Geotechnical Measurments and Explorations

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Lecture No. # 39

Another one I want to show, last last class we have finished it boring log network, how what is the boring log data, how to represent, just want to show.

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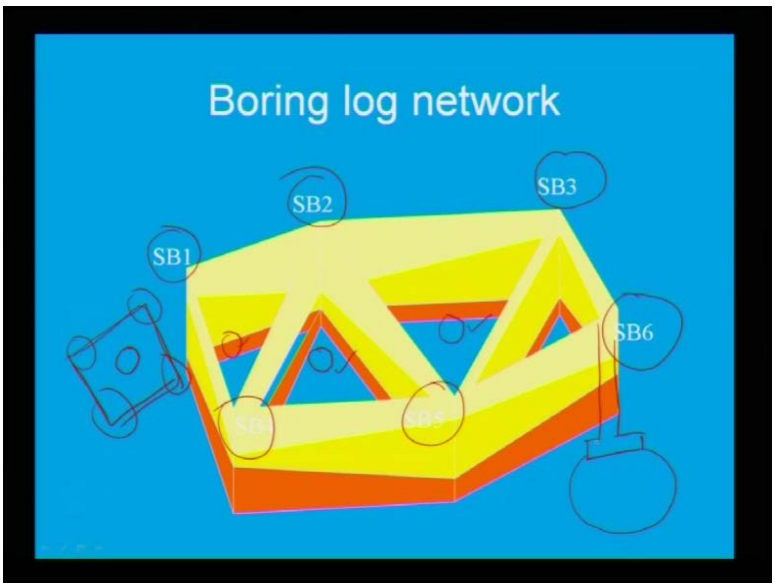

Look at this picture, this is a proposed plan of this site, and this way this construction has to be made; this is a top view plan view, you can see look at the top view and this is your top view of this proposed structures. So generally, what happened? If this kind of building or multistory building once it has been planned, generally what happened? Borings, how many numbers of bores and where to be done, it has to be decided first.

So in this case, this is your borehole 1, borehole 2, borehole 3, borehole 4, borehole 5, borehole 6. If you look at here, every corner every corner of this proposed structure, every corner this boring has been proposed; and it is up to the design engineer or it is up

to the geotechnical engineer to decide how many number of boreholes to be done. But generally, this is the generally in the corner, if this kind of proposed plan may be structure you can go for 1, 2, 3, 4, - 4 corners. However, my concern is sometimes after seeing this boring log data, say 1, 2, 3, once you have done bore boreholes and collect soil samples from this boreholes and test in the laboratory. After doing these, if you found that these soil profiles are not same, these soil profiles are varying from one location to other location, other location to other location. In that case you may include more boreholes at the center.

This is just a, this there is there is nothing straight forward rule, this is a this is a thumb rule initially, you planned for six. After seeing this boring log data of the six, if you see this soil profile is varying from one bore log to other bore log, then you may decide additional boreholes may be carried out at the center of the proposed plan; this is your proposed plan of the structure at the center additional one, additional one, additional one. Similarly, if this is my proposed plan of a square or rectangular shape, after doing two boreholes and conducting the test, you may decide also at the center. So, what will happen? Once you decide at the center, you will get a soil profile data not only around the periphery. The basic reason behind it where you want to do this proposed construction, generally you go around the periphery of the proposed structures, because these foundations, it is supposed to be the foundation will be lying here.

Column and beam will come at the corner, may be at the center at the periphery, so that you will be knowing what is the soil profile. So, this is generally, in practice people do. But once you recommend if you see that this soil profile is not of uniform or it is varying from one borehole to other borehole, then you decide you may go for additional borehole at the center of this proposed plan. Then what you will get? You will get overall idea.

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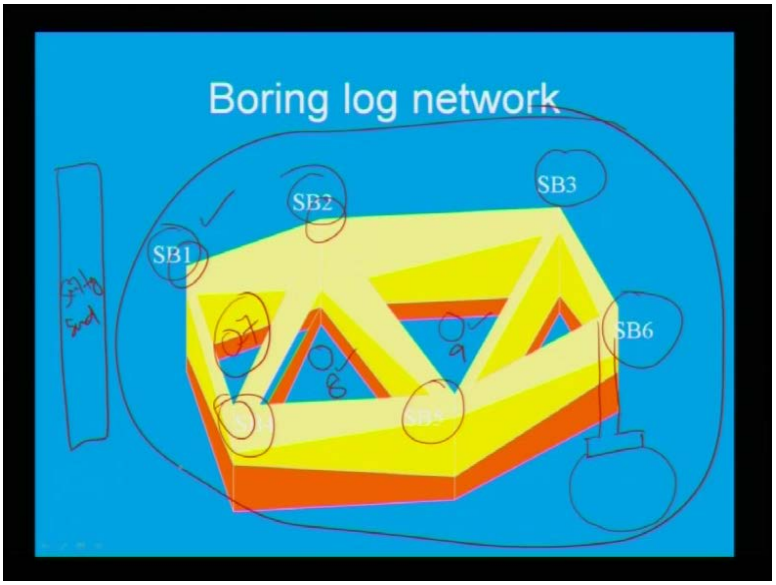

In this proposed plan, in this particularly in this proposed plan, how the soil profile vary, across the six, 1, 2, 3, 4, 5, 6, 7, 8, 9; that means around the periphery and across the center, how how much variation you are getting this soil profile. Is it a large variation, is it a small variation, if it is a large variation, how to interpret you will have to take average value or you will take most adverse conditions for the design point of view. These are the consideration generally it depends upon the design engineer. Suppose say in this case borehole one, and in this case say 1, 2, 3, 4, 5, 6, 7, 8, 9, seven eight nine suppose say borehole number one, you are getting a silty sand kind of profile, across this you are getting a silty sand.

