Laboratory Practices in Earth Sciences: Landscape Mapping

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Welcome all. So, in this lecture we are going to talk about how the total station or even we can say the other than the total station we use RTK is real time kinematics to map the landforms. And this is one of the most important parts wherever whichever terrain you take or may be the aspect even in civil engineering we need this type of mapping. But in particular earth sciences and the geology we take or we can say geomorphology where we are dealing with the surface morphology or surface topography then we need to go for this type of mapping. And nowadays this precise mapping is done to also understand the evolution of the landforms or the landscape in total provided you have the edges. So, the following lecture may be in one or two other lectures we will talk about the dating part of the landforms.

That means, we will try to obtain the age of that landform and try to understand how fast that landform or the landscape has evolved over the time period. So, total station will just give a brief explanation here, but this will also be attached with the lab where you will understand more about it. So, I will just try to give some brief information about the total station survey in landform mapping. Now, why is digital mapping of the landform required? As I mentioned briefly in detailed topographic mapping it provides us with a precise log of an outcrop in a few meters square to a million-meter square area.

You can extend this on a larger scale, but nevertheless I would like to mention here that nowadays this method also is slowly getting redundant because of the evolution of science and all that we have now moved to the mapping technique using aerial surveys by UAVs or drones. So, that again, but nevertheless this is not the point that we should ignore this type of mapping because some locations we would not be able to fly, but so in that case you need to have this type of topographic mapping to be done by total station. So, precise mapping by measuring points usually what we are doing is x, y, z or we also call this or you can call z and that is you are giving the coordinates. So, basically what we are doing is that if suppose this is the point you want to measure on the surface. So, you have your station here.

So, with this station you are with respect to that north or may be the parameters which you have said mainly we are looking at the coordinates. So, that is what we usually call easting, northing and then we have the elevation. So, that is you can say the slope of the terrain. So, basically, we are looking at a horizontal plane and measuring the angle with respect to this. So, this is what we will get the coordinates of this point here and at the same time we also if this is topography here.

So, then we also try to measure what the elevation of that is. So, we are also measuring the vertical angle or we can also talk about the slope. So, we are usually using the two hemispheres. Maybe we can say that this one is horizontal measurement as well as the vertical measurements we are taking and that will give you the x, y and z. So, and the most important part here is that this measurement you will get in mm accuracy. So, with millimeter accuracy you can do the mapping using a high resolution total station.

So, considering our goals and related techniques, surveying with the total station instrument is useful for measuring the following. So, one is the topographic profiles and precise leveling. Fluvial landforms you can map where you will get the relative height of the terraces, offsets of the small-scale fluvial channels, channel cross sectional areas you can also extract if you have done the detailed survey of any region. Now, the point here is that you will get the relative height here. So, relative height usually we do if we are not requiring any precise sort of an elevation change or so then, but we need to have an understanding of what is the relative height of any landform.

For example, you are having like we usually take the terraces. So, if you want to take that then this is your river bed. So, if this is your river bed then with respect to that what is the so with respect to this one what is the relative height over here and with respect to same what is the relative height of this point and similarly, over this here also. So, that will give you the relative height between with respect to this thing, but at the same time if you want to have the precise height of any landform then you can even use the benchmarks which are provided by the survey of India or because since we are having high resolution GPS antenna here that is what we are using differential GPS. So, that will give you respect to the MSL.

So, this also you can get provided and also the coordinates you will get with respect to the north you will get that of the given particular point which you are measuring in the field. Now, coming to the other part, mostly in our lab, what we are using is mapping of the landforms and if you are having the tectonic landforms that are displaced by during an earthquake. So, that also we measure what we call co seismic rupture and associated deformation because for us that is. So, for example, I will just explain here that if suppose there is in the flat surface here and there is a fault which has displaced this later on during an earthquake and then you see such a short of a topography. So, there is a displacement here of this surface.

So, this height is important for us. This height is important for us. So, if you have the age of this from somewhere from this portion of the sediments then you can calculate that fine in a given year how old it is and what is the height in relation you can calculate the period of its uplift that how many earthquakes were required to uplift that area. We can also map the terrace risers and fault scarps, but mostly you can focus on what we are talking about: topographic mapping of any given area and that is related to the mapping. So, total station fundamentals if we take as I briefly explained.

