Application of Soil Mechanics
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Lecture – 32

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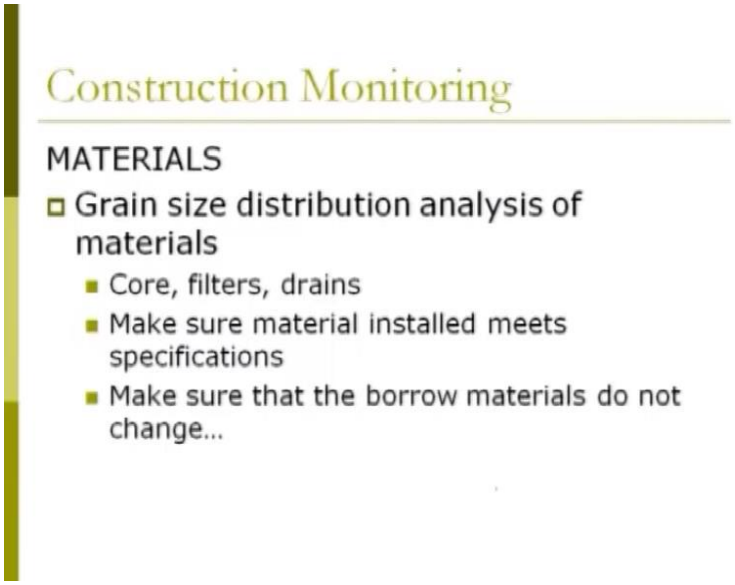

So, last class we have started constructions, and a construction monitoring. So, we have started this materials materials in this materials a grain size distribution analysis of material like core filters, and drains, then a you should slow that, and sure that material install meet this specification makes your that as I explained also earlier borrow material do not change; that means, improve take borrow material from one place in half to take this said material from the same place.

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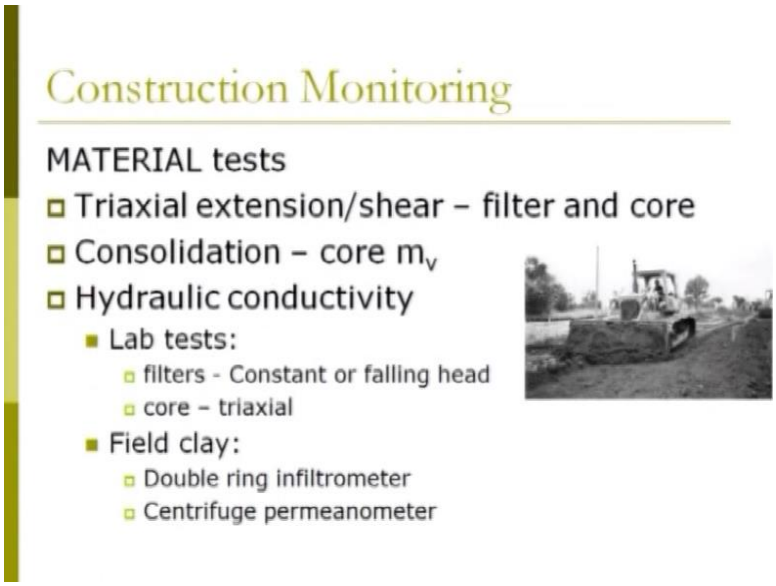

Then material tests; that means, a triaxial extension as well as shear test or filter, and core or filter, and core, and consolidation for core material, because you need to half less permeable material, then head only conductivity lab test for filter as well as core, and field clay; that means, of double ring infiltrometer, and centrifuge permeanometer.

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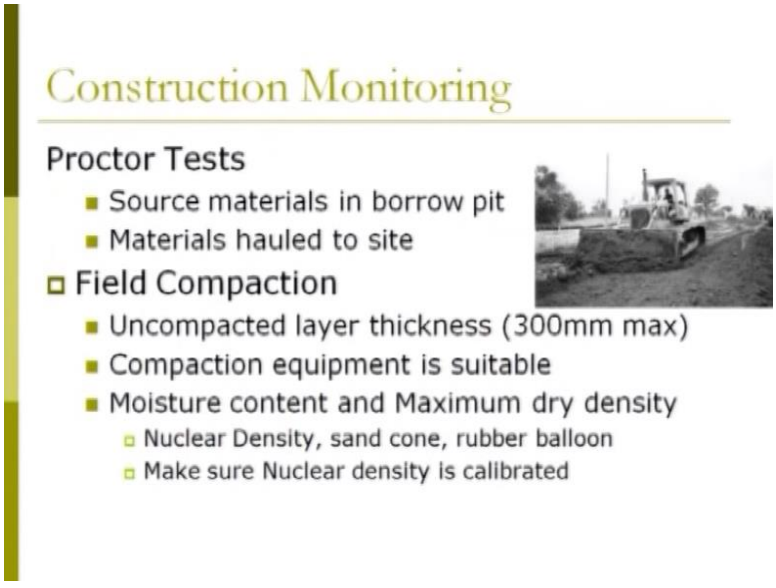

Proctor test a will half to conduct proctor test for this source material in the borrow pit, and material hauled to this site field compaction uncompacted layer thickness; that means, three hundred m m maximum compaction equipment is suitable moisture content, and maximum

dry density will have to do by means of nuclear density sand core or rubber balloon method makes sure that if your using a nuclear density, then nuclear density a equipments would be calibrated.

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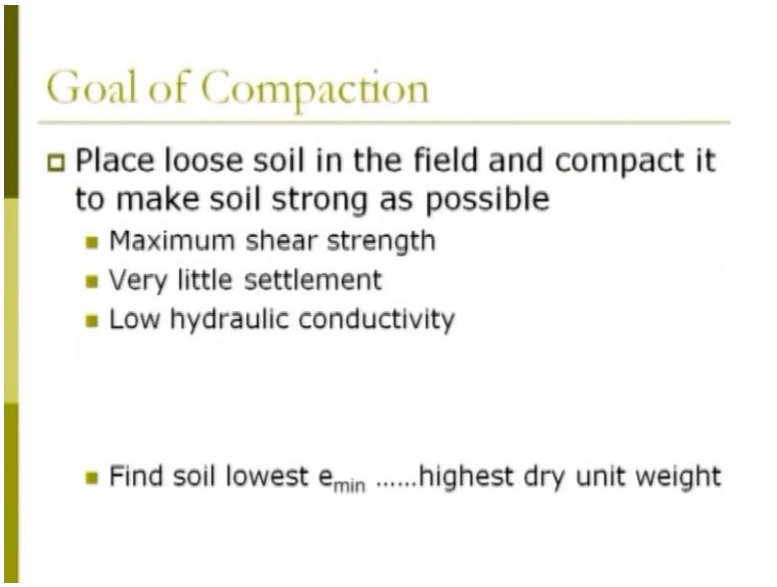

And place a loose soil in the field, and compact it to makes soil strong as for as possible. So, that you will get maximum shear strength, and very little settlement, and low hydraulic conductivity or soil lowest aim highest dry unit weight.

