GPS Surveying
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Lecture - 15
Quality Assessment of GPS Surveying (Position & Baseline)

Welcome friends! Today I am going to discuss on quality assessment of GPS surveying. As you know that during GPS surveying we do collect GPS observables, which are being processed to get the position of points and base line. Now, the position what we have derived out of GPS observable or and the baselines that we have got from the GPS observable, whether that is meeting our specification or not; that means, whether these parameters has achieved the standards that we are looking for the particular project or not, that has to be assessed and that assessment is called the quality assessment.

Now, in order to asset that quality we need to know first what are the different standards that we follow for GPS surveying, then on the basis of the standard, then we have to compute some measures which will be tested on the basis of standards to find out the quality or standard of the GPS surveying.

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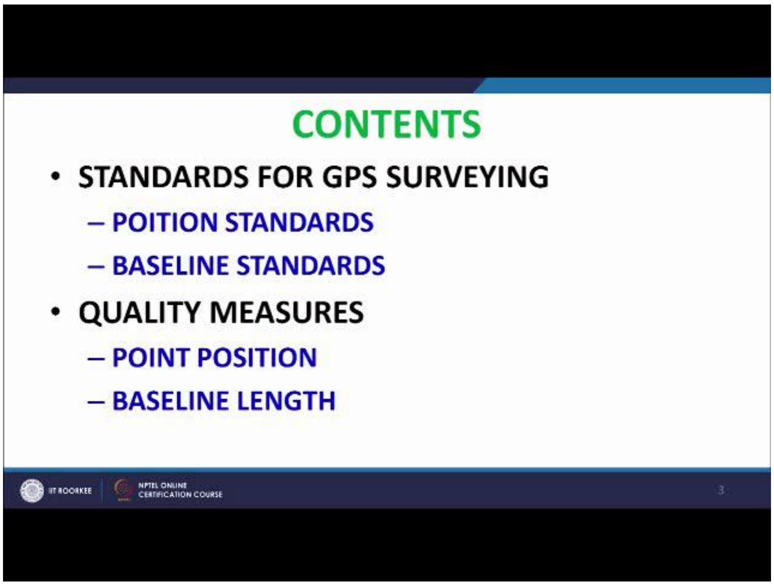

So, in this class we will be talking on; first, we will talk on the standards of GPS surveying and followed by the quality measures that we will compute to identify the standard of our surveying or quality of our surveying. Now, the standard of GPS surveying is being defined by the root mean square error, for position. And, it is the parts per million for the baseline.

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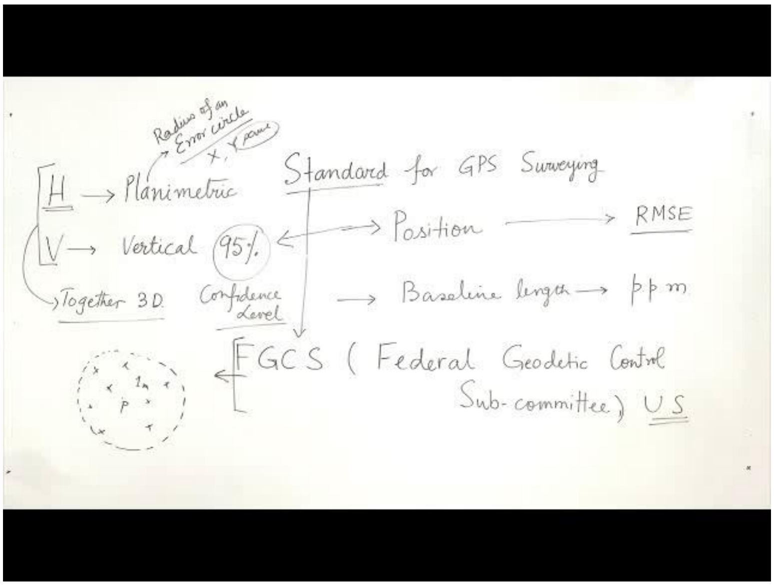

