Basic Surveying

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

Module - 3
Lecture - 1

Linear Measurements

Welcome again to this video lecture on basic surveying. Now, today, we will start a new module - it is module number 3, and the name of module is 'Linear Measurements'. What we will start today with is lecture number 1. What we have seen so far in the basic concepts of surveying - whatever we did in the last module - all those things were very, very important about the surveying, because we discussed that why we need the surveying, what are the basic principles of surveying - working from whole to part, maintaining check, redundancy in observations, adjustment of the observations - so all those things are very important points.

Then, we came to the other aspect - you know, like the classification of surveys; what are the different kinds of surveys. If we consider the curvature of the earth and we measure the distances along the curvature, and also we consider the curvature - in that case, if at all we are forming a triangle on the surface of the earth, it will not be a plane triangle, it will be a spherical triangle. So, that kind of survey, where the curvature is considered - we do that survey in very large areas, and that kind of survey is called geodetic survey. Then, for our engineering applications - we saw it, our engineering projects are little - no, the area is not very big, not very wide. So, if our area of concern is generally smaller, and if it is so, we go for a survey which is called plane surveying. And in the case of the plane surveying, we consider our earth to be flat. Though we are measuring the distances - so we measure the distances along the horizontal line, even if we are spreading the tape on the surface of the earth, and we are measuring the distances along that. We consider that little part of the earth to be flat. So we project our earth, which is curvature, for a small area on a horizontal plane. As we saw it, for x and y mapping, it is all right, because the error was very, very less; miniscule. Half of our ‘Z’ - the elevation point of view - in case of the elevation, we cannot consider earth to be flat. We saw it that just in 10 kilometres, there was a difference of 8 metre if you are measuring the elevations or heights of the points on the surface of the earth, for a flat surface and then from the geoid. Now, talking about the geoid - the geoid was a equipotential surface. Mostly, as we will see later on also, we use Mean Sea Level as our geoid, and then, with reference to that geoid which works as the datum, as the reference, we measure the elevations of all the points which are on the surface of the earth. So, by projecting those points along the direction of the gravity on geoid, we know now, the elevations. Mind it - we discussed it in detail - the elevation surveying in engineering means, if point A is higher than point B, water from A should flow to point B. So, always we should keep this thing in mind.

Then, we are talking about the measurements; automatically, we have to talk about the errors. So in errors, we talked about the sources, then the types of the errors - where from the errors come; what are the sources, what could be the type, you know, it could be the blunder; it could be the systematic error which follows the law, where you can write the mathematical model and eliminate it; or random error. Then we saw the treatment of the each, particularly for the random s. Because the random errors, they follow the normal diffusion curve and that tells us lot about the observations. We saw also how to eliminate the outliers. We saw also why we say some measurements to be the weighted observations or weighted measurements, how we give them weight. So this was all what we have already discussed. If we are beginning with this linear measurements module, we should know about that background also.

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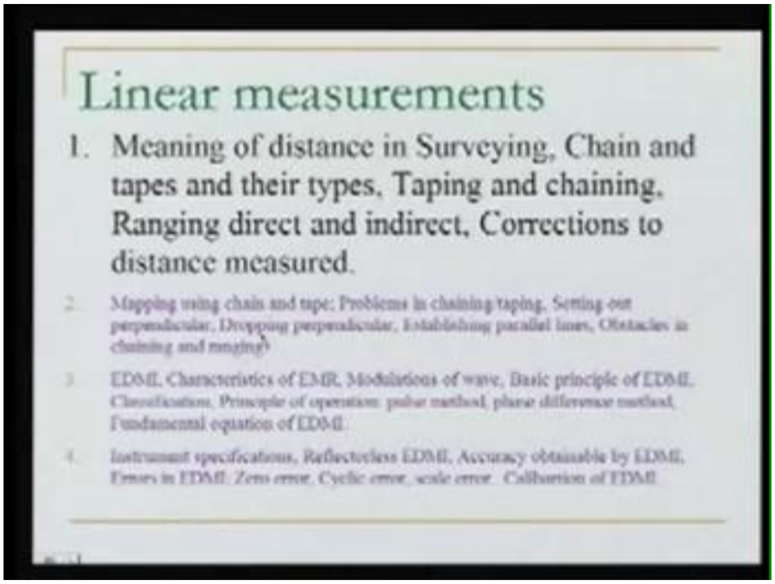

Here, in the linear measurements, today we will start with the meaning of ‘distance’ in surveying - what is the meaning of distance here - or the length measurement. Then we will talk about some instruments which are conventional, like the chain and tapes, what are their types. We will see the operation of taping and chaining; how do we measure a length there in the field using tape or chain. Along with, there will be discussions on ranging - direct and indirect method. Because we can - we will discuss this, what the ranging is, how can we do - how we can do it by a direct method and an indirect method. Then, again, here there will be errors in the measurement of distance, so we need to apply some corrections. So, we will be talking about this particular part.

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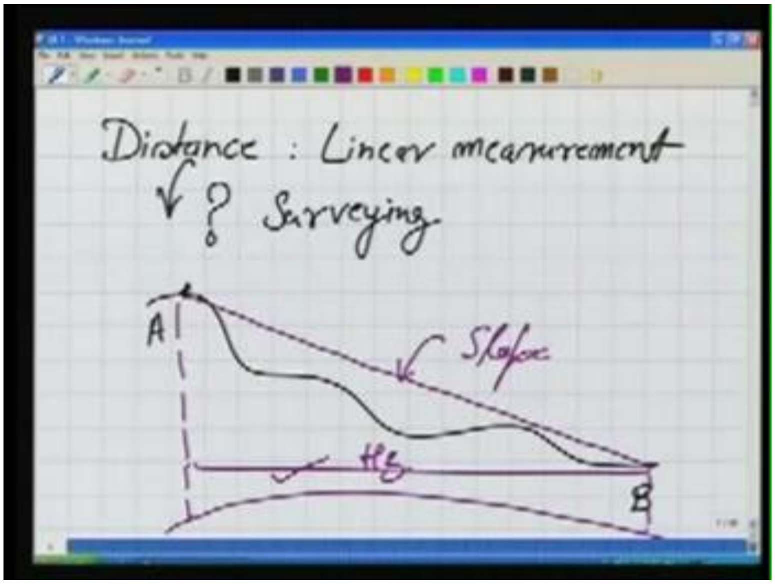

Well, we will start with distance measurement or we can say, linear measurement. First of all, what is the meaning of distance in surveying? What do you mean by it? For example, let us say, if we have two points - this is the surface of the earth, and we have a point here and another point here (Refer Slide Time 06:05). Point is A, another point is B. Well, what we can do, we can measure a distance between these two as this (Refer Slide Time 06:25). What this distance is? This is actually the sloping distance or slope distance. In surveying, we never measure this distance; we measure it, but whereever we mean by distance, we mean, not the sloping distance. We convert this sloping distance again in something which we need, and what we need, we need always the horizontal distance, or maybe the distance along the curvature - depends upon what kind of survey we are doing, the plane surveying or the geodetic surveying (Refer Slide Time 06:53). In case of geodetic, we mean the distance along the curvature, in case of the plane surveying, the distance means distance on a horizontal plane. So, this is the distance (Refer Slide Time 07:18). So, whenever we will be talking about measuring any distance, we mean we are measuring this horizontal distance, because we are mostly talking about the plane surveying - a surveying which will be useful for engineering applications. Well, if this is so, what are the methods? And in these methods, we will start with something which is very, very conventional.

