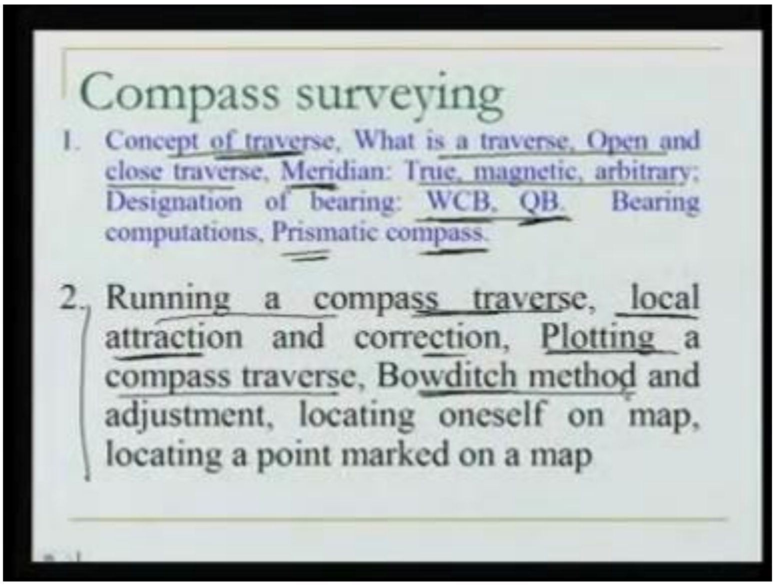
Surveying
Prof. Bharat Lohani
Department of Civil Engineering
Indian Institute of Technology, Kanpur

Module - 4
Lecture - 2

Compass Surveying

Welcome again to this series of video lecture on basic surveying, and today, we are on module 4, which is on compass surveying. We started it in our previous lecture, so this is the lecture number 2 in compass surveying.

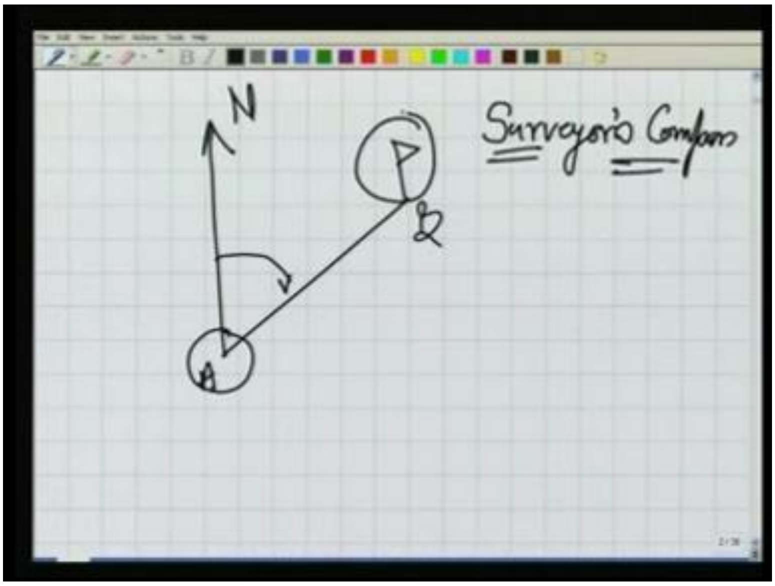
(Refer Slide Time: 00:33)



Now here, in compass surveying, what we have done so far? In our last lecture, we talked about the concept of traverse because if we need to know about compass surveying, we need to know where we are going to use it. So, we need to know about the traverse, because traverse is a thing where we need to measure the angles, and we measure these angles making use of the bearing, and bearings are determined using the compass. So, we talked about why we need the traverse, then, we talked about the types of the traverse - it is open or closed - what they are, what are the advantages when we can work with these kinds of traverses. Then, we discussed the meridian. The meridians could be true meridian, magnetic meridian and arbitrary, because we make use of these in order to measure the bearings, and the bearings can be represented in two systems: WCB - stands for whole circle bearing - and quadrantal bearing. We know how we can convert these two bearings also, from one system to other system; we can determine them. And then, finally, we saw one kind of compass, which is the prismatic compass. We saw the specifications of the instrument: how it is made, what are the various parts of it, how we make use of this in the field.

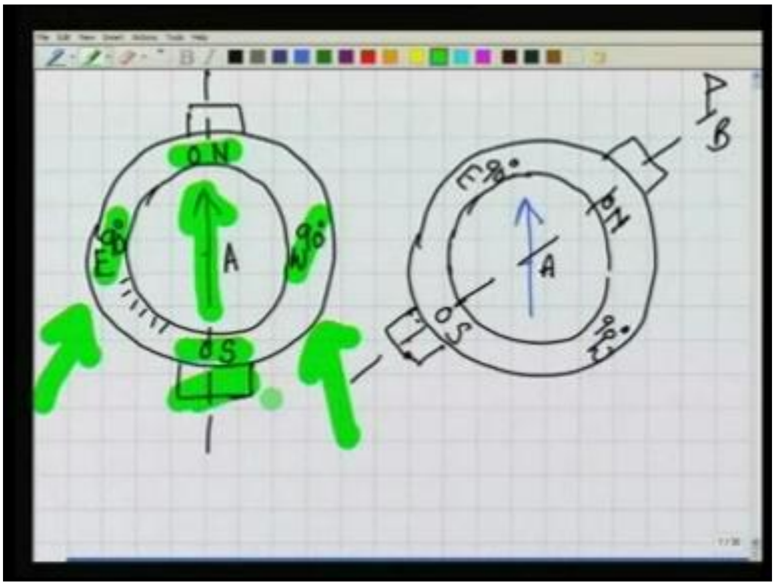
Today, before we talk about the other things, we will briefly discuss about another compass, which is the surveyors compass, because when you are in the field, you might need to use it sometimes. So, we should know that what the surveyors compass is. Then, after that, we will see about the local attraction - what is it, why it is important when we are doing the compass surveying. Then, we will run a traverse; how we can do a map with the help of compass surveying. Then, we will talk about some corrections, and of course, how we can plot our compass traverse. There are a couple of methods - we will look into this Bowditch method - it is a graphical method for finding the error or error adjustment. Then, this is very important and very interesting: we can locate oneself -ourselves on a map or maybe we can locate a point which is marked on the map onto the ground. So, these are the things which we will try to see today.

(Refer Slide Time: 03:06)



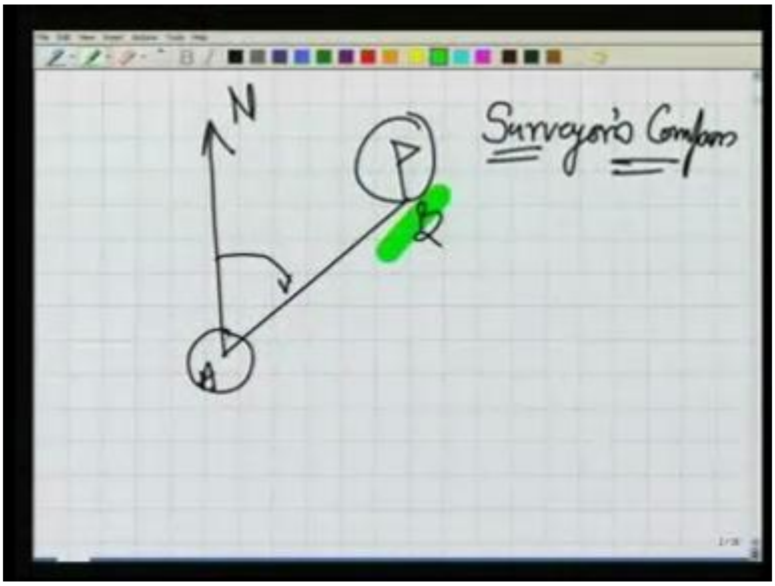
So, we will begin with surveyors compass - we will look into some important things of this surveyors compass. We are not looking at the instrument directly; the prismatic compass is the one which is mostly used in the field - mostly, we will find in the field operations, being used - but still, we should know about the surveyors compass. Well, the job is, again, we want to measure a bearing here, and what we will do with the surveyors compass, we will occupy the point A, and we want to measure the bearing of line AB, and there at B we have a ranging rod (Refer Slide Time 03:30).

(Refer Slide Time: 03:43)

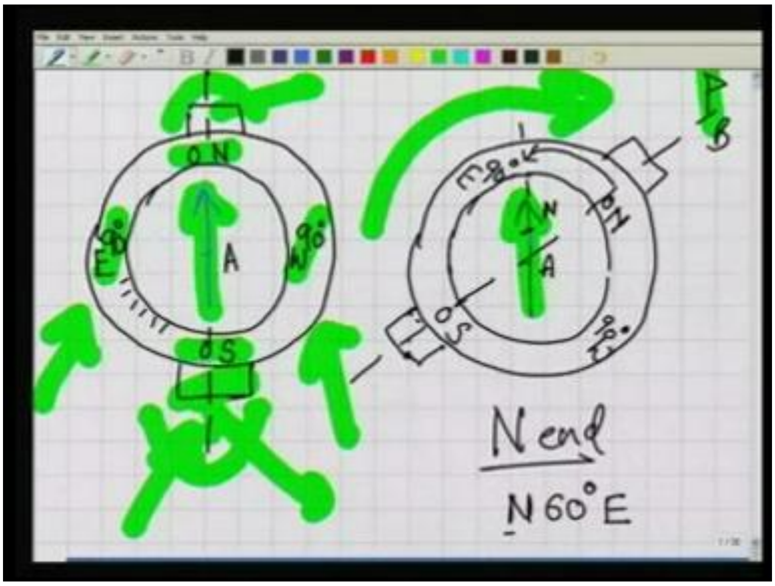


What is there in the surveyors compass? How it is different than the prismatic compass? Now, in this case, all these black lines - this is the body of the compass (Refer Slide Time 03:43). The interesting thing here is, along with the body, we have also the graduations, so these graduations are, unlike prismatic compass, in the body of the compass. In the case of the prismatic compass these were along with the needle, so there was a ring of the graduations, and the middle was fixed to that (Refer Slide Time 04:06), while here, in this case, the needle is separate. What I mean? If I rotate this prismatic compass, for example, here, if you see, if I rotate this prismatic compass here, this particular body (Refer Slide Time 04:22), the needle will stay where it is, because needle is pointing in the north direction - that is the direction of the north (Refer Slide Time 04:27) - it will not change its position; only the compass will rotate, only the graduations will rotate. Now, how the graduations are? They are written zero north, zero south, 90 degrees east, 90 degrees west (Refer Slide Time 04:40). Now, you will notice here that east and west, they have exchanged their place from a usual way - why it is so? Otherwise, the west should have been here, the east should have been here (Refer Slide Time 04:53). It is in order to facilitate reading the observations.