So, GPS standard for GPS surveying is defined for position and baseline length. And, the position is defined by the root mean square error and, length by parts per million. Now, these standards may vary from organization to organization, from country to country. There is such, no such unified standard available all about the world. But, generally we consider the standard defined by FGCS; Federal Geodetic Control Subcommittee. This is the organization that is available in US. So, there standard, we are considering in GPS surveying as a standard. Now, the FGCS has defined the position standard, in terms of root mean square as it is written. That is, they have defined the horizontal and vertical, actually the position may be planimetric, for planimetric position (Refer Time: 04:32) for horizontal standards and may be independently vertical or we may sometimes go together as the 3D position.

Now, FGCS has taken 95 percent confidence level. Now, what is this? Actually, if we know this is the position, true position, then the observed position should be 95 percent within the standard that has been defined. Suppose, we have defined that now for FGCS, for the planimetric, they have defined an error ellipse; reduce of an error circle or an ellipse; error circle. Let us say the component in X and Y is same.

So, now suppose this is the true position of any point, now, and if suppose 1 meter is the error, permissible error, radius of the error circle is 1 meter. So, if we draw a circle of 1 meter around the true position P, then the observed position in 95 percent cases should be within this circle. Then, we will say that this set of observation follows the standards which we are looking for.

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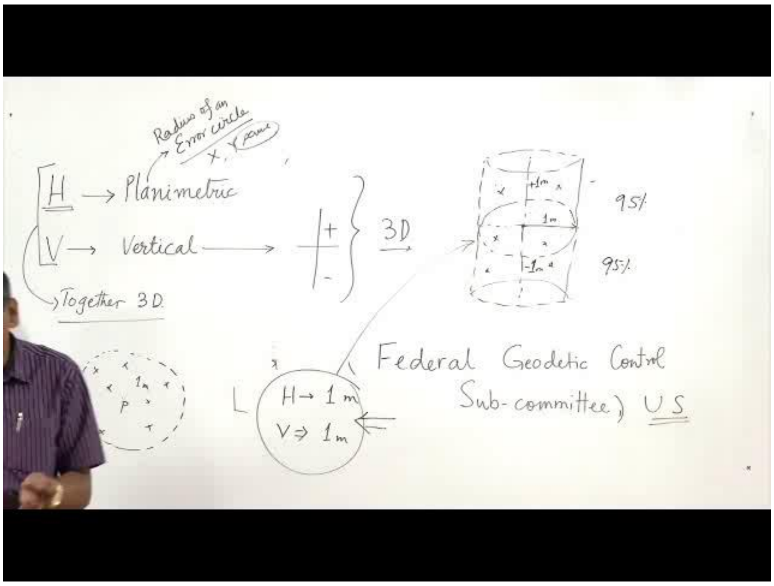

Now, in case of vertical we do define one, a line, uncertainty line, so plus minus this. So with this the 3D, for 3D, we define a cylinder. Suppose, this is the point, so around this point, this is the error ellipse and this is the height uncertainty.

So, we will get a cylinder like this; that means, if our true position is this, then we will; our set of observation of which 95 percent lies within this cylinder. Then, we will say that that set of observation has met this standard has required by our project. There is an example for our project horizontal accuracy, we are looking for. Suppose, 1 meter planimetric accuracy and vertical accuracy, suppose also we are looking for 1 meter. So, in these cases we will (Refer Time: 08:09) a cylinder having this radius 1 meter, and your one meter above and one meter below this line. So, we will have a cylinder having height of 2 meter and radius of 1 meter.

Now, if we have a set of measurement which we, if see that all of them are within this, at least 95 percent of them are within this cylinder, then that set of observation are meeting these criteria. If less than 95 percent are not within this or if less than 95 percent is within this, then we will say that this set of observation is not followed our standard, so we will be need to take better set of observation, so that that condition made by this two (Refer Time: 09:13) standard. So, that is about the positioning standard and as per this FGCS consideration.

