Projection

Objectives: At the end of this lesson you shall be able to
- **define projection**
- **classify projection**s
- **state the types of pictorial projection.**

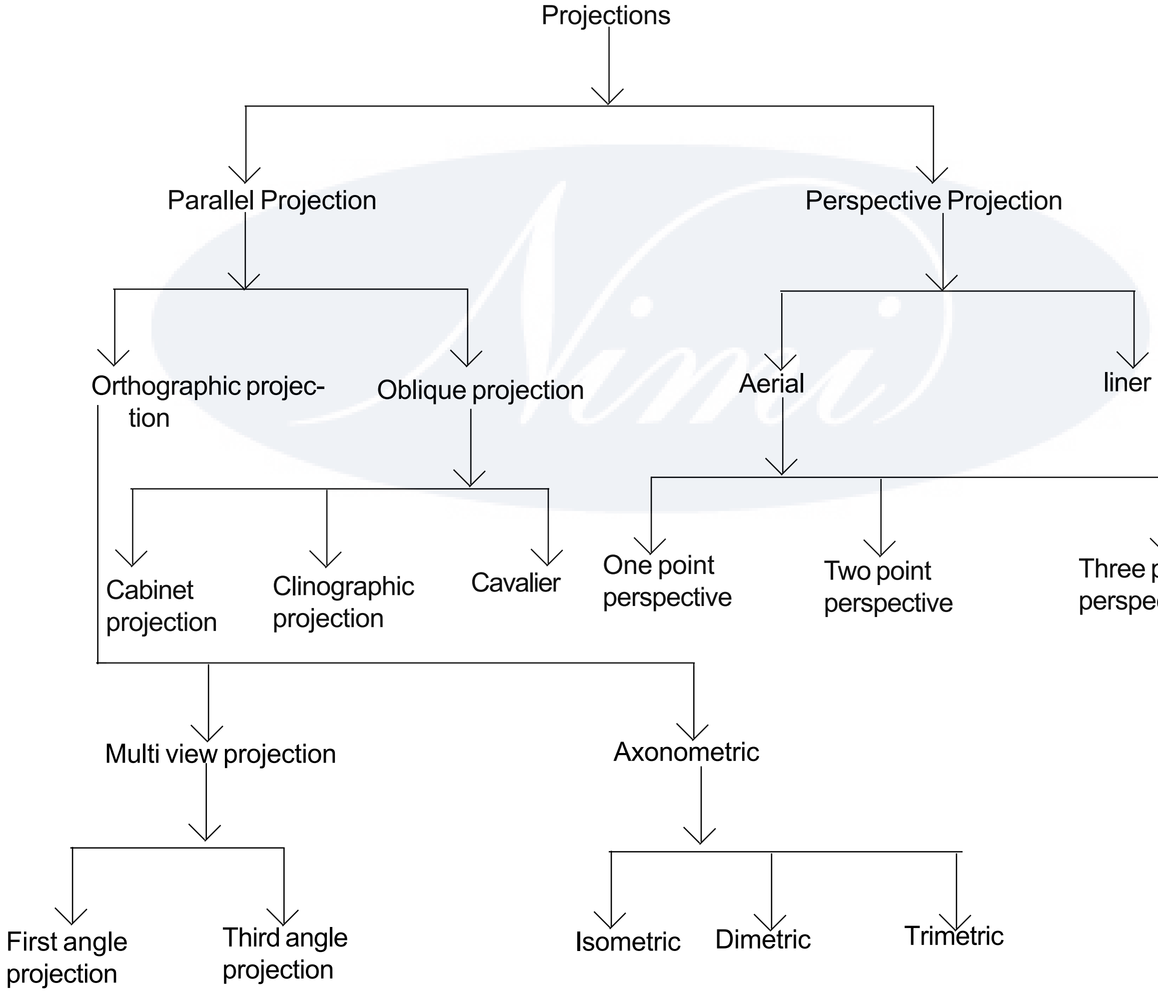
Introduction

As object, have three dimensions like length, width and height/ thickness. The shapes and sizes of three-dimensional objects have to be represented on a sheet of drawing paper, which has only two-dimensional planes.

For obtaining the image of an object, various points on the contour of an object, are thrown forward on to a plane by means of straight lines or visual rays.

The figure formed by joining various points thus obtained on the plane, is the image of the object and is called Projection.

Classification of projections



Pictorial projection

It is used for easy understanding of the drawing and visualizing the object for the persons without technical knowledge. These drawings create three dimensional effect and they reveal the shape of an object, approximately, when an observer, views the object.

But for orthographic projection, persons without technical knowledge cannot understand easily, hence, trainee shall develop the ability to convert orthographic views into pictorial views.

Isometric projection

Isometric projection is a type of pictorial projection in which the three dimensions of solid are not only shown in one view but their actual sizes can be measured directly from it. In isometric projection, there are three principle axes such as height axis, length axis and width axis. Three axis of the object are equally inclined 120^0 to each other and the three dimensions length, height and width are equally fore-shortened by using an isometric scale.

Important points for isometric drawings

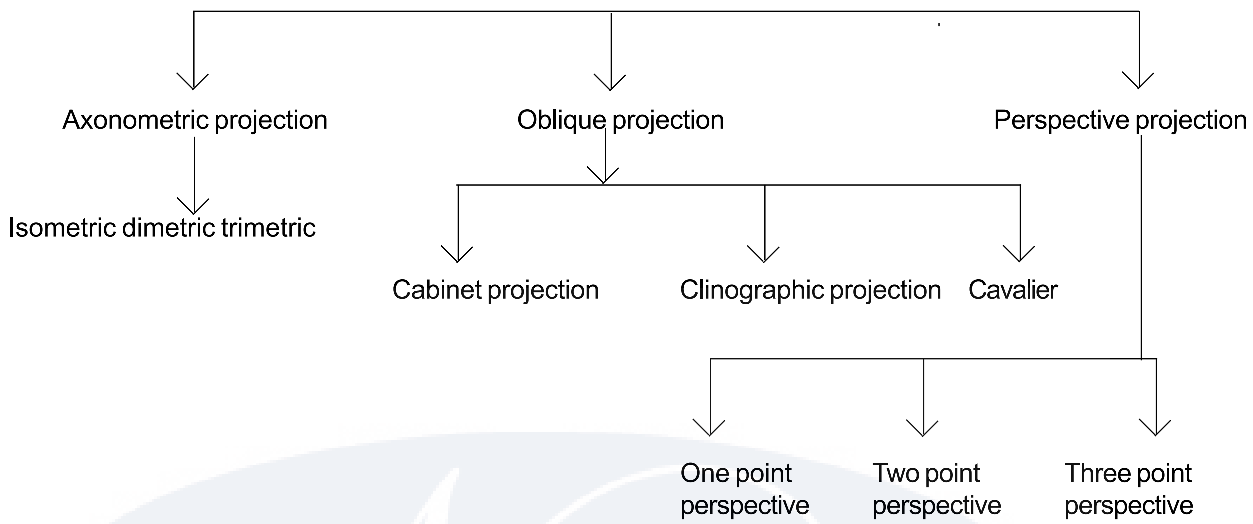
1 In isometric view, the two sides are inclined at 30^0 to the height axis.

2 The length may be drawn on the right or left depending on the side view of the orthographic projection of the object.

3 Hidden features are not to be shown in isometric views.

4 Vertical lines will be drawn vertical, while horizontal line will be drawn at a angle 30^0 to horizontal.

Types of pictorial drawings



Difference between Isometric view and projection

Isometric View	Isometric projection
Draw to actual scale	Draw to isometric scale.
When lines are drawn parallel to isometric axes, the true lengths are laid off.	When lines are drawn parallel to isometric axes, the lengths are foreshort -ened to 0.82 times the actual lengths.

Oblique projection

Pictorial projections are becoming more popular due to use of a computer in a modern drawing, dimensional object on the projection plane by one view only. This type of drawing is useful for marking an assembly of an object and provides directly a production drawing (working drawing) of the object for the manufacturing purpose.

Definition

When an observer looks towards an object from infinity the line of sight (projectors) will be parallel to each other and inclined to the plane of projection.

Types of the oblique projection

1 Cavalier projection.

2 Cabinet projection.

1 The oblique projection is based on scales by which the receding lines are drawn.

2 When the receding lines are drawn to full size scale and the projection inclined at an angle of 30^0, 45^0, 60^0 to the plane of projection. Such oblique projection is known as cavalier projection.The inclined lines in an oblique projection are called receding lines.

3 If the receding lines are drawn to half size scale such oblique projection is known as the cabinet projection.

The difference between the Oblique and Isometric Projections

Sl.No.	Oblique Projection	Isometric Projection
1	Projectors from an object are parallel to each other and incline to the plane of projection.	Projector from an object are parallel to each other and perpendicular to the plane of the picture.
2	The object is placed in such a way that one of its prominent faces remains parallel to the Plane of projection.	The rest on one of its Faces. The object is kept in such way that its three mutual perpendicular edges (axes)make equal angles with the plane of the Projection. The object stands on one of its Corners.

Sl.No.	Oblique Projection	Isometric Projection
3	The object is drawn with the actual Dimensions.	The object is drawn with the reduced (About 82%) dimensions.
4	The faces of object which are perpendicular to the plane of the projection will be Distorted in the shape and size.	All the faces of the object distorted in the Shape and size.
5	The choice of position of the object.	The choice of position of the object is not possible.

Orthographic projection

If the projections from the object are perpendicular to the projection plan, then such a projection of the object is known as Orthographic Projection. A thorough knowledge of the principles of pictorial projection is required for converting pictorial views into orthographic views.

General Procedure

1 Determine the overall dimensions of the given object for the required orthographic views.

2 Draw rectangles for the views using suitable scale. It is also required to keep sufficient space between the views and from border lines.

3 Draw centre lines for circles and arcs.

4 Draw circles and arcs of circles first, next draw straight lines for the main shapes of the object.

5 And finally draw straight lines and small curves for the minor details of the object.

Points to be considered for converting a pictorial view in to orthographic views

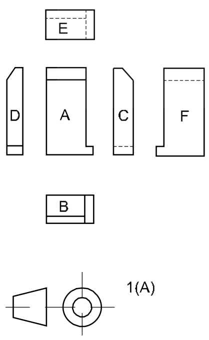
- Dimensions which are parallel to the direction of viewing will not be seen. Edges which are parallel to the direction of viewing are seen as points. Surfaces which are parallel to it are seen as lines.
- The visible edges and the intersection if the surfaces are shown by object lines. But the hidden edges are shown by dotted lines.
- The centre linens of the symmetrical parts like whole cylinder etc. should be clearly shown.

System of orthographic projection

Orthographic views can be obtained by two methods:

<table>
<tr><th>First Angle projection</th><th>Third angle projection</th></tr>
<tr><td>
Arrangement of views in first Angle projection.

With reference to the front view the other arranged as follows:



1(A)

The view from above is placed underneath

The view from below is placed above.

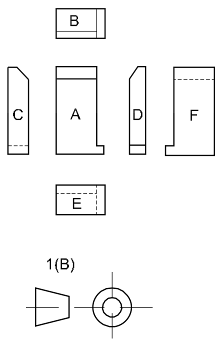
The view from the left is placed on the right.

The view from the right is placed on the left.

The view from the rear may be placed on the left or on the right as may be found convenient .

The distinctive symbol of this projection is Fig 1a
</td><td>
Arrangement of views in Third Angle Projection.

With reference to the front view the other arranged as follows:



1(B)

The view from above is placed above.

The view from below is placed underneath

The view from the right is placed on the right.

The view from the left is placed on the left.

The view from the rear may be placed on the left or on the right as may be found convenient .

The distinctive symbol of this projection is Fig 1b
</td></tr>
</table>

- When a hole or a cylindrical part in seen as a circle draw two centre lines intersecting each Other at right angles at its centre line for its axis.
- When a centre line coincides with a visible edge it is drawn as a dotted line.
- When a hidden edge coincides with a visible edge, it is drawn an object line (visible out line)

First angle projection

- When the object is placed in 1st quadrant such that it is between the projection plane and the observer, the projection so obtained is called first angle projections.

Third angle projection

- In this case, the object is placed in the 3rd quadrant and the planes of projections are in between the object and the observer.

Basic principles

- Depending upon the relative position of the object, the picture plane and the station point, the following situation may arise:
- If the picture plane is in between the object and the station point, a normal perspective is obtained.
- If the object is in between the picture plane and the station point, a larger perspective is obtained.
- If the station point is in between the object and the picture plane, the perspective is reversed.

Projection of points and lines

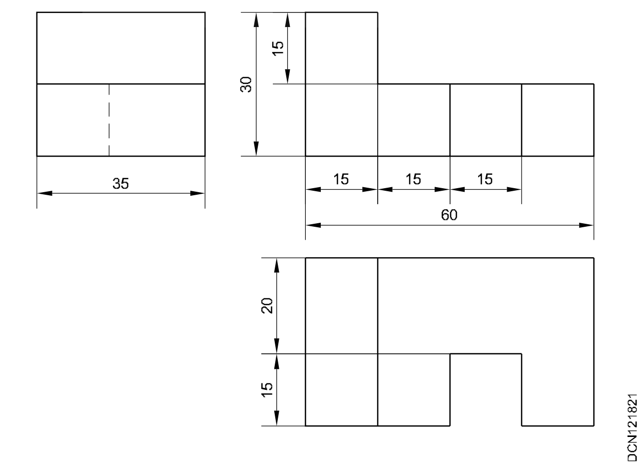
Objectives: At the end of this lesson you shall be able to
- **explain the four dihedral angles**
- **state the meaning of orthographic projection**
- **explain terms plan and elevation as applied toorthographic views**
- **state the relative position of views in first and third angle projection**
- **state the projection of lines of different orientation.**

Graphics are preferred by engineer's and craftsman to communicate their ideas. When graphics are used for communication it is called graphical language. Those who donot have the knowledge of this language are professionally illiterate.

The saying that "A picture is worth a thousand words" is very much relevant in technical work.

An engineering drawing conveys many different types of information of which the most important thing is the shape of the object. Fig 1 shows a sample drawing. In this drawing the shape of the part is represented by three views.

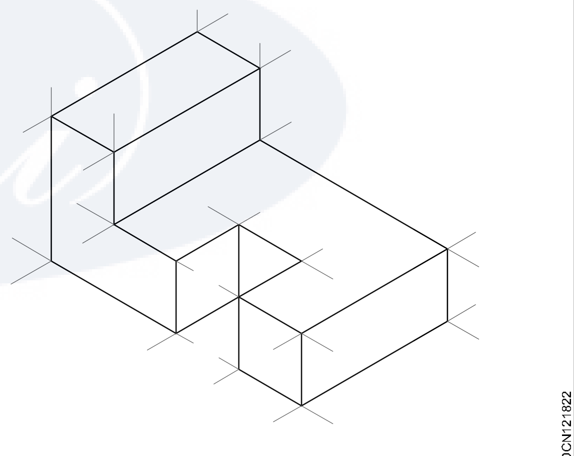
Fig 1



For an untrained person it will be very difficult to conceive the shape of the object from the above drawing.

But in Fig 2, the same object is shown pictorially in a different ways and the shape is easily understood even by a layman.

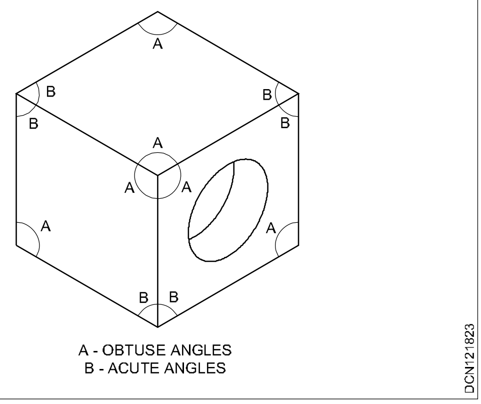
Fig 2



From Fig 1 & 2, it is clear that there are different ways of describing the shape of a part on a paper. Figure 1 is called as Multiview drawing or Orthographic drawing and the method adopted in figure 2 is called pictorial drawing. The different views in a multiview drawing are called as 'Orthographic views' or Orthographic projections.

To describe the shape of a part in engineering drawings, multiview or orthographic view method is preferred as only Orthographic view can convey the true shape of the object. Whereas in pictorial drawing through this shape is easily understood and it is distorted. To emphasise this point, see Fig 3, wherein a cube with a circular hole is represented pictorially. We know that all corners of the cube are of 90°. But in the pictorial drawing in Fig 3, the same 90° is represented at some places by acute angles and at some other places by obtuse angles.

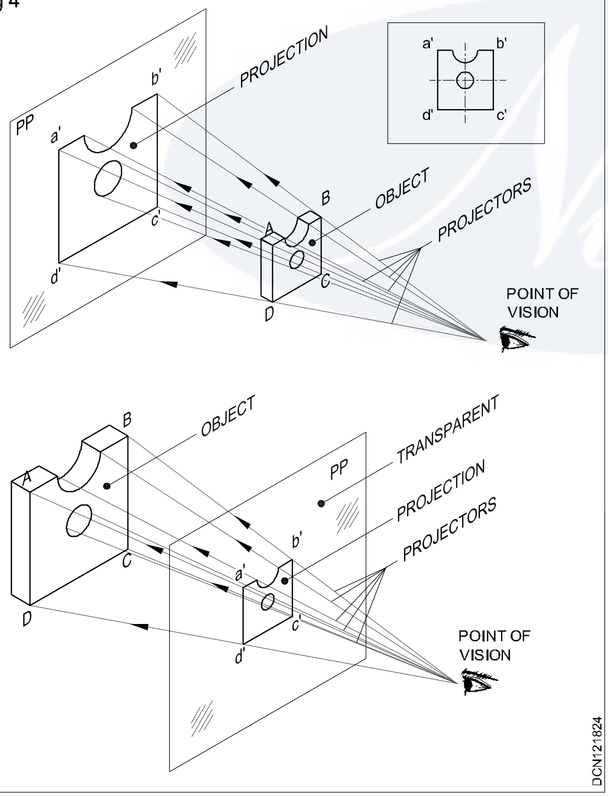
Fig 3



Projection: Projection is commonly used term in draughtsmans vocabulary. In the context of engineering drawing, projectors means image and it is comparable to the image formed on the retina of the eyes. (Projection can also be compared to the image of the object on the screen, where the film is projected (by the cinema projector) by the light rays.

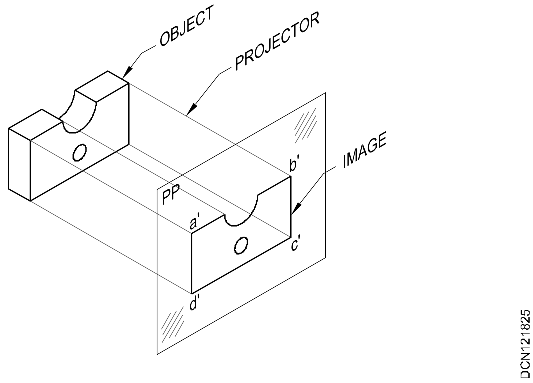
Projection or images can also be formed inbetween the eyes and the object by keeping a transparent plane. (Fig 4)

Fig 4



In this figure 4 the rays from the object converge to the eyes and this image (Projection) is smaller than the object. However if the rays are parallel as in the case of rays coming from the sun, the image (Projection) will be of the same size as that of the objects. Such a projection is called orthographic projection. The parallel lines/rays drawn from the object are called projectors and the plane on which image is formed is called plane of projection. In orthographic projection, the projectors are perpendicular to the plane of projection. (Fig 5)

Fig 5

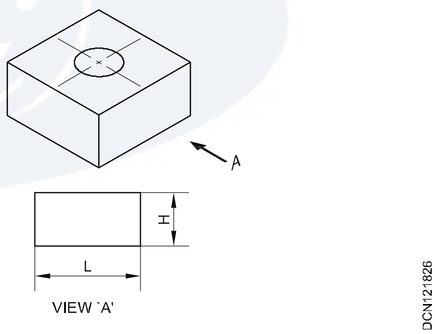


Orthographic projection: The term orthographic is projection derived from the words. Ortho means straight or at right angles and graphic means written or drawn. The projection comes from the Old Latin words PRO means forward and Jacene means to throw. The orthographic projection literally means "Throw to forward", "drawn at right angles" to the planes of projection.

An orthographic system of projection is the method of representing the exact shape and size of a three dimensional object on a drawing sheet or any other plain surface such as drawing board.

A single orthographic view of an object will show only two of its three dimensions. The view in figure 6 shows only the length and height of the object only.

Fig 6



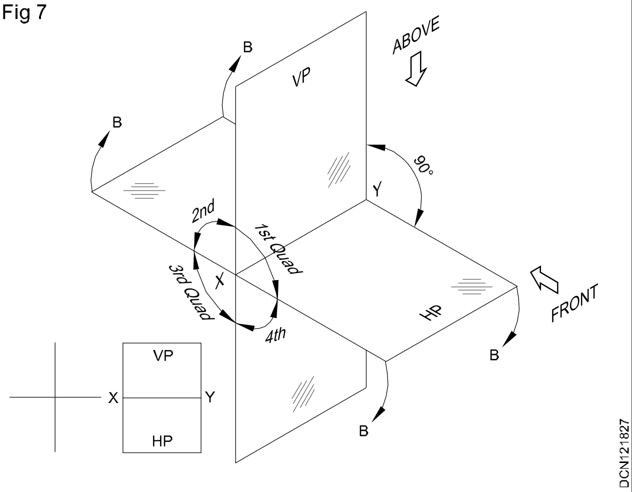
Therefore, it becomes necessary to have an additional view to show the missing dimensions (width). Therefore, we have to make two views to represent the three dimensions of an object.

The two views thus required are to be obtained on two different planes which are mutually perpendicular (one HP and one VP) with the object remaining in the same position. The projection or the view obtained on the horizontal plane is called the top view or plan and the view obtained on the vertical plane is called elevation.

First angle and third angle projection: One vertical plane (VP) and one horizontal plane (HP) intersect at right angles to each other. (Fig 7)

All the four quadrants have one HP and one VP formation. As per convention in mathematics, the quadrants are numbered as 1st, 2nd, 3rd and 4th. These four quadrants are called four dihedral angles, namely 1st angle, 2nd angle, 3rd angle and 4th angle.

