Surveying
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Module - 4
Lecture - 1

Compass Surveying

Welcome to this video lecture series on basic surveying and today, we are going to start a new module. This is module number 4. This module number 4 is about compass surveying. Now, in the case of the compass surveying, we will be talking about various things, beginning with the lecture number 1.

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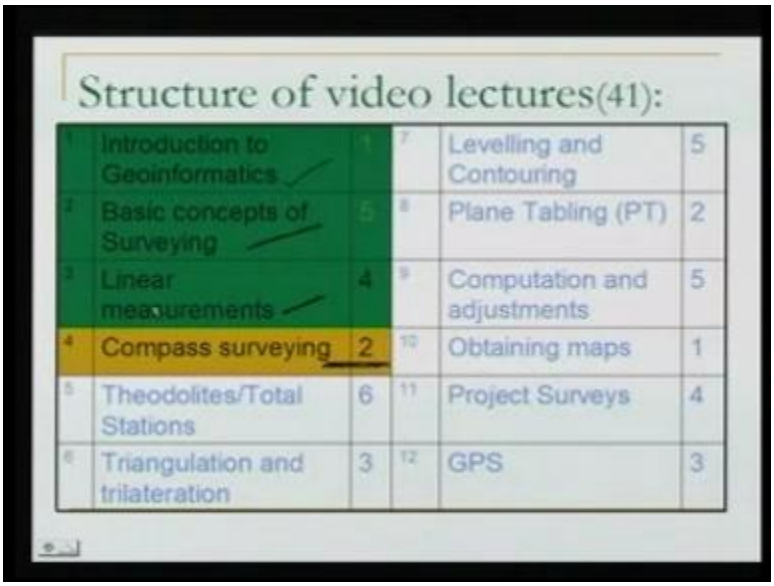

You must have heard of the compass - the word - and we will try to cover this entire compass surveying in this module 4 in two lectures. Here, in module number 3 - and the module number 3, it was about linear measurements. So, what we saw in the case of the linear measurements? We saw various methods by which you can measure the distances - we started with the chain, tape and then we went to some modern techniques, for example, the EDMI - the electronic distance measuring instrument. So, using all these,

we can measure the distances. There are some more methods for measuring the distances; we did not touch all of them. For example, there is tachometry, some of the optical methods are there by which we can measure the distances, but the methods which we have touched are the ones which are more common and which we should know. And while talking about this linear measurements, we saw many associated concepts - you know, what is the meaning of the distance in surveying; how do we measure it if it is - we are using the chain; we need to carry out the ranging; why do we carry out the ranging - in order to establish intermediate points between the two points where we are going to measure the distance; what are the methods of the ranging. Then we saw, can we really make use of chain or tape in order to make a map, and we saw, yes, we can make a little map using chain and tape. What we are doing in that case? We were measuring the chainage and we are taking the offsets. Chainage - the distance along the survey line, offset - the distance of a detail from the chain or from the survey line, and using these measurements, the offsets could be perpendicular offset, oblique offset. So, whatever the way we have recorded these in our field book - field book was observations as well as a rough map of the area - we take it to the laboratory, to our office, and we can make a map. So, this is what we have seen. Then, we looked into detail of the EDMI - why do we use the EDMI; what do we do with the EDMI; how we specify the accuracy of the EDMI. So, this is all we have done so far.

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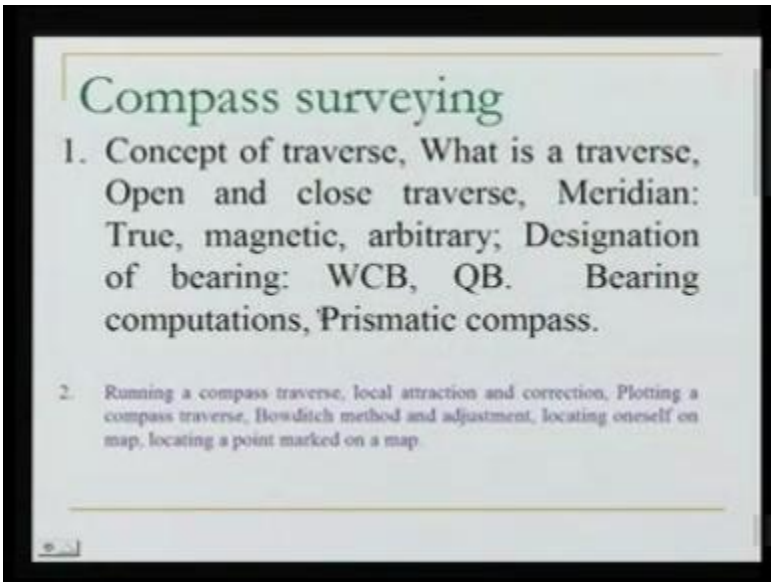

And today, we will start talking about the compass surveying. In compass surveying, first, before we go further to the compass, we will see the concept of 'traverse'. Once we start talking about these, then the things will become more clear to us that what is a traverse - some definitions of open and close traverse; we will look into the meridian, which could be true magnetic or arbitrary; we will look into how we designate the bearing - right now, the bearing, word may not be very clear to you, but once we discuss it, it will become clear to you, that what is the meaning of bearing; what are the systems in which we record it - the WCB and the QB; and then finally, some computations for the bearing; and we will look into one compass instrument, which is the prismatic compass, which is mostly used instrument. We will also try to see in some other instrument also, which is the surveyors compass. So, this is what we are going to talk about today.

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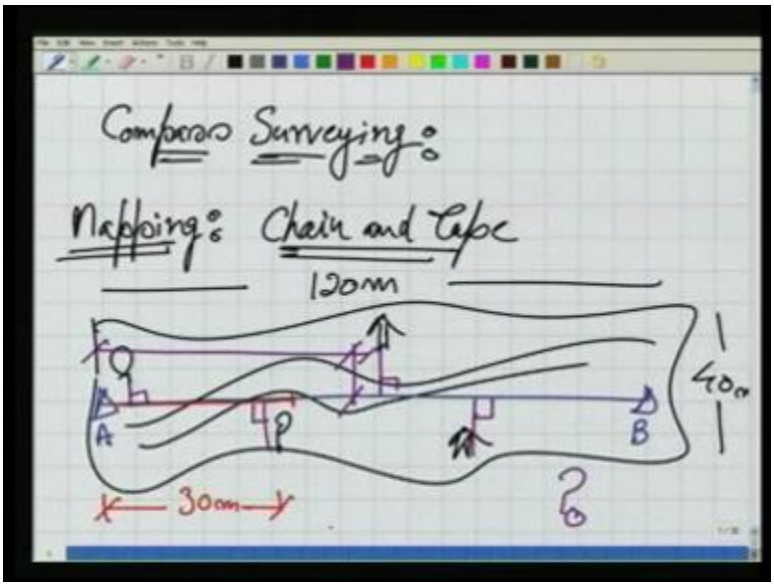

So, in compass surveying, we will be making use of the compass, as is obvious, but before we get into it, let us see that why we need, really, the compass surveying - some basic concepts. Let us start talking about the mapping - we have done a map using chain and tape. If you remember what we did in that case, we had a linear kind of a stretch, and we saw that it was around, you know, maybe 120 metres long and some 40 metres wide (Refer Slide Time 04:45). Then, there were various things here - maybe a road, some houses or some trees. In order to make a map of this area, what we did, we stretched out our chain here (Refer Slide Time 05:09), or rather, I will say this is the survey line, and in this survey line, these two - A and B (Refer Slide Time 05:16) - are the survey stations. We stretched our chain along this survey line because the chain is 30 metres only, so it will only cover a little part of the survey line (Refer Slide Time 05:27). So, in order to do that, we need to do the ranging. Then, later on, for each object, for example, here, we start taking the offsets - any object here (Refer Slide Time 05:45) - we start taking the offsets, and by taking these offsets of the objects from the survey line, we record the chainage. So, the chainage was distance along the survey line, and the offset is the distance of the detail (Refer Slide Time 05:58). Using this, we can do the mapping; we can make the map; we can plot the map. Now, I am going to pose a question - the

question is, can we really use this method everywhere, in all the circumstances? Now, start thinking about it - is it really possible?

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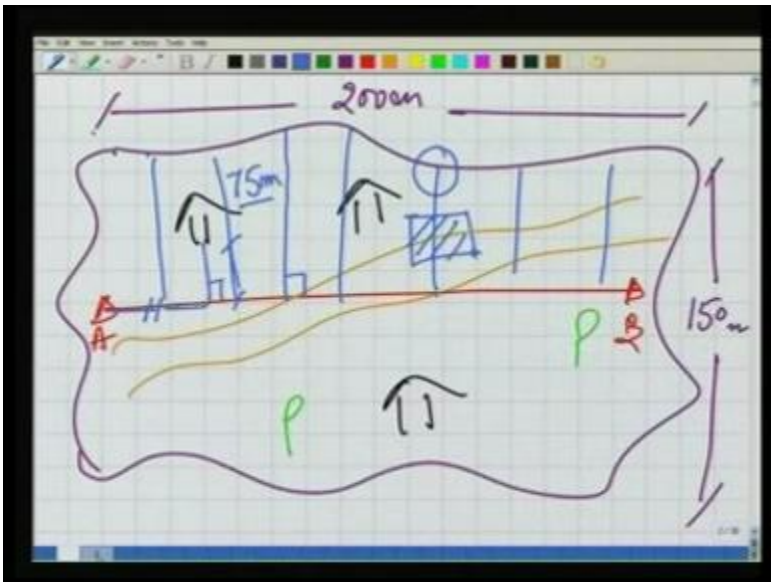

I am going to give you one another example. Let us say our area is now - that is our area (Refer Slide Time 06:33), and here, it is 200 metres long and also, it is 150 metres wide, and the area has, as usual, maybe some roads or some houses or maybe some trees here (Refer Slide Time 06:53). That is our area; we want to make a map of this area. If you go with the usual method, well, I stretch a tape or chain here - that is my chain line or the survey line, A and B (Refer Slide Time 07:15) - conceptually it looks all right - yes, why cannot we do it? Well, we start taking the offsets and measuring the chainage, so we are measuring the chainage and taking the offsets. Now, for this boundary here (Refer Slide Time 07:37), can you guess what will be the length of the offset? The offset will be around 75 metres long. While we are working with the tape, how do we make the offsets in the field? We have to erect the perpendicular or the oblique offsets, and we swing the tape in order to make it perpendicular. If you swing your tape which is 75 metres long - can you think of it? - that is not possible. Or, otherwise also, measuring this entire boundary, taking so many offsets of the order of 75 metres (Refer Slide Time 08:08), is not advisable. Now here, in this case, maybe you can measure the distances, but there

might be some cases where the distance you cannot measure also: you want to take the offset to this point, but there is a building here (Refer Slide Time 08:23); we cannot take this offset. So what is there? We cannot really make the map like this.