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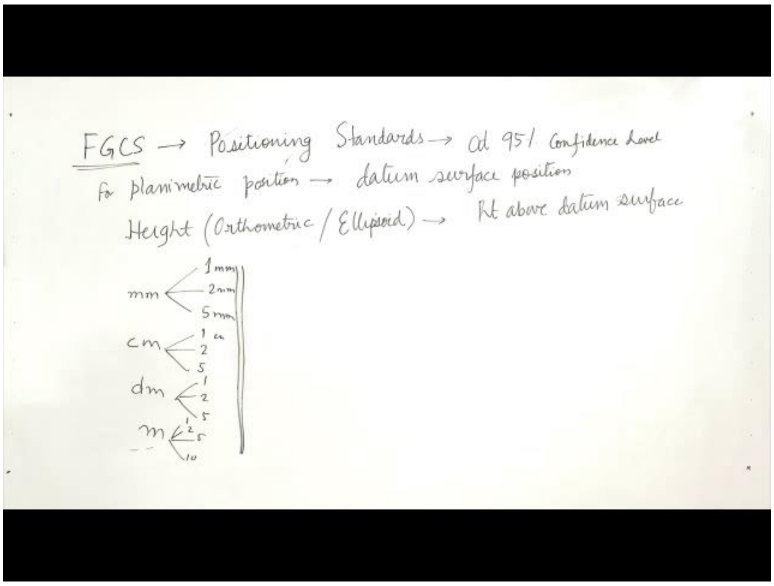

FGCS positioning standards, which is considered to be at 95 percent confidence level and, for planimetric position the position we considered at the datum surface, datum surface position. And, for height may be orthometric height; that means, height above geoid or it may be ellipsoid height. So, height above and height, it is height above datum surface. Under this consideration, the FGCS has defined four categories of millimetre standard, centimetre standard, decimetre standard and meter standard.

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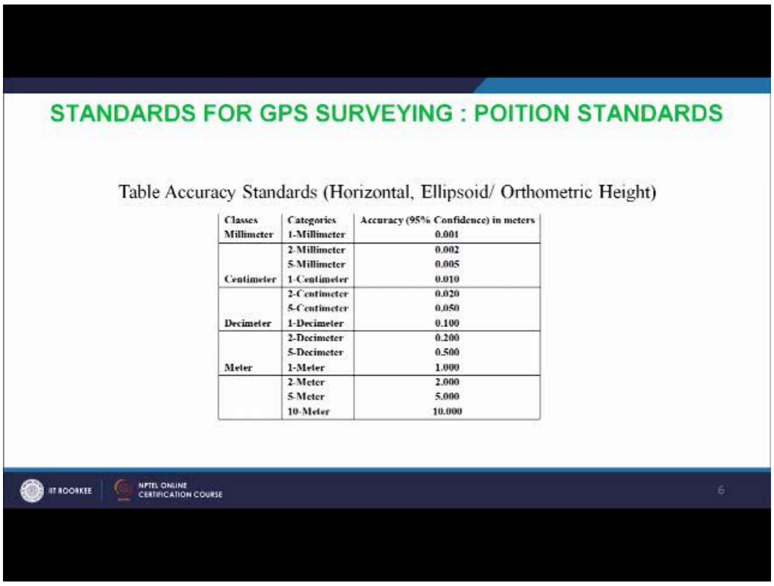

Classes	Categories	Accuracy (95% Confidence) in meters
Millimeter	1-Millimeter	0.001
	2-Millimeter	0.002
	5-Millimeter	0.005
Centimeter	1-Centimeter	0.010
	2-Centimeter	0.020
	5-Centimeter	0.050
Decimeter	1-Decimeter	0.100
	2-Decimeter	0.200
	5-Decimeter	0.500
Meter	1-Meter	1.000
	2-Meter	2.000
	5-Meter	5.000
	10-Meter	10.000

So, out of these again they have decided to have three. Under millimetre, 1 millimetre, 2 millimetre, 5 millimetre, like that. You can see here that centimetre 1, 2 and 5 centimetre; decimetre: again 1, 2 and 5 centimetre and meter: 1 meter, 2 meter, 5 meter and 10 meter.