Fig 7



To draw two views of an object, we assume that the object is placed in any one of the quadrant/angles, 1st angle & 3rd angle Fig 8a, 9a and its plan and elevation projected to the respective planes. Now tomake it possible to draw the two views (Plane & elevation) in one plane i.e the plane of the drawing paper, the horizontal plane is assumed to be unfolded in clockwise direction through 90° Fig 8b & 9b. We proceed this way, when the views are made. When the object is placed in the 2nd or fourth quadrant the plan and elevation will get super imposed (one up on the other) Fig 10a & b. Due to this reason the 2nd and 4th angle are not used for making engineering drawings as the three dimensions cannot be easily identified. Hence for representing the three dimension of the object, we assume the object is placed either in 1st angle or in 3rd angle. (Fig 11 & 12)

Fig 8

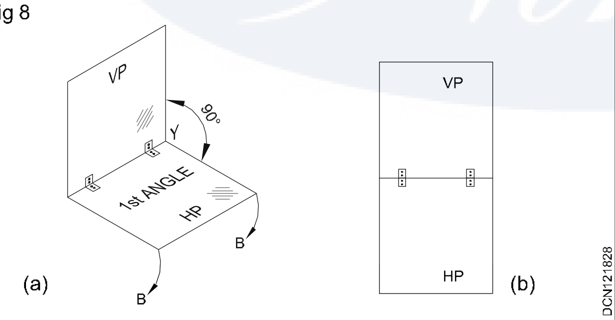
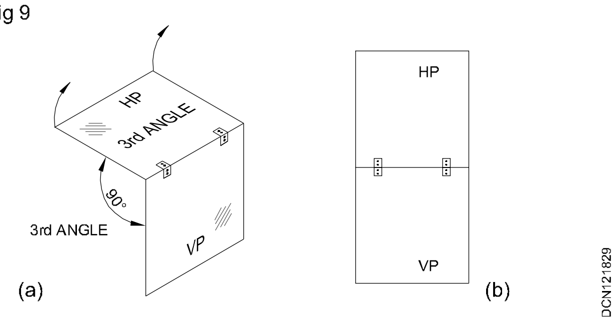


Fig 9



The placement of plan and elevation when the horizontal plane is unfolded will be different in these two systems. It may be observed in Fig 13 that in the first angle projection plan (top views) will be directly below the elevation, whereas in 3rd angle projection plan lies directly above the elevation. (Fig 14)

Fig 10

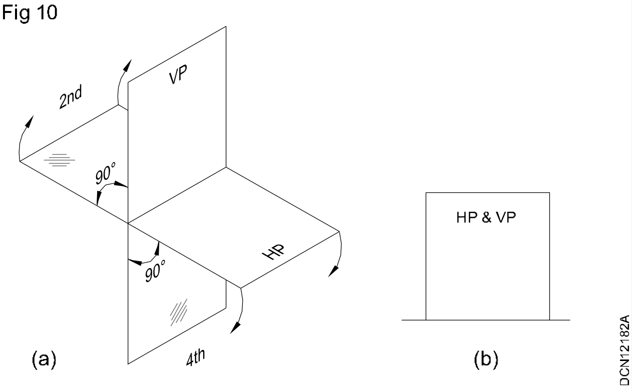


Fig 11

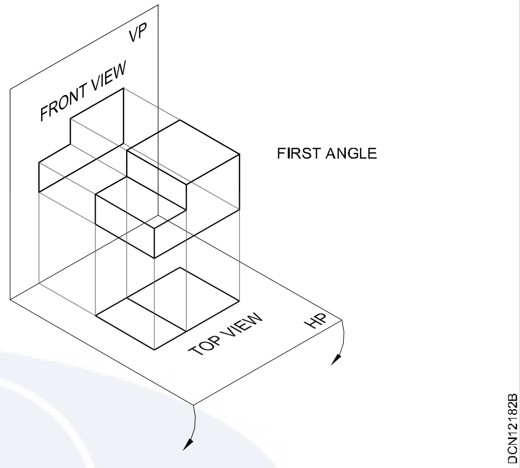


Fig 12

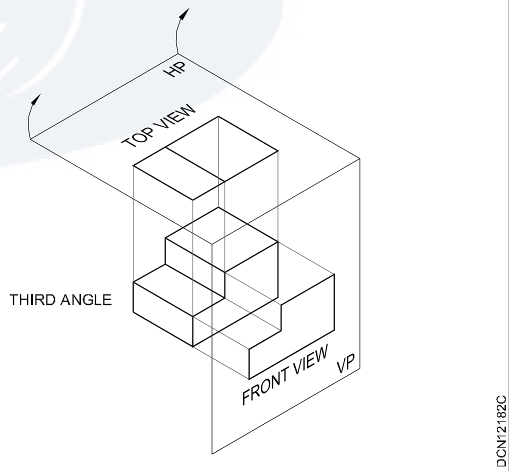
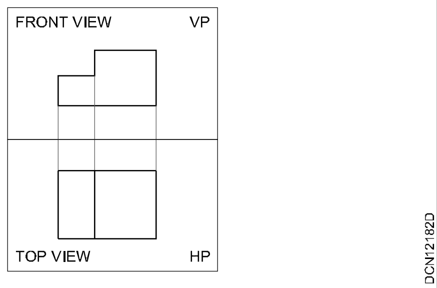
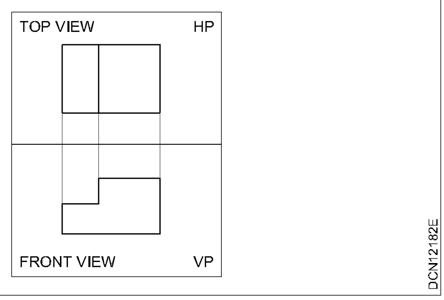


Fig 13



Views can be drawn in any one of these two methods. However Indian STandard (BIS) has recommended the first angle method to be used in our country.

Fig 14



Orthographic views are drawn, based on the principle of projection. To acquire sound knowledge to make orthographic views, one has to study solid geometry which deals extensively with principle of projections. Remember that the purpose of studying solid geometry is to have clear in sight of principle of projection which is the basis of describing the shapes of solid objects on a plain paper.

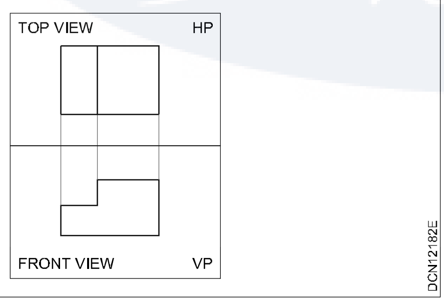
Solids are made of planes and planes are made of lines and lines and made of points. Hence the solid geometry will be dealt in the order of points, lines, planes and solids.

Projection of a point: The projection of a point no matter where it is placed relative to the plane of projection will always be a point.

Figures 15 to 18 shows the projection of a point which is at a distance of 'h' and 'd' respectively from HP and VP respectively, where it is placed in 1^{st}, 2^{nd}, 3^{rd} and 4^{th} quadrant. Here, F and T are the directions of the views for projections to VP and HP.

The projectors of a point when it is placed in 1st quadrant is shown in Fig 15.

Fig 14



At Fig 15 (i, ii, iii), the two planes forming the quadrant are in horizontal and vertical position whereas at Fig 16, the two plans lie on the same plane. (After rotating the HP clockwise).

Fig 15

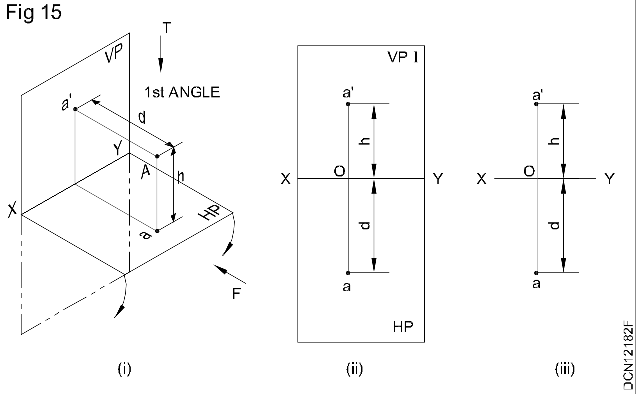
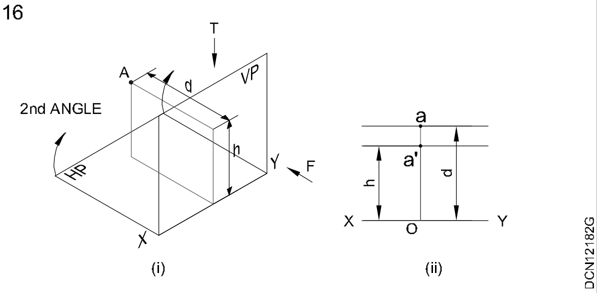


Figure 17 shows the projection of the point only as it is customary not to show the planes of projection.

Fig 16



The projector of the point on VP is marked as c' and the projection point on HP is marked as c. The distance 'h' and 'd' are also shown in these figures.

Marking conventions in Orthographic projections: In all the examples in plane and solid geometry the following conventions are practiced.

- The intersection line of VP and HP is marked as XY.
- The point to be projected is marked by capital letters and its projections are marked with corresponding small letters.

Example

In figure 15 point to be projected is marked 'A' and its projections are marked as 'a' in HP, a' and a" in VPI and VPII. In this figure VPII is not shown. Hence a" will not be seen. It may be noted that the distance a'. 0 is equal to the distance 'h' of the point from HP. Also the distance a0 is equal to the distances 'd' of the point from the vertical plane.

Projection of the points when it is placed 2^{nd}, 3^{rd} and 4^{th} quadrant is shown in a similar way at i & ii in figures 16,17 & 18.

Fig 17

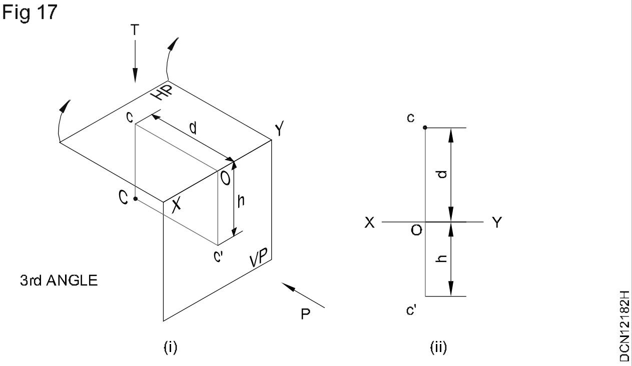
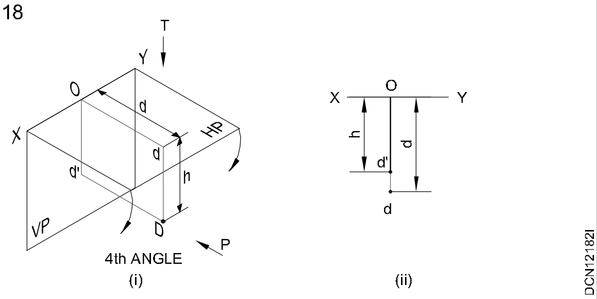


Fig 18



Projection on a third plane: In our study of making orthographic views, so far we had considered projection only on two mutually perpendicular (one HP and one VP) planes. Sometimes it will be necessary to have projection on additional planes also.

Figure 19 & 20 shows one more plane added to the two planes forming the first angle and third angle (first quadrant and third quadrant) and the projection of a point 'P' on all these planes. The added plane is marked as VPII. VP II and HP are rotated to lie in the same plane (Fig 19 & 20) as VPI. We know that the projection on HP is called as plan or top view and the projection on VPI is the front elevation. The third view on VPII is called side elevations while VPI and HP are called as principle planes, the additional vertical plane (VPII) is called as auxiliary vertical plane. The principle projection of a point as it is applied to a solid part is shown in Fig 21 i & ii.

Fig 19

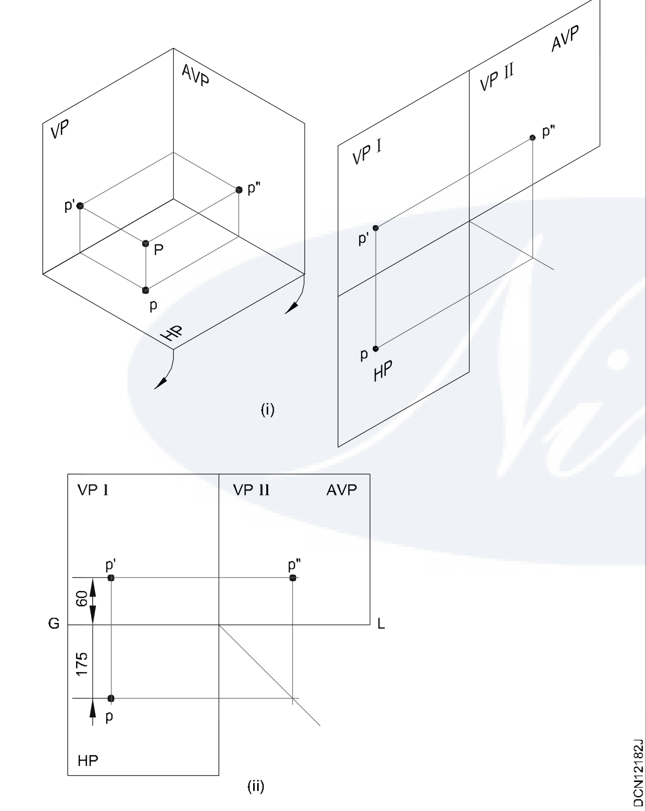


Fig 20

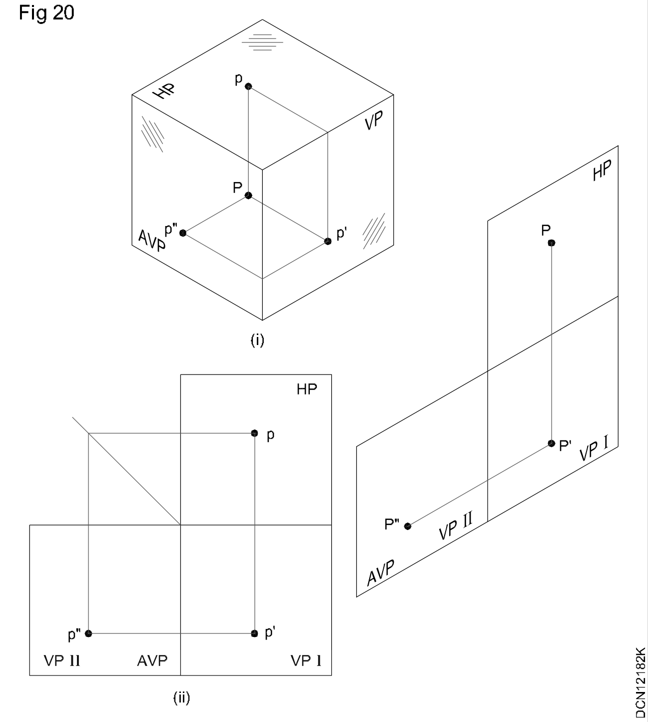
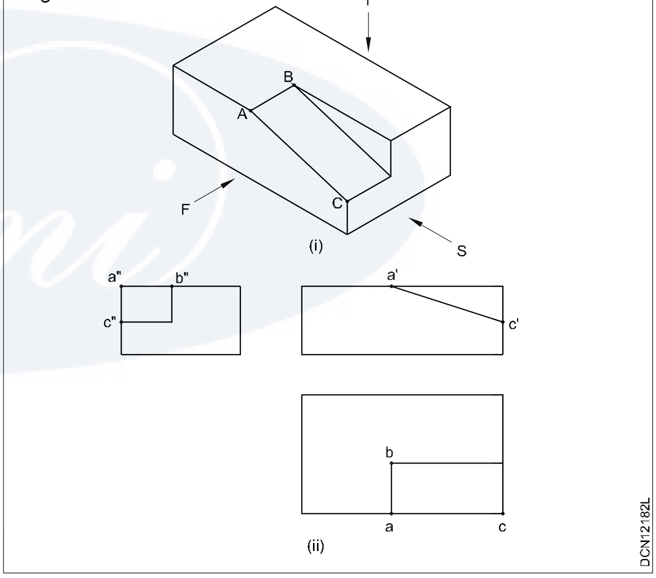


Fig 21



Projection of a line: A straight line connects two points. In otherwords the line has a start point and one end point.

By projecting start point and end point as discussed earlier and joining them we get the projections of a line. However the following points should be noted as guidelines.

– If a line is parallel to the plane of projection, the projection will be of the same length as that of the line. (Fig 22)

– If a line is perpendicular to the plane of projection, it will be a point.

– If a line is inclined to the plane of projection, its projection is smaller in than the actual length of the line. (Fig 23)

– If the line is inclined to all the true planes i.e plane of projection (HP, VPI and VPII) its projections will be of in smaller than the actual length of the line in all the three planes. (Fig 24)

Fig 22

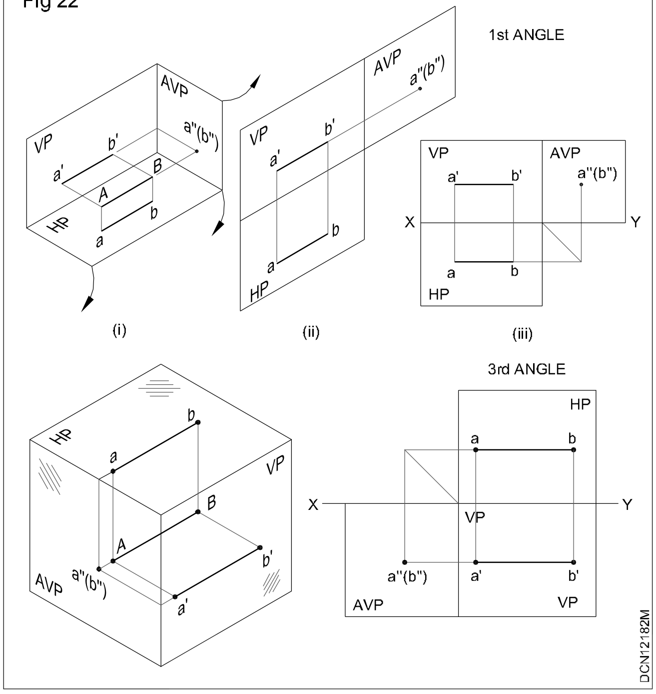


Fig 23

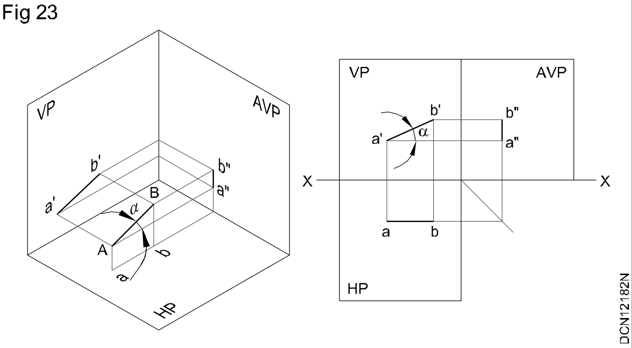
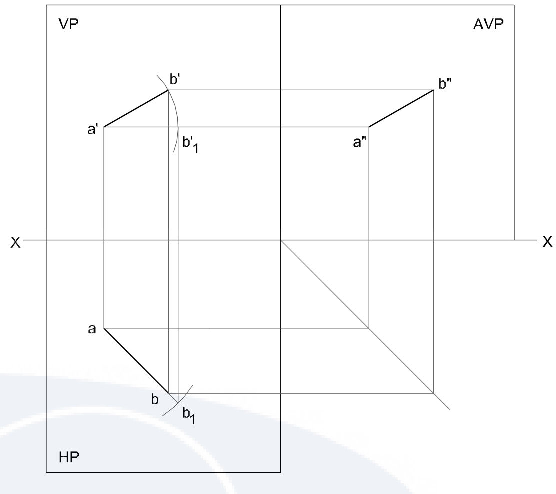


Fig 24



Projection of plane figures

Objectives: At the end of this lesson you shall be able to

- **distinguish between a two dimensional and a three dimensional figure**
- **identify the type of surfaces the object is composed of**
- **explain as to how the projection of a given surface will be on the different planes of projection**
- **state the meaning of the term true shape and the condition to obtain true shape and the views.**

Two dimensional and three dimensional figures: We know that solid object are enveloped by surfaces while solids are classified as three dimensional surfaces and implies volume and two dimension implies area.

When we draw orthographic views to represent solids in effect, we are drawing the projection of the solids.

Types of surfaces (Fig 1)**:** Surfaces may be flat or curved. Flat surfaces are also referred as planes. (Plain surfaces) Flat surfaces, depending on their orientation, may be vertical, horizontal or inclined. Fig 1 shows a solid and it has flat surfaces and curved surfaces. Flat surfaces are marked as F_1,F_2 etc.

Surfaces F_1,F_4,F_6,F_8,F_9,F_{10},F_{12},F_{13} and F_{14} are vertical surfaces.

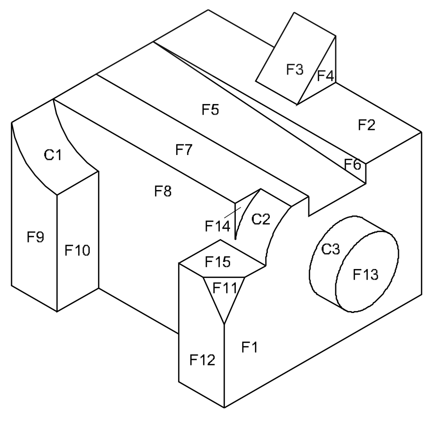
F_2, F_7 and F_{15} are the horizontal surfaces.

C_1,C_2 and C_3 are the curved surfaces.

F_3, F_5 and F_{11} are inclined or oblique surfaces or their combination.

For example in F_3 is rectangular while F_{13} is circular. But surface F_1 is a combination of several plane figure.

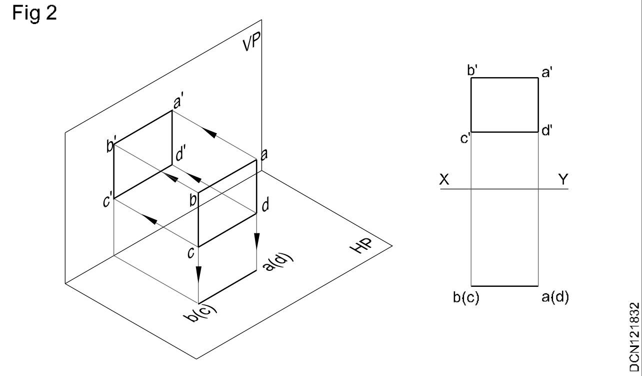
Fig 1



Projection of Flat surfaces: While drawing the projection of surfaces (plane figures) the following points should be noted.

If the surface is parallel to the plane of projection, the resulting projection will be the true shape of the surface. (Fig 2)

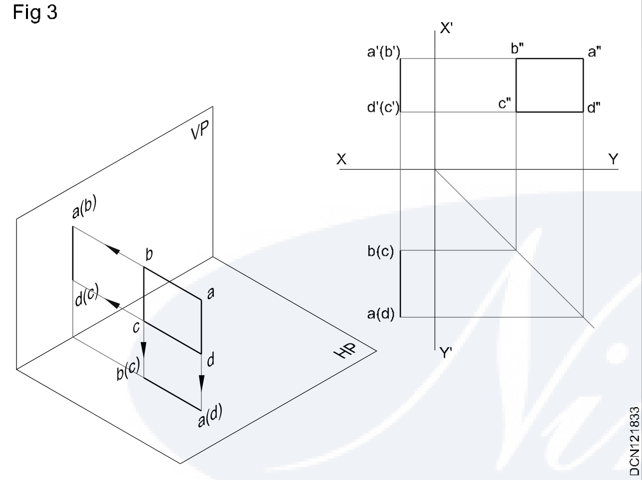
Fig 2



True shape: When the projection of a surface is identical to the surface projected, the projection is said to be of true shape.

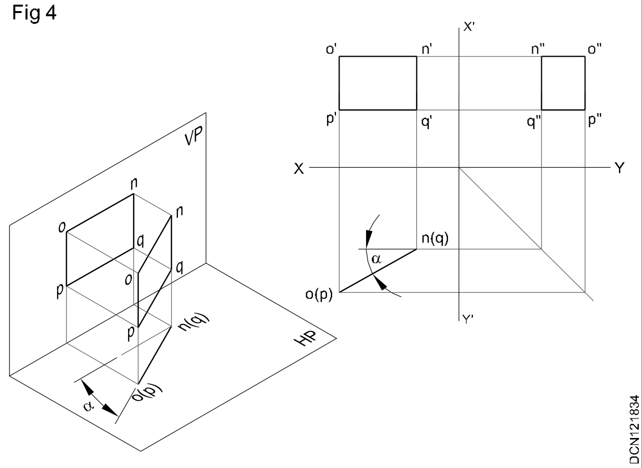
When the surface is perpendicular to the plane of projection, the resulting projection will be a straight line. (Fig 3)

Fig 3



If the surface is inclined to the plane of projection, its projection will not have the true dimensions. They are fore shortened. (Fig 4)

Fig 4



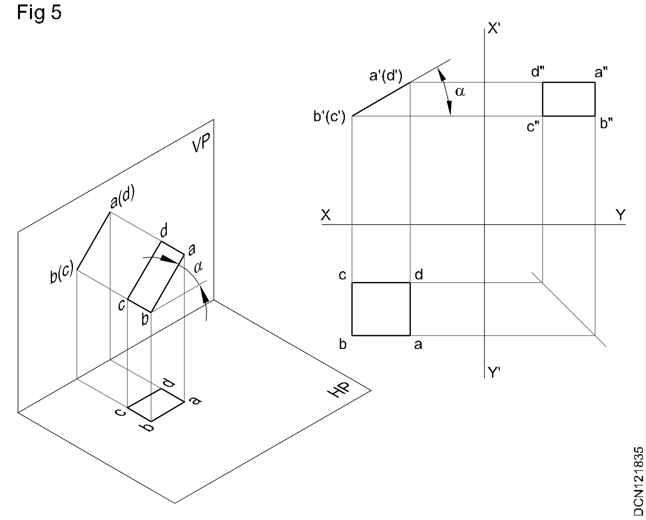
Foreshortened view: Where the projection of a surface is not identical tot he surface projected, the projection is said to be foreshortened.

In figure 4, the length pq or the length on is of true length in plan, but in front elevation and in side view same is foreshortened in a different way according to the inclination of the surface to the plane of projection.