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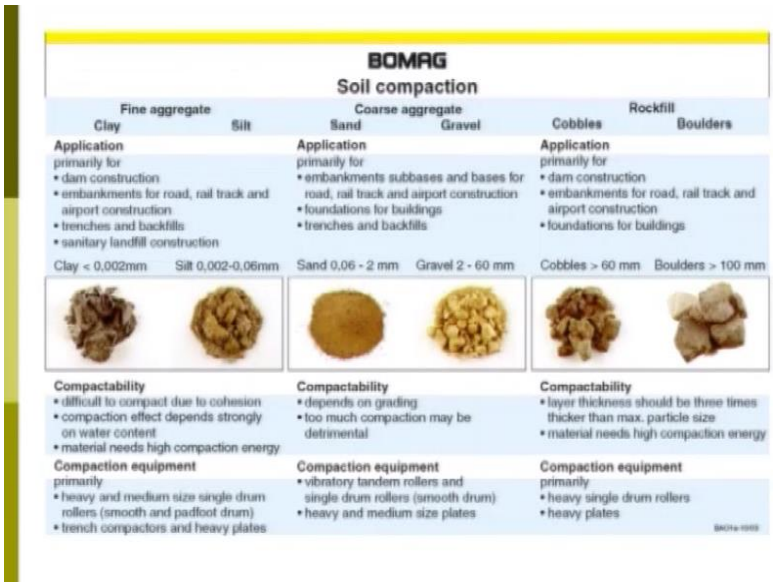

Take the per soil means lowest that you will achieve high dry unit weight of to these way of

completed, then oils are this is at table for this a soil compaction. If you look at this attachment divided into one two three four five six parts fine aggregate make it into fine aggregate make it into clay, and silt coarse aggregate a it, it is sand, and gravel, and rock fill cobbles, and boulders if you look at this clay application primarily application primarily for dam construction dam construction embankment for road rail track.

Airport construction trenches, and backfill, and sanitary landfill construction a clay fraction generally would take if it is a less, then is finer than two point zero zero two m m or two micron silt is from point zero zero two to point zero six, and compatibility a difficult to compact due to the cohesion if you go for a compaction for clay soil, and difficult to compact, because of cohesion compaction effect depends of depends strong on water content, because you will half to hard water it depends strongly one water content material needs high compaction energy, then compaction equipment primarily heavy, and medium size single drum roller primarily.

If the clay soil has been used for this a dam construction this a equipment is used single drum or medium size single drum roller smooth or pad foot drums trench compactor, and heavy for trench compactor, and heavy plates also used now if you comeback for sand, and gravel for particularly course aggregates sand, and gravel application is primary for embankments soft basses; that means, embankment soft base base for road road base rail track airport construction foundation for building course aggregate general used foundation for building trenches, and backfield you see it is given year in the pictorial view how the sand looks, and your gravel how it looks general range is two to sixty m m, and sand is six micron to two I means two mm, and compatibility; that means, depends upon the grading; that means, a depends the your great size a gren grand size distribution too much compaction may be in detrimental.

And compaction equipment generally used vibratory rollers of single drum rollers; that means, smooth drums you can used heavy, and medium size plates if you are using compaction by means of plates, then you can go for heavy, and medium size plate if you compare both these fine as well as course aggregate for these heavy plates as well as trench compactor used, but in this case heavy, and medium size plates as been used, then rock field; that means, corbels, and boulders application primarily for dam construction embankment for road, and drill track, and airport construction foundation for building, and a the size of the corbels is a greater than sixty mm, and boulders are greater than hundred mm look at this

how this boulders looks like corbels looks like, and compatibility layer thickness would be three times three times thicker, then maximum particle size; that means, layer thickness is you will half to take you will half to decide what is the thickness of the layer to be compacted it should be maximum; that means, it is three times, then your maximum particle size material lead needs high compaction energy particularly the material needs high compaction energy compaction equipment primarily huge heavy single drum rollers, and heavy plates these at the overall soil compaction. If you want to huge for your dam constructions suppose fine aggregate course aggregate or may be rock field what should be your what should be your compaction what type of compaction you're going to huge, and what is your compaction equipment you're going to use, and how means these these gives if brief idea means what type of equipment you are a going to use, if it is a fine aggregate if it is course aggregate, and if it is a rock field.

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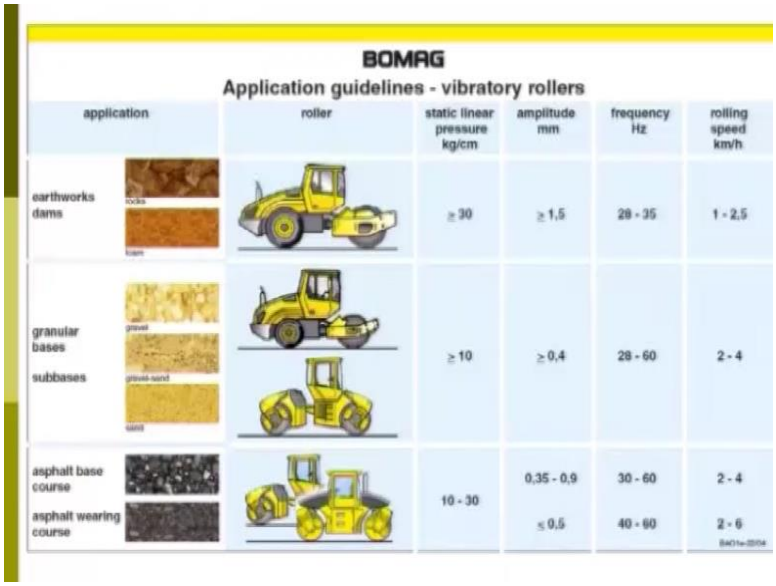

Now, application guidelines for particularly vibratory rollers these are all your rollers if you look at is rollers a earth work dams particularly earth work for particularly dams rocks, and loams granular base, and sub base; that means, gravel gravel gravels sand sand asphalt base asphalt base is your road road particularly asphalt base course, and asphalt wearing course, and this static liner pressure, because you will have to apply a minimum amount of pressure. So, that you will get value of would be minimum, and maximum density should be achieved its should be k g per c m k g per linear pressures k g per c m square. So, if you if you apply it should be greater than thirty thirty for particular earth work dams, and for granular bases,

and sub bases its would be greater than equal to ten it should not be less than ten for asphalt base course, and asphalt wearing courses. It is bearing between ten to thirty, and a amplitude, then what amplitude will give in a mm; that means, it is greater than one one or five, it is greater than zero point four zero point three five to zero point nine frequency generally what frequency you are going to apply in terms of hours, it is twenty eight for earth work dams twenty eight to thirty five for granular base, and soft bases twenty eight to sixty for asphalt base course, and asphalt wearing courses thirty to sixty, and forty to sixty, and rolling speed k m for our what is your rolling speed you are going to apply want two point five two to four, and two to four, and two to six.

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Look at this how this it foot a sheep foot sheep foot roller it looks like, if you look at this it put rollers there are there are just threaded parts around the periphery of the roller. So, that it has been used particularly for clay soil, because it has a high cohesive.