So, centimetre: again 1, 2, 5 centimetres; decimetre: again 1, 2, 5, but in meter it is 1, 2, 5 and 10 meter. So, this is the way how they have given the standard. This is what for the point position.

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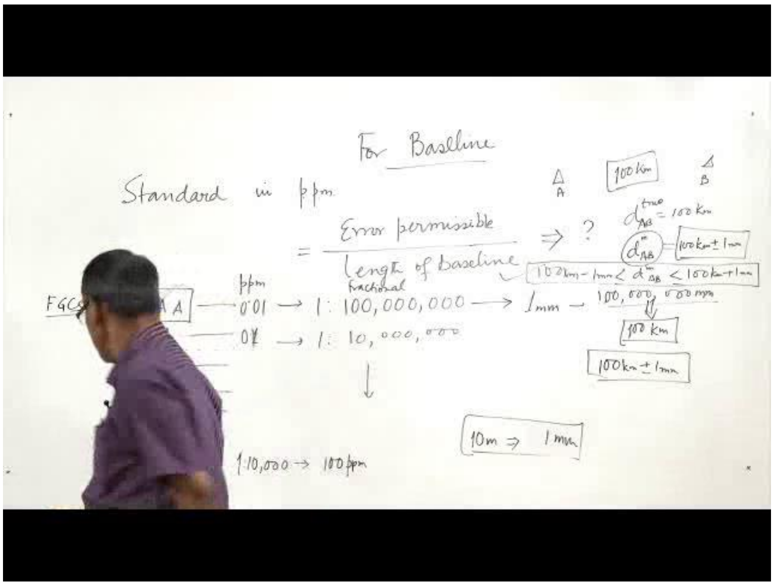

Next, for baseline, the standard has been defined; standard has been defined parts per million. Now, how it is being we got? It is the error permissible divided by the length of baseline. So, this is the value which we have to get. And, we have to see this value is what is amount, and that should be compared with this standard. Again, FGCS has defined seven standards. And, they have termed this as order; like A A order, then A order, B order, C-1, C-2-1, C-2-2, then C-3.

So, now each of this having the parts per million as given in the table that 0.01 part per million or we can say one is to (Refer Time: 13:34). Similarly, if we say this is the parts per million as a fraction, that is, one is to like this. We can get all about detail, here in this table.

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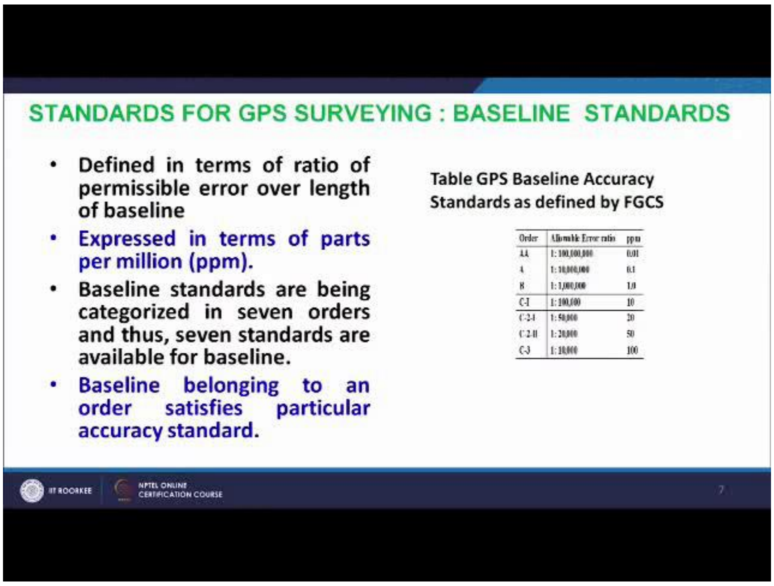

Now, what is this actually? Let me explain; that means, if the baseline is order A A, then we will allow an error of 1 millimetre in measuring a distance of 1, 00,000,000 at the millimetre. So, in measuring a distance of this millimetre, we will allow error of 1 millimetre. Now, this means 100 kilometres.