(Refer Slide Time: 05:04)



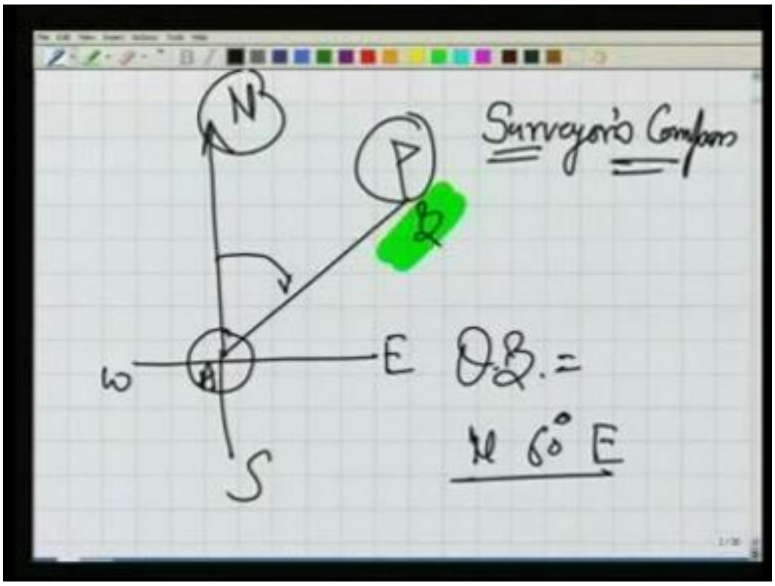
(Refer Slide Time: 05:08)



Well, what we do now, in order to measure our bearing to point B (Refer Slide Time 05:04), what we do, we rotate our instrument -rotating means, this is one vein - this black box here is one vein (Refer Slide Time 05:10) - which we say the 'eye vein'.

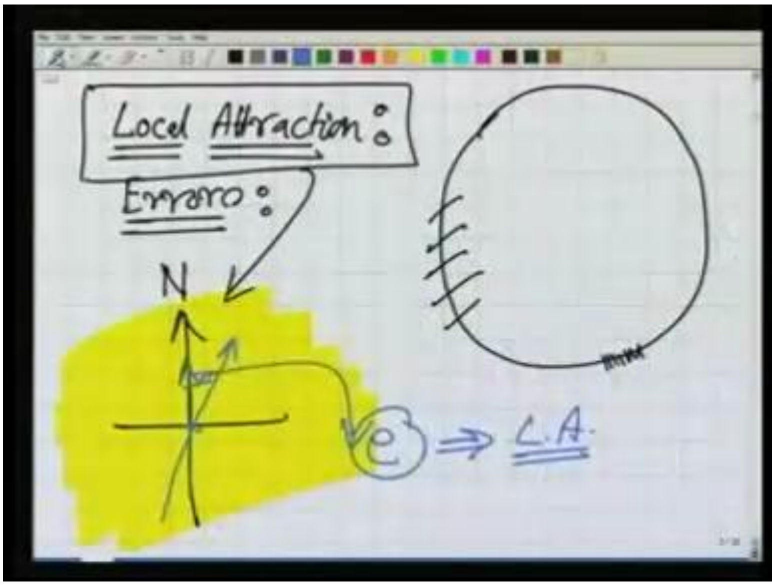
You keep your eye here, and this is the object vein (Refer Slide Time 05:20) - it has got a slit - sorry, a wire here - a wire is here and a slit (Refer Slide Time 05:24), so now, using this slit and the wire, we look in the direction of the object for which we want to measure the bearing. So, in order to bisect B, we will have to rotate our instrument this way while the needle will stay where it is; so needle maintains its position. Now, what we do, we read the observations, in the case of the surveyors compass, against north end of the needle - north end - and that is the north end here, N (Refer Slide Time 05:58). So, we will read the observations here or the graduations here. As you can see over here, the graduation which we will read is from north, towards east (Refer Slide Time 06:10) - some particular value. So, I can write it as from north, let us say 60 degrees towards east (Refer Slide Time 06:19) - this is what my compass is showing me.

(Refer Slide Time: 06:27)



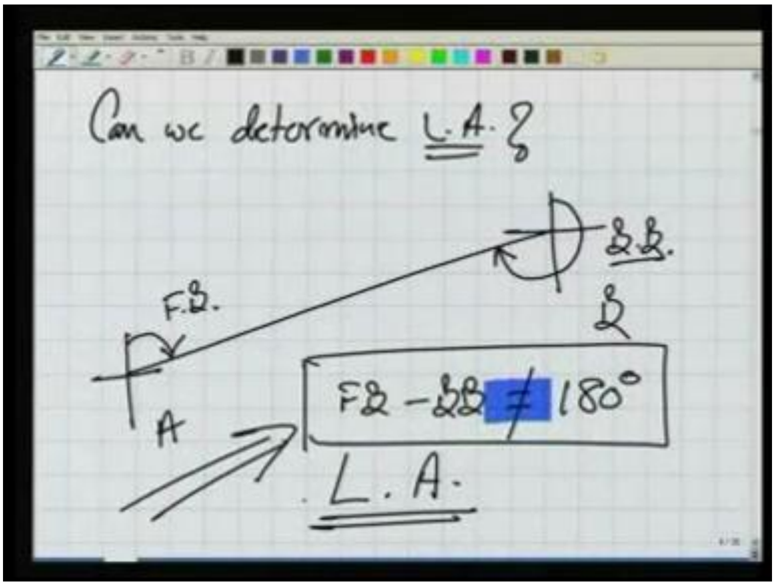
What is there in the area? In the area - well, yes, it is so - over here, this is north, south, east and west (Refer Slide Time 06:30), and in the QB system, in the quadrantal bearing system, the bearing is north to east, whatever is the bearing value (Refer Slide Time 06:42), and this is what we are observing here using our instrument. So now, you will understand that why the graduations are written in a different way.

(Refer Slide Time: 07:00)



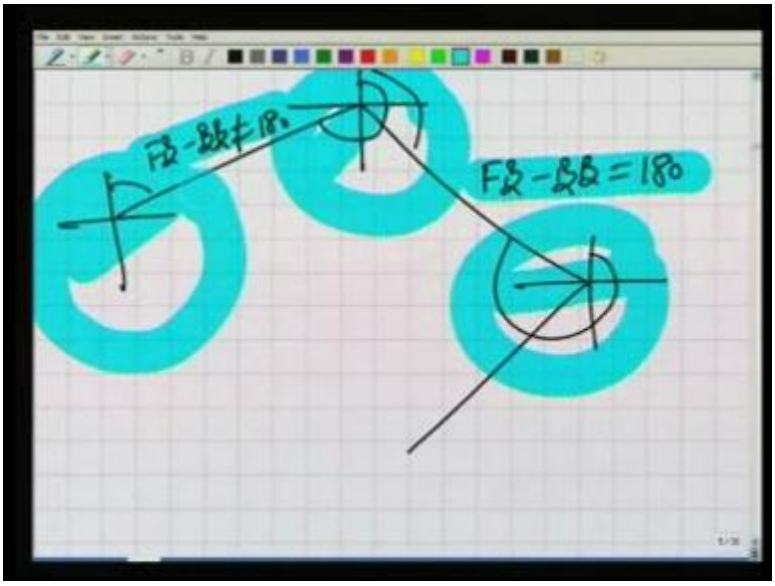
Well, the next thing which we are going to look at is local attraction. What it is? Because we are talking about - when we are talking about the compass, we should know about the errors also. What are the errors which could be there in the compass? As we saw in our last lecture, the errors could be: number one, because of the observer. Now, in the case of the compass, the errors could be, I hold the compass inclined, so the needle is not free to rotate (Refer Slide Time 07:25) - I did the observations wrong, so again, because of the observer. There could be errors which are because of the instrument; after wear and tear of the instrument, the needle is not free to rotate anymore, or rather, it takes lot of time to adjust. So, what is there now? The error is because of the compass now, or maybe the circle in which the graduations are written, the graduating circle - this graduated circle - may have the graduations which are not uniform (Refer Slide Time 07:55). So, there may be a case because of the instrument also, when the errors may come. Finally, because of some external factors which are beyond the control of either instrument or the observer, which is the natural sources. Local attraction is one such source. We are not looking in other errors, but we will look at local attraction in detail. What the local attraction is? At any point, if this is the direction of north (Refer Slide Time 08:28) - when I say north here now, I mean the magnetic north, because we are talking about the compass; compass makes use of magnetic meridian, so we are only talking of the magnetic north - if I hang a needle here, the needle should be aligned along this direction - this blue line is the needle; magnetic needle (Refer Slide Time 08:49). The meaning of the local attraction is, there are some other forces, magnetic forces, which are influencing the magnetic field in this area where we are working. In this particular area (Refer Slide Time 09:09), there are some other magnetic forces. What will happen because of that? The earth's magnetic field is working; some external magnetic fields, some other - maybe a transformer or something - that is also working. So, what we will end up with? We will end up with, our needle will not point in the north direction; rather, it will point in some resultant direction - so, this is now the direction (Refer Slide Time 09:29). My needle will not hang in the north direction; rather, it will hang in some other direction; it will achieve of the equilibrium in this direction because of the resultant forces. Now, if that is the case, we are using a needle like this, or maybe we are working in an area like this, this particular error here - we say, let us I write it as 'e', error - as local attraction (Refer Slide Time 09:53). Now, this local attraction may be also because of some magnetic items which are in my pocket. So, we do not consider those things as the local attraction because this is something because of the observer; observer is not the careful person - we should take all these objects away. So, local attractions are basically only for those reasons which are beyond the control of observer.