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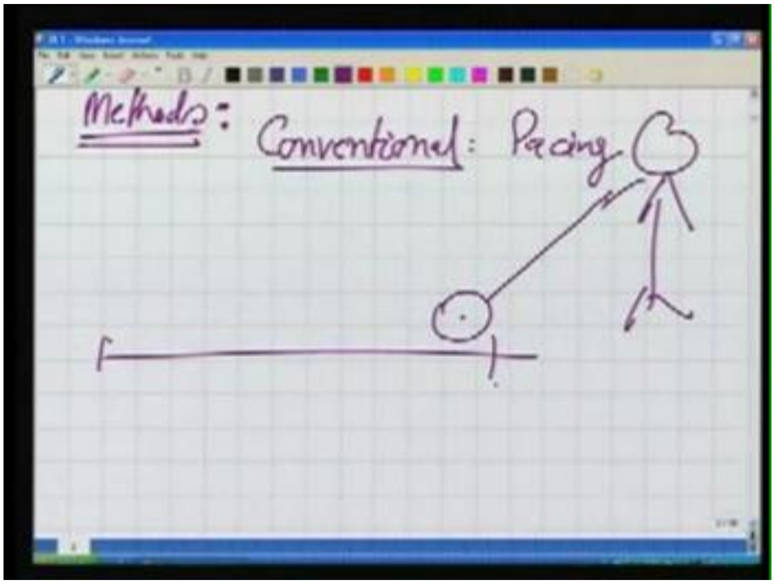

Of course, there could be the methods like pacing - you walk along, count how many paces, convert it to the distance. There are some other devices - for example, a little wheel, and you know the diameter of the little wheel, and a person is walking there on the ground with the little wheel, and you measure how many rotations this wheel has made, and you can measure the distance between two points (Refer Slide Time 08:08). Well, we will talk about another one, which is very often used, and we say that as chain. Now, during this course, will talk about some methods which are kind of conventional methods, kind of, you know, they are on the verge of being obsolete; they are not, still, many people are using them. But there are also some modern instruments which can do the same job very fast. Why is the requirement of talking about those instruments then? Because, still, in field, you will find some people are making use of these equipments, these instruments, to measure any observation, to take any observation. So this is why we need to talk about it, and also another thing - in order to understand the basic meaning of observations, to understand the basic fundamentals, we would not like to jump straight to the very, very sophisticated instrument - rather, we will start with some very basic instrument, and this is why there is a need to talk about these.

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Yes, will go about these slightly faster, and I will expect you go to any text book and read about these things in the text book also. What the chain is, a chain - as I will show you here - I kept a chain here (Refer Slide Time 09:45), and for this chain, it has two ends - in a moment, when we go to the field, we use this chain for measuring the distances, and this is the a very very conventional instrument for measuring the distances. Now, in the case of the chain, we have at two ends, two handle, and these two handles, when I spread the chain, will be - as in the scales - 30 metres apart. Well, the characteristic of the chain is, each link here - for example, what is the meaning of a single link? A single link means, it starts from the center of the circle here (Refer Slide Time 10:31), to the center of the circle here, and this is distance is 20 centimeter. Why it is kept 20 centimeter? Because it is comfortable to handle the chain this way. Now, you can guess how many such links are there in this chain. Also, for two links - the link here and this link here (Refer Slide Time 10:52) - they are jointed by three rings.

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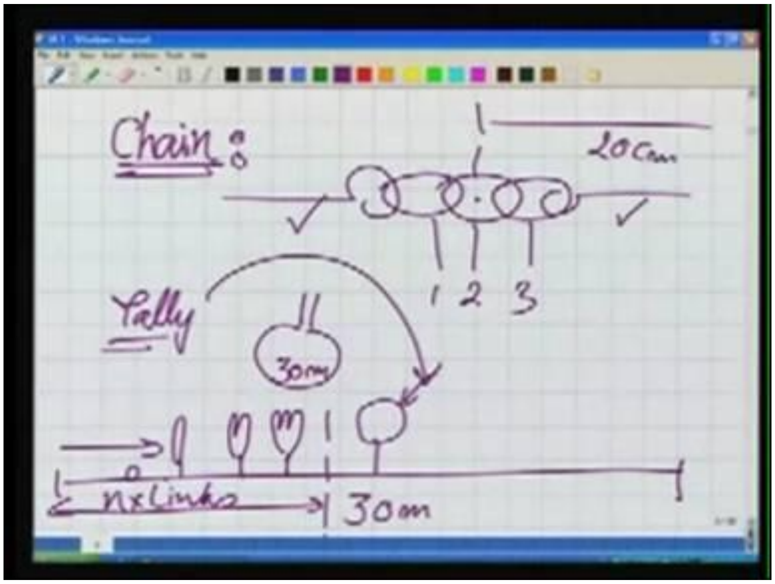

If I draw it here in the diagram, these three links mean we have a solid ring here (Refer Slide Time 11:03), then one ring, centre ring, one more ring, then another solid ring. So we have got these three rings joining two links, while the distance, 20 centimetre, is from the centre of centre ring (Refer Slide Time 11:02). Now, why these three - one, two, three (Refer Slide Time 11:28)? They are three in order to ensure proper flexibility so that we can keep it in any way - to ensure the proper flexibility. The material mostly is a mild steel, and this a very common instrument for measuring the distances. And this chain, in this case, it is 30 metre - it comes in different lengths also. Now, where the length is written? Mostly, you will find the length of the chain is written there in the handle, or maybe in the centre. There is a little tally, and that tally indicates, by a little circle (Refer Slide Time 12:08), and you will find 30 metre is written there also. I gave you one word, tally - what the tallies are? Along your chain, once you are measuring from one point to the other point, the distance is 30 metre (Refer Slide Time 12:24). While you are walking along this, you need not to count how many links you have walked through, because if you want - if you are somewhere here, for example, you want to know what this length is. To know this length, to know this length, you have to either count all the rings, or all the links - let us say ‘n’ into links (Refer Slide Time 13:00), but that is very time-consuming. So, in order to facilitate fast work, there are some tallies. Tallies - at every 1 meter, there is a brass ring and at every 3 metres, for this chain, there will be a particular feature which we will see. This is for 3 metres, this is for 6 metres, 9 metres and so on (Refer Slide Time 13:23). So, for the middle of that chain, we have a ring like this (Refer Slide Time 13:36), which is at 15 metres from both the ends. So, these brass items are called the tallies. They help you in order to determine the length of the chain.

Now, along with the chain, what we will do now, we will go to the ground and we will measure the distance using the chain. While you are measuring the distance using the chain, we will make use of some other things. For example, a plumb-bob (Refer Slide Time 14:16). We know, all of us have seen, this is the plum bob, and in case of the plum bob, there is a twine, a thread, and from this a heavy bob is suspended. We will see why we need it.

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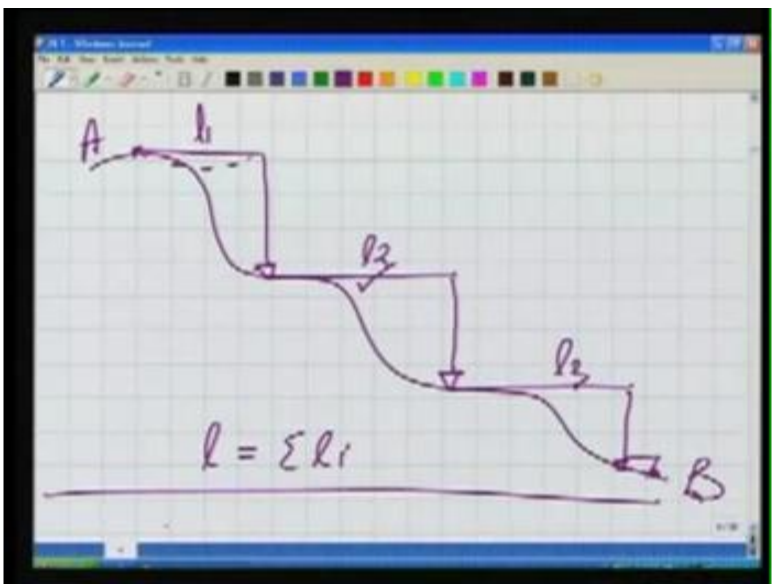

I will just give you one little example here, where it may be required. Let us say you have to measure the distance between two points A and B (Refer Slide Time 14:37), and the area is sloping. Because the area sloping, I cannot keep my chain along the line like this (Refer Slide Time 14:43); the ground is undulating. So what I do, I put one end of the chain here (Refer Slide Time 14:54) and I stretch it, by ensuring that this sag is not much.

If the sag is there, we can apply correction for that, and then from this point on (Refer Slide Time 15:10), I will drop my plumb-bob. So this plumb-bob will give me the end of the chain there in the ground; you have to project it. So from this point on, again, we will measure the another segment - so the segment l_1, l_2 - then again, we will drop the plumb-bob (15:30), and now again, we will have the chain, again the plumb-bob - and this is how, l_3 and the final one. So, our total length 'l' will be 'sigma l_i'. So, we make use of plumb-bob in order to project this point down there. So, that is one instrument which is useful.

