Geosynthetics Engineering: In Theory and Practices
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Module - 11
Lecture - 52
Designing With Geotextile Tube

Dear student warm welcome to NPTEL phase two program video course on Geosynthetics engineering in theory and practice. My name is Professor J. N Mandal department of civil engineering Indian institute of technology Bombay, Mumbai, India; this lecture number 52, and module eleven designing with Geotextile tube.

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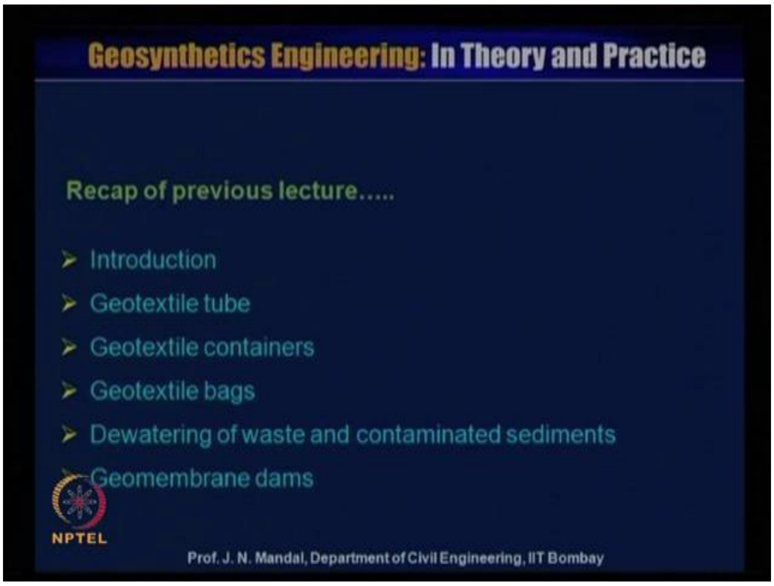

So I will now forecast the recap of the previous lecture. That is introduction Geotextile tube, Geotextile container, Geotextile bag dewatering of waste contaminated sediment and geomembrane dam.

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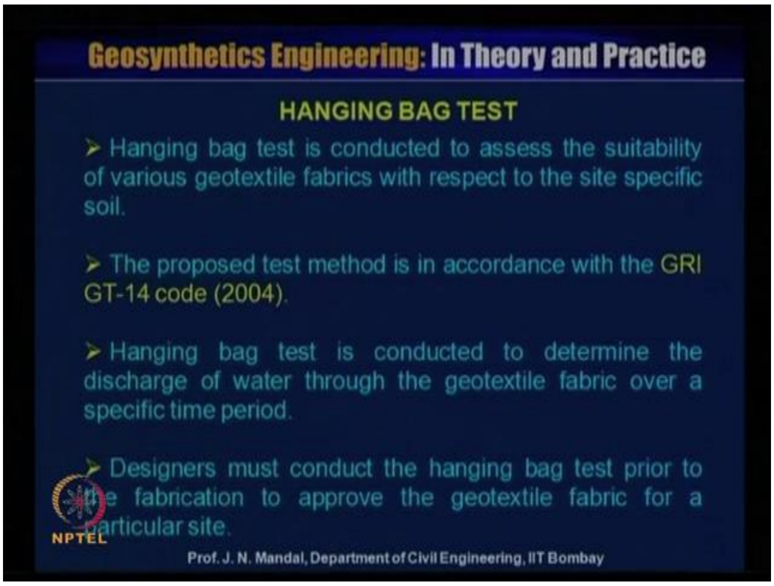

Now, I will proceed for the hanging bag test you know geotextile tube encapsulated the soil that may be used to replace the rock as conventional building block in marine. The hydraulic structure and this concept is not new many people have used the jute bag filled with the sand to protect the dam from flooding. This kind of geotextile bag or the container or geotextile tube can be extensively used for the slope protection erosion control dewatering of municipal sewage sludge and drinking water treatment plant and or and the agriculture and the agricultural ponds.

So, this kind of technology is not very expensive and it is easy to treat the sludge or the slurry, so hanging bag test it is not reported in India, so far in my knowledge goes. So, present study addresses the performance of hanging bag test for dewatering of different type of the slurries it may be the fly ash it may be Powai soil, it may be the marine clay also apart from this. We have also performed the environmental analysis of this study before and after the test have done to check the efficacy of the dewatering system in removing the contamination from the slurry utilizing the geotextile tube.

Now, a hanging bag test is conducted to assess the suitability of various geotextile fabric with respect to cite specific soil. The proposed test method in accordance with G R I G T-14 code in 2004 hanging bag test is conducted to determine the discharge of water through the geotextile fabric over a specific time period.

Designer must conduct the hanging bag test prior to the fabrication to approve the geotextile fabric for a particular site it is not so easy that if you know only the apparent opening size of the geotextile. It will satisfy this criteria, but it is recommended that one should also proceed for the hanging bag test this is very important for the selection of the proper kind of the geotextile tube.

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So, we have performed some experimental program on three types of the soil was selected for the hanging bag test that is one Powai lake soil fly ash as well as marine clay you can see this figure Powai lake this is the fly ash and this is the marine clay.

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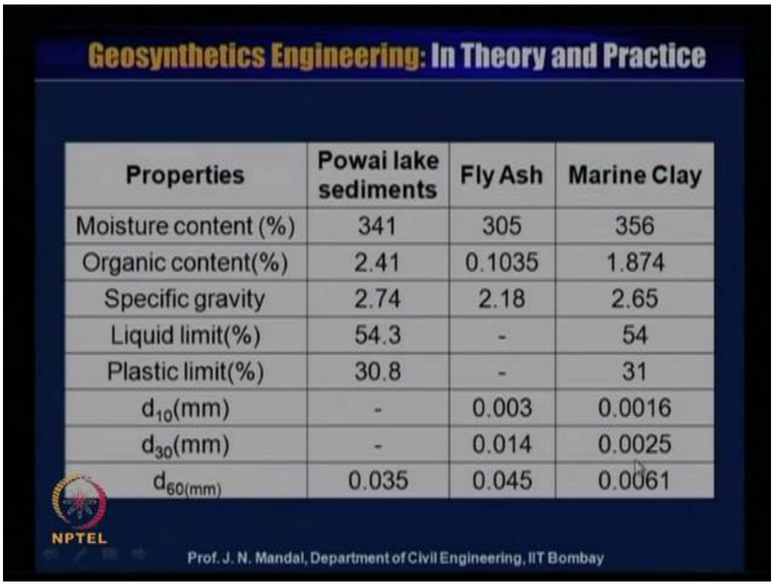

Properties	Powai lake sediments	Fly Ash	Marine Clay
Moisture content (%)	341	305	356
Organic content(%)	2.41	0.1035	1.874
Specific gravity	2.74	2.18	2.65
Liquid limit(%)	54.3	-	54
Plastic limit(%)	30.8	-	31
d_{10}(mm)	-	0.003	0.0016
d_{30}(mm)	-	0.014	0.0025
$d_{60(mm)}$	0.035	0.045	0.0061

Some properties of this Powai lake sediment fly ash and marine clay are reported in this table and moisture content will take about 341 percent for Powai lake 305 percentage for fly ash and marine clay 356 organic content for Powai lake 2.41 percent, fly ash 0.1035 percent and marine clay 1.874percentage. Specific gravity for Powai lake 2.74 fly ash 2.18 and marine clay 2.65 liquid limit Powai lake sediment is 54.3 percentage.

Marine clay is 54 percentage plastic limit for Powai sediment is 30.8 percentage and marine clay 31 percentage and d 10 and d 30 and d 50 for the grain size distribution curve I will show you later. That is d 10 for fly ash 0.003 and marine clay 0.0016 d 30 is for fly ash 0.014 millimetre and marine clay 0.0025 millimetre and d 60 for Powai lake 0.035 millimetre fly ash 0.045 millimetre and marine clay 0.0061 millimeter.