Now here if you are in the seventh number of borehole you are getting, you are getting a mixture of sand silt and clay. Now it is up to you to decide which parameter you are going to consider particularly this part of footing; means footing definitely if there is a column, there is your footing here, there is a foundation here, there is a foundation here, if this is a proposed structure. Now, whether you will take most adverse condition or you will take easiest one? That means if you take sand kind of things, may be footing and footing load whatever you are getting, depth of the foundation will be very shallow.

If you are going to consider this kind of effect there is a clay, so that means the plasticity

index will come into picture, and liquid limit, plastic limit and all this fine grained property will come into picture; based on that, the strength property C and phi will change; whether you will consider this or this, generally you will go for most adverse conditions for this design. This is about I show you how you decide this boring, where you have to do the boring, and if required how you will decide you additional number of boring to be done.

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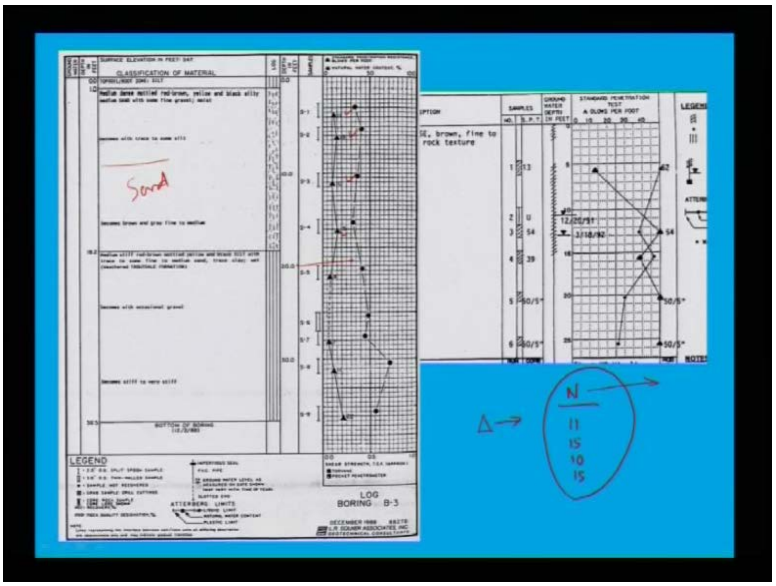

Now come back to another interesting one, there are different types of annexure you can provide in soil classification. If you look at here, earlier I have shown last class about the data logger or borehole loggers, how the data has to be provided. In some cases, how they provide? If you look at here, depth they have written, the ground they have written, where is your water table first step, this is your ground water, where is your water table lying? First column; second column is your depth, this is your depth in feet or meter, and third column is nothing but is your, third column is your classification of soil as per your testing from laboratory and field you can classify it.

Then samples, at what depth you collect undisturbed sample? If you look at here, I also explain here at this depth, at this depth, this sample has been, undisturbed sample has been collected. If you look at here at the right side, natural moisture content versus your

SPT value, variation of SPT value instead of writing n. Earlier I show that some column you write only value of N - penetration value. Instead of writing N if you show the variation of penetration value along the depth, with your, what is your natural moisture content you collect; if both the variation if you show it, that will be a great particularly you can decide where you can lay your foundation.

If look at here, this triangle this is your standard penetration recorded up to depth of 36.5 feet. Instead of writing n, suppose here N is equal to 11, N is equal to 15, instead of writing N value, I want to show a plot, how the plot is varying over the depth. So, what is this advantage? In a first instant, the site engineer, design engineer, he can see instead of taking N value, he can see how the profile varying.

If you look at here, almost N is constant between the depth of say 2 feet to 20 feet, the penetration value is almost same that means this, what does it mean? If N is a kind of constant; that means what does it mean? That means the soil is same, the kind of soil you are getting it is same, if you look at the classification, the classification says also same. It says medium dens moulted, red brown, yellow black silty medium sand with fine gravel and moist. Look at here, silty sand is available from 2 feet to around 18.2 feet, and it confirm whether here SPT value means, if there is any mistake either in soil classification or in SPT, it will you you can confirm seeing this profile. Suppose there is a mistake in soil classification doing in the laboratory; suppose here it is silty sand, some depth you will get some sand; so it is not possible that this over the depth, the N value should be constant.

Look at here N is 11, N is 15, N is 10, N is 15 means, value N value up to this depth up to 18.2; if you look at 11, 15, 10, 15, means almost N value is varying between 10 to 15; that means it cross check, it completely cross check, whether your laboratory test are correct or not. Again suppose your laboratory test you are getting, up to this 18.2 meter depth you are getting this laboratory test, from there suppose you get kind of silty sand. If this meter, depth of silty sand is there and there is no water table; of course, if there is water table, definitely N value will change, because this water table correction will come in to picture.

So if there is no water table that means your field penetration value should be kind of more or less it kind of same. So this reflect this data whatever done in the laboratory and field, they each other supplement that means they are the correctness of this data are very good or excellent you can say.