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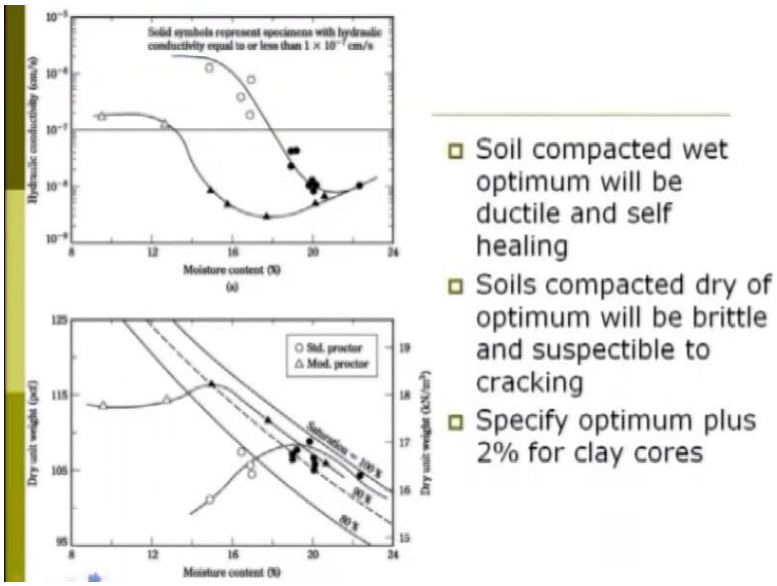

So, the rolling can be done very effectively. Now soil compacted wet optimum will be ductile ends, and self healing, and soil compacted dry optimum will be brittle, and susceptible to cracking, and specify optimum plus two percent for clay cores what you mean by, if you look at your compacted in weight optimum, and compacted in dry optimum if this is my compaction curve for example, if this is my compaction curve if this is my compaction curve. If you look at the compaction curve; that means, dry you look weight verses moisture content, and this is your this is your this value in this compaction curve this value is coming about this is your maximum dry density corresponding to your o m c optimum moisture content left hand side.

This site this site is your dry dry optimum means from optimum it is your dry side, and this site is your wet site this site is your wet site wet site this is your dry site now if you look at here; that means, soil compacted on wet optimum will be ducktail, and selfealing will be slightly ducktail, and selfealing for wet wet site; that means, this site of the right hand site of the o m c similarly soil compacted in dry optimum similarly soil compacted in dry optimum; that means, this site from here to this site dry optimum site generally it is a brittle, and there is a chance of crack. So, generally you will half to specify what is your compaction generally optimum plus minus two percent or clay course; that means if this is my o m c. So, let us say fifteen percent is your o m c this is your optimum moisture content which is your dry density generally you will rec recommend for two percent; that means, fifteen percent plus two seventeen percent of your compaction moisture density for particularly clay course.

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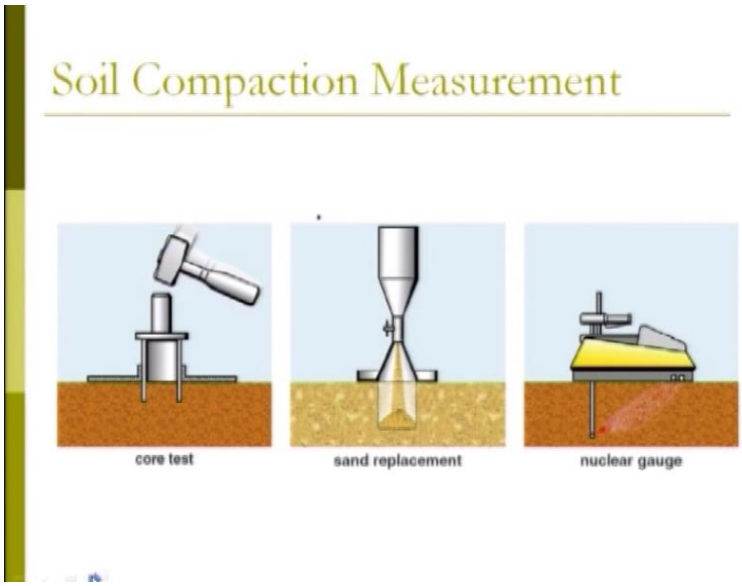

Now, soil compaction measurement how do you measure its soil compaction measurement there are different web different a, as I said earlier one is your core test of there is your sand replacement method, and third is your nuclear gauge this is your nuclear gauge method.

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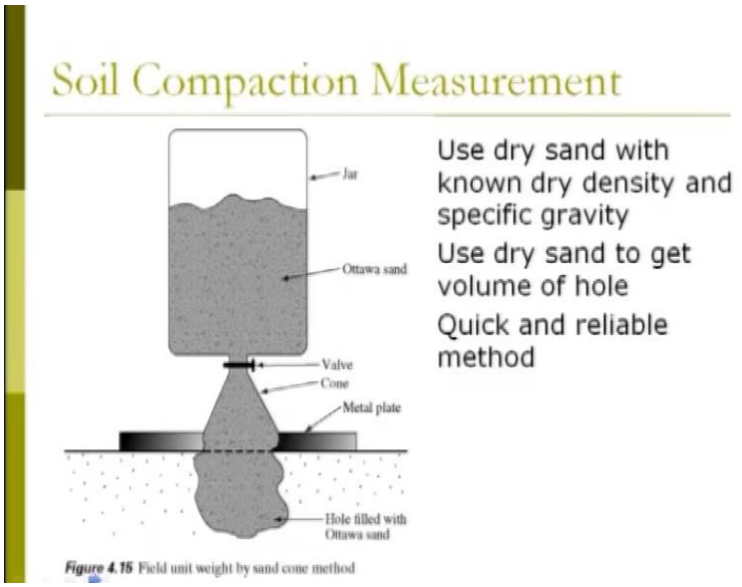

Now, in this in case of a soil compaction measurement by means of sand core method a used dry sand with known dry density. If you using by means of sand replacement method in this case what you are going to do use a dry sand use dry sand with known dry density before you are using this method you should known what is the dry density of that sand, and

specific gravity also, and specific gravity also use dry sand to get volume of hole quick, and reliable method once you are using a dry sand; that means, volume of hole it a particularly it will be quick, and it gives a reliable test. If you go back if you see this by means of sand core method a hole has been specify hole has been maid; that means, ones you make a hole you know you know this height you know this height you know his a width, then you can know this what is that volume of this hole, and with that volume you will apply of a dry sand to poor inside so; that means, wet of the volume of the hole replace by dry sand.

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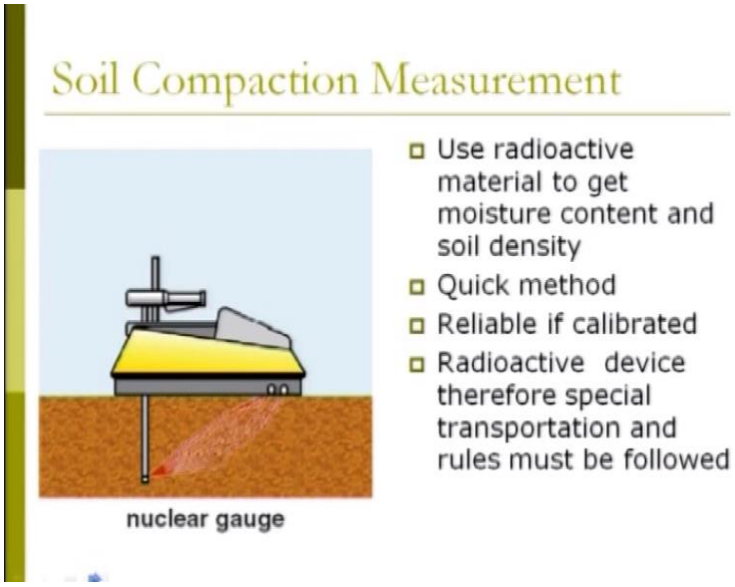

If you know, then you can find it out what is your a compaction how much your compaction as been dam means by means of your sand core method another one is more most effective now digit has been used that is called nuclear gauge method that is called nuclear gauge method in nuclear gauge method what happened generally ready active materials been used to get moisture content soil density if you look at here this generally a nuclear gauge is they are from ready active material has been used to get the moisture content, and soil density it is a very effective, and quick method reliable it is very reliable you will half to calibrate every time once you do it, you will half to calibrate with known a density once you know if you know the density of this soil known density for known, then you calibrate from this a by means of nuclear gauge how much you are getting, then you take it, then do this where where the your soil compaction as been maid radioactive device there for special transformation, and rules must be followed the means for calibration has to be done, and, because ready active device it is a it is a ready active devise defiantly you will half to follow

certain rules, because it should not be expose to public.