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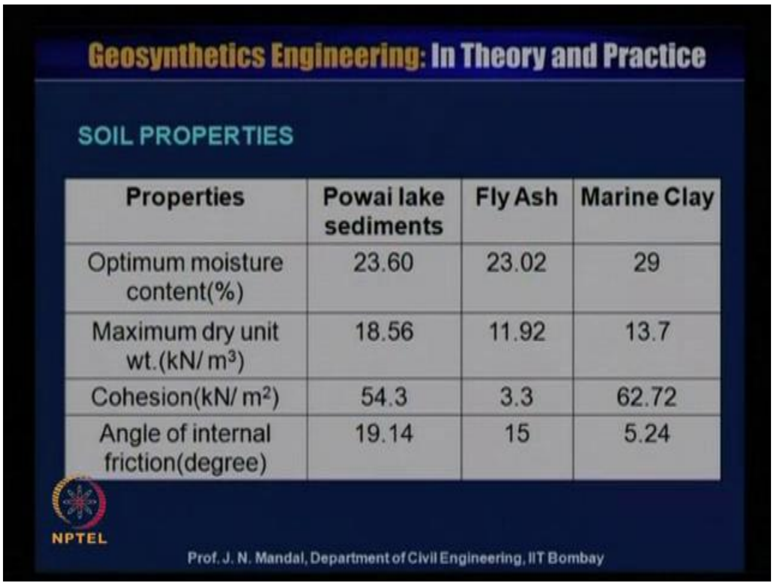

So, also that soil properties is continue this optimum moisture content for Powai lake 23.60 percentage fly ash 23.02 percentage marine clay 29 percentage maximum dry unit weight is for Powai lake 18.56 kilo Newton per meter cube fly ash 11.92 kilo Newton per meter cube. Marine clay 13.7 kilo Newton per meter cube cohesion for Powai sediment 54.3 kilo Newton per meter square fly ash 3.3 kilo Newton per meter square. Marine clay is 62.72 kilo Newton per meter square angle of internal friction angle for Powai sediment 19.14 degree fly ash 15 degree and marine clay 5.24 degree.

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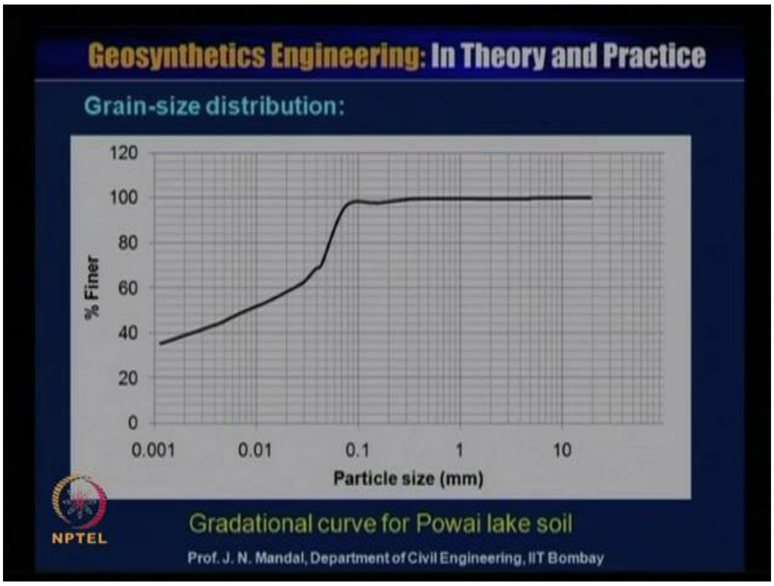

So, these are the grain size distribution curve for the Powai lake from where you can calculate this value d 10 d 50 d 60 or C U C C this is the curve between the percentage of filter and the particle size this is the gradation curve for Powai lake.

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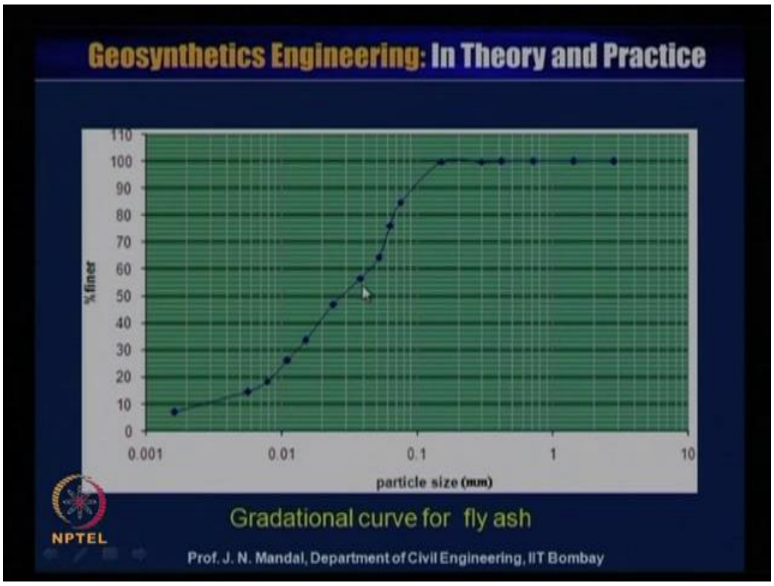

Next, this is the gradation curve for the fly ash, so from this curve also you can calculate d 10, d 50, d 60 whatever the parameter you require C U and also C C.

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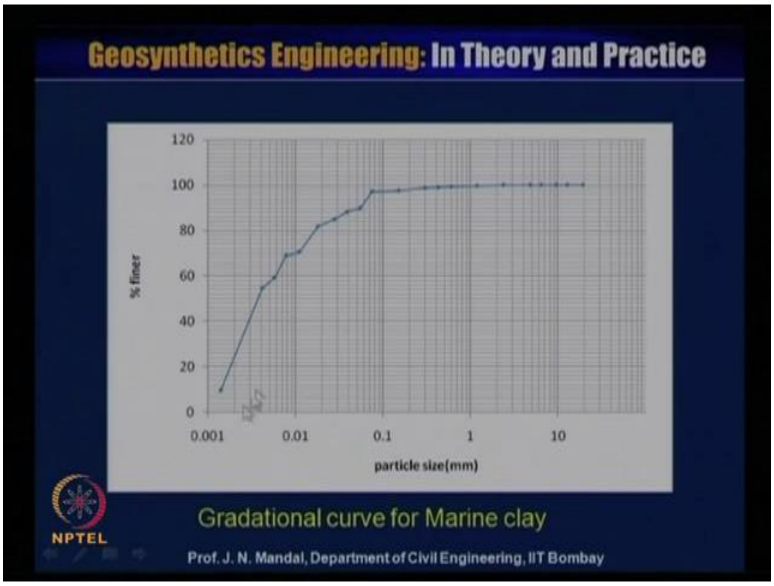

This is the gradation curve for marine clay this is the particle size versus percentage of finer.

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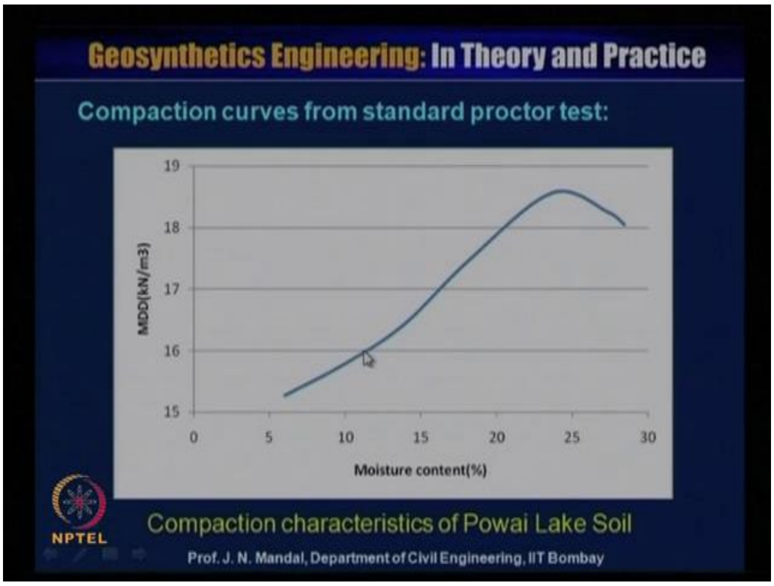

So, from this all this curve you can calculate these properties, basic property. Now, apart from this grain size distribution curve also compaction curve for standard proctor test also have been performed and this is the compaction characteristics of Powai lake soil.