So, if we measure a baseline of having length 100 kilometre, and if we end up with a solution which provides at error of 1 millimetre; that means, our measurement length can be plus minus 1 millimetre. So, the measured distance between the two stations, if the actual distance between the two stations A and B is 100 kilometre. The distance between A and B is 100 kilometre. That is the true distance. And, if we measure the distance between A and B and we get the distance measured 100 kilometre plus minus 1 millimetre, d is equal to this; that means, d AB; d measured A B should be (Refer Time: 15:55). So, if we get these things the measured distance is equal to or more than this or equal to or less than this, then we will say that d, our measurement, is of the order of A. So, for the baseline we got is A order, similarly, for other orders.

So, there we can see 1 is to 10,000 C-3, which provides an error of 100 parts per million; that means, if we measure a distance of 10 meter, we may allow an error of 1 millimetre. In measuring a distance of 10 meter, we are allowing an error in measurement of 1 millimetre. That is what is called C-3. Now, with this background with the standard of GPS surveying, now we want to find out what is the quality of our GPS surveying.

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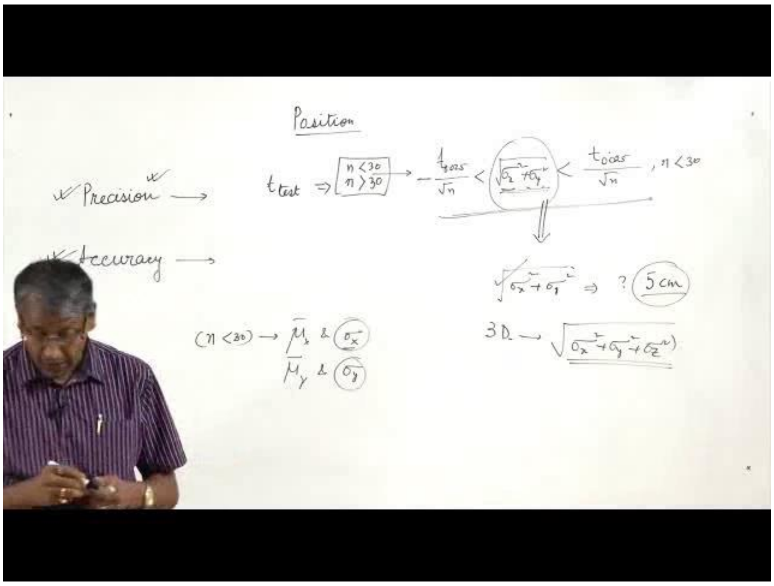

So, in order to do that we need to know two parameters - one is called precision; another is called accuracy. Now, if we have the true value of the position or the length of the baseline, then we can go for accuracy measurement. But, if we do not have the actual value of the position or the length of the baseline, then we should go for precision. Now in case of position, the precision will do test by using the t test. And that will depend upon number of observation. If it is less than thirty or more than thirty, depending upon that we should follow these relations that t zero point zero two five is called root of n square root of sigma x square plus sigma y square t, this is minus, and n is less than thirty.

The meaning is that now sigma x and sigma y are the standard deviation of the measurements. Suppose, we have taken n measurements which are less than thirty, so, of all these measurements we will get the mean and standard deviation. So, sigma x and mean in y direction, sigma y. So, these sigma x and these sigma y is this, and is called square of, and is called root mean square error. So, this is root mean square error of the observed data. And that should be; that should lie within this. So, if this is, if the observations satisfy this condition, then we will go for test of this with standards.

Now, we will see what is the value of, this is square plus, what is this value of this? Now, if it is, suppose we have this thing as 5 centimetre, then as per our previous definition that it will be under the category of 5 centimetre.