If a surface is inclined to a vertical plane, the angle of inclination will be seen on HP and vice-versa. (Fig 4)

If a surface is inclined to horizontal plane the angle of inclination will be seen on VP and vice-versa. (Fig 5)

Fig 5

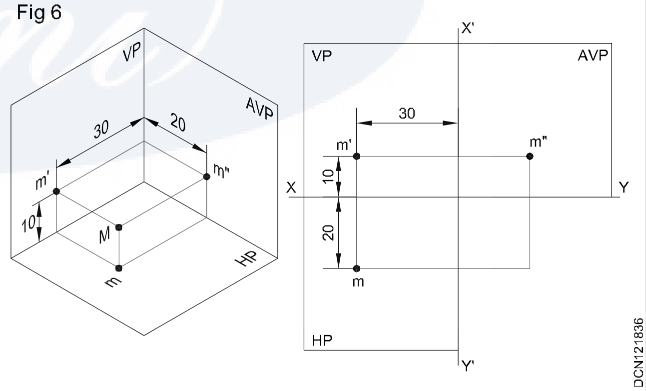


Guidelines to be followed: The intersection (folding lines) between HP and VP is marked as XY whereas the intersection between VP and AVP is marked as X'Y'.

In exercises/problems wherein the distances of the object (point, line, surface) from HP, VP and AVP are not given a convenient distances may be assumed and followed.

Terminology of views/projections: (Fig 6)

Fig 6



- The view projected on HP is termed as plan or top view.
- The view projected on VP is termed as elevation or front elevation or front view.
- The view projected on AVP is termed as side view or end view or side elevation or end elevation.

The distance from XY to a point in the plan and to the corresponding point in the side view from X,Y, is equal to the distance from VP.

The distance from XY to point in the front elevation and to the corresponding point in the side view from XY is equal to the distance of the point from HP.

The distance from X,Y, to a point in the front elevation and the corresponding point in the plan from X,Y, is equal to the distance of the point from AVP.

The above three statements may be summerised as follows:

the distance of a point from one plane will not reflect in the projection on that plane, but it will be reflected in the projections of other planes.

This can be observed in the figure shown.

Point M is 10 mm from HP, 20 mm from VP and 30 mm from AVP.

In the figure B, the projections of point M in the three planes and distances from XY and X,Y, are marked.

Point M is really 10 mm from HP, but the distance of 10 mm is not reflected in HP. Similarly 20 mm is not reflected in VP and 30 mm is not reflected in AVP.

Distance of 10 mm from HP is reflected in front and side views.

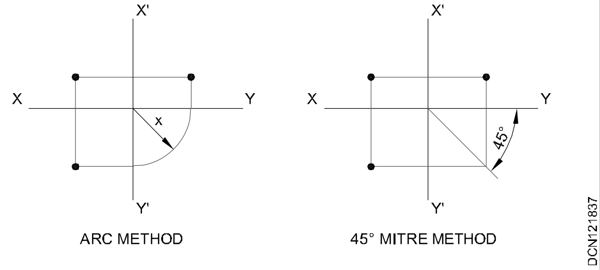
Distance 20 mm from VP is reflected in plan and side view.

Distance 30 mm from AVP is reflected in plan and front view.

If we know the projection of point in two planes, its projection to third plane can be obtained by projecting from the given/known two views and transfering distances.

For example, if you draw the front view and side view of a point (Fig 7), plan can be completed by drawing projection from the front view and side view. Transfer of distances from two views to third view may be done either by arc method or by 45° mitre line method.

Fig 7



Following standard conventional markings are to be followed for points, lines and surfaces on plan, front view and side views.

Plan	Final	just an alphabet	(a)
	1st stage		(a1)
	2nd stage		(a2)
Elevation	Final	alphabet with	(a')
	1st stage	a dash	(a1')
	2nd stage		(a2')
Side elevation	Final	alphabet with	(a")
	1st stage	two dash	(a1")
	2nd stage		(a2")

Geometrical solids

Objectives: At the end of this lesson you shall be able to

- **define various geometrical solids**
- **define solids of revolutions**
- **state the method of drawing the three views of solids in different position**
- **auxiliary view**
- **sectional views.**

Solids: Solids are the objects which have definite shape, size and occupies certain space. They have three dimensions viz., length, breadth or width and height. According to their shapes. They are classified into two groups.

– Polyhedra

– Solid of revolution

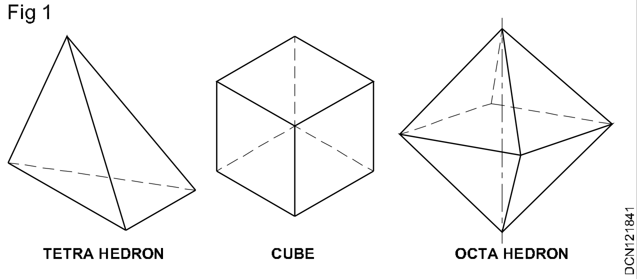
Polyhedra: are solids having (poly-many) more than thre flat surfaces called faces. The ends of surfaces meeting with each other are called edges. When the faces are identical to each other, they are called `Regular Polyhedra'. Depending on the number and shape of faces regular polyhedrons are named. Of the many regular polyhedrons three are defined below:

Tetrahedron: A solid having four equilateral triangular faces solid having least number of flat surfaces.

Cube or Hexahedron: A solid having six regular square faces.

Octahedron: A solid having eight equilateral triangular faces. (see Fig 1)

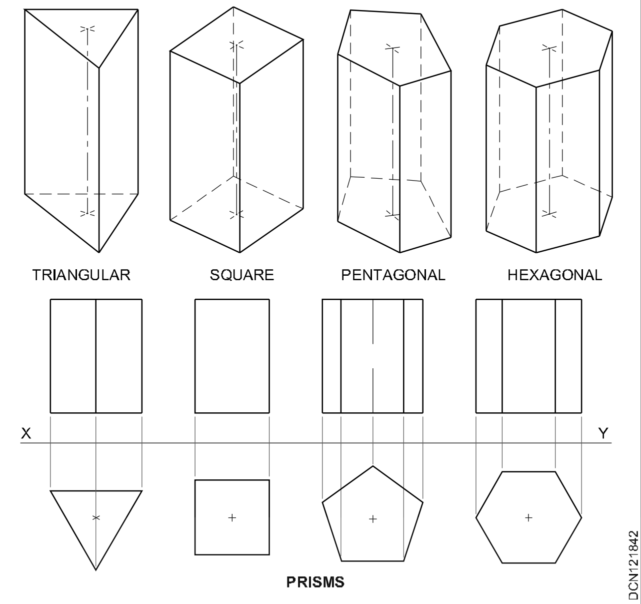
Fig 1



When solids are not composed of identical surfaces, such polyhedrons are either Prisms or Pyramids.

Prism: Prism is `Polyhedron' having two identical end faces. The top and bottom base surfaces are joined by parallelograms or rectangular surfaces. Imaginary line joining the centre of the end faces is called the axis. The axis is right angles to the end faces. Prisms are in general designated according to the shape of the end faces. Eg. Square, rectangular, triangular, hexagonal, pentagonal, octoganal (Prisms) etc. Prisms are right or oblique, the axis of regular prisms is at right angles to the face. Whereas in oblique prisms the axis is inclined to the end face. (Fig 2)

Fig 2

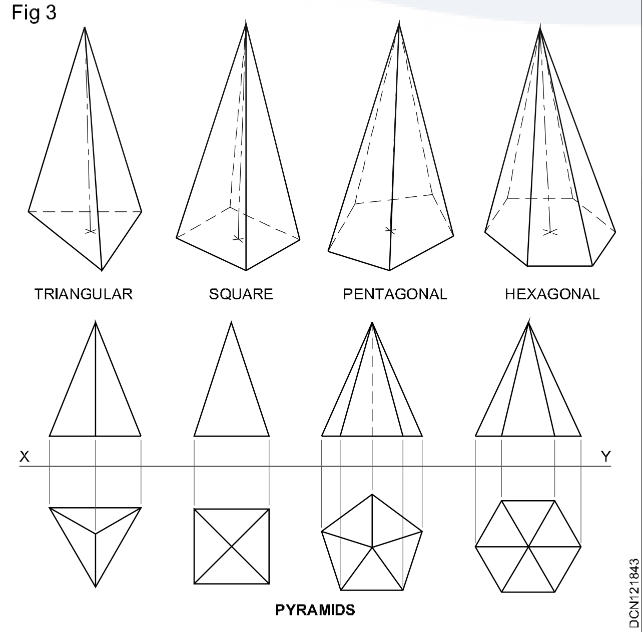


Pyramids: Pyramids are polyhedra solids having a base surface whose shape may be triangular, square or polygon and as many slant triangular faces as there are sides in the base. All the slant triangular faces join at a common point called APEX.

Similar to prisms, pyramids also are known by the shape of their base viz triangular, square, rectangular, pentagonal, hexagonal etc. The imaginary line joining the centre of the base to the apex is called the AXIS.

Fig 3 shows some pyramids and their views.

Fig 3



Solids of revolution: When a plane figure revolves about an axis a solid is generated.

Example

The solid shown in the Fig 4 is formed by the revolution is formed by the revolution of the plane (Fig 4a) ABC about the axis AB.

Geometrical solids like cylinder, cone and sphere are solids of revolutions.

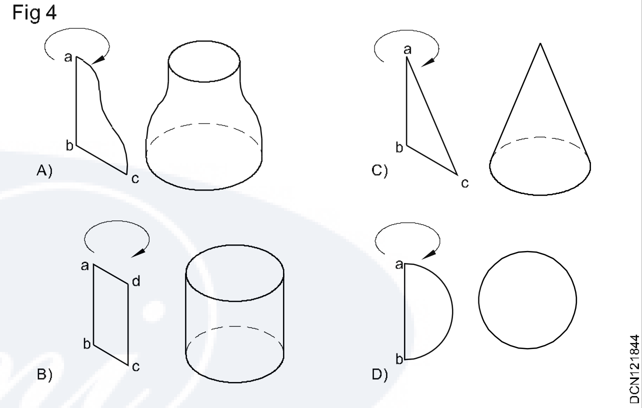
Cylinder: When a rectangle rotates about one of its sides a cylinder is generated.

Cylinder has two flat circular faces and a curved surface. (Fig 4b)

Cone: When a right angled triangle revolves about one of its side formign the right angle, a cone is generated. Cone forming has a circular face and a slant curve surface. (Fig 4c)

Sphere: When a semi-circle revolves about its diameter a sphere is generated. A sphere has no flat surface. (Fig 4d)

Fig 4



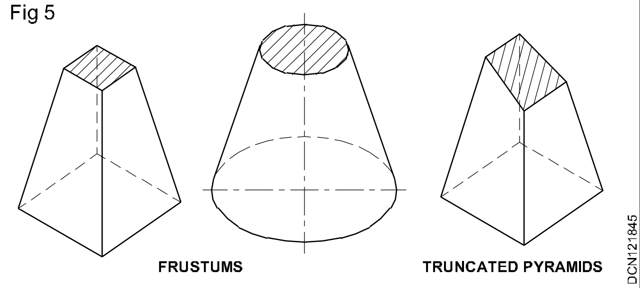
The term solids of revolution is a mathematical concept and a physical requirement in geometry.

Frustums: When the pyramids or cone are cut parallel to the base and top of remaining the pyramid or cone is removed, the parts are called frustums.

If the cutting plane is at an angle to the axis/base, of the pyramids or cone they are called "Truncated pyramids or cones".

Fig 5 shows frustums and truncated pyramids.

Fig 5

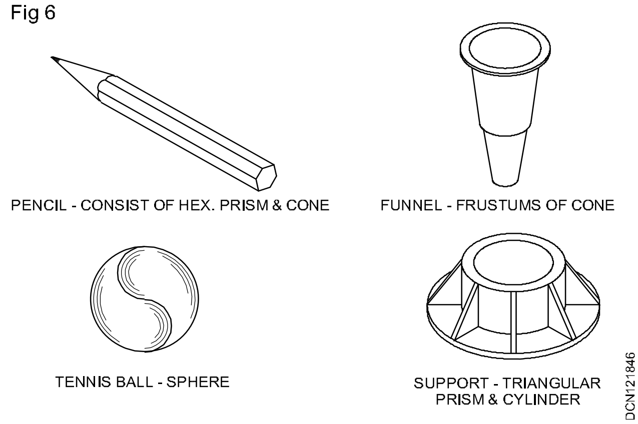


All items we use are solids. Their shapes may confirm to individual geometrical solids like prisms, cones or other combination.

Figure 6 shows some such items.

Views of solids: When dealing with projection of plane figures earlier was stated that solids are enveloped by planes and therefore drawing the views of solids would actually mean drawing the views of planes the solids aer composed of.

Fig 6



The faces of solids which are parallel to the planes of projection will be seen in true shape in the respective planes. When planes are not parallel to the plane of projection the views will have a disorted look.

Figures 7,8,9,10,11,12 & 13 indicate the plan, elevation and end view of some solids for the position defined against each.

Fig 7

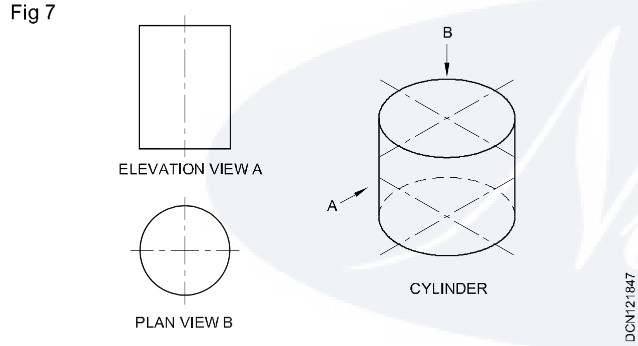


Fig 8

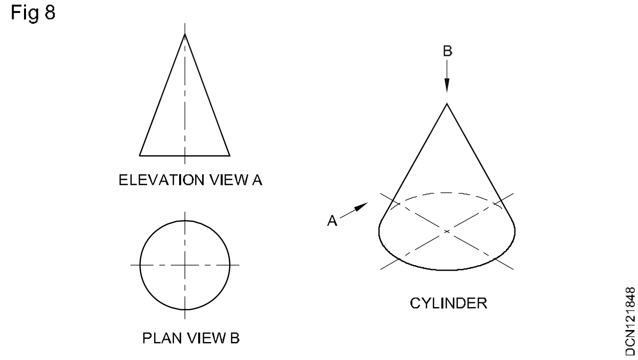


Fig 9

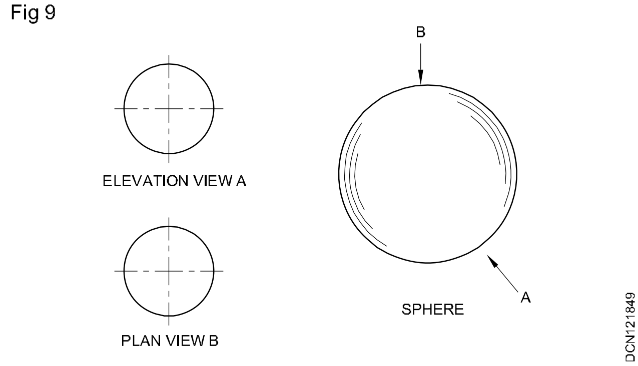


Fig 10

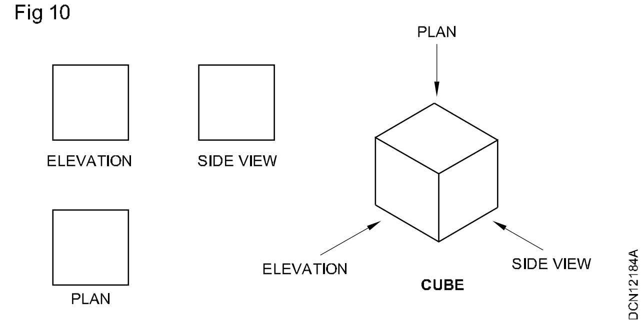


Fig 11

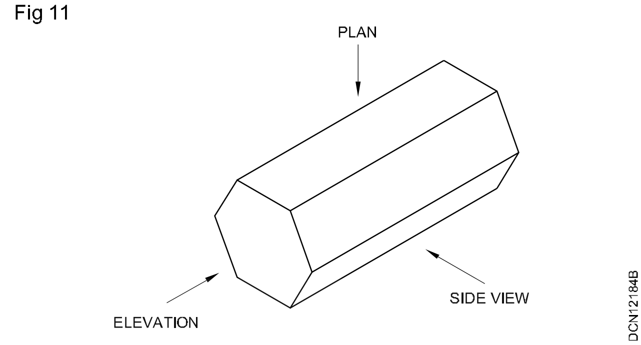


Fig 12

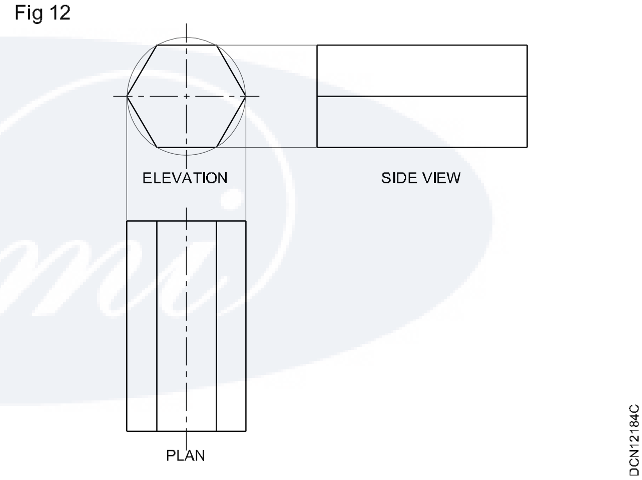
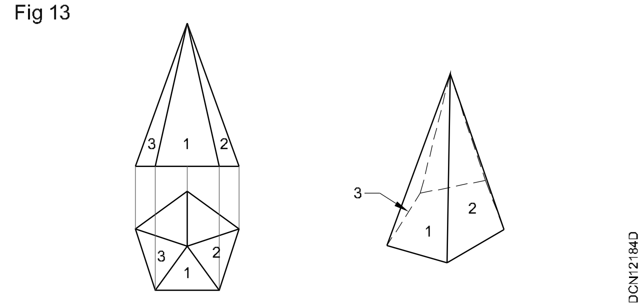


Fig 13



While drawing the views of solids all the edges of solids may not be visible in the views concerned. For example in the figure shown the edge will not be visible in the front view. Such edges ae referred as hidden or invisible edges. All visible edges in a view are drawn usually thick lines. But, invisible edges are drawn using dotted lines of medium thickness. (The thickness of dotted lines is inbetween thickness of thick lines and construction lines) Dotted lines are short dashes.

In some cases it is required to show the axis of solids. Axis is represented by another type of line called centre line.

Centre lines are thin lines consisting of alternating, alternat long and short dashes. (Figs 14,15 & 16)

Fig 14

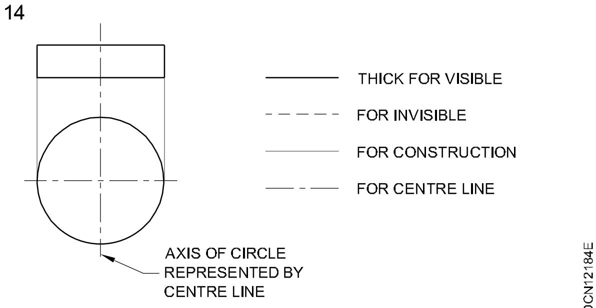


Fig 15

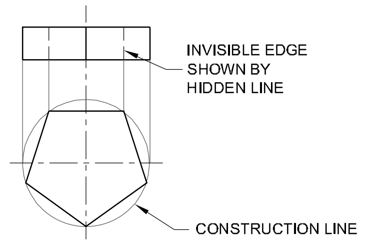
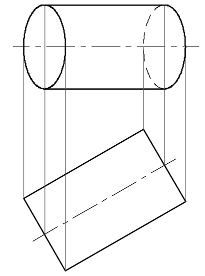


Fig 16



Pictorial projection

Objectives: At the end of this lesson you shall be able to

- **state the importance of pictorial projection**
- **list the kinds of pictorial projection**
- **describe the types of axonometric projections**
- **state what is isometric projection**
- **differentiate between isometric projection and isometric view.**

Knowledge gained so far in solid geometry will enable you to describe the shape of an object by drawing its orthographic views. Such as front view, side view, plan etc. Since all the three dimensions/faces of the object are not visible in any one single view, the shape cannot be conveived just by looking at it. To understand the shape from such views one has to analyse the views and think in 3 dimension.

Pictorial projection: It is possible to show all the 3 faces/ dimensions of an object in one view itself. Such orthographic views are called pictorial drawings or pictorial projections. To get the pictorial drawing the object (say a cube) has to stand on one corner such that 3 of its mutually perpendicular faces are inclined to the plane of projection. (Fig 1)

Fig 1

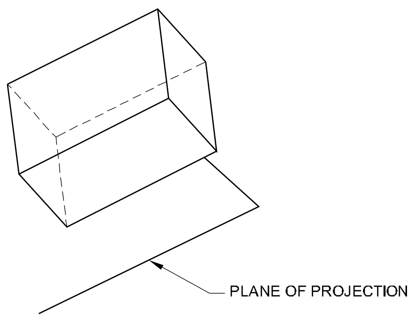
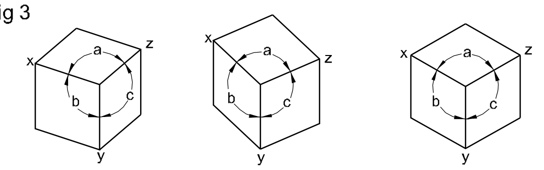


Fig 2 shows the front view, plan and side view of a rectangular prism positions in the manner stated above. Here notice that two of the views (Plan and side view) lock like solids, the reason being that in each of these two views we can see the three faces of the prism. So in this example both the plan and side view are pictorial views in its own right.

Depending on the angle of inclination of the faces with the plane of projection, pictorial projection are classified as Timetric, Dimetric or Isometric.

In trimetric projection (Fig 3a) the three faces make unequal angles with the plane of projection whereas in dimetric (Fig 3b) projection 2 faces make equal angles. In isometric projection all the three faces make equal angles. (Fig 3c)

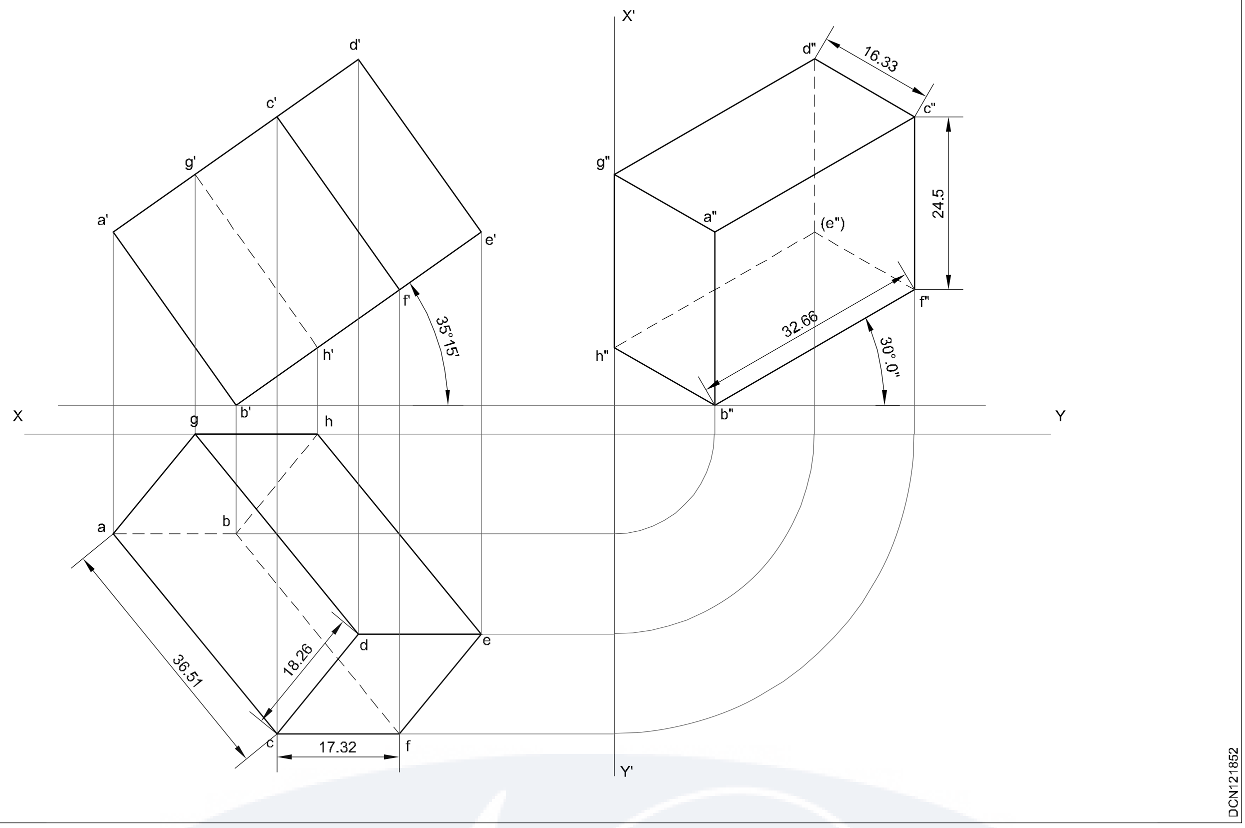
Fig 3



The projections - trimetric dimetric and isometric projection are generally grouped in one heading called "Axanometric" projection.