(Refer Slide Time: 10:32)



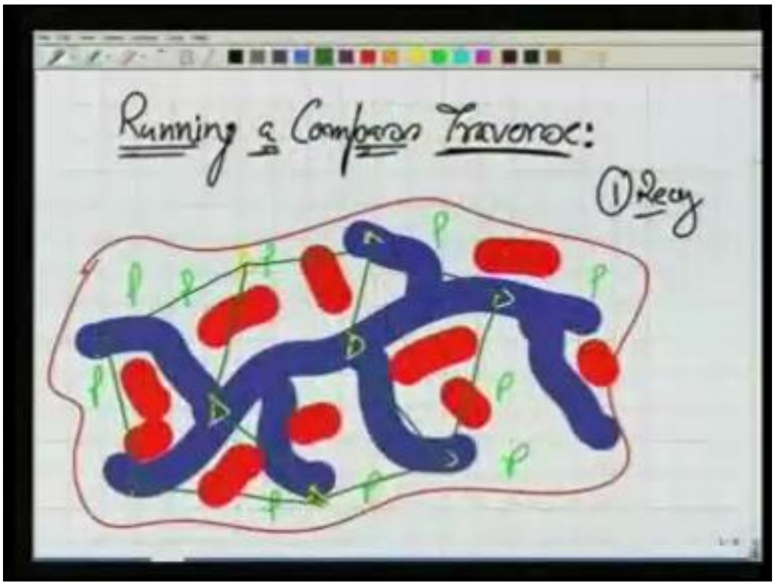
Well, if the local attractions are there, how to take care of that? Can we determine them? Can we determine local attraction; how do we find it that our observations are being affected by it? Well, let us take a case: there is a line AB - the survey line. We have observed the bearing at A, as well as, we have taken the bearing at B (Refer Slide Time 10:51), and these two bearings, as usual, we say fore-bearing and back-bearing (Refer Slide Time 11:00), because we are moving from A to B. And you know it that the fore-bearing minus back-bearing should be 180. Well, if it not so, then you start suspecting there are errors. As we discussed, there are many more sources of the errors - error because of the observer, error because of the instrument - many more sources of the errors are there. So, this ‘not equal to’ (Refer Slide Time 11:29) - this could be because of many more reasons; many reasons, but the most prominent one is the local attraction. Or, if we consider the observer is very careful; the instrument is correct - there is no problem with the instrument, it has been checked; observer is also very careful, then these errors because of the instrument, because of the observer, will be very small or negligible within the scope of the work. So, if at all in that case, if this is so (Refer Slide Time 12:01), whatever is the error now, it is because of the local attraction. Well, how to determine this, whether the local attraction is there or not, and where it is? So this (Refer Slide Time 12:11) gives an indication that yes, there is local attraction in either of these two points (Refer Slide Time 12:17). How to find it?

(Refer Slide Time: 12:23)



Let us say we have these three lines (Refer Slide Time 12:23) - we have taken the bearings in all the places, so we have the fore-bearing and back-bearing - fore-bearing and the back-bearing (Refer Slide Time 12:26) - we find that the fore-bearing minus back-bearing for this line is not equal to 180, while here, fore-bearing minus back-bearing is equal to 180 (Refer Slide Time 12:40). If this is so, what is our conclusion? We conclude from here that this station as well as this station (Refer Slide Time 13:00) are free of the local attraction, because the difference of the bearings is 180. So, if it is so, our conclusion will be: well, this station has got the local attraction because of this (Refer Slide Time 13:12). So, we know now, well, our stations here, here (Refer Slide Time 13:18) are free of the local attraction, while this station has the local attraction, and having known this, we can accordingly apply correction for the local attraction, which we will see in a moment.

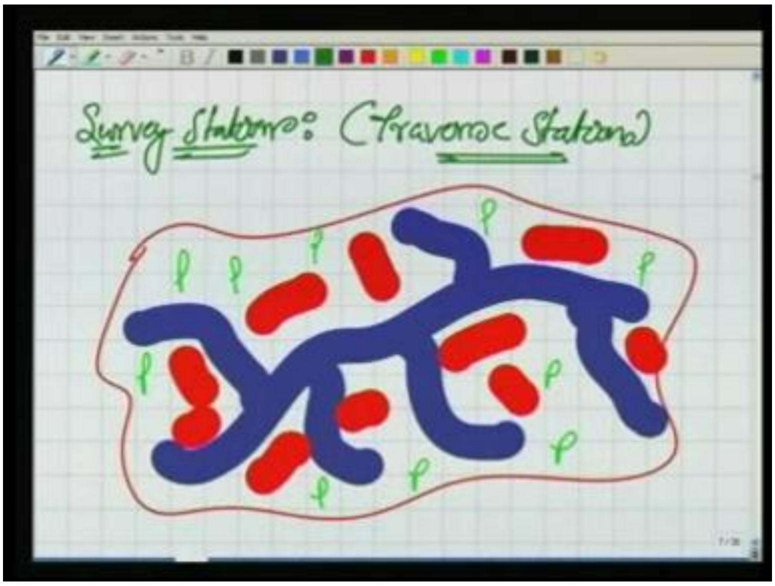
(Refer Slide Time: 13:40)



Now, before we go into that - the corrections for the local attraction - let us talk about running a compass traverse. We know traverse; what I will do, I will give you the various steps which we need to follow in the ground in order to run a compass traverse. Well, I will give you a problem - the problem is: again, let us say we have some area, and there in that area, we have, for example, a road having some branches there (Refer Slide Time 14:03). We also have some houses (Refer Slide Time 14:21) - all these are the houses. As you know, this could be any ground. There also are a couple of trees, as usual (Refer Slide Time 14:33). A ground may be like this, and we want to make a map of this ground, and we want to do it with the traverse; compass traverse. We want to plot the entire boundary of this township - all the roads, all the buildings and all the trees. What the steps should be? Where should we begin with;

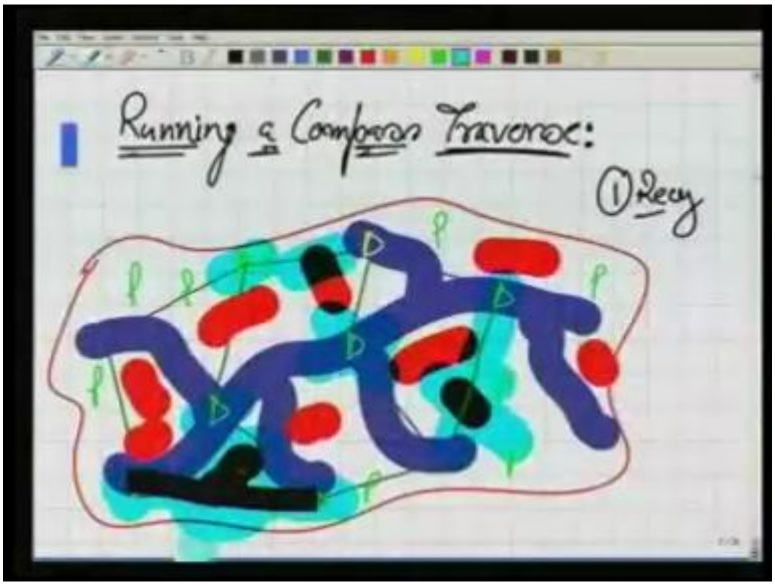
what should we do? So, the very first step in order to make a map will be, as usual, the reconnaissance survey -the recy, or sometimes a recy survey or reconnaissance survey. What we do? We go to the ground and we observe it. We can start taking our stations; these are the stations which will be our survey stations (Refer Slide Time 15:17) where we are going to form our compass traverse, and let us say the survey lines are like this (Refer Slide Time 15:33). There is a close traverse which we are choosing, as well as, there are some further links (Refer Slide Time 15:42). Well, this is our idea, the network of the area, by using these control points.

(Refer Slide Time: 16:00)



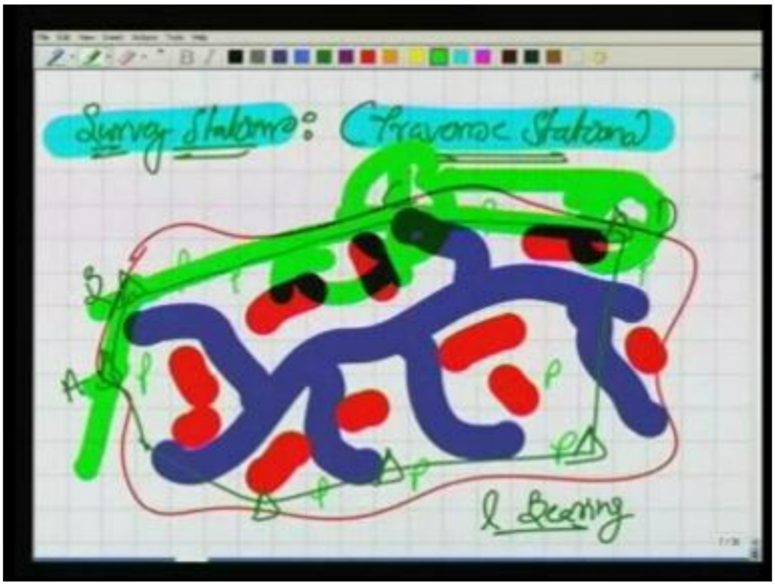
So, very first step, as you noted, is locating the control points. Now, once we are talking about this control points or survey stations - also, they are called traverse stations - how should we select them? Does anything come to your mind, that in order to select the traverse station, we should have? We should keep some guidelines in our mind, some precautions.

(Refer Slide Time: 16:31)



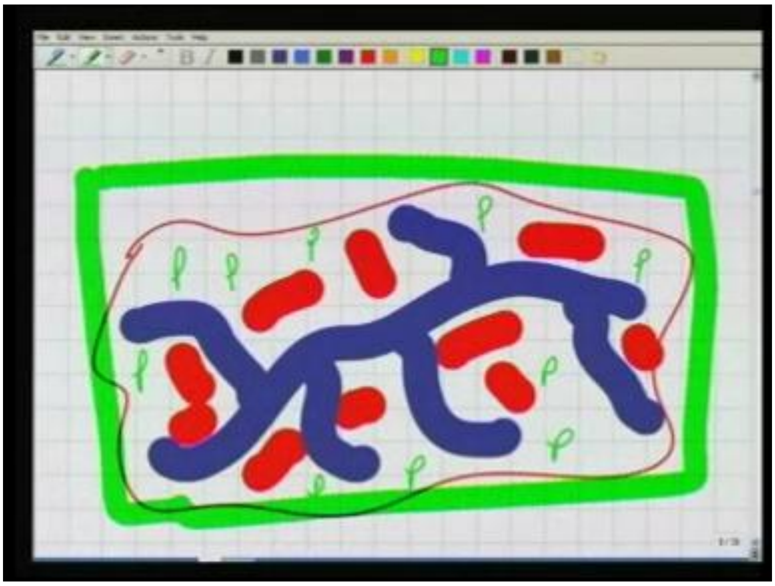
Once you see it, number one, you should be able to measure the distance between the points (Refer Slide Time 16:37), because we are going to do the traversing. Traversing means, we are going to measure the bearings and we are going to measure the lengths. So, if the ground here is undulating, you cannot measure the length, so you should be able to measure the length. Of course, here, you can see a building (Refer Slide Time 16:53), so this line selection is not good; we should select our lines such that they do not pass through the buildings like this. So, number one: measuring the length. Number two, all these stations should be in commanding positions (Refer Slide Time 17:06) so that they can see more of the area. Number three: over here, we have one station here, we have one station here, and in between this, the survey line (Refer Slide Time 17:13). The inter-visibility is not there, because we need to have inter-visibility - then only I can measure the bearing from this point to this point (Refer Slide Time 17:28) - if we have the inter visibility. So, these are the things. And also, for example, let us say we have selected a traverse station here (Refer Slide Time 17:38). For this station particularly, this is a very busy junction and every time the traffic will be there. So, we can - now, we can say, well, this is not a really approachable area - it can be approached, but for work, it is not a good area to occupy. So, we should select our traverse stations also in those places where we can approach easily; which we can occupy easily, where we can locate our instrument and we can start taking the observations. So, all these things, we need to take care of, we need to keep in our mind, when we are selecting these traverse stations.