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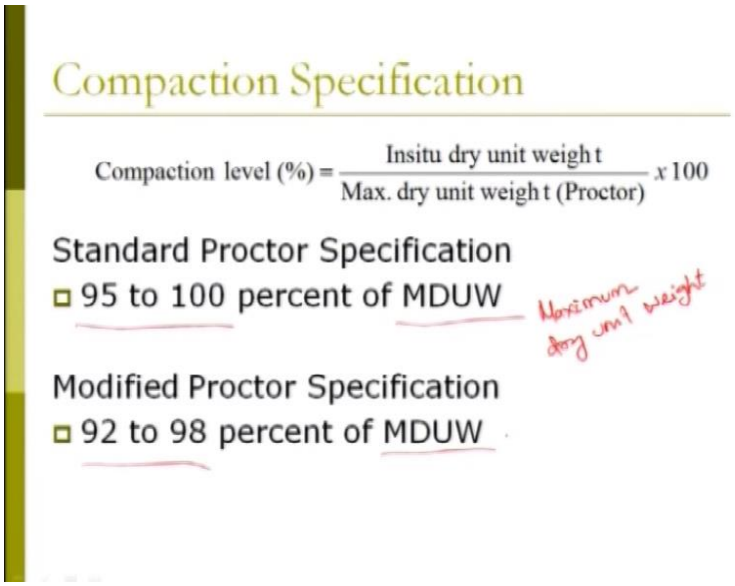

Compaction level compaction level; that means, insitudry unit weight divided by maximum dry unit weight proctor into hundred percent into hundred it generally a mention in terms of percentage standard proctor specification, and ninety five to hundred percent maximum dry unit weight m d u w is maximum dry unit weight. Similarly if you are there are as I said earlier; there are two Mmethods; one is your standard proctor method, another is your modified proctor method in case of modified proctor method generally this compaction label the once you compact. If you get a compaction level of ninety two ninety eight percent; that means, you have a achieved your compaction level, if you are using a standard proctor generally ninety five to hundred percent has been use; that means, that is your standard. So, it is your m d u w is your a maximum dry unit weight by using modify proctor specification that been ninety two ninety eight ninety five two hundred how do you find it out compaction level institute dry unit weight what is your insitu condition, and maximum dry unit weight by means of proctor into hundred.

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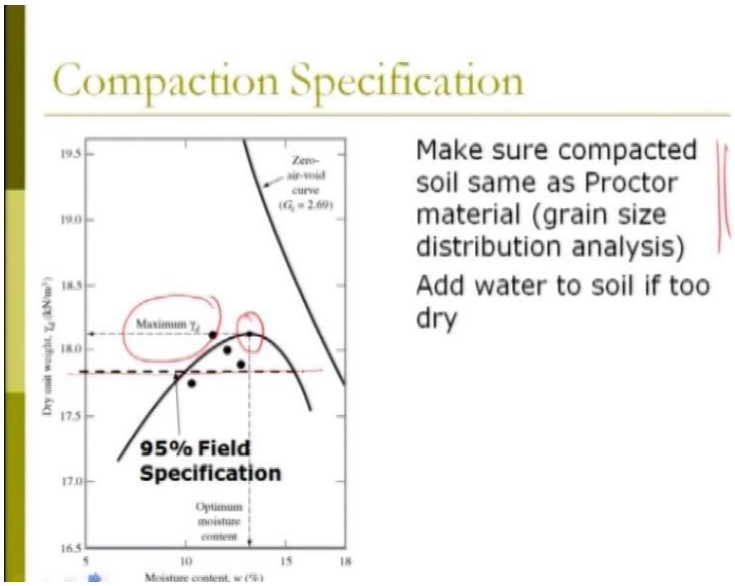

If you look at here in terms of graphical point of view there is a compaction curve dry unit wet for says moisture con moisture content, then this is the this is your compaction curve this is your compaction curve, and this is your optimum moisture content, and with respect to optimum moisture content whatever you're getting that is your maximum dry density, and with this a ninety five percent fields specification you have to mark a ninety five present of field specification a makes your compacted its oil same as proctor material, means whatever your compacting soil in the ground it is a same material it has been use while doing in the laboratory test its do not be a different material, and this is this is your specification, and you can mark it your ninety percent field compaction line where it lies.

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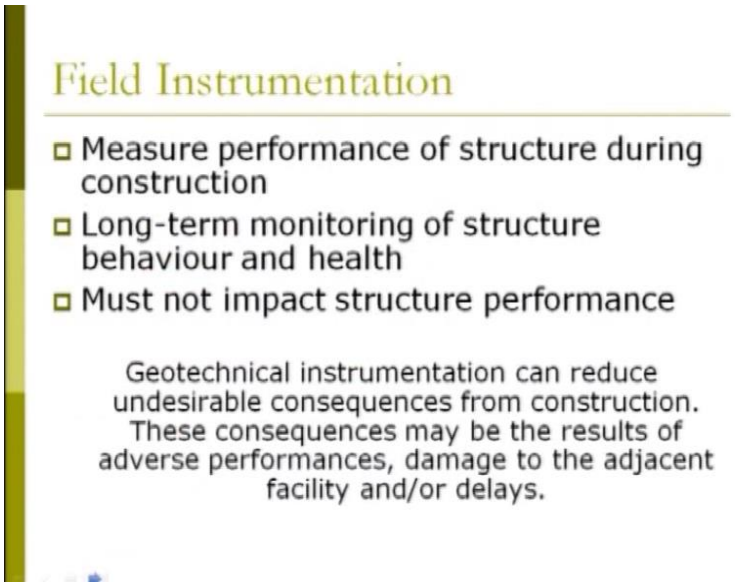

Then then past is your past part is your measurements, then is your instrumentation second part is your field instrumentation generally particularly a dam; these are all a by sensitive project as well as the cost is very high generally the field instrumentation; that means, you will half to make the field instrumentation depends you will half to make instrument in the field particularly during the constructions for that measure performance of structure during the construction means how during the construction, how it is how what is the performance of that if it is earth field dam; that means, what is that performance, then long term monitoring of structure behavior, and health particularly long term monitoring of structure behavior, and health must not impact structure performance it is would not be use to would not be a impact your structural performance whatever you have doing your field instrumentation.

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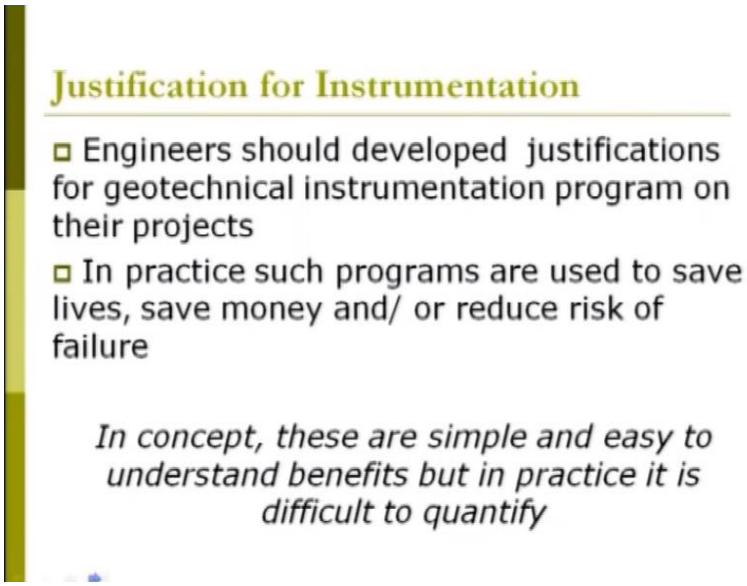

Engineers should developed justification for geotechnical instrumentation program on their project means particularly if geotechnical engineer is they are you will half to justify. In practice such programs are used to save lives save money, and reduce risk failure reduce particularly there if there is a chance of risk of failure, you can if you measure it hardly, then you can rectify.