In the three types (trimetric, dimetric and isometric) of pictorial projections mentioned above, because the faces of the object are not parallel to the plane of projection the views will not show the true size and shape of the object. The shapes are distorted and lengths of edges are fore shortened. Referring to Fig 2 it may be seen that the true

Fig 2



dimensions of the prims is 40 x 30 x 20. But in the front view these dimension measure 32.66 x 24.5 x 16.33 and in plane this corresponding measurements are 36.51 x 17.32 x 18.26. The reason for different lengths in front view and plane is that individual faces make different angles to their respective plane of projection.

Pictorial projections will enable even a common man to understand the shape quickly, even though these pictorial views have a distorted look. In any case, these views are very useful for describign the shapes.

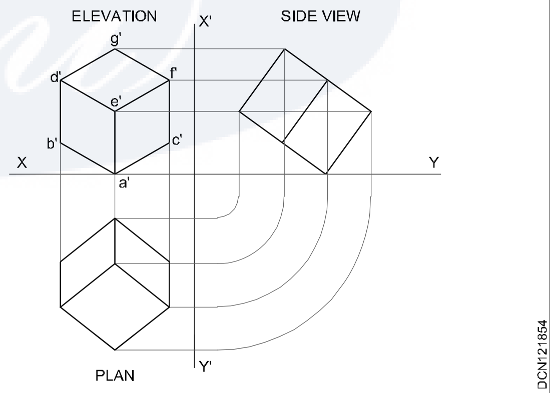
Out of the three types of axanometric projections, isometric views are preferred due to an advantage and hence it is dealt in move detail.

Isometric projection: In an isometric projection the three mutually perpendicular faces make the equal angles with the plane of projection The term isometric is derived from the Greek word ISO means equal and metra means measurement.

The projection of a cube, the three faces which make equal angles with vertical plane is shown in Fig 4. Here the front view is the isometric projection. Notice that the a'b', a'e', c'f', e'f', c'd', d'g', g'f', b'd', a'c' which represent the various edges of the cube are of equal lengths meaning that all have the same amount foreshortening. Because of this reason isometric projection will give a more natural appearance than trimetric and dimetric and this is extra advantage of isometric projection.

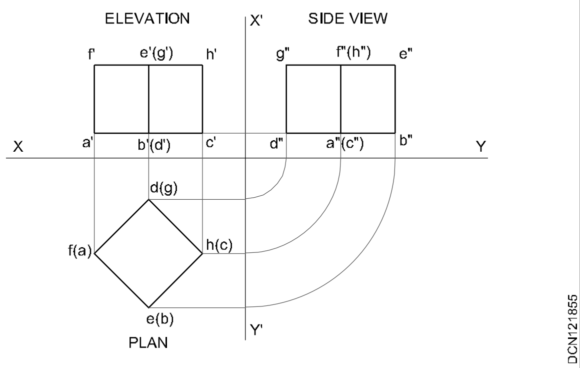
Isometric projection - Method of construction: We can make the isometric projection of any object using the principle of orthographic projection. But the method is best understood by constructing the isometric projection of cube or rectangular prism. The position required for isometric projection may be brought about as follows.

Fig 4



Place the cube on HP such that two of its mutually perpendicular faces make 45° will VP (the plan and side view elevation in the position will be as in Fig 5).

Fig 5



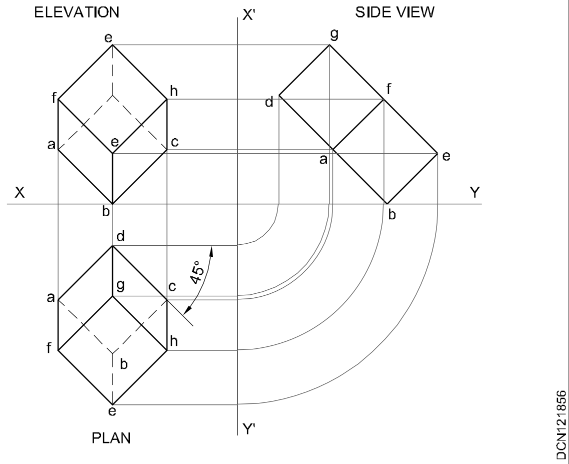
Next tilt the cube towares you with the corner b on HP. Tilt the solid diagonal DE will be at right angles to VP. Now the 3 mutually perpendicular faces will make angles (35°16') with HP. The three views of the cube in this position are shown in Fig 6. Now the elevation will be the isometric projection. To obtain this proceed as follows:

- First reproduce the side view in Fig 5. Such that DE is parallel to XY line.
- Project from the above side view and the plan in Fig 5 shall be reproduced in Fig 6.
- Draw the elevation

Note : In figure 6, a plan for the tilted position is also drawn. But this is not an isometric projection. Actually it is a dimetric projection.

It may be observed from the above construction that the isometric projection gives 3d (3 dimensional) effect as we are able to show the length, breadth and thickness in the same view. however, making isometric projections this way is complicated and time consuming. Therefore, simpler method have been deviced to make pictorial drawing that are identical isometric projection and these methods are discussed below.

Fig 6



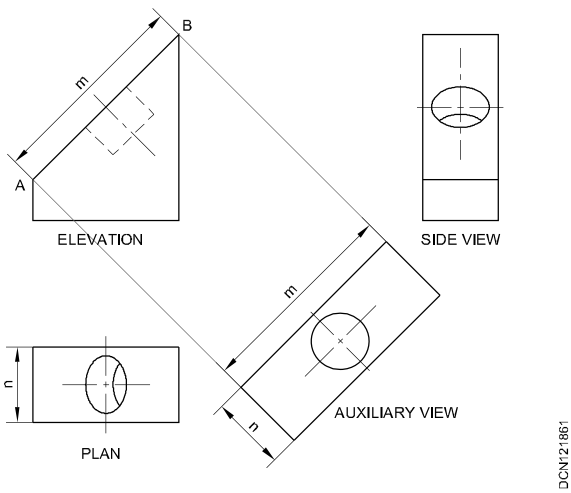
Auxiliary views

Objectives: At the end of this lesson you shall be able to
- **explain the concept of an auxiliary view**
- **state and explain auxiliary front and top views.**

In our lesson on projection of solids it was seen that projection of surfaces which are not parallel to the plane of projection will not show the true shape of the surfaces. In other words when there are inclined surfaces in solids their true shape cannot be shown in plan and elevation. In such cases, true shapes are shown by projecting the inclined surface to a plane parallel to the inclined surface. Such planes are called auxiliary planes, the views projected on auxiliary planes are called auxiliary views.

Figure 1 shows the views of a simple solid having an inclined rectangular surface with a blind hole, axis of which is perpendicular to the inclined surface.

Fig 1

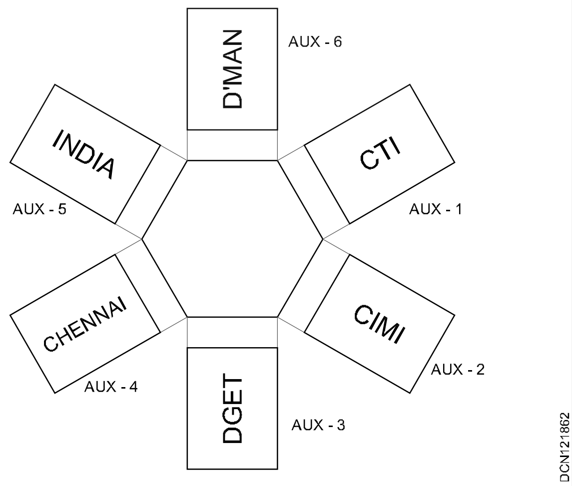


The length and breadth of the inclined surface are m and n.

It may be seen that neither the plan, elevation nor the side view reveal the true shape of the inclined surface and the cylindrical hole. Therefore, in order to show the true shape a new plane, auxiliary plane, parallel to AB (inclined surface) is created and the surface is projected on that plane. Notice that the projected view (auxiliary view) shows the true shape of the inclined surface and hole in it.

There can be any number of auxiliary views depending upon the shape of the component. For example, to reveal the treu shape of the details of surfaces of an hexagonal prism we may draw six auxiliary views as shown. (Fig 2)

Fig 2

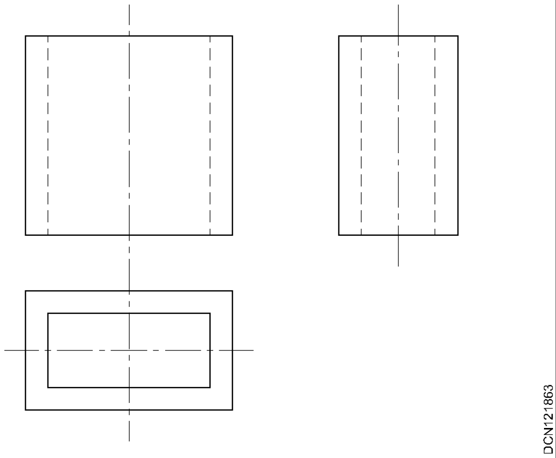


When auxiliary views are drawn we do not make the full view of the object on the auxiliary plane, but only details required to show the true shape is made.

In the normal Orthographic views (plan, elevation and side view), the internal details, their features and relative positions which cannot be seen are shown by dotted lines.

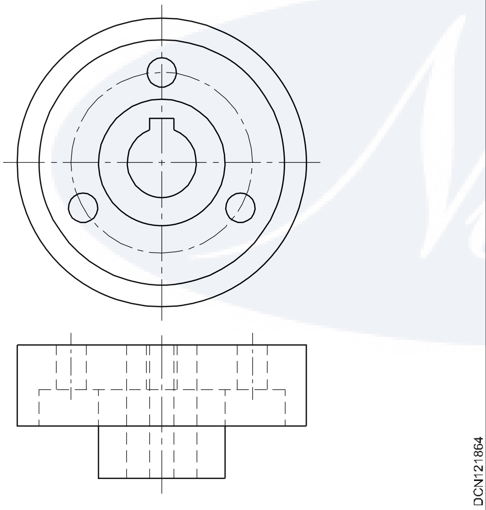
For example in the object shown in figure 3 the hole is invisible in the elevation and side view. Hence it is represented by dotted lines.

Fig 3



When there are too many dotted lines in a drawing (Fig 4) it is difficult to conceive the details of the object. In such a cases, details can be shown clearly and reading of drawing can be made easier by resorting to what are known as "Sectional views".

Fig 4



Sectional views: For obtaining sectional views an object is assumed to be cut by an imaginary plane called cutting plane. The part between the cutting plane and the observer is assumed as removed to reveal the internal details. Then the projection of part left out is projected/drawn as usual and the view thus made is the sectional view. (see Fig 5)

To distinguish a sectional view the surface formed when it is cut by the cutting plane is "hatched". (Fig 6)

Hatching means filling the surface with equi-distant parallel lines.

If the surfaces of a prism or pyramid cut at an angle, the true shape of the surface cut is available in auxiliary view. The auxiliary view surface is to be drawn with hatched lines. Reference: Procedure of Ex.No.7.1.1 to 7.1.5 - Trade Practical Book.

Note: Application of sectional views are dealt in more detail in future lesson.

Fig 5

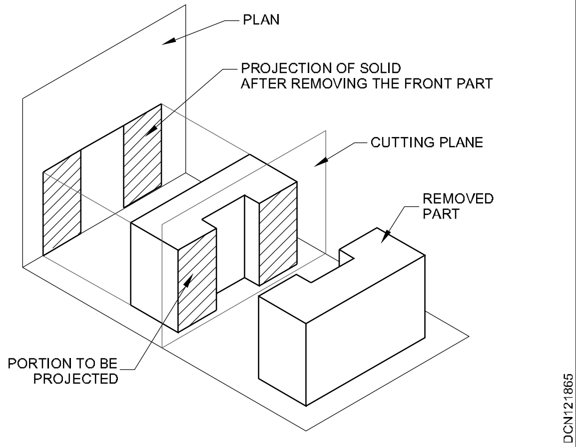
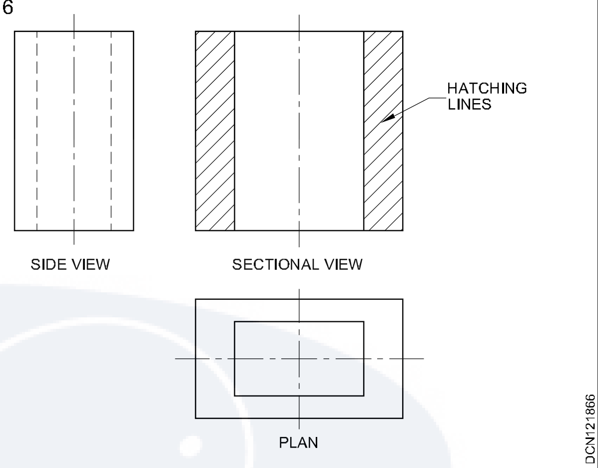


Fig 6



In order to avoid projectors crossing the views, auxiliary views are sometime drawn in 3rd angle projection even though the other views are in first angle projection.

All the views in Fig 1 is drawn in 1st angle projection. But auxiliary view can be shifted above the elevation.

Note: In figure 6, a plan for the tilted position is also drawn. But this is not an isometric projection. Actually it is a dimetric projection.

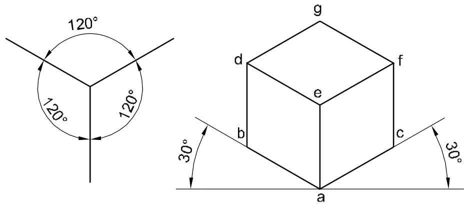
It may be observed from the above construction that the isometric projection gives 3d (3 dimensional) effect as we are able to show the length, breadth and thickness in the same view. However, making isometric projections this way is complicated and time consuming. Therefore, simpler method have been deviced to make pictorial drawing that are identical isometric projection and these methods are discussed below.

Simpler method of isometric projection: On analysing the isometric projection in Fig 6, it will be seen that three mutually perpendicular edges of the cube are at an angle of 120° to each other. These three lines which represent the mutually perpendicular edges are called isometric axes. (Fig 7)

So to draw the isometric projection say of a cube, we firstdraw the three mutually perpendicular edges as in figure and set other lengths. Since of the lengths are foreshortened in isometric projections we must use an "isometric scale" to find out the foreshortened lengths.

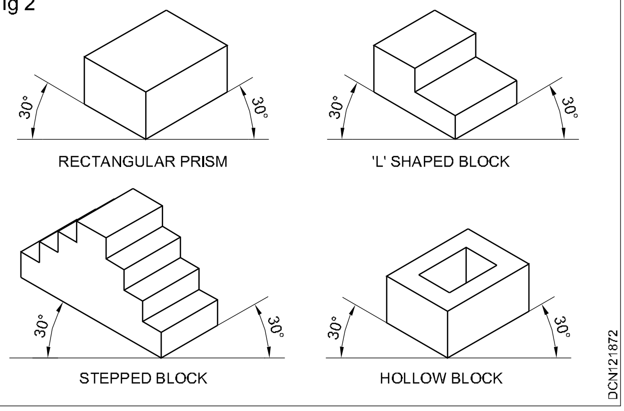
Thereafter, other edges are drawn parallel to the respective isometric axes to complete the figure.

Fig 1



Instead of drawing the isometric axes, first we can also start from the point `a' .(Fig 7) At this point also 3 mutually perpendicular edges meet. While two of these edges make 30° to the horizontal, the other edge is vertical. (90° to horizontal) After drawing the two 30° lines one vertical line the parallel lines are drawn to complete the cube. Few

Fig 2



other objects drawn this way are shown in Fig 8. The length of each edge of corner will be less than the true dimensions and it can be determined by using an isometric scale.

Isometric projection

Objectives: At the end of this lesson you shall be able to
- **state the method of isometric projection**
- **explain isometric scale**
- **explain box method of isometric view**
- **explain off set method of isometric view.**

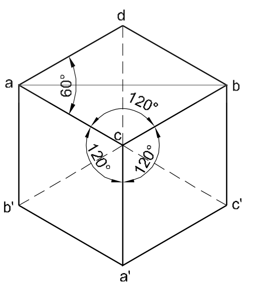
Isometric scales are used to get the foreshortened lengths required for isometric projection.

Before constructing an isometric scale, you must understand is the relationship between the true length of an edge and the length of the same in isometric projection.

To determine the relationship between the true length and corresponding length in isometric projection, proceed as follows:

Consider the isometric projection of a cube. (Fig 1)

Fig 3



Separately draw the top face of the cube adbc and join the longer diagonal ab. (Fig 2)

Note that the diagonal ab is of same length both in the isometric view of the face and the true face. Assume the top true face of teh cube as afbc.

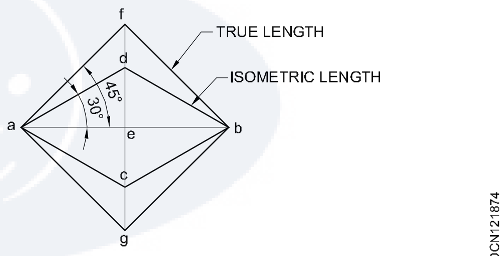
Now superimpose the true top face afbg keeping the diagonal ab common. (Fig 2)

$\angle FAE = 45° \text{and} \angle DAE = 30°$

x $AE = AF \times Cos45° \text{and} AD = AE \div Cos30° = AF \times$

$$\frac{\text{Isometric length}}{\text{True length}} = \frac{AD}{AF}$$

Fig 4



$$\frac{AD}{AF} = \frac{AF \times Cos45°}{AF \times Cos30°} = \frac{Cos45°}{Cos30°}$$

$$\frac{AD}{AF} = \frac{AF \times Cos45°}{AF \times Cos30°} = \frac{Cos45°}{Cos30°} = 0.8165$$

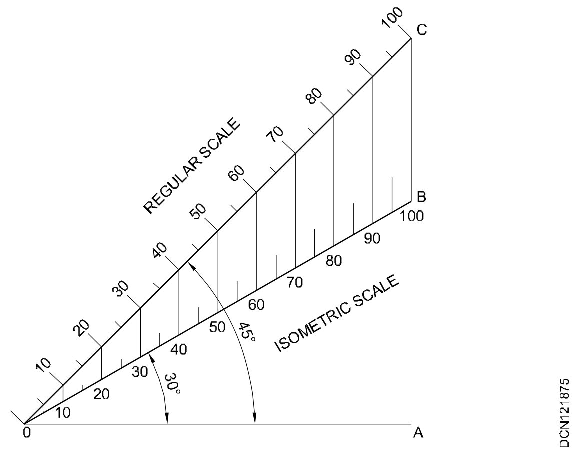
AD = 0.82 AF. This means that the length of a line in isometric projection is 0.82 times of it true length. While drawing an object in isometric projection, the dimensions on or parallel to isometric axes are reduced to this proportion. To make things easier we can construct a scale to the above ratio. Such a scale is called as isometric scale.

Procedure to construct

Isometric scale (Fig 3)

- Draw a horizontal line OA.
- Draw lines OB and OC making 30° and 45° with OA respectively.
- Mark 5 mm, 10 mm, 15 mm upto 100 mm on line OC.
- From the marked points on the regular scale OC, draw perpendiculars to OA meeting at OB.

Fig 5

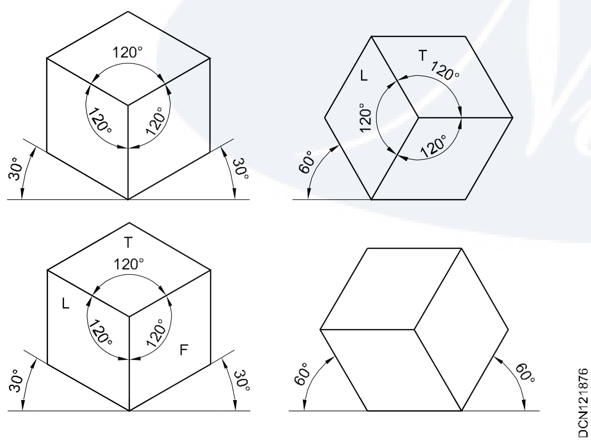


– Print the corresponding values on the line OB resulting in the isometric scale.

Orientation of isometric axes: While the isometric axes make 120° to each other they may have different orientation as shown in Fig 4. Each of the orientation show3 of the 6 faces (left, right, top, bottom, front and rear) are shown in different combinations.

Isometric view and Isometric projection: A drawing is made with true lengths (dimensions) is called isometric view or isometric drawing. Whereas the same drawing made with isometric lengths is termed as isometric projection. (Fig 5)

Fig 6



Isometric and non-isometric lines: Fig 6 shows the isometric view of a shaped block. Here all lines except AB, BC and DE are parallel to isometric axis. Lines such as then which are parallel to isometric axes are called isometric lines whereas such as lines AB, BC and DE which are not parallel to isometric axes are called non-isometric lines.

The length of non-isometric lines will not follow the scale used for isometric lines. To proove this point consider the non-isometric lines AB or BC. The true length of both AB and BC is 5 cm while BC will be longer. Because of this reason non-isometric lines are drawn first by locating their starting and end points on isometric lines.

To locate the end points and to draw the non-isometric lines two methods are employed. They are

– Box method

Fig 7

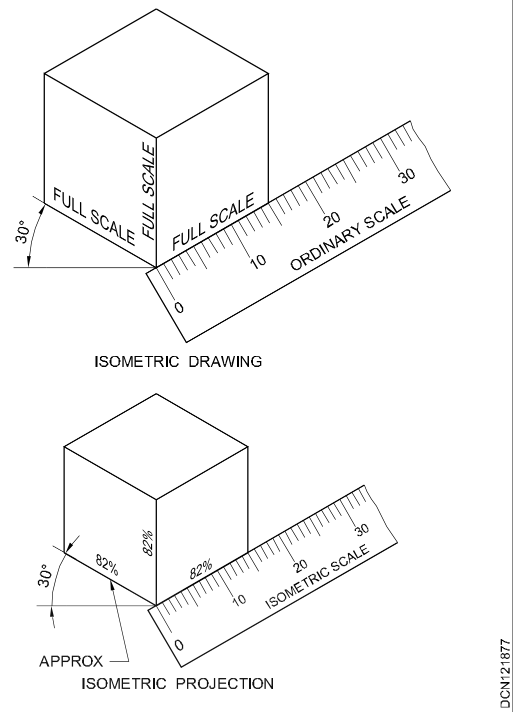
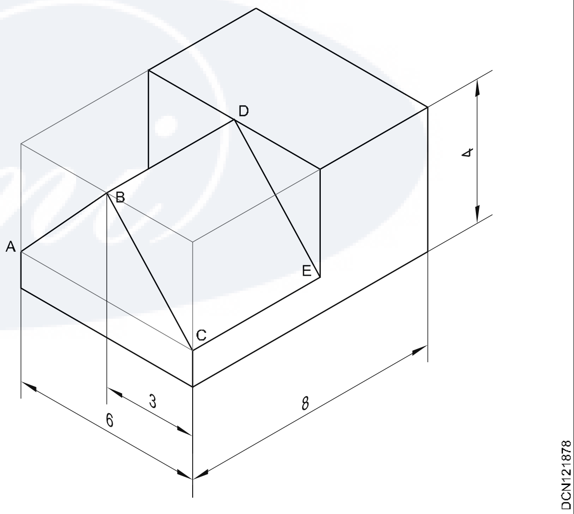


Fig 8



– Off-set method

Box method: The object is assumed to be inside a rectangular box. Starting and end points are located and marked. By joining the points isometric view is drawn.

Off-set method: This method is most suited for the objects consisting of number of planes at a number of different angles.

> **These methods are not only useful for isometric views involving non-isometric lines but also for the isometric views involving isometric lines.**

Box method of drawing a pyramid

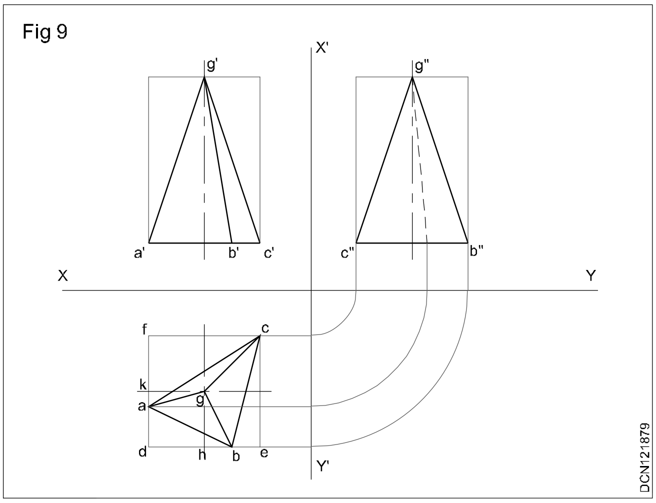
Example

Draw an isometric view for the triangular pyramid shown in

Fig 7 using a box method.