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Well, one solution could be, if - some of you may be thinking like this - for the same area which is 200 metres and 150 metres, well, someone can say, for these - the road, these houses and the usual trees (Refer Slide Time 08:53) - well, can we do one more thing? I have one chain line here, another chain line here, another chain line here, and one chain line here (Refer Slide Time 09:04) - it is AB, A dash B dash, A double dash B double dash, A triple dash and B triple dash (Refer Slide Time 09:12). Now, we have - by taking these chain lines, what we have done? We have reduced the problem of taking the offsets. Now, our offsets are smaller; I can take the offsets about this line (Refer Slide Time 09:30), just in its nearby area, and here also, I can take the offsets. No problem, as far as taking the offsets is concerned - we can take all these offsets, but will it serve the purpose? Start thinking; you have noted down this entire thing in your field book (Refer Slide Time 09:55). Similarly, here also, this entire thing is in your field book (Refer Slide Time 10:00); here also, all these observations are on your field book. Now, when you are going to plot it in the drawing sheet, you can plot, for example, let us say, this line AB, as

well as all these offsets (Refer Slide Time 10:13). So, this entire area can be plotted. This entire area is plotted; now you can plot this area also (Refer Slide Time 10:25), but there is a question now: when you are plotting this area and this area - the chain line AB and the chain line A dash B dash - how are you going to relate them?

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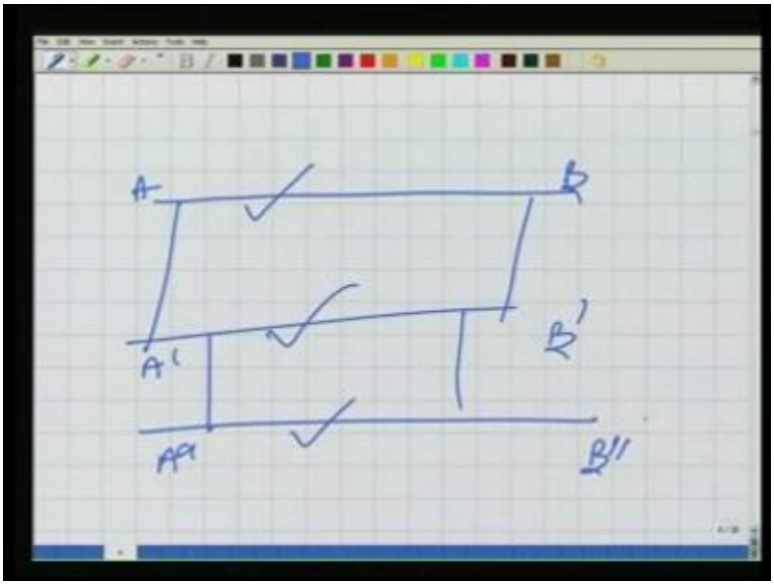

Let us say this is the our - in our map - chain line AB (Refer Slide Time 10:45).Where do I plot the chain line A dash B dash? Should it be here, A dash B dash, or should it be here, A dash B dash (Refer Slide Time 10:48)? Now, this is important - we need to know a relationship between these chain lines also; there has to have some measurements which connect these together. If you cannot connect it, where to plot it? So, relatively, they should be fixed in the ground. So, we can go for a thing like this, but we need to take some extra measurements there, which relate this chain line to this chain line (ddd), and this chain line to this chain line (Refer Slide Time 11:26), so that we can fix them relatively also. And this is how we can plot the area, but this particular method which I just noted down, it is not really a very efficient way of doing it.

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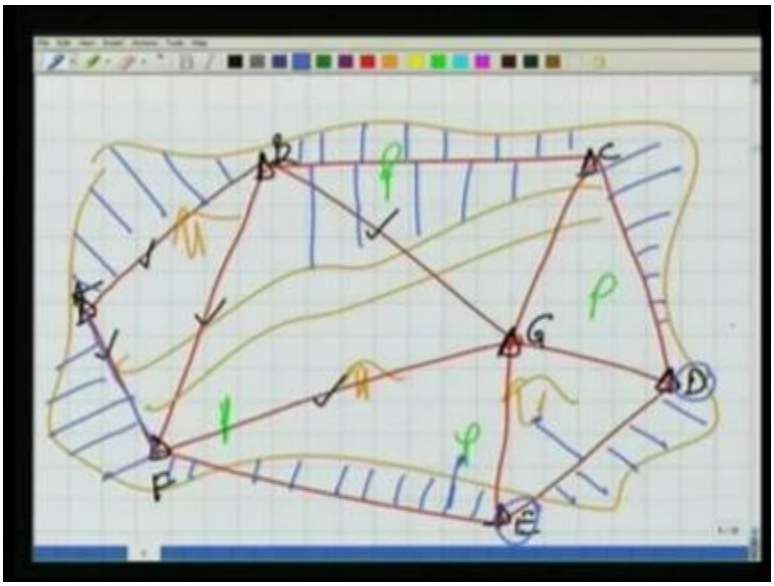

What we can do? For our area - the usual things, and maybe some trees here (Refer Slide Time 11:47) - what better way of doing this; of relating these different lines? Can we really do a thing like this: let us say I take a survey line which is passing near to the boundary (Refer Slide Time 12:06), then I take another one, I take another one, I take another one here, I take another one, one more (Refer Slide Time 12:10) - all these are the survey lines. Now, what do we see here? We see here that we end up with A, B, C, D, E, F and G (Refer Slide Time 12:28) - all these are the survey stations, and they are jointed by survey lines. I can measure all these lengths - that is not a problem - I can measure all these lengths because I have ensured that my these lines, they pass through nearly flat area; there is no obstruction. Also, at the same time, you can see it here now, taking the offset is easy; I can plot this boundary here (Refer Slide Time 13:01). So, while I am plotting this boundary, I am plotting with respect to the line BC - also, this road (Refer Slide Time 13:11) For the boundary here, I can take these as offsets (Refer Slide Time 13:16). For the boundary here (Refer Slide Time 13:19), I can use the line A and F, because this line is - this line is A and F. For the boundary here, I can use line F and E (Refer Slide Time 13:33) - take the offsets. This tree can be plotted with respect to the same line here (Refer Slide Time 13:37), this house can be plotted with respect to the

line E and D, and also this boundary (Refer Slide Time 13:48). Similarly, here (Refer Slide Time 13:49). We have taken all these observations in our field book.

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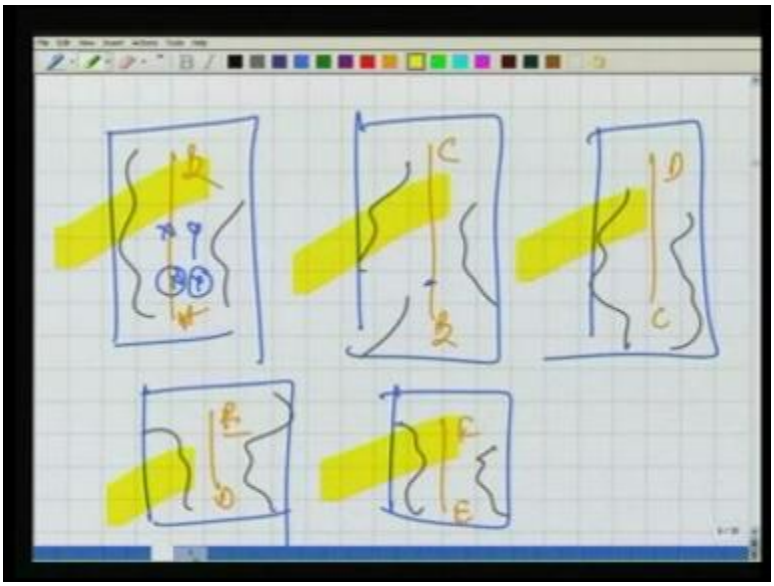

What we will have? We will have several pages of the field book - let us say these are the pages of the field book (Refer Slide Time 13:59), and over here is line AB, over here is the line BC, CD, DE, EF (Refer Slide Time 14:09), and so on, and we have also the values of the chainages - X,Y; XY (Refer Slide Time 14:24) - the chainages and the offsets - all written; everywhere, and also, we have the approximate or rough idea of the area. The rough drawing, rough sketch, of the drawing is here, in the field book. We know that how to produce it. Now, using all these pages of the field book - all these are the pages of the field book - what we can do, we can combine them together in order to make the map.

