e)

6) A joint in fig 8(f) be made stronger as shown in the fig 8(g).



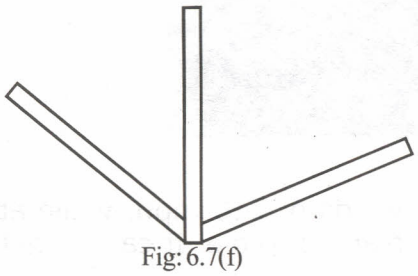


Fig: 6.7(f)

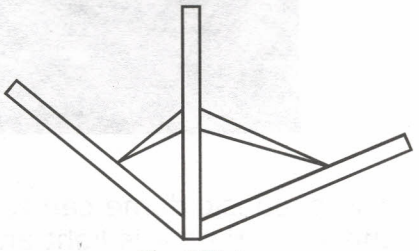


Fig: 6.7(g)

7) Truss

Different types of trusses are shown in the figure. Different triangles are joined together to get the required shape and strength.

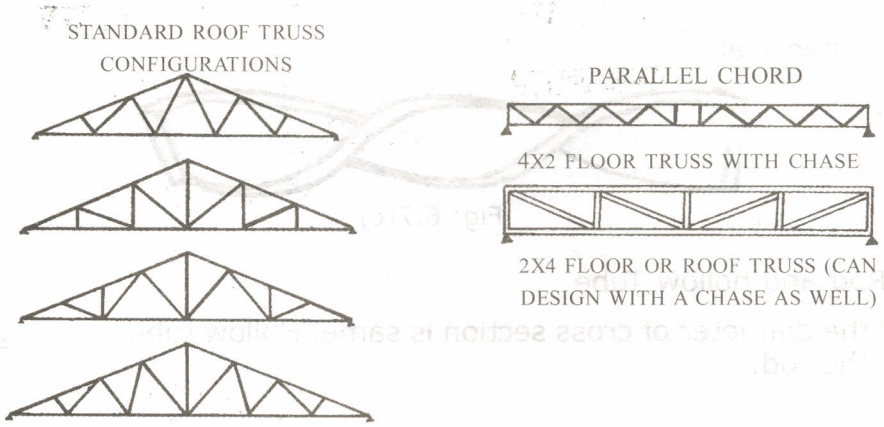


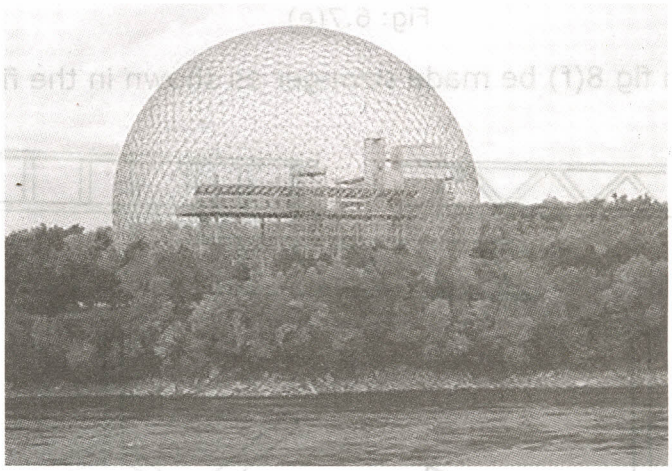
Fig: 6.8

8) Geodesic Dome structure

Architect "Buck Minster Fuller" had shown the method of constructing a geodesic dome structures. In which round building is constructed by connecting frames. In this type of construction, wall and roof are not separately constructed but both are combined in single round. In this way buildings can be constructed with large diameter without any column.

Advantage of geodesic structure is as follows :

- It provides the greatest strength for the least volume of weight.



- The geodesic dome can withstand winds of 210 mph, while at the same time it is light and easily transportable. It can be put up in hours.
- A geodesic dome can withstand cyclones and earthquakes far better than conventional buildings.

The geodesic dome is the only structure that actually gets stronger, lighter in density and cheaper per square foot with size.

Cost effective housing structures

Low cost housing does not mean inferior or low quality housing. Many organizations worked on cutting down construction cost by using alternatives to conventional methods and inputs. It is about the usage of local and indigenous building materials, local skills, energy saver and environment-friendly options. Famous architect Laurie Baker said "a cheaper house is not just for the poor. One can cut unnecessary expenditure even while building beautiful houses'.

INTEXT QUESTIONS 6.4

Write True or false:

i) Despite smaller thickness ferrocement structure are strong.

ii) Cement can withstand tensile load.

iii) If diameter of cross section is same, hollow tube is stronger than the rod.

iv) It is necessary to connect two different materials to create strong object.

v) Geodesic domes are preferred in earthquake and cyclone prone region.

6.11 WHAT YOU HAVE LEARNT

In this chapter, you studied history of construction. You learnt about different types of construction. You studied different elements of RCC construction. You learnt about different ways to lay bricks. You studied basic instruments used in construction. Now you know about different structures used to get strength for construction.