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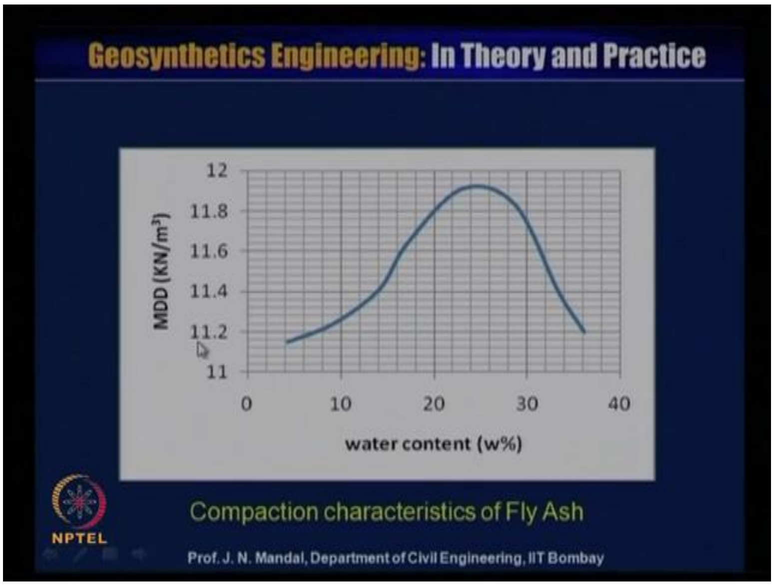

This is the maximum dry density versus the moisture content, so we can calculate what will be the maximum moisture content and the corresponding the maximum dry density. This is the compaction characteristics of the fly ash this is maximum dry density versus water content, so we have calculated the water content and corresponding the maximum dry density.

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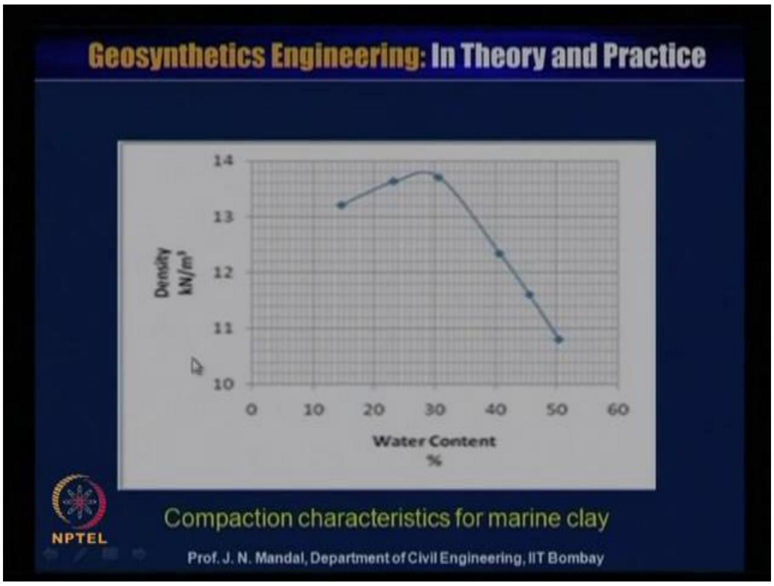

This is the compaction characteristics for marine clay, so we can calculate what will be the maximum water content and corresponding the dry density of marine clay.

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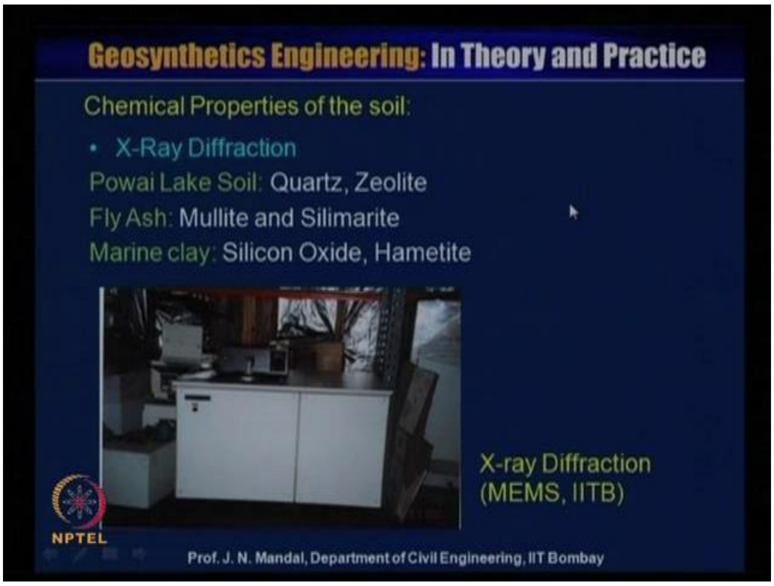

Now, also we have performed the chemical properties of the soil that is x-ray diffraction. So, for Powai lake soil, that is quartz and zeolite fly ash mullite and the silimarite and marine clay silicon oxide and haematite. So, this test has been also this performed in M E M S in I I T Bombay, so this is x-ray diffraction curve equipment.

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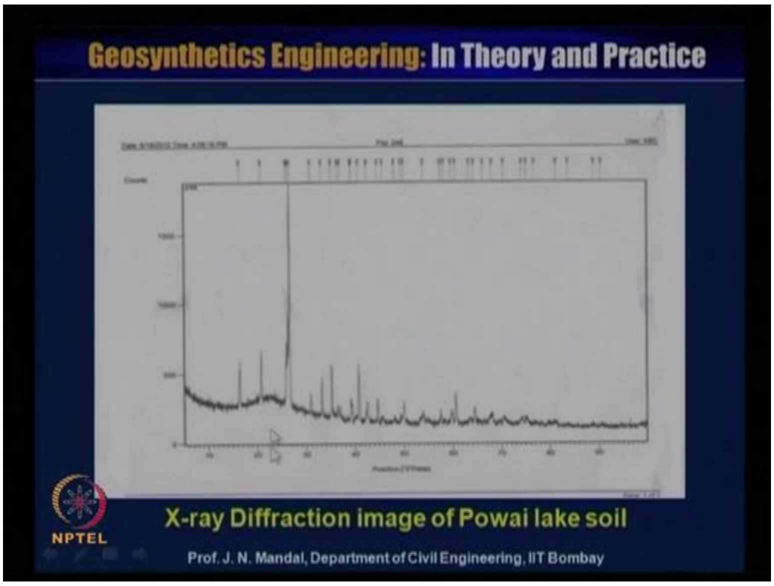

Now, this is x-ray diffraction image of the Powai lake soil, so you will be knowing how is the characteristics of the x-ray diffraction image for Powai lake. This x-ray diffraction images of this fly ash this x-ray diffraction image of the marine clay.