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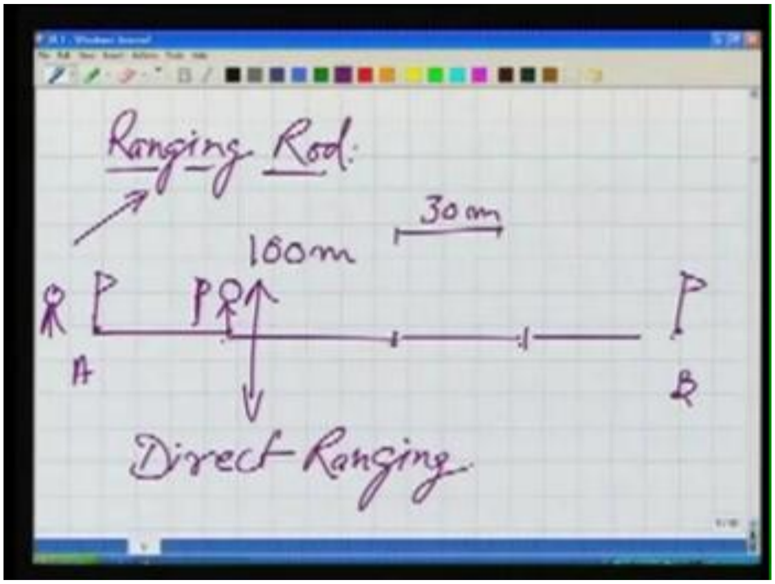

Then, another instrument or another very simple thing which is kept here is called 'ranging rod'. I will write its name here - this is called ranging rod. As you see, this ranging rod - we will make use of this in measuring the distances; in doing a term called 'ranging'. So, once we go to the ground, we will do the ranging. What is the meaning of that? If you are here at point A and point B, you want to measure the distance between point A and B, which is, let us say, is around 100 meter (Refer Slide Time 16:35). The chain that you have is only 30 metre. Then what you need to do, you need to put multiple lengths of the chain over here (Refer Slide Time 16:54). Not only one will do, so 30, 30, 30 and rest. Well, while we are doing it, we must ensure that we are putting this chain along the straight line. Starting from A to B - all these points, intermediate points, should be in the line A and B. How do we do that? We start with one ranging rod here, another ranging rod here (Refer Slide Time 17:21), and a person standing here directs a third person who is walking with the ranging rod. So, this person here is walking transverse to this direction (Refer Slide Time 17:36) with the ranging rod, and the moment this person finds that this ranging rod is in line of end B, he directs him to stop. So, this is how you will locate this point. This method, we say the 'direct ranging' method.

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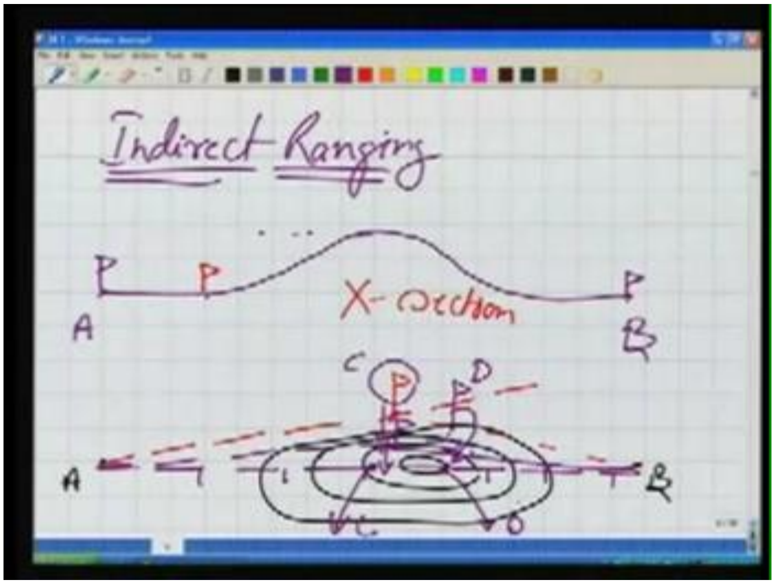

I will tell you one more: that is called ‘indirect ranging’. When we use it - just one example - there may be many, many more cases. One example could be, let us say, in between A and B, the ground is slightly undulating like this (Refer Slide Time 18:28), and the length of the ranging rod - this height - this height of the ranging rod is less than this total elevation. Well, we have one ranging rod here, another ranging rod here (Refer Slide Time 18:42). Now, a third person is walking here with the ranging rod. We cannot see from A the ranging rod B - we cannot see it because of this hump. So what what to do in this case? We go for a thing called indirect ranging. Now, next diagram that I am drawing - this was the profile, this was the cross-section of the area. I am going to draw now the top view or the plan view of the area. Well, in the plan view, my point A, then point B (Refer Slide Time 19:24). Well, somewhere where the hump is, you are standing in the side of the hump - let us say that hump is just like this (Refer Slide Time 19:35). I am just trying to draw contour kind of figure, and this shows: yes, there is a hump; the area is higher here. What we do here? We start with a point - let us see - which is outside, so the third person who is carrying this ranging rod with him is outside this hump (Refer Slide Time 20:01). The only thing is, he can see, from this point, B as well as A. Well, now what we can do, we can mark this line (Refer Slide Time 20:18). Now, from this point on, we can also see B - yes, so now, from this point, you are able to see A and B.

One more ranging rod - I am showing it by a different colour - we put here (Refer Slide Time 20:44), so that from this point, I can see this ranging rod and this (Refer Slide Time 20:43). So, this ranging rod is put in the line shown here. Next, this ranging rod - the person with this ranging rod (Refer Slide Time 20:54), he moves inward, so that from this point here, we can put the ranging rod in this line. So, the next ranging rod is kept here. Again, from this point, this ranging rod starts moving inward (Refer Slide Time 21:14), so that from here, we can see our ranging rod - if it is D and C - so, the C ranging rod can see the D as well as B. Again, from this point on, we ask - the D will ask - ranging rod C to move inward till he finds that from D, he can see C and A in a line. So, we keep doing it, and ultimately, you end up being in the line, so you will have two points - C and D. C and D, which will be on line AB, and these two points will be on the top of the hump. Then, by making use of these two points - because I can see from CA, I can see from DB - I can also establish some intermediate points. So, this is the method of the indirect ranging.

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So, what we will do, we will go to the ground, and now, we will see how we can measure the distance using the chain. The very first system in the field is to open the chain - and how to open the chain? I will show you that thing. We hold the chain like this, in our hand, and this way, and we throw the chain (Refer Slide Time 22:40). So that way, we can open the chain. This is how we open the chain. So, we want to measure the distance between a point here (22:53), the other point is there. Now, in this process, there will be a leader - as he is the leader having the ranging rod, arrows and the chain - while I am the follower, and I will follow him. I am holding one end of the chain here, while the leader is moving to the other point. The leader will move up to around a one chain length. Now, I am directing the leader to be along the line, that is, by ranging. So, I am asking him to move along the line and he keeps moving and keeps moving and keeps moving till he is in that line. Now, the leader will spin the chain along the line so that the chain is along these two points. So, at the end of the chain, now the leader puts the arrow (Refer Slide Time 23:54). So this stands as one chain length. Now, the leader moves with the chain and rest of the arrows and ranging rod. He moves further to the other point. Well, the follower now collects all the arrows which are put there in the ground one by one. In this case, length of the distance is only less than 70 metre, so only one arrow is collected.

Now, the next job will be finding the length from this point, where I am standing, to the point there. In the meantime, the follower is also coming with other end of the chain. So, he puts the other end of the chain, there in the ground where the arrow is, and he also collects all the arrows which is put by the leader, so that we can count how many chains were there. Well, the next job is to read the chain from this point to the end of the line. What is the reading? So, at that other end of the distance - this point - now we need to read what is the value in the chain. Now, what we will see, will see how to read along the chain. To measure the distance along the chain, what we do, as we discussed, we make use of the tallies, like, at 1 metre from this end is one little ring, and if we move further at 3 metre, we have the first link, then at 6 metre, we have got two. So, three twice is 6. Similarly, this is for 9, this is for 12, finally, this is for 15, so we make use of this for measuring the length.

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At the end of the day, we have to fold the chain, so we put the chain in such a way so that the 15-metre mark is here, and the chain is spread in two. Now, to fold the chain, you fold them link by link till we meet both the handles. So, we saw, there in the ground, how to measure the distance using chain, and we learned a lot about the chain.