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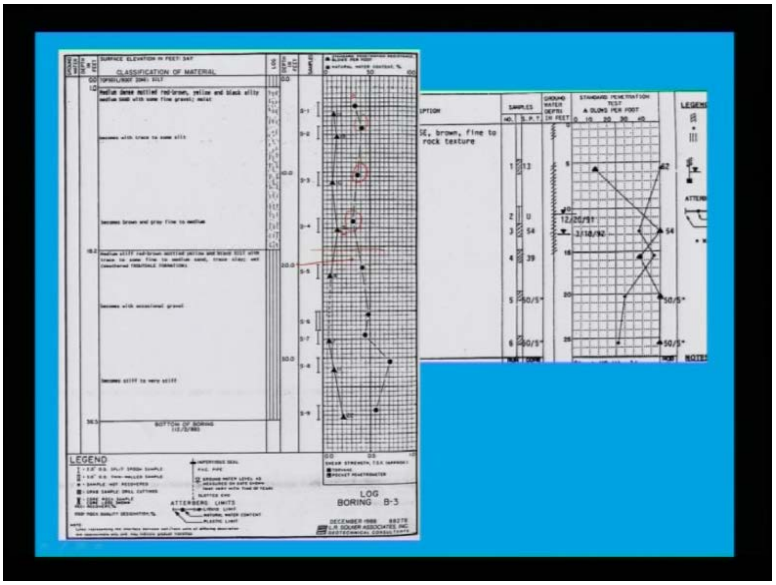

Then look at the moisture content profile, natural moisture content as I said earlier, so how much water present every 2 meter depth or 2 feet depth, how much water present inside the soil. If you look at this, again this moisture content also almost consistent, it kind of constant; here it is varying water content is say 48 percent, 47 percent, 46 percent 46 percent, almost it is also consistent. So this way preparing a data logger in this way is a more better way to represent, and it will be very easy to extrapolate; somebody can first instant somebody can visualize, he can say how the penetration value varies; and based on the penetration value, what should be your strength value that can be indirectly you can interpolate or extrapolate.

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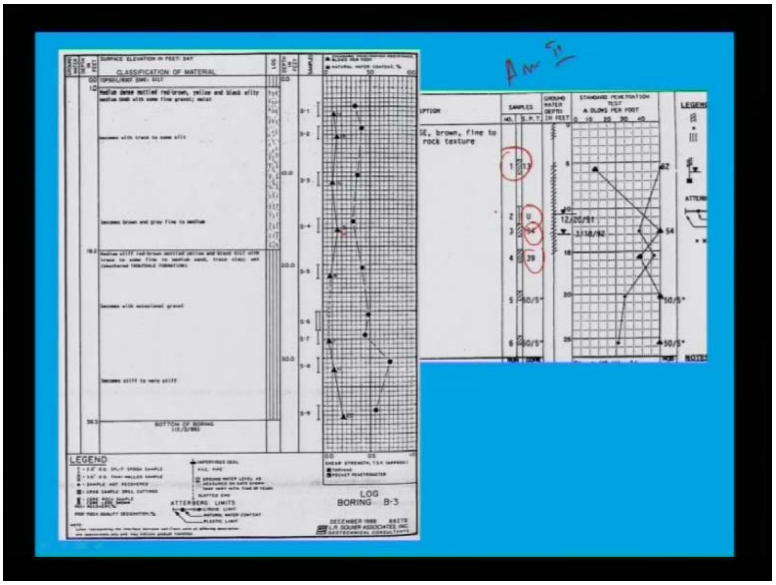

Now if you look at here, it has taken a bigger one, you see standard penetration, blow count and water table has been shown, and your SPT has been shown you can show it, you can take it out, and show outside also, you can put it annexure one, you can put it annexure two, so that you can visualize. You see first SPT has been done at 1 1.3, then 554, 39, these are all SPT value and undisturbed, view for undisturbed sample has been collected. And here you are showing that how you are penetration blow, how it is varying that you can clearly also show for different cases.

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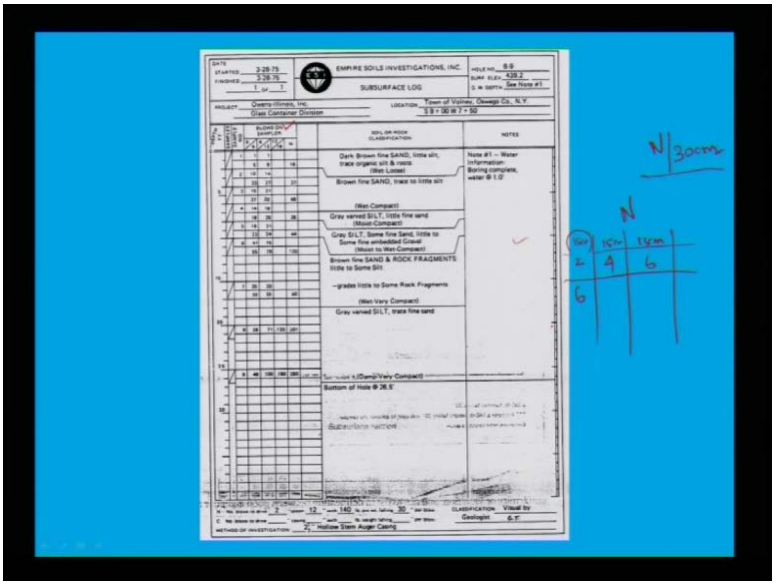

These are the two things I have shown you; one is this is the thing I have shown last last class, this way also you can report that means column one is your depth, second is your sample, third is your sample number 1, 2, 3, 4, 5, then you can show blow and sampler; that means you can show that three blows means, how the SPT has been done? Sometimes the design engineer also asks instead of showing N per 30 centimeter blow, you can show entire N count, what they will do? This is your N simple they write N, this is your sample blow n; so what they generally they put it? 15 centimeter, 15 centimeter, 15 centimeter. Then they leave it to design engineer they decide. So, generally we discard penetration value for first 15 centimeter. Despite we discard, please provide; so it will be clear picture, so first penetration 15 centimeter is 2 N value, second 15 centimeter is say 4, third 15 centimeter say 6.