- Construct a rectangular box to the overall size of the pyramid (Fig 8a)
- Mark the distances ad and be from the plan of Fig 7 in the base of the box.

Fig 9

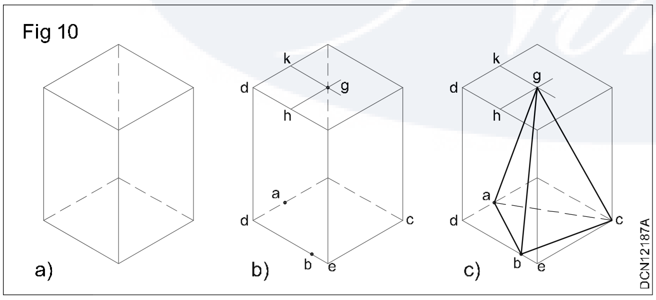


- Mark the distances kg and dh on the top face of box. (Fig 8a)
- Join the points AB, BC, CA, AG, BG and CG and complete the isometric view of the pyramid in box method. (Fig 8b)

Off-set method of drawing a pyramid

Example

Fig 10



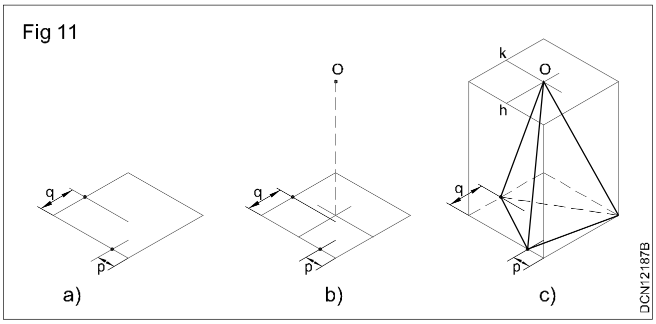
Same triangular pyramid (Fig 7) is considered for drawing isometric view using offset method.

- Draw an isometric square/rectangle considering the corners of the base of the pyramid. (Fig 9a)
- Locate the corners 1,2 & 3 with help of offsets P and Q.
- Locate the projection of the vertex O_1 on the base by offsets x and y and draw the vertical centre line O_1O to the height of the pyramid. (Fig 9b)
- Join 1-2, 2-3, 1-3, 0-1, 0-2, 0-3 and complete the isometric view of the pyramid. (Fig 9c)

Angles in isometric projection: The angles of inclined surfaces will not have true value in the isometric projection, but will be more in some cases and less in other cases.

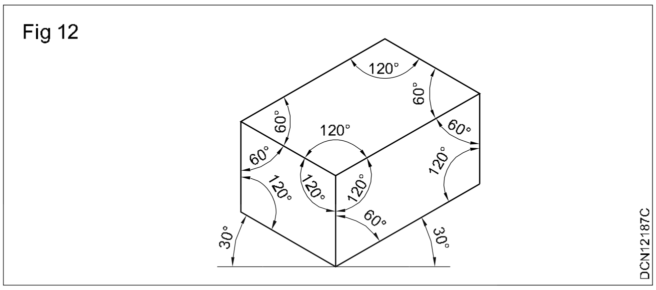
For example, in the isometric view of prism shown in Fig 10 the true value of all the angles is 90°. But in isometric projection the angles are 60° in some cases and 120° in others.

Fig 11



Isometric circles: The term isometric circle refers to the shape of circle in isometric view. An isometric circle will be elliptical in shape as shown in Fig 11 while drawing isometric view of cylindrical features isometric circles will have to be used. (Fig12)

Fig 12



An isometric circle can be drawn either be plotting/offset method or by arc method.

Fig 13

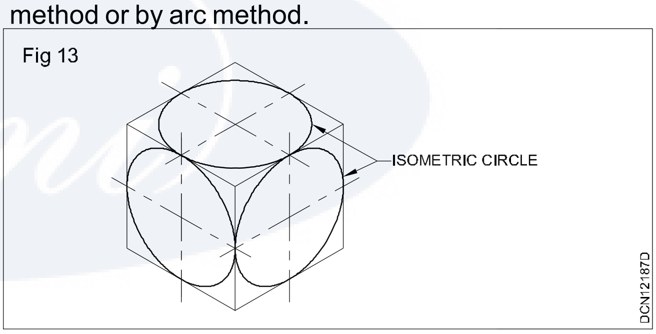
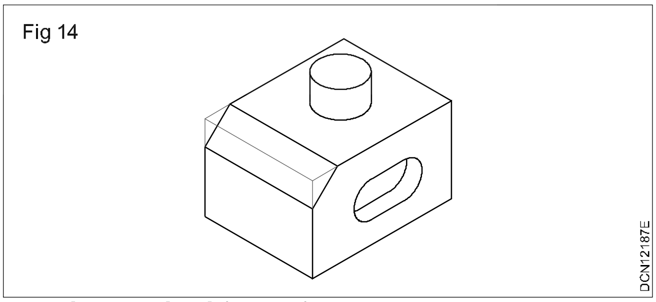


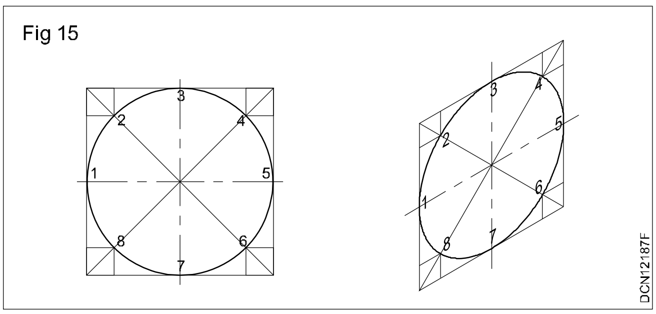
Fig 14



Plotting method (Fig 13)

- Draw a square of side equal to the dia of circle and inscribe the circle.

Fig 15



– Divide the circle into any number of equal parts and mark points such as 1,2,3,4,5,6,7,8 on the circle.

– Through the points 1,2,3 etc draw lines parallel to the both the axis of cylinder.

– Draw isometric view of the square.

– Mark points corresponding to 1,2,3....8 with isometric view of the square as points 1',2',3'....8'.

– Join these points with a smooth curve to for an ellipse.

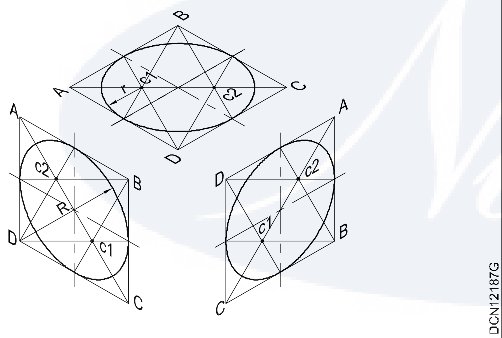
Note: The orientation of the isometric circle will depend upon the plane on which the circular feature exists.

Arc method: Isometric circles drawn by offset method is the ideal method of making isometric circles as the ellipse obtained this way is geometrically true. But by free hand we cannot get a clear line.

Fig 14 shows the construction of isometric circle in 3 different orientation by arc method. Four arcs are to be drawn and the centres an C_1, C_2, B & D. While centre B and D are the corner of the rhombus C_1 and C_2 are intersection points of the longer diagonal with lines from points B or D to the mid point of the side of the rhombus.

Note: The arc method gives a clean ellipse, but this ellipse drawn this way will slightly deviate from true ellipse. It

Fig 16



does not matter for our purpose.

The isometric circles can also be drawn using templates which can be bought from stationary shops.

Isometric views profiles: The profile MN of the block shown in Fig 15 is irregular in nature. The isometric views of such lines may be drawn by offset method described earlier. The points 1,2,3 and 4 lie on the profile. Lines A-1, B-2, C-3, D-4 are isometric lines and their length are same both in Fig 15 & Fig 16. After getting the points 1,2,3 & 4, they joined by smooth curve.

Note: In offset method more the number of points, better will be the accuracy of the curve.

Isometric projection of sphere: The Orthographic view of a sphere seen from any direction is a circle of diameter equal to the diameter of the sphere. Hence, the isometric projection of a sphere is also a circle of the same diameter.

The front view and the top view of a sphere resting on flat surface are shown in Fig 17a.

O as its centre, D is the diameter and P is the point of contact with the surface.

Fig 17

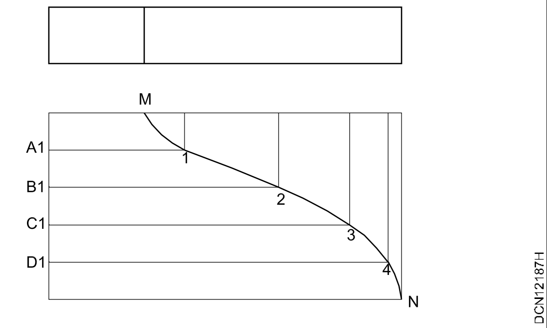


Fig 18

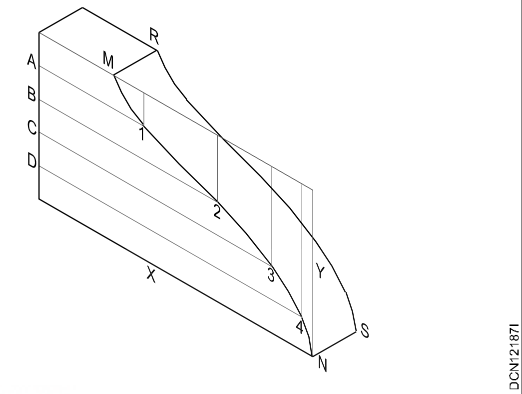
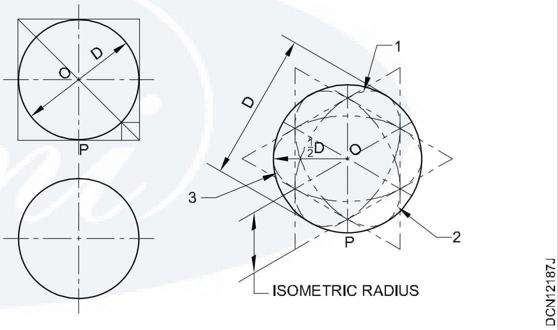


Fig 19



Assume a vertical section the centre of the sphere. Its shape will be a circle of diameter D. The isometric projection of this circle are ellipses 1 & 2 Fig 17(b) drawn in two different vertical positions around the same centre O. The major axis in each case is equal to D. The distance of the point P from the centre O is equal to the isometric radius of the sphere.

Again, assume a horizontal section through the centre of the sphere.

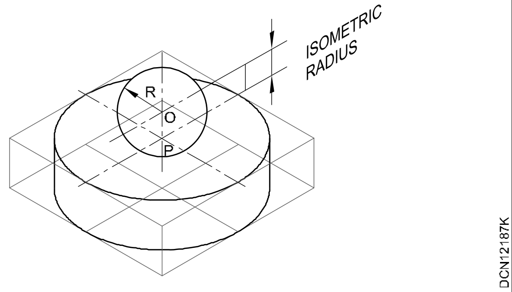
The isometric projection of this circle is shown by the ellipse 3, drawn in a horizontal position around the same centre O. In all the three cases 1,2 & 3 the outermost points on the ellipse from the centre O is equal to 1/2 D.

Thus, it can be seen that in an isometric projection, the distances of all the points on the surface of a sphere from its centre are equal to the radius of the sphere. Hence, the isometric projection of a sphere is a circle whose diameter is equal to the true diameter of the sphere.

Also the distance of the centre of the sphere from its point of contact with the flat surface is equal to the isometric radius OP of the sphere.

It is therefore of the utmost importance to note that isometric scale must invariably be used while drawing isometric projection of solids in conjunction with spheres or having spherical parts.

Fig 20



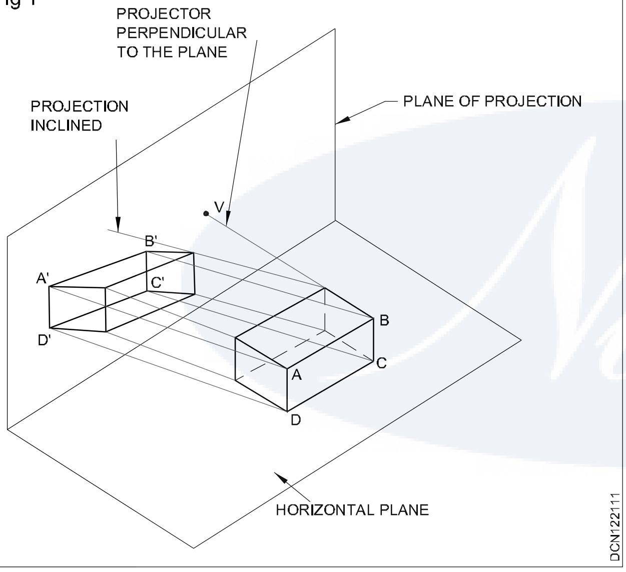
Oblique projection

Objectives: At the end of this lesson you shall be able to
- **state what is an oblique view**
- **compare oblique view with isometric view**
- **identify the different types of oblique views**
- **explain various angle used for drawing oblique views**
- **list the hints on positioning and drawing oblique views.**

Oblique projections are yet another type of pictorial projections, they differ from isometric projections in two ways.

– In oblique projections, projections are oblique (inclined) to the plane of projection. whereas in isometric projections projectors are perpendicular to the plane of projection. (Fig 1)

Fig 1

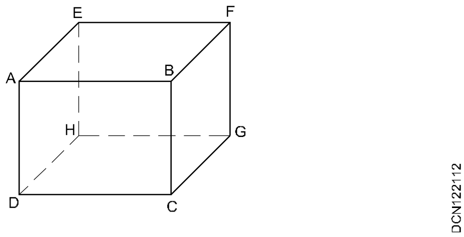


– In an oblique projection one of the principal faces of the object is kept parallel to the plane of projection, but in isometric, none of the faces of the object is parallel to the plane of projection.

> **Even though one of face of the object is positioned parallel to the picture plane, we still get a pictorial view and the projections are inclined to both HP and VP.**

Because one of the principle faces of the object is parallel to the plane of projection. In the oblique projection, the projection of this face and faces parallel to it will appear in true size and shape. In the oblique projection of a prism is shown in Fig 2, the faces ABCD and EFGH are parallel to the plane of projection and they appear to be true in size and shape. The other four faces which are perpendicular to the plane of projection do not appear in true shape. (all these four faces are seen as parallelogram) However the vertical edges of these faces are parallel to the plane of projection and hence the projection of these edges will measure to their true lengths.

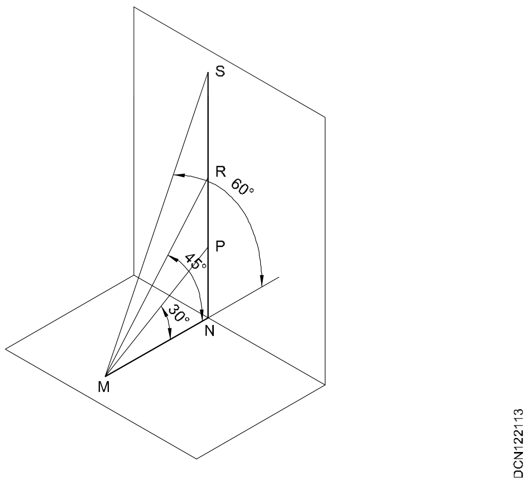
Fig 2



Projection of edges such as AE, DH, BF and CG which are perpendicular to the plane of projection will measure differently depending on the angle of inclination of the projectors. If the inclination of the projectors is 45° the projections of these edges measure to their true lengths. If the angle is less than 45° the projection of such perpendicular edges will measure less than the true length, if the angle of inclination of the projectors is greater than 45°. Projection of such perpendicular edges will measure more than the true length.

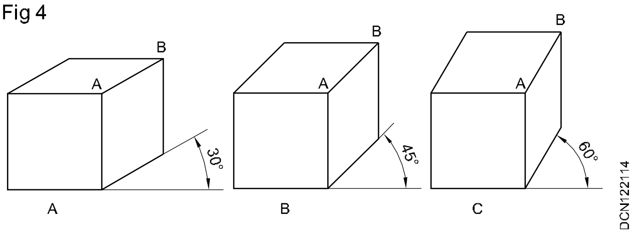
In the Fig 3, a line MN is drawn perpendicular to the plane of projection. NP, NR and NS are its projection when the projectors are 30°, 45° & 60° respectively. NR is equal to MN, NP is less than MN and NS is greater than MN.

Fig 3



Figures 4a,b and c shows the oblique views of a square prism when the angle of the projectors are 30°, 45° & 60°. Because of the variation of the length of edges (AB) which are perpendicular to the plan of projection the views give a rather distorted picture of the prism. This is a disadvantage of oblique projections over isometric projections.

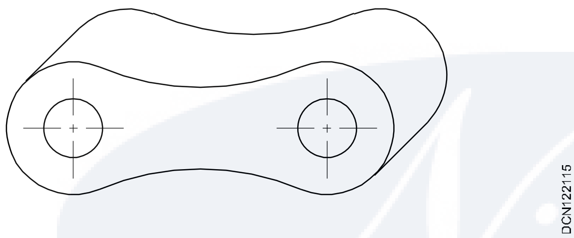
Fig 4



Oblique projections nevertheless have an unique advantage what we want to make pictorial drawings of object having curved features. For making isometric views of a curved feature we have first to draw their orthographic views in order to find out the offsets of points lying on the curve. But this difficult procedure is not necessary in the case of oblique views.

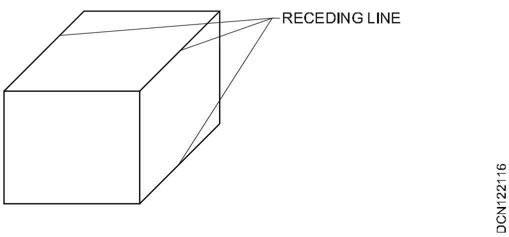
For example the component shown in Fig 5 has several curved features. While drawing oblique view of this component the curved features are drawn to true shape using compass. This is relatively easier method in comparison to the drawing of the same component in isometric view.

Fig 5



Inclination of projectors: While projectors can have any angle of inclination, usually oblique views are drawn to either 45° or 30°. The inclined lines in the oblique drawings are called receding lines (Fig 6) and they are more commonly drawn to 45°. The scale of lines along receding may be 1:1 (true lengths) or 1:2 (half of the true length).

Fig 6

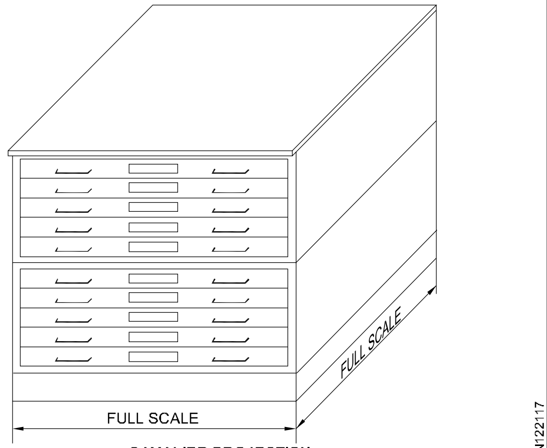


Oblique drawing drawn to 1:1 (Fig 7) are called as cavalier projections and those drawn to 1:2 (Fig 8) are called as cabinet projections. These two terms are of academic interest only and mostly we refer these views as oblique projections/drawings only.

In comparisn a cabinet projection will look less distorted than a cavalier projection.

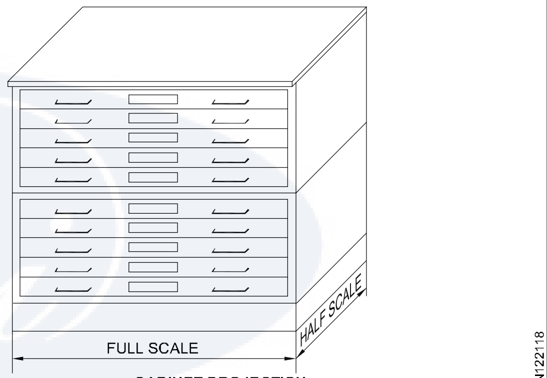
Procedure for drawing oblique views: The procedure for creating oblique drawing is very much similar to that for drawing isometric views. To make isometric view we start from drawing three isometric axes at the desired orientation. In oblique drawing also we start by drawing three axes at the desired orientation. But here two of the axes are perpendicular to each other while the third axis (receding axis). Make 45° or 30° to the horizontal. The orientation of the axes may be any one of the four possibilities given in the figure 9.

Fig 7



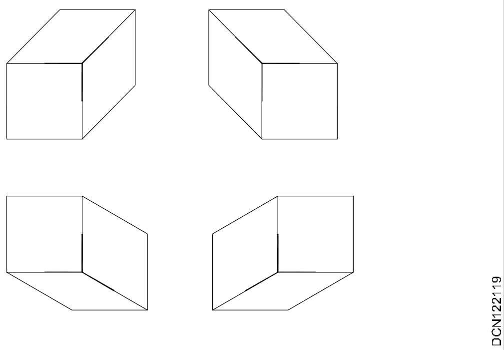
CAVALIER PROJECTION

Fig 8



CABINET PROJECTION

Fig 9



Object positioning in oblique drawing: Remember to position the object in such a way as to make best use of the advantage offered by oblique projection. The face that has the maximum curved details should be placed parallel to the plane of projection. See example in Fig 10.

Another point to note is as far as possible, place the longest dimension parallel to the plane of projection. (Fig 11 a & b)

Few examples of oblique drawings are shown in Fig 12.

Fig 10

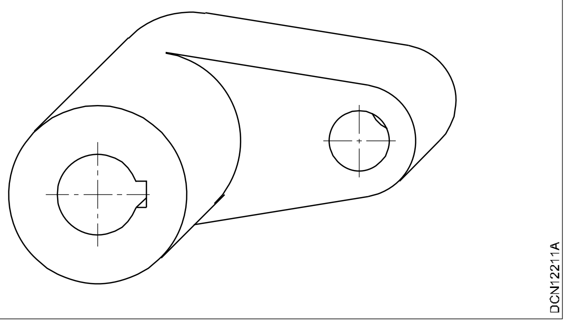


Fig 11

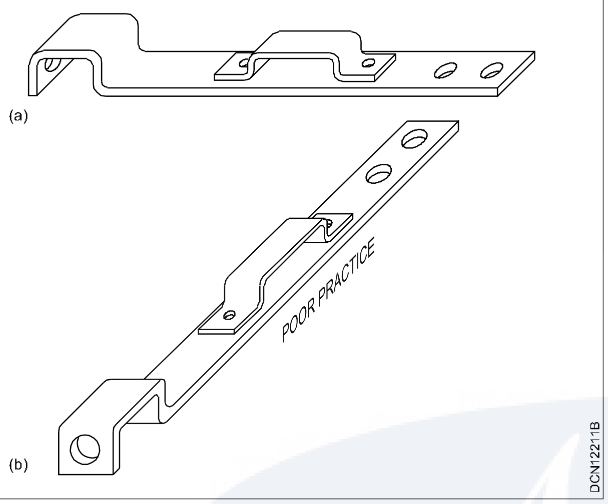
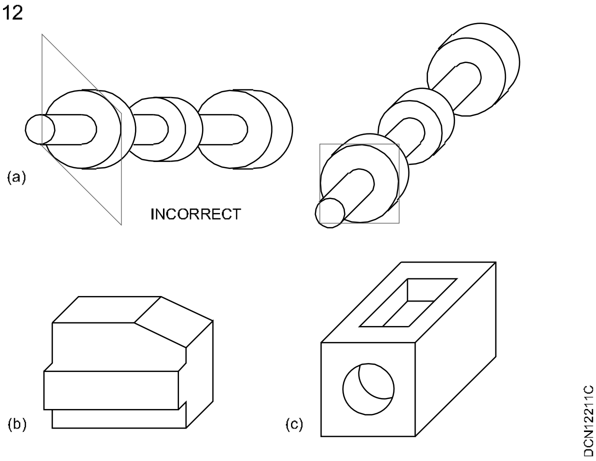


Fig 12

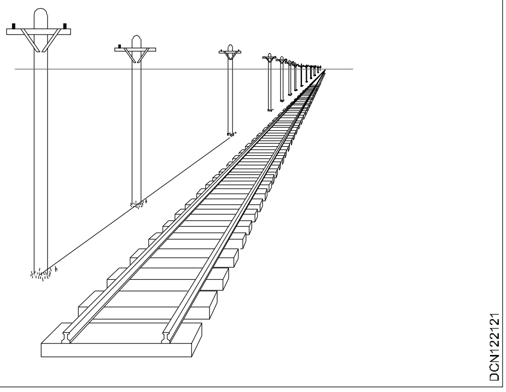


Perspective views

Objectives: At the end of this lesson you shall be able to
- **explain perspective projection**
- **explain various terms used in perspective projection**
- **differentiate between the three types of perspective views.**

Perspective projection: Perspective projections are pictorial views that look more like a photograph or rather it is a pictorial view similar to how an object looks like when it is viewed by the human eye. The basic characteristic of a perspective view is that parallel feature look tapered or converging as the distance from the feature increases from the observer's eye. (Fig 1) whereas in axonometric and oblique projections the projectors are parallel to each other. (Fig 2)

Fig 1



For producing a perspective view/projection, you should be familiar with the following terminologies. (Fig 3)

Ground plane (GP)**:** It is the horizontal plane on which the object is assumed as resting on which the observer stands.