So, we usually look at the parameters and calculations and the total station itself is a digital theodolite with EDM that is your electronic distance measurement and that will measure your will give you the coordinates that is what we were talking about the x y and then it will also the CPU with the net will calculate even the angle between that and will give you the even the elevation depending. So, how it works is just a brief idea and then how we take the points in the field while explaining the following slide. So, this is the dissection of the total station. What we say nowadays is the robotic total station. So, earlier what we used to do is that we used to place our total station at one point. So, this is your, this is what we call the station.

So, this has been stationed here and then suppose we have such a topography here. So, usually this will allow us to fire a laser ok. So, this will allow us to fire a laser and there will be a post which is again it will be having a particular height and then it will have a prism here ok. So, the prism and then we have to focus the center of this prism through this lens which has been shown here and then we have to match the proper cross wires ok. So, within the lens you will find there is a cross wire here and that you should try to focus with the center of the prism here.

So, usually earlier what we used to do is that we if we are if you want to measure this point then the person will move with the the the post and then move here and that that we will take the point here and will say record. So, it will record the point and then again, the person will take the post here and then move on to the second point and again. So, this required two people. One is sitting here like and then another one is moving with the post. But now with what we call the robotic stations it can easily sense this ok.

So, once you have set this unit so, it will sense this wherever you are moving and what that what we call the locking of the prism is ok. So, wherever you move the station will also move ok and then from here itself you can say you can give the command of measure the point. So, it will automatically measure the point provided this is not having any obstacle in between ok. So, unless and until this laser is fired and it can move through then there is no issue on that part ok. So, that is what we call the new development of robotic stations and this picture which I am showing you is a robotic total station which allows you to use it by having only one person.

So, further if you look at what I was talking about that it usually measures. So, this is your prism and that will remain your center of target ok. So, most of the time this is your station here and where you will give east north that is at coordinates and the height of the station is also to be taken into consideration at the same time you will also have to take the height of the post ok. That is your right from the center of the prism that we will take from this you will take up to this ok. So, that is the height of the prism as I have shown here.

So, this will be your H R actually ok. So, that also has to be taken into consideration and that has to be feeded to the C P A ok or you can say that at least to the microprocessor. So, that will be taken as a reference ok. So, this is one important part when while staying at the station of course, you have to level these three legs ok. You have to level it and to horizontal and then you have to fix up your total station on top of this.

At the same time you have to fix up the height ok. Depending on how much the obstacle is in the surrounding area you cannot go for 10 meters height and all that ok. Maximum you can put 2 to 2.5 meters or 3 meters, but mostly we focus and we try to confine ourselves to 2 meters of height. And this also again depends upon how high is the height of the person who is who has set up this total station.

So, these are some trivial points, but very important because that may affect your overall measurements. So, basically what are these two as I told that h i that is the instrument height and then the rover height if we take or maybe you can say the post height that will be a center of target. So, with respect to this you are measuring this topography actually. So, what you are taking is that horizontal angle and then vertical what we call the slope distance ok. That is also what will give you that what is the difference in the.

So, as soon as the height changes the slope of with respect to your station and the post will change actually. So, theodolite measures your horizontal angle and vertical ok vertical angle that is your v. So, this is what you are having the horizontal angle and horizontal angle and the vertical angle of a line of sight from the center ok. So, again everything is governed from the center of the station. So, this is your center here and as well as the center of the target actually.

So, this you have to take into consideration. So, theodolite measures the horizontal angle and vertical angle of a line of sight. This is your line of sight, actually ok. This is your line of sight. So, this which you are looking at is the line of sight.

So, line of sight from the center of T s to the center of the target on a point. So, this is your point actually ok of interest that is your measure. So, if you then again if you move here then this will be your interest point to be measured and then the center here will be your target center or center of target. So, the center of T s is at the intersection of the rotation axis ok, the rotational axis of horizontal and vertical circle. So, earlier, older instruments which we were using for the measurements were not having the vertical movement that was restricted ok, but in total stations this is the advantage we are having ok.