So, generally N uncorrected, N uncorrected should be 6 plus 4, it is 10. So, instead of providing N corrected to all, you just provide sometimes they provide 3 N values every 15, 15 centimeter N values; that is also another way, it will be easier job for sometimes design engineer; sometimes field engineer what happen? The N if it is a 2, we say that first initial penetration blow for 15 centimeter we generally take it, we generally discard, because it is kind of soil is loose, and it will say it will act as a sitting load, but sometimes first 15 centimeter penetration blow sometimes it give 6; that means you

cannot discard. So it will help the design engineer see the complete profile of N value, complete profile of N value instead of giving only one N value of 10, the design engineer can see want to see complete N profile value that will also helpful for design.

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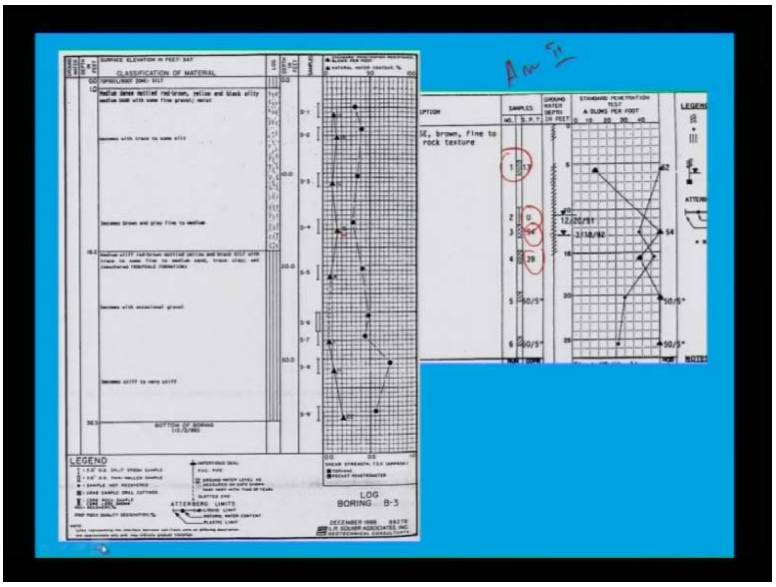

Now, this is about your field test report; whatever I have shown you, this is about your field test report SPT N and moisture content, where you collect your sample? You collect sample at what depth? And whether it is a disturbed sample you collect, undisturbed sample you collect, where is your water table, and general soil classification; this is annexure one general soil classification you say silty sand. Whether the general soil classification is correct or not; that is again a question mark. Means, you have done this classification based on your laboratory test remember; that means you have to provide all the laboratory test in the report also, because this design engineer also they can check, cross check whatever calculation you have done, whether it is correct or not. So to supplement these, once you say that it is silty sand.

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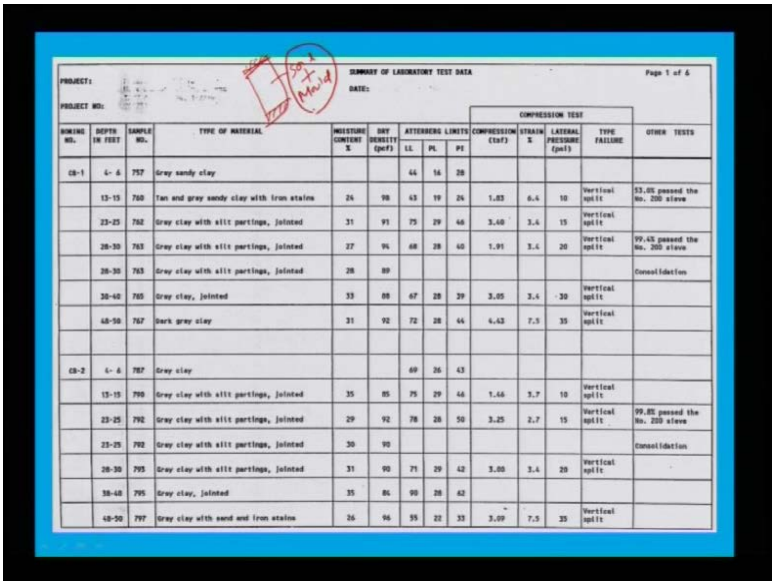

PROJECT:

PROJECT NO:

SUMMARY OF LABORATORY TEST DATA

DATE:

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BORING NO.	DEPTH IN FEET	SAMPLE NO.	TYPE OF MATERIAL	MOISTURE CONTENT %	DRY DENSITY (pcf)	ATTERBERG LIMITS LL	PL	PI	COMPRESSION TEST: COMPRESSION (tsf)	STRAIN %	LATERAL PRESSURE (psf)	TYPE FAILURE	OTHER TESTS
CB-1	4- 6	757	Gray sandy clay			44	16	28					
	13-15	760	Tan and gray sandy clay with iron stains	24	98	43	19	24	1.83	6.4	10	Vertical split	53.0% passed the No. 200 sieve
	23-25	762	Gray clay with silt partings, jointed	31	91	75	29	46	3.40	3.4	15	Vertical split	
	28-30	763	Gray clay with silt partings, jointed	27	94	68	28	40	1.91	3.4	20	Vertical split	99.4% passed the No. 200 sieve
	28-35	763	Gray clay with silt partings, jointed	28	89								Consolidation
	38-40	765	Gray clay, jointed	33	88	67	28	39	3.05	3.4	30	Vertical split	
	48-50	767	Dark gray clay	31	92	72	28	44	4.43	7.5	35	Vertical split	
CB-2	4- 6	787	Gray clay			69	26	43					
	13-15	790	Gray clay with silt partings, jointed	35	85	75	29	46	1.46	3.7	10	Vertical split	
	23-25	792	Gray clay with silt partings, jointed	29	92	78	28	50	3.25	2.7	15	Vertical split	99.8% passed the No. 200 sieve
	23-25	792	Gray clay with silt partings, jointed	30	90								Consolidation
	28-30	795	Gray clay with silt partings, jointed	31	90	71	29	42	3.00	3.4	20	Vertical split	
	38-40	795	Gray clay, jointed	35	86	90	28	62					
	48-50	797	Gray clay with sand and iron stains	26	96	55	22	33	3.09	7.5	35	Vertical split	