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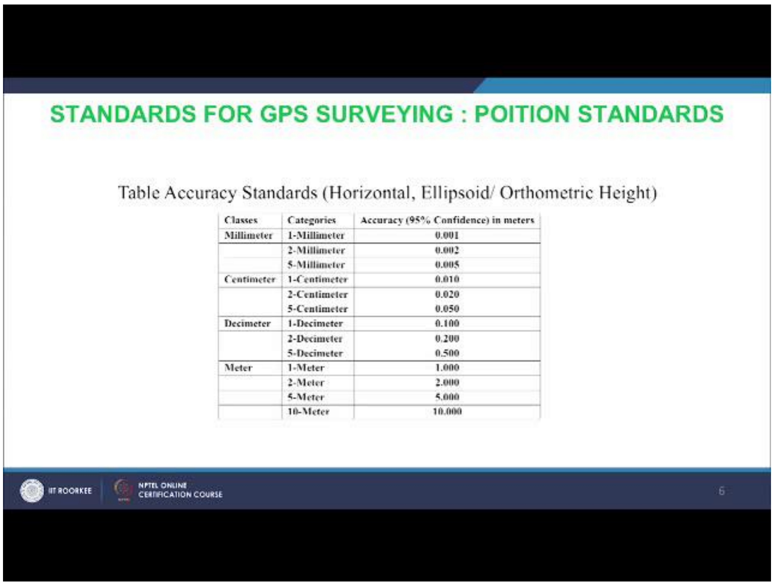

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So, we can say that this is our accuracy or this is the standard of this. So, depending upon this value we will be telling it that. But before that, we have to satisfy this. Similar to this, if the number of observation is more than thirty, then we have to use this formula.

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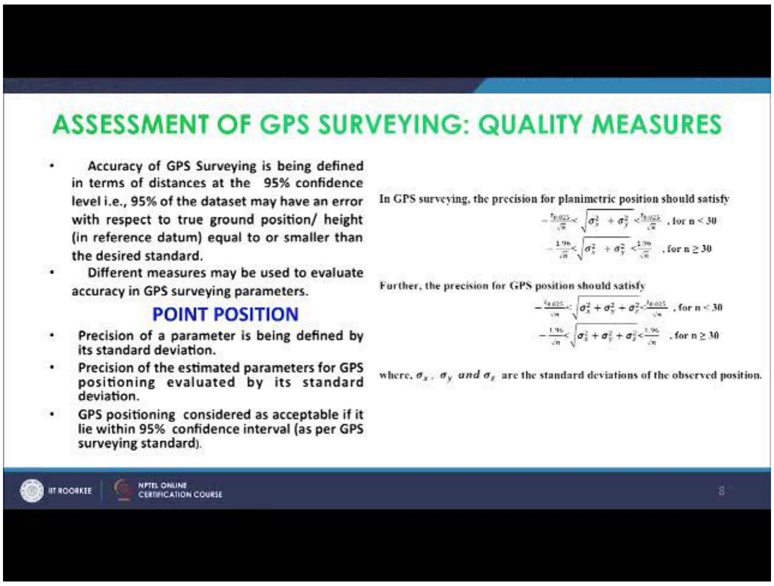

Now, this is for two dimensional cases. Now, if we see, if we want to find out the three dimensional position, so instead of these we have to take the root mean square error of X, Y and Z. So, this is the root mean square error of X, Y, Z position of the observed location. And, we have to see this test saying what we done.

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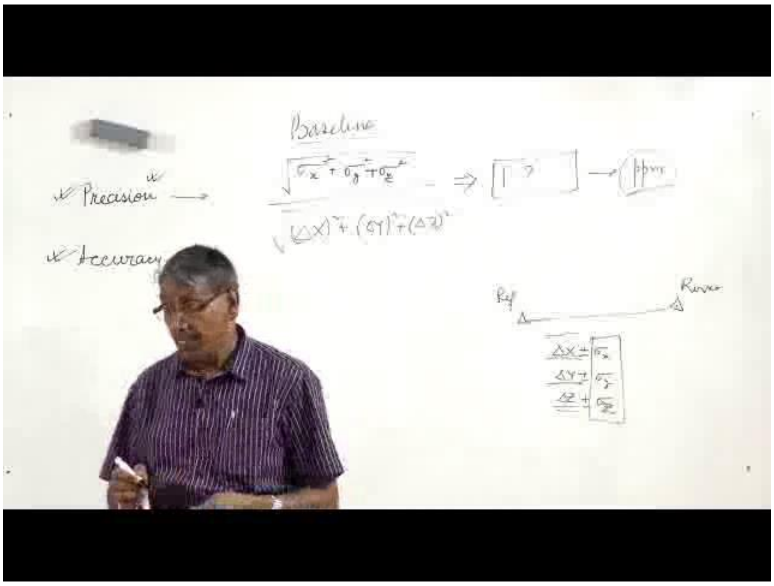