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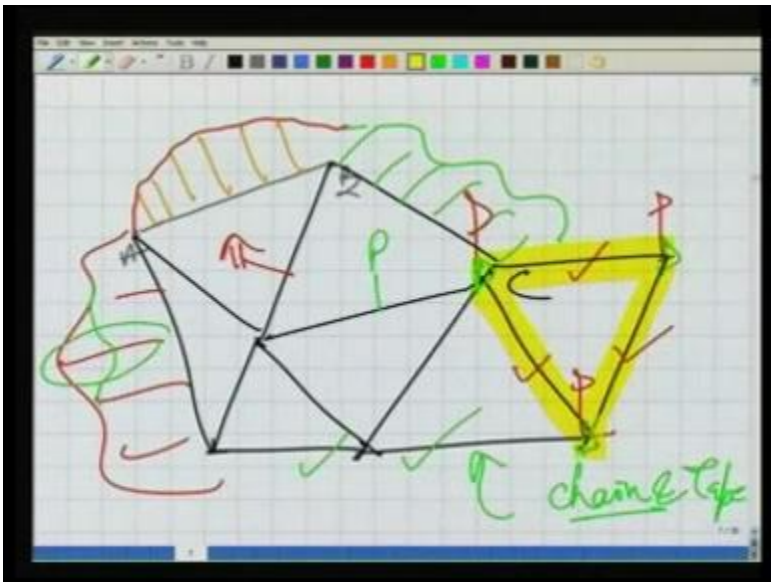
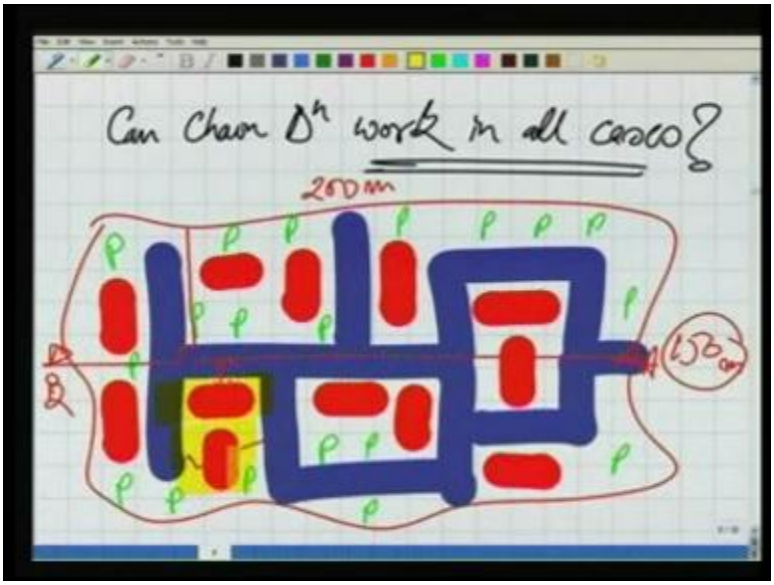


Well, I will start with line AB. I know that I have taken the offsets, and the offsets are certain values here (Refer Slide Time 15:04), and I joined these in order to make my boundary. Then, I have got the another line BC, and I also have the another - the other set of offsets, so it plots the other set (Refer Slide Time 15:15). Similarly, by plotting this entire skeleton (Refer Slide Time 15:27), because this entire skeleton can be plotted now, this way, and the entire area can be plotted, because we know all these offsets for this house - for example, the offset was taken from here, for this tree, the offset was taken from here (Refer Slide Time 15:42). So, what we are seeing here? Again, the concept of working from whole to part. For our entire area here, what we did? We did not start taking the measurements from single offset, single detail, rather, what we did, we started taking the observations in a big way: first, we made a network of triangles there, so this network of triangles is skeleton of the area. The skeleton of the area is captured, and then, in our drawing, in our drawing sheet, we can plot this skeleton of the area. This skeleton of the area or these set of triangles are done very accurately. Well, later on, we can start plotting the offsets - the individual details - so this is really the working from whole to part. First, we have fixed the skeleton - the entire area; then, we are plotting the individual details. So, what happens in this case? If my skeleton of the area - this net of triangles- is correct, if I am committing a little mistake here (Refer Slide Time 16:51),

then my boundary will look only like this (Refer Slide Time 16:53); not that my entire map will have any impact of this. So really, we are making use of the working from whole to part. What we are saying here, we can make use of only chain or tape, because this entire survey of this triangulation can be done using only chain and tape. What you are doing there? You are establishing some stations, and you have got the ranging rods there: one ranging rod, another one, another one (Refer Slide Time 17:25), and everywhere, you are measuring these distances, and these distances can be captured, can be measured using the chain or tape. So, we are not carrying out any extra measurements; only the linear measurements. So, using chain and tape, we can do triangulation; we can plot the things. So, we saw that, you know, we started with the linear thing (Refer Slide Time 17:53); that we are using the chain and tape just for a linear thing, but we can use chain and tape also for a broader area, as you have seen in this case (Refer Slide Time 18:00), and we can make the map using the field book records.

(Refer Slide Time: 18:15)



Well, there is a question - the question is, can this do in all the cases? Can chain triangulation work in all cases? And this is where you have to think. Start thinking of your neighbourhood - your school, your college campus - can you really do chain triangulation in all those cases? I am going to make a map here, or maybe an area. Let us

say there is an area, and this is the boundary of the area (Refer Slide Time 18:44). The size of the area is, for example, again, 200 and 150 metres. There are couple of roads, and let us say the roads are - all these are the roads here (Refer Slide Time 19:00). Then, there are couple of buildings - I am plotting these buildings by red colour. Let us say there is one building, another building, another building, one more, one more, and all these are the buildings (Refer Slide Time 19:16), and the buildings have got height; they are high buildings. There are also, as usual, several trees (Refer Slide Time 19:37). A typical area may look like this. Now, your job is, you have asked, 'Go to this area and make a map'. Let us start - can we use really a single chain length, as in this case (Refer Slide Time 20:04)? We cannot. We cannot use a single chain here, in this case - we cannot use it because the area is very wide; our offsets will be very large, there are many more problems. Can we really make the triangles? If I start thinking of making triangles here - before we go for the triangulation, just using a single chain - let us say we are using a single chain here. In this area, if I put my single chain somewhere here (Refer Slide Time 20:40), my station A and station B. See? We cannot do this surveying using single chain. Number one, the offsets are very long; there is 150 metres of the order of 75metres. Number two, another problem: if I need to measure an offset to this building (Refer Slide Time 21:00), what will happen? This particular building is the obstruction here (Refer Slide Time 21:08); this is an obstruction to this building, because the buildings may be one storey, two stories - I am not supposed to climb over the building, so how to carry out the measurements? That is the problem. If we - as we are talking about the chain triangulation, can we use the chain triangulation, then? Well, what kind of triangulation we can do here? Can we think of some triangulation - some triangulation scheme?

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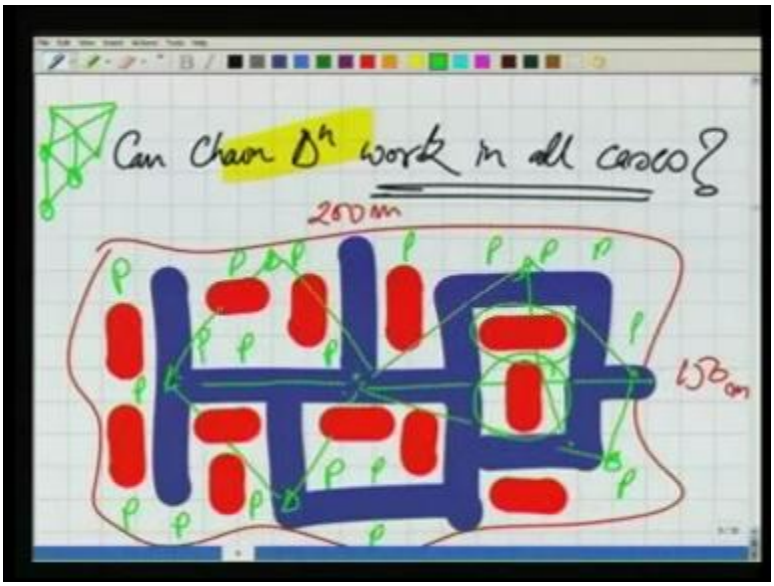

The important thing is, in the case of the triangulation, all the stations - three stations - should be inter-visible (Refer Slide Time 21:40). This station, this station, this station (Refer Slide Time 21:46) - all these three should be inter-visible. But ensuring inter-visibility here is really a problem. For example, let us say I take this as one station, another station (Refer Slide Time 21:53) - where should I take the third station? These two are visible; can I take the third here (Refer Slide Time 22:00)? I cannot, because this building is obstructing the line of sight. Here also, it is obstructing the line of sight; here also, it is obstructing the line of sight - I cannot take anything here, so making a net of triangles here, in this figure, is really difficult. I can go for this line, a line here, maybe another one here, another one here (Refer Slide Time 22:16), but it is not triangle. If I make - want to make it a triangle using this line, I cannot. Neither I can there, because we have - lines of sights are obstructed because of these buildings. Now, I have made a rough drawing here. You can think of your neighbourhood, just outside the room where you are looking at this video lecture - think of that area. So triangulation can be done in only those areas which are flat, visibility is clear, and only in those cases we can do that triangulation, but not for an area like this. So, what to do; what kind of figure we can go for? Because, we need to make a map.

(Refer Slide Time: 23:02)

There is - the answer is - the answer of this is, no, we cannot do the triangulation .So what we can do? The answer lies in traverse. Now, what is traverse? Traverse is - I will generate a traverse here - in a traverse, we do measure lengths and angles (Refer Slide Time 23:29). For example, here, if I know all the internal angles here (Refer Slide Time 23:36) and also all the lengths - all these are observed in the field - this kind of figure is called a traverse. Now, can we make a traverse here, and will the traverse solve our problem? Let us start from here: that is my station A, I take a line like this (Refer Slide Time 23:59), and here is intermediate station B and C. Then, from B, I go like this to C; from C, I go like this to D; from C, again, I can go like this to E; then again, here to F, and here, G, and maybe somewhere here again - that is also an intermediate one, H (Refer Slide Time 24:13). Well, we can keep going like this, and we can cover the entire area, but will it serve our purpose? Well, I can take the offsets for these buildings, this tree from the line here (Refer Slide Time 25:00) ; I can also take the offsets to these buildings from these survey lines. So now, really, the buildings are not obstructing; all the buildings can be plotted, all the trees can be plotted, also the roads can be plotted. I can take these offsets in the road; here in the road, I can take these offsets to the road. So, roads can be also plotted. So, using these offsets, the entire area can be plotted. Wherever the offset is shorter, I can take the offsets from there, and I can do the plotting - for the

boundary line here, for example (Refer Slide Time 25:40). Well, so this is, we say, the traverse. Now in the case of the traverse, what we saw? What we saw?