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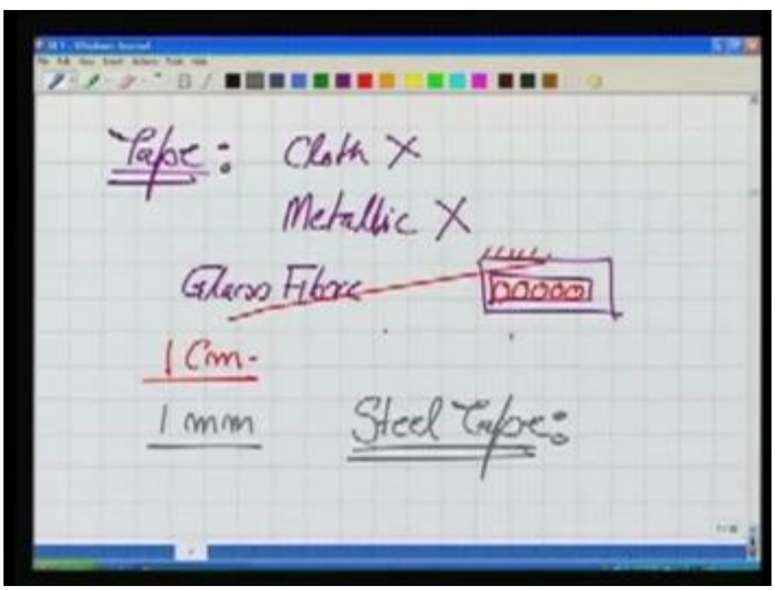

The another instrument for measuring distance is tape, and this is the one which is still used very often. You will find people having the tape and measuring the distances. What the tape is? Tapes are generally made of - you must have seen - some cloth, but we do not use these in surveying, because surveying involves working in the field where there is water, there are many other things which will damage this. We had also metallic - metallic tapes where we had some little fibres of metal running, and they were coated by some plastic. This is also not being used now much. The new tape which is mostly used now is glass fibre. Now, in this tape, the construction is like this - if I am drawing this section (Refer Slide Time 27:25), this is the plastic coating, and within this plastic coating, we have some wires or some fibres of glass running. So, this is a very good tape, because in this case, we have a plastic coating where the graduations are written. I will show you one example of this. The example of this tape is here (Refer Slide Time 27:54) - this is the tape by ((femens 00:27:55 min)), and that is the tape. Now, in the case of the tape, we have the graduations written on both the sides, and in this case, the least count is 1 centimetre. There are many, many cases where you will find the tapes having the least count of 1 millimetre also. One thing very important we should keep in mind whenever we are measuring the distances, either with chain or tape: the end of the tape or the chain is the point here (Refer Slide Time 28:34). Similarly, in the case of chain also, please ensure that we should measure from here (Refer Slide Time 28:42), because the last length is smaller and it is obvious. We have another tape which is also used very often and for accurate measurements - that tape is called steel. Steel tape - what it is? As you can see here, this tape is made of steel and here also, the graduations are, in this case, in millimetre, and we start measuring again from the end of it - just this end. So, they are used - you know, specific uses; where should we use the steel tape, where should we use the fibre glass tape? - so there are specific uses of this. And depending upon the field, depending upon the bigger requirements - if I am looking for accurate measurements, I will go for a steel tape; if I am going to plot the details taking the offsets, I will go for a fibre glass tape.

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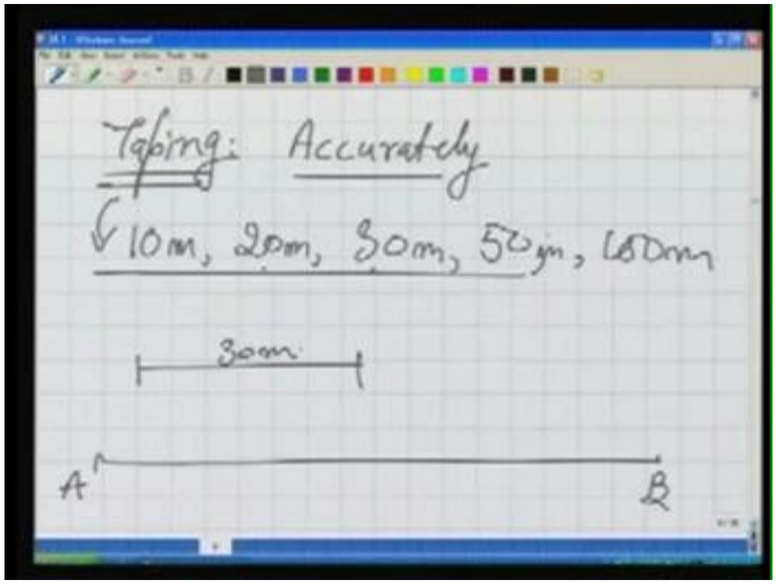

Now, what we will see, we will see next the operation of taping. The meaning is, how we can measure accurately using a tape. What are the steps involved - because while we are talking about this, there will be many things which will come in picture, and those things we should know. Now, in case of taping, let me also tell you that these tapes, they come in various lengths: 10 metre, 20 metre, 30 metre, 50 and even 100 metre also. Now, if your jusdgement - which tape you are going to use for your work – well, we are taking, let us say, any of these tapes for our purpose, and we want to measure the distance between two points, A and B, using a tape which is, let us say any length – here, 30 metre. So, what are the steps involved? Some things which we should take care - number one, of course, we will have the ranging rods at A and B. Number two, we will need to do the ranging, as in the case of chaining - we did measure a distance with the chain. Similarly, here also, we will need to establish intermediate points along the line AB. So, this establishing intermediate points along this line AB is the ranging. So, we will need to do the ranging.

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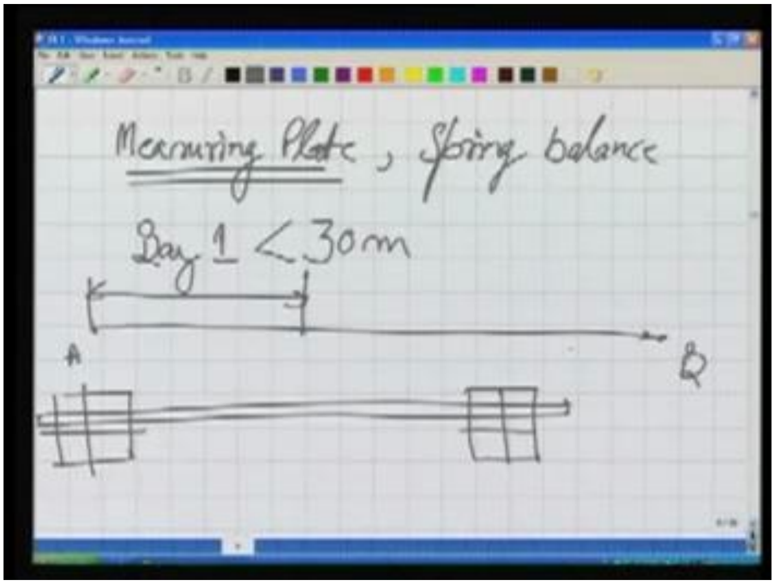

Then third, what we do, we spread our tape. For example, our points A is here and the B is here (Refer Slide Time 32:00). Now, this is very interesting; this very important - how do we spread the points? We make use of 'measuring plate' and also spring balance. Now, why we are making use of this? Number one, we will talk about the measuring plate. What we do, where our point is, A, I keep - if I am drawing this in plan now, we will have a measuring plate like this (Refer Slide Time 32:44).

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As I can show you here, a measuring plate may look like this - this is not the actual measuring plate, but it may look like this, where we have lines running here; we have some references made. What we do, we spread our tape above this measuring plate. Now, this is my tape, and it runs till the next measuring plate, and there are also the lines (Refer Slide Time 33:14). So, what we are doing - in this length AB, we are trying to measure a part of it, let us say, the bay number 1. We are trying to measure accurately the distance between these two, and this distance is, of course, less than 30 metre, because our tape is 30 metre. So, at the two ends – here, at A and here, at B - we have our measuring plates. This measuring plate is resting on point A, while this one is somewhere in between (Refer Slide Time 34:06).