Station point (SP)**:** It is the point where the observer's eye is located while viewing the object.

Picture plane (PP)**:** It is the (imaginary) vertical plane, resting between the station point and the objects being viewed. This is the plane (surface) on which the perspective view is formed.

Ground line (GL)**:** It is the line of intersection of the picture plane with ground plane.

Horizon plane (HP)**:** It is an imaginary plane, at the level of the eye i.e. station point. It is a horizontal plane above the ground plane and at right angle to the picture plane.

Auxiliary ground plane (AGP)**:** This plane is placed above the normal HP and the object. The view from top view (TV) of the object and of the perspective elements are projected on this plane.

Horizontal line (HL)**:** It is the line of intersection of horizontal, plane and the picture plane.

Fig 2

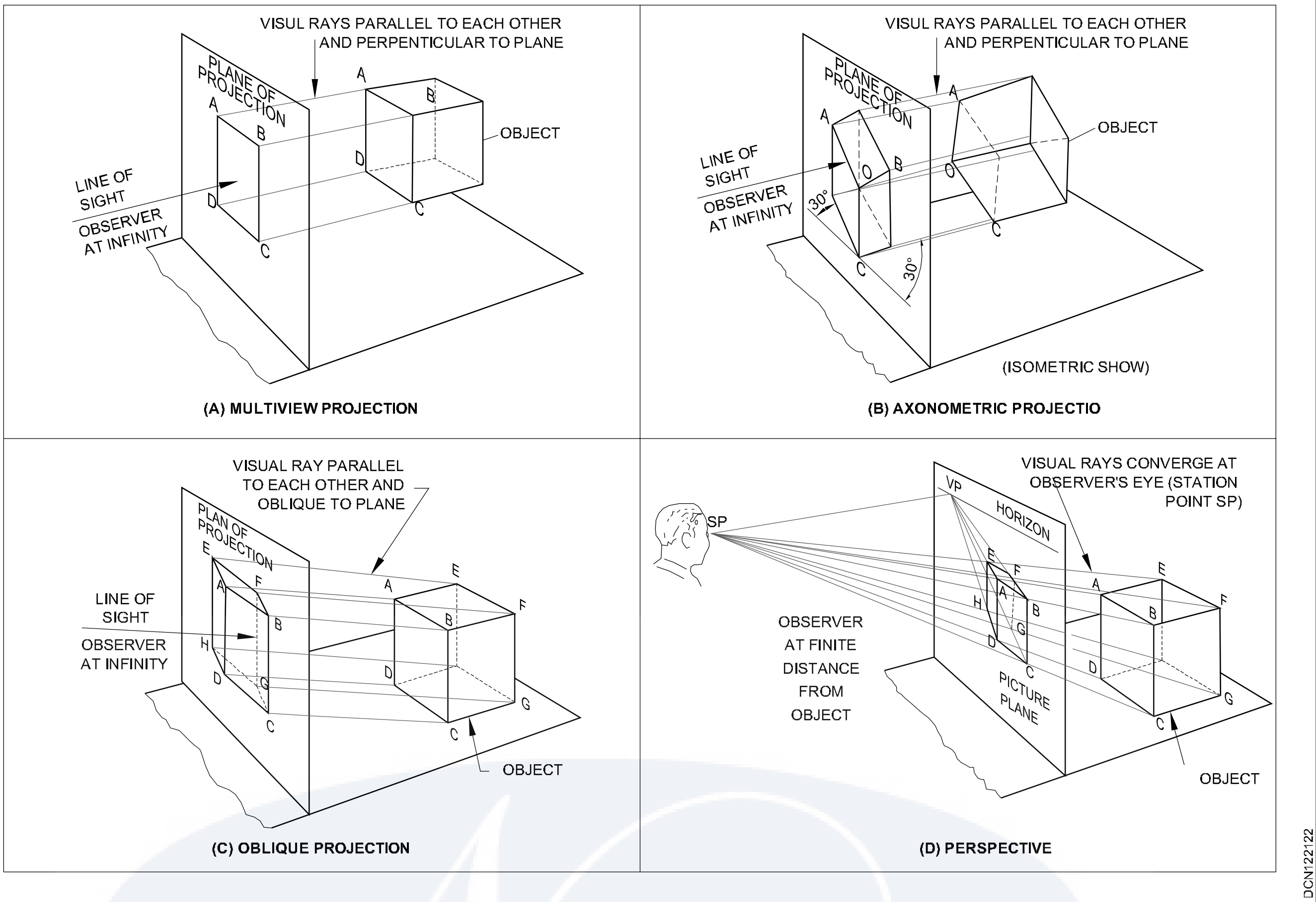
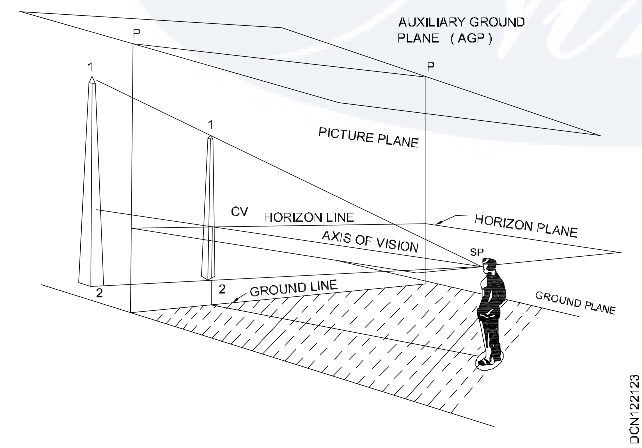


Fig 3



Axis of vision or perpendicular axis (PA)**:** It is the line drawn through the station point perpendicular to the picture plane.

Centre of vision (CV)**:** It is the point on the picture plane where at which the perpendicular axis passes through the picture plane.

Central plane (CP)**:** It is the imaginary vertical plane, which passes through the station point and the centre of vision. It is perpendicular to the picture plane as well ground plane.

Position of station point: Station point is the viewing point and its location should be where the object can be viewed to the best advantage.

The appearance of the finished perspective drawing depends very much on the position of the station point and hence considerable care must be exercised in selecting its location. The following points may serve as guidelines for selecting the location of the station point.

- the distance from the picture plane to the station point shall be atleast twice the maximum dimension (width, height or depth) of the object.
- visual rays from the station point to the outermost boundaries of the object shall be within a cone having an angle of not more than 30°.
- the station point should be offset slightly to one side and should be located above or below the exact centre of object if the object is small.
- when making perspective of tall objects such as buildings the station point shall in at the eye level of the viewer who is standing on the ground.
- The location of the station point shall be fixed so that the angle between the visual rays from the station point and the outermost boundaries of the object is approximately 30°. (Fig 5) If this angle is very wide, the picturisation may not be good.

Position of object

- The object is assumed to be placed on the ground plane. (GP)
- The object is placed either with one principal face parallel or at an angle to the picture plane.

– If kept at an angle the value of the angle shall be 30° for objects like rectangular prism. (Fig 4)

Fig 4

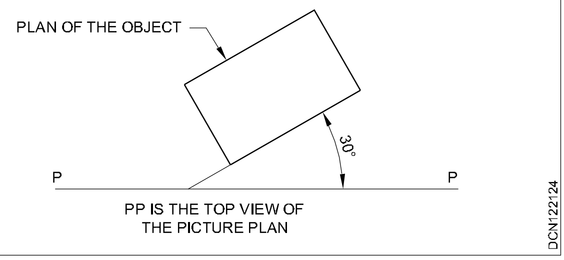
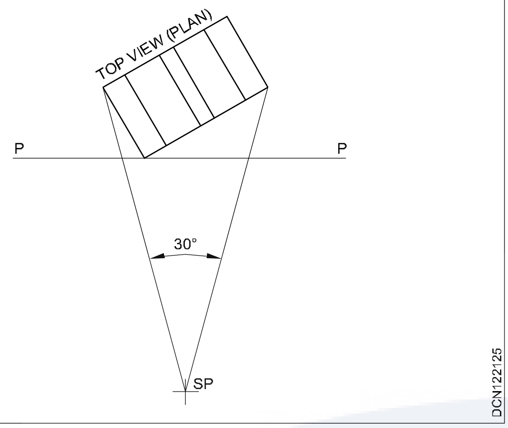


Fig 5



The position of the picture plane with reference to the object determines the size of the perspective view. When the object is placed behind the picture plane, the view is reduced as it is moving towards the picture plane, the view increases. When the object is placed in front of the picture plane, the view is bigger than the object. If the object is on the picture plane, the height of the view is same as the object.

Vanishing point (VP)**:** It is a common knowledge that parallel features like the one shown in Fig 6 appears to meet at a point in infinity and this point is termed as "Vanishing point".

In practice, the point at which the visual ray from the eye (station point - SP) to that infinetely distant vanishing point pierces the picture plane is referred to as the vanishing point.

Note that the vanishing point will be at the same height as that of station point and will lie on the horizon line (HL).

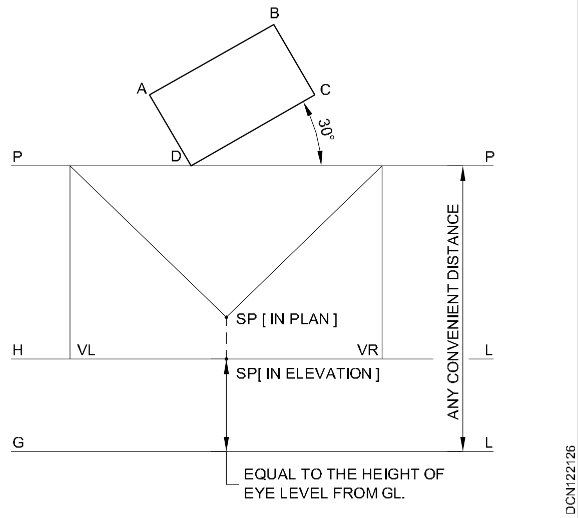
Procedure for determination of vanishing point

– Draw three parallel lines PP, HL and GL to represent picture plane (PP), Horizon plane (HP) and Ground plane (GP).

Note: In figure 6 the plane of the paper is the picture plane. The auxiliary GP (AGP) is rotated to bring it in plane with the picture plane. so the AGP extends above and below the line PP which also is the top view of the picture plane. The lines HL and GL are the elevations (front view) of horizon plane and ground plane respectively.

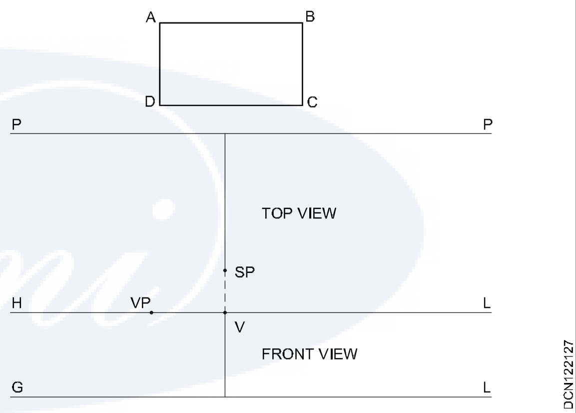
The distance between PP and GL may be decided as per our convenience. The distance between GL and HL will be equal to the height of station point. (eye level)

Fig 6



– Draw the plan of the object in the desired/defined positions. The plan will be above the line PP as the object is behind the picture plane or touching the picture plane. (In Fig 7 the plan of a rectangular prism is drawn)

Fig 7



– Mark the top view of the SP. This will be below the line PP. The picture plane is inbetween the SP and the object (rectangular prism).

– Draw the line from SP parallel to DC meeting PP at R.

– Draw the line from SP parallel to AD meeting PP at L.

– Project R and L vertically down to meet HP at VR and VL.

Now VR and VL an vanishing points at right and left of the object and they are at the same height as the height of SP.

Instead of placing the rectangular prism at an angle as in previous Fig. If it is placed such that one of its principle face is parallel to the picture plane there will be only one vanishing point as against two in the previous case. Because the lines AB and CD and parallel to the picture plane this set of lines will not have any vanishing point. The only vanishing point will be for the lines AD and BC which are perpendicular to the PP.

To obtain this vanishing point draw a line from station point (SP) parallel to AD (Perpendicular to PP), mark the point V and extend the line down to HL. The intersecting point on HL is the vanishing point V. This point incidentally coincides with the front view of station point and centre of vision.

Methods of drawing perspective views: Basically there are two methods for constructing perspective drawings. They are:

– Vanishing point method

– Visual ray method

Depending on the position of the object relative to the picture plane vanishing point method is further classified as

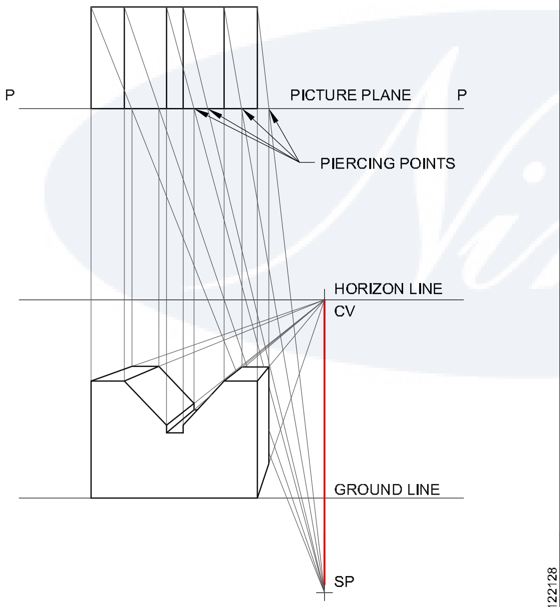
– One point perspective

– Two point perspective

– Three point perspective

One point perspective (Fig 8 & 9)**:** In this method the bottom face of the object is parallel to the ground and one of its vertical faces is parallel to the picture plane. One point perspectives are also called as parallel perspective. Fig 8 & 9 are examples of parallel perspective. Notice that there is only one vanishing point in both the examples and it coincides with centre of vision (V).

Fig 8



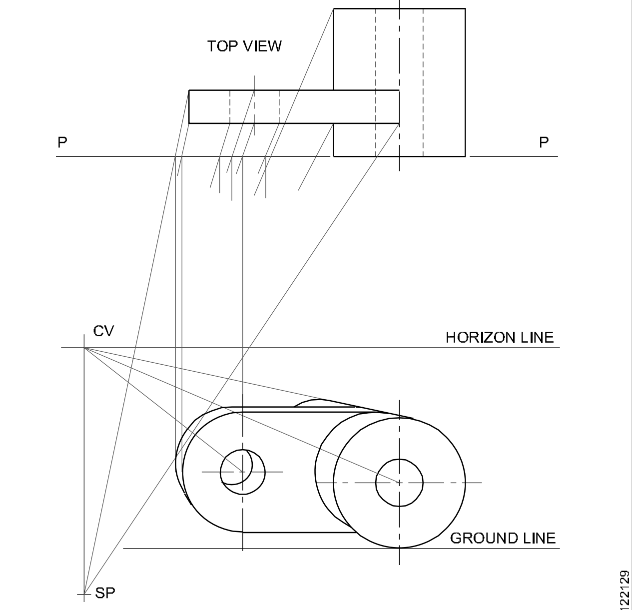
PARALLEL PERSPECTIVE

One point perspective has the similar advantage as oblique drawings in the sence that we can draw curved features parallel to the picture plane and draw the circular features using compass.

Two point perspective (Fig 10)**:** Also called as angular perspective. In this method of construction the vertical faces of the object are at an angle to the picture plane while the bottom face to parallel to the ground plane. As these are two sets of parallel edges, two vanishing points are required for this construction. Examples of two point/ angular perspective are shown in figures.

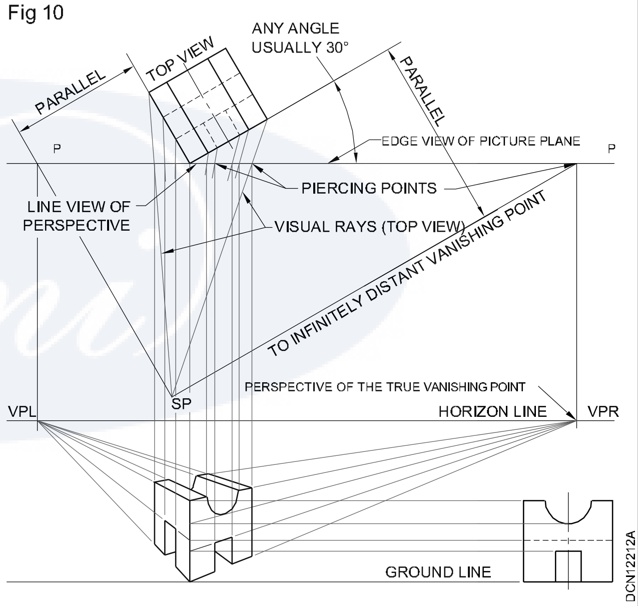
Three point perspective: In this type of perspective all the three prime faces are inclined to the picture plane. The object is placed in a similar fashion as in axonometric projection.

Fig 9



CIRCLE IN PARALLEL PERSPECTIVE

Fig 10



For such position of the object three vanishing points are required for making the perspective. This method is used only very rarely and hence it is not dealt in detail.

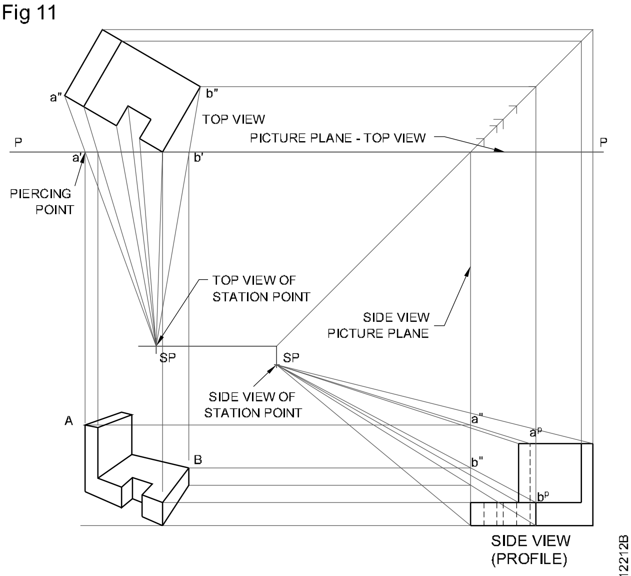
Visual ray method: Using this we can make a perspective drawing by projecting from the plan and elevation of the object. (Fig 11)

In figure the object is placed such that vertical faces are inclined to picture plane (This corresponds to the position for angular perspective). The side view for this position is drawn on the ground line. Now projectors are drawn from top view and side view for obtaining the perspective of the block.

The most generally used method for creating a perspective is two point method. (Angular perspective)

General procedure for making perspective drawing: The general steps for making perspective drawings are given below in the order of sequence. While reading these steps reference may be made to figures.

Fig 11



PERSPECTIVE DRAWING - ORTHOGRAPHIC METHOD

To make a perspective drawing

– Draw the top view (edge fo the picture plane)

– Orient the object relative to the picture plane so that the object will appear to advantage, and draw the top view of the object.

– Select a station point that will best show the shape of the object.

– Draw the horizon and ground line.

– Find the top view of the vanishing points for the principal horizontal edges by drawing lines parallel to the edges, through the station point, and to the picture plane.

– Project from the top views of the vanishing points to the horizon line, thus locating the vanishing points for the perspective.

– Draw the visual rays from the station point to the corners of the object in the top view, locating the piercing point of each ray with the picture plane.

– Start the picture, building from the ground up and from the nearest corner to the more distant ones.

Reference

Detailed procedure for each of the methods of making perspective drawing is given in the relevant section of the exercise book.

Note: Pictorial drawing of the perspective type are more difficult to make in comparison to Axanometric and oblique drawings. Therefore it is not a method of preference to make pictorial views of machines and component. However it is very popular among architech as they can create photographic like picture of the finished building etc even before the construction begins.

Admixtures of concrete and application

Objectives: At the end of this lesson you shall be able to
- **state the classification of admixture by function**
- **uses of concrete admixture.**

Admixtures are those ingredients in concrete other than portland cement, water, and aggregates that are added to the mixture immediately before or during mixing (Fig 1) Admixtures can be classified by function as follows:

Fig 1

Liquid admixtures, from left to right : antiwashout admixture, shrinkage reducer, water reducer, foaming agent, corrosion inhibitor, and air-entraining admixture. (69795)

1 Air-entraining admixtures

2 Water - reducing admixtures

3 Plasticizers

4 Retarding admixtures

5 Hydration- control admixtures

6 Accelerating admixtures

7 Corrosion inhibitors

8 Shrinkage reducers

9 Alkali-silica reactivity inhibitors

10 Coloring admixtures

11 Miscellaneous admixtures such as workability, bonding, dampproofing, permeability reducing, grouting, gas-forming, antiwashout, foaming, and pumping admixtures.

Table 1 provides a much more extensive classification of admixtures.

Concrete should be workable, finishable, strong, durable, watertight, and wear resistant. These qualities can often be obtained easily and economically by the sleection of suitable materials rather than by resorting to admixtures (except air-entraining admixtures when needed).

The major reasons for using admixtures are:

1 To reduce the cost of concrete construction.

2 To achieve certain properties in concrete more effectively than by other means.

3 To maintain the quality of concrete during the stages of mixing, transporting, placing and curing in adverse weather conditions.

4 To onvercome certain emergencies during concreting operations.

Despite these consideratin, it should be borne in mind that no admixture of any type or amount can be considered a substitute for good concreting pratice.

The effectiveness of an admixture depends upon factors such as type, brand, and amount of cementing materials; water content; aggregate shape, gradation, and proportion; mixing time; slump; and temperature of the concrete.

Admixtures being considered for use in concrete should meet applicable specifications as presented in Table .1 Trial mixtures should be made with the admixture and the job materials at temperatures and humiddities anticipated on the job. In this way the compatibility of the admixture with other admixtures and job materials, as well as the effect of the admixture on the properties of the fresh and hardened concrete, can be observed. The amount of admixture recommended by the manufacturer or the optimum amount determined by laboratory tests should be used.

