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

Module - 2
Lecture - 1

Basic Concepts of Surveying

Okay, hello! So, we are here in our second video lecture which is on basic surveying. Now, here it is what we have done already.

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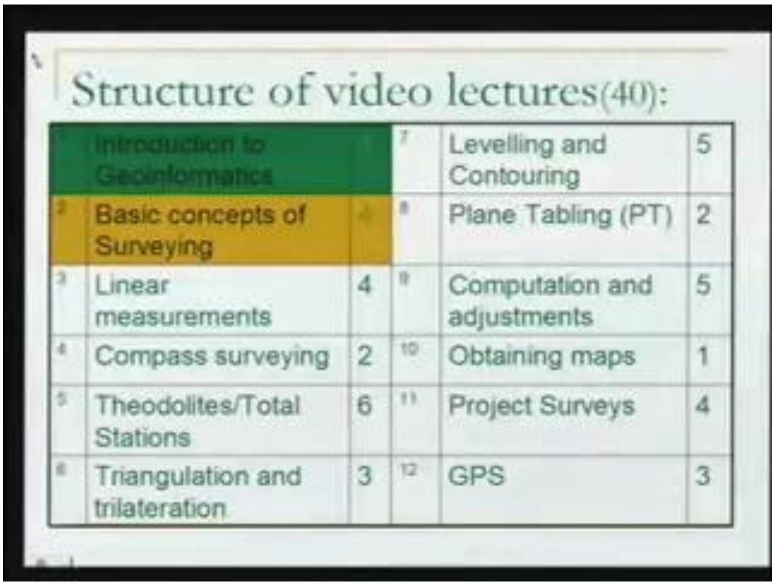
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I would like to go through this every time in all our video lectures so that we know where we are. We have already discussed ‘Introduction to Geoinformatics’. When we are talking about the geoinformatics we discussed that geoinformatics has got basically two components: component number one is measurement of geoinformation and component number two is management of geoinformation. Now, geoinformation is everything; whatever is there on the surface of the earth, slightly below, slightly above, is the geoinformation. So, we want to measure it. In measurement of geoinformation also, there are two aspects: number one, you want to locate where it is - that means the XYZ coordinates of the earth’s features. Number two, you want to identify what the geoinformation is - whether it is a house, tree or what. Well whatever the information has been collected, we wanted to manage it so that we can come off with fruitful results out of the geoinformation. So, that was the thing which we discussed last time.

Then, we looked into various tools which are used for measuring geoinformation. For example, we looked into the conventional way; primitive way – hand, rod. Then we came into the development - we talked about the land surveying. The earlier way the land surveying was used to be done. Then we talked about the electronic surveying. Well, there was some problem when we want to do the surveying, because we have to occupy the ground. So what we looked into? We looked into that, we need to do it in such a way that we can do it fast, even for those areas which are not accessible. So, what we did in that case? We flew using an aeroplane - or you may remember the example of the pigeon fitted with the camera in the belly and they would fly in the enemy terrain, take the photographs. So the photographs which you say 'aerial' photographs - they may be overlapping, so it is possible from these photographs that we can generate three dimensional model of the ground and using those models, what we can do, we can measure XYZ. You can also identify from the photographs the object; what the object is. Well, in the case of the photography, there were problems: we have to go and fly every time; it is a costly affair. So people have started thinking something more: can there be something which is flying every time, up there in the space, and is observing the earth?

So, there came the satellite remote sensing, and we have seen the how the satellite remote sensing developed from 1972, when the observation started commercially. So now, there is a leapfrog jump in terms of the spatial resolution - there are data now which are available in half a metre resolution, which is very good - we saw some examples also. And using the satellite data also, we can do what we want to do in geoinformatics, that is: we can measure XYZ, we can identify what the object is.

Well, one more tool which we discussed was the GPS. With the GPS, wherever you go with the receiver, you know your position. Well, I am standing here. From here, my receiver observes the satellite, it measures the distances, computes its position in a coordinate system. So, wherever I am, I will know my position using the receiver.

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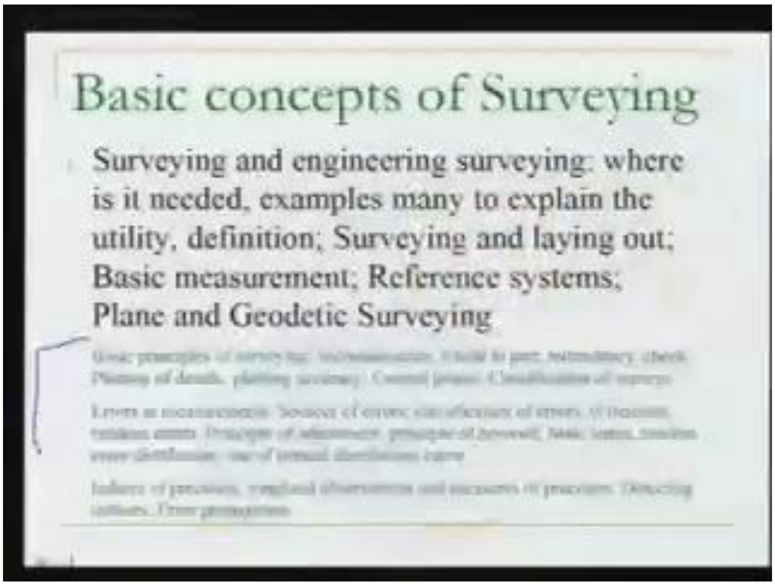

So what we are going to do today, we are going to talk about the another module, which is: 'Basic Concepts of Surveying'. So, this is our module number two. This module will have four lectures, and in these four lectures, we will talk about this (Refer Slide Time 4:28) later on, while today, we will talk about these (Refer Slide Time 4:31) in this first lecture of module two, which is: surveying and engineering surveying, why we need it, examples that why we need it, then some definitions. We would also like to see the difference between terms 'surveying' and 'laying out', then some basic measurements, what are the reference systems, plane and geodetic surveying. So this is all we will try to cover in this present lecture.

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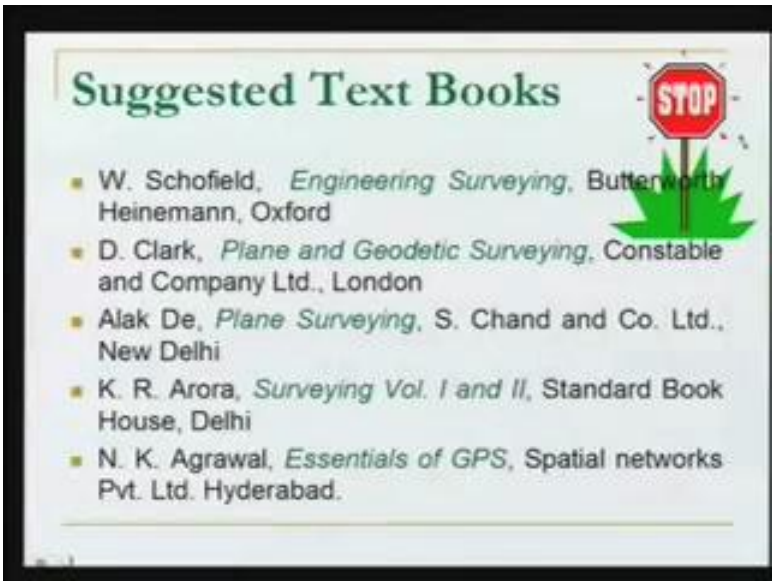

Before I go further, I must give you the text books and the reference books which I am referring, and you can also go to your library or you can purchase some of these books from the market. You can stop your video here so that you can note down these names properly. These are the lists of the text books.

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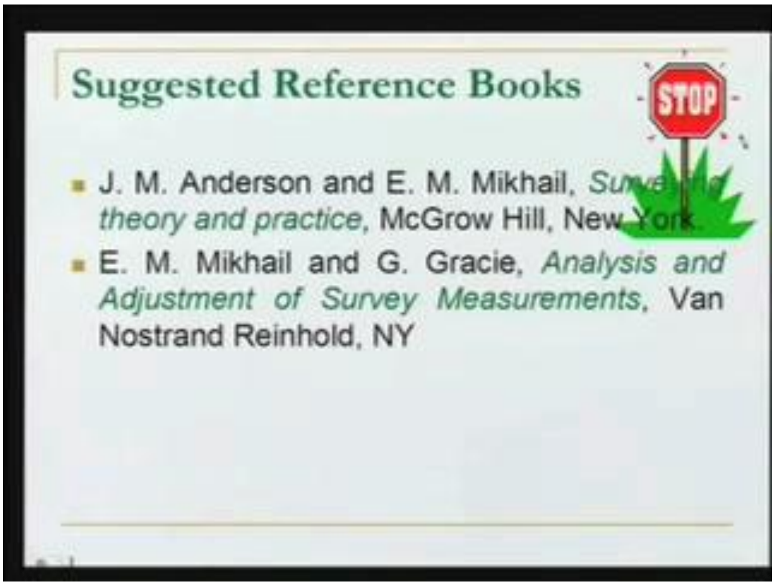

Some more books which are the reference books. You can again stop your video here and you can note down the names of these reference books.

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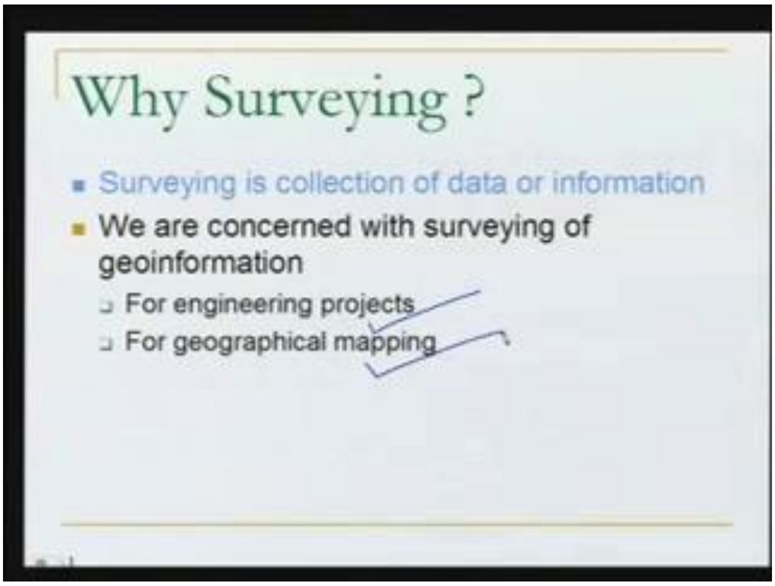

Well, so we begin the lecture number one of module two now. Well, we will try to see - because we are basically talking in this video lecture about the surveying - so we should know ‘why surveying?’. To answer this: surveying as a term - the literal meaning of the surveying is ‘data collection’ or ‘information collection’. We all do it, in any field. So that is the dictionary meaning of surveying. As such, we - the engineers - why we are concerned with surveying? Whether it is civil engineer, mining engineer, or whether apart from the dealing in the geography, ideology and environmental engineer - anything - how we are concerned with the surveying? Our concern is, we would like to do the surveying basically for engineering projects, as you can see in the slide (Refer Slide Time 6:29), or maybe for the geographical mapping. So, that is our concern of the surveying.

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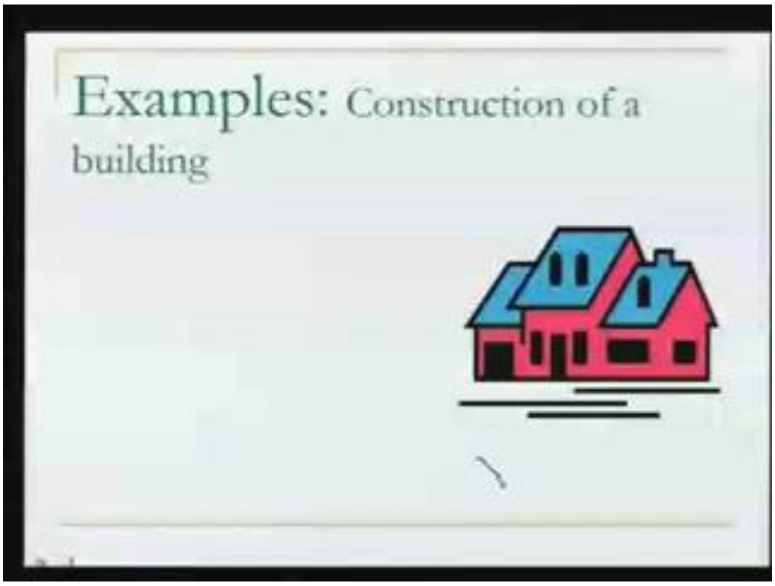

Well, I will give you one example - this example will explain that why we need surveying. Think of a house; we want to build a house, all of us. This is a very, very common thing - in many common sense, the answers can come, if you just think: you have to build a house. What are the steps? What do you do? Let us assume that it is a big building, okay- a college building, a huge building. We want to build those big buildings, what should be the steps?