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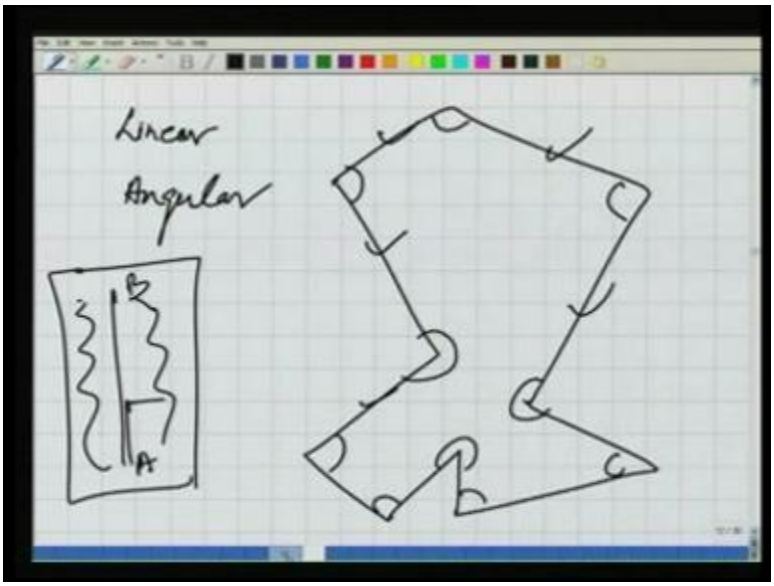

What we are doing, we are taking two measurements: number one is linear, and angular. So, basically, a traverse could be any figure like this (Refer Slide Time 26:05), where we know all these angles and the lengths.

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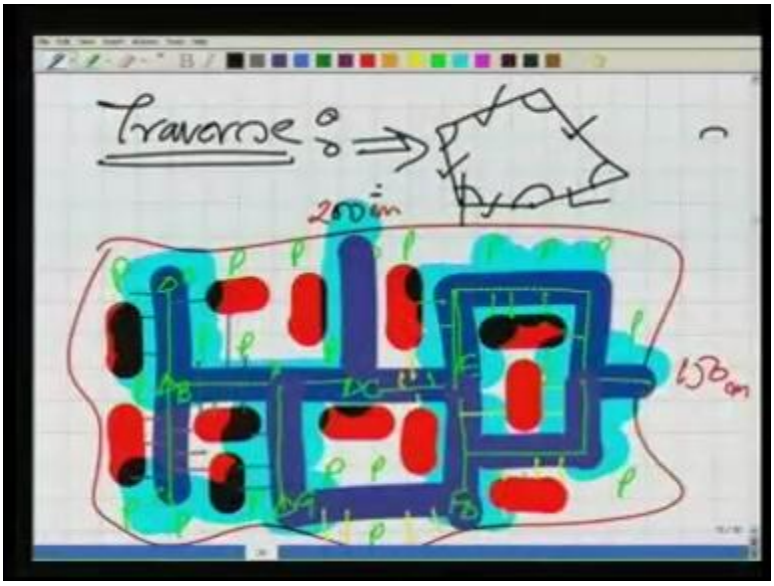

Well, in this case also, in this example, can we really plot it on our sheet; on our drawing sheet? I can take it to our field book, because in taking it to the field book, what we can do, this entire area which is highlighted (Refer Slide Time 26:34) can be represented AB in the field book page, one page (Refer Slide Time 26:44). A and B (Refer Slide Time 26:47) - so the entire area is shown here - the chainages and the offsets. Similarly, the area here - another line, another line, another line here (Refer Slide Time 27:00) - all these individual lines can be recorded in the field book the way they are appearing there in the ground.

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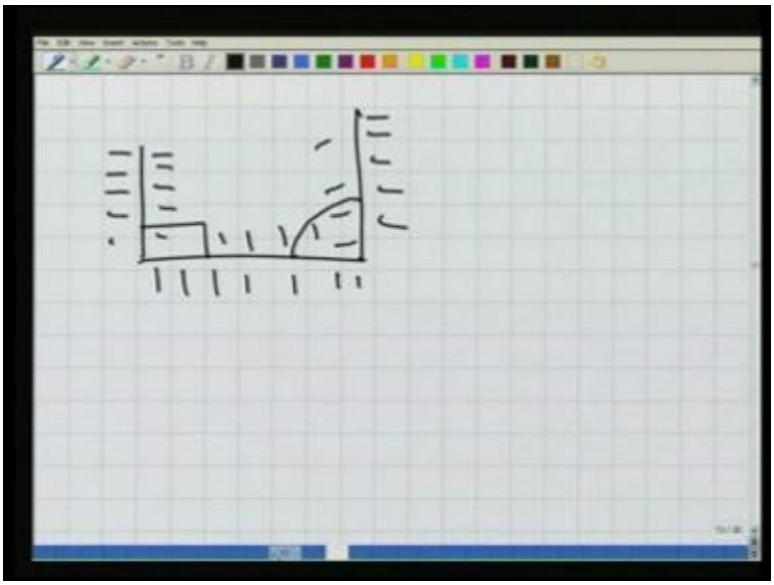

Now, in order to make a plot of this, in order to make a plot, what we will do? We will start with any line here, for example (Refer Slide Time 27:19) - and its offsets. So, the things are plotted. Next, we have somehow measured the angle from here to the other one, whatever is this angle value (Refer Slide Time 27:29). So, I know this line also, and I can plot the offsets; maybe another line and the offsets (Refer Slide Time 27:39), because we know this angle.

(Refer Slide Time 27:46)

Now here, in this figure, as you observe, the angles are mostly right angles, but it appears like they are in a right angle; that may not be the case always. We may have the angles which are acute angles, obtuse angles, depending on the field. Right now, in this case, the road network of that area is at 90-degree angles. That is why we can do it, but that may not be the case always.

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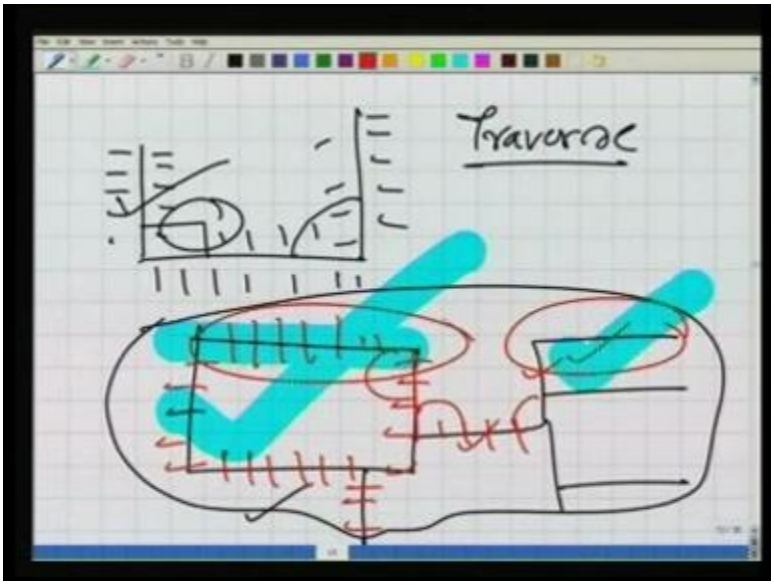

So, what we see here? One very important thing of the term which is called traverse - because by measuring these lengths and these angles (Refer Slide Time 28:17), we are able to relate, or put them in relation to each other, in our drawing sheet. So, that may be a traverse here (Refer Slide Time 28:22). So, once this is the - and this (Refer Slide Time 28:31), we say the skeleton - the skeleton of the area. So again, we are working from whole to part. The skeleton here is the traverse, and we are bringing this traverse on our drawing sheet, and then later on, we are doing the plotting of the offsets (Refer Slide Time 28:46). So, working from whole to part, and this skeleton or the traverse helps us to put these lines together in relation to each other, because there, in the field, there is a relationship between this line and this line (Refer Slide Time 29:03) - a geometric relationship. The moment we have carried out the measurements of all the angles here and these lengths - all these lengths and angles, so, this line and this line (Refer Slide Time 29:16) in our map also, they are geometrically related the way they are related in the ground. So, this is really important thing about the traverse.

(Refer Slide Time: 29:48)

Now, we will see the types of the traverse. In types of traverse, there are two types: one is open and the other one is closed. What these are? In the case of the open traverse, as you can see here - if I highlight by different colour now - the open traverse is, for example,

we start from here and go here and then along this road (Refer Slide Time 29:57), so all these three lines and these angles, they make an open traverse because the traverse is not closed. However, here, if I go along where I am highlighting - this entire thing is closed (Refer Slide Time 30:16).

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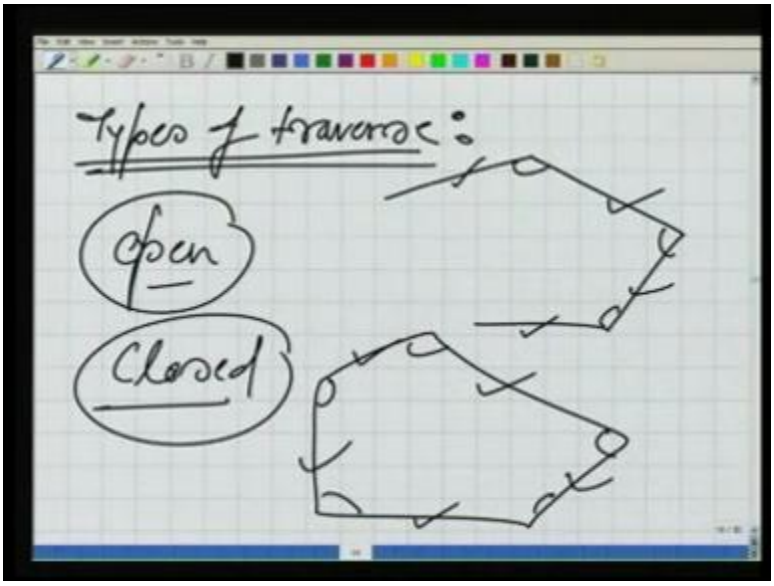

To explain it in the figure; an open traverse is something like this. We have started our measurements, and we have taken all these observations - linear and angular, we have measured these lines and these three angles (Refer Slide Time 30:29), so this is our open traverse. Close traverse? Here - all these lengths are measured and as well as, all the angles are measured (Refer Slide Time 30:43). This is the close traverse. As you can see, depending upon the application, where should we use open and where should we use close? That very much depends upon what kind of problem we have.