(Refer Slide Time: 18:05)



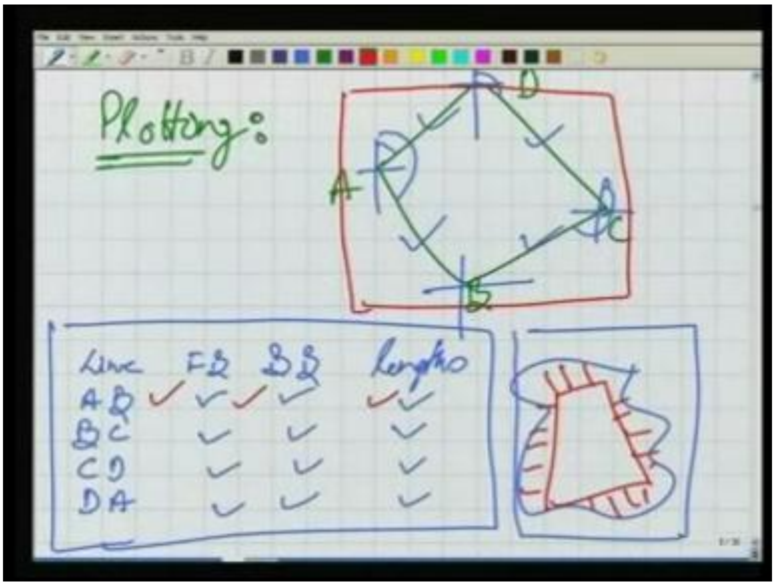
Well, once the traverse stations are done, the second job is, we start measuring these lengths (Refer Slide Time 18:18). I am now selecting a new survey grid - sorry, the traverse; now, we have these as traverse stations (Refer Slide Time 18:29). So, next job will be, we start measuring the length and as well as the bearing. How do we do it? We will start occupying from A, B, C, D and so on (Refer Slide Time 18:47). Occupying the station A - we occupy A, and then we measure the bearing of line AB, as well as, we measure the length of AB. Now, we go to B, we measure the fore-bearing of line BC and the back-bearing of line BA, and we measure the length BC; then we go to C, we measure the fore-bearing of CD, and the length - and the back-bearing of CB, and the length CD. So, what we are doing? At each survey station, we are taking the observations for fore-bearing and back-bearing, and as well as the length of the line. Again, whenever we are taking the observations, keep in your mind that we do not take only single observation; we should go for multiple observations. You take the bearings multiple times; you measure the lengths multiple times - maybe once from D to C, then second time from C to D, because we want to ensure that redundancy is there in the observations.

(Refer Slide Time: 20:00)



Well, once all these things are done, now we want to make a map of this (Refer Slide Time 20:04). So, whatever observations we have collected, our second job will be plotting of the observations.

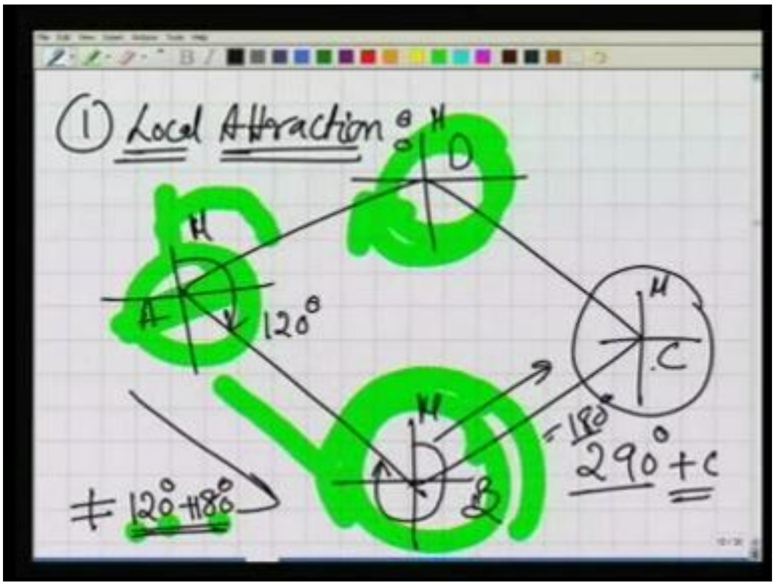
(Refer Slide Time: 20:15)



Now, before we plot what the observations will look like, let us say, for a small traverse ABCD (Refer Slide Time 20:24), where at each place, we have taken the bearing, as well as, all these bearings are measured, as well as the back-bearings and we have also measured these lengths. So, we can write this as - let us say the line lines are AB, BC, CD and DA (Refer Slide Time 20:52) - we can write their fore-bearing and back-bearing. So, the fore-bearing, whatever is the value, back-bearing of BA, whatever is the value - all these values can be written here, as well as, we are writing their lengths, whatever the unit - all these lengths are written there. So, this is what is the field observation - the table which you are getting from the field (Refer Slide Time 21:25), and whenever we work in the field, ensure one more thing, that we should always have a rough map of the area with us. So, in our note book, we have also a rough map. Just a rough map - that is my rough map (Refer Slide Time 21:38); this is how I had taken my ABCD, and then later on, because you are making a record of the area, so you are also observing the offsets and other things. So, right now, we are more concerned about only the traverse, because we already know about the offsets - how to take offsets, how to make use of them. Right now, we are concerned about the skeleton of the area; the traverse, which we are doing there. For the traverse, all these will be the observations (Refer Slide Time 22:13). Now, once these observations are there, what all we can do with these observations?

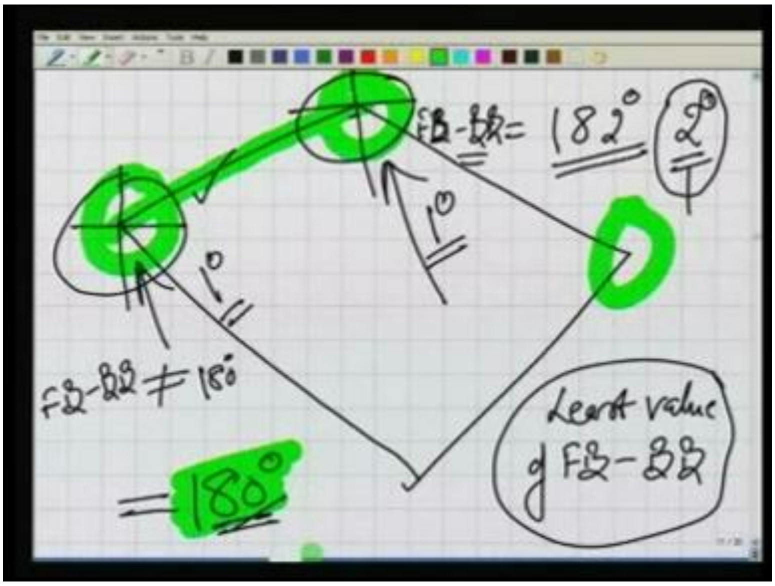
Number one: we need to look for local attraction before we go to plot. We cannot plot these observations directly, because these observations may be wrong; something may be wrong with these observations. So, we need to start looking into the errors. Now, here in this traverse, if some of the points - for example, let us say B point had the local attraction (Refer Slide Time 22:46) - if it had the local attraction, what will happen? For this line, as well as for this line - line AB and line BC (Refer Slide Time 22:53) - the difference of back-bearing and fore-bearing will not be 180, while if the line, or the station C and D and A, they are free from local attraction, the line AD and line DC will have the difference of back-bearing and fore-bearing equal to 180, or very near to 180, we can say. So what we do, from these observations, we find the differences of back-bearing and fore-bearing, and we will locate this difference. If this difference - as in this case, for AB and BC - the difference of fore-bearing and back-bearing is not equal to 180 (23:39), so we suspect, yes, at B, there is local attraction. Now, how to take care of it; how to eliminate this local attraction from the observations?

(Refer Slide Time: 24:01)



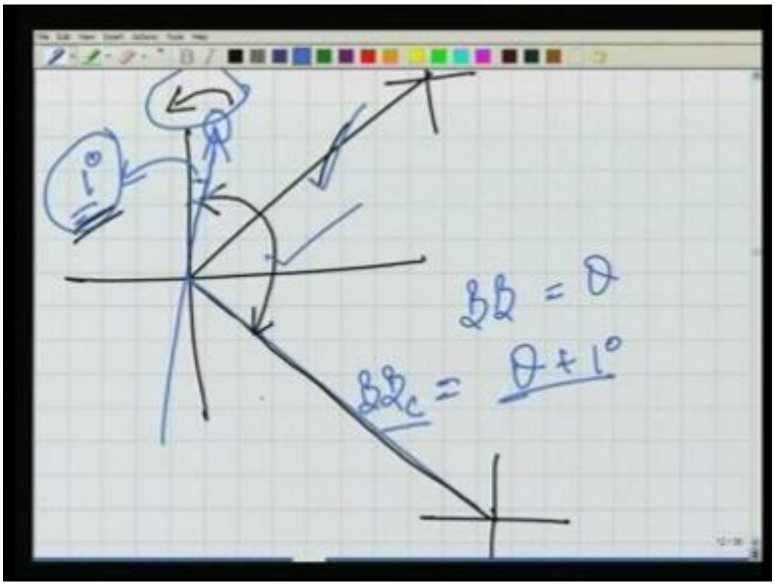
So, for doing that, we have to determine the quantity - what is the amount of the local attraction? A, B, C and D (Refer Slide Time 24:05)- these are the - this is north at every point (Refer Slide Time 24:15). Now, the differences we have found - let us say the difference in A and B - the observation of back-bearing, or rather, fore-bearing, because we are moving in this direction AB - this particular value is 120 degrees (Refer Slide Time 24:32), while this particular value here, the back-bearing (Refer Slide Time 24:41), is not equal to 120 plus 180; it is not so. Then, whatever is the discrepancy, that is the amount of the local attraction. And we know our A is free of the local attraction, because we found the difference of the bearing to line AD, which is the back-bearing of line DA, and fore-bearing of DA. This is the fore-bearing of DA, back-bearing of DA (Refer Slide Time 25:18) - the difference of these two was 180, so we knew that A and D are free of local attraction. So, whatever is the local attraction in line AB is because of station B and so, we can locate now if this difference of fore-bearing and back-bearing of AB is not equal to this particular value, 120 plus 180. So, whatever the discrepancy, that is, the error, at this point - at point B - what we can do? If, for example, the value observed at B was 290, let us say; just for example, we are taking that the value observed at point B, the back-bearing of line AB, was 290, so we will apply some correction to this, because we know the discrepancy - so, that amount of correction will be applied here. If we apply this particular correction here, the same correction should also be applicable for in this direction (Refer Slide Time 26:26), so this should make the difference of back-bearing and fore-bearing of line BC, again, equal to 180. This is how we are applying the corrections.