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Number one, very important: there has to be a site. We need to select a site. Then number two: we go to the area where the site has been selected and we want to know what the topography is. How is the topography - is this a sloping surface; is this a flat, plain surface? Are there any rivers or, small channels, or is this an undulating topography? Where are the trees, where the adjacent houses, where are the fields, what is the natural landscape - we need to know about this.

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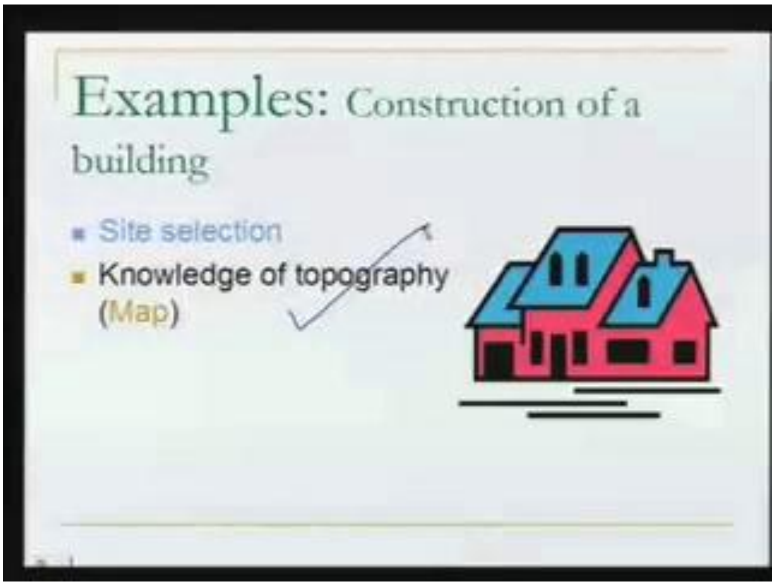

So, we need to know the knowledge of topography. So, this knowledge of topography and also - trying to write here in a single word – map. We need to make a map of the area and then, once we have made a map, what do we do?

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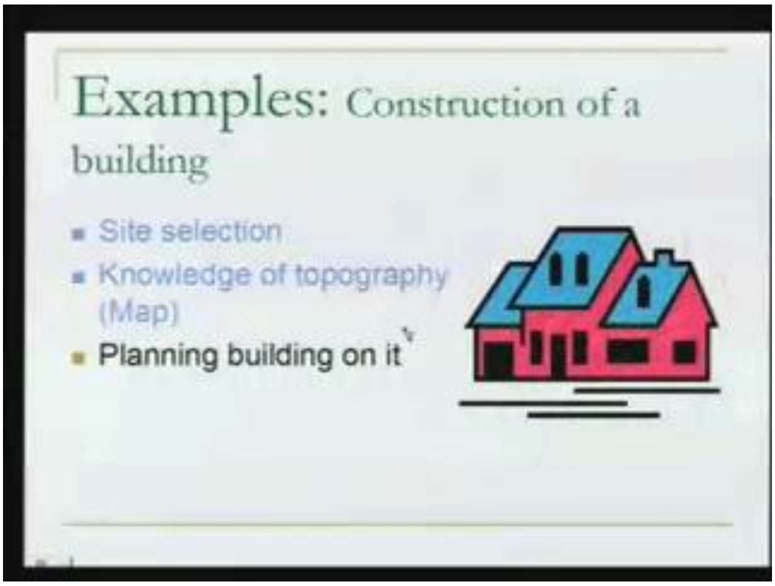

This is very important - of course, you know it - you have to plan a building; a big building. Do you go to that area itself and start planning the building? No; what we do, we will make a map and take the map into a laboratory in our office, and then we sit with the map and we start planning the things. In planning, the things we take care of: well, we should not damage the adjacent landscape; we should not obstruct the adjacent channel network; we should not destroy, the forest, which is very precious. We want to plan in such a way so that our requirements are met, as well as, the natural landscape is kept as it was. So finally, what we do - working on that map, we will plan our building. Well, now at this stage, you have planned the building on your map - what to do now?

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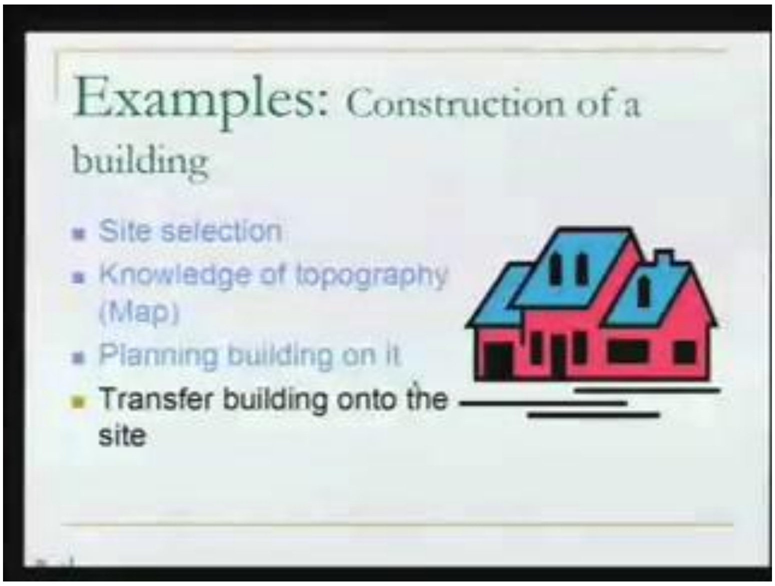

Think of the ground - the ground is still like that! Just virgin, natural ground. Trees, fields, river networks - just like that. There is no building as such so far. But whatever you have planned on the map has to be transferred on to the ground. So this is where, actually, we need to transfer our building onto the site. Now, throughout this exercise, where all we require the surveying? You should think about that, we require surveying in order to make a map. We wanted to measure the geoinformation which is present there in the terrain. Then, we came to the office, we planned the building, now we again require surveying to transfer the map or the plan which we had done at the office to the site. So this is also where we will need surveying.

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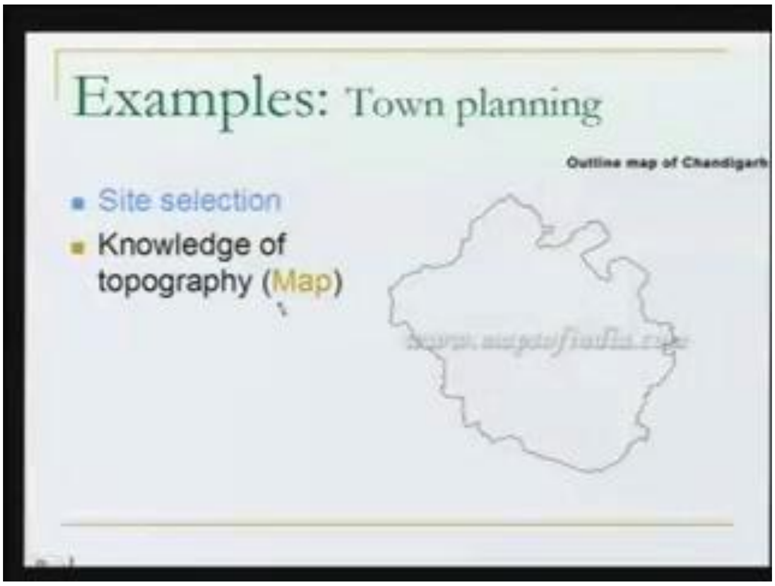

Well, another example I would like to give you - and this is an example of town planning -and for that, I have chosen the town of Chandigarh; we know it is a very beautifully planned town. What I mean in this case - in order to plan a town, what we need? First of all, we need a site. So, the site for the Chandigarh is, for example, as shown here in the map. Initially, when the town was being planned, what was there in that site? No town, of course. There were fields, villages, rivulets, maybe some roads - that is it, nothing more than that. So someone going to this area - what he needs to do? He needs to know the topography, because if I give you a task - you have to plan a town - and that virgin area where the Chandigarh is established now, you have to plan a town in that, and I put you there. Can you plan the town, there in the ground? No, you cannot, because while we are in the ground, we cannot see the entire area of Chandigarh in one view. So, it is not possible you can plan the town there itself. What we need to do, we need to bring that area, some way, into our laboratory, and this is where we need to make a map.

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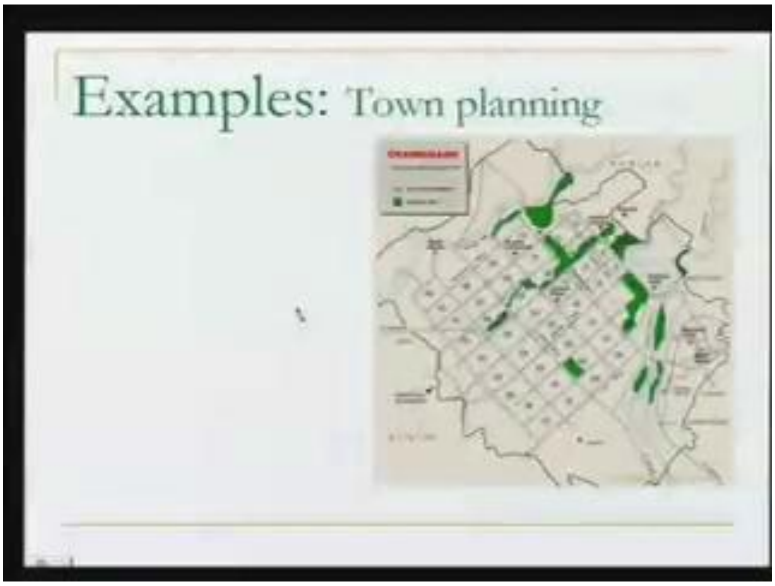

Well, the map of the area may look like – if you just forget for a while these roads here – so, just forget these roads, okay; just think of the river, this natural landscape, some more rivers, the lake here – so, this is what was there in the area before the town was planned.

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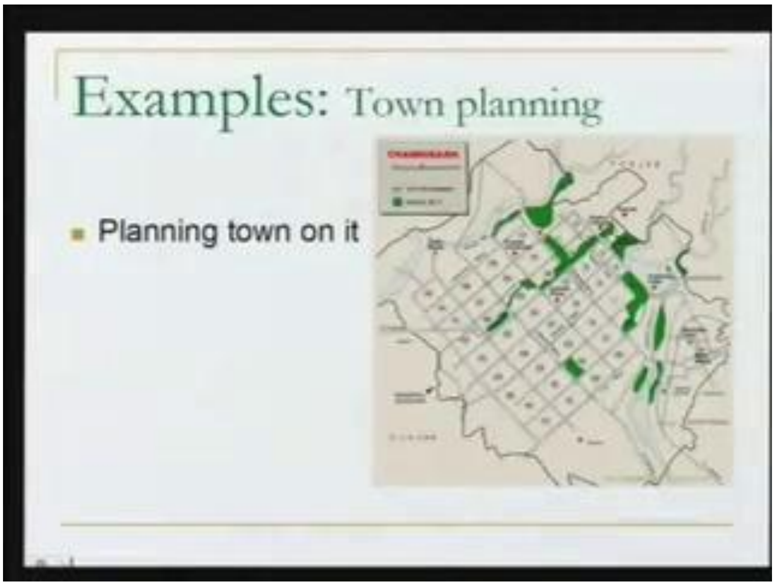

Now this map was given to a town planner. He worked over the map, he found what could be the best possible network of roads, or the town planning, for this area. So the town planner, he sat with the map and he planned: we want to have our road in this particular pattern. So the roads here are in the gridiron pattern, and the town was planned like that because it was found that the town planned this way will be the most optimal planning for the particular area. So, the natural landscape of the area is taken into account, okay: where the rivers are, that has been taken into account; where the lakes are, that has been taken into account, okay; and where the roads - which are coming into the town, if at all they were there at that time - it has been taken into account. So, this particular job, we cannot do there in the ground itself; we need to bring ground into the laboratory.