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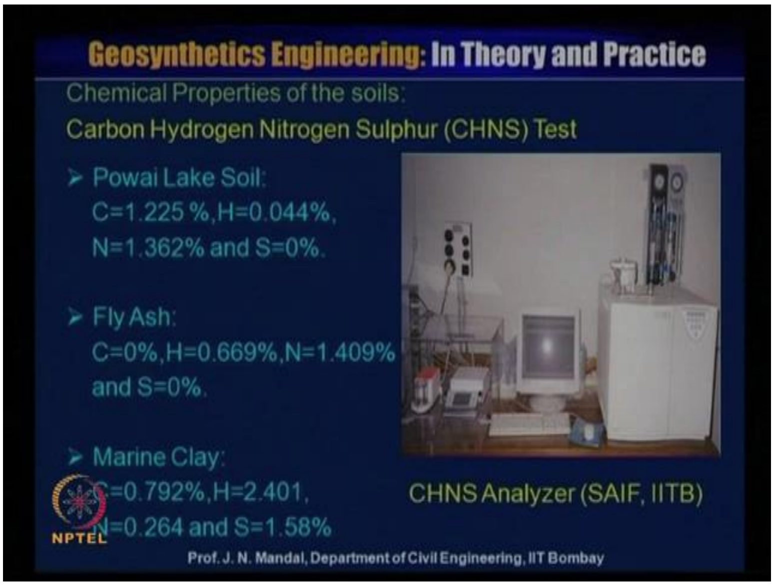

Chemical properties of the soil carbon hydrogen nitrogen sulphur C H N S test this test has been performed in S A I F, I I T Bombay. This is the equipment has been used the

Powai lake soil that carbon is 1.225 percentage hydrogen 0.044 percentage nitrogen 1.362 percentage. Sulphur 0 percentage fly ash carbon 0 percentage hydrogen 0.669 percentage nitrogen 1.49 percentage and sulphur 0 percentage marine clay carbon zero 0.7902 percentage hydrogen 2.401 percentage nitrogen 0.264 percentage and sulphur 1.58 percentage.

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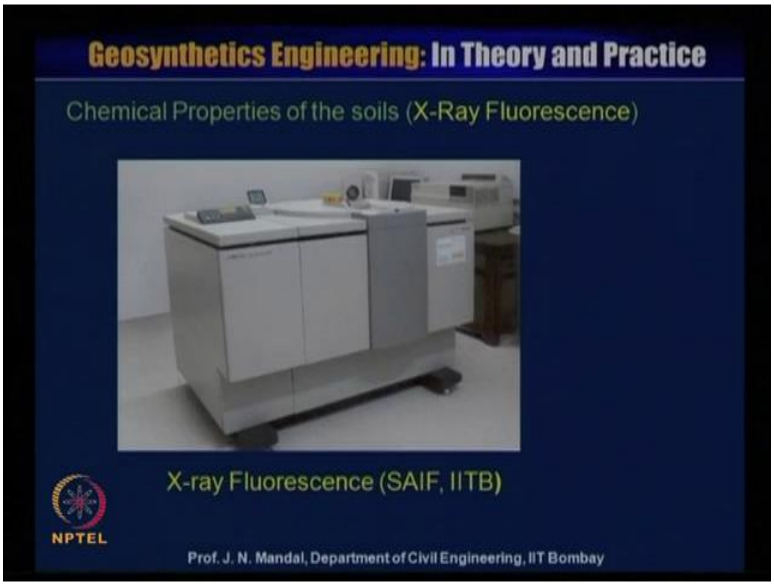

So, this is the chemical properties of the soil x-ray fluorescence test this is the equipment has been used and this is from S A I F, I I T Bombay.

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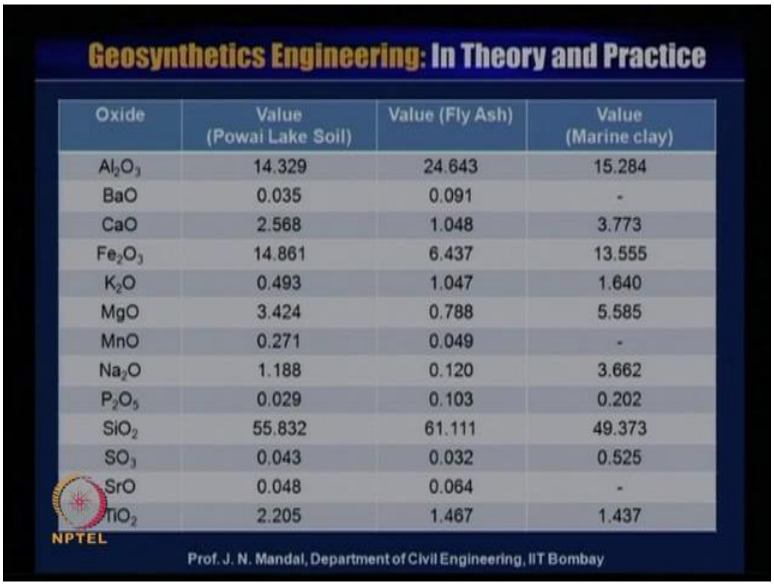

Oxide	Value (Powai Lake Soil)	Value (Fly Ash)	Value (Marine clay)
Al_2O_3	14.329	24.643	15.284
BaO	0.035	0.091	-
CaO	2.568	1.048	3.773
Fe_2O_3	14.861	6.437	13.555
K_2O	0.493	1.047	1.640
MgO	3.424	0.788	5.585
MnO	0.271	0.049	-
Na_2O	1.188	0.120	3.662
P_2O_5	0.029	0.103	0.202
SiO_2	55.832	61.111	49.373
SO_3	0.043	0.032	0.525
SrO	0.048	0.064	-
TiO_2	2.205	1.467	1.437

From this test we can obtain that oxide that what will be the value for Powai lake soil value for fly ash and value for marine clay. So, A l 2 o 3 for Powai lake 14.329 and for fly ash 24.643 and marine clay 15.284 b a o Powai lake 0.035 and fly ash 0.039 c a o for Powai lake 2.568 and fly ash 1.048 and marine clay 3.773 F e 2 o 3 Powai lake 14.861 fly ash 6.437. Marine clay 13.555, k 2 o for Powai lake 0.493 fly ash 1.047, and marine clay 1.640 m g o 3.424 for Powai lake 0.788for fly ash and 5.585 for marine clay.

M n o for Powai lake 0.271 and for flay ash 0.049 n a 2 o for fly ash 1.188 and for fly ash 0.120 and marine clay 3.662 p 2 o 5 for Powai lake 0.209 and fly ash 0.103. The marine clay 0.202 s i o 2, for Powai lake 55.832, and fly ash 61.111 and marine clay 49.737 3 s o 3 for Powai lake 0.043, for fly ash 0.032 and for marine clay 0.525, S r o for Powai lake 0.048 and fly ash 0.064 t i o 2, for Powai lake 2.205 fly ash 1.467 and marine clay 1.437.

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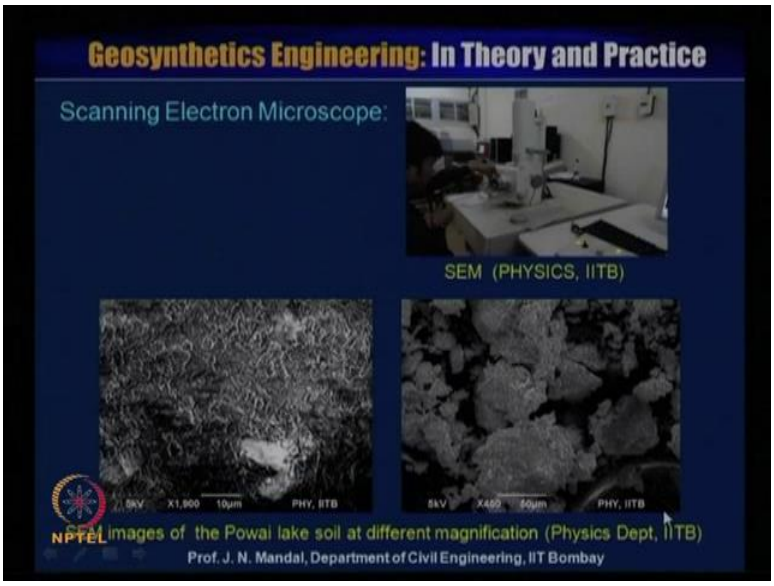

So, this is the scanning electron microscope this is for S E M physics I I T Bombay and you can see here that S E M image of the Powai lake soil at different magnification. This is from the physics department I I T Bombay, you can see that what will be the size and the shape of the Powai lake soil, but it is the micron effect for this soil and how it looks. Similarly, this is the S E M image of class a fly ash at different magnification, so this is the for five this is for the 20 micron.