(Refer Slide Time: 26:44)



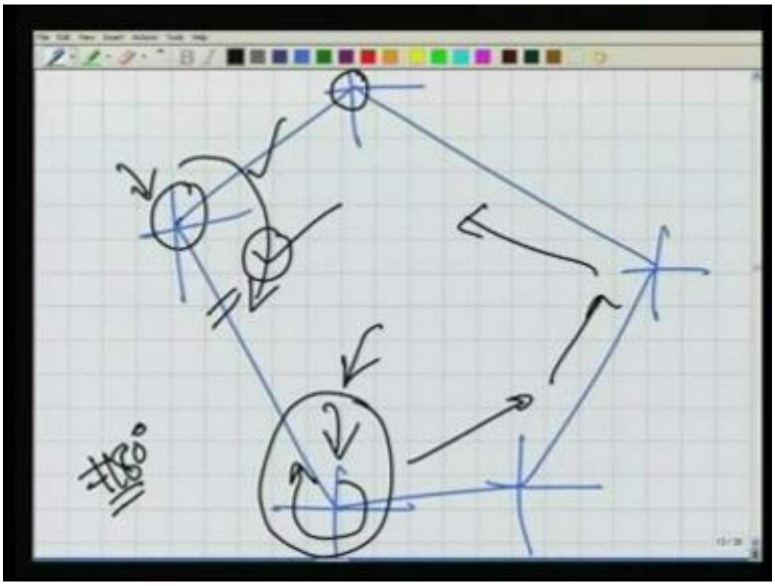
There is one more method - for example, let us say in a traverse, for none of the lines the difference of fore-bearing and back-bearing is 180; for none of the lines. In the earlier case, what we are looking for? We are looking for a line, any line, in our traverse, for which the differences are - the difference is - 180, and we assume that both the stations for that line (Refer Slide Time 27:10) were free from the local attraction, and then we applied the corrections to others. But this will not be the case always. If it is so; none of the lines is free from local attraction; there is some local attraction in each of the lines. What we look for? We look for the least value of this difference; least value of fore-bearing minus back-bearing - for which line this is least, because one of the lines it will be least. So, what we do, let us say for example, for this line (Refer Slide Time 27:50), this value is least, so we start applying correction from this line. If it is least for this, and the difference in back-bearing and fore-bearing in this case is 182 degrees; fore-bearing minus back-bearing - if it is 182 for this line, and this is the least; others are more - so what we do? We equally apply the correction. For example, the discrepancy here is 2 degrees, so we equally apply this correction to both these stations (Refer Slide Time 28:38). That means, we apply correction of 1 degree here and 1 degree here (Refer Slide Time 28:47). So, if we apply the correction of 1 degree here and 1 degree here, what will happen? Now, the difference of these fore-bearing and back-bearing will come out to be 180, because of course, we need to take into account the proper sign, because our aim is, we want to make the difference in fore-bearing and back-bearing of line - whatever this line is - 180, and we know it is not so by 2 degrees, and we are making assumption that we are going to apply the correction equally at this station and this station. So, we want to apply the correction equally, so we will take care of the proper sign, and by applying that, we are ensuring now after applying the corrections to the fore-bearing and back-bearing of this line, now if you find the difference, the difference is 180. Well, once it is done, we assume now, whatever is the fore-bearing here, that is correct; whatever is the back-bearing here, that is correct.

(Refer Slide Time: 30:01)



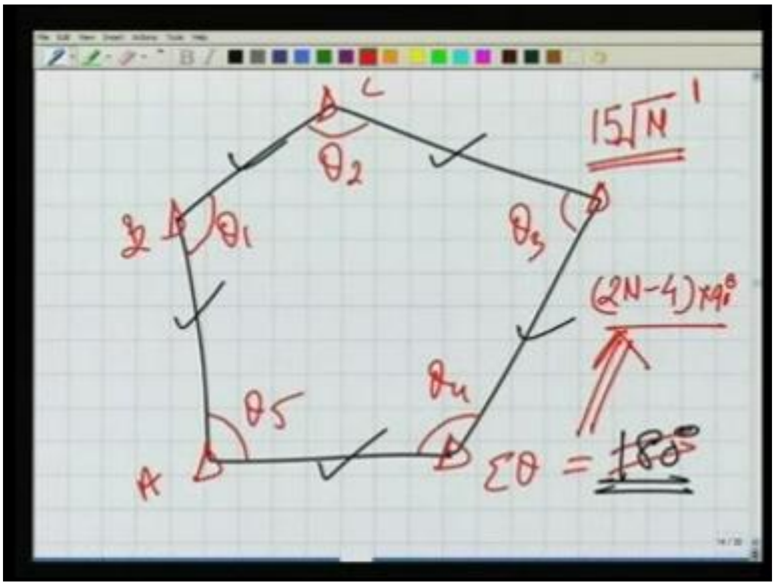
And whatever amount of the correction, for example, because of the local attraction the north was turned in this direction (Refer Slide Time 30:05), and this is 1 degree of error, and we know - as we have seen in the previous case, we had applied some corrections here - and we know it is 1 degree. Now, there is other line (Refer Slide Time 30:24), so the lines here (Refer Slide Time 30:29), these are the traverse lines. We applied the corrections for this one (Refer Slide Time 30:34), so this is also free of the local attraction here. Now, we want to apply a correction for this (ddd30:39). So, what we know, at this point, the north was required to be rotated this way (Refer Slide Time 30:45) by 1 degree in order to apply the correction - that is what we have done. So, whatever was the bearing observed for this line (Refer Slide Time 30:55), that will be the value - if I delete here, this small one (Refer Slide Time 31:02). Because we are - in actual practice, what we are doing, we are observing the bearing from this line (Refer Slide Time 31:09), which is in the north - or not north, rather, the magnetic needle is pointing in this direction (Refer Slide Time 31:18) because of the local attraction. So, we are taking observations - the bearing of this line - from here (Refer Slide Time 31:21). So, for this bearing also, we need to apply the correction as we have done the correction for this line (Refer Slide Time 31:29), because we know, at this point, the correction is in this direction, by this amount (Refer Slide Time 31:34). So, we will increase this bearing also (Refer Slide Time 31:38) by whatever is the amount, so, if whatever is the back-bearing, let us say the back-bearing value was theta, we will do theta plus 1 degree - that will be the new value; the corrected value. So, we have corrected back-bearing value for this line.

(Refer Slide Time: 32:00)



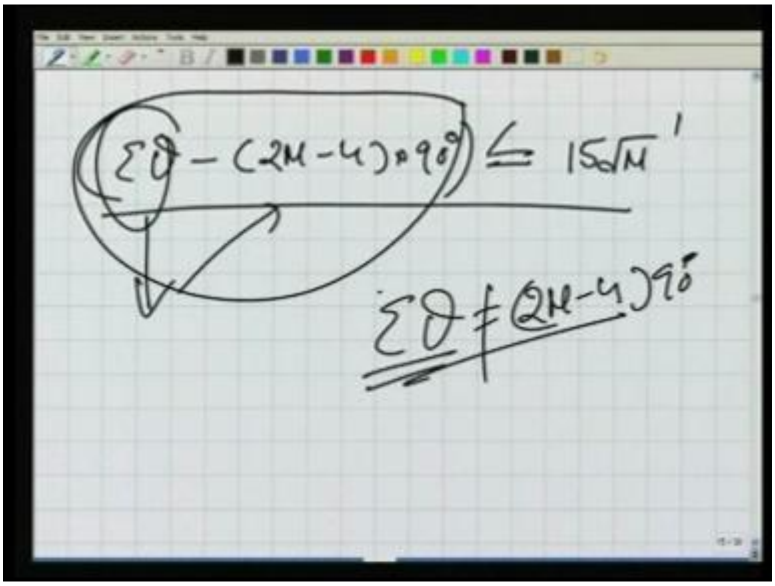
Once it has been corrected, we find the difference, from now, in a traverse. What we have done so far? We started from the least back-bearing minus fore-bearing line (Refer Slide Time 32:11), applied the corrections equally - this and this (Refer Slide Time 32:17). Well, now, we know the amount of the correction to be applied here (Refer Slide Time 32:21), so we applied that correction also to the bearing of this line at this point (Refer Slide Time 32:23). Now, whatever - after applying the corrections, we assume that this bearing (Refer Slide Time 32:33) is correct, because the correction has been applied. Then, we find the difference of observed bearing here and the bearing here (Refer Slide Time 32:37), and this difference will not be equal to 180, yes. If it is not equal to 180 we apply now correction only to this point (Refer Slide Time 32:52), because already correction has been applied here. So, we apply the correction only to this point. So now, we know what is the amount of the correction which we need to apply at this point, and then, so on - we keep going for all other points.