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It a reasons to a install instrumentation; that means, indicate impending failures provide warning it also give some warning if there is any problem reveal unknowns it gives what are

the unknowns you left for the design evaluate critical design assumptions critical design assumptions assess contractors means, and methods it also assess suppose you are you have already design something, and contractor has given some specification, and methods it also assess where there it is staling with her this contactors means ten method minimize damage due to this adjacent structure, if there are structures nearby it will minimize by means of instrumentation.

Then control construction you can how a control our the construction you can change on the field from the beginning that if there is a any mistake you can change a during the construction control the operational. So, how you're doing this construction this enter of operation as also been control provide data to help select remedial methods to fix problem; that means, it gives a data provide data to helps select remedial methods to fix problems documents performance for assessing damages inform stakeholders satisfy regulation regulators reduce litigation, and advance state of knowledge this more important your state of knowledge also you will again state of knowledge day to day basis how actual we have done in the test in the laboratory we limit in the field, how it is how fire how fire where there it is close to this laboratory a where there it is how for it is from this laboratory test where there it you are getting this result of to your desirable a design parameters.

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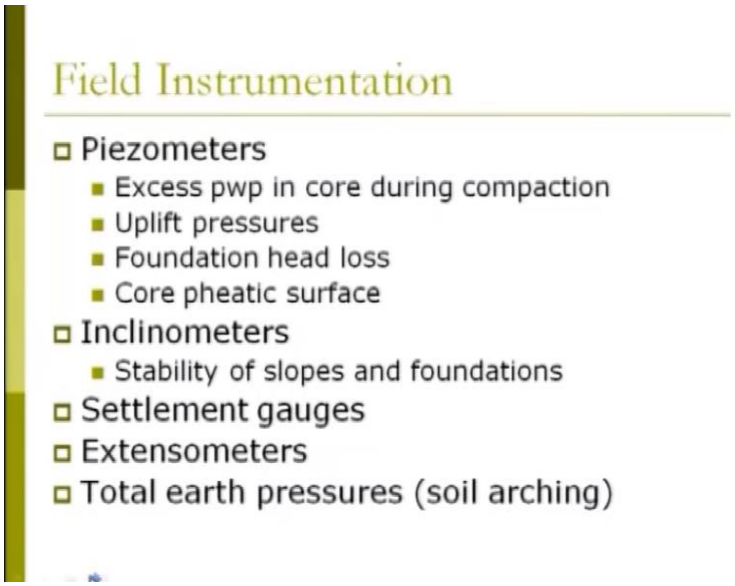

Field instrumentations: There are different field instrumentation; one is your piezometers, piezometer generally use to measure excess for water pressure p w p; p w p is your core

water pressure generally it has been a name as be w p excess for water pressure in the core during compaction; that means, if there is a compaction during compaction you can measure a excess for water pressure uplift pressure piezometer gives an idea what is your uplift pressure as I said if this is a dam section, if this is a dam section, then if this is your off stream this is your downstream.

If this is your pralines, then it gives if pralines exit in the downstream face, then if there is any uplift pressure built, then it can give also uplift pressures, and foundation head loss how much head loss; that means, water passes from upstream to downstream what is your head loss, then core pharisaic surface, if this is the core, if this is the core, then what this phreatic surface core phreatic surface also at gives; that means, piezometer wide application number one measurement of excess core water pressure in the core during compaction are during construction second is your uplift pressure; that means, at the downstream face what is your uplift pressure genetic third is your foundation head loss how much is your foundation head loss, then fourth is your core phreatic phreatic, it is wrong it is not phreatic it is phreatic, P h p h r e a t i c core phreatic surface.

Then this this is your use of your piezometers second one is your field instrumentation that is your inclinometers; that means, inclinometers generally used to measure this a stability of slops, and foundations where there it is a stable if there is a slope if there is a slope this kind of slope where there this slope a stable or not it can measure it by means of a inclinometers, then there are settlement gauge gauges settlement gauges generally use to measure this settlements settlements of the foundation settlement of the compacted layers, then extents of meter, then earth pressure earth pressure total are pressure; that means, earth pressure soil earth pressures earth pressure generally provide along the soil to measure if is there any soil arching, if is there any soil arching. So, these are the different field instrumentation different parts; that means, piezometer inclinometer settlement gauge gauges extensometers total earth pressures.

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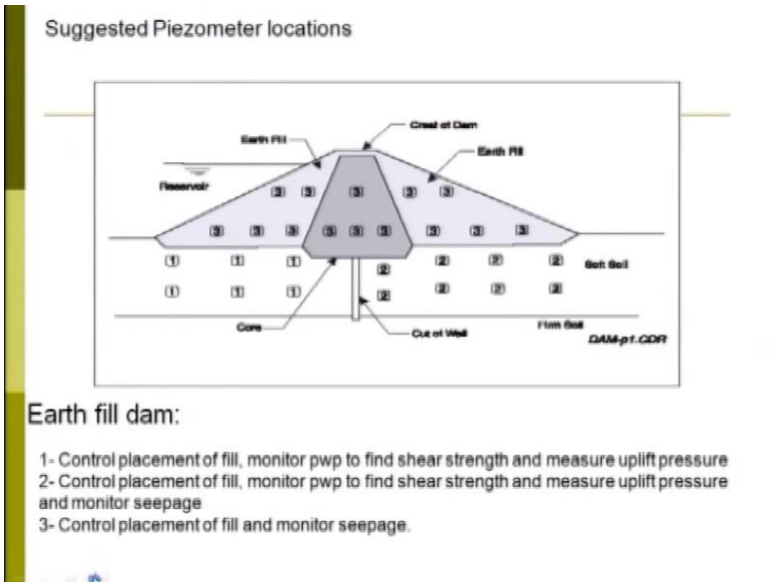

Now, suggested piezometer locations, if this your earth dam, and this is your core this is your core, and this is your earth fills suggested piezometer location, if you look at here generally this is a cut of wall, this is your core you can provide piezometers piezometers along the fill as well as along the core core as well as well as bottom first number one is your control placement of fill. If you see number one this is a number one point; that means, control placement of fill this means your placement of fill has been done it will control; that means, it will monitor pore water pressure to find shear strength, and measurement of uplift pressure why the piezometer location at these, because it will control the placement fill, because this is a fill material also it measure the shear strength measurement of uplift pressure two is your it is, and off stream site along the fill it is in the downstream site along the fill second is your also this is your second control the placement of fill monitor for water pressure, p w p is your pore water pressure to find shear strength a measurement of uplift pressure, and monitor also seepage it monitor also seepage, how much is your seepage is passing from off stream to downstream also it monitor, then threat. If you look at your threat these are all threat points along the inside your a dam the threat point means control placement of fill control the placement of fill how it has been place it will be control also monitor the seepage how much water passes through these are dam also it.