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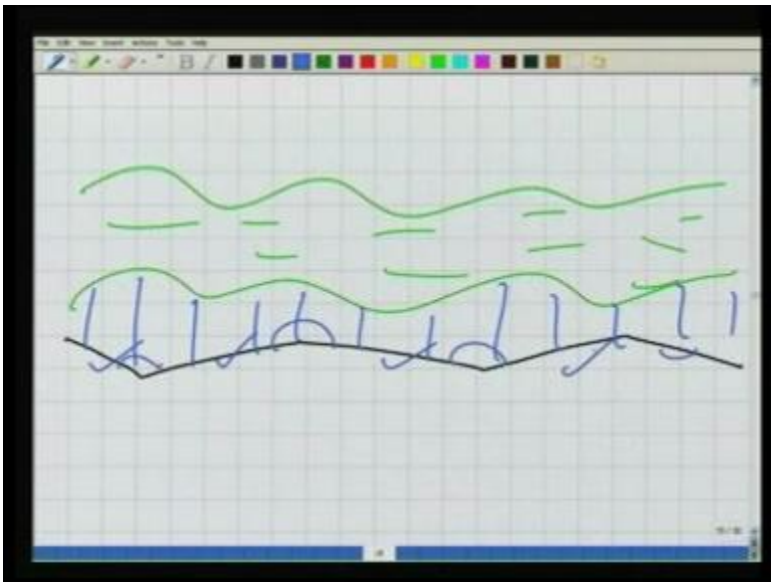
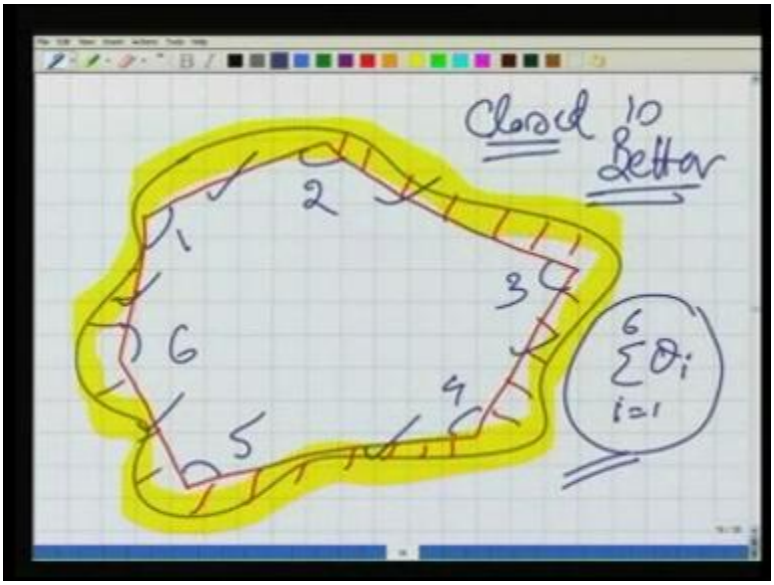


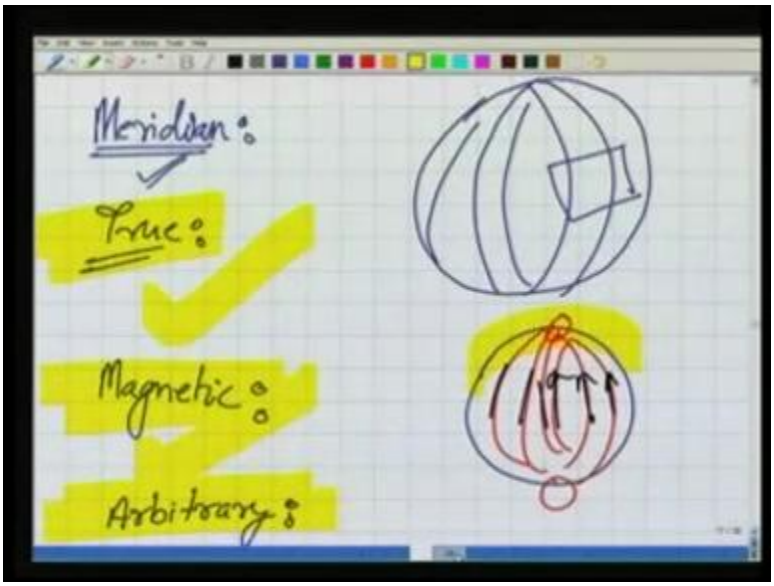
For example, let us say, if you have an area which is the river. Well, that is our river here (Refer Slide Time 31:08), and you want to plot the boundary of the river. So, to plot your bank, we need to have a traverse. We should go along with the river and we can take all these offsets (Refer Slide Time 31:25). Now, we have measured these lengths and these angles, so this is an open traverse.

(Refer Slide Time: 31:42)



But, in some other circumstances, where - for example in a garden - there is a garden - for this garden, we need to find its area; we have to determine the area of the garden. What I will do, I will go for a traverse all along the boundary here (Refer Slide Time 31:53), and I will close it. Then I am taking all these offsets (Refer Slide Time 32:01). So, by doing all these; by measuring the offsets and by measuring these angles, these lengths - everything measured, what we can do, we can plot it on a sheet, and then, on that sheet, we can plot this boundary. The boundary can be plotted on our map, and once it is plotted in our boundary, we can find the area of this using any instrument, planimeter or some other methods - putting it on a graph sheet, counting number of the squares there - so the area of the boundary can be determined. So, in these cases, we need to go for the open traverse. Otherwise also, the open traverse is better. Why it is better? Sorry, the closed one; the closed is better. Why closed is better? Because, in the case of the closed, you have a check. For example, here, if we have one, two, three, four, five and six internal angles (Refer Slide Time 33:04) measured, so you know what should be the sum of i 1 to 6 (Refer Slide Time 33:16) - what should be the sum of all these angles for a traverse; for a closed figure? You know it theoretically, and you are measuring this also in the field - then, you have a check; if the measurements in the field deviate by a large amount from the theoretical sum, you suspect there is something wrong in your survey. But this thing cannot be done in case of the open traverse, because there is no check as such.

(Refer Slide Time: 34:09)



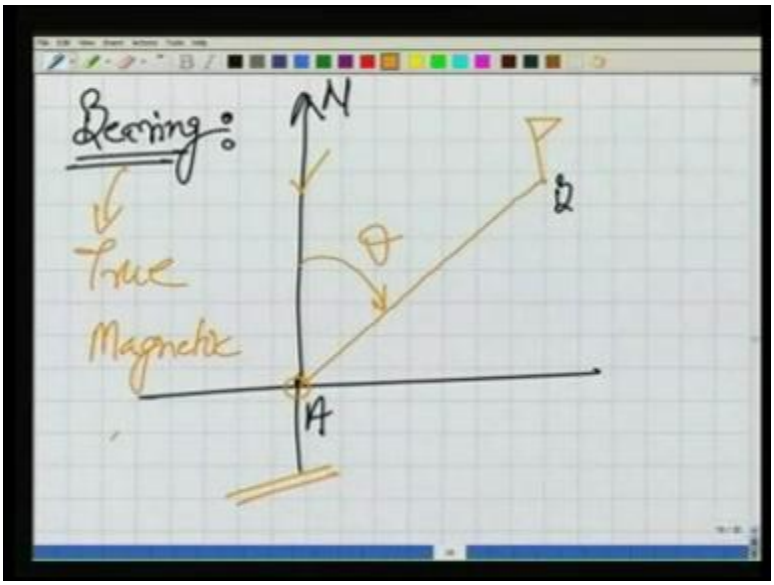
Having seen this concept of the traverse, where we need to measure the length and angle, now we will go for the compass, because compass makes it possible to measure the angles, while the lengths, we can measure it still with the EDMI or tape or chain. So, in the case of the compass - before we talk about the compass, let us talk some terms; some definitions. Number one: we will start with the meridian. Meridian is nothing but a reference plane. For example, if I want to measure an angle right now, what I can do, I can take this plane as a reference plane in front of me (Refer Slide Time 34:22), and I need to measure an angle over here (Refer Slide Time 34:27). So, at this point where I am standing , if the meridian is passing through me - a plane - I can measure the horizontal angle. So, we need a reference. Now, the references which we can use are: number one is the true meridian. Now, true meridian - what is it? If you can think of - just imagine, you know, we have an earth, now on the earth there are the geographical north and south (Refer Slide Time 34:50). You can think of that; you have to use your imagination - geographical north and south. I am standing somewhere on this earth here (Refer Slide Time 35:04). Let us say for you, I am - you are standing here. Now, the point where you are standing, the geographical north and the geographical south (Refer Slide Time 35:09) - if you join all these three, it will make a plane, or we can say, it will make a great circle; a circle on the surface of the earth (Refer Slide Time 35:16). So, all such planes or circles

which we can make on the surface of the earth are called the true meridians. Now, how many of these will be there? Infinite. Because a person could be anywhere on the surface of the earth, and so, in each case, there could be one possible great circle or one possible plane which is consisting of the axis of rotation or axis of the spin of the earth and the observer. So, just keep that in your mind. Right now also, if I am standing here, there is - for example, if the north is here, south is here (Refer Slide Time 35:59), and there is a plane passing through me - me as an observer. So, that - this plane is the meridian; true meridian.