So, in this way first we have to see that we should test first the precision, further it satisfy the fundamental criteria, then we can categorize it to the category of a standard. Now, in case of baseline we do find out the value sigma X square, sigma Y square, sigma Z square. Now, as you know that one will go for GPS surveying for a baseline. So, we will get del X, del Y, del Z; that means, if it is the reference, this is the rover. With respect to rover about this baseline, we will get along with that. We will get (Refer Time: 22:00). So, these are the standard deviation of the parameter del X, del Y, del Z, with respect to baseline; with respect to baseline.

So, in case of baseline we have to take the ratio of this and square root of del X, del Y, del Z. So, this will provide us some value; one is to something, some value; that means, and that we have to convert it in terms of parts per million. And, this we have to check with the standard that is there with this. And, depending upon this value we can say which order baseline is this one. So, this is on the basis of precision measurement of the baseline.

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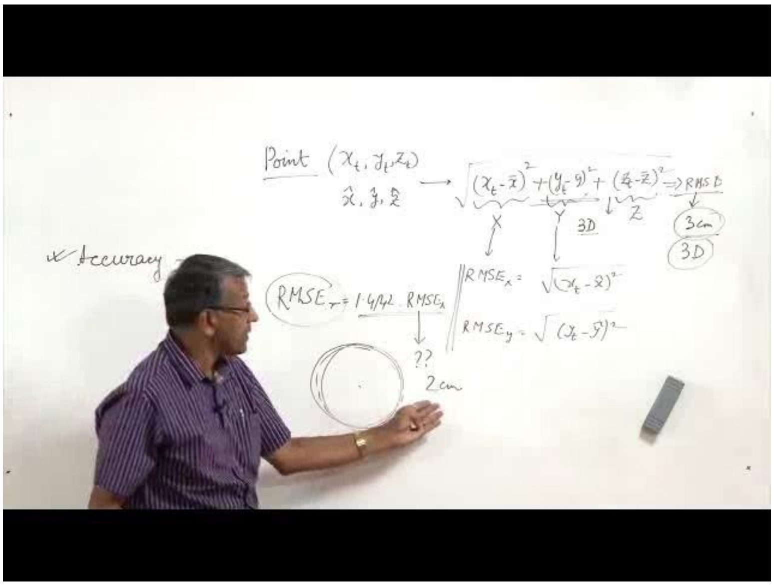

As I told you that accuracy measures we will be taking and we will know the true values of the position of the points. Suppose, a point is having x t, y t, z t is the known point. Now, and the observed value for that is x bar, y bar, z bar. Then, we will have x t minus x bar square y t minus y bar square z t minus z bar square root. It is the root mean square error of the point.

Now, we have to see what is the value of this with the; now, for, this is the three dimensional position. And, for two dimensional positions it will be; this is for only x direction, this is for y direction, this is for z direction. So, it, we call it root mean square error x. This is this part; x t minus x bar whole square. Similarly, root mean square error y t minus y bar square, like this. Now, then we may define condition. In some cases, we may assume, we may allow in our work, root mean square in x should be equal to root mean square in y direction. Then, it is the circular error. In that case, the amount of error, root mean square error will be equal to one point four one four two root mean square error in x direction or in y direction.