To supplement this silty sand, you have to provide this is your data, complete summary of laboratory test data; that has to also attached in soft soil explorations. You see project, project number as I said, date this is the thing. Then first one is boring, where you have taken your undisturbed sample; boring 1, boring 2, where boring number 1, boring number 2; in boring number 2, what is your depth and sample you have taken; depth 4 to 6 meter you have taken sample, sample number always you provide, if it is number 1 you 1, 2, 3, 4, 5, 6, like this sample number to be there, here sample number is there. At what depth you collect your undisturbed sample? Say a depth of 4 to 6 feet you collect undisturbed sample, 13 to 15 50 you collect undisturbed sample, this has to be clearly mentioned.

Then type of material you say that see gray, the movement you we use gray, then here gray, dark gray, these are all visual appearance. As I said last class means, visually you see this soil, visually you see, and you identify whether a gray, dark gray, white, red or brown that should be come here. Then this sandy clay look at here, this sandy clay is nothing but your classification, it has come from your classification, even if here sandy clay, here it is silt, clay with silt, these are the things. Then definitely your natural moisture content as I said you find it out natural moisture content, then most important parameter that you want you will provide density. When you collect the soil sample, how

do you measure the density, field density?

The movement you collect the tube from the ground, this is your tube, this is your tube, it has been sealed at the top and at the bottom it has been sealed. So, with this seal sealed tube, you find it out what is the weight; and dry it find it out what is the dry weight of means find it out the weight, then make the soil sample out. You know, this is your weight of soil plus this mould mould soil plus this mould, you know the empty (( )) of mould. Then you find it out what is your weight of or mass of soil, mass by volume that is your density. You will get it in by directly your density of your undisturbed sample collected you can get it. So, every step the density has been it has been recorded, if you look at here density has been mentioned. This is detailed laboratory data.

Then once you density mentioned, then you go for sieve analysis data, classification data as well as Atterberg's limits. Atterberg's limits for what? It is for fine grained soil classification, it is for fine grained soil classification. If you look at here liquid limit, plastic limit, plasticity index everything, write it; liquid limit you calculate from the laboratory, plastic limit from where you find it out this plasticity index. This is all about classification data classification data, then your real engineering data, engineering property or strength parameter C and phi, how do you get this, where you will give it from here.

If you look at here compression test, compression test means, either you go for triaxial test or direct shear test, from where what is your compression, what is your strength? That means at this strain, this is your failure load you are getting; so this strain this is your failure load you are getting. Then also you give lateral arc pressure, lateral arc pressure means that is your K 0 - lateral arc pressure at rest; from where you will get it K 0? As I said earlier from your dilatometer, pressure meter, you can find it out your K 0. This value you provide your K 0.

Now, type of failure; what kind of type of failure, you are getting from this. Then other test, other test means you can say that from the classification set, if you look at here 53 percent pass number 200 sieve; it means 50 percent 53 percent below, 47 percent is finer, soils are finer. Everywhere else you provide it, every alternative then also consolidation

data, another other data also they have not done it, if you do it, you provide is consolidation data, C v - coefficient of consolidation, then provide coefficient of permeability, provide your coefficient of permeability, how much permeability, what is your coefficient of consolidation.

This summaries means, it is in summary form like this called data sheet, these are called data sheets, it has to be attached at the end of your project report. So page 1, page 2, page 3, page 4 either you provide for one boring each boring, one data set, second number of boring another data set or you can combine depending upon how you want to provide them. But this is necessary and it is a must for geotechnical engineer to provide, once you do this soft soil explorations.

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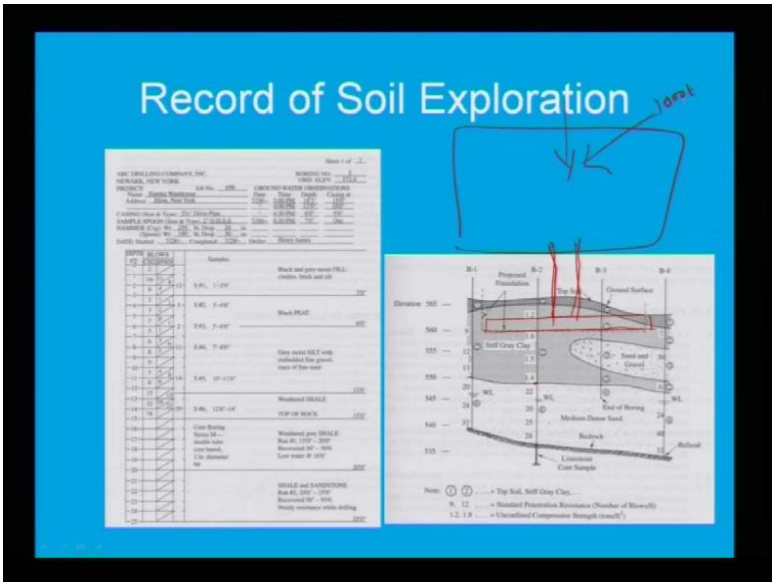

This is another way of representation; look at this, this is another way of soft soil representation, you see. If you look at here, here it is retain proposed foundation, the recommendation has been given. If you look at here, they have made a map, this way also you can provide like make a single line, they have written borehole 1, B-1, B for borehole, 1 for first borehole; B-2 - borehole 2, B-3 - borehole 3, B-4 - borehole 4. So all the borehole they put it, just overall they are showing. Then elevation; elevation means during the survey where the ground is lying from the mean syllable, then they put it 1 2 3

means, 1 2 means, different types they put it 1, 2, 3, 4, 5, 6, 9, 10, up to this, they provide it; 1 2 means, top soil; what is the top soil? It is stiff clay, they mark it.