Table 1

Concrete admixtures by classification

Type of admixture	Desired effect	Material
Accelerators (ASTM C 494 and AASHTO M 194, Type C)	Accelerate setting and early - strength development	Calcium chloride (ASTM D and AASHTO M 144) Triethanolamine, sodium thiocyanate, calcium nitrite, calcium nitrate
Air detrainers	Decrease air content	Tributyl phosphate, dibutyl phthalate, octyl alcohol, water-insoluble esters of carbonic and boric acid, silicones.
Air-entraining admixtures (ASTM C 260 and AASHTO M 154)	Improve durability in freeze-thaw, decier, sulfate, and alkalireactive environments improve workability	Salts of wood resins (Vinsol resin), some synthetic detergents, salts of sulfonated lignin, salts of petroleum acids, salts of proteinaceous material, fatty and resinous acids and their salts, alkylbenzene sulfonates, salts of sulfonated hydrocarbons
Alkali-aggregate reactivity inhibitors	Reduce alkali-aggregate reactivity expansion	Barium salts, lithium nitrate, lithium carbonate, lithium hydroxide
Antiwashout admixtures	Cohesive concrete for underwater placements	Cellulose, acrylic polymer
Bonding admixtures	Increase bond strength	Polyvinyl chloride, polyvinyl acetate, acrylics, butadiene-styrene copolymers
Coloring admixtures (ASTM C 979)	Colored concrete	Midified carbon black, iron oxide, phthalocyanine, under, chromium oxide, titanium oxide, cobalt blue
Corrosion inhibitors	Reduce steel corrosion activity in a chloride -laden environment	Calcium nitrite, sodium nitrite, sodium benzoate, certain phosphates or fluosilicates, fluoaluminates, ester amines
Dampproofing admixtures	Retard moisture penetration into dry concrete	Soaps of calcium or ammonium stearate or oleate Butyl stearate, Petroleum products
Foaming agents	Produce lightweight, foamed concrete with low density	Cationic and anionic surfactants, Hydrolized protein
Fungicides, germicides and	Inhibit or control bacterial and fungal growth	Polyhalogenated phenols, Dieldrin emulsions, Copper compounds
Gas formers	Cause expansion before setting	Alumimum powder
Grouting admixtures	Adjust grout properties for specific Accelerators applications	See Air- entraining admixtures, Accelerators, Retarders, and water reducers
Hydration control admixtures	Suspend and reactivate cement hydration with stabilizer and activator	Carboxylic acids, Phosphorus- containing organic acid salts
Permeability reducers	Decrease permeability	Latex, Calcium stearate

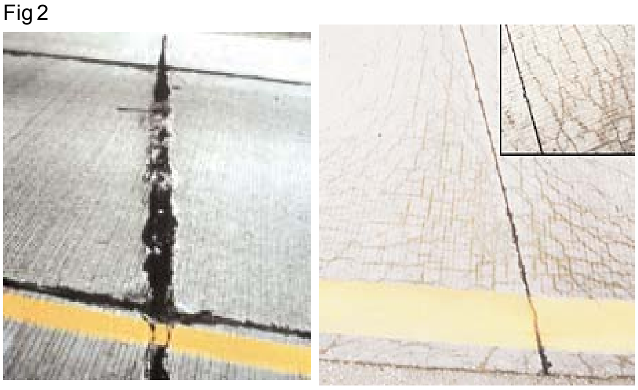
Type of admixture	Desired effect	Material
Pumping aids	Improve pumpability	Organic and synthetic polymers, Organic flocculents, Organic emulsions of paraffin, coal tar, asphalt, acrylics, Bentonite and pyrogenic silicas, Hydrated lime (ASTM C 141)
Retarders (ASTM C 494 and AASHTO M194, Type B)	Retard setting time	Lignin, Borax, Sugars, Tartaric acid and salts
Shrinkage reducers	Reduce drying shrinkage	Polyoxyalkylene alkyl ether, Propylene glycol
Superplasticizers* (ASTM C 1017, Type 1)	Increase flowability of concrete Reudce water-cement ratio	Sulfonated mealmine formaldehyde condensates, Sulfonated naphthalene formaldehyde condensates, Lignosulfonates, Polycarboxylates
Superplasticizer* and retarder (ASTM C 1017, Type 2)	Increase flowability with retarded set Reduce water- cement ratio	See superplasticizers and also water reducers
Water reducer (ASTM C 494 and AASHTO M 194, Type A)	Reduce water content at least 5%	Lignosulfonates, Hydroxylated carboxylic acids, Carbothydrates, (Also tend to retard set so accelerator is often added)
Water reducer and accelerator (ASTM C 494 and AASTHO M 194 Type E)	Reduce water content (minimum 5%) and accelerate set	See water reducer, Type A (accelerator is added)
Water reducer and retarder (ASTM C 494 and AASHTO M 194, Type D)	Reduce water content (minimum 5%) and retard set	See water reducer, Type A (retarder is added)
Water reducer - high range (ASTM C 494 and AASHTO M 194, Type F)	Reduce water content (minimum 12%)	See superplasticizers
Water reducer-high range- and retarder (ASTM C 494 and AASHTO M 194, Type G)	Reduce water content (minimum 12%) and retard set	See superplasticizers and also water reducers
Water reducer - mid range	Reduce water content (between 6 and 12%) without retarding	Lignosulfonates, Polycarboxylates

* Superplasticizers are also referred to as high range water reducers or plasticizers. These admixtures often meet both ASTM C 494 (AASHTO M 194) and ASTM C 1017 specifications.

1 Air - entraining admixtures

Air-entraining admixtures are used to purposely introduce and stablize microscopic air bubbles in concrete. Air-entrainment will dramatically improve the durability of concrete exposed to cycles of freezing and thawing (Fig 2) Entrained air greatly improves concrete's resistance to surface scaling caused by chemical deicers (Fig 3) Furthermore, the workability of fresh concrete is improved significantly and segregation and bleeding are reduced or eliminated.

Fig 2



Frost damage (crumbling) at joints of a pavement (top),frost induced cracking near joints (bottom), and enlarged view of cracks

Fig 3

Scaled concrete surface resulting from tack of air entrainment, use of deicers, and poor finishing and curing practices

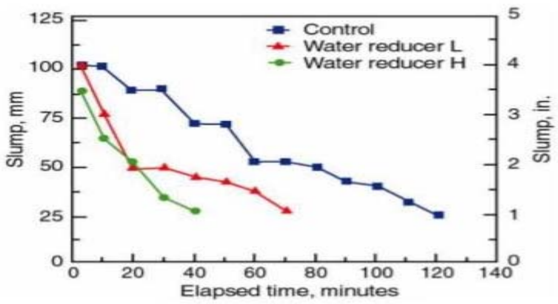
Air-entrained concrete contains minute air bubbles that are distributed uniformly throughtout the cement paste. Intrained air can be produced in concrete by use of an air-entraining cement, by introduction of an air-entraining admixture, or by a combination of both methods. An air-entraining cement is a portland cement with an air-entraining addition interground with the clinker during manufacture. An air-entraining admixture, on the other hand, is added directly to the concrete materials either before or during mixing.

The primary ingredients used in air-entraining admixtures are listed in Table 1. Specifications and methods of testing air - entraining admixtures are given in ASTM C 260 and C 233 (AASHTO M 154 and T 157). Air-entraining additions for use in the manufacture of air-entraining cements must meet requirements of ASTM C 226. Applicable requirements for air-entraining cements are given in ASTM C 150 and AASHTO M 85.

2 Water - reducing admixtures

Water- reducing admixtures are used to reduce the quantity of mixing water required to produce concrete of a certain slump, reduce water - cement ratio, reduce cement content, or increase slump. Typical water reducers reduce the water content by approximately 5% to 10%. Adding a water - reducing admixture to concrete without reducing the water content can produce a mixture with a higher slump. The rate of slump loss, however, is not reduced and in most cases is increased. (Fig 4). Rapid slump loss results in reduced workability and less time to place concrete.

Fig 4

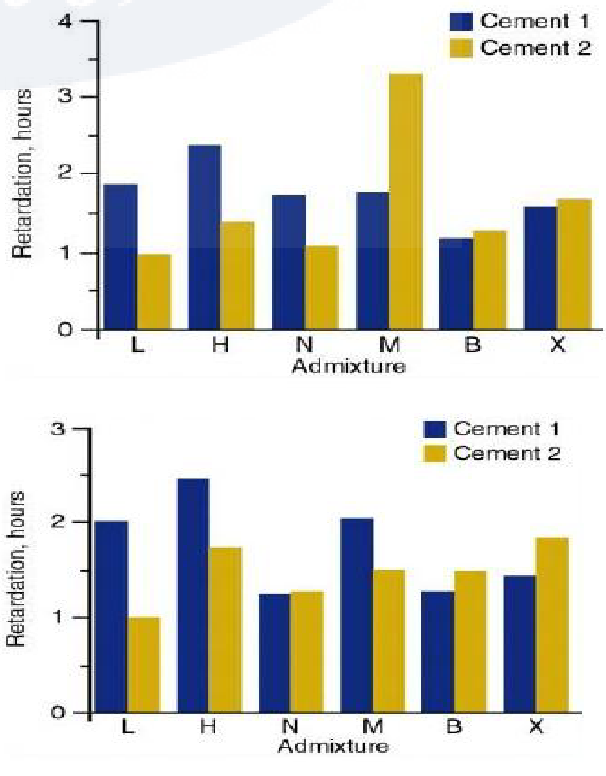


Slump loss at 23°C (73°F) in concretes containing conventional water reducers (ASTM C 494 and AASHTO M 194 Type D) compared with a control mixture

An increase in strength is generally obtained with water-reducing admixtures as the water - cement ratio is reduced. For concretes of equal cement content, air content, and slump, the 28 day strength of a water-reduced concrete containing a water reducer can be 10% to 25% greater than concrete without the admixture. Despite reduction in water content, water- reducing admixtures may cause increases in drying shrinkage. Usually the effect of the water reducer on drying shrinkage is small compared to other more significant factors that cause shrinkage cracks in concrete. Using a water reducer to reduce the cement and water content of a concrete mixture- while maintaining a constant water - cement ratio- can result in equal or reduced compressive strength and can increase slump loss by a factor of two or more.

Water reducers decrease, increase, or have no effect on bleeding, depending on the chemical composition of the admixture. A reduction of bleeding can result in finishing difficulties on flat surfaces when rapid drying conditions are present. Water reducers can be modified to give varying degrees of retardation while others do not significantly affect the setting time. ASTM C 494 (AASHTO M 194) Type A water reducers can have little effect on setting, while Type D admixtures provide water reduction with retardation, and Type E admixtures provide water reduction with accelerated setting. Type D water-reducing admixtures usually retard the setting time of concrete by one to three hours (Fig 5). Some water - reducing admixtures may also entrain some air in concrete. Lignin-based admixtures can increase air contents by 1 to 2 percentage points. Concretes with water reducers generally have good air retention (Table 2)

Fig 5



Retardation of set in cement- reduced mixtures relative to control mixture. Concretes L and H contain conventional water reducer, concretes N, M, B and X contain high - range water reducer

The effectiveness of water reducers can concrete is a function of their chemical composition, concrete temperature, cement composition and fineness, cement condent, and the presence of other admixtures. The classifications and components of water reducers are listed in Table 1 for more information on the effects of water reducers on concrete properties.

Mid- range water reducing admixtures

Mid-range water reducers were first introduced in 1984. These admixtures provide significant water reduction (between 6 and 12%) for concretes with slumps of 125 to 200 mm (5 to 8 in.) without the retardation associated with high dosages of conventional (normal) water reducers. Normal water reducers are intended for concretes with slumps of 100 to 125 mm (4 to 5 in.) Mid -range water reducers can be used to reduce stickiness and improve finishability, pumpability, and placeability of concretes containing silica fume and other supplementary cementing materials. Some can also entrain air and be used in low slump concretes.

High-range water reducing admixtures

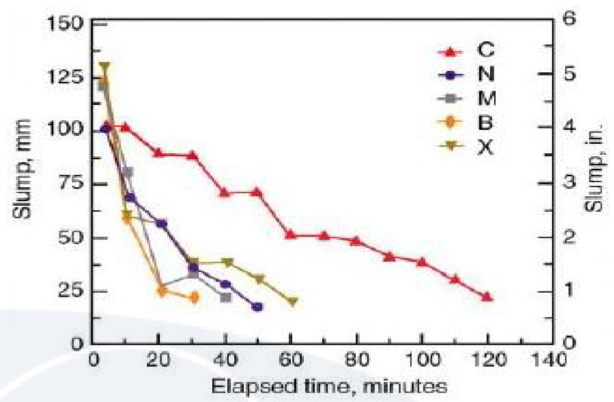
High- range water reducers, ASTM C 494 (AASHTO M 194) Types F (water reducing) and G (water reducing and retarding), can be used to impart properties induced by regular water reducers, only much more efficiently. They can greatly reduce water demand and cement contents and make low water-cement ratio, high -strength concrete with normal or enhanced workability. A water reduction of 12% to 30% can be obtained through the use of these admixtures. The reduced water content and water- cement ratio can produce concretes with (1) ultimate compressive strengths in excess of 70 MPa (10,000 psi), (2) increased early strength gain, (3) reduced chloride-ion penetration, and (4) other beneficial properties associated with low waer -cement ratio concrete (Fig 6).

Fig 6

Low water to cement ratio concrete with low chloride permeability - easily made with high-range water reducers- is ideal for bridge decks.

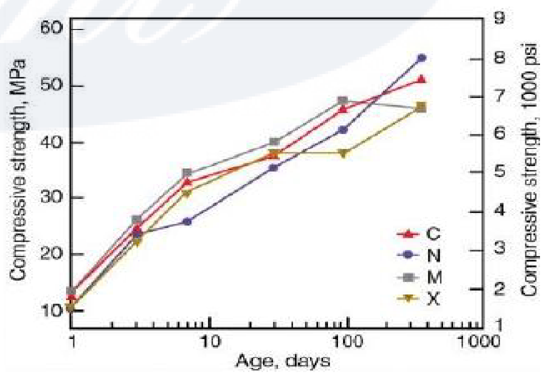
High- range water reducers are generally more effective than regular water - reducing admixtures in producing workable concrete. A significant reduction of bleeding can result with large reductions of water content; this can result in finishing difficulties on flat surfaces, when rapid drying conditions are present. Some of these admixtures can cause signficant slump loss (Fig 7). Significant retardation is also possible, but can aggravate plastic shrinkage cracking without proper protection and curing (Fig 5). Drying shrinkage, chloride permeability, air retention (Table 2), and strength development of concretes with high - range water reducers are comparable to concretes without them when compared at constant water - cement ratios (reduced cement and water contents) Fig.8.

Fig 7



Slump loss at 23°C (73°F) in mixtures containing high- range water reducers (N, M, B and X) compared with control mixture (C)

Fig 8



Compressive strength development in cement - reduced concretes; controls mixture (C) and concretes containing high- range water reducers (N, M, and X)

Concretes with high-range water reducers can have larger entrained air voids and higher void- spacing factors than normal air-entrained concrete. This would generally indicate a reduced resistance to freezing and thawing; however, laboratory tests have shown that concrets with a moderate slump using high- range water reducers have good freeze-thaw durability, even with slightly higher void- spacing factors. This may be the result of lower water-cement ratios often associated with these concretes.

When the same chemicals used for high -range water reducers are used to make flowing concrete, they are often called plasticizers or superplasticizers (see discussion below).

3 Plasticizers for flowing concrete

Plasticizers, often called superplasticizers, are essentially high - range water reducers meeting ASTM C 1017; these admixtures are added to concrete with a low-to-normal slump and water- cement ratio to make high - slump flowing concrete (Fig 9). Flowing concrete is a highly fluid but workable concrete that can be placed with little or no vibration or compaction while still remaining essentially free of excessive bleeding or segregation. Following are a few of the applications where flowing concrete is used; (1) thin-section placements (Fig 10), (2) areas of closely spaced and congested reinforcing steel, (3) tremie pipe (underwater) placements, (4) pumped concrete to reduce pump pressure, thereby increasing lift and distance capacity, (5) areas where conventional consolidation methods are impractical or can not be used, and (6) for reducing handling costs. The addition of a plasticizer to a 75 mm (3 in.) slump concrete can easily produce a concrete with a 230 mm (9 in.) slump. Flowing concrete is defined by ASTM C 1017 as a concrete having a slump greater than 190 mm (7 1/2 in.) yet maintaining cohesive properties.

Table 2

Loss of air from cement reduced concrete mixtures

Mixture	Initial air content, %*	Final air content %*	Percent air retained	Rate of air loss, %/ minute
C Control	5.4	3.0	56	0.020
L Water	7.0	4.7	67	0.038
H reducer	6.2	4.6	74	0.040
N	6.8	4.8	71	0.040
M High -range	6.4	3.8	59	0.065
B Water	6.8	5.6	82	0.048
X Reducer	6.6	5.0	76	0.027

* Represents air content measured after addition of admixture

* Represents air content taken at point where slump falls below 25 mm (1 in.)

Fig 9

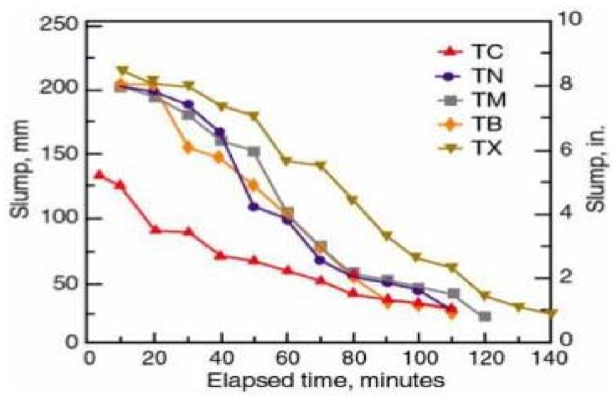
Flowable concrete with a high slump (top) is easily placed (middle) even in areas of heavy reinforcing steel congestion (bottom)

Fig 10

Plasticized, flowing concrete is easily placed in thin sections such as this bonded overlay that is not much thicker than 1 1/2 diameters of a quarter.

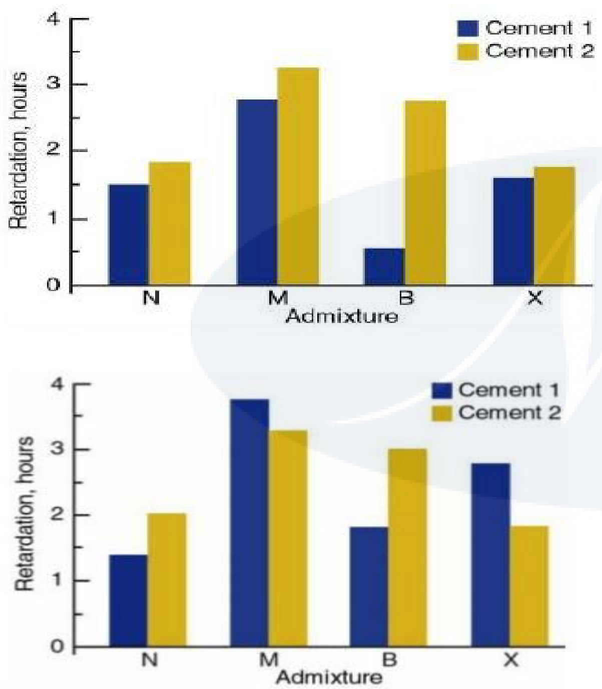
ASTM C 1017 has provisions for two types of admixtures; Type -1 plasticizing, and Type 2- plasticizing and retarding/ Plasticizers are generally more effective than regular or mid -range water- reducing admixtures in producing flowing concrete. The effect of certain plasticizers in increasing workability or making flowing concrete is short - lived, 30 to 60 minutes; this period is followed by a rapid loss is workability or slump loss (Fig 11). High temperatures can also aggravate slump loss. Due to their propensity for slump loss, these admixtures are some times added to the concrete mixer at the jobsite. They are available in liquid and powder form. Extended-slump-life plasticizers added at the batch plant help reduce slump-loss problems. Setting time may be accelerated or retarded based on the admixture's chemistry, dosage rate, and interaction with other admixtures and cementing materials in the concrete mixture. Some plasticizers can retard final set by one to almost four hours (Fig 12). Strength development of flowing concrete is comparable to normal concrete. (Fig 13)

Fig 11



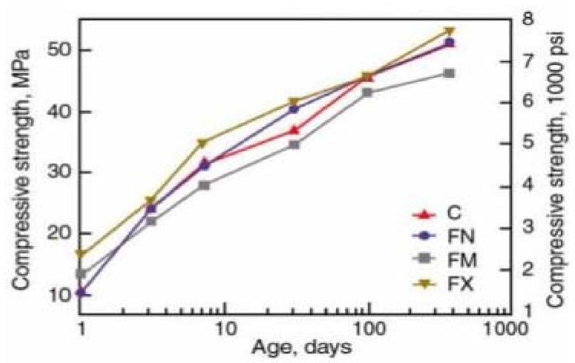
Slump loss at 32°C (90°F) in flowing concretes (TN, TM, TB and TX) compared with control mixture (TC)

Fig 12



Retardation of set in flowing concrete with plasticizers (N, M, B and X) relative to control mixture

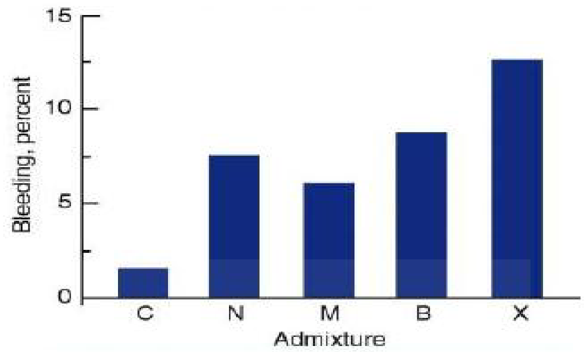
Fig 13



Compressive strength development in flowing concretes. C is the control mixture. Mixtures FN, FM and FX contain plasticizers

While it was previously noted that flowing concretes are essentially free of excessive bleeding, tests have shown that some plasticized concretes bleed more than control concretes of equal waer-cement ration (Fig 14); but plasticized concretes bleed significantly less than control concretes of equally high slump and higher water content. High - slump, low-water-content, plasticized concrete has less drying shrinkage than a high - slump, high - water-content conventional concrete, however this concrete has similar or higher drying shrinkage than conventional low-slump, low water- content concrete.

Fig 14



Bleeding of flowing concretes with plasticizers (N, M, B and X) compared to control (C)

The effectiveness of the plasticizer is increased with an increasing amount of cement and fines in the concrete.

Plasticized flowing concrete can have larger entrained air voids and greater void- spacing factors than conventional concrete. Air loss can also be significant. Some research has indicated poor frost- and deicer-scaling resistance for some flowing concretes when exposed to a continuously moist environment without the benefit of a drying period. However, field performance of flowing concretes with low water to portland cement ratios has been good in most frost environments.

Table 1 lists the primary components and specifications for plasticizing (superplasticizer) admixtures.

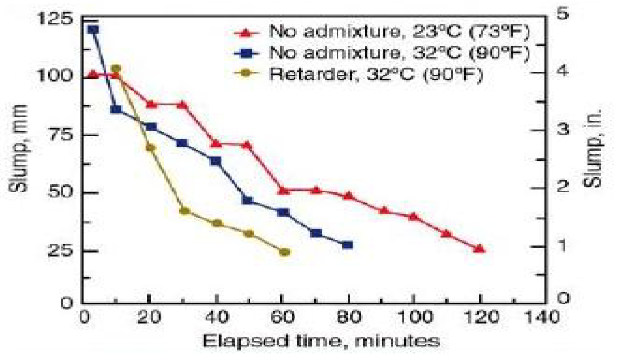
4 Retarding admixtures

Retarding admixturs are used to delay the rate of setting on concrete. High temperatures of fresh concrete (30°C (86°F) are often the cause of an increased rate of hardening that makes placing and finishing difficult. One of the most practical methods of counteracting this effect is to reduce the temperature of the concrete by cooling the mixing water and / or the aggregates. Retarders do not decrease the initial temperature of concrete. The bleeding rate and bleeding capacity of concrete is increased with retarders.

Retarding admixtures are useful in extending the setting time of concrete, but they are often also used in attempts to decrease slump loss and extend workability, especially prior to placement at elevated temperatures. The fallacy of this approach is shown in Fig 15, where the addition of a retarder resulted in an increased rate of slump loss compared to the control mixtures.

Retarders are sometimes used to : (1) offset the accelerating effect of hot weather on the setting of concrete; (2) delay the initial set of concrete or grout when difficult or unusual conditions of placement occur, such as placing concrete in large piers and foundations, cementing oil wells, or pumping grout or concrete over considerable distances; or (3) delay the set for special finishing techniques, such as an exposed aggregate surface.

Fig 15



Slump loss at various temperatures for conventional concretes prepared with and without set- retarding admixture

The amount of water reduction for an ASTM C 494 (AASHTO M 194) Type B retarding admixture is normally less than that obtained with a Type A water reducer. Type D admixtures are designated to provide both water reduction and retardation.

In general, some reduction in strength at early ages (one to three days) accompanies the use of retarders. The effects of these materials on the other properties. Therefore, acceptance tests of retarders should be made with actual job materials under anticipated job conditions. The classifications and components of retarders are listed in Table 1.

5 Hydration - control admixtures

Hydration controlling admixtures became available in the late 1980s. They consist of a two part chemical system; (1) a stabilizer or retarder that essentially stops the hydration of cementing materials, and (2) an activator that reestablishes normal hydration and setting when added to the stabilized concrete. The stabilizer can suspend hydration for 72 hours and the activator is added to the mixture jost before the concrete is used. These admixtures make it possible to reuse concrete is used. These admixtures make it possible to reuse concrete returned in a ready-mix truck by suspending setting overnight. The admixture is also useful in maintaining concrete in a stabilizhed non -hardened state during long hauls. The concrete is reactived when it arrives at the project. This admixture presently does not have a standard specification.