So, the center of the target is the intersection of the axis of the center of the rod and the axis of tilting ok. Now, further we will see more points here. So, this is what was explained in the previous slide. So, basically what we are doing is we are taking the measurements in this circle as well as vertically we are also measuring in this circle ok. So, this vertical and the horizontal will give you this angle because you are not moving in the same line you are moving in different points also.

So, that will also be taken into consideration as well as the vertical angle you will take and that is your slope ok. So, that will also change depending on the elevation change here ok. So, further the your EDM instrument is built in a telescope to measure the slope distance this is your slope distance and that will vary depending on the height ok. And the slope distance is between the center of T s and the center of the prism not the center of target ok. So, this is again an important point we need to keep in mind about the slope distance.

So, this is your slope distance that you are having. So, basically it is like the line of sight also, but you have to always carefully do that that makes you getting the proper reading that is you are you are having you are looking at the center of the of a prism ok. Then the CPU calculates the coordinates that are easting northing and the h is your height in a rectangular system of the point under the target with reference to T s coordinates ok. So, this has to be given first ok. So, what usually we do if we just want to take the reference points.

So, we usually do give 100, 100 or 1000, 1000 and with respect to that this will be obtained actually the coordinates and the heights will be obtained when you are taking the measurements. But as I said that if you are using the reference point and a precise one then you can enter this information over here in the T s that is what is your coordinates and the height of that particular point ok. So, that will then whatever the measurements you are doing will be with respect to this. So, this will become a reference to your measurements ok. Now, there are a few more things which we usually take that as soon as the station is established we take one what we usually call the back point back side point and all that to just have the reference for that and then we start our measurements ok.

So, this part we will try to explain to you in the actual lab which we are going to perform on the ground ok. So, this will help you in further understanding of what exactly we are doing and what we are measuring ok. So, this is what we will just look at again that the CPU calculates the coordinates that is east, north and h, h is your height in a rectangular system of a point under the target with reference to the T s coordinates ok, using the measured polar coordinates that is your s, d, h, s, h, z and the and v ok. So, and the instrument height h i this is your instrument height h i and target height h r target height h of the and the several correction factors and the constants which have been used to obtain the actual your east, west and north ok. Because when we are measuring this is the unknown point ok, this point is unknown this is not known to the system, the system only knows that it has this coordinates that is your station coordinates ok.

So, it knows that only even it does not know what is the height that is your d h ok, because this you will have to in any case you will have to take into consideration when you are measuring. So, you need to subtract this from the height and even you have to take into consideration the h i when it calculates ok. So, when feeded to the system it will give you the exact coordinates ok. So, this is what you are having in the triangular system where you will get the exact coordinates.

So, the east, north and h ok. Now, further preparation usually we require like this are of course, again very seriously the point should be taken very seriously, because lot of or I would say that many such incidents have come across where we lost the total station ok, the main unit and because of the carelessness or not having proper understanding of that ok. So, T s usually is quite heavy, not so heavy, but yes of course, it cannot be just pulled on with one hand and all that. So, need to be so always take the best care following do and don'ts as given below. Always carry the T s in a locked hard case. This is what comes with that. Take the T s out of the case only beside a firmly set tripod.

So, this is your tripod ok. So, once the tripod is set to level ok, then only you remove your T s from the box ok. Before that it should not be removed and kept idle ok. Then do not move or carry the tripod with T s ok. So, sometimes what happens if you have to move the station. Suppose you have set up the T s and the total station has been set up. Now, if you want to move this station because of some reasons where you are unable to look at your target center or the post office or the prism, then usually we try to say that ok let us shift this station here ok and then we measure again.

So, but should not be done along with this actually ok, should not be done along with this. So, this is and use both the hands to hold the T s. So, you need to usually take care of what you are holding with two hands here. So, one is picked up with this here and another is placed at down ok.

So, you just firmly use that ok. Never release the handle before the T s. So, there are more points which I think you can go through, but the few I just have explained are the most important ones and there are many more points which have to be taken into consideration before you start the measurements. So, further equipment checklist is there which you can do that you need to first move on ok, because and as I told that you need to set up the back-side point and take the measurement that will give you the reference point also ok. So, like for example, this is the instrument that I was talking about. It is a dissection of that and this is a high-resolution unit and with this only we will give you the lab-like demonstration. So, for example, as I said that mostly we in our lab use to map the topography of the cross section of the river and all that.