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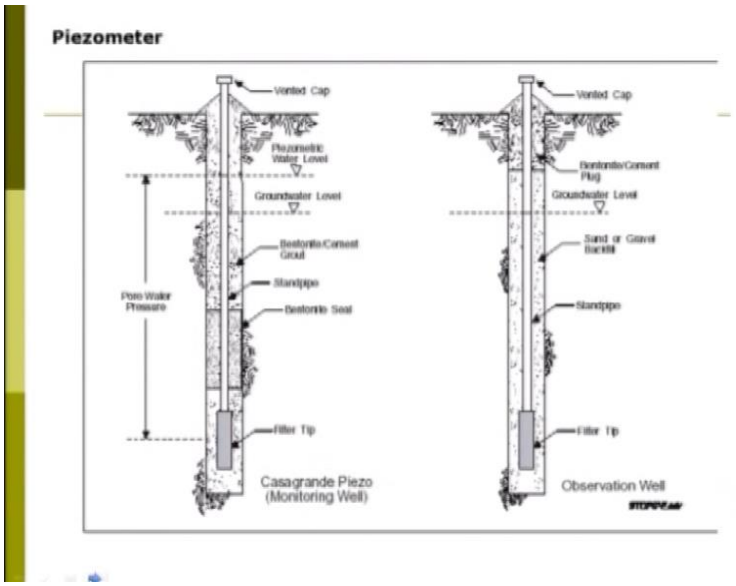

Monitors piezometers a piezometers generally if you look at this piezometer how it looks particularly piezometer its a it is a constructional view, and piezometer water pressure has been given a there is a stand pipe, then ventonites cement grout has been done, then there is a filter tip, then a it has been connected with the vented cap means detail view of your piezometers has been a it has been zone.

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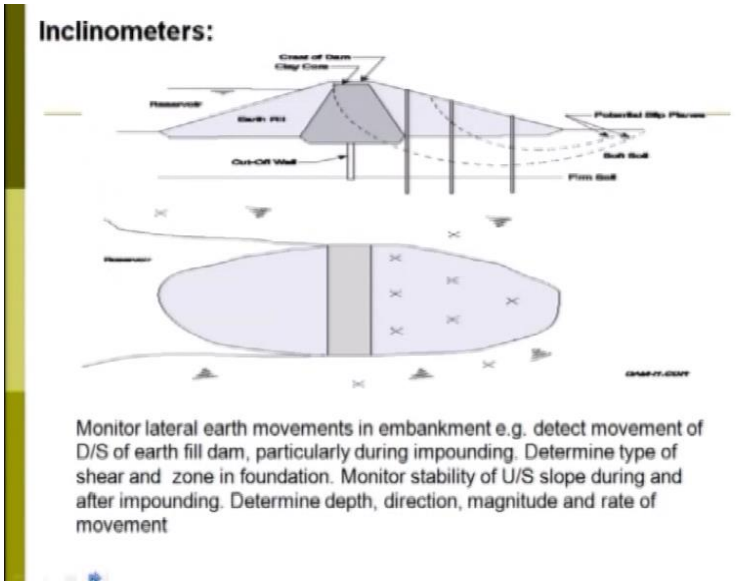

Second part is your second part is your inclinometer, if you look at the inclinometer inclinometer what happened it measure your where there this sloop a stable is there in lateral

movement are not. If you look here this is a dam cases in these case inclinometers as been provided along the slope one two three.

So, it generally monitor lateral are pressure movements. If there is a movement of this slope lateral are pressure movement in a embankment this is an embankment that is dictate movement of downstream of a earth fill dam a movement you have done by means of filling compacting downstream face, if this is my off stream. This is your downstream it dictates dictate any downstream slope movement in the downstream any fill material or any, any, any movement of this soil in the downstream face particularly during impounding, and determine types of shear, and zone of foundation also determine types of shear, and zone of foundation means how it shear types of shear, and zone of foundation monitor stability of off stream slope during, and after impounding also it monitor a stability of slope of the your off stream face also it determine depth direction magnitude, and rate of movement look at here depth along the depth means after after along the depth, and direction where there it in x y or z direction particle lateral or may be incline direction any direction, then magnitude how much what is that rate of settlement, and how much is your rate what is that rate it determines rate direction magnitude, and rate of movement, this is about this use of this inclinometer thiphical inclinometer.

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If you look at this typical inclinometer at has been strong, and different parts a, it has been typical case has been taken a from this James cook university in Australia, how this

inclinometer has been used.

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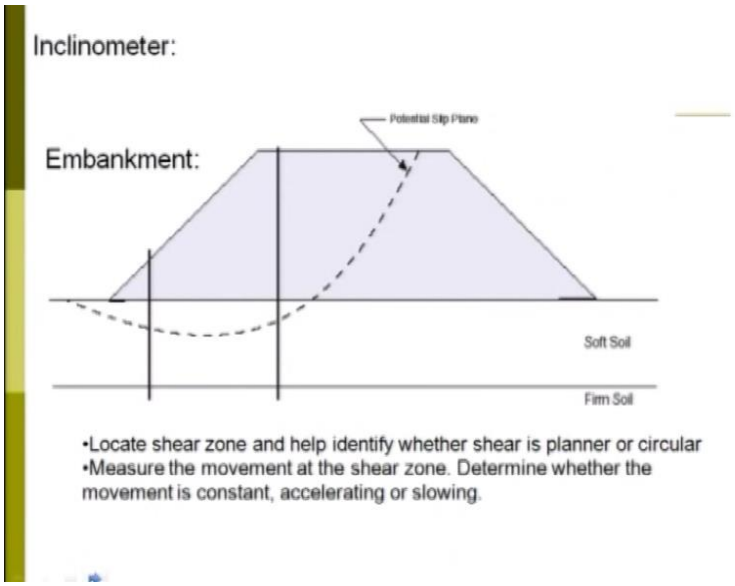

As I said in embankment locates shear zone, and help identify whether shear is planner or circular, if I provide the inclinometer. If you look at here this is your inclinometer this is your inclinometer potential slip plane; that means, these slip plane is simply a planer or slip plane is a secular in slip that you can determine by means of inclinometer measure the movement are shear zone along this shear zone if this is the shear zone along the shear zone it may measure how it move movement along this shear zone, and whether movement is consent are constant rate or maybe it is in the faster rate in details you can find it out by means of inclinometer.

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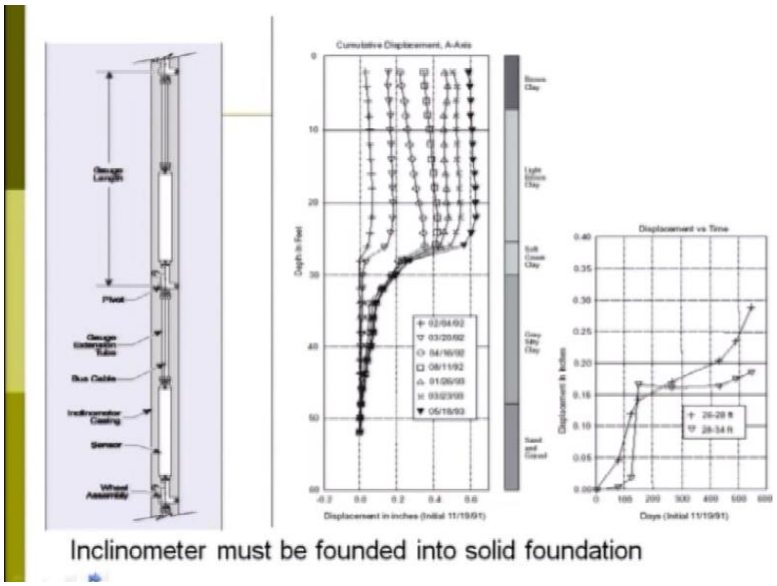

So, inclinometer what is the basic part is inclinometer must be founded into a solid foundation. So, that it should not be a it should not be disturb if it is a week foundation inclinometer also move inclinometer should not move if should be founded inside a solid foundation. So, that it is a stable. So, these at the a results a some of the results of the inclinometer how there are movements at the top part, then had the bottom it there is movement it has been stone similarly some results also displacement versus as been stone by measuring come your inclinometers.