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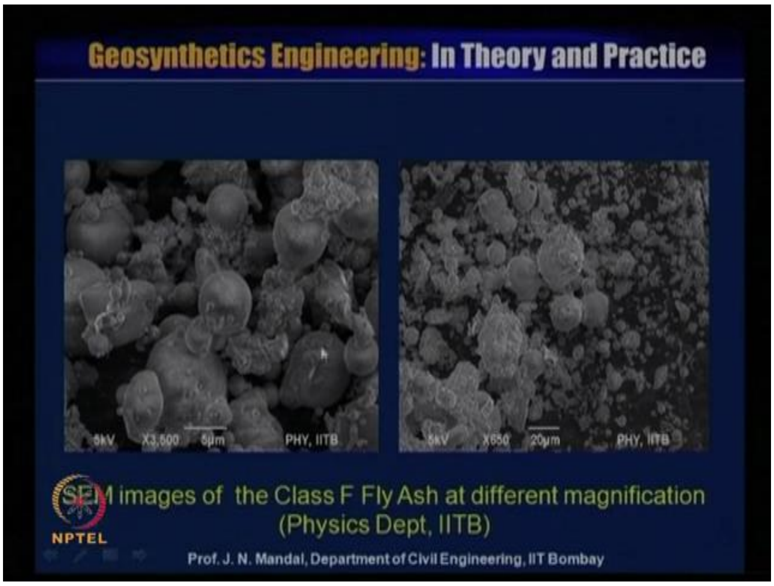

This is the S M E image of the marine clay at different magnification this is physics department I I T Bombay this is for the 20 micron.

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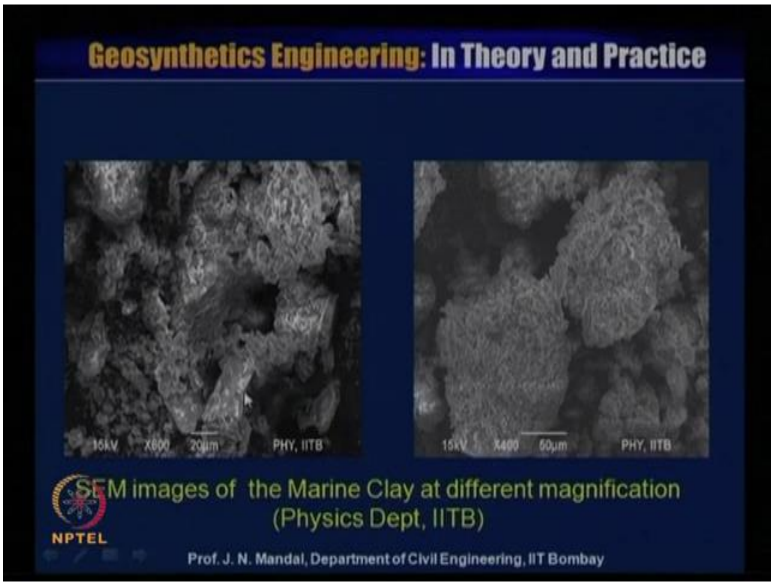

This enlarged from about fifty micron see that how there is a formation of the void also in this soil.

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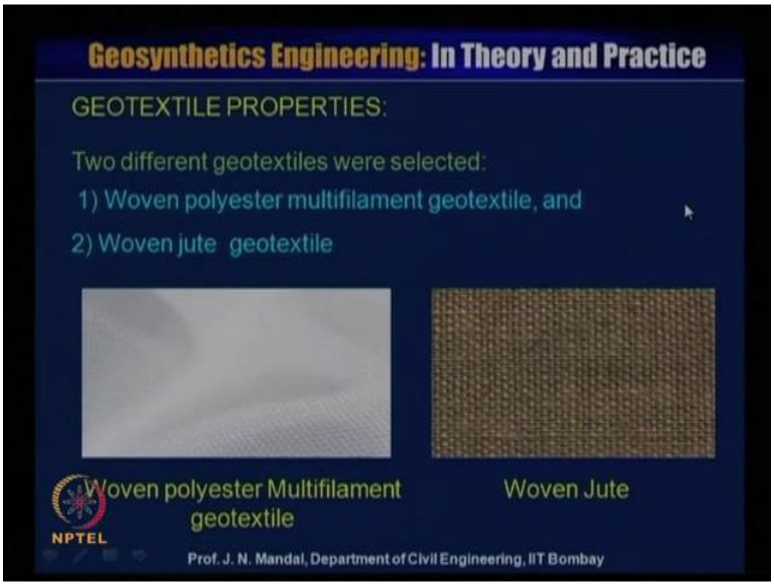

So, apart from these soil characteristics also we should understand the behaviour of the geotextile properties. So, two different geotextile was selected; one is the woven polyester multifilament geotextile, and the woven jute geotextile.

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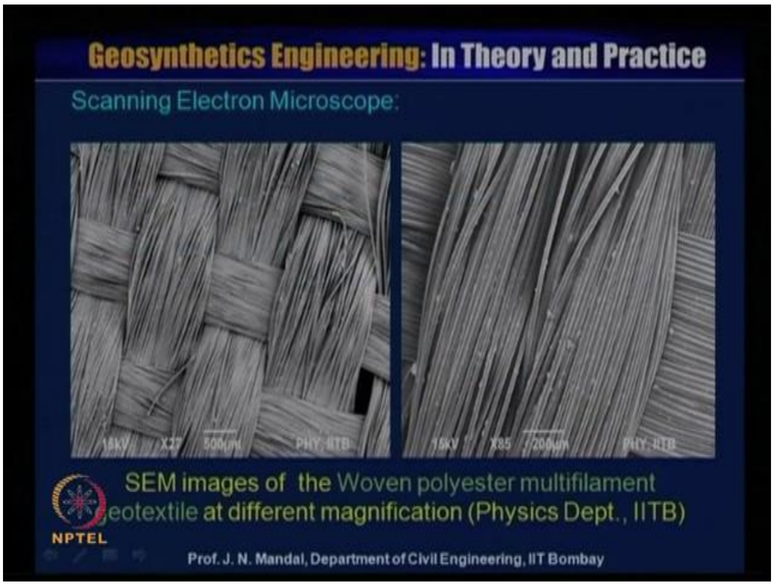

So, this is the scanning electron microscope S E M image for the woven polyester multifilament geotextile at different magnification, you can see here what is the filament this is the woven geotextile material multifilament. So, enlarge from these are the filament forming 200 this is the S E M image of the woven jute geotextile at different magnification. So, you can see here in a magnificent form how the filament or the filaments are almost perpendicular to each other.