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Well, having planned the town, again, the same thing: now the town is planned in a map, as you can see here (Refer Slide Time 13:01). Here, in this map, the town is planned. Still, there in the ground, there is nothing. The ground is still, same - some rivers, villages, agricultural fields – that is it; there is nothing on the ground. So what we need to do now - the last thing? We need to transfer this gridiron pattern - or we can say, the town - there on the ground. So there also - this transfer the town onto the ground - we need to do the surveying. So now you know, in this exercise also, where all we required the surveying.

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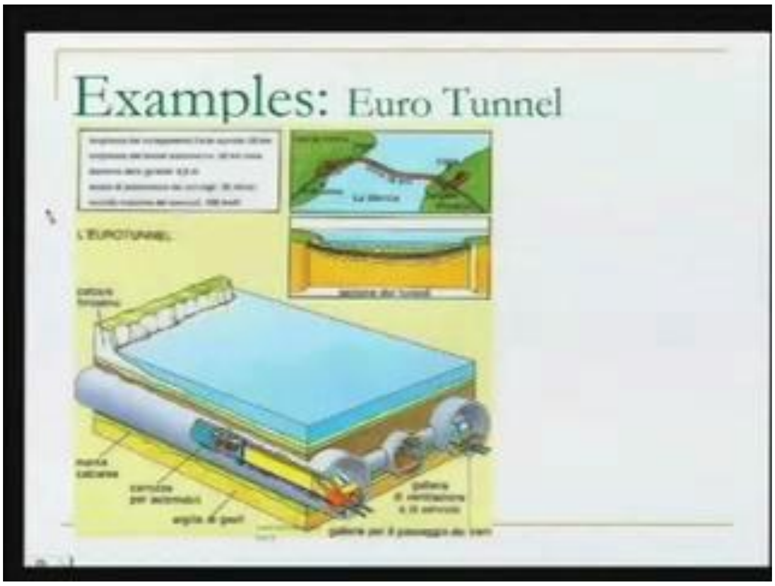

So another example where we need surveying – now, this is one more example here, this is very, very interesting example - and this is the example of Euro Tunnel. As you can see here - you may be knowing also - this Euro Tunnel is a tunnel between United Kingdom and France. It starts from the Folkestone and goes to the Calais. Now, it is very interesting ((seeing)) (00:14:11) structure. Why it is so, because this entire tunnel is underground, or you can say, undersea. Up here is the English Channel, as you can see (Refer Slide Time 14:17).

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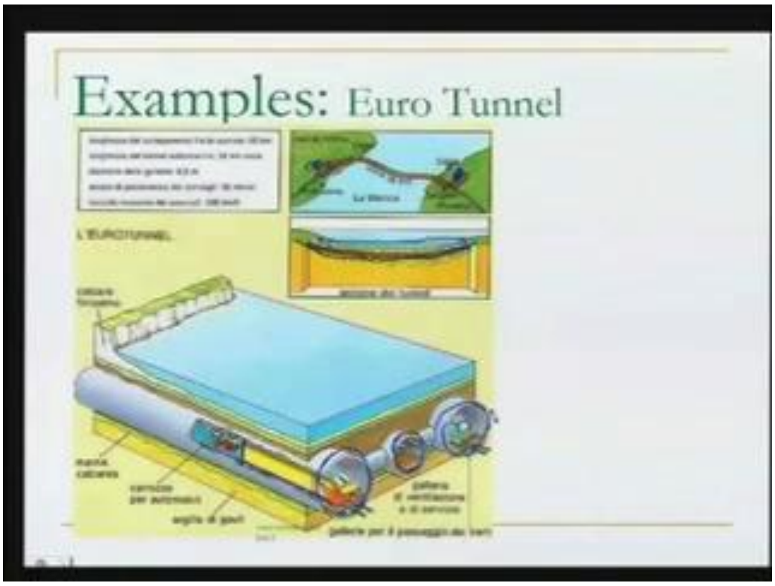

The job was - as given in this slide, this figure - the English wanted three tunnels: one, two and three. One is for going, coming and is the service tunnel - you can take it like that. So we wanted these three tunnels – one, two and three – somewhere, here inside the ground, very deep undersea. Well, the challenge in this case: the engineer started digging from France site, as well as from the United Kingdom site, simultaneously; they started digging from both the ends. Now the job was that, while they are digging from both the ends, they should meet at one point, is not it? It is not that they start from here (Refer Slide Time 15:11), they start from here, and they meet, and they do not meet - they just go like that; no, they can start from both the ends, they should meet at the same point with very, very accurate measurements. There should not be any deviation in these two centre lines, and this, surprisingly – and no, of course, with the help of the technology - it happened.

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This is the photograph. Well, the engineers from United Kingdom and France, they met at a single point, with millimetre-level accuracy. Now, how did it happen? If you start thinking about that - see, you are digging a tunnel from one end and also from the other end. You are working throughout under the ground, but see, you are meeting at a same point, and your centre lines are not deviating by millimetres. How did it happen? Naturally, the people who started moving from United Kingdom, they knew where they are going, and the people from France also - they knew where they are going. They were going as per some specified directions, elevations and other things.

So, in doing this also, we need - exactly - the measurement, so we need to measure the things. While we are planning the things, we need to measure; when we are executing the project also - I am moving in this direction. So, I need to know which direction I should move: should I keep moving straight, should I move slightly in slope, my slopes will be more, or what. So these dimensions or these specifications were given by the design engineer. The job of the surveyor there was to ensure that the tunnel is proceeding in the right direction. So, this is where we need surveying.

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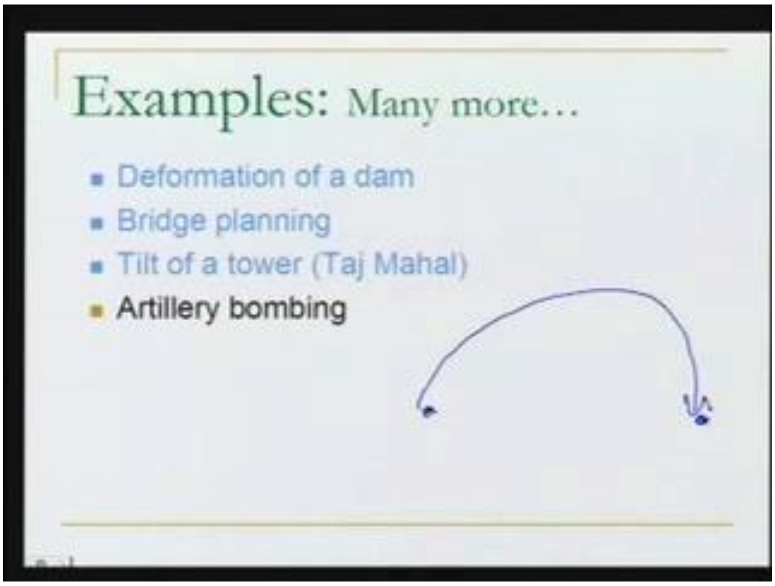

There are many more examples - I will not go into details of all of these, but there are many more examples. Deformation of a dam - a dam gets deformed with the water, upstream, so we need to measure it because, if the deformations, they go more than certain value, what will happen? The dam may fail. Bridge planning, as in the case of the road - this is very interesting. There is lot of, hue and cry now, that the minarets of Taj Mahal, they are tilting. How do we say they are tilting? We need to measure it. Now, how do we measure it? So definitely, we should have a way of surveying method by which we can measure the tilt of a tower. So, this is where, again, we can make use of surveying because we want to measure the things. We have the techniques, we have the tools by which we can measure the geoinformation, and this is also geoinformation: a tower, and if at all it has tilted, and if it has a very tough tilt, we need to determine that.

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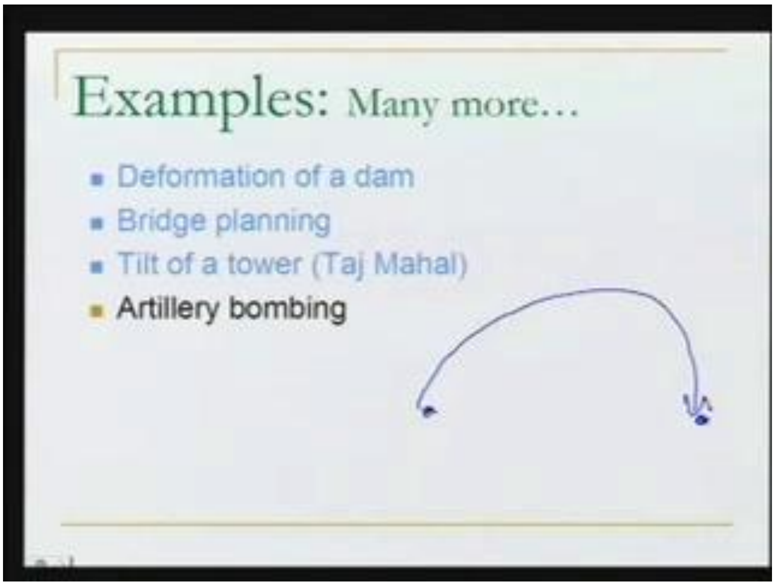

Similarly, there are some examples in military. In the case of the military, for example, the artillery bombing. They want to start from a point, they want to damage a target. So, what they want to do, they want to fire the artillery in a trajectory in such a way that it will fall on the target.

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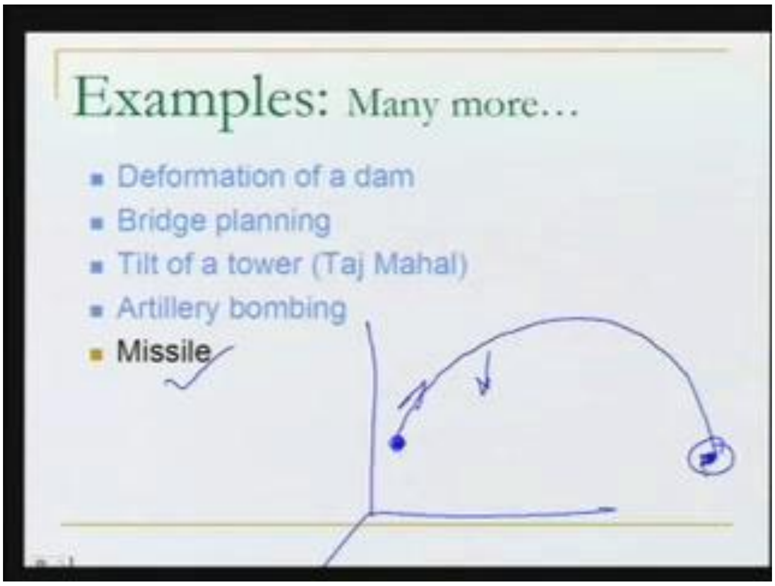

Similarly, same thing is applicable for the missile. In the case of the missile, again, they want to fire the missile from a point so that it will destroy the target, and the target is a given target; a particular building. Now, just think of that: the missile can be fired with certain velocity vector here. We know what kind of forces are acting on that - from atmosphere, from the gravity. So, we can model its trajectory, but in order to fall at this point in this coordinator hand (Refer Slide Time 19:04), we should know the coordinate of the starting point and the end point. Now, the question is: how do we know the coordinate? You are firing a missile from, for example, let us say in India, to other part of the world, so you should know the coordinates of the place in India, as well as the other part of the world. So you need to know these two coordinates in one reference. Is not it?

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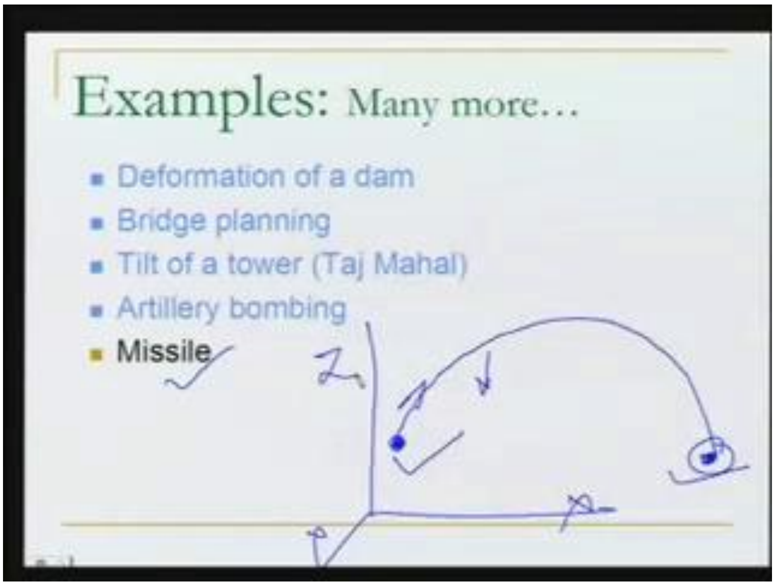

For example, here, you know the coordinate of this point, you know the coordinate of this point, in this particular reference it is X, Y and Z. Once you know this, then only you know what kind of velocity vector you need to give to your missile here, so that it will exactly target this area. So there are many more examples like this where the surveying can be used. We know now that why we need to do the surveying, is not it? We have seen so many examples.