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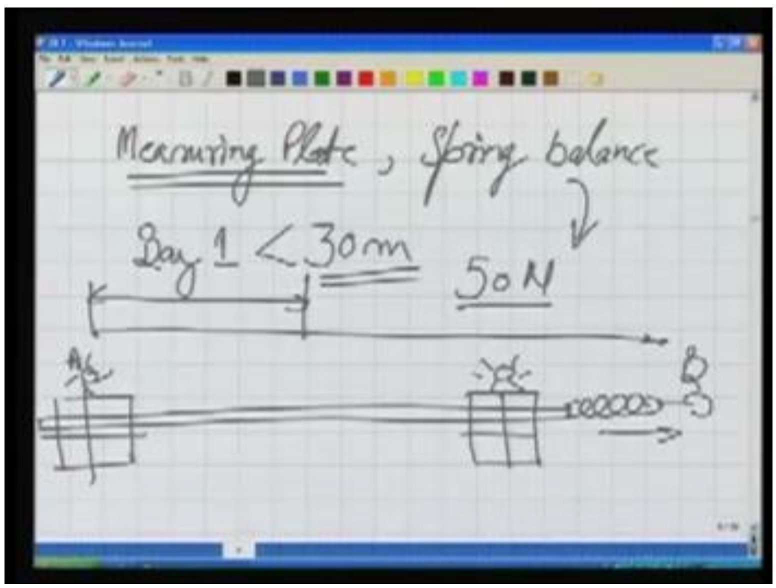

Using this spring balance - the use of the spring balance, now - using the spring balance, we apply a pull, because you know, when this tape is made - when this steel tape or any tape is made - the length of the tape, if you say, is 30 metre, it is at a certain specified pull. That pull may be 50 newtons, so it is given at that pull - 50 newton pull. So what we do, we apply the corresponding force here - the corresponding pull here (Refer Slide Time 34:46) - so that our tape is stretched to its standard pull; so there is no error because of the less pull or more pull. Well, at that time when the pull is exactly the standard pull, we measure these two points. Someone reads here (Refer Slide Time 35:06) and someone reads here, carefully. So, we record the length l_1 in the first bay. Similarly, we also record - at the time when we are measuring this - the temperature t_1.

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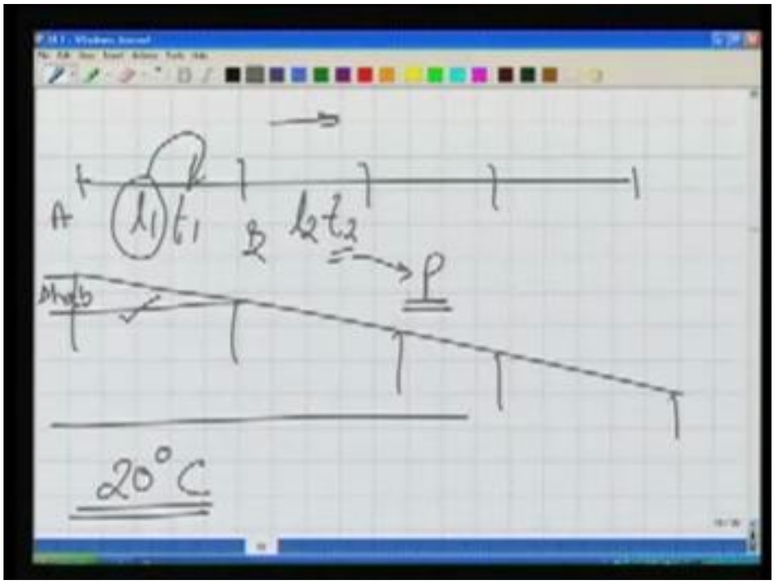

So, in a long bay, for each point, we measure the length and temperature while the pulls applied was the standard pull. If at all point A and point B have different elevations, for example, this way (Refer Slide Time 35:45), we also measure the difference in elevation 'delta hAB'. Why? Ultimately, by measuring this length l_1, we apply correction to this length using the temperature which is there in the field, because when this tape was made, it was made at a certain standard temperature. For example, 20 degree celsius – that is the temperature at which most of the tapes are made; their standard length is at this temperature. So, the temperature there in the field will be different. If it is different, we need to apply correction - that is why we are measuring for each bay. While we are measuring the length, we are also measuring the temperature. If the pull applied is not 50 newton, the standard pull, we also measure the corresponding pull, because we can apply the correction also for the pull. So, what - and then, when we are measuring the difference in elevation between these two, we are converting this sloping distance, then in horizontal distance, if you know this difference in elevation. So, what we have ensured, we have ensured that we are applying all kinds of corrections, and then we are finding the horizontal distance between these two points.

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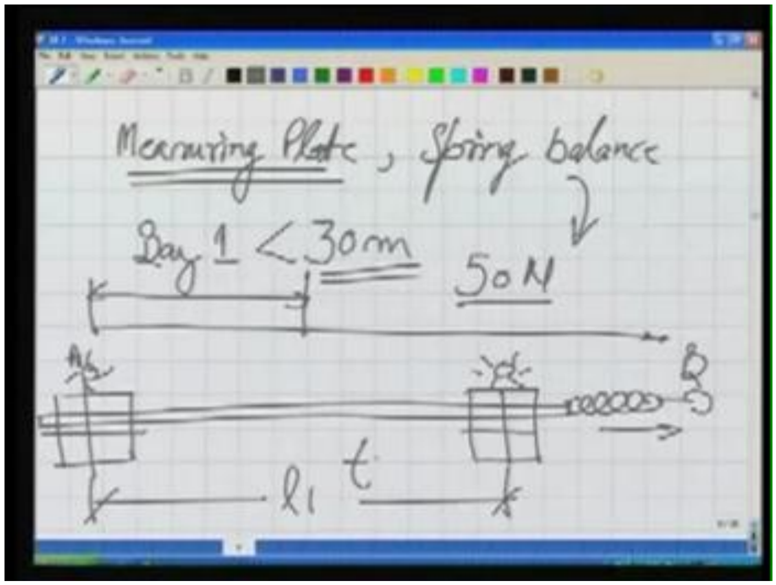

So, we have to be very careful when we are measuring the distances or when you want to measure the distances accurately with tape, and because the tapes are generally used to measure the distances accurately. So, we have to be very, very careful about all these steps.

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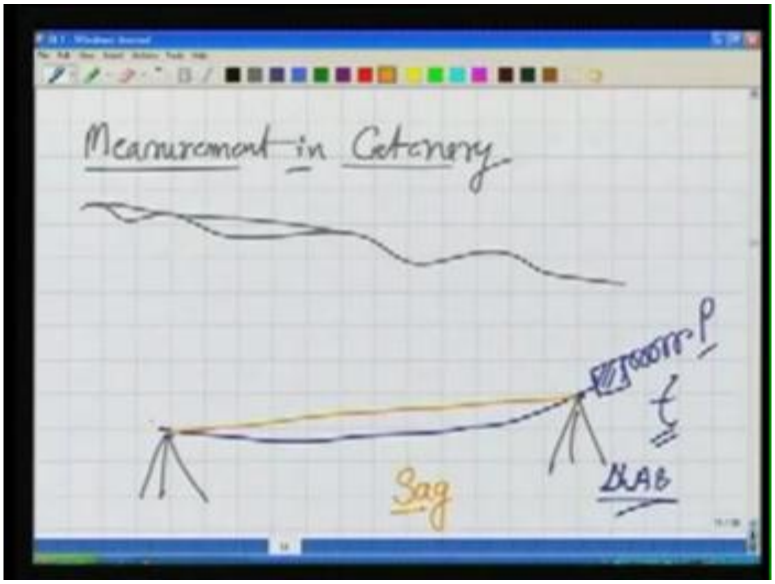

Another method, which is called ‘measurement in catenary’. Now, in earlier case, what we are doing, if my ground had some undulations I was keeping my tape here (Refer Slide Time 37:56), so tape will also have some undulation; it will follow some undulations. I want to avoid it; I do not want to keep it along the ground. I do not want to keep it over the ground, so that my measurements are very accurate. What is done in this case, in between two points, we have some adjustments like tripods, and let me make these tripods at two different elevations - that is the one, and that is the other one (Refer Slide Time 38:26). In between, we suspend our tape – let us say the tape is suspended here (Refer Slide Time 38:40), so naturally, when the tape is being suspended, tape will be in a catenary; it cannot be straight here, because the gravity is working. Then, we apply using our spring balance, a particular force ‘P’. We also measure the temperature when we are taking the observations, we also measure the difference between A and B – ‘delta hAB’, we also measure this difference. Now, our tape is suspended in the air. By taking the observations for pull, difference in elevations, the temperature, and also, we will apply the correction to this length, because the actual length - sloping length - is here; this is the sloping length (Refer Slide Time 39:35), while my tape is along a sagging line. So, we need to apply correction for this also. So, we can apply correction for this, which we say ‘sag’. So, we can apply correction for sag also. By applying all these corrections, the distance between these points A and B can be determined very, very accurately. Actually, mostly, earlier, when the electronic instruments were not there, in order to measure any length very precisely, very, very accurately, this particular method was used. This is just the single bay; there could be multiple number of bays like this, and that will give very accurate distance between two points.