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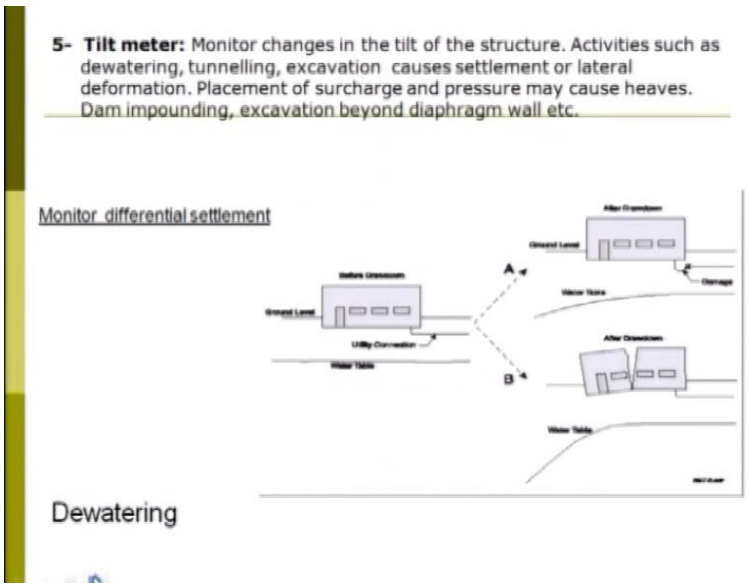

There are also called tilt meter it monitor changes in the tilt of the structure, if there is a structure whether this structure as been tilted or not it has been it I generally use to monitorThe tilt of the structure activities also as dewatering tunneling excavation causes settlement or lateral deformation you can measure it placement of surcharge pressure may cause heaves dam impounding excavation beyond diaphragm wall also you can measure monitor differents settlements also dewatering. So, this is called a tilt meter will generally called inclinometer all tilt meter is the same name as been change, because it will measure the a monitor for the changes of the tilt in the structure that is the why name has came tilt meter.

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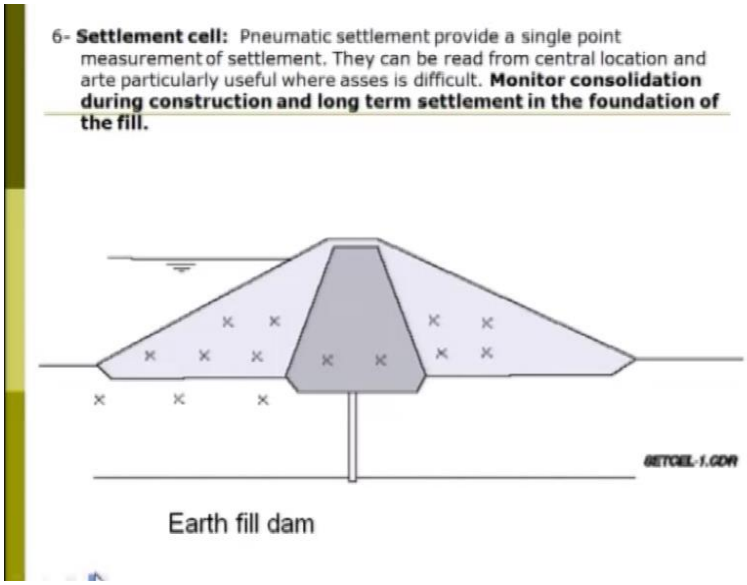

Then settlement gauge of settlements sales settlements gauge a settlement says generally is a numatic settlement provide at a single point measurement of settlement. If you look at here, they can be read from the central location, and partially useful where asses is difficult, and monitor Consolidation during the construction, and long terms settlement in the foundation of the fill, this is most important the settlement cell monitor consolidation during construction means, if this my fill material. If I allow the settlements cell during the construction how much consolidation occur, it will also monitor also in long term in long term if this dam how much it settle it of the foundation soil it also monitor.

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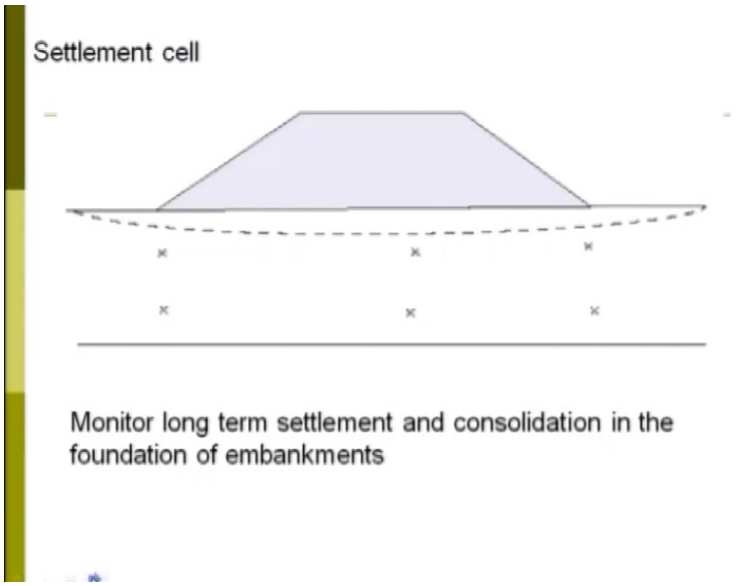

As I said monitor long term settlement, and consolidation in the foundation embankment this is an embankment foundation embankment it place the settlement sail. So, it can measure long term a particularly long term settlement.

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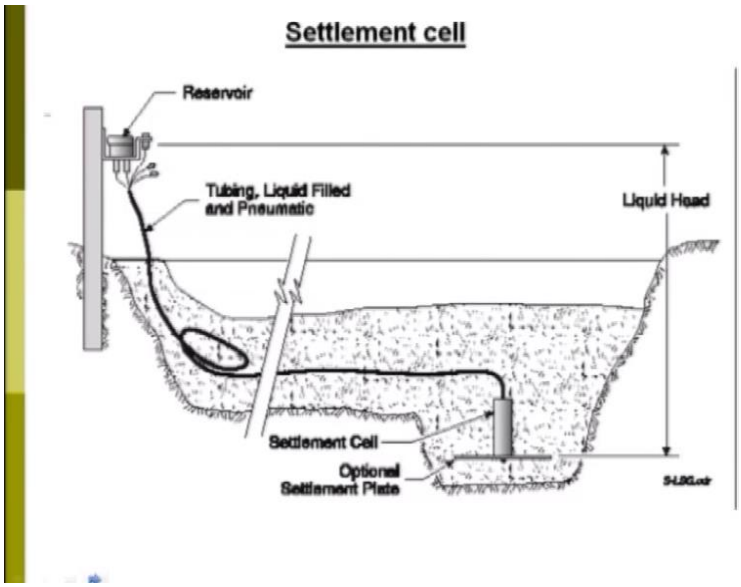

It can measure the a typical settlements cells.