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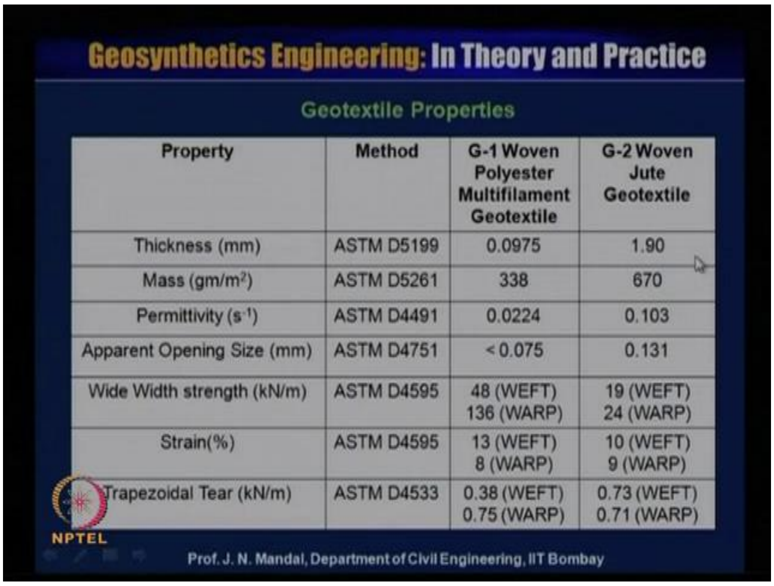

Property	Method	G-1 Woven Polyester Multifilament Geotextile	G-2 Woven Jute Geotextile
Thickness (mm)	ASTM D5199	0.0975	1.90
Mass (gm/m^2)	ASTM D5261	338	670
Permittivity (s^{-1})	ASTM D4491	0.0224	0.103
Apparent Opening Size (mm)	ASTM D4751	< 0.075	0.131
Wide Width strength (kN/m)	ASTM D4595	48 (WEFT) 136 (WARP)	19 (WEFT) 24 (WARP)
Strain(%)	ASTM D4595	13 (WEFT) 8 (WARP)	10 (WEFT) 9 (WARP)
Trapezoidal Tear (kN/m)	ASTM D4533	0.38 (WEFT) 0.75 (WARP)	0.73 (WEFT) 0.71 (WARP)

So, from this we have also performed this properties of this material that is the thickness as per A S T M d 5 119 that is woven polyester multifilament is geotextile is 0.0975 for woven jute geotextile 1.90 mass as per A S T M D 5 261. This is for woven polyester is 338 gram per meter square and jute geotextile 670 gram per meter square permittivity A S T M D 4491.

Now, for the woven polyester multifilament geotextile 0.0224 and jute geotextile 0.103 apparent opening size as per A S T M D 4751 for woven polyester geotextile is less than 0.075 millimetre. For just geotextile 0.131 millimetre wide width strength as per A S T M D 4595, there is a weft and warp direction weft direction for polyester geotextile 48 and warp direction 136 kilo Newton per meter.

In case of jute geotextile weft is 19 kilo Newton per meter and warp direction 24 kilo Newton per meter and corresponding strain as per A S T M D 4595 for the polyester geotextile in weft direction 13 percentage warp direction 8 percentage. In case of jute geotextile the weft direction 10 percentage and warp direction 9 percentage trapezoidal tear as per A S T M D 4533. That is weft direction 0.38 kilo Newton per meter warp direction 0.75 kilo Newton per meter and for jute geotextile in the weft 0.73 kilo Newton per meter and warp direction 0.71 kilo Newton per meter.

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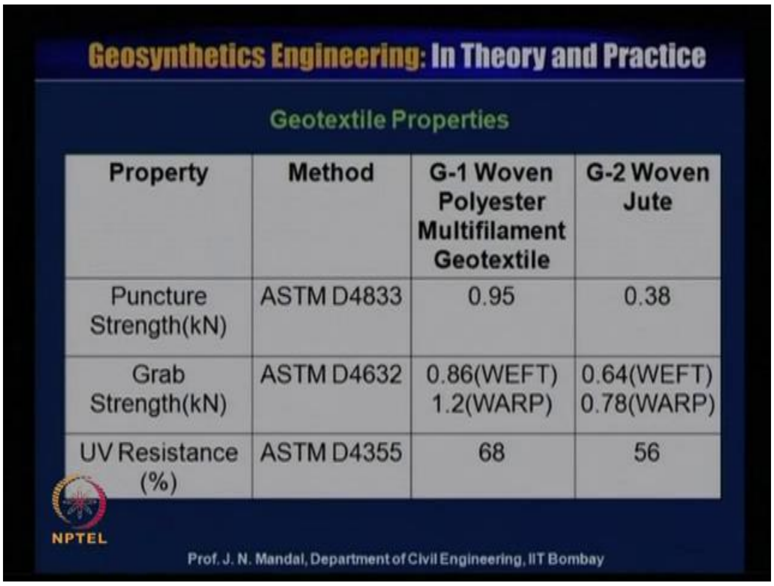

Now, apart from this property we have also performed the puncture strength as per A S T M D 4833 for polyester this is 0.95 kilo Newton for woven jute geotextile 0.38 kilo Newton per meter grab strength as per A S T M D 4632. In the weft direction for polyester geotextile 0.86 kilo Newton, and warp direction 1.2 kilo Newton for jute geotextile. Then weft direction 0.64 kilo Newton and warp 0.78 kilo Newton and U V resistance percentage as per A S T M D 4355 in the woven polyester is 68 percentage and the woven geotextile is 56 percentage.

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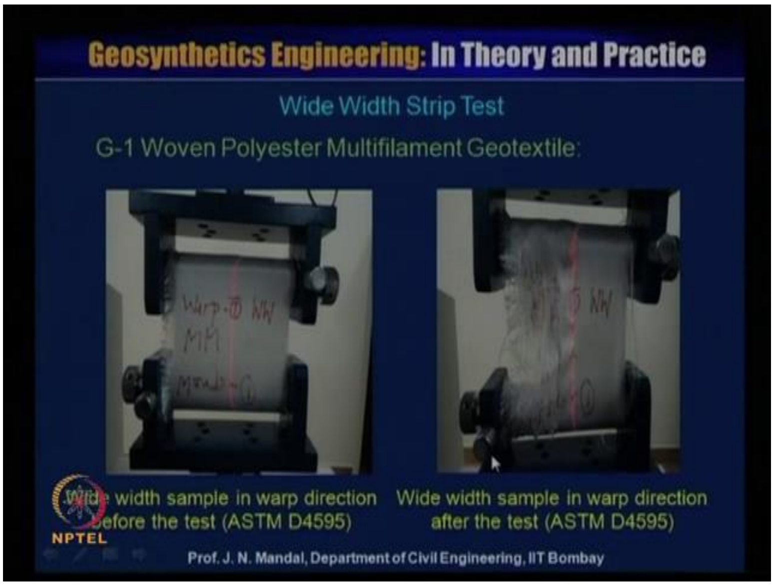

So, this is the wide width strip test that is for woven polyester multifilament geotextile this is the wide width sample this is about the 200 millimetre the width and 100 millimetre is the gauge length. This is the test for the warp direction this is the before the test as per A S T M D 4595 and you can see the after the test in the warp direction as per A S T M D 4599. This is very typical failure of the woven polyester multifilament geotextile in the warp direction. Similarly, this wide width test also I have performed in the weft direction before the test and then this sis the after the test you can see that what will be the nature of the failure of the woven geotextile in the weft direction.

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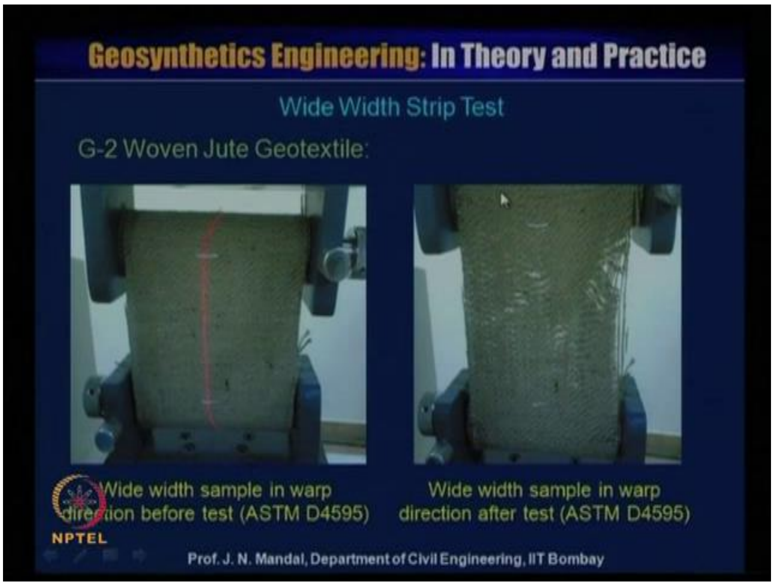

Now, this is the wide width strip test for the woven jute geotextile material this is wide width sample in the warp direction before the test as per A S T M D 4595. You can see that this is the failure of the sample after the test of jute geotextile, this is very typical nice failure of jute geotextile this is in the weft direction this is the before the test and also after the test.