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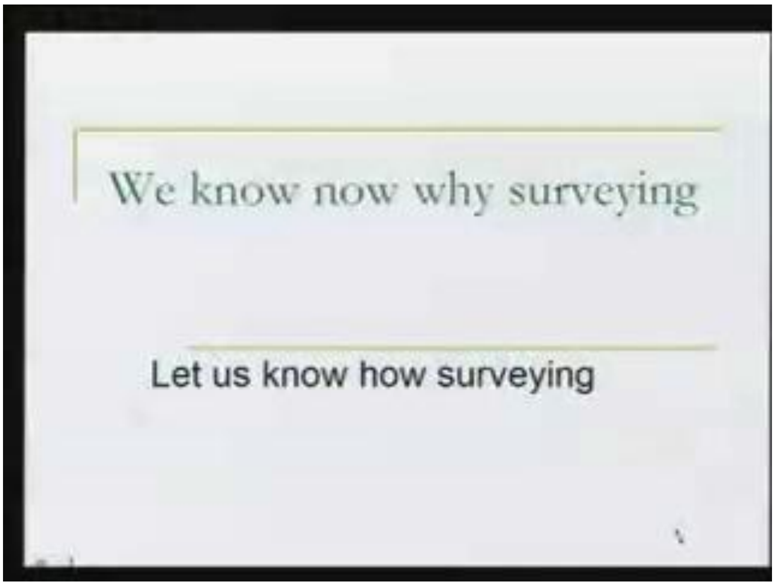

And we know what surveying is - surveying is basically measurement of geoinformation. We want to measure the geoinformation, we want to make use of that, we want to analyse it properly, so that we can come out with some fruitful result. Now, the second part of that: we should know now, ‘how do we do it?’ - what are the methods, what are the equipment which we use in doing the surveying? Well, first of all, we will begin with definition. We will try to define the surveying. Of course, I know now that by this time you know what the word surveying is, how it is related with the engineers - specifically civil engineer, mining engineer, environmental engineer or may be a geographer or a geologist. We know what surveying is for us.

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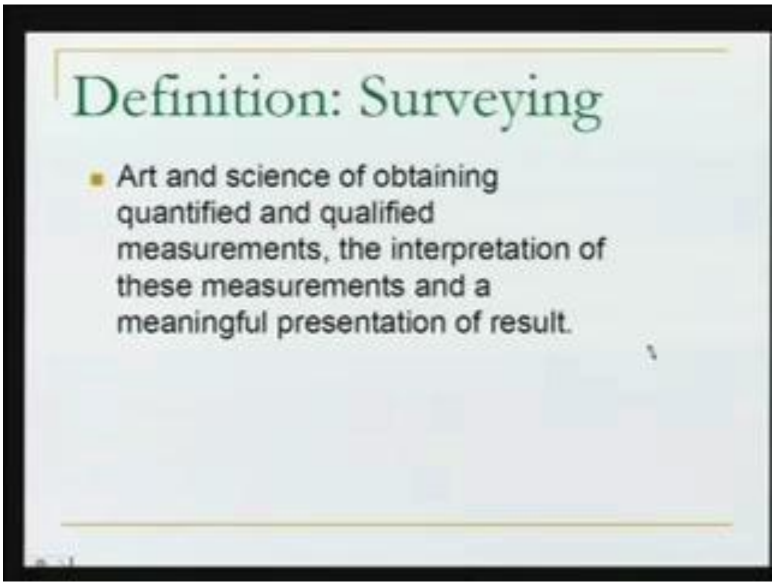

As far as the definition is concerned, we can define it is as written here: ‘art and science of obtaining quantified and qualified measurements, the interpretation of these measurements and a meaningful presentation of result’. This is what we had been talking about in all our examples so far. We want to carry out some quantified measurements – qualified; we should be sure about the measurements. And the measurements of what? Geoinformation. We want to interpret those measurement. Analysis - we want to interpret what we have measured, and then finally, we want to present it in a meaningful way; the presentation of the result. So, this definition similarly identifies or defines what the surveying is.

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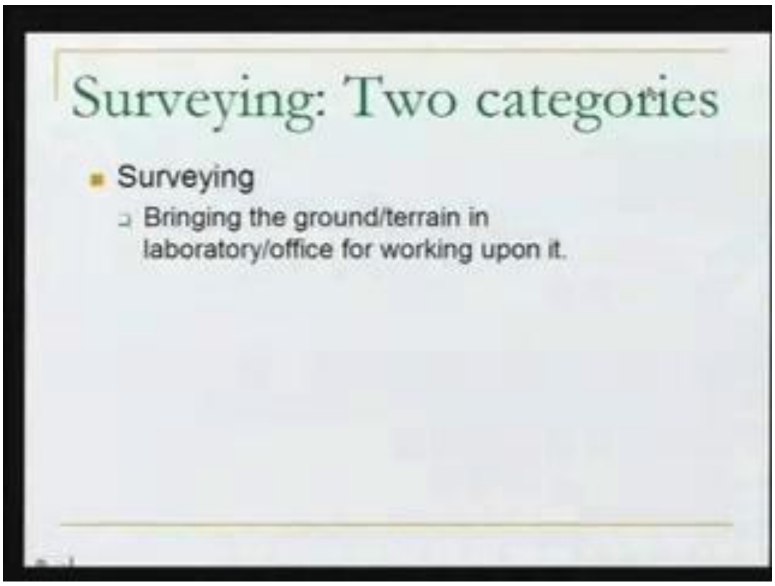

Now, what we will see - have seen it also, but I would like to now be very specific in that - we say the surveying is of two types, or we can categorize the surveying in two categories. Number one is surveying itself. In all the projects, if you think of all the projects what we did - in the case the town planning, what we did - we went to the ground first, we made a map of the ground - is not it? - and then we took this map into our laboratory. So, the map is here in our laboratory. So, this part is called surveying - when we are bringing the ground, terrain, in laboratory, office, for working upon it, is not it? So, this is surveying, we say.

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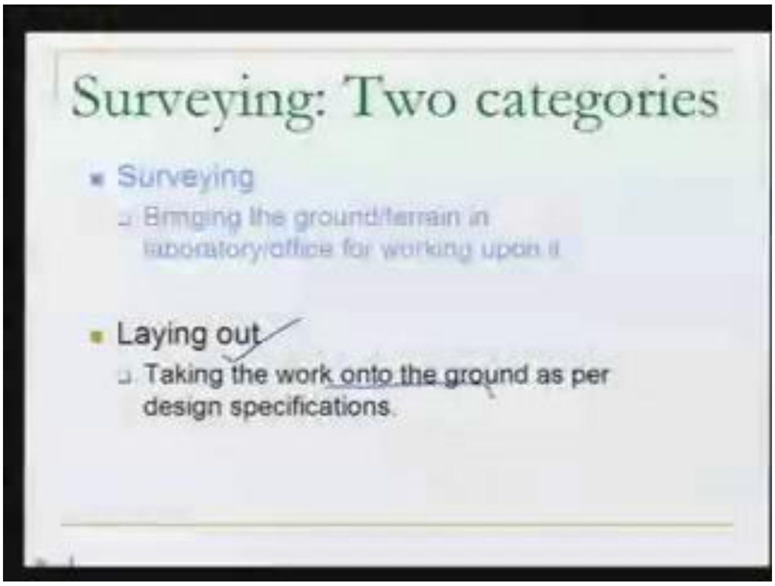

Then, the second part: you should be able to tell me now what the second part is; I believe you can guess it. The second part is - the map is in the laboratory, we work upon it, we plan a town on that, then this town is to be taken onto the ground. So that is the second part of surveying, and we give it a name as ‘laying out’. So, what is laying out? ‘Taking the work onto the ground as per design specifications.’ So what we have seen? We have seen two types of surveying – basically, these are the two things which we should do in surveying: we bring the ground in the laboratory; now, we work on that, there is some plan, some building, some base or road alignment. Then, next job: we want to transfer it onto the ground; laying out part. Well, having said that, what we will do? We will now look into some basic measurements.

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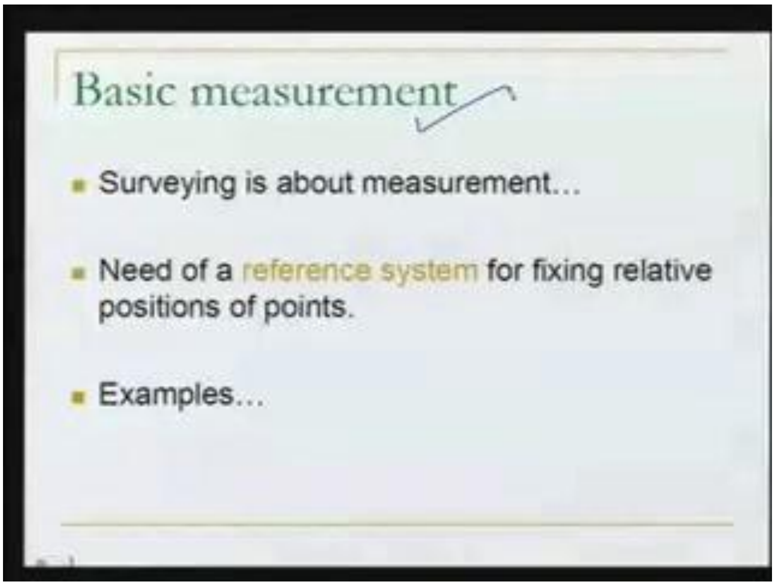

As I have written here, surveying, you have seen, is about measurement - is not it? - in both the cases, whether we are bringing the ground in the laboratory or whether we are taking a plan, a design, from our map, from our laboratory onto the ground - in both the cases we need to do measurements. Now, when we talk about the measurement, there is one thing very important, that is, whenever we do measurement, we need a reference system. This is very important. I will give you an example of that. The example is, it is about one of my friend, he comes to my house and he tells me that his son is one year old; my friend has a son and he is one year old. So, I asked him, your child is one year old, how tall he is. So my friend tells me that my child is this old, this tall (Refer Slide Time 24:52). I am surprised; a bit confused – one-year-old kid, and this tall? He said, ‘Yeah, he is this tall’. I said, ‘Are you sure he is this tall? Your child is only one year old! He said, ‘Oh, I forgot! I sorry - I am sorry, I forgot to put my other hand.’ So, he says, well, my child is this tall. So, what he did, he forgot to put his the other hand, and this is very important example – actually, it looks like a joke, but this is very important. Why it is important - he was saying his child is this tall (Refer Slide Time 25:27). Now, the moment he says he forgot to put the other hand, what he is doing? He is giving a reference now, is not it? So, without reference, we cannot say anything about the measurement.

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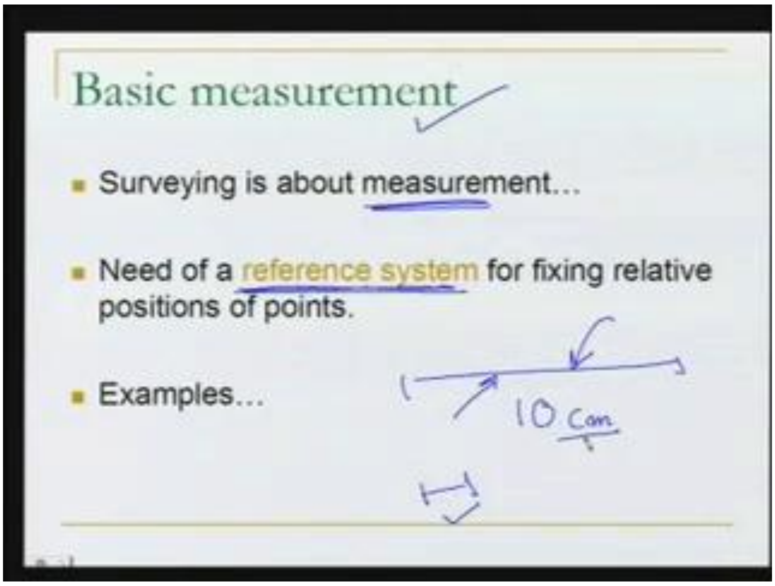
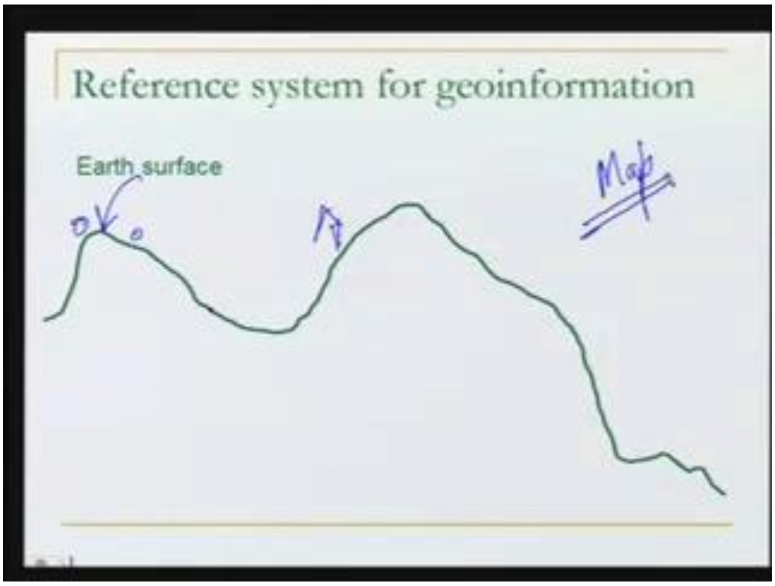


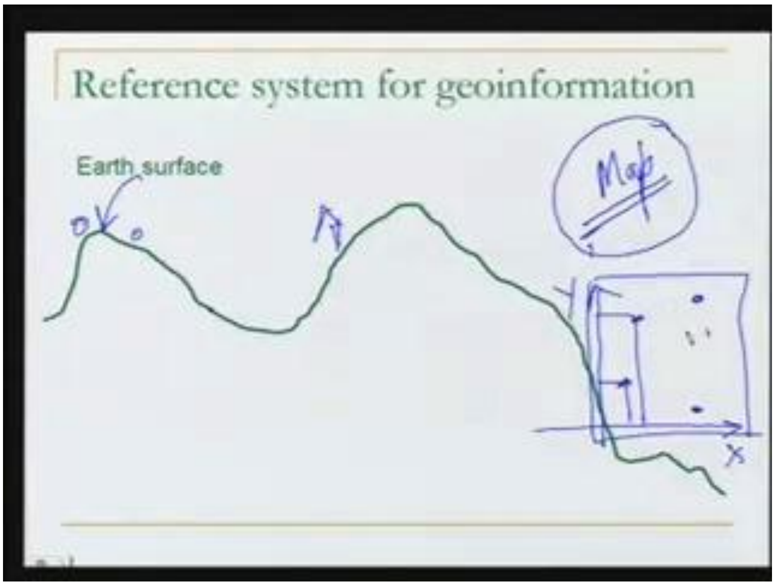
You say a line is - let us see - you say a line is there (Refer Slide Time 26:44), I say it is 10. What is the meaning of 10? Nothing; it does not convey anything - we need a reference. What is the reference here? The reference here will be 10 centimetre. When we write 10 centimetre, what do we mean? There is a reference; a standard - for example, a little bit like this (Refer Slide Time 26:08), and the length of this standard is 1 centimetre. Our this length (Refer Slide Time 26:18) is 10 times this length, so our this length is 10 times a centimetre. So just saying '10' does not convey anything; we need to convey the reference. The reference here is the centimetre; a unit centimetre. So, the idea is, the point is, whenever we are doing measurements, we need a reference; we need a datum. Here, in the case of the child, he said, 'Well, my child is this tall' (Refer Slide Time 26:45), is not it? So, what we are doing, we are putting a datum here. This point, or this surface (Refer Slide Time 26:50), we can say datum. So, 'this child is this tall' - without this datum, it does not convey any meaning. The same thing, we will try to continue into the surveying.

(Refer Slide Time 28:00)



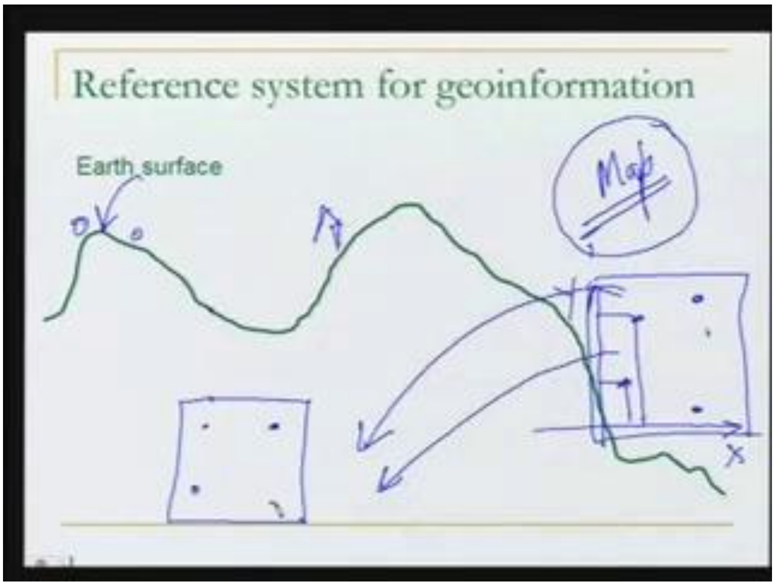
So what we will do, we will try to see the reference system for geoinformation, because our aim here is to measure the geoinformation. So, for geoinformation also, we need a reference. Now, what could be the reference for geoinformation? What about earth surface? Let us say this is the surface of our earth, –as you can see here – that is the surface of earth. There are some houses, bridge, rivers, - all those things. Now, when we say we need to measure the geoinformation or, if you go back to the examples, we went to the ground, we made a map. So, what is a map, by the way, if you define the map? When we make a map, what we try to do? In making a map we will try to bring the ground into the laboratory - is not it? - and you will notice what the map is - map is a representation of the ground. Whatever is the geometry there in the ground between different objects, different features, the same geometry is brought here into the lab, and this is the map. So, any measurement that we carry out on our map should be same, if we measure the distance between those two points there on the ground. So, basically, our map is geometric representation; a representation in which we are preserving the geometry of the ground, and then bringing it in a sheet of paper – that is the map.

(Refer Slide Time 29:30)



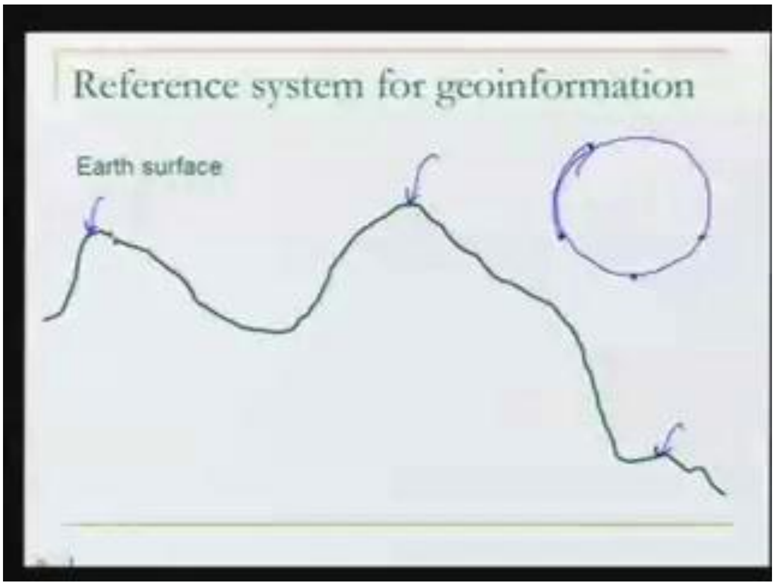
Well, now second thing: in the map also, when we are trying to preserve the geometry - let us say this is an area here (Refer Slide Time 28:56). In this area, we have got some two, three features. Now, this is ground; this particular area is ground. What I want to do now, I want to make a map of this area, so what I will need, I will need a system of reference. Let us take it as here X (Refer Slide Time 29:21) and here Y, fine. In this X and Y, I can measure the coordinates of all the points.

(Refer Slide Time 29:34)



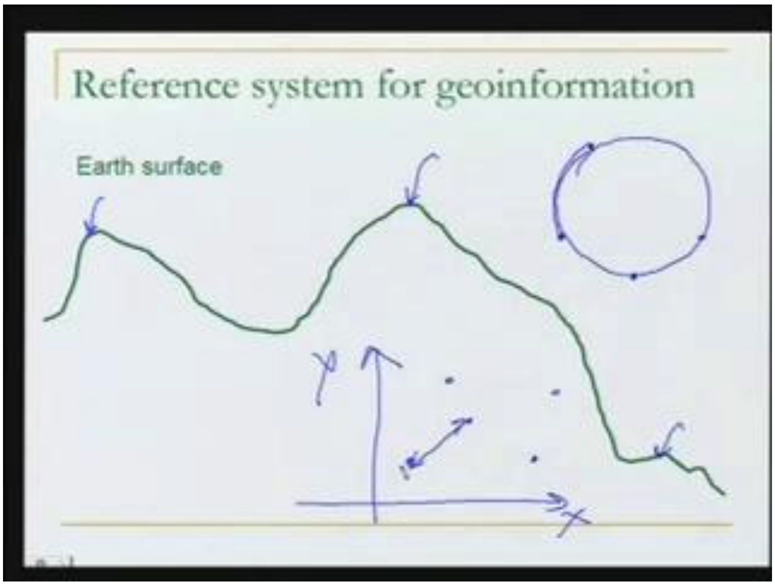
And what I can do, I can transfer this entire thing into a little sheet, where these points will be representing their positions. So, for this ground, this is a map – obviously, because the geometry which was there between these points, among these points, is preserved here,. So, what we need in order to measure these - we require a reference system X and Y. Now, start thinking about the ground of our earth feature - what could be the reference system when they are talking about the entire earth?

(Refer Slide Time 30:16)



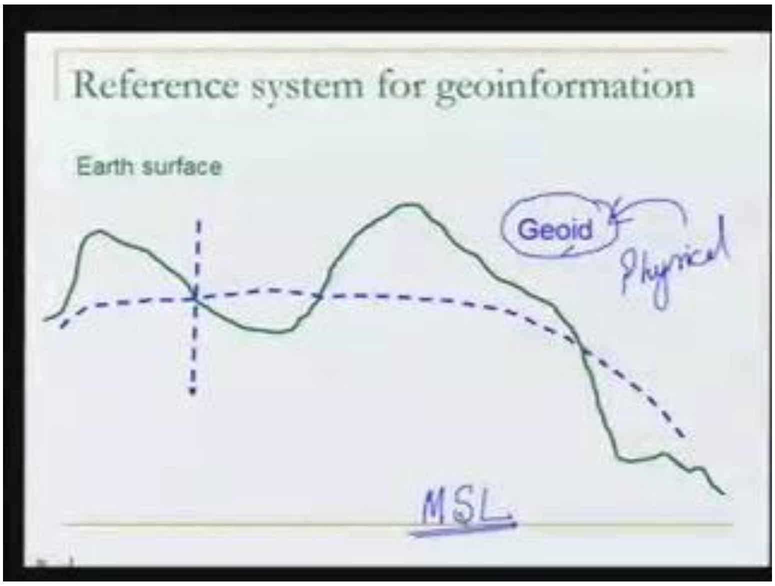
Okay, I will delete all these things from the screen now, well. What could be the reference system when we are talking about the entire earth - can you think of something? Our earth is as such, we can take it spherical for a moment now, like this (Refer Slide Time 30:27). I want to map the relative positions of these points (Refer Slide Time 30:34); what is their distance? These points may be located here, here, here (Refer Slide Time 3:40). How do I measure their relative positions, their distances? Even if I measured their distances some way, what is the nature of the surface in between them, is not it? So, we need a reference. What the reference could be, for our earth? For example, can we use our earth surface as such as a reference? Let us say, I say this surface is the reference (Refer Slide Time 31:09) - it does not sound very good; how come the surface is reference?

(Refer Slide Time 31:20)



In our previous example, we had a reference like this - X and Y (Refer Slide Time 31:23). There, you had some points, you had measured these points, and your map was ready. So the idea of the reference is, you can take all these measurements with that one, and using the reference, you can now determine anything. For example, I want to determine the distance from a point here (Refer Slide Time 31:45) to this point. What I need to do, I need to just measure this in our map, convert it to the scale, and we know what the distance is. But you should take the ground - just think of the undulating surface of the ground - you one point here (Refer Slide Time 32:04), one point here, a third point here. You cannot measure, because the ground is not a mathematical surface – here, in this case, this XY plane is a mathematical surface which is defined mathematically. So, each and every point in this surface is fixed. But as this is a natural ground, it is not a mathematical surface, so we cannot take the ground as such as the reference. I believe you are getting it. Then, next, if it is not surface, or if the ground surface cannot be taken as the reference, what could be the reference in order to make a map of the entire earth, or may be a part of the earth?

(Refer Slide Time 32:50)

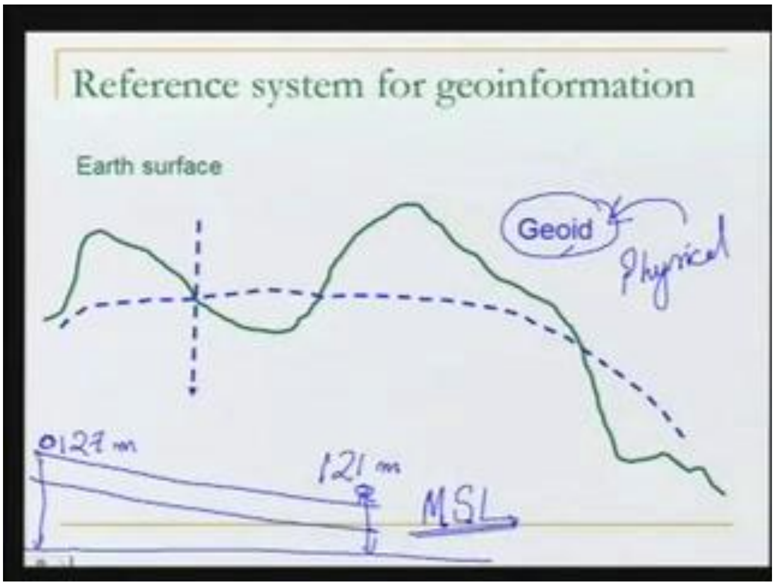


Well, we will see one more curve here, and this curve is called geoid. Now, what is the meaning of geoid? The meaning of geoid is, it is basically an equipotential surface. Let me define it. The meaning of 'equipotential surface' is: everywhere in this surface, the potential is same. What potential we are talking about? Well, we are talking about here, the gravity. I will try to explain it here. Now, what is the meaning of that? See, just think of a surface here (Refer Slide Time 33:26), and that is the direction of gravity, and this surface, if it is perpendicular to the direction of gravity. Everywhere - everywhere you draw a perpendicular to the surface, and that is the direction of the gravity. So this is why we say there is an equipotential surface - everywhere on the surface the gravity - amount, vector - is same. So what we can do, we can define for our earth a surface like this.

Can you think of a physical surface which is also a geoid? Any surface which is physically available to us, and which, we can say, has the property of being equipotential. Well, the surface is: the water body - is not it? The surface of the water body is in such a way that everywhere, the surface of the water is perpendicular to the direction of the gravity. So this is a natural equipotential surface, or we can say, a natural geoid.

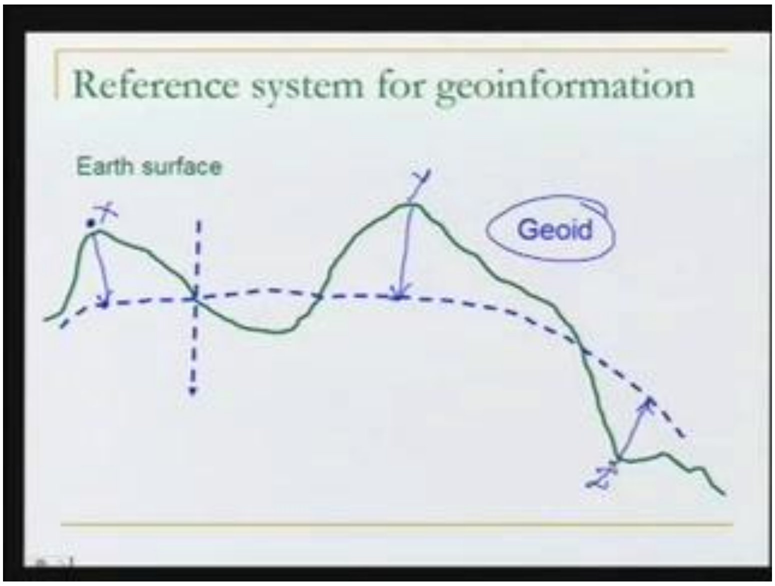
Well, now, we will talk about the geoid; how we can make use of this geoid. You must have heard of a term called 'MSL'. Very often, in all the railway stations, you will find the elevation or the height of the railway station is given from ‘Mean Sea Level’. Now what is this Main Sea Level? Mean Sea Level is also the average surface of sea, which is measured over a period of 19 years. We take 19 years so that the effect of various tides, surges, can be eliminated. So this is the average surface of the sea. So the average surface of the sea will represent a geoid; everywhere the potential is same, everywhere it is perpendicular to the direction of gravity. Now you can visualize the surface, is not it? All over our earth, you can see, you can have the visualization of the surface which you say the ‘Mean Sea Level’. So what is there? The height of these stations - the railway stations, we are talking about - is referred from the Mean Sea Level.

(Refer Slide Time 35:53)



Now, the meaning of that: if there are two stations one here (Refer Slide Time 35:58), one here - the height of this is 127 metre from Mean Sea Level, and the height of this is 121 metre from Mean Sea Level. What is the meaning of that? The meaning is, if this surface is Mean Sea Level (Refer Slide Time 36:14), then the height here and the height here are correspondingly these two values from that Mean Sea Level. As we go higher in the hills, we go away from Mean Sea Level, so the height increases, okay?

(Refer Slide Time 36:54)



Okay, I will delete this all again, and will come back to our same geoid thing. So I believe geoid is familiar to you - geoid is an equipotential surface. Now, how we can make use of the geoid? Well, another example I will give you here. Let us say - because we can now say that each and every feature which is on the earth, on the geoid, let us say we project it like this (Refer Slide Time 37:10). In order to create a map, a point here, X (Refer Slide Time 37:18), is projected on the geoid, and if it is positioned here; another point Y is projected on the geoid - here its position; another point Z is projected on geoid. So these points are above the geoid and this point is below the geoid, okay?

Now, what is the meaning of this projection? Let me give you one more example here. What is the meaning of the projection? So, if you look here (Refer Slide Time 37:53), and down there is the floor, let us say there are some objects here- one object I keep here, another one I keep here, another one I keep here. Just visualize these three, okay: one, two, three (Refer Slide Time 38:00). I want to make a map, okay? So, what is the meaning of map? I want to represent the horizontal distances between these points. So what I need to do, I need to project them in one plane. Down there is the floor - what I do, I drop a perpendicular from this point, along the direction of the gravity, to the floor (Refer Slide Time 38:22). Similarly, for this point also, along the direction of the gravity, I drop the perpendicular there on the floor; for this point also.

So, these 3 points which are located in different XYZ coordinates in my plane are now projected there in the surface.

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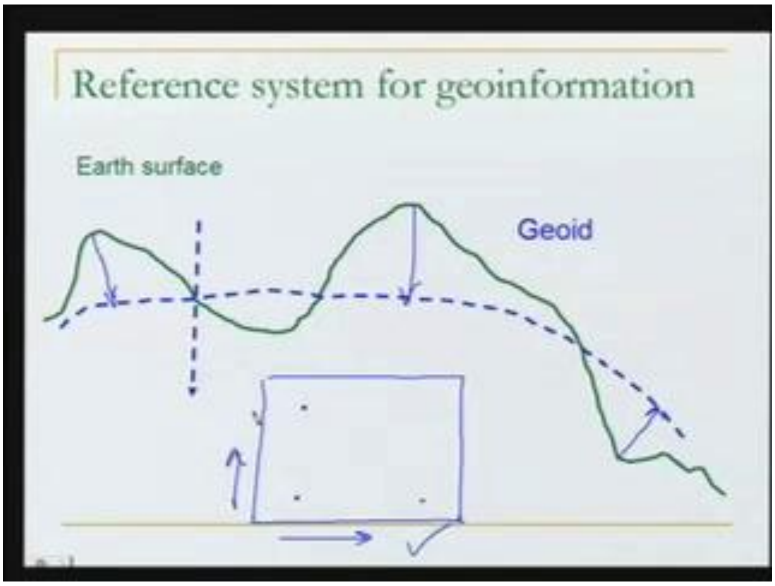
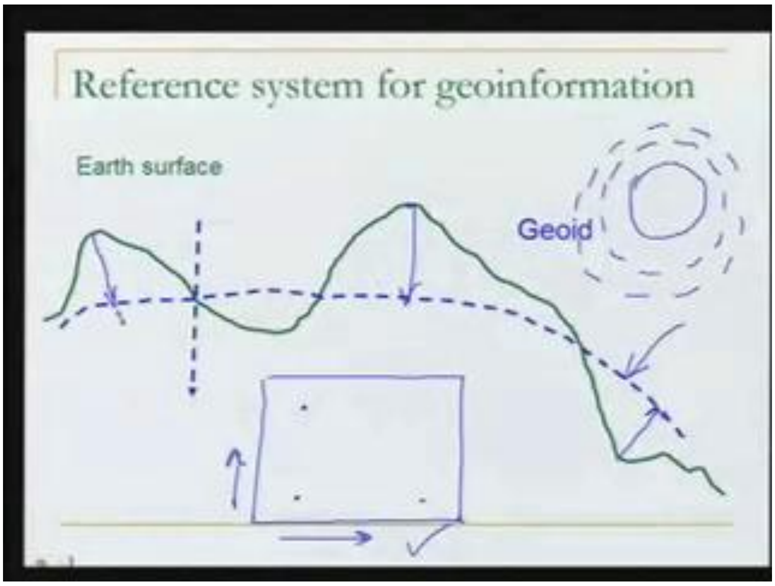


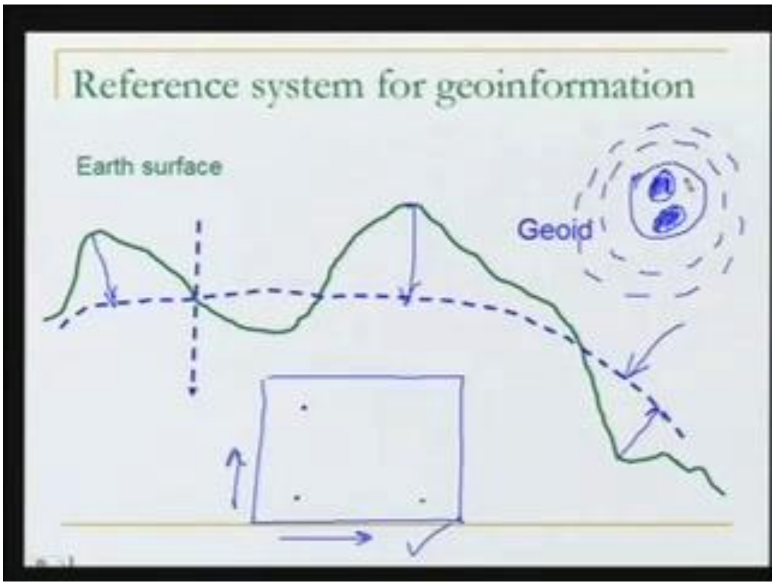
So what this map will look like? The map will look like three points (Refer Slide Time 38:44), is not it? So now, these three points form my map. Now, in our map we have a reference system, as we have seen - X and Y - it is a mathematical surface. Now, we will look into - because that was a very small example; of projection, of map making, of requiring a reference. But when we look into the broad earth, we want to measure the geoinformation. We need a reference for that also. So, we are talking here, this utility of the geoid. geoid is an equipotential surface, and we can have a feel of the geoid; you can see it: a physical surface there, as marked by the surface of the water body. Now the question is, can we use geoid as a reference for plotting or for projecting the points which are there on the surface of the earth onto it? Then the next question - because the reference has to be mathematically defined - is a geoid mathematically definable? If at all we can use the geoid as a reference, in what case we can use it as a reference? So, we will try to answer those questions now.

(Refer Slide Time 40:13)



Well, as we said, the geoid is an equipotential surface, and if our earth is a perfect sphere, its geoid will be also spherical, provided the gravity distribution of the gravity force all over the earth is uniform or, we can say, the mark of the earth is uniform. So, we will have a spherical geoid like this - not only one, we can have many geoids; each of these surfaces will be equipotential, as in this case. So it is, you know - looks like onion; you can peel it off, there are many layers. So similarly, geoid - there are many level surfaces which are possible; all are equipotential, all satisfy the condition of being the geoid. Well, as we are saying that we can project our points onto the geoid, but is that geoid is mathematically definable?

(Refer Slide Time 41:12)



So look into that - if you look inside the earth, the distribution of the mass is not uniform; somewhere it is more, somewhere it is less. Now what does it do?

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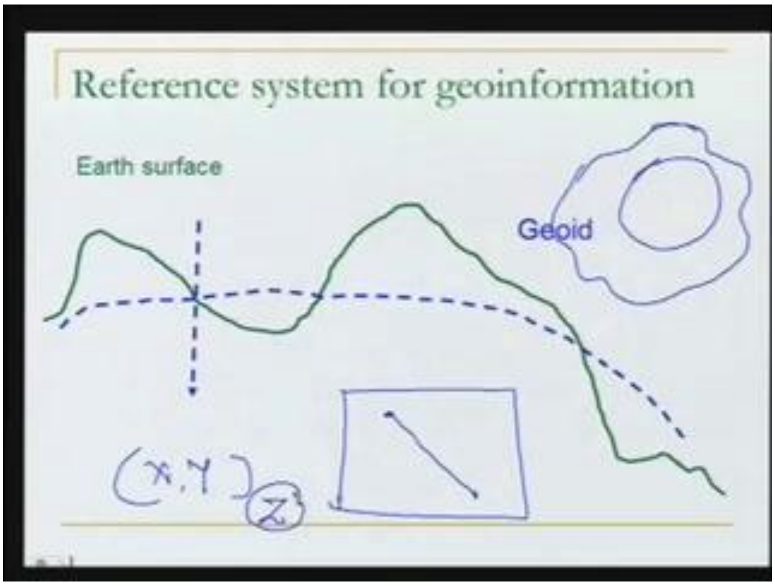
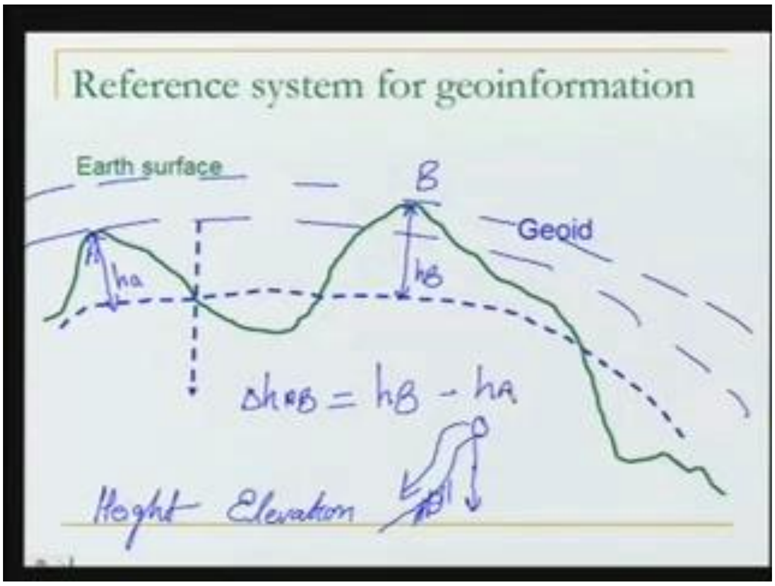


Because of the non-uniform distribution of mass, the - if I draw it again - because of this non-uniform distribution of the mass, for earth, the geoid will be of a shape which will be different. Now this shape of geoid is not mathematically defined, so even if we project our point onto the geoid, we do not know anything between what is happening there. In case of our simple map, each and every point is defined. You take any two points, you can measure the distance between these two because this is the mathematically defined plane, but that is not so with the geoid. So basically, for making XY measurements, or the planimetry, we cannot use the geoid. Let us look into the 'Z' - can we make use of geoid to measure the Z?

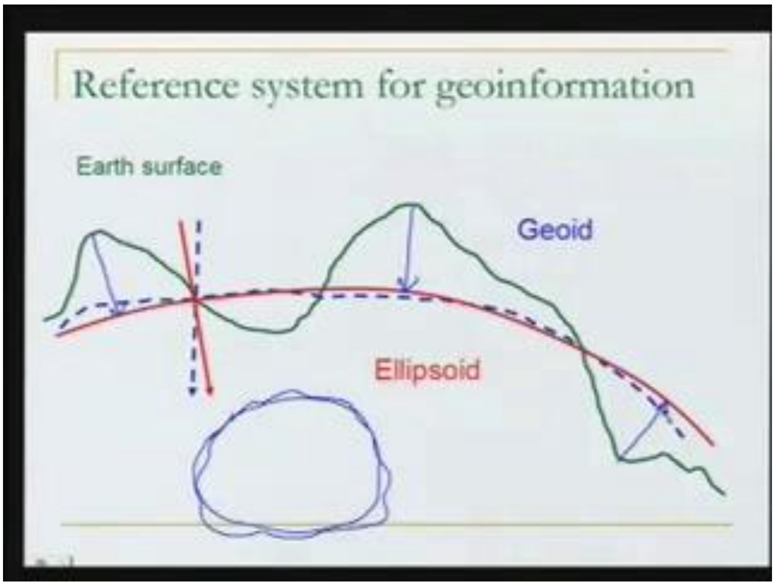
(Refer Slide Time 42:20)



Okay, I will clean my slide again, and we will come back to this again. Now, what is the meaning of height or elevation? Height is a general term, or we can say, elevation. Whenever we say the height of something, we need a reference. So, we are looking now into this aspect: whether a geoid can be used as a reference for elevation measurement. Well, if this surface is geoid here (Refer Slide Time 42:46), there will be a geoid surface which will pass from here also (Refer Slide Time 42:52), and which will be nearly parallel to the surface. As well as, there will be another geoid of surface which will be passing through the point B, while this is point A.

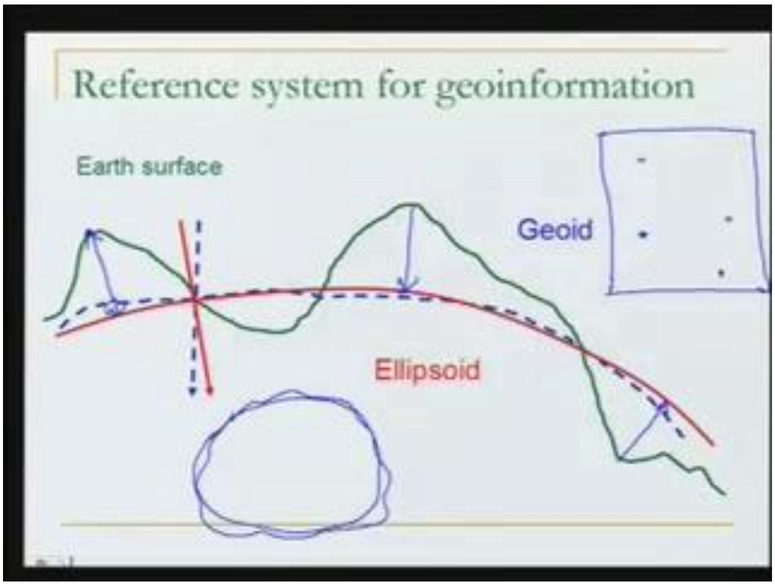
So one thing we observe here: what is the meaning of height in surveying? In our general engineering, the meaning of height is, if you put the water droplet anywhere (Refer Slide Time 43:22), the water droplet will flow as per the gravity. So the water droplet will always try to come down as per the gravity. If you put this water droplet on a surface - this is a surface (Refer Slide Time 43:35) - then it will flow here, in this direction, because of the gravity. So we say 'height' - we say two points, a point A is lower than point B if the water droplet flows from B towards A. So we say point B is higher than point A. So, that is the basic definition of elevation. Now, how you are going to make use of geoid? The height of point B from the geoid is represented by this line (Refer Slide Time 44:10). What is this this? This is the - in the direction of gravity, if from B, we meet the geoid at this point (Refer Slide Time 44:17), then this is the height of B from geoid. Let us say we write it as ‘hB’. Similarly, for point B - for point A, you can write this as ‘ha’. Well, the distancing between these two points, if you write it as delta hAB, then that will be equal to hB minus hA. Well, we will see here, how do we? This is basically what we are doing: we are trying to find this delta hAB is nothing but the difference in height of these two level surfaces, or these two geoids, which are passing through point A and point B. Also, what this gives us? That B has a higher elevation because, if you put a water drop here (Refer Slide Time 45:24), it will tend to flow towards A. Well, if you can measure the height, but still we said the geoid is not good enough to measure our X and Y, because it is not mathematically definable.

(Refer Slide Time 45:49)



So in that case, we will have to define another surface, and this surface is called ‘ellipsoid’, which is shown here by the red colour. Now what is this ellipsoid? The ellipsoid of our earth surface is slightly undulating; we can fit our earth with an ellipsoid; so this is the best fitting ellipsoid to the surface of the earth. For a particular part of the earth; maybe it is applicable more here than any other part. So this is an ellipsoid which is fitted to the earth. Now, this is an ellipsoid, so we know mathematically the equation of ellipsoid. So the same ellipsoid is shown here by the red line. Well, this ellipsoid will not be parallel to the geoid because these two are different surfaces. What we can do now, we can project our points onto the ellipsoid (Refer Slide Time 46:46). And similarly, here. Now, what is the advantage? The advantage is, I know the characteristics of the ellipsoid between these two points because it is mathematically defined.

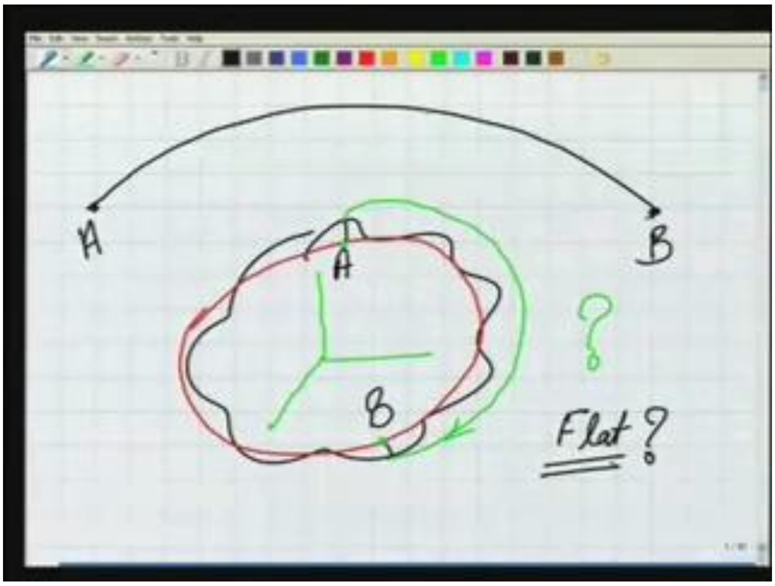
(Refer Slide Time 47:06)



Once, I had made a map, and in this map some points are plotted there. I know this entire surface of this map mathematically because I know it is part of an ellipsoid, is not it? So, we need to define this reference so we can project our earth’s points, earth’s features or the geoinformation on the ellipsoid, and we can plot their XY, and - we can see here - we can also plot the altitude. For example, here in this diagram, the height of this point (Refer Slide Time 47:44) or the elevation of this point from the ellipsoid is called the ellipsoidal height. The height from the ellipsoid - ellipsoidal height.

The height of the point from the geoid from here (Refer Slide Time 47:57) up to here is the geoidal height, and the difference in between geoid and ellipsoid - this particular difference is the ‘geoidal separation’ - how the geoid is separated from the ellipsoid. Well, again, I will come back to one example that why we need these references, and why we need to find the references for our entire earth.