If you look at here, why I was saying just before I was saying that the soil profile may change; look at here very clearly. In borehole 1 and borehole 2, there is not much change. If you look at here stiff gray clay, it is up to 550 elevations here, and borehole 2 it is also 550 elevations, same soil is there, fine. Now, the moment you go to borehole 3 and borehole 4, look at here, the stiff gray clay is there up to 560 of your elevation; then between 560 to 550 sand gravels are available. Look at the how the profile vary, you cannot say that with a single borehole or may be two boreholes, the soils will be same.

Look at these four boreholes, borehole 1 and borehole 2 are identical, completely identical soil profile, the moment you go to borehole 3 and borehole 4, this sand patches, sand gravel is very less in borehole 3; and borehole 4 is it is more wider, this is the basic difference as far as the design is concerned. Because why these things I am discussing again and again, you have to decide where you are going to lay your foundation; this is your building, at what depth below the ground surface you want to construct the foundation, so that above the foundation, above the foundation, the building can be erected, the building can be erected. Because this foundation if it cannot rest properly in the soil, the strength whatever you are going to get to resist the load coming to the structure by means of soil.

What will happen, if this whatever suppose this total load coming to the structure, let us say 1000 ton or 10000 ton is your proposed structure load; that means if this is a building, how much load in this building is about to come? Suppose this building is about to take… Imagine, where you are standing? I am sitting in a room, this building is going to take, what is the load, this building will, with this building there lot of chairs people will move around, and this complete wind load, dead load, suppose this building has a load of 1000 ton. So, definitely this building, how it will resist, this load will be transfer from super structure to soft structure, then to foundation, and foundation will be acted by 1000 ton. If this 1000 ton foundation we will take the load, who will take this load 1000? Obviously, this will be taken by the soil; by what? By means of strength parameter your C and phi; if your C and phi is not, value is not large enough, then it is

not going to take, so what will happen? The building will collapse; the building will collapse; that is why this borehole has to be cross check with each other.

So, if you look at this 1 and 2, go to the third and fourth, here you are getting a sand gravel, small patches; if you go to fourth borehole, look at here, the patch will be more; so this is the basic difference. Instead of laying footing here, because footing it is a stiff clay, fine grained soils are more, if I bring that footing slightly down, so it will lay in a foundation over the sand soil, where it can resist more load than your than your clay soil. So this that is why this boreholes and interpretation is more important for design engineers to decide all these things.

Then another part if you look at here; another major parameter is varying, if you look at here, where exactly your bedrock means particularly rock rock surface, is it in the shallow surface or is it in the is it in the kind of deep surface? Bedrock has to be located, also water table, is this water table varying from borehole 1, 2, 3, 4? If you look at here, water table is absolutely not varying, it maintains constant depth that means it is fine; water table is not fluctuating; your conclusion is water table is not fluctuating.

Sometimes, what happens? Water table here somewhere else, here somewhere else, because of the soil profile. So now, second part third part is where is your bedrock? Whether this foundation is a shallow foundation or deep foundation, depending upon the soil profile, you have to decide, where you want to provide your foundation; it is at the shallow depth or deeper depth. If you consider these two layers, I do not think your foundation, because this is a fine grained soil, silty gray clay, so it is not possible for a shallow foundation. Then in that case, what will happen? You look for other alternative arrangement.

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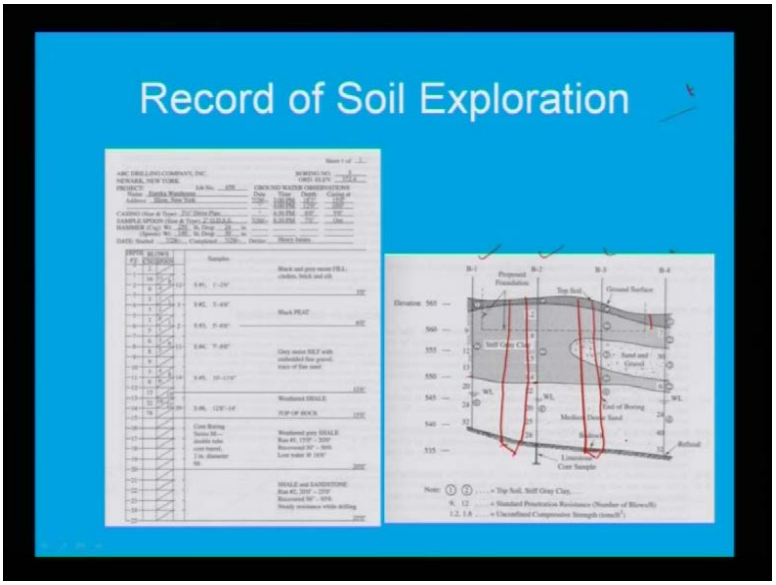

What other alternative arrangement? Other alternative arrangement is your kind of deep foundation in the form of pile, in the form of pile. The movements you go for deep foundation in the form of pile, then you want to locate somewhere else some hard stratum should be there, either sand, gravel or bedrock.