6 Accelerating admixtures

An accelerating admixture is used to accelerate the rate of hydration (setting) and strength development of concrete at an early age. The strength development of concrete can also be accelerated by other methods : (1) using Type III or Type HE high- early strength cement, (2) lowering the water- cement ratio by adding 60 to 120 kg/m^3 (100 to 200 lb/yd^3) of additional cement to the concrete, (3) using a water reducer, or (4) curing at higher temperatures. Accelerators are designated as Type C admixtures under ASTM C 494 (AASHTO M 194).

Calcium chloride ($CaCl_2$) is the chemical most commonly used in accelerating admixtures, especially for non-reinforced concrete. It should conform to the requirements of ASTM D 98 (AASHTO M 144) and should be sampled and tested in accordance with ASTM D 345.

The widespread use of calcium chloride as an accelerating admixtures has provided much data and experience on the effect of this chemical on the properties of concrete. Besides accelerating strength gain, calcium chloride causes an increase in drying shrinkage, potential reinforcement corrosion, discoloration (a darkening of concrete), and an increase in the potential for scaling.

Calcium chloride is not an antifreeze agent. When used in allowable amounts, it will not reduce the freezing point of concrete by more than a few degrees. Attempts to protect concrete from freezing by this method are foolhardy. Instead, proven reliable precautions should be taken during cold weather, Cold- Weather concreting).

When used, calcium chloride should be added to the concrete mixture in solution form as part of the mixing water. If added to the concrete in dry flake form, all of the dry particles may not be completely dissolved during mixing. Undissolved lumps in the mix can cause popouts or dark spots in hardened concrete.

The amount of calcium chloride added to concrete should be no nore than is necessary to produce the desired result and in no case exceed 2% by mass of cementing material. When calculating the chloride content of commercially available calcium chloride, it can be assumed that.

1 Regular flake contains a minimum of 77% $CaCl_2$.

2 Concentrated flake, pellet, or granular forms contain a minimum of 94% $CaCl_2$.

An overdose can result in placement problems and can be detrimental to concrete. It may cause; rapid stiffening, a large increase in drying shrinkage, corrosion of reinforcement, and loss of strength at later ages.

Applications where calcium chloride should be used with caution.

1 Concrete subjected to steam curing

2 Concrete containing mebedded dissimilar metals, especially if electrically connected to steel reinforcement.

3 Concrete slabs supported on permanent galvanized steel forms.

4 Colored concrete.

Calcium chloride or admixtures containing soluble chlorides should not be used in the following.

1 Construction of parking garages

2 Prestressed concrete because of possible steel corrosion hazards.

3 Concrete containing embedded aluminum (for example, conduit) since serious corrosion of the aluminum can result, especially if the alumnium is in contact with embedded steel and the concrete is in a humid environment.

4 Concrete containing aggregates that, under standard test conditions, have been shown to be potentially deleteriously reactive.

5 Concrete exposed to soil or water containing sulfates

6 Floor slabs intended to receive dry-shake metallic finishes.

7 Hot weather generally

8 Massive concrete placements.

The maximum chloride-ion content for corrosion protection of prestressed and reinforced concrete as recommended by the ACI 318 building code is presented in Table -3. Resistance to the corrosion of embedded steel is further improved with an increase in the depth of concrete cover over reinforcing steel, and a lower water - cement ratio. Stark (1989) demonstrated that concretes made with 1% $CaCl_2$- $2H_2O$ by mass of cement developed active steel corrosion when stored continuously in fog. When 2% $CaCl_2$ - $2H_2O$ was used, active corrosion was detected in concrete stored in a fog room at 100% relative humidity. Risk of corrosion was greatly reduced at lower relative humidities (50%) demonstrates how to calculate the chloride content of freshconcrete and compare it with recommended limits.

Table 3

Maximum chloride - ion content for corrosion protection on reinforcement

Type of member	Maximum water soluble chloride-ion (Cl) in concrete percent by mass of cement
Prestressed concrete	0.06
Reinforced concrete exposed to chloride in service	0.15
Reinforced concrete that will be dry or protected from mositure in service	1.00
Other reinforced concrete construction	0.30

* Requirements from ACI 318 tested per ASTM C 1218.

Several nonchloride, noncorrosive accelerators are available for use in concrete where chlorides are not recommended (Table 1). However, some nonchloride accelerators are not as effective as calcium chloride. Certain nonchloride accelerators accelerators are specially formulated for use in cold weather applications with ambient temperatures down to 7°C (20°F).

7 Corrosion inhibitors

Corrosion inhibitors are used in concrete for parking structures, marine structures, and bridges where chloride salts are present. The chlorides can cause corrosion of steel reinforcement in concrete (Fig 16). Ferrous oxide and ferric oxide form on the surface of reinforcing steel in concrete. Ferrous oxide, though stable in concrete's alkaline environment, reacts with chlorides to form complexes that move away from the steel to form rust. The chloride ions continue to attack the steel until the passivating oxide layer is destroyed. Corrosion-inhibiting admixtures chemically arrest the corrosion reaction.

Fig 16

The damage to this concrete parking structure resulted from chloride- induced corrosion of steel reinforcement

Commercially available corrosion inhibitors include; calcium nitrite, sodium nitrite, dimethly ethanolamine, amines, phosphates, and ester amines. Anodic inhibitors, such as nitrites, block the corrosion reaction of the chloride-ions by chemically reinforcing and stabilizing the passive protective film on the steel; this ferric oxide film is created by the high pH environment in concrete. The nitrite-ions cause the ferric oxide to become more stable. In effect, the chloride-ions are prevented from penetrating the passive film and making contact with the steel.

A certain amount of nitrite can stop corrosion up to some level of chloride-ion. Therefore, increased chloride levels require increased levels of nitrite to stop corrosion.

Cathodic inhibitors react with the steel surface to interfere with the reduction of oxygen. The reduction of oxygen is the principal cathodic reaction in alkaline environments.

8 Shrinkage - reducing admixtures

Shrinkage-reducing admixtures, introduced in the 1980s, have potential uses in bridge decks, critical floor slabs, and buildings where cracks and curling must be minimized for durability or aesthetic reaons (Fig 17). Propylene glycol and polyoxyalkylene alkyl ether have been used as shrinkage reducers. Drying shrinkage reductions of between 25% and 50% have been demonstrated in laboratory tests. These admixtures have negligible effects on slump and air loss, but can delay setting. They are generally compatible with other admixtures.

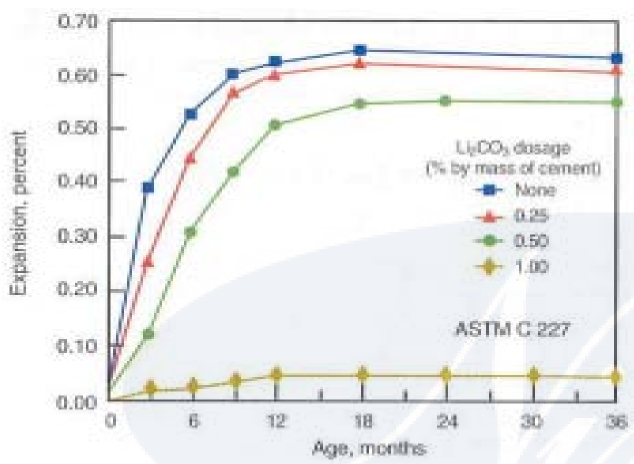
9 Chemical admixtures to reduce alkali-aggregate reactivity (asr inhibitors)

Chemical admixtures to control alkali-silica reactivity (alkali-aggregate expansion) were introduced in the 1990s (Fig 18). Lithium nitrate, lithium carbonate, lithium hydroxide, lithium alumnium silicate (decrepitated spodumene), and barium salts have shown reduction of alkali-silica reaction (ASR) in laboratory tests. Some of these materials have potential for use as an additive to cement. There is little long-term field experience available on the effectiveness of these materials.

Fig 17

Shrinkage cracks, such as shown on this bridge deck, can be reduced with the use of good concreting practices and shrinkage reducing admixtures

Fig 18



Expansion of specimens made with lithium carbonate admixture

10 Coloring admixtures (Pigments)

Natural and synthetic materials are used to color concrete for aesthetic and safety reaons. (Fig 19). Red concrete is used around buried electrical orgas lines as a warning to anyone near these facilities. Yellow concrete safety curbs are used in paving applications. Generally, the amount of pigments used in concrete should not exceed 10% by weight of the cement. Pigments used in amounts less than 6% generally do not affect concrete properties.

Fig 19

Red and blue pigments were used to color this terrazzo floor.

Unmodified carbon black substantially reduces air content. Most carbon black for coloring concrete contains an admixture to offset this effect on air. Before a coloring admixture is used on a project, it should be tested for color fastness in sunlgiht and autoclaving, chemical stability in cement, and effects on concrete properties. Calcium chloride should not be used with pigments to avoid color distortions. Pigments should conform to ASTM C 979.

11 Dampproofing admixtures

The passage of water through concrete can usually be tracted tobe existence of cracks or areas of incomplete consolidation. Sound, dense concrete made with a water-cement ratio of less than 0.50 by mass will be watertight if it is properly placed and cured.

Admixtures known as dampproofing agents include certain soaps, stearates, and petroleum products. They may, but generally do not reduce the permeability of concretes that have low cement contents, high water-cement ratios, or a deficiency of fines in the aggregate. Their use in well - proportioned mixes, may increase the mixing water required and actually result in increased rather than reduced permeability.

Dampproofing admixtures are sometimes used to reduce the transmission of moisture through concrete that is in contact with water or damp earth. Many so-called dampproofers are not effective, especially when used in concretes that are in contact with water under pressure.

Permeability - reducing admixtures

Permeability- reducing admixtures reduce the rate at which water under pressure is transmitted through concrete. One of the best methods of decreasing permeability in concrete is to increase the moistcuring period and reduce the water- cement ratio to less than 0.5. Most admixtures that reduce water -cement ratio consequently reduce permeability.

Some supplementary cementing materials, especially silica fume, reduce permeability through the hydration and pozzolanic - reaction process. Other admixtures that act to block the capillaries in concrete have been shown to be effective in reducing concrete corrosion in chemically aggressive environments. Such admixtues, designed for use in high- cement content/ low -water- cement ratio concretes, contain aliphatic fatty acid and an aqueous emulsion of polymeric and aromatic globules.

Pumping aids

Pumping aids are added to concrete mixtures to improve pumpability. Pumping aids cannot cure all unpumpable concrete problems; they are best used to make marginally pumpable concrete more pumpable. These admixtuers increase viscosity or cohesion in concrete to reduce dewatering of the paste while under pressure from the pump.

Some pumping aids may increase water demand, reduce compressive strength, cause air entrainment, or retard setting time. These side effects can be corrected by adjusting the mix propertions or adding another admixture to offset the side effect.

A partial list of materials used in pumping aids is given in Table 1. Some admixtures that serve other primary purposes but also improve pumpability are air-entraining agents, and some water- reducing and retarding admixtures.

Bonding admixtures and bonding agents

Bonding admixtures are usually water emulsions of organic materials including rubber, polyvinyl chloride, polyvinyl acetate, acrylics, styrene butadiene copolymers, and other polymers. They are added to portland cement mixtures to increase the bond strength between old and new concrete. Flexural strength and resistance to chloride-on ingress are also improved. They are added in proportions equivalent to 5% to 20% by mass of the cementing materials; the actual quantity depending on job conditions and type of admixture used. Some bonding admixtures may increase the air content of mixtures. Nonreemulsifiable types are resistant to water, better suited to exterior application, and use in places where moisture is present.

The ultimate result obtained with a bonding admixture will be only as good as the surface to which the concrete is applied. The surface must be dry, clean, sound free of dirt, dust, pain, and grese, and at the proper temperature. Organic or polymer modified concretes are acceptable for patching and thin- bonded overlayment, particularly where feather-edged patches are desired.

Bonding agents should not be confused with bonding admixtures. Admixtures are an ingredient in the concrete; bonding agents are applied to existing concrete surfaces immediately before the new concrete is placed. Bonding agents help “glue” the existing and the new materials together. Bonding agents are often used in restoration and repair work; they consist of portland cement or latex-modified portland cement grout or polymers such as expoxy resins. or latex.

Grouting admixtures

Portland cement grouts are used for a varity of purposes: to stabilize foundations, set machine bases, fill cracks and joints in concrete work, cement oil well, fill cores of masonry walls, grout prestressing tendons and anchor bolts, and fill the voids in preplaced aggregate concrete. To alter the properties of grout for specific applications, various air-entraining admixtures, accelerators, retarders, and nonshrink admixtues are often used.

Gas - forming admixtures

Aluminum powder and other gas- forming materails are sometimes added to concrete and grout in very small quantities to cause a slight expansion of the mixture prior to hardening. This may be of benefit where the complete grouting of a confined space is essential, such as under machine bases or in post-tensioning ducts of prestressed concrete. These materials are also used in larger quantities to produce autoclaved celluar concretes. The amount of expansion that occurs is dependent upon the amount of gas-forming material used, the temperature of the fresh mixture, the alkali contnet of the cement, and other variable. Where the amount of expansion is critical, careful control of mixtures and temperatures must be exercised. Gas-forming agents will not overcome shrinkage after hardening caused by drying or carbonation.

Air detrainers

Air- detraining admixtures reduce the air content in concrete. They are when the air content cannot be reduced by adjusting the mix proportions or by changing the dosage of the air-entraining agent and other admixtures. However, air -detrainers are rarely used and their effectiveness and dosage rate should be established on trial mixes prior to use on actual job mixes. Materials used in air-detraining agents are listed in Table 1.

Fungicidal, germicidal, and insecticidal admixtures

Bacteria and fungal growth on or in hardened concrete may be partially controlled through the use of fungicidal, germicidal, and insecticidal admixtures. The most effective materials are polyhalogenated phenols, dieldrin emulsions, and copper compounds. The effectiveness of these materials is generally temporary, and in high dosages they may reduce the compressive strength of concrete.

Antiwashout admixtures

Antiwashout admixtures increase the cohesiveness of concrete to a level that allows limited exposure to water with little loss of cement. This allows placement of concrete in water and under water without the use of tremies. The admixtures increase the viscosity of water in the mixture resulting in a mix with increased thixotropy and resistance to segregation. They usually consist of water soluble cellulose ether or acrylic polymers.

Compatibility of admixtuers and cementitious materials

Fresh concrete problems of varying severity are encountered due to cement admixture incompatibility and incompatibility between admixtures. Incompatibility between supplementary cementing materials and admixtures or cements can also occur. Slump loss, air loss, early stiffening, and other factors affecting fresh concrete properties can result from incompatibilities. While these problems primarily affect the plastic- state performance of concrete, long-term hardened concrete performance may also be adversely affected. For example, early stiffening can cause difficulties with consolidation of concrete, therefore compromising strength.

Reliable test methods are not available to adequately address incompatibility issues due to variations in materials, mixing equipment, mixing time, and environmental factors. Tests run in a laboratory do not reflect the conditions experienced by concrete in the field. When incompatibility is discovered in the field, a common solution is to simply change admixtures or cementing materials.

Storing and dispensing chemical admixtures

Liquid admixtuers can be stored in barrels or bulk tankers. Powdered admixtuers can be placed in special storage bins and some are available in premeasured plastic bags. Admixtures added to a truck mixer at athe jobsite are often in plastic jugs or bags. Powdered admixtures, such as certain plasticizers, or a barrel of admixture may be stored at the project site.

Dispenser tanks at concrete plants should be properly labeled for specific admixtures to avoid contamination and avoid dosing the wrong admixture. Most liquid chemical admixtures should not be allowed to freeze; therefore, they should be stored in heated environments. Consult the admixture manufacturer for proper storage temperatures. Powdered admixtures are usually less sensitive to temperature restrictions, but may be sensitive to moisture.

Liquid chemical admixtuers are usually dispensed individually in the batch water by volumetric means (Fig 20). Liquid and powdered admixtures can be measured by mass, but powdered admixtures should not be measured by volume. Care should be taken to not combine certain admixtures prior to their dispensing into the batch as some combinations may neutralize the desired effect of the admixtures. Consult the admixture manufacturer concerning compatible admixture combinations or perform laboratory tests to document performance.

List of common concrete admixtures (Additives)

Fig 20

Liquid admixture dispenser at a ready mix plant provides accurate volumetric measurement of admixtures.

Admixtures are added to concrete batch immediately before or during mixing concrete. Concrete admixtures can improve concrete quality, manageability, acceleration or retardation of setting time among other properties that could be altered to get specific results. Many, not to say all, concrete mixes today contain one or more concrete admixtures that will help your pouring process driving odwn cost while increasing productivity, The cost of these admixtures will vary depending on the quantity and type of admixture being used. All of this will be added to the cubic yard/meter cost of concrete.

Concrete admixtures : Set - retarding

Set retarding concrete admixtures are used to delay the chemical reaction that takes place when the concrete starts the setting process. These types of concrete admixtures are commonly used to reduce the effect of high temperatures that could produce a faster initial setting of concrete. Set retarding admixtures are used in concrete pavement construction, allowing more time for finishing concrete pavements, reducing additional costs to place a new concrete batch plant on the job site and helps eliminate cold joints in concrete. Retarders can also be used to resist cracking due to form deflection that can occur when horizontal slabs are placed in sections. Most retarders also function as water reducers and may entrain some air in concrete.

Fig 21

Concrete admixtures, hisham ibrahim / getty images

Concrete admixtures : Air - entrainment

Air entrained concrete can increase the freeze-thaw durability of concrete. This type of admixture produce a more workable concrete than non-entrained concrete while reducing bleeding and segregation of fresh concrete. Improved resistance of concrete to severe frost action of freeze/thaw cycles. Other benefits from this admixture are:

- High resistance to cycles of wetting and drying
- High degree of workability
- High degree of durability

The entrained air bubbles act as a physical buffer against the cracking caused by the stresses due to water volume augmentation in freezing temperatuers. Air entrainers admixtures are compatible with almost all the concrete admixtures. Typically for every one percent of entrained air, compressive strength will be reduced by about five percent.

Fig 22

Concrete admixtures, hisham ibrahim / getty images

Water - reducing concrete admixtures

Water-reducing admixtures are chemical products that when added to concrete can create a desired slump at a lower water- cement ratio than what it is normally desinged. Water- reducing admixtures are used to obtain specific concrete strength using lower cement content. Lower cement contents result in lower CO_2 emissions and energy usage per volume of concrete produced. With this type of admixture, concrete properties are improved and help place concrete under difficult conditions. Water reducers have been used primarily in bridge decks, low-slump concrete overlays, and patching concrete. Recent advancements in admixture technology have led to the development of mid - range water reducers.

Fig 23

Water reducing admixture. Lester lefkowitz / getty images

Concrete admixtures : Accelerating

Accelerating concrete admixtures are used to increase the rate of concrete strength development or to reduce concrete setting time. Calcium chloride could be named as the most common accelerator component; however, it could promote corrosion activity of steel reinforcement. Nonetheless, concrete best practices such as proper consolidation, adequate cover and proper concrete mix design could prevent these corrosion issues. Accelerating admixtures are especially use ful for modifying the properties of concrete in cold weather.

Fig 24

Accelerating admixture : Natalie Fobes / Getty images

Concrete admixtures : Shrinkage reducing

Shrinkage reducing concrete admixtures are added to concrete during initial mixing. This type of admixture could reduce early and long-term drying shrinkage. Shrinkage reducing admixtures can be used in situations where shrinkage cracking could lead to durability problems or where large numbers of shrinkage joints are undesirable for economic or technical reasons. Shrinkage reducing admixtures can, in some cases, reduce strength development both at early and lather ages.

Fig 25

Justin Sullivan / Getty images

Concrete admixtures : Superplasticizers

The main purpose of using superplasticizers is to produce flowing concrete with a high slump in the range of seven to nine niches to be used in heavily reinforced structure and in placements where adequate consolidation by vibration cannot be readily achieved. The other major application is the production of high -strength concrete at w/c's ranging from 0.03 to 0.04. It has been found that for most types of cement, superplasticizer improves the workability of concrete. One problem associated with using a high range water reducer in concrete is slump loss. High workability concrete containing superplasticizer can be made with a high freeze- thaw resistance, but air content must be increased relative to concrete without superplasticizer.

Fig 26

Banks photos / getty images

Concrete admixtures : Corrosion - inhibiting

Corrosion - inhibiting admixtures fall into the specialty admixture category and are used to slow corrosion of reinforcing steel in concrete. Corrosion inhibitors can significantly reduce maintenance costs of reinforced concrete structures throughout a typical service life of 30-40 years. Other specialty admixtures include shrinkage-reducing admixtures and alkali-silica reactivity inhibitors. Corrosion - inhibiting admixtures have little effect on strength at later ages but may accelerate early strength development. Calcium nitrite based corrosion inhibitors do accelerate the setting times of concretes over a range of curing temperatures unless they are formulated with a set retarder to offset the accelerating effect.

Fig 27

Frank cezus / Getty images

Fig 28

Are you following the right steps when pouring concrete in winter?

Fig 29

The basics for mixing concrete

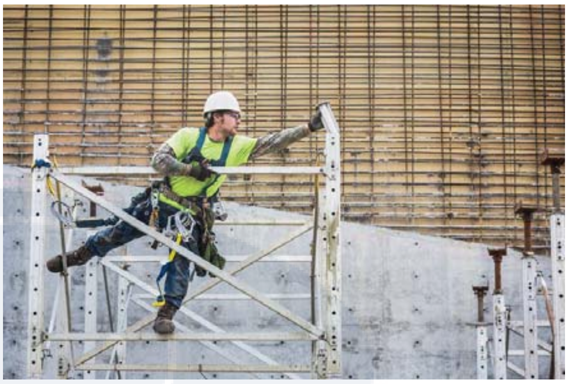
Fig 30

Tips and recommendations for placing concrete in hot weather

Fig 31

Are you using the right cement when curing concrete during winter?

Fig 32



Prevent cold - weather damage following these masonry tips

Fig 33

Uses, Benefits and drawbacks of fkly ash in construction

Fig 34

Contraction, expansion and construction are all concrete joints

Fig 35

A new admixture is capable of minimizing concrete shrinkage

Fig 36

How to solve curling, cracking, scaling and more concrete problems

Fig 37

Want a concrete with no cracks and no joints? this might be for you

Fig 38

Use and applications of autoclaved aerated concrete (AAC)

Fig 39

Self- compacting or consolidating concrete has many advantages

Sand

Objectives: At the end of this lesson you shall be able to
- **define sand**
- **state the characteristics of sand**
- **state the type of sand**
- **state uses of sand.**

Sand

- Sand particles consists of small grains of silica.
- Sand is formed by decomposition of sand stone due to various effects of weather. Decording to the material sources sand is obtained. Artificial sand is prepared by crushing stones and gravel to powder.

Characteristics of good sand

1 Sand should be clean and free from coatings of clay and silt.

2 Sand should be free from salt

3 Sand should be coarse, angular, hard and sharp grows

4 Sand should not contain organic matter.

5 It should be strong and durable

6 It should be chemically inert.

7 Sand should pass through 40.75 mm sieve and entirely retained on is sieve of 75 micron

Types of sand

There are three types of sand

1 Pit sand

2 River sand

3 Sea sand

1 Pit sand

- Pit sand is found as deposits in soil
- It is obtained by forming pits into soils.
- Sand is excavated from a depth of about 1 m to 2 m from the ground level.
- Pit sand consists of sharp, angular grains and also free from salts.
- For preparing mortar, clean the pit sand free from organic matter.

2 River sand

- River sand is obtained from bed of rivers
- River sand consists of fine round grains
- Colour of sand is almost white.
- River sand is available in clean condition
- This sand is used for purposes

3 Sea sand

- This sand is obtained from sea shore.
- Sea sand consists fine rounded grains like river sand
- The colour of sea sand is light brown.
- Sea sand contains salts.
- The salts absorb moisture from the atmosphere and causes dampross, efflorescence and disintegration of work.
- Sea sand retorts the setting action of cement
- Due to above reason, to avoid the use of sea sand for engineering works.

Classification of sand according to the size of grains

1 Fine sand

2 Coarse sand

3 Gravelly sand

1 Fine sand

- Sand passing through a sieve with clear opening of 1.5875 mm is known as fine sand. This sand is used for plastering.

2 Coarse sand

- Sand passing through a sieve with clear opening of 3.175 mm is known as coarse sand. This sand is used for masonry work.

3 Gravelly sand

- Sand passing through a sieve with clear opening of 7.62 mm is known as gravelly sand. This sand is used for concrete work.

Bulking of sand

- The presence of moisture is sand increases the volume of sand is called bulking of said.

Uses of sand

- Sand is used as binding materials to make the mortar economical.
- It is used for making mortar and concrete
- Sand helps in early setting of mortar
- Sand increases the density of mortar
- Sand is used to fill the basement.