Now, how do we establish this? True meridians are established in any area, at any point, using the observations to the sun or astronomical bodies, and these are constant; the true meridian at this place will not change, and we can use it as a reference. For a small survey, for example, because our earth is like this (Refer Slide Time 36:36), so all these true meridians will converge there in the poles, but for a small area, very small survey (Refer Slide Time 36:46), we can consider the true meridians to be parallel. For example, here only, there is one true meridian over here, another one here, another one here (Refer Slide Time 36:53) - a series of true meridians. Though all these true meridians, they converge at poles, but we can consider - for a small area - them to be parallel. So, these are the parallel lines as such, or parallel references. Generally, we do not use true meridian in our usual surveys, because establishing true meridian is tough; it is difficult. What we use is the magnetic or the magnetic meridian. Let us define it: if I have got a needle here - the magnetic needle (Refer Slide Time 37:29)) -and I suspend it freely, what will happen? After vibrating it for some time, it will align itself along the force line - the magnetic forces of the earth - and it will align so along the magnetic north and magnetic south of the earth, because we can think of the earth - if that is our earth here (Refer Slide Time 37:54), we have the magnetic lines passing through north and south, so at any point our needle will align itself along these lines (Refer Slide Time 38:09)). Now, as you can see, getting a magnetic needle is very easy, it is not tough, so we can say establishing a magnetic meridian is also easy; you just take a magnetic needle, suspend it. The direction it is making is the meridian. So, we can define it as, you know, a plane in which our meridian needle had oriented itself. Again, for a small area, we can consider these

magnetic meridians also to be parallel to each other, while for entire earth, they converge again in the poles - magnetic poles. We also use one more term that is called ‘arbitrary meridian’. Arbitrary means, it is neither magnetic nor true. For example, right now, I say, ‘Well, I have to establish a meridian,’ and I take a line -any line from where I am standing - and there is a tree. Well, this line or this plane (Refer Slide Time 39:04) is a meridian - arbitrary meridian. Then, in order to measure any angles, I start making - measuring - the angles from here (Refer Slide Time 39:11). So, I can establish these arbitrary meridians also, there in the ground.

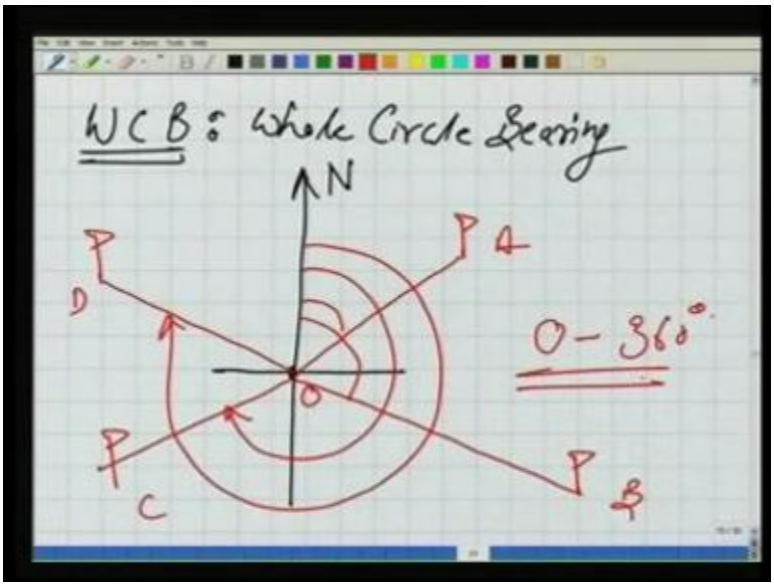
(Refer Slide Time: 39:23)



Having seen these meridians the another term which we will see is ‘bearing’. So mostly, we use magnetic meridian in the field. All our surveying instruments - mostly, they will have the magnetic meridian; they will measure the magnetic - establish the magnetic meridian. Now, this bearing also - if our meridian is this (Refer Slide Time 39:43), let us say it is north , we are standing here, at any point, and the point where I am standing is A (Refer Slide Time 39:51), and there is a line or another point here - B. Over here is a ranging rod (Refer Slide Time 39:58), and this is the point where I am standing. We can take it here - I am standing at A, somewhere, there is a ranging rod - and I want to measure now, bearing of this ranging rod with respect to the magnetic meridian. So, what

is the meaning of that? The bearing means this angle theta (Refer Slide Time 40:23). So, we are using this reference. The bearing could be true, could be magnetic or arbitrary, depending what meridian we are using. So, that is the meaning of the bearing.

(Refer Slide Time: 41:00)



Now, how do we make use of the bearing? This part, we will see now. In order to understand the use of bearings, we will have to understand the systems. How do we write the bearings? The very first system is called WCB, which stands for Whole Circle Bearing. Now, what is this? In the case of the whole circle bearing - or, let me do it the other way round: we are talking about the systems in which we can write the bearings. Let us say the direction of north at a particular point is this (Refer Slide Time 41:30), or this is the magnetic meridian - I write N here. We have a line or a ranging rod somewhere here, and a ranging rod here, and a ranging rod here, and here - A, B, C and D (Refer Slide Time 41:43) - and the observer is at O. I want to measure the bearings, so the bearings will be measured as, for example, the angle here, the angle here, and maybe this angle and this angle (Refer Slide Time 42:05). So, the whole circle bearing means, measuring the bearing of the line - line is OA, OB, OC and OD from the magnetic meridian - always clockwise. So, naturally, this could be ranging from 0 to 360 degrees. That is one system.

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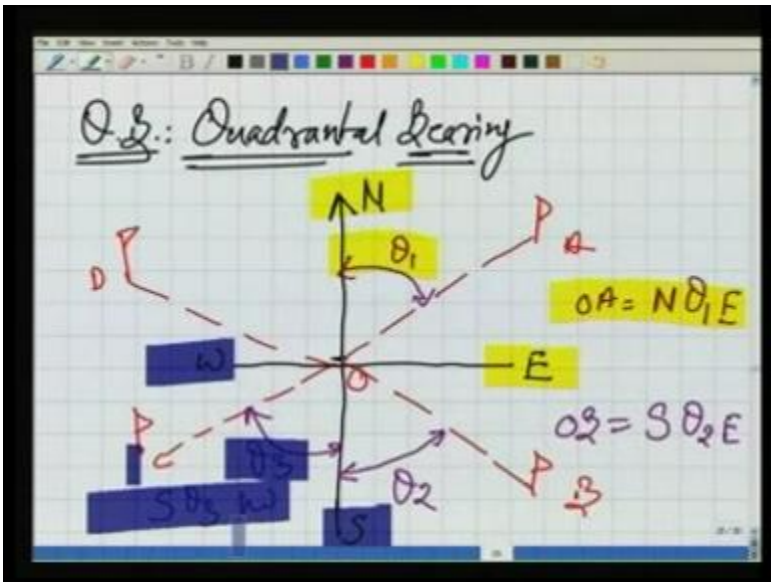
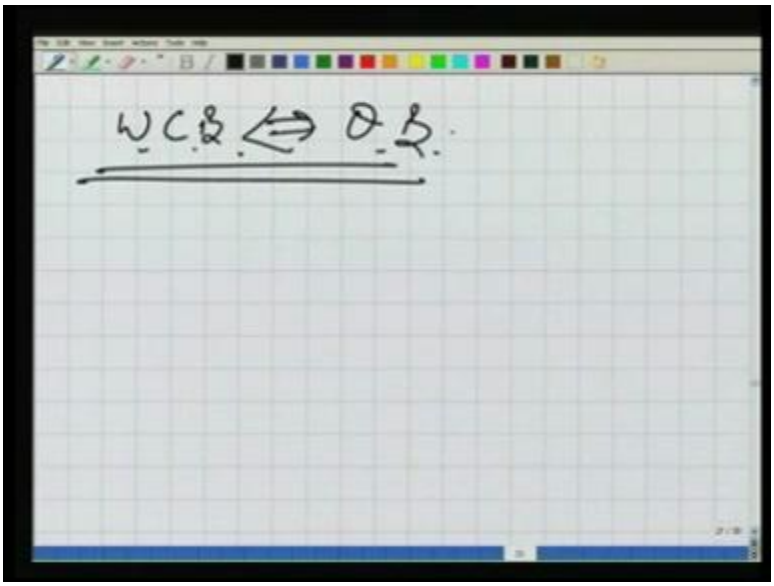


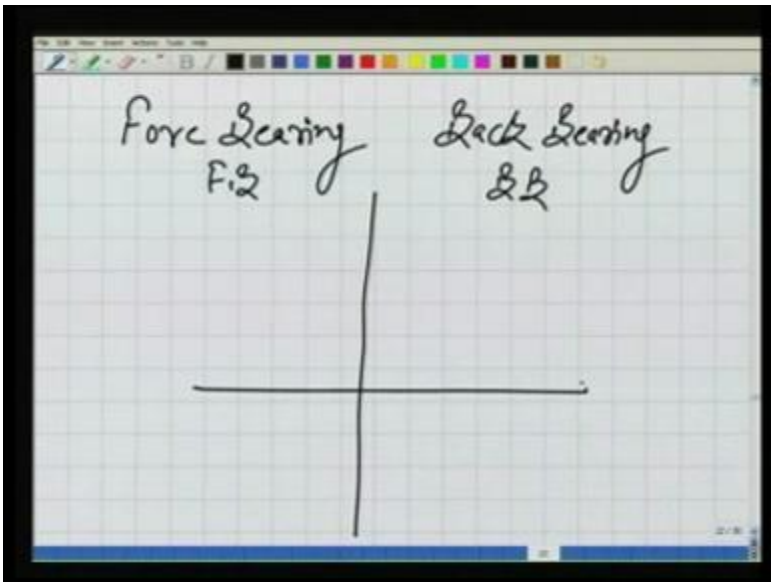
The second system is QB, which stands for Quadrantal Bearing. Now, what this system is? Again, here, in this case, let us say this is the magnetic meridian (Refer Slide Time 42:58) - so, N; this is the point where the observer is O; and we have again, A, B, C, and D, some ranging rods, and all these are, you know, we can define them, join them by these lines (Refer Slide Time 43:23). So, basically, we are interested in measuring the bearings of lines OA, OB, OC and OD. Now, in this second system of bearing, how do we measure it? That is our east, obviously, and west and south (43:40). We write the bearings as, let us say I am writing this bearing: this angle measured is theta 1. So, the bearing of line OA is 'North theta 1 East' (Refer Slide Time 43:51). What did we do here? Look at that: from north to east, the angle is theta 1, so that is why we write it as North theta 1 East. Similarly, I can write it as - for another line, let us say the line is here, OB (Refer Slide Time 44:27), and that angle is theta 2, so for OB, the bearing is South theta 2 East, or also, for example, here, this bearing to OC will be - if this angle is theta 3 - South theta 3 West. Now why we are writing it? Because it is from south to west, angle value is theta 3, so that is why we are writing it this way.