(Refer Slide Time: 33:14)



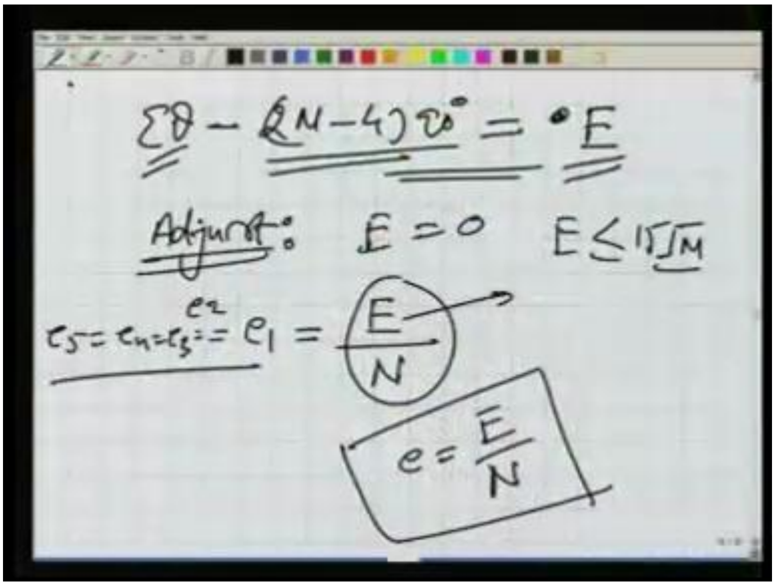
So, what we achieved by doing this? Finally, in our traverse, all these lines, the back-bearing and fore-bearing will differ by 180, and we assume that we have applied the corrections using this particular methodology. Once the corrections have been applied - this is our traverse - what next? After applying the corrections, we can determine these internal angles (Refer Slide Time 33:39), because if you know the bearings of all the lines you can compute these internal angles also. Well, there in the ground - this is a very important concept - all these are the traverse stations (Refer Slide Time 33:54). If you look there in the ground, there in the ground these points A, B, C are some physical points, and in the ground, if you draw a traverse passing through all those points, then is it closed figure, and sum of internal angles of that traverse should be a particular value, which we say that should be 2 N minus 4 times 90 degrees (Refer Slide Time 34:22). We know it for a traverse - ‘N’ is number of the lines here. So, for a close traverse - there in the field it is a close traverse; we know it is a close traverse. Now, once we can compute these internal angles - because using the bearings these internal angles are computed - then you will find sigma theta. Is it equal to 180 - sorry, is it equal to this particular value (Refer Slide Time 35:02) or not? If it is equal to this particular value or it deviates from this only by 15 and root N minute (Refer Slide Time 35:14), in compass surveying we assume it to be acceptable accuracy.

(Refer Slide Time: 35:30)



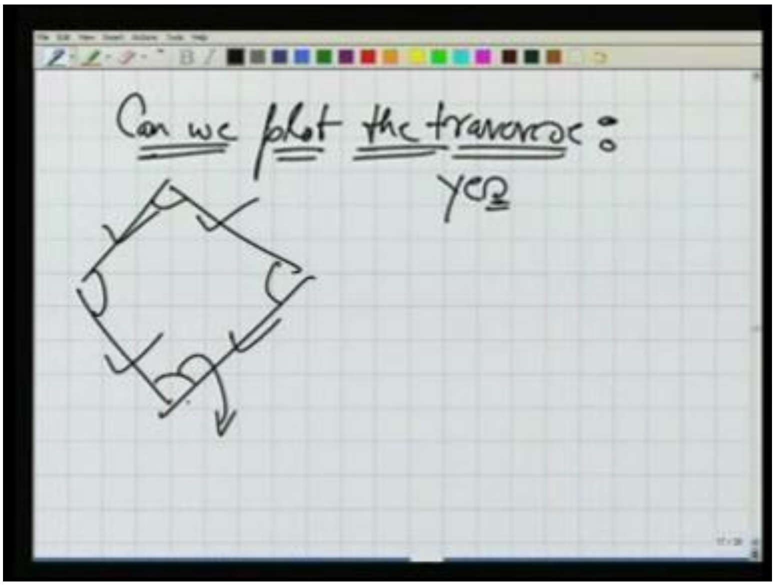
If the difference of - I will write it again, sigma theta minus 2 N minus 4 into 90 degrees - if this is - if this deviates from 15 and root N; this value is less than or equal to 15 and root N minutes; over here, this is in minutes (Refer Slide Time 35:50), so you convert this also in minutes - the survey is considered to be acceptable; permissible. However, it is not so. What does it say? Ideally, all these angles (Refer Slide Time 36:09) should sum to this particular value (Refer Slide Time 36:11), but that is not so. If that is the case, what we need to do, we need to ensure that our angles do sum to this particular value, because we have done a survey in the field, and the traverse there in the field is a close traverse. For that close traverse, this particular condition should satisfy; It is a close traverse, but what is happening here? Somehow, the angles which we have measured are deviating or having some errors, and the sigma theta of this is not satisfying that it should be equal to 2 N minus 4 into 90 - it is not satisfying this; these are not equal. So, what we need to do, we need to then apply the correction; we need to do the adjustment. Initially also, in our some previous lectures, we were talking about adjustment - adjustment of the observations - so, we need to adjust our observations.

(Refer Slide Time: 37:14)



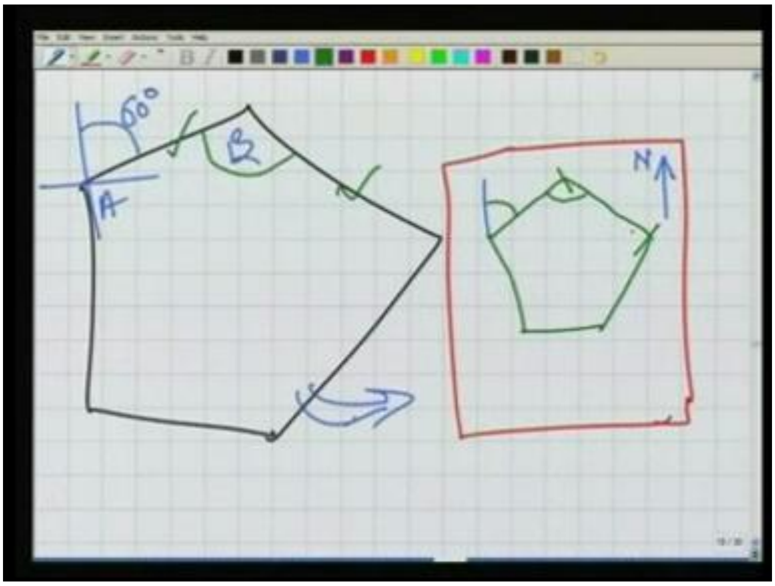
Now, how do we adjust our observations? Sigma theta minus 2 N minus 4… 90 - whatever is this value; is the total value, let us say I write it as capital E, so that is the total error. So, to apply the correction, what we do, we find the sigma theta and 2 N minus 4 into 90 - where N is again the number of the sides - and the difference of these two, let us say, is capital E. So, what it is? Capital E is the total error in angles, internal angles. How to adjust it? Basically, this E should have been 0 - in ideal case, it should have been 0 or very small. We say that E should have been less than or equal to 15 and root N for permissible case. If it is more, we are going to adjust, so the adjustment procedure is very simple: for any angle - let us say I write e_1 as the error in angle theta 1 - then, it can be written as the total error divided by number of the sides. So, what we are doing? Basically, this e_1 is same as e_5, e_4, e_3 and e_2 - all are same; we are equally distributing this total error in all the internal angles. There may be some other ways of doing it - you do not want to distribute it equally; you want to distribute by giving some weight - this particular angle needs to be given more weight, less weight and you want to distribute this e accordingly. So there will be a different model, but here, in this model, the error e is equally being distributed in all. And of course, when you are solving any numerical, when you are doing a laboratory exercise, you have to ensure that you are taking care of the proper sign, so that we want to satisfy this condition.

(Refer Slide Time: 39:26)



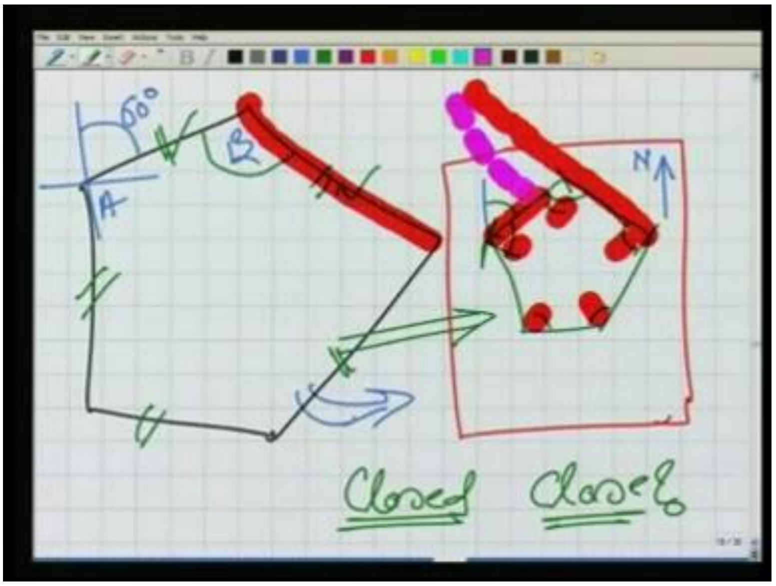
Well now, the next question: the error has been distributed; can we plot the traverse? What we have done so far? After taking the observations from the field, we came to the laboratory or our office, we have applied the corrections for local attraction by whatever the method we discussed - two methods - and as well as, we have now applied the correction in our internal angles. Well, yes, we can plot the traverse now, because what we have now, for any traverse, if you have all these lengths known (Refer Slide Time 40:01), as well as the internal angles known, you can apply the - you can plot it. How we are determining these internal angles? Because we know the bearings from there; because initially, we had measured the bearings - we corrected the bearings for local attraction, and then, using those corrected bearings, we found the internal angles, applied the correction for closing of the all angles or sum of all angles - we have applied the correction for that and now we can plot it. Whatever the method you can use - if you are using the CAD, you can plot it there in the CAD; you can plot it on your drawing sheet, because you know all these basic things.