6.12 TERMINAL QUESTIONS

1) Write reason:

   i) In old temples, stone columns are placed close to each other.

   ii) Arches are used to build big halls or bridge.

   iii) Triangle is more stronger than square under load.

2) Write different simple instruments used by meson.

4) Write down advantages of ferrocement construction.

5) Write down advantages of geodesic structure.

6.13 ANSWER TO INTEXT QUESTIONS

6.1 i) False ii) true iii) false iv) true

6.2 i) Reinforced cement concrete ii) wall bearing structure, RCC structure iii) foundation iv) plinth beam v) cantilever

6.3

	A	B
i)	Spirit level	Leveling horizontal level
ii)	Plumb	Leveling vertical length
iii)	Red trap bonds	Cooler houses
iv)	Spanish bond	bearing wall
v)	Stretcher bond	Single brick wall

6.4 i) True ii) False iii) True iv) False v) True

SUGGESTED ACTIVITY

- Observed different types of trusses used in your surroundings. Draw sketches of trusses used in old houses, poultry shed, tin roof shed, polyhouses.

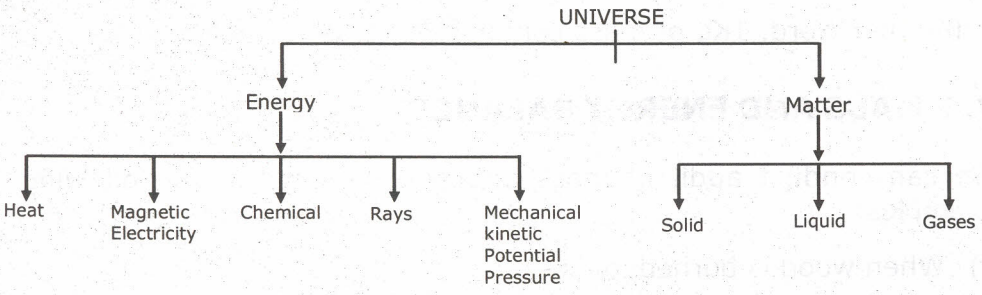
7

MASS AND ENERGY

7.1 INTRODUCTION

We are the part of universe. Our earth is in solar-system and our solar system is in a galaxy. There are many galaxies in the universe. All that exists is in the universe. The universe is endless. The universe cannot be created or destroyed. The universe is made up of matter and energy.

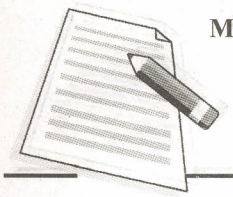
There are different types of energy, shown as above. Matter in the universe is available in solid, liquid and gases states. It is not possible to create or destroy total of matter and energy that exists in the universe. We can change matter and energy from one form to another.



7.2 OBJECTIVES

After reading this lesson you will be able to-

- Understand the law of conservation of mass and energy;
- Calculate efficiency of some of the daily applications.



7.3 LAW OF CONSERVATION OF MASS AND ENERGY

Energy can neither be created nor destroyed. Only one form of energy can be converted into another form is law of conservation of energy.

Einstein showed relation between mass and energy. It is expressed by the formulae : $E = m \times c^2$ (m = matter in Kg, C = speed of light 3×10^8 in m/s^2).

He showed that mass and energy can be converted into each other. But it is not possible to convert matter into energy in normal conditions. It can be done in nuclear reactors.

How much energy is stored in 1 Kg of mass?

$E = m \times c^2$ (m = matter in Kg, C = speed of light 3×10^8 in m/s^2)

$E = 1 \text{ kg} \times (3 \times 10^8)^2$

$= 1 \times 9 \times 10^{16}$ Joules

This means 1 kg of mass can release 9×10^{16} Joules of energy.

You must have confused with the above numbers. Let's calculate, what such amount of energy means?

First convert it into calories. 4.2 Joules = 1 calories

Therefore, 9×10^{16} Joules = $(9 / 4.2) \times 10^{16}$ calories

= approx. 2×10^{16} calories

Therefore, 1 Kg of mass contains approx. 2×10^{16} calories

Generally, 1 gm of oil contains 10000 calories.

1 kg of oil contains = $10000 \times 1000 = 10000000 = 10^7$ calories

Therefore, to get 2×10^{16} calories energy we will need 20 lacks tons of oil.

In other word, 1Kg of mass contains 20 lacks tons of oil.

7.4 MASS AND ENERGY BALANCE

We can conduct audit of mass and energy. Let's study following examples:

1) When wood is burned in air–

100gm of wood when burned in air, it produces 2g. of ash. Where did the balance of 98 g. go?

If you carry out detailed investigation, you may find some gas and vapour goes into air. In the above example, we found 143.79g. of Carbon dioxide (CO_2) and 58.9g of water vapour gets generated in the process.

The material balance is written as follows: