Engineering/Architectural Graphics – Part 1
Orthographic Projection
Prof. Avlokita Agrawal
Department of Architectural and Planning
Indian Institute of Technology – Roorkee

Lecture – 24
Orthographic Projections
Projection of a Plane Inclined to both the Reference Planes - I

Good morning, welcome to the 4th lecture of this week 5 of ongoing online course on architectural graphics or engineering graphics, which you commonly know of as engineering drawing. And in this week, we have been learning about drawing orthographic projections of planes given various different conditions. So far, what we have started with was a very simple plane which was perpendicular to both the planes and then we moved onto draw orthographic projections for a plane which was parallel to one of the planes and perpendicular to the other.

And then gradually, we moved on to draw orthographic projections for planes, which were inclined to one of the reference planes and perpendicular to the other. Now, today, in this lecture, we will learn to draw orthographic projections of planes, which are inclined to both the reference planes such planes are called oblique planes. They are in concept in principle, they are very similar to drawing orthographic projections of lines, which are inclined to both the reference planes.

So, that is where we will start with that is the basic fundamental that we will use and then we will see how to draw orthographic projections of oblique planes. So, I will again start **(Video Starts: 01:50)** by taking the example of this quadrant and try to explain you what do we mean when we say it is an oblique plane and once we have figured out what this oblique plane is, we will try to draw the orthographic projections of those planes.

So, let us assume that this is again a triangular plane, the original condition to start with begin with that it was parallel to one of the reference planes here, in this case, horizontal plane and it was perpendicular to the vertical plane. Now, if I incline it by say, 30 degrees, that it makes an angle of 30 degrees with the HP and it is still perpendicular. So, what do we get? We still get the same length of the line whatever was seen in VP when the plane was being parallel to the HP and it is just inclined by 30 degree and the same thing.

So, what happens in this case is that this point which was originally seen here in the HP is now moving, but it is the locus of this is still the same horizontal projection which is this. So, we got this. Now, assume that this plane is inclined at 30 degrees to VP also. So, what does it mean? So, we have a plane which is like this and now, this plane is inclined to 30 degrees as well. Now, we can understand this if we take the example or we start by understanding that this is one line.

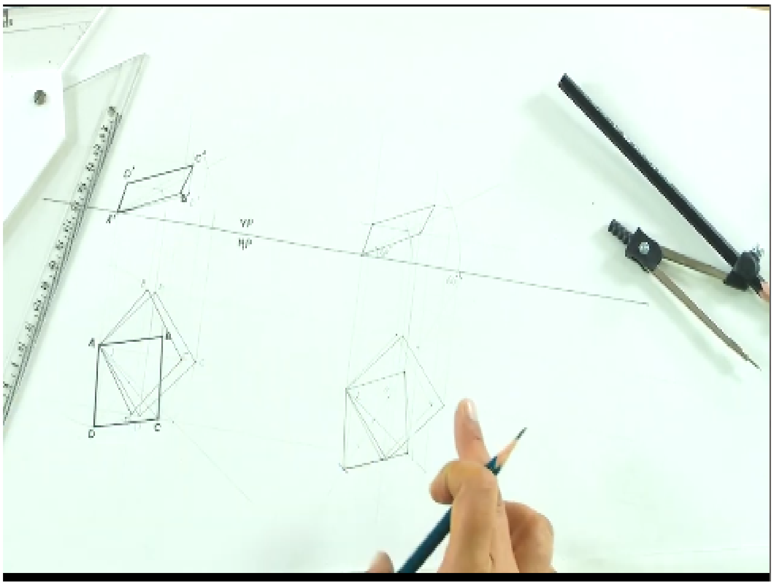
To start with, this is just one line which is the side of this triangle. This line is now inclined at 30 degree and we are saying that it is further inclined at 30 degree to the VP. Now, what happens in that case? The same procedure as we used for drawing the orthographic projections of lines is utilised here. Many at times in planes, we do not get the rotation of one of the lines or what we will get because in this case, it is a simple plane.

It is is a triangular plane. What if it was a circle? So, sometimes, we may not be defining the inclination of any specific line that is in case, it is given as the diameter making an angle of 30 degrees with HP or 30 degrees and 30 degrees with VP; in that case, we can follow the same path. If not in that case, whatever is the given condition will be represented, but the essence remains that if a plane or a line is inclined to both the reference planes. We will not be seeing the true angle in either of the planes.

Ideally, it would be very difficult; it will be rare to see a true angle in one of the reference plays until unless the condition specify so. So, that is what we are going to be seeing and it requires 2, 3 different steps. To draw the orthographic projections of oblique planes or doubly inclined planes. So, let us see those steps. And see how to go about drawing the orthographic projections in that step by step manner **(Video Ends: 05:13)**.

So, let us assume to start with a very simple case. Now, let us assume that there is a square plane, which has one of its points in horizontal plane. So, it has one of its points in horizontal plane and it is inclined at 30 degrees to HP and its diagonals which is joining the point in HP that diagonal is making an angle of 30 degrees with VP. So, let us start by drawing the projections for this case.

(Refer Slide Time: 05:58)



So, let us go step by step. To begin with, let us assume that we have this square which is parallel to HP and perpendicular to VP. Now, this square has one of its points in HP and the rest of the square is going to be inclined. To begin with, what we will have and assuming any square size for example, a 4 centimetre side. So, let us start by drawing this 4 centimetre side square here. This is the square which we are assuming.

Now, since it has only one point in HP that is why we have taken it as a diamond or it is rotated. Otherwise, when we start to incline it, it will become very difficult for us to incline it about one point, if we keep it straight. Now, let us take the projections of this square. So, this is not the final given condition. It is just the starting assumption that the plane is parallel to HP and it is perpendicular to VP.

So, this is what we are seeing. I am very lightly labelling the square to start with. So, this is the square A, B, C, D and I will also draw the diagonals. So, we are saying that AC is the diagonal and BD is another diagonal. So, this is what we are going to be drawing. Now, the next condition says that this diagonal AC or this plane ABCD is inclined at 30 degrees to HP. So, what do we draw? We draw an inclination of 30 degrees to HP.

So, see, we make a line at 30 degree to HP and we take the projections of these points. So, the inclination is in HP and the object the plane is perpendicular to VP. We will be seeing this inclination in VP. So, this is what we have got. So, this is now the BD. This is C and this is A. Now, we get back the projections back on to HP. just like we did for singly inclined planes. Please incline to one of the reference space. So, what we have now is.

So, this is the new ABCD which is for a plane which is inclined at 30 degrees to HP and it is still perpendicular to VP. So, in VP, we are still seeing the true length of the diagonal AC. So, this is the second shape, which is slightly deformed of a square is the new ABCD. Now, in this case, what we have seen is that this diagonal AC is still seen in true shape and that is what we are getting here. So, this is the reduced shape now.

This AC is going to make an angle of 30 degree with VP. So, what do we take here? I am just drawing the horizontal projection. So, what we have we will draw an angle of 30 degrees with VP now. From this point A, which is in HP, so, I make another angle 30 degrees here and what we do here is, we again take this AC. So, this is where our new AC in plan is going to be seen.

And what we would do is, we would take the locus of these points, which is what we were doing earlier and we take the projection from the vertical the equal shape projection from the vertical onto this. So, this is the final point C, which is precisely how we were drawing the projections of lines which were inclined to both the planes. So, this is AC and the same thing, we are doing here.

So, we taking the projection of this point onto this line, which is the new projection of point C. And if we are drawing it correct, both these projections should be matching up, which is exactly the case. So, now, what we have drawn so far is this final C which is inclined at 30 degree to both horizontal plane as well as vertical plane. So, this is the final C. So, the A point remains the same and C is here, same as there.

So, we have this AC and exactly the same thing we can do for this point B. So, we will get this point B which will be here. So, we have the point B and D which is represented by this horizontal line. Now, what is happening is these 2 points are also rotated. So, this line which was originally perpendicular even in this case, when we tilted this plane by 30 degree to HP, it remained parallel to HP and then when we incline this entire plane, then it became inclined to VP by 60 degrees.

So, what we still have is the true length of this diagonal BD because it is still remaining parallel to HP. So, what do we draw? We have this point AC and we have this diagonal BD which is perpendicular to the AC. It is remaining perpendicular or it is inclined by 60 degree. So, what we can do? We can move this B and D at the same distance from A as it was. So, what we have here is AD which was the revised position.

So, we now have this AD which is the distance which this point D was making from this point A and there is this distance B which B was making from this point A again so, which remains constant. And now, we have to make a line which is perpendicular to this final AC. So, what we have now is a point D which moves here and this point B which is onto this diagonal, which is now making an angle of 60 degree with VP.

And now, if we project the B and D back onto the vertical plane, so, we have B and horizontally this B will come here and then we take the projection of this point D back which is here. So, what we have finally is a very deformed shape which is seen in our vertical plane, the final shape in HP is this. Sometimes, in books what you will see that as we have drawn this final shape onto the same shape, because it was easier for us to move it.

Sometimes, you will see that they take this shape outside and draw it all over. So, that it is easier, we just have to measure the distances, the same distances using compass or scale and then we will draw them separately. So, that there is no confusion between these. So, this is the final shape of this square, which is having its a diagonal inclined to both HP and VP. So, this is A, B, C and D and here we have A, C, B and D in dash.

This is the front view of the square and this is the top view of the square which is inclined to both the planes. This is VP here and this is HP. Now, just see what we have done. What we have done is; we started with this diagonal AC because the inclination of this plane could be determined by using this diagonal AC. This diagonal AC was inclined at 30 degrees to VP and also 30 degrees to the HP which is what we have just drawn here.

And then we took the horizontal projection how this plane is going to move and then we took the trace of the same diagonal AC coming from the VP onto here and took the same thing there, which is what the final projection of diagonal AC was and around it. Then we drew BD. So, in this case, we very clearly knew that while we were moving the plane about one of its diagonals. The other diagonal continued to remain parallel to the reference plane.

This sometimes might be tricky for you to understand. So, let me explain it to you again. Just imagine that **(Video Starts: 20:20)** this board is a horizontal plane, horizontal reference plane and this triangle or maybe I can take this. So, this is that square, assume this is the square and this square is resting on one of its corners here. So, what are we doing? This is A and this is C. So, what is happening in the original position? This is the square. It is resting in HP.

Now, we incline it by 30 degrees. We incline it by 30 degrees. So, what happens? This BD which is represented by this line dispenser, so, what happens? While we move it, this pencil still remains parallel to HP. So, we will get the true shape of BD; true size of BD here. Now, when we tilted it, when we tilted it like this, even then, even then, that BD still remained parallel to HP, but it was just making a different angle with VP that is what has happened **(Video Ends: 21:24)**, that is why we will still have the true shape of BD represented here.

When everything around it, it evolved and then we will always have that the points will be different, points will match up. And that is what we have done here. We have, I think I have slightly committed a mistake here, if you see the B, the projection of B was coming up here. So, this was the point which we should have connected and not this point, this B, mistook as the projection which was coming from C as the projection for B.

So, what we will actually have is this. So, this is going to be our final C. So you always, it will always B that you will have the projections matching up both in HP and VP and which is a mandate for orthographic projections because they are perpendicular; they are orthographic.

So, this is our final projection B dash. So, we got the BD as the true shape represented in HP, and all other shapes are changed skewed, because there is nothing which is parallel to VP.

It is making a certain angle with VP and that is what we have derived out of a very stepwise process. This is step by step. So, I hope you have understood the process of drawing the doubly inclined planes. Now, suppose we had the same plane and instead of the angle which AC makes with VP, we were given the final angle which BD makes with the VP. In that case, what would happen? In that case, since the BD as we were understanding, in this same given condition BD was still parallel to HP.

And now, we say that keeping the point A as fix. Now this BD makes a certain angle say, 60 degrees. So in that case, what happens? This entire shape which we had got as the second rhombus ABCD here that would be rotated in such a manner that a true angle which BD makes with VP is reflected. It is seen here. Let us quickly see that to give a slight twist to the same problem. So, we start again with the same square which was a square of 4 centimetres side.

So, we start with the same square and we take the projections onto the vertical plane. Now, what it says that this diagonal AC makes an angle of 30 degree with HP. So, we draw this angle of 30 degree which will now be reflected in the VP and take the projections. So, this is this diagonal AC, AC and let me also draw this diagonal BD for our reference here. So, that is the diagonal BD.

Now, what we have now is this diagonal inclined, so, we get back the projections. So, what we have as a revised shape is this. This is now representing a condition where this square is tilted inclined at 30 degree to HP and in this condition, BD is perpendicular to VP and parallel to HP. Now, what we have is: we have to incline this BD about A by 60 degrees so, that it makes an angle of 60 degree with the VP.

So, what we have is that through A, this square will still be in rotated in such a manner that this BD now makes an angle of 60 degrees. So, what happens that this distance suppose this is the new point O which was the centre of the square. The distance from A to O remains the same and the point is rotated. So, what we will have? We will have a line making an angle of 60 degree with VP, which is what we have done here.

So, this is making and this is the line where your B and D will be and the line perpendicular to it passing through A will have the diagonal AC. So, what we will do? We will draw a perpendicular passing through O, passing through A and intersecting this line. Now, we know that this point B and this point D are going to lie on this line and this point C is going to come onto this line. We will only take the distances and then move them. So, what we have here?

This distance AC is now here onto this diagonal which is the new C and perpendicular to it. So, this distance O to B will now be marked here, which is going to be the same distance as O to D. So, the final shape of this square is this O okay. So, this is the revised Oh sorry. So, what we have here is this is the point where we will have our centre and this is the new B and this is the new D that is joined them.

So, this is A to D; C to B. So, this is the point where C is from O. This is the new rhombus that we get and then we take the projections of these points back up. So, what we have? The A remains the same. The point C is here, which is the horizontal and vertical projection of this point and the point D is here and the point B is here. So, we now have final shape as this and in this case, the angle of 60 degree will be seen as 60 degrees, that is the UT offered and again here, this line AC remains at 30 degrees.

So, we will also see the true angle 30 degree in this case, because it is not the same line which is being tilted. It is this line which makes an angle and that is how we will see this entire thing shifted slightly. So, this is the angle 30 degree here and this is the angle 60 degrees here and we see this entire object looks very similar, but it is slightly different from this shape as we are still seeing the true angle here.

So, I hope this has made the projection of oblique planes or doubly inclined planes slightly clearer to you. This is a little bit tricky. So, that is why we will continue the same lecture in the next lecture also, the last lecture of this week, where we will take one more example of oblique planes and we will try to understand how to draw orthographic projections for oblique planes.

So, thank you very much for joining me here today. We will continue with this lecture on oblique planes tomorrow. So, kindly join tomorrow as well. Thank you and see you tomorrow.