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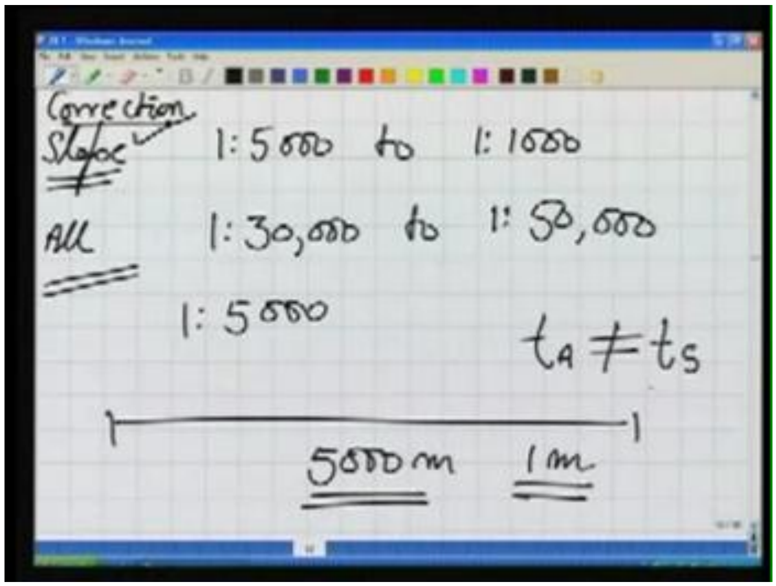

Well, what kind of accuracy we can achieve by our measurements using the tape? The tape is the one which is mostly used. If we are applying correction only to the slope, we can get an accuracy of 1 in 5000 to 1 in 10,000. If you are applying all corrections, then, the kind of the accuracy which is given by taping is 1 is to 30,000, to 1 is to 50,000. Let me also tell you - because this is also a way of reporting the measurements or the accuracy - what is the meaning of this? The meaning of 1 in 5000 is, if you are measuring a distance of 5000 units - let us say metre - there will be a possible error of 1 metre. The error in the measurement is of order of 1 metre. So, this is a very, you know, a method in order to report the accuracy of the observations. But the second thing - because the taping has to - in all our steel tapes, we have to apply correction for temperature, because the temperature in field or in actual - if I write A - is not same as temperature at which the tape was made standard. Is there a tape for which - now, why it is happening; why the tape is expanding? Tape is expanding because of the thermal expansion coefficient of the material. So, can we have a tape for which the coefficient of thermal expansion is very less?

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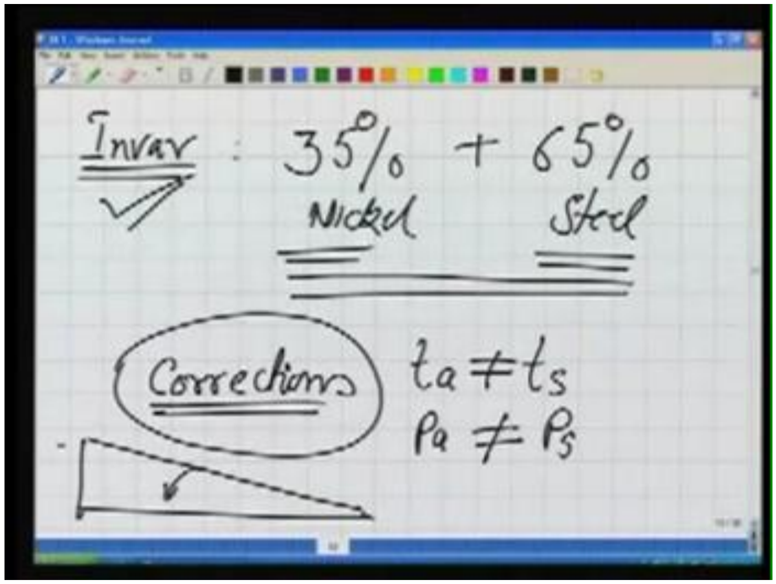

Well, that material is ‘invar’. Invar is a combination - an alloy - of 35 percent nickel and 65 percent steel. Now, this particular material, invar, has got very less coefficient of thermal expansion. So, whenever we need very accurate measurements, we can go for invar. The only problem with the invar tape is, they are brittle; they are not as good as to work with as our glass fibre or steel tape. Well, in all our taping operations, or maybe the chaining also, we saw, and we have been talking about this, that we need to apply corrections. Corrections for the temperature there in the field; temperature actual is not same as temperature of the standard. The pull - pull applied to the tape is not actual one; is not same as the pull which was a standard pull. Similarly, many more things - for example, we need to apply the corrections for the sloping distance; we are measuring between these two points A and B, and these two points are at different elevations, so we need to apply correction again for the sloping distance. So, what we will see, we will see what all these corrections are, and how we can apply them one by one.

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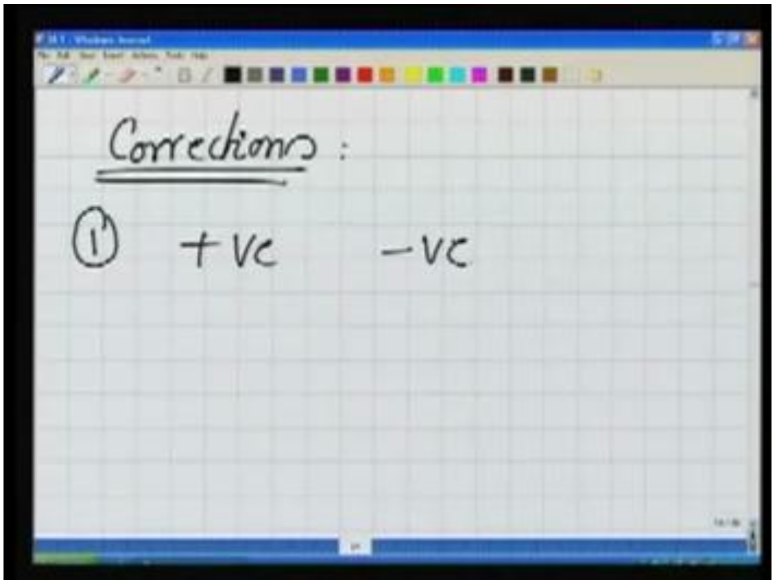

So, in the corrections, we will start with the correction number one, which we say ‘correction for standard length’. Now, one thing we should know here: our corrections may be positive or negative, depending what kind of error is occurring there.

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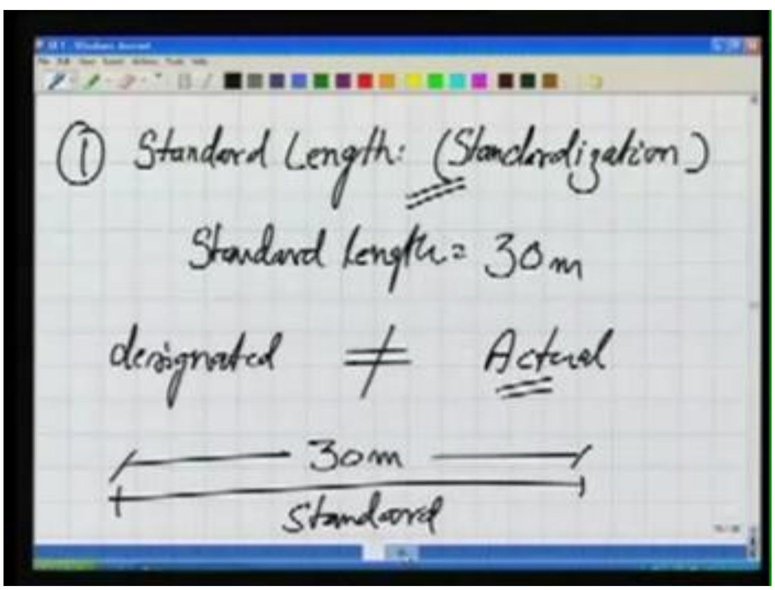

Now, in this first correction which is for the standard length or standardization, what is happening there? This tape - the standard length of this tape, as written here - is 30 metre.