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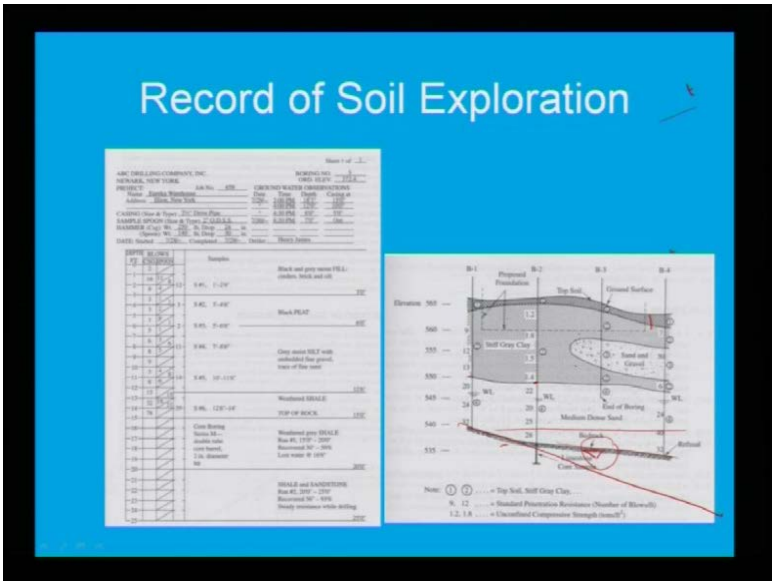

If you look at here, look this bed rock is varying at an elevation 540, almost 540 to 535, the bedrock is varying bedrock is not supposed to be uniform, it is not necessarily that bedrock would be it will be kind uniform throughout no, it may vary in this way, it may vary in this way, may be it may be constant throughout. So bedrock in this case almost kind of a uniform depth you are getting; that means if you want for a deep foundation, it will be helpful, the pile can be resisted over the bedrock. So the moment, the load will transfer from soil to foundation, foundation to… Who is going to take the load? The load will be taken by either soil or bedrock.

So this is the philosophy how means particularly this interpretation is kind of a judgment over the period of time as an engineer, if you if you have a experience over the period of time, your judgment will change from time to time. More you experience more filter judgment you can provide; so to be safer side, to be honest, to be safer side, if you have a cross borehole nearby like this, if I have done only two borehole, I can say soil profile is stiff clay or may be gray clay, here is gray clay, that is fine; that means there is soil profile is uniform, no.

Look at the borehole four, in this gray clay some patches are there, where you are getting of a sand and gravel, may be who knows, may be borehole it may be completely change soil profile. It is based on your judgment, whether you are going to do or not to do how to interpret how to means, how to give the result, so that design engineer should not face any problem.

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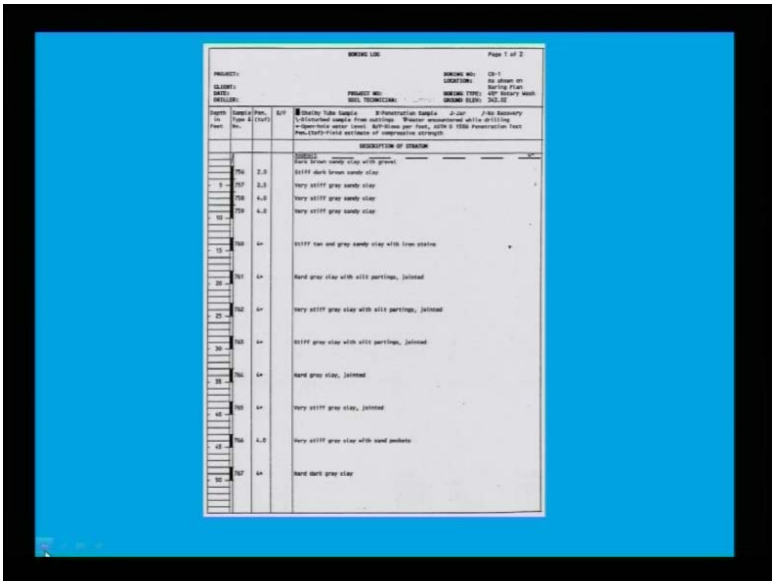

This is your first part as I said means yesterday also I explained this is your first report, first page one, bore log data; simple depth, type, penetration and your classification, page one. This is your if possible in second attachment, in second profile if possible give penetration blows every 15, 15 centimeter blow, 15, 15 centimeter depth. Then you can show this how the soil profile is varying, how water table is varying, what is your bedrock, small diagram you can provide this is your page number two.

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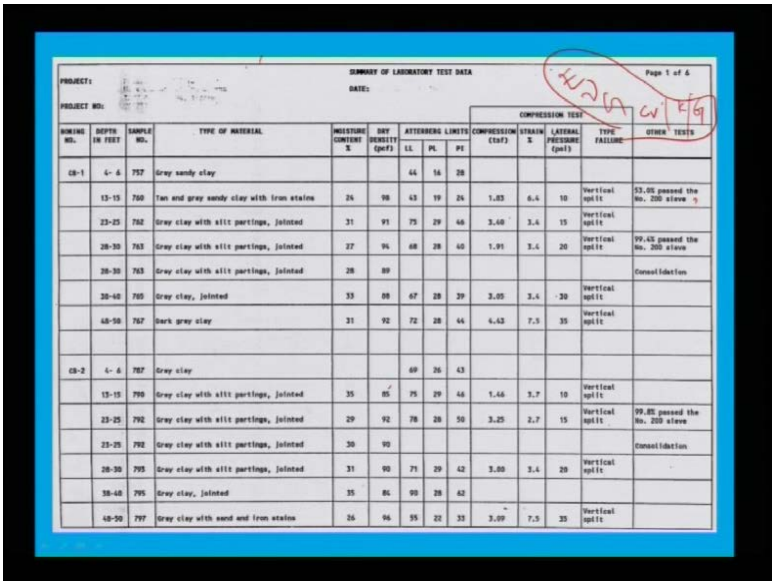