(Refer Slide Time: 45:28)



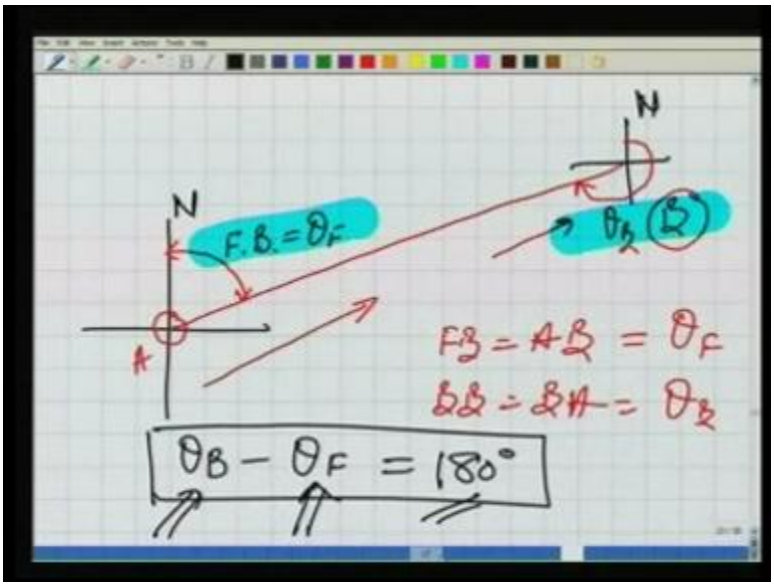
So, this is the another system of writing the bearings, and as it is obvious - as it is obvious that you can make use of these bearings and you can convert WCB to QB and vice versa. If you know the values in any of the systems, you can convert it; it is a simple conversion.

(Refer Slide Time: 45:46)



Now, we are going to look into the other thing - some more terms. One is ‘fore bearing’, and the other is ‘back bearing’. It is written also as FB and BB. What these are?

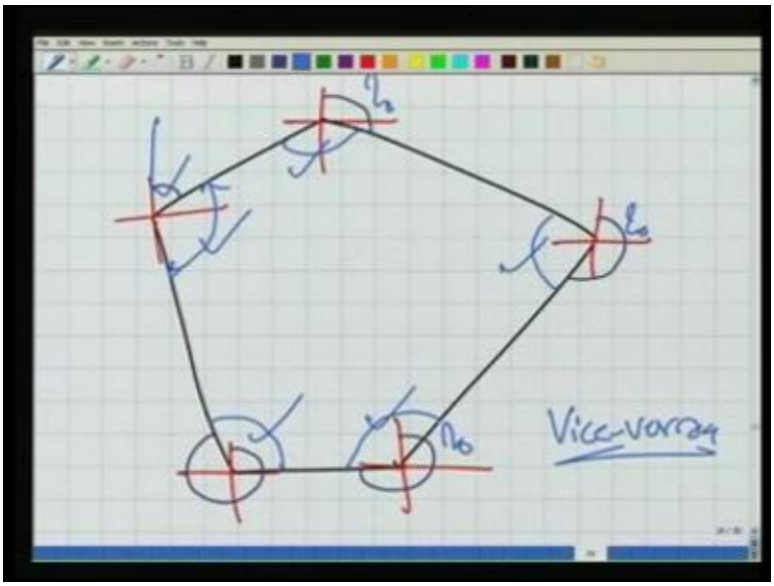
(Refer Slide Time: 46:06)



Let me draw it separately here - that is the direction of north here (Refer Slide Time 46:08), and similarly, here also - this is the direction of North (Refer Slide Time 46:12). There are two points, point A and point B, and a line joins these two points (Refer Slide Time 46:21). I am standing at A - the observer is at A - and this is the direction in which I am proceeding (Refer Slide Time 46:30); I am going in this direction in my survey. So, if I observe the bearing of this line AB, this particular value (Refer Slide Time 46:36), this is called fore bearing - let us say this is theta F. Then, if I have reached the point B - I am at the point B now - going at the point B, I can measure the bearing of line BA. So, I am measuring the bearings earlier as - the fore bearing was for AB, and the back bearing is for BA. Now, how do we decide whether we are going forward or not? You know if it is the - basically, the direction of our movement, and we have taken these bearings as, let us say, theta B. So, theta F and theta B. Can you see there should be some relationship between these - these two values - fore bearing, back bearing? You can make it out very easily from here that there should be a relationship between these two, and that relationship should be: if you take the back bearing minus fore bearing, that should be

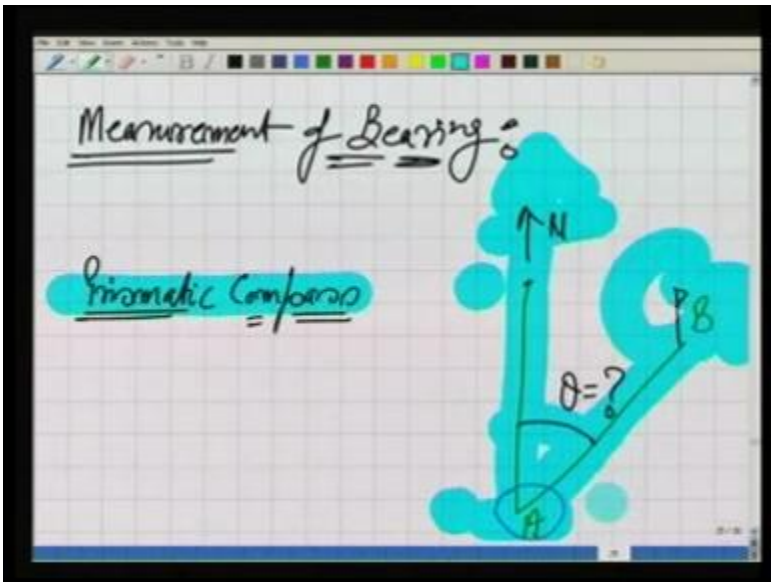
180 degrees, and this is the case when these are observed without any error; there is no error, then these things should be satisfied.

(Refer Slide Time: 48:16)



Next, we are going to - if you have, for example, a traverse, and in that traverse, you know the bearings at each point of all the lines (Refer Slide Time 48:17). Bearings means, as we know, all these angles of all these lines (Refer Slide Time 48:27). You know all these angles, so if, by knowing these bearings, it is also possible that you can determine these internal angles. I am not going to solve any numerical problem here; rather, I will advise you to please go through any textbook and solve the numerical problems - it is a very simple problem. If you know the bearings of all the lines, you can determine the internal angles of the traverse, and of course, similarly, vice versa: if you know the internal angles of all the lines and bearing of one line - let us say you know all these (Refer Slide Time 49:12), and you know the bearing of one single line, then all these can be determined. Whatever system you want to - in WCB or QB - everything can be determined.

(Refer Slide Time: 49:32)

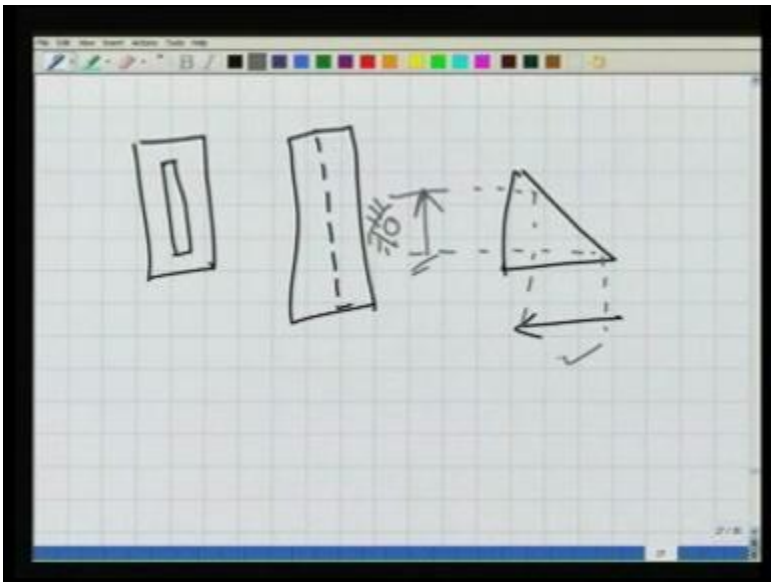


Now, let us get into that how we can measure the bearing - measurement. So, we are going to see that how we can measure the bearing. As we have seen what is the meaning of the bearing, this is the magnetic meridian (Refer Slide Time 49:48), so direction of north - our observer is at A, and there is a ranging rod at B, and we are interested in observing this angle theta, which is the bearing. Now, there are a couple of instruments in order to do that - we have seen one, which is the prismatic compass. I will tell you about the various parts of the prismatic compass now.

(Refer Slide Time: 50:12)

The prismatic compass comes in a cover. When you open it, it will be clamped like this (Refer Slide Time 50:17). What I can do here, I can open the vein number one and number two here (Refer Slide Time 50:22). Now, this is ready for taking the observations. We will see the various parts of it - what they are, what they do. Over here, I can tilt it up and keep it on top of the circle (Refer Slide Time 50:38) - now, this is absolutely ready for taking the measurements. Now, on this particular part here, in this vein, there is a little slit - a very fine slit is there (Refer Slide Time 50:53). What is the meaning of slit?

(Refer Slide Time: 51:00)



The slit means, if I draw it here, the slit is a very narrow opening (Refer Slide Time 51:04), while at the other end, over here, in this vein, there is a wire (Refer Slide Time 51:09). Wire is on the other end; we have a very thin wire or thread. Now, we make use of the compass, so that we are looking through this slit and this wire, and we can align it along any line (Refer Slide Time 51:28). So, I can use my master eye - my right eye - and look through it, so that it is aligned along a line. I am at point A, I am looking to point B.