(Refer Slide Time: 40:49)



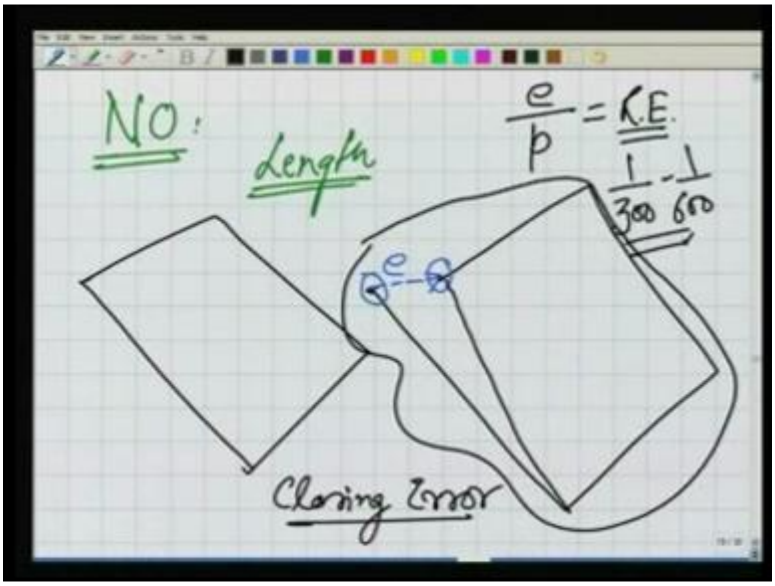
Starting from any point, let us say I can do one plot for you - there in the ground, the traverse was like this (Refer Slide Time 40:50), and here in my drawing sheet, I want to plot it, if this is my drawing sheet (Refer Slide Time 40:55). Why I am going to plot you - plot this thing for you? Because I am going to give you one more concept, or rather, a tradition; a standard. There in the ground, for this line (Refer Slide Time 41:10), for example, let us say the bearing was measured as 60 degrees. Now, I want to take this ground on my sheet. One thing we must always ensure whenever we are making a map: ensure that the map is such that, for that area, the north points towards top (Refer Slide Time 41:29). This is important; always, we should ensure this. Now, how we will ensure this? Well, we know the bearings of the lines. Let us say we take A and B lines, and the bearing of this line (Refer Slide Time 41:42) is 60 - so what we do? We start from a point using our rough sketch of the area and we say, well, the bearing of first line is 60, so we draw a line at 60 degrees (Refer Slide Time 41:59). And then, later on, we know this length of the line, so we cut that length of the line (Refer Slide Time 42:06). At this point, we know the internal angle, so we can plot the internal angle. Again, we can cut a distance after converting it to the scale, up to that (Refer Slide Time 42:16), and keep doing it, so that you have got a plot (Refer Slide Time 42:19). You can make use of the internal angles for plotting it, you can make use of bearings for plotting it; depending on how you want to do it.

(Refer Slide Time 42:33)



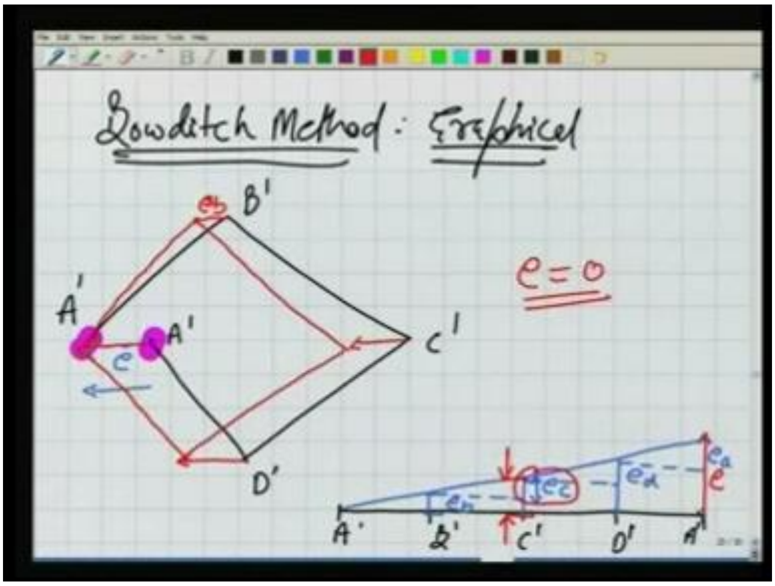
Now, the question is - a big question here, I have shown this plot to be closed - look at that - we started from here and we reached finally here (Refer Slide Time 42:36), so we say this kind of traverse as closed. Now, the way we are plotting it right now - will our traverse close? That is the question. Now, will it close or not, after doing the plotting the way we have done? We applied the corrections for angles - yes, our angles are now corrected - and sum of all these angles satisfy the condition there, where here in this case, if N is 5, we know the sum of these internal angles will satisfy the geometric condition of this traverse, but still, will our traverse close after doing the plot? The answer for this is, ‘no’. Why ‘no’? Because, so far, we have not applied any correction for length; we have applied the corrections only for angles, because there in the field, all these lengths (Refer Slide Time 43:49), they have some relationship to each other. While we are observing these lengths in the field, let us say we committed a big mistake in measuring this length (Refer Slide Time 44:01). Despite our all angles being correct now - obviously, adjusted now - our length has got error. So, what will happen? This line will come here, and this line will end here (Refer Slide Time 44:12), so our traverse is not closed. Closed means, it is not closed (Refer Slide Time 44:22).

(Refer Slide Time: 44:26)



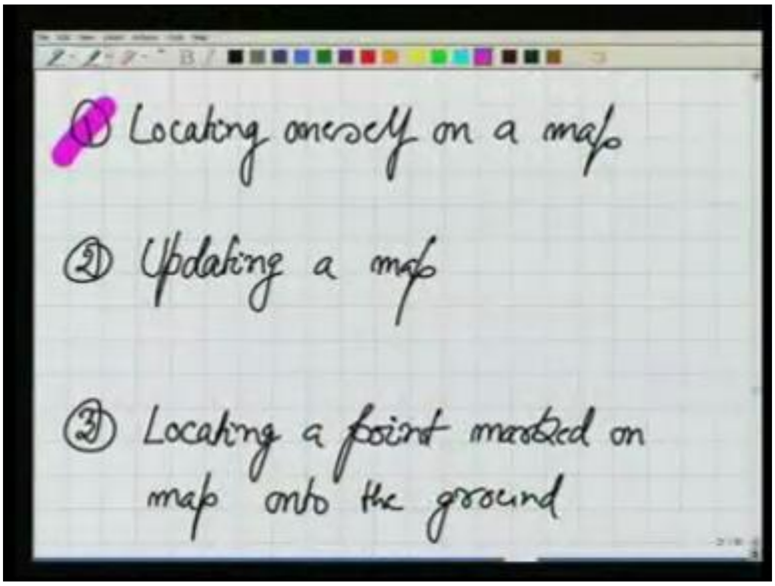
So, what we end up with? We end up with, for any figure in the ground - let us say that was the figure in the ground (Refer Slide Time 44:31) - what we might end up with, we might end up with a plotted traverse like this (Refer Slide Time 44:38). So, traverse is not closed, and there is an error ‘e’. So this error is called the ‘closing error’, and this ‘e by p’ (Refer Slide Time 45:05) - ‘p’ is the perimeter; perimeter of this traverse - is the relative error of the traverse. Generally, with the compass, we should be able to get a relative error of 1 by 300 to1 by 600. If we are careful, we should be able to - with the compass and chain or tape - we should able to get an accuracy like this, so we have to ensure, yes, if it is too bad, we need to recheck our work; we need to apply the corrections in all these. What the problem right now is? The traverse here is not closed - as you can see. Ideally, this point should have been here (Refer Slide Time 45:52). Then, the traverse would have closed something like this (Refer Slide Time 45:57), but it is not so. What to do next?

(Refer Slide Time: 46:00)



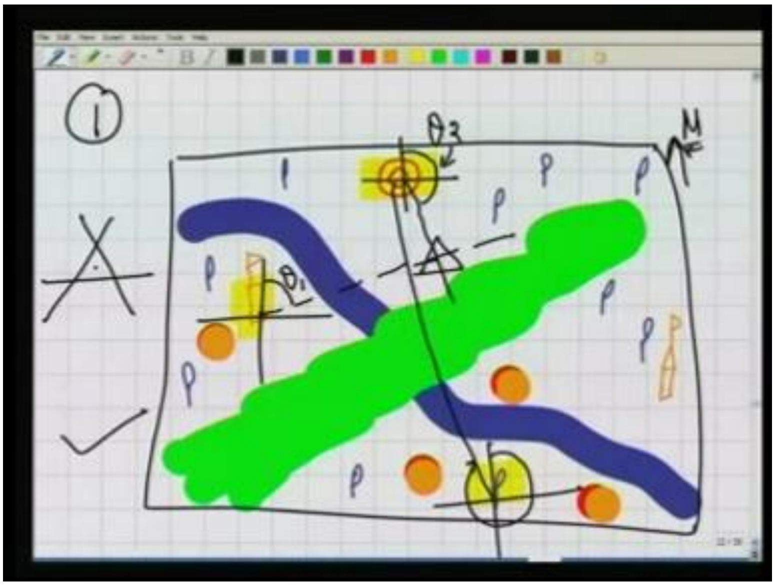
Well, next, we are going to look into a method which is called Bowditch method and also Graphical method, for applying correction for a condition like that. Now, what is this method? It is a very simple method, and as we were seeing, let us say this is a traverse which is not closed (Refer Slide Time 46:25). Now, because this traverse is not closed, we started plotting from here: A, B, C, D and A dash again (Refer Slide Time 46:39). Ideally, this A dash should have been at A dash (46:52), but it is not so because of the error. Now, how to apply correction for this? We apply the correction for this by a linear rule, and in that - I am drawing it graphically here - what we do? We draw a line equal to the perimeter of the traverse. So, for example, let us say we start from A dash, B dash, C dash, D dash and again A dash (Refer Slide Time 47:09). Now, the total error which is there - let us say it is ‘e’ (Refer Slide Time 47:28). Now, to apply the correction, it is a very simple graphical method, because mostly, when you are doing the plot and you do not have any computing instrument with you, you can do this correction graphically (Refer Slide Time 47:35). Now, this A dash to A dash is the perimeter of traverse; ‘e’ is the total error of misclosure. How to apply the correction? To apply the correction - because we are saying we are - assumption here is, we are applying the corrections as per the length; in proportion to the length. So, at B dash, the B dash should move by this amount (Refer Slide Time 48:15), which we say - let us say, e_b - error at B - because this is - you can see by the similar triangles here, as a simple linear rule. Now, the C dash - C dash should move, or the correction at C dash is e_c, correction at D dash is e_d and correction at A dash is e_a. So, what we do? We move this B dash by e_b amount, the B dash, and we move it again in the same direction as that of e (Refer Slide Time 48:56), because the idea is, we want to bring A dash on this A dash. So, to bring it, what we do, we move this by e_b (Refer Slide Time 49:10). Now, to move the C, because we see the C needs to be moved, or the correction is, e_c there. However, the point B has already moved by e_b amount, so the total correction at C dash will not be e_c; rather, from this point to this point (Refer Slide Time 49:33) - the total correction. So, we move it by this total value, again, in the same direction (Refer Slide Time 49:40). Similarly, D dash. So, finally, A dash moves by this amount (Refer Slide Time 49:50), and all these points are connected and the red line here is the corrected traverse, or the correction has been applied, and there is no closing error; e is 0 now. So, this is just a very simple linear method of applying the correction to our traverse. Now, we will see some applications of this compass surveying. Of course, one important application of compass surveying is making the maps or plotting the boundaries - all those things can be done by compass surveying.