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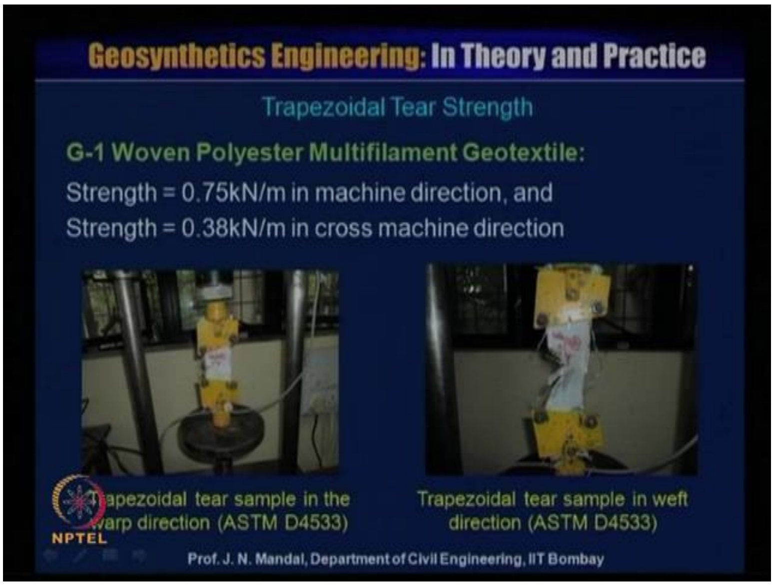

So, trapezoidal tear stress this is woven polyester multifilament geotextile this is strength about 0.75 kilo Newton per meter in the machine direction and strength 0.338 kilo Newton per meter in the cross machine direction. This is trapezoidal sample in the warp direction this is the trapezoidal tear sample in the weft direction.

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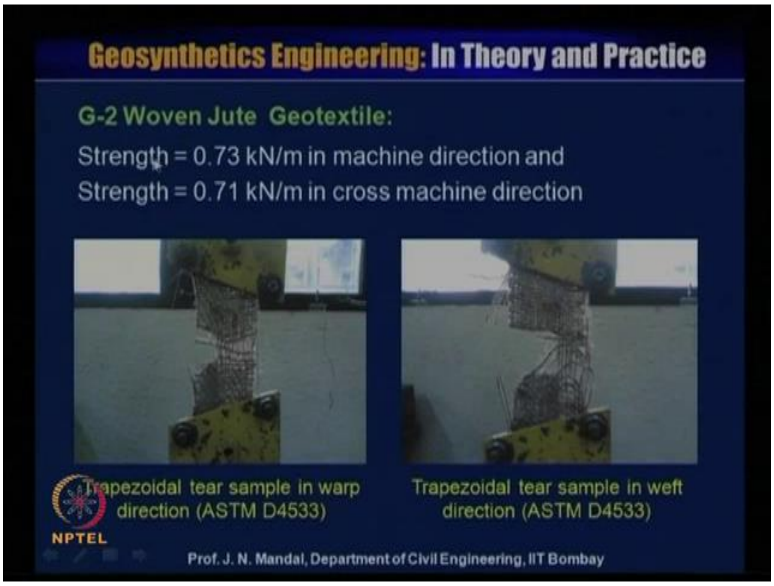

Similarly, for woven jute geotextile this is also the trapezoidal tear sample in the warp direction. This is in the trapezoidal tear sample in the weft direction and strength is 0.73

kilo Newton per meter in the machine direction and strength is 0.71 kilo Newton per meter in the cross machine direction.

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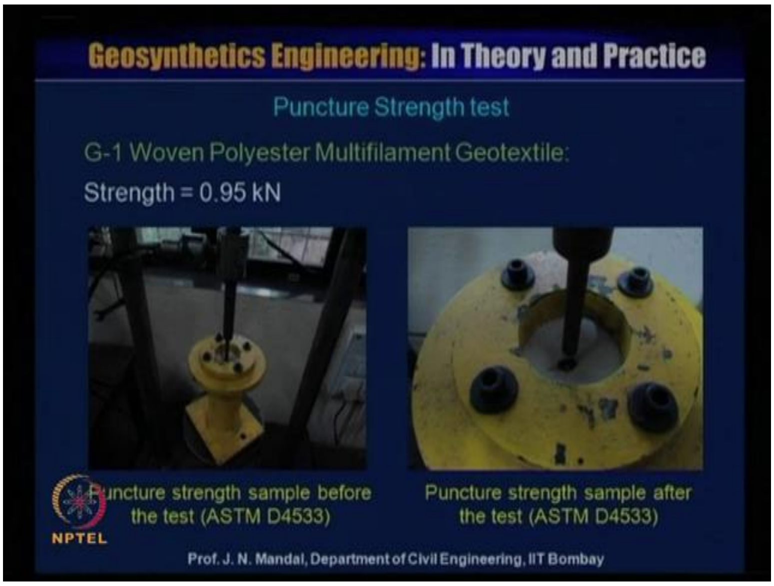

This puncture strength test that is woven polyester multifilament geotextile strength 0.95 kilo Newton this is puncture strength sample before the test A S T M D 4533. This is the puncture strength sample after the test you can see here.

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There is a formation of the hole of the sample polyester geotextile. Similarly, for jute geotextile also puncture test has been performed and puncture strength is 0.58 kilo Newton per meter this is before test.

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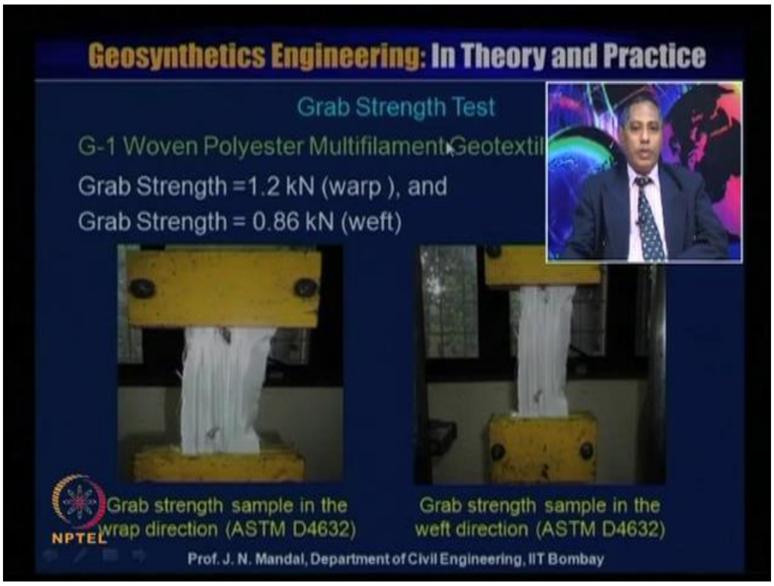

This is after test grab strength test also grab strength sample in the warp direction and grab strength sample in the weft direction and grab strength value is 1.2 kilo Newton in the warp and grab strength 0.86 kilo Newton in the weft direction.