So, this is one example from Kangra valley where we took the profile across this one and this gave us the topography that is seen here. So, we have taken a number of points. Now, depending on the topographic break, ok. So, once you because you can see the terrain ideally like when you are in the field. So, you may plan your survey if this is the line like a line along which you want to take the measurements ok.

And as I said that it is not necessary that you always take the points in one line, only that you can take points anywhere ok. Since the station is set ok it will give you the readings accordingly ok. So, now what my point here is that why you want to plan your survey here depending on this. So, you need to first have a proper understanding of the landform here and then depending on that you may reduce or you may increase the point surveys ok. For example, if you see here this is only one point which we have taken in the flat area ok.

For maximum you can take two points here, but as you have the topography you can have more closely spaced points ok. Now, this will give you typical could handle in terms of the. So, you may have the variation of 20 centimeters or 50 centimeters depending on whether you can do that. So, an RTK and PPK survey if the RTK is real time kinematic and this is post processing kinematics ok. So, you can even do the processing later on, but in RTK you have like two stations ok.

Like one is set up anywhere, even if you can, you can set up over the top of this you can have the receiver on and antenna you can fix. Otherwise you can use the base here, you can have one antenna here and another antenna is a rover which you can take ok. Now, this type of mapping that is RTK and PPK will not require your line of sight or the or the points where your total station fires the laser and you have to capture with your prism that is not required ok. So, you just set up the one GPS over here and another you put as a rover here and you keep moving ok. Depending on what is the time frame you need and how many seconds you want to collect the data.

So, every 50 seconds or 1 second you want to collect or 1 minute or so, but usually we usually keep 50 seconds or so. So, we can have precise data and then you need to hold this post precisely. Again, the height of this post has been given to the system here and the height of the station also where the GPS has been put that has also been entered here. So, you keep moving and this will give you the points exactly what we are looking at that is your x y and z ok. So, this will also provide and you can have multiple points where you do not need to focus with the or connect with the total station ok.

So, this is the advantage of RTK and if you are covering a very large area ok. So, for example, this area which we did with the RTK you can see the topography we have we were able to obtain was very precise and we were able to even measure the displacement of this channel here ok. So, this is how you can generate based on the triangulations you can generate a very good digital elevation model ok. So, this you can do if you are doing RTK and all that ok. Another example of this is from Kutch. The earlier one was from Kangra valley where we used the RTK and generated this DEM.

Another one is from the Kutch area where we lived in this particular area. This is the area which we mapped. This is the old settlement, ancient settlement we did and the topographic or we can say the DEM which was prepared was something like this. So, this is the variation in the height of the area and this allowed us to extract the topographic profiles as we have shown here ok. So, this is the advantage again of RTK that you you you took like thousands of points have been taken because we kept on walking here like this and very closely and then further we moved like this also ok and that helped us in generating many many points within very high accuracy that allowed us to generate this DEM as well as if you want to have the cross section here or topographic profile you can say topographic you can take this or you can want to take at interval given interval that also you can do ok. An advantage of another one of this total station was that one can use it for scanning the outcrops ok. So, this is the scanning which we did for one of the trenches which was open in Punjab.

So, this is the exposed wall we have photographed and digitized completely ok. And also, we can map because it has a laser which can continuously keep on measuring or recording the topography of the vertical section as well as horizontal also. So, I will show the example of the C notch which we did with the total station here and this was this is the total station which we used and it has an inbuilt scanner also what we call terrestrial scanner. And this helped us in preparing the overall topography of the exposed trenches ok. And this helped us even because we have taken this from different angles ok.

For example, one measurement was done from here another one was done from here and this was actually ok. So, this allowed us to have a complete area and digital platform which we moved and we also were able to measure the height here that I would show here. So, this is the height which we have measured of this point here which has been shown here. So, you get all the information that you are required in terms of the measurement of the outcrop ok. So, this is the height of the and then we also confirm this locally by doing it manually at the local site.

So, this is the importance of the measurements which we can do with the help of a total station and also use the RTK and the terrestrial laser scanner. So, with this I will end this lecture and we will see you in the next lecture with the on either on OSL or that is OSL dating part or maybe we will look at the GPR point ok. So, I will stop here with this ok. Thank you so much.