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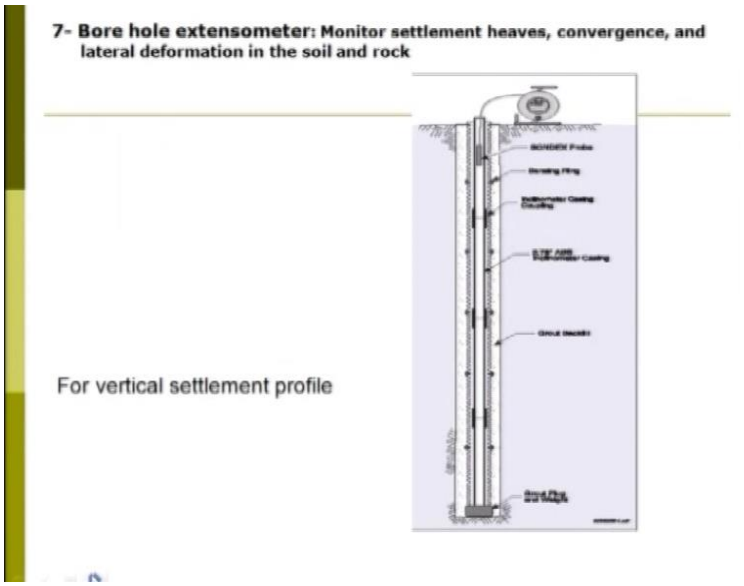

Bore on extensometer in this bore hole extensometer it has been provide also another one is your bore hole extensometer another way of bore hole extensometer monitor the settlement if convergence, and lateral deformation the soil, and rock this is called bore hole extensometer inside the bore hole, and extensometer has been provided for particles settlement provide a profile it has been use to measure your vertical settlement profile.

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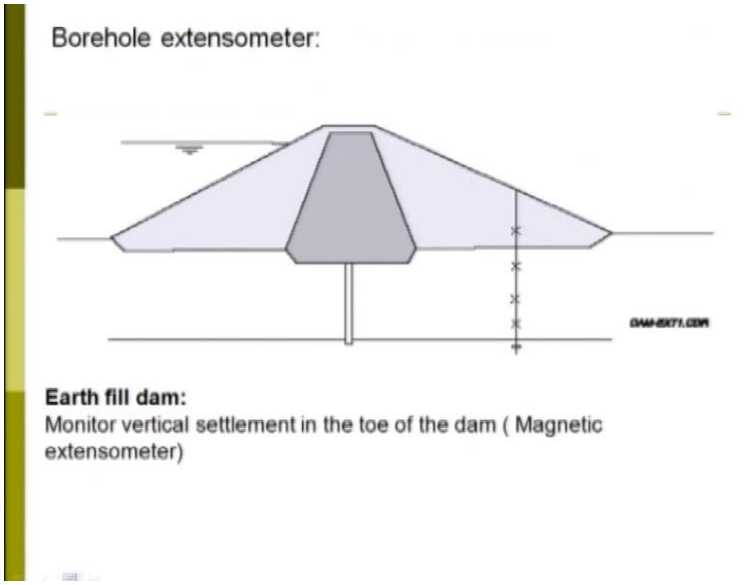

A generally it has been used in, if you look at here this is called bore hole extensometer monitor verticals settlement particularly earth fill dam in the toe the dam in the toe the dam,

if this the hill this is the toe in the toe of the dam, it can measure your vertical settlement monitor settlement to determine where there construction can continue or not.

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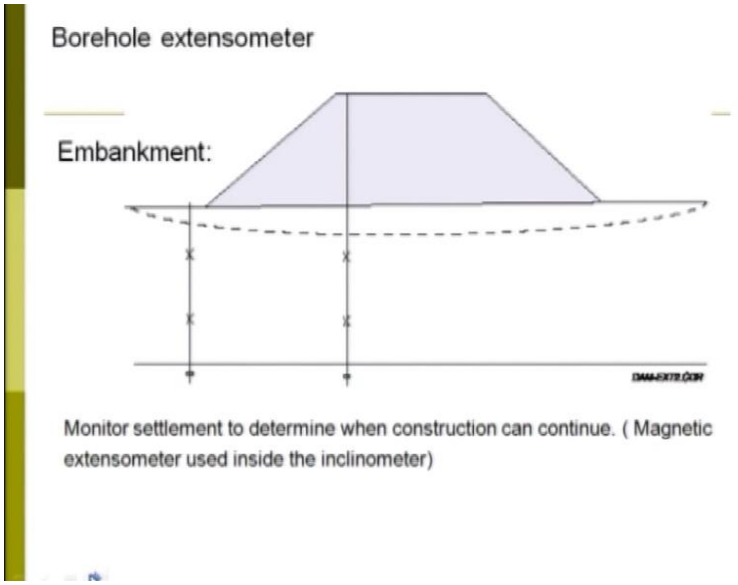

It bore all extensometer verticals settlement it measure where there it can also decide where there the same construction can continue or if you want to modify the construction techniques.

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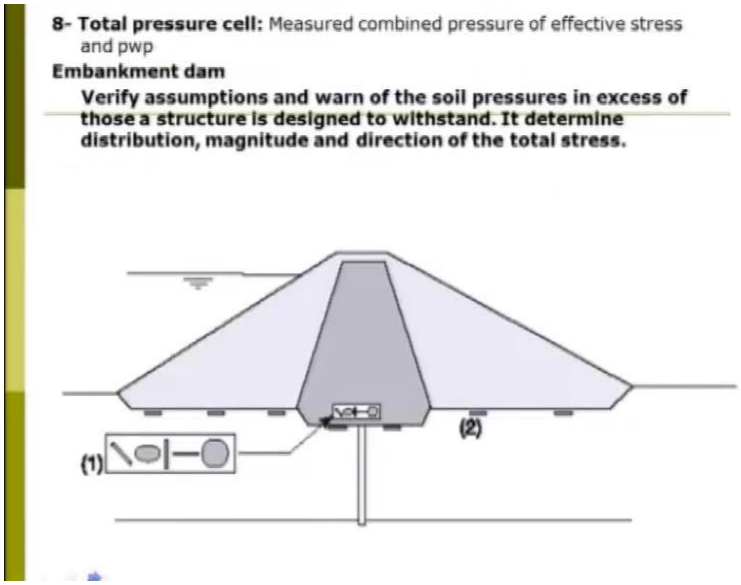

There are total as I said total pressure cell, it is measure combine pressure of effective effective stress as well as pore water pressure the movement you use your total pressure sale,

it will measure two parameter one is your what is your effective stress as well as how much is your pore water pressure develop. So, embankment dam particularly embankment dam verify assumption, and warns of soil pressure in excess of those a structure is designed to withstand it determine distribution magnitude direction of total stress it determine distribution magnitude, and direction of your total stress what is your stress distribution what is its magnitude, and in what direction?

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It is their it measure earth pressure cell how it typical looks are pressure cell it is a usually you can see how the earth pressure cell it looks, and total pressure cell how it has been put it inside, then typical instrumentation of large dam, and these your instrumentation in particularly your rock field dams also an earthen dam. So, of to these I can stop it here, a next class I will continue the other part of this.

Thank you.