(Refer Slide Time 48:25)



So, one example - we know, if a missile is to be fired from one part of the earth onto the other part of the earth, what these points are on the surface of the earth. We know, we have seen it also, in the first - earlier, that in order to fire this missile from here (Refer Slide Time 48:47) to this particular point, we need to know the coordinates of this point and this point, both in one reference system. Now, what that reference system could be? Because these two points should be very far - intercontinental distances - so why we need for our earth - if that is our earth (Refer Slide Time 49:09) - why we need a geoid - an ellipsoid for this? A mathematically defined surface - because a point here, let us say, this point A, this is here - A (Refer Slide Time 49:23) and this point is B, which is - for example, if A is here (Refer Slide Time 49:28), let us say the B is here. The missile has to be fired from here (Refer Slide Time 49:37), and it has to reach the target. So we can do this thing only if we know the coordinate of point B and coordinate of point A in one reference system, and now the one reference system for us is the ellipsoid. Now, how do we define the ellipsoid? The ellipsoid will be defined by a coordinate system which has its origin somewhere in the centre of the earth.

So we will talk about it in detail in our other lectures. So, for this reason - because we need coordinates of any part of the world in one reference system - so we need to define this kind of reference system. So, what this reference system is doing? It is - if we are taking the distance, the distance between A and B - it is taking the curvature of the earth also into account in order to determine the distance. And accordingly, this particular missile has been fired, because we need to know about the curvature of the earth. But there is one question - because in this case we are considering the curvature of the earth - but the big question is: do we always need to consider the curvature? Can we consider our earth to be flat, or should we always consider it as curvature? We are going to look into that.

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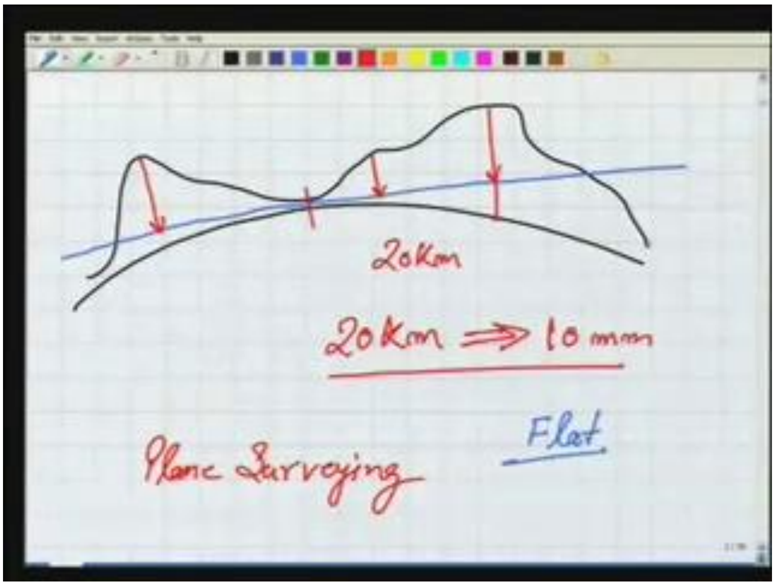
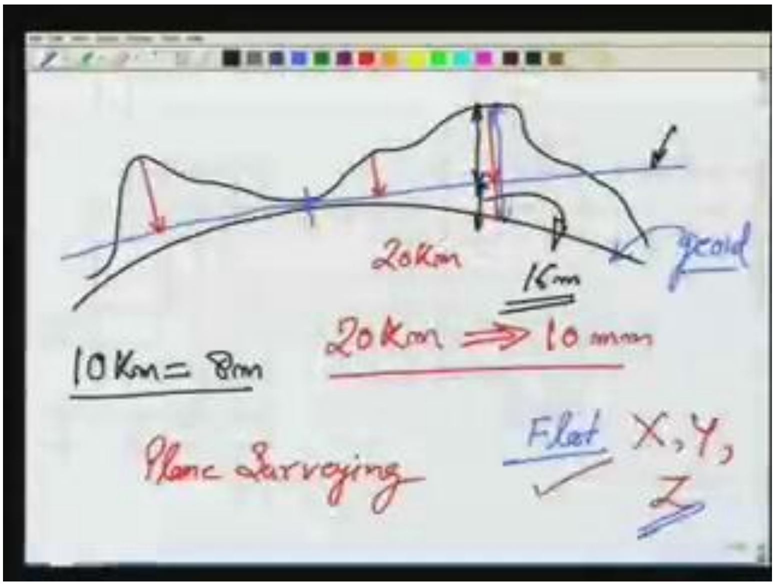


I am going to give you one little diagram here. Well, if I take a little part of the earth here (Refer Slide Time 51:13), there are some features on this, over the surface of the earth. What I do? I draw a tangent at any point. For example, let us say, here (Refer Slide Time 51:33), I draw a tangent to the surface of the earth. Now, when I say, ‘let us consider the earth to be flat’ - if you consider the earth to be flat for measurement, what is the meaning of that? The meaning of that is, our points, which are here (Refer Slide Time 51:56), I am projecting those on the tangent plane - okay? So what we are doing, it is the same thing, what example I had shown here - we are considering our this (Refer Slide Time 52:15), because this is also a part of the earth, but I considered here, this floor, and the floor is flat. When I projected my points onto the ground, I did not consider the curvature of the earth. Rather, I simply measured the distance between the points in a horizontal plane, because I know, for a small area it does not matter. For a small area - and this is said that up to a distance of 20 kilometres - there will be a difference in the arc and the chord. For example, for this point itself, let us say from here (Refer Slide Time 52:52) to this point, the distance is 20 kilometres. So the difference in distances between the arc and the chord - the corresponding chord - will be only 10 mm. So this is considered very less - very, very small. So, what does it mean? The meaning is: for our small areas - small areas means, for example, let us say the engineering surveying areas, any engineering project - a dam site, a building site, a town planning - a town which is spread in an area of 5 kilometre, about 5 kilometre - that kind of the stuff; you want to make a map for a university campus - another small area - all those cases, we can consider our earth to be flat because it does not matter; the differences in the distances is very, very less if you consider it to be flat or not flat. So, this kind of surveying when we consider our earth to be flat is called ‘Plane Surveying’.

(Refer Slide Time 54:14)



Well, can you always do so? Can we really do it for all X, Y and Z also? Because when we are talking about the distance - distance means in a plane; that means in X and Y - how about Z? You look here, in this diagram itself. Now, in this diagram, if you are plotting the Z - let us say this is our geoid (Refer Slide Time 54:36) - that is our geoid here. And now, what we are doing? We are plotting our points onto this geoid to measure the Z. So, that means, this particular height (Refer Slide Time 54:51) - this total height along the direction of the gravity - will be the geoidal height. Similarly, for this point (Refer Slide Time 54:58), that will be the geoidal height. If we consider earth to be flat, then instead of this height, what we are doing, we are measuring this (Refer Slide Time 55:14) as the height of the point, because we are considering - if we are considering our earth to be flat in Z also, to measure the Z also, Z dimension or the elevation - if you are considering our earth to be flat, and we are projecting everything on this flat surface, we are measuring the elevations from this surface - what kind of errors are involved? So here, in this case, you will see that the amount of the error in this case is this much (Refer Slide Time 55:43) - this separation. Error when, if we consider this blue line here (Refer Slide Time 55:50) - the geoidal height; height from the geoid, this black one (Refer Slide Time 55:55); the height from the horizontal surface. So, there is a certain amount of error. Now, how much this error is? Now this error is in a distance of 10 kilometre; this error becomes 8 metre. Just think of that: in a distance of 10 kilometre along the arc - we said earlier that this distance is 20 kilometre - if this distance is 20 kilometre here (Refer Slide Time 56:25), the error in measuring height from the geoid and in measuring the height from the horizontal plane, the difference between these two - that means the error is of order of 16 metres. This is 16 metres (Refer Slide Time 56:47) - this is too much. Just imagine: area of 10 kilometre - 10 kilometre, you know – a small town could be 10 kilometre, and we are introducing an error of 16 metre in that if we are measuring their heights from the horizontal plane.

So what we mean by this? We mean by this that we can use horizontal plane or we can consider our earth to be flat for making a map, which is only plotting X and Y - not height. However, if, in a map, we have to also show the height; the elevation, or we have to carry out the measurements also for the elevation, we cannot consider it for the - from the horizontal plane. In that case, we cannot consider our earth to be horizontal. What we have to do in that case, rather: we have to measure our heights from geoid.

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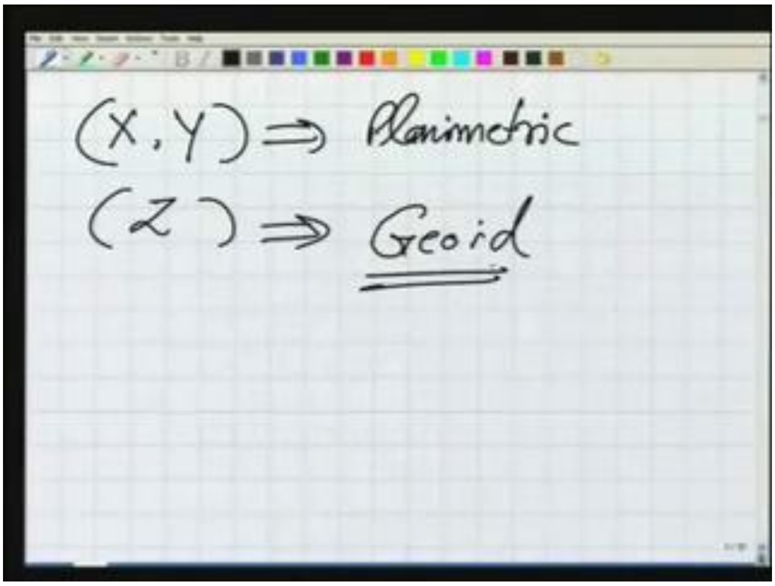

So that means, this becomes clear here: when we are measuring for an engineering project, the map in X and Y, which we say ‘planimetric’ map. Planimetric means, only X and Y are being plotted. If only a map is to be made which is planimetric, we can consider our earth to be flat. That means, we are not measuring the curvature distances. Even if we are measuring along the curvature, we will consider that distance to be the distance on the flat plane. However, for Z, we cannot do so; we had to measure our Z from geoid. So by some means, we have to establish the geoid, we have to establish the level surface, and we have to find the relative heights or the reduced levels from the geoid.

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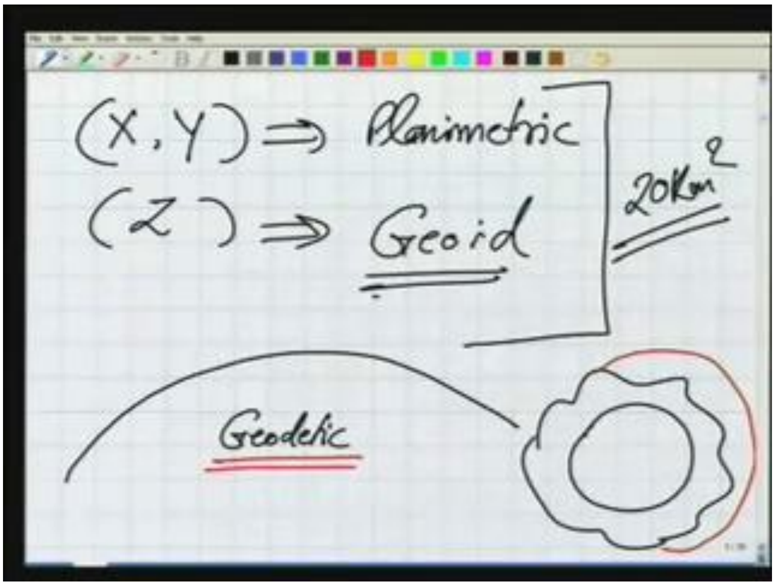

So mostly, in all engineering surveys this is what we do, because mostly, in engineering surveys our areas are small; our projects will be limited in less than 20 kilometre square - even if it is slightly more than that. So, we need not to consider the curvature of the earth. Now, having said that, we will come back to one term here - because we described a term; that was the plane surveying - so, when we consider the curvature of the earth also into account, we say that kind of surveying to be 'geodetic surveying'. When we are considering the curvature of the earth, this is truly the case. Now, the other example which I gave you - that was our earth (Refer Slide Time 59:35), and you wanted to fire a missile from a point here to a point here. So, in this case, you will need to consider the curvature of the earth; it has to come into account. So, in that case, the surveying that we will do will be the geodetic surveying. However, for our engineering projects, we can very easily and comfortably consider our surface of the earth to be flat, and that is the surveying which is called plane surveying.

Well, we finish here this video lecture. Thank you.