(Refer Slide Time: 51:51)

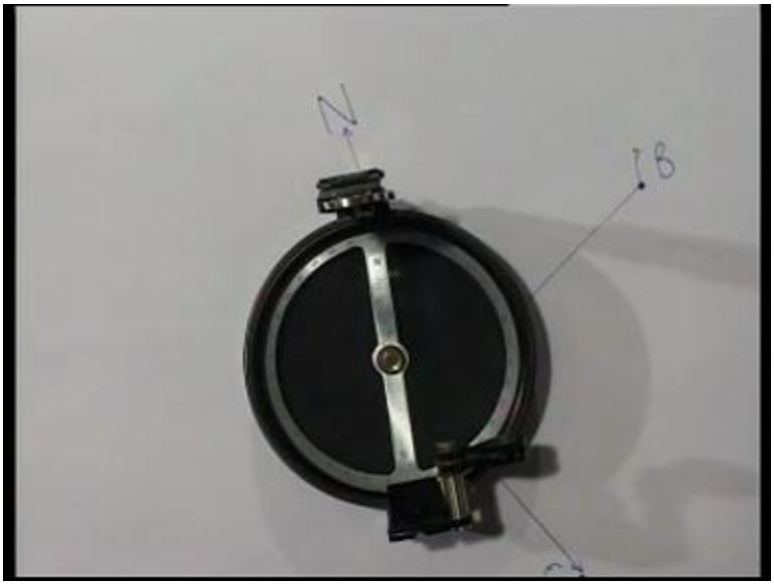
Well, over here, you will see there is a mirror also - this is a mirror - mirror fitted here (Refer Slide Time 51:48). We can tilt this mirror, and the use of the mirror is, if the line of sights are inclined - for example, the ranging rod is not horizontally in front of me; rather ,down there (Refer Slide Time 52:02), so I can see the ranging rod in the reflection of - through the mirror. So, that is why we use the mirror. Also, we have got some coloured glasses here (Refer Slide Time 52:12), because we are looking through this slit; we need to see the readings here. So, the coloured glasses help us to reduce the intensity of light sometimes, when it is required.

(Refer Slide Time: 52:28)

Now, over here, if I show it this way (Refer Slide Time 52:27), we have a measuring circle or the graduated circle - we will see the configuration or the specification of this in a moment. Nonetheless, along with this vein is fitted a prism, and the use of the prism is, my eye is here, on this side - the eye is kept here (Refer Slide Time 52:46), and the graduations are written down there (Refer Slide Time 52:51. So, what is the role of prism? The prism will take these graduations and will reflect it here (Refer Slide Time 52:57). Now, this is - there is a very interesting thing about these graduations; the graduations in this circle, they are written inverted. Why they are inverted? If this is the prism here (Refer Slide Time 53:11), and this is the graduation, then how it will be

reflected? It will be reflected like this (Refer Slide Time 53:23), and this is how it will be seen. So, the role of the prism is to invert these graduations, because eye is here (Refer Slide Time 53:32) - this is where my eye is. We make the graduations inverted in the circle down there because we can see them inverted - sorry, erected, so the prism erects those inverted graduations.

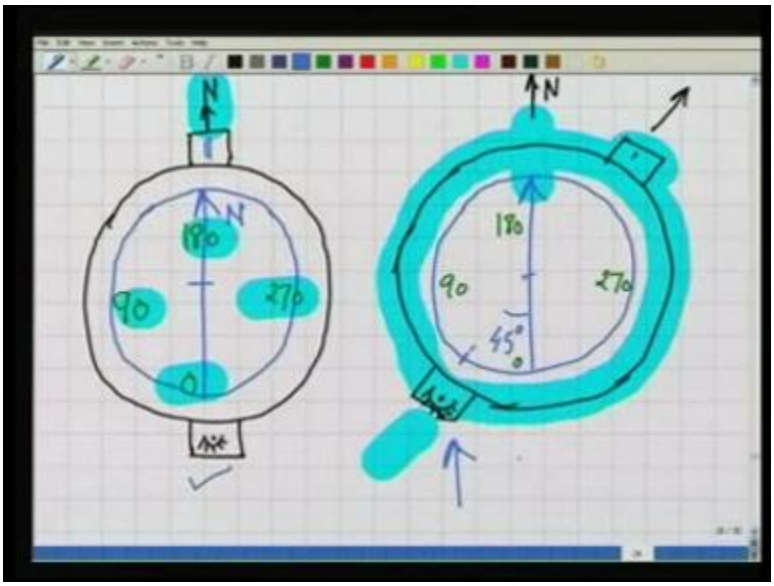
(Refer Slide Time: 53:53)



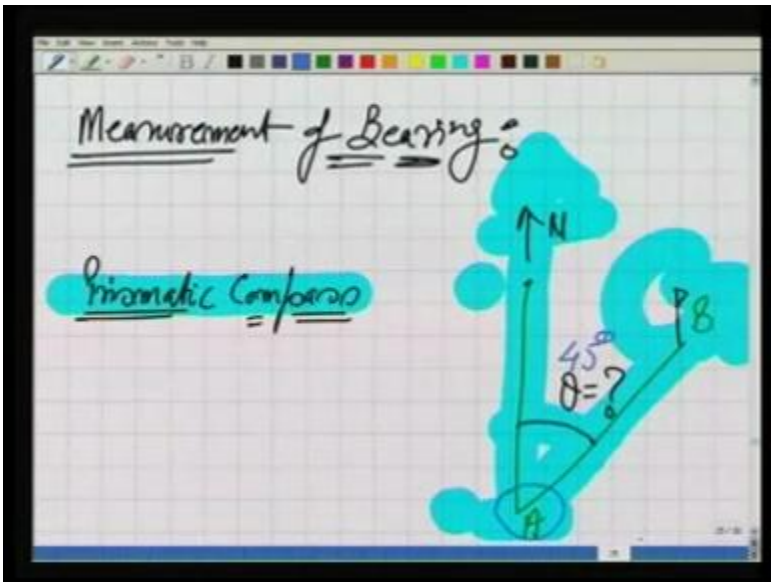
Now, we will see it that what this circle is like. So here, we are looking into the construction of prismatic compass, and here, you can see that is the body of the prismatic compass. The important thing about it is the graduated circle. Where is the needle - the magnetic needle? Because we have talked about that; the compass is based on a magnetic needle. The magnetic needle, in this case, is attached with this graduated circle. We cannot see it because this is underneath this white aluminium strip (Refer Slide Time 54:16). Now, this needle is suspended, or this graduated circle and the needle combined, they are hanging with a very, very smooth jewel here (54:32) - this is to ensure the friction-less movement of the needle. Right now, if this is the direction of north (Refer Slide Time 54:40), as you can see, with the rotation of the instrument, I am rotating the instrument - the needle and the graduated circle, they keep there (Refer Slide Time 54:44). Well, this is how you can see they can move. So, basically what will happen in

this case? The graduated circle and the needle, they always maintain one direction - the direction of the north. Let us say I need to measure the bearing of a point B (55:06). What do we do? This is the eye vein, and this is the object vein; here is the little wire and the slit (Refer Slide Time 55:10). Well, the person, the observer, keeps his eye here (Refer Slide Time 55:18) and rotates it so that the eye from here can bisect this particular target (Refer Slide Time 55:21) or the ranging rod. Now, in this case, whatever is the reading over here, in the graduated circle, is the value of this bearing or this angle. Now, we will see how this graduated circle is written; how the readings are written in this graduated circle.

(Refer Slide Time: 56:02)



(Refer Slide Time 57:09)



To measure the bearing, as we saw, we keep our prismatic compass at A, as we have seen (Refer Slide Time 55:55), and how the prismatic compass - for example, here is the point A. The prismatic compass is graduated in a very typical way - we should know it. Right now, for example, the prismatic compass is kept in such a way that this is the eye vein; the object vein, where a little twine or thread is there, wire is there (Refer Slide Time 56:15). This is the direction of north; all these are aligned. So, our needle that is below line here, having 'N' here, it will be suspended in the direction of the north, so that direction of north is here (Refer Slide Time 56:36). Now, as you see, this blue line here, or this blue circle, is the graduated circle, which is attached to the magnetic needle. The graduations, they start from 0 over here, then 90, 180, 270 (Refer Slide Time 56:53). Now, why they start this way? We will see it in a moment. Now, as you can see here in this diagram (Refer Slide Time 57:09), well, in order to measure the bearing of line AB, initially, in my instrument, my eye vein was here, and the object vein was here, and I was looking in this direction (Refer Slide Time 57:12). Now, I rotate my instrument till I bisect this ranging rod at B, so when I bisect the ranging rod at B, as you can see here (Refer Slide Time 57:29), what happens there? This needle will stay where it was - because the needle is to point in the north direction, it will stay there, so the graduated circle will also not move. What moves? Only the instrument or only the body of the

prismatic compass - only this black line (Refer Slide Time 57:45) - it moves along with the eye vein and the object vein. Now, at this moment, if I look through the prism there - the prism is kept here (Refer Slide Time 58:01) - if I look through it, it will read the graduated circle here (Refer Slide Time 58:05), so the reading in this case will be, as you can see, around 45degrees (Refer Slide Time 58:10), and of course, the graduations I have written here erected - they are not erected, they are inverted; then only this prism will erect them. So, our bearing, as we can see here (Refer Slide Time 58:24), is around 45degrees, and this is what we are observing over here. So, this is how we can take observations with the prismatic compass.

So, what we saw today, we saw the significance of the traverse. We cannot use the chain - simple chain survey everywhere; we cannot use the simple chain triangulation everywhere, so we need to go for traversing. In traversing, we need to measure the angles. We can make use of a very simple instrument, compass, to measure the angles using the bearings, and to measure those bearings we saw some terms - fore bearing, back bearing, their relationship, and also, how we can measure it using the prismatic compass. The prismatic compass, by the way, you can use it either on your hand or maybe in a stand. So, you can fix it on a stand and then you start measuring the bearings with that. In the case of the prismatic compass, the moment you bisect something, at the same time you can see the readings also, through the prism.

Thank you very much.