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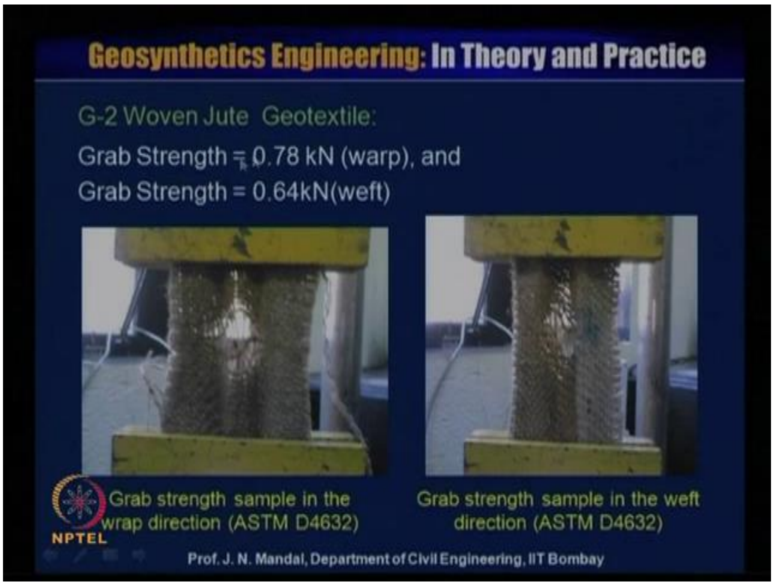

This is for woven jute geotextile this is the grab strength sample in the warp direction you can see very typical failure and also this is a grab strength sample in the weft direction. The value for grab strength is 0.78 kilo Newton in the warp direction and grab strength is 0.64 kilo Newton in the weft direction. So, all these test has been performed in our geosynthetic research and testing laboratory.

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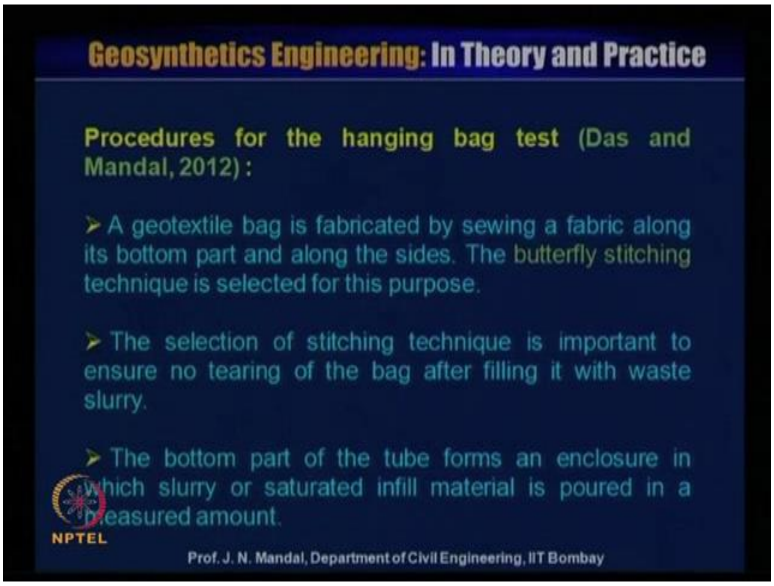

Now, I proceed for the hanging bag test Das and Mandal 2012. Now, a geotextile bag is fabricated by sewing fabric along it bottom part and along the side the butterfly stitching technique is selected for this purpose. The selection of stitching technique is important to ensure no tearing of the bag after filling it with waste slurry. The bottom part of the tube form an enclosure in which the slurry or the saturated in fill material is poured in a measured amount.

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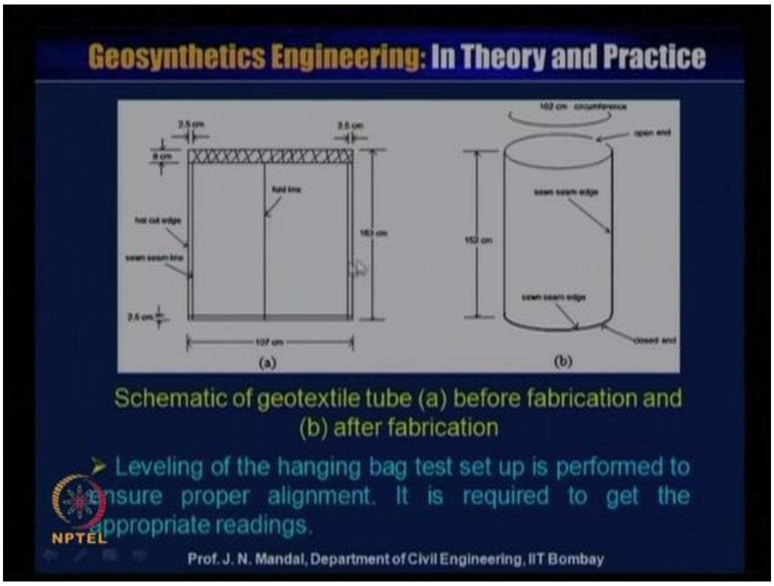

Now, this is the schematic of geotextile tube before the fabrication and this is the after fabrication. I can show you here that this is the geotextile tube and this is about 107 centimetre and this height is about 163 centimetre and this is 22.5 centimetre and this part is 8 centimetre, this is 2.5 centimetre, this is 2.5 centimetre. This is geotextile is the seam this is the seam line this is the hot outer edge, and this is the hole line here and it looks like a kind of a cylindrical this is the closed end and this is the open end.

So, in the close end this has been sewn seems edge and also that one side it has been also seam edge m and this length of the geotextile tube is 152 centimeter. This is the open end this is 102 centimeter circumstances, so it was like this that it is a fabric. It is it is made of the polyester woven and also the jute geotextile material, it is like this in the cylindrical in the shape.

So, this is either the jute geotextile or the woven polyester geotextile and this part is being sewn this side also sewn and butterfly sewing has been adopted and also the bottom part also has been sewing, this part also has been sewing and this slurry to be inserted into this geotextile tube from the top. So, this is a kind of the geotextile that bag we are talking about levelling and the this is the hanging bag test setup is performed to ensure proper alignment it is required to get the appropriate reading.

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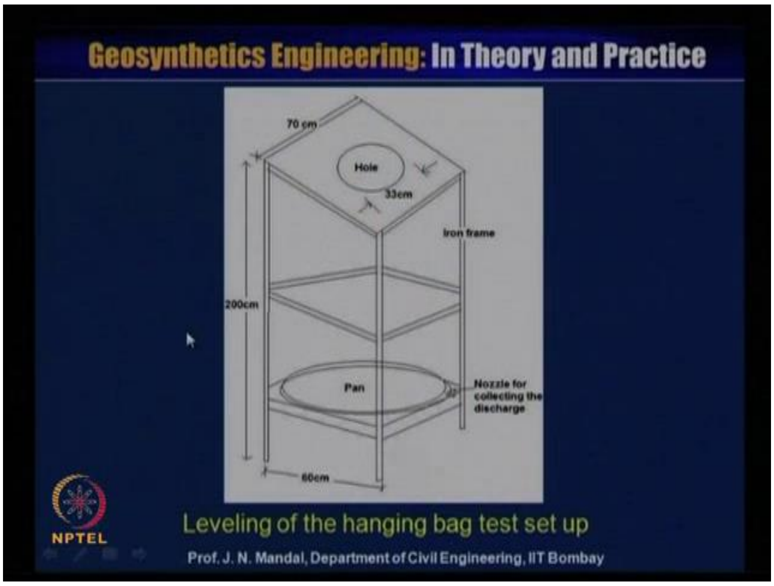

Now, this is the levelling of the hanging bag test set up, so you can see that this is made of made of steel this is a kind of the frame which has been fabricated and also developed. So, this is the frame and this is about 60 centimeter and this is 200 centimeter and top is this is 70 centimeter seventy, seventy, seventy and there is a hole, this is diameter about 33 centimeter. This is all the steel iron frame and at the bottom there is a pan where that when through the geotextile tube the slurry will pass and the water may come out from the bottom of the geotextile tube and you have to be collect at the this pan. So, this is the nozzle for the collection of the discharge from the geotextile tube, so this is the levelling of the hanging bag test up so proper alignment also required. So, I will show you that more picture that how you will perform the test and how you will install the geotextile tube into this frame.

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