So, ultimately it is the radius of the circle, which is defining the error circle; that means, now this value, now we have to see what is this value. Depending upon these value, suppose it is 2 centimetre, then from our chart we can say 2 centimetre means this is our standard of our measurement. So, in this way we do, we can compute the, we can see what is the standard of our GPS surveying. Now, if it is this value, this is root mean square of z, (Refer time: 26:00). Suppose this is 3 centimetre, then we can say that three dimensional standard is 3 centimetre. If the, this value is 2 centimetre, then we can say planimetric standard is two centimetre. In this way, by comparing this table and computing in this way, we can say what is the standard of this GPS surveying.

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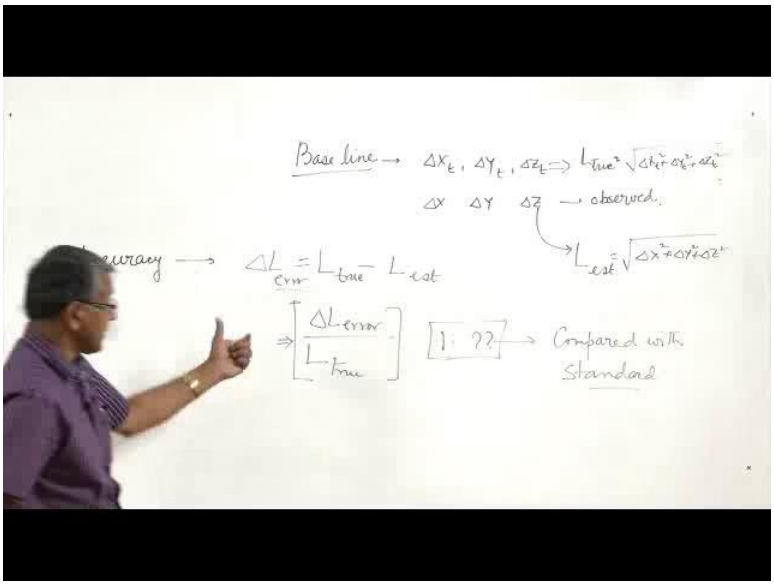

For base line; suppose, we know this is the component of the baseline and true component along x direction, true component along y direction, true component along z direction. And, suppose del X, del Y, del Z are the observed component. Now, from this we will be getting L estimated which will be equal to del X square plus del Y square plus del z square. And, this is the true L, length true which is del X t del Y t.

Now, this L true minus L estimated is the error in observant length. And, this error divided by L true provides us the value one is to how much. And that is to be compared with the standard table to know what is the standard measurement of the baseline measurement; in this way how we can get the standard of our survey work. And, if we find that the standard that we have found after measurement is meeting the specification of our GPS surveying project objective has been achieved. Otherwise, if the project objective has not been achieved; that means, if the standard that we have found is less than what we are looking for our project, then we have to repeat whole our surveying work and we have to improve our measurement to achieve this standard with project demands.

So, in this way actually baseline can be analysed in two different ways. One is called fixed baseline analysis; another is called repeat baseline analysis. In fixed baseline analysis, only one base line, single baseline we will take only once. And, we will do this analysis. In repeat baseline analysis, we will take observation of the same baseline repeatedly for two, three times. And then, we will go for this part of estimation. And, we will see whether our baseline standard is meeting the project objective or not.

With this, I want to conclude. But before conclusion, I want to summarize that the GPS surveying parameters should be assessed in order to find whether our GPS surveying meet the objective of the project demand or not. To test the quality of GPS surveying parameter, that is, basically the position and the baseline, we need to first know the basic standard that is available. In general, that is, varies from place to place or organization to organization.

However, the FGCS standards may be taken as the general standard. In order to; and the FGCS has considered the 95 percent confident level as the basis for its standard. And for point position, it is the root mean square error. And, for the baseline it is the parts per million, which has been taken as the standard to define the standards. And, to test the quality of the GPS surveying we need to measure the precision or accuracy, depending upon the availability of the true value or not. And that has to be compared with the standards that are being defined. And from that comparison, we will be able to judge whether the GPS surveying has met the quality that is looking for the particular project.

We will be meeting in the next class; which will be on procedure for GPS surveying, first part.

Thank you very much.