So this is, we say, the ‘designated’ length. The designated length - something which is written there. But is this really 30 meter? What is the actual length? Are they same or not? Because this is 30 metre at certain temperature, or maybe something may go wrong - let us say I was working with this tape and something goes wrong with this tape, and someone has cut it, and then taken a little part of it out, and then again pasted it. So, what has happened? A little piece of the tape has gone away, or maybe, if you are talking about the chain - let us say one little link of the chain is missing. So, if one link of the chain is missing, we are saying the chain is 30 metre, but actually, if you measure it about some standard - if it is a standard length, we know exactly this is 30 metre, because we have established it, and these are there in the ground. We have fixed two points using some very accurate measurements which are 30 metres away. Now what we will do, we will take our chain or our tape, we will put it on that standard, and if you find that our designated length is not same as the actual length, we need to apply correction. So, that correction is called ‘correction for standard length’.

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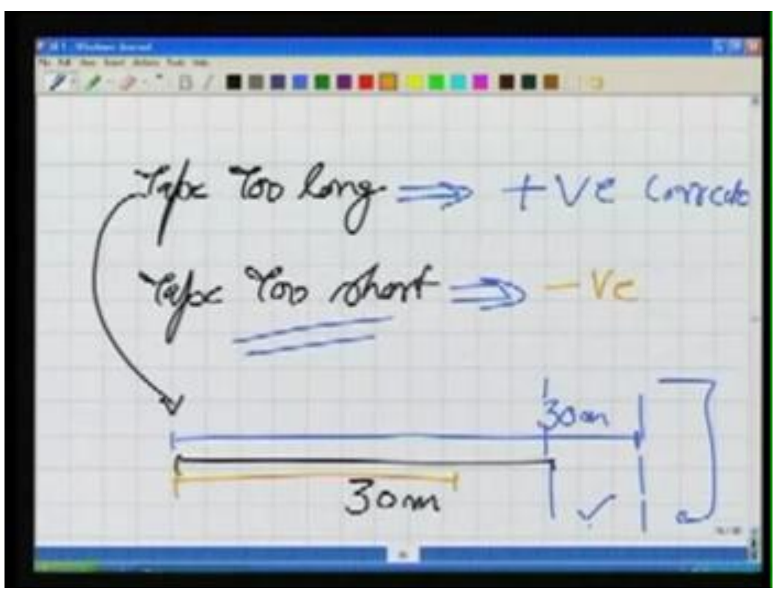

Now, how do we apply that correction? There are two terms: one is ‘tape or chain too long’, the other one is ‘tape or chain too short’. What is the meaning of this? The meaning is - I will explain only one and the second will be automatically clear to you.

Well, if, in our standard of 30 metres, you are spreading your tape. So this tape - the designated length of the tape is 30 metre, but somehow, maybe, also you know by continuous use of the chain or tape, it has now expanded. So, though we are saying the designated length is 30 metre, but the actual length is more than that, we say it to be too long. If it is so, what kind of correction will be there? What will be the size of correction or the sign of correction? Of course, the size of the correction - the amount of the correction - will be this difference (Refer Slide Time 47:26). So, in each measure of our tape, we need to apply this correction. Which direction? We should apply, as in this case, what we are doing, we are measuring a length of 30 metres less than that, because here in this case, we are measuring it less. So, if you are measuring it less, our correction has to be positive. So, this particular value will be added to the measurement. I think this is clear to you, and if it is, you can also find what will be the correction if the tape is too short. The 'too short' means – now, my tape is like this (Refer Slide Time 48:14). The 30 metre tape is only this much; two, three links are missing. The correction, in this case, will be negative.

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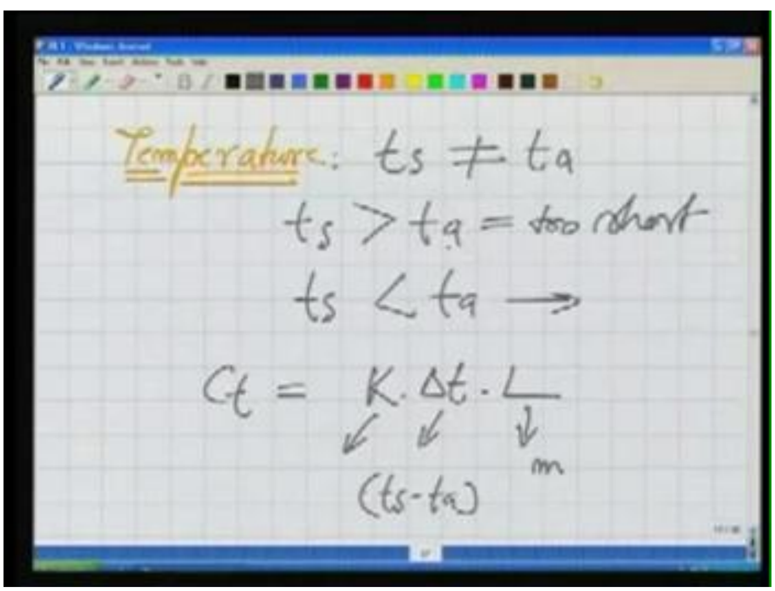

Now, the next correction that we will talk about is correction due to temperature. Well, as we said, the temperature of standard - the standard temperature - is not same as temperature there in the field; actual temperature. Now, there may be one case, t_s is more than t_a, or t_s is less than t_a. If t_s is more than t_a, the actual temperature there in the field is less than the standard temperature. What will happen? Our chain or tape is shrunk; its length is shorter, so this is the case like 'too short', and you know what kind of sign of the correction will be there if the tape is too short. Similarly, you can also find here (Refer Slide Time 49:29) - in this case, it would be too long. Now, what is the amount of the correction? The correction is written as C_t - this is given as K times delta t into L, where L is the length measured in metre, K is the coefficient of thermal expansion and delta t is the difference in t_s minus t_a. So, using this, we can find the correction to our tape.

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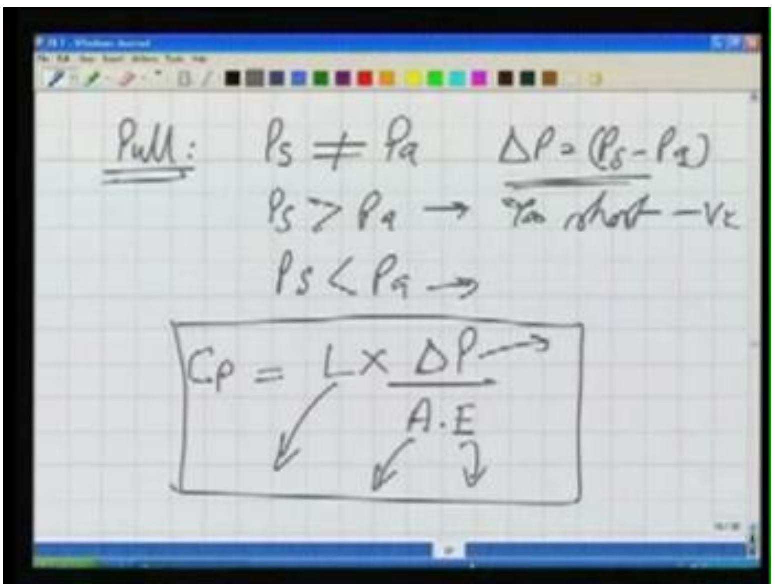

Well, the next correction is very important for us – 'due to pull'. We know, in order to measure the distance, we have to stress our chain or tape and we have to apply certain pull. The pull at which the chain or tape was made is the standard pull, P_s - it may not be same as the actual pull. So, if you are using a spring balance there in the field, you can also measure the actual pull. So, what we need to do, we need to apply correction for this difference in pull, which is P_s minus P_a. Now, again, in this case, if P_s is more than P_a, there will be another case when P_s is less than P_a - the actual pull is less than the standard pull. So, the meaning is, chain or tape is slightly shrunk. If it is so; if it has slightly shrunk, it is too short, and if it is too short, the correction will be negative. Similarly, you can find for this case - it is too long; correction will be positive. Now, what is the value of the correction? The value of the correction we write as ‘C’, correction due to pull ‘P’ is equal to: ‘L’, the measured length, multiplied by ‘delta P’ divided by ‘A’ into ‘E’ (Refer Slide Time 51:39). Now, where L is the measured length, delta P- we know - the difference in pulls, A is the cross section area of the chain or tape, because we need this. And, E is - you can guess - is the Young’s modulus of elasticity. So, by applying this, we can find the correction due to pull.