SUMMARY OF LABORATORY TEST DATA

PROJECT:

PROJECT NO:

DATE:

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BORING NO.	DEPTH IN FEET	SAMPLE NO.	TYPE OF MATERIAL	MOISTURE CONTENT %	DRY DENSITY (pcf)	ATTERBERG LIMITS			COMPRESSION TEST				OTHER TESTS
						LL	PL	PI	COMPRESSION (tsf)	STRAIN %	LATERAL PRESSURE (psi)	TYPE FAILURE	
CB-1	4- 6	757	Gray sandy clay			44	16	28					
	13-15	760	Tan and gray sandy clay with iron stains	24	98	43	19	24	1.83	6.4	10	Vertical split	53.0% passed the No. 200 sieve
	23-25	762	Gray clay with silt partings, jointed	31	91	75	29	46	3.40	3.4	15	Vertical split	
	28-30	763	Gray clay with silt partings, jointed	27	94	68	28	40	1.91	3.4	20	Vertical split	99.4% passed the No. 200 sieve
	28-30	763	Gray clay with silt partings, jointed	28	89								Consolidation
	38-40	765	Gray clay, jointed	33	88	67	28	39	3.05	3.4	30	Vertical split	
	48-50	767	Dark gray clay	31	92	72	28	44	4.43	7.5	35	Vertical split	
CB-2	4- 6	787	Gray clay			69	26	43					
	13-15	790	Gray clay with silt partings, jointed	35	85	75	29	46	1.46	3.7	10	Vertical split	
	23-25	792	Gray clay with silt partings, jointed	29	92	78	28	50	3.25	2.7	15	Vertical split	99.8% passed the No. 200 sieve
	23-25	792	Gray clay with silt partings, jointed	30	90								Consolidation
	28-30	795	Gray clay with silt partings, jointed	31	90	71	29	42	3.80	3.4	20	Vertical split	
	38-40	795	Gray clay, jointed	35	86	90	28	62					
	48-50	797	Gray clay with sand and iron stains	26	96	55	22	33	3.09	7.5	35	Vertical split	

And page number three fourth onwards first one you give summary of detailed laboratory data including all C v K all the laboratory test whatever we explained. If you have done you are also cyclic test shear modulus also you can provide, how it is varying the shear modulus also soil stiffness value, soil stiffness is your E, mu, G if you have done this test, also you want to incorporate, then you can provide every depth wise. This is your detail summary of laboratory test data; this is your third part.

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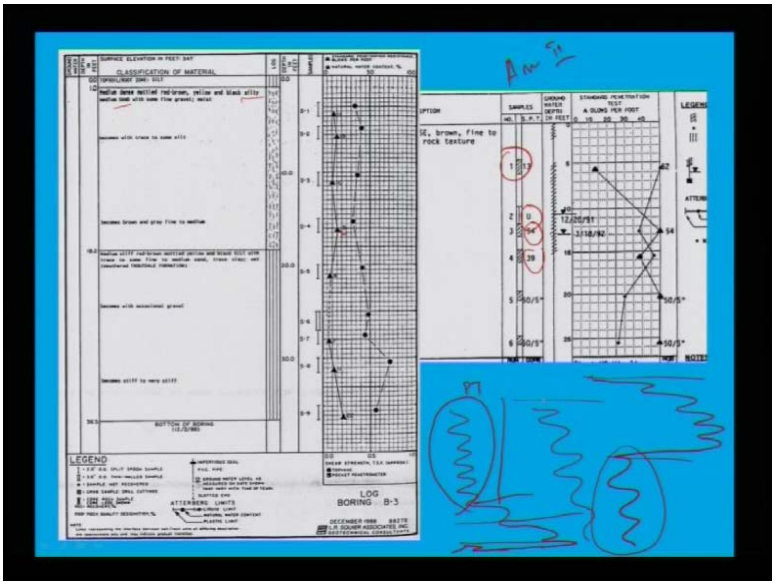

Then fourth part is your detail summary of your field data, if you have done, any kind of field test like here it has been done standard penetration test. So fine, if instead of standard standard penetration test, if somebody has done cone penetration test that is fine or if it is cone penetration test instead of standard penetration test you show that CPT value - cone penetration test how this penetration resistance is varying over the depth. That means, if this what does it mean this diagram, I am showing there are two diagram of cone penetration; one is like this, one is like this, what does it mean? The cone penetration resistance value is constant over this depth of the soil, and it is varying abruptly from here to here; that means the soil property expected to change from this depth to this depth.

Here also from at the sallow depth the soil property is changing, but here almost resistance value is same. Whatever field data you have done, you have to show in the fourth part, the first is your laboratory summary, fourth is your field summary. Also if you have your shear wave velocity data, shear wave velocity data, variation of shear of wave velocity for dynamic property that also you show in a diagram. So this is your fourth part of these things, this is completely end of how to report your laboratory test data and field test data from for this soft soil explorations, how the report to be represented. One more lecture I am going to show from this field test data, how to predict your earth quake resistance; that is your next class. Thank you.