(Refer Slide Time: 50:38)



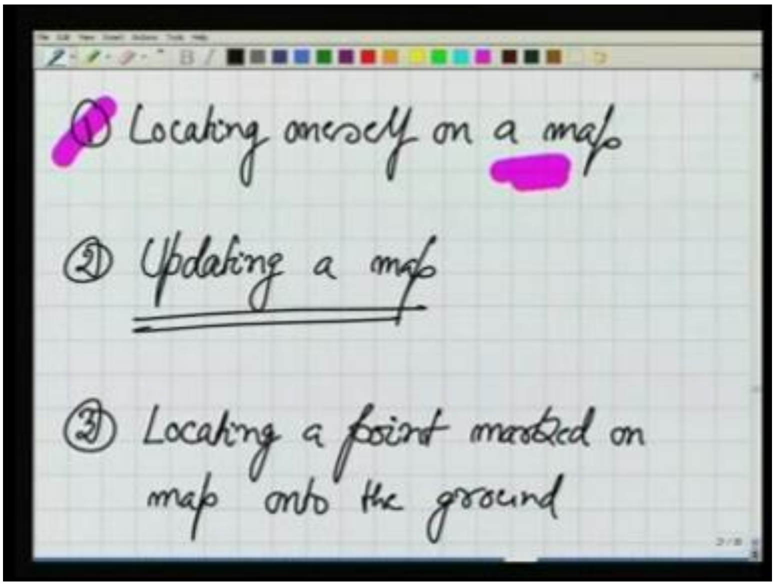
So, other things which we can do with the compass surveying: here, we will see in these different categories. Number one is: locating oneself on a map. So first, we will see this particular problem - what it is, locating oneself on a map. Let us say the problem is: I am given a map and with that map, I am there in the ground, somewhere; I do not know where exactly I am. The area may be forest or maybe a big field - I do not know exactly where I am on the map. I am standing on the ground with the map in my hand.

(Refer Slide Time: 51:12)



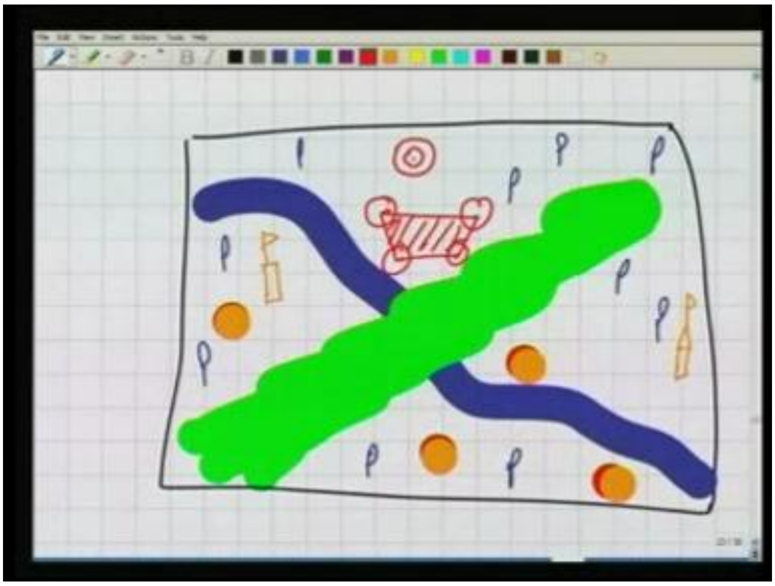
Let us say, well, as I have shown here (Refer Slide Time 51:16), this is a map, and this is the map which is given to us and we are somewhere in this area - somewhere; somewhere in this area, but we want to know where we are; we want to locate that point where we are standing on this map. How should we do it? As we know, maps always will point - north will be towards the top (Refer Slide Time 51:35). I am - wherever I am, I do not know, but I want to locate it. The procedure is, standing here, I first locate some permanent points there in the field, which are also plotted. For example, let us say I locate a temple or maybe a tower and a tree - these are three permanent things which I can see in the field. I can identify: yes, that tree is there, this tower is there or this brick kiln is there or this huge electrical or transmission tower is there - some of the things which can be located. Having done that, from the point where I am standing, I take bearing, using the prismatic compass, to these points. So, point number one, I have taken the bearing. Well, this bearing is the fore-bearing; wherever I am standing is the fore-bearing value of that. What I can do, I can compute also the back-bearing from that point to me by adding or subtracting 180. So, let us say that my first observation was taken for this point, and I found at this point the back-bearing was a certain value (Refer Slide Time 52:46). That is the value of the back-bearing (52:55) - I can draw a line on my map, because I know I did not observe back-bearing; I did not observe this theta value; rather, I determined it using the fore-bearing. Similarly, for some other object, I take the fore-bearing. Let us say it is - the object is - here (Refer Slide Time 53:14). So, at that object, I had observed the fore-bearing, and then I compute the back-bearing, and the back-bearing is this value - theta 2 (Refer Slide Time 53:19) - this is theta 1(Refer Slide Time 53:25) - and I draw the line, so the intersection of these two lines over here (Refer Slide Time 53:33) is the point where I am standing. Well, in order to ensure that we are doing it correctly, what we do, we observe to some other point also, let us say, this tree, and from this tree again, I find the back-bearing and draw the line (Refer Slide Time 53:43). Now, these three lines - I can show these three lines may not meet in a point but in a triangle. So generally, we take the centroid of the triangle to be the point where we are (Refer Slide Time 54:02). So, this is how we can locate ourselves in a map.

(Refer Slide Time 54:16)



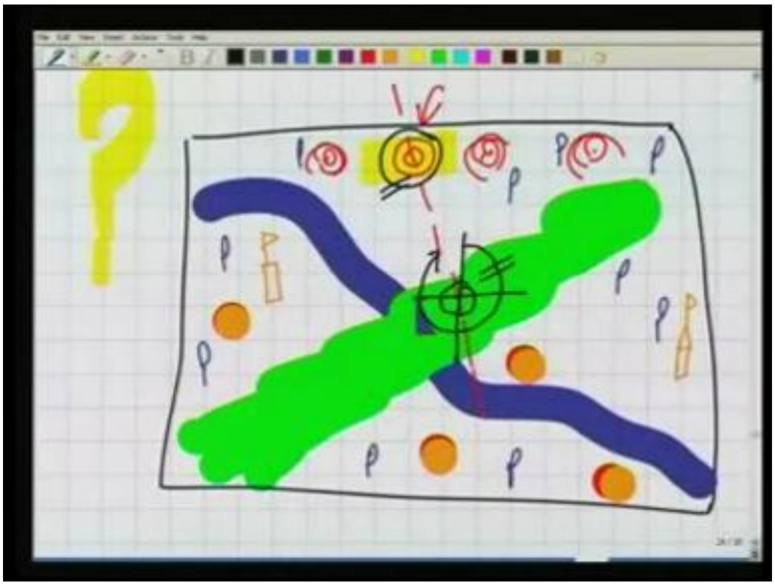
If this is the case, we can make use of this in order to update a map also. Updating means, we have a map, we go to the ground and we want to see what are the things in the ground which are new, but not appearing in the map.

(Refer Slide Time: 54:30)



If that is the case, for example, here, in this ground, we find there is a building, but it is not in the map. So, what I will do, I will stand on four corners of the building and locate those four points here (Refer Slide Time 54:41). How do I locate? The similar way. Wherever I am standing, I am trying to find that location using the back-bearing observations - or fore-bearing observations, converting them to the back-bearing - to three well-defined points and locating these individual points (Refer Slide Time 54:58) - the building is located.

(Refer Slide Time: 55:16)



Finally, we can also make use of this compass in another interesting thing. So far, what we were doing? We were locating ourselves. Now, what I want to do - in this map, there is something, let us say this particular object (Refer Slide Time 55:16). I am in the field with this map, and there in the field, I want to locate this particular object - where it is. I want to locate that point or this particular feature. Many times, this feature you can locate just by sighting also. Well, this is a very high rise tower; you can locate it easily, but if there are ten such towers - there are ten such towers here (Refer Slide Time 55:42) - you are confused; you cannot locate it just by sighting now. You are interested in this particular tower to be located - how to locate it? Of course, the idea will be: first of all, we will locate where we are. Let us say it is located that we are here at this particular point (Refer Slide Time 56:02). We will locate ourselves on the map - once we have located ourselves on the map by the method which we have just done, what we will do now? We will take the fore-bearing, or rather, we will - in our map, we will draw a line and we will measure the fore-bearing, at this point where we are standing, for this object (Refer Slide Time 56:19). If that is the value of the fore-bearing which we are computing from the map; we know it, that we are here, so we are computing this fore-bearing to a particular tower. Once we know this fore-bearing, next, our job will be using this prismatic compass, because in the case of the prismatic compass, while I am seeing through the prism (Refer Slide Time 56:55), I can see the graduations; the observations, as well as, I can sight the object. So, I keep rotating, I keep rotating, keep rotating till the observation or the reading here is equal to this fore-bearing value (Refer Slide Time 57:03). Once it is so, I am assured; I am sure now, well, this particular tower is in this line of sight. So then, out of those ten towers, whichever is in this line of sight, we will ensure that yes, that is the tower in which we are interested.

So, what we discussed today? We started our discussions with surveyors compass, then we started talking about the errors in the compass, most importantly, the local attraction. We also saw that how we can make a compass traverse - that is called running a compass traverse, how to write the observations, then, doing the computation. When we are going for the compass traverse, the steps: number one, reconnaissance - locating the points in the ground, the traverse stations; measuring the bearings; measuring the lengths of the line; coming to the laboratory and then looking for the errors- the local attractions; finding those points in the traverse where the local attraction is not there or least; then, applying the correction accordingly. After applying the corrections for local attraction, we apply the correction for internal angles - they should satisfy a geometric condition. Having done that, we plot the traverse, and after plotting the traverse, you will find that the traverse is not closed. Then, we see whether the work which we have just performed was as per the accuracy required or not. If it is not, we might redo the work, or if it is, we will try to adjust the errors. So again, we use the Bowditch method for adjustment of the errors. We can apply the correction that way; our traverse will be adjusted. Well, we also saw some of the applications of the compass, which you know: compass is very useful in military, in adventure sports - people use the compass whenever they are going out, in order to locate themselves in the map; in order to locate a point which is there in the field onto the map. So, all these things require to be done in order to also locate something which is in the map onto the ground, where it is. All those questions can be answered with the help of the compass.

Thank you very much.