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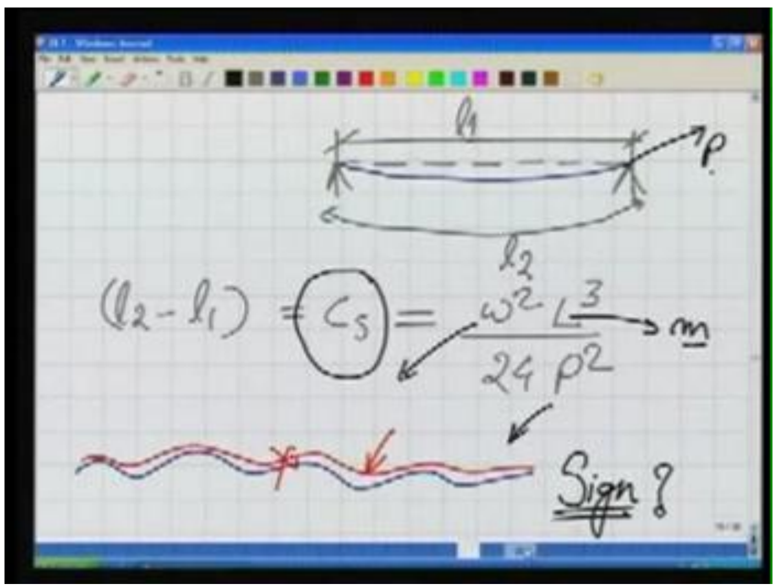

Well, the next correction: if you are stretching your chain or tape between these two points - so we are interested in measuring the distance between these two points A and B (Refer Slide Time 52:34) - what we do, we stretch our tape or chain in between these two points. Well, let us say I stretch it here (Refer Slide Time 52:46) - I am trying to measure more accurately and I am not stretching my chain or tape there on the ground. If I stretch it, let us say the red colour shows the chain or tape spread on the ground, and the ground has got some undulation - maybe that is very little - very, very little undulations, but the length measured now will be wrong, because my tape is also following those undulations, unless I am sure about the ground that it is perfectly horizontal. For accurate measurements, we should not do this. So, what we do, we suspend our tape or chain in between these two points, and if you are suspending it, because the gravity is working, we can never get the tape in the horizontal line; in a horizontal plane. It will always have some sag because of the gravity. Whatever pull you apply, it will have the sag. So what is the meaning of the sag? Now, the distance between these two points is actually, let us say, l_1, while the tape is measuring along the sag, and the length of the tape is l_2. So what we see? There is a difference in l_2 minus l_1, and this is the correction due to sag. So, we need to know about this correction. To know about this correction, the value is - as I am writing here - the value is w^2L^3- I will delete this)ddd 54:38) - L^3 … 24 times P^2. Now, what these terms are? Instead of T here, I would like to write P, because we are using the term T (Refer Slide Time 54:54). Now, here, these terms: we will start with number one. W is unit weight of tape per metre - or the weight of the tape per metre; per unit length. So, weight of the tape per unit length is W. L is the length, total length, which is measured in metre. P is the pull which is being applied - P. So, we can measure this P because of spring balance. We have measured a distance, as here in this case, it was l_2 - so, that is L, and we know about the tape - what is its weight per unit length. So, by doing that, correction to sag can be found. Now, what will be the sign for this correction? I am leaving it to you - use your brain and try to find what will be the sign - will it be positive or negative?

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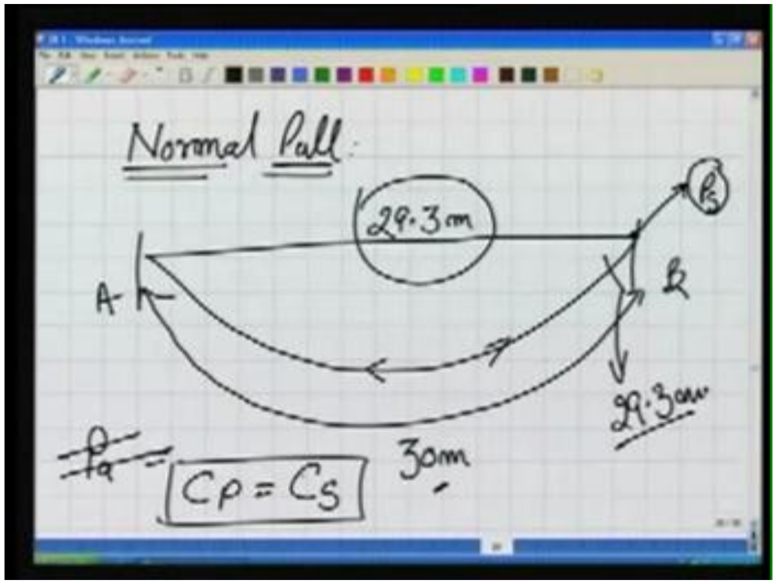

Well, I am going to give you one more term now, and that is called ‘normal pull’. What is the meaning of normal pull? There in sag - the tape is in sag, we know the tape is in sag we; we are applying a pull here. So, what is happening? Let us say this distance is actually 29.3 metres. Let us say the distance between these two points A and B is 29.3 horizontal distance. But because of the sag, we have a total of 30 metre tape stretched. So, the tape is measuring this distance to be 30 metre because the sag is working, while the actual distance is 29.3. This is at a certain pull P, which is the standard pull. So, there is no error in the pull in this 30 metres. What I do now, I increase this pull slightly - if I am increasing this pull, my chain or tape will expand now. So, it will expand, and I apply this pull to an extent so that the graduation in this tape or chain, which is 29.3 metre, reaches here (Refer Slide Time 57:48). What is the meaning of that? Well, even if the tape does not sag, I apply the pull so that it reads 29.3 only. So, this is the case when the pull applied is - or rather, the other way round, we can say: the correction due to pull is same as correction due to sag; they are cancelling each other. So, if they are cancelling each other, that kind of pull we say the normal pull.

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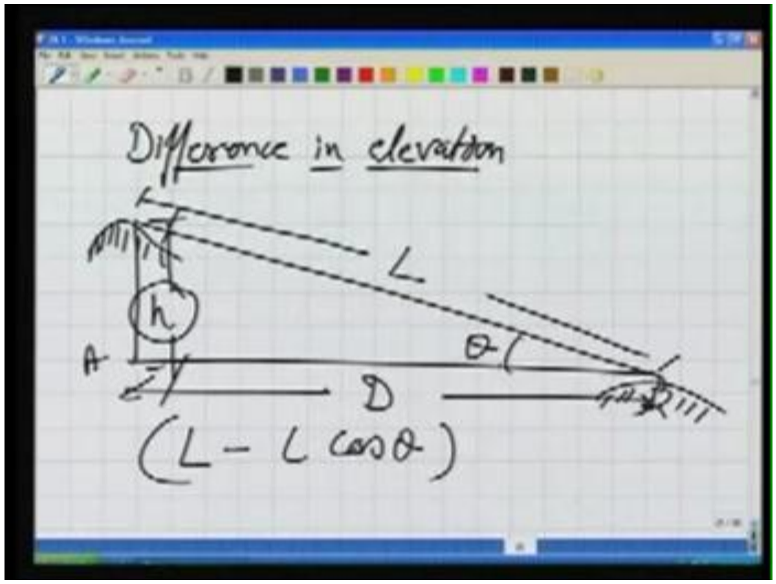

Now, we will look at one more correction, and that we say ‘correction for difference in elevation’. This is very simple, and just by using your simple geometry, you can find it. If there are two points at A and B - that is my surface of the earth - here, and here (Refer Slide Time 58:56), what I am measuring, I am measuring this length L. If you know this angle theta - let us say you are measuring this angle theta also - you can easily find what will be the correction, that is, the difference between L minus ‘L cos of theta’ - that is the amount of the correction. Or, if you can measure this difference in elevation between these two points - H. So again, you can find this horizontal distance D using the Pythagoras theorem here. So, you can apply corrections if you know the difference in elevation H, or the angle here - so correction can be applied. So, we have seen today the distance measurement using tape and chain and various corrections we need to apply for it. We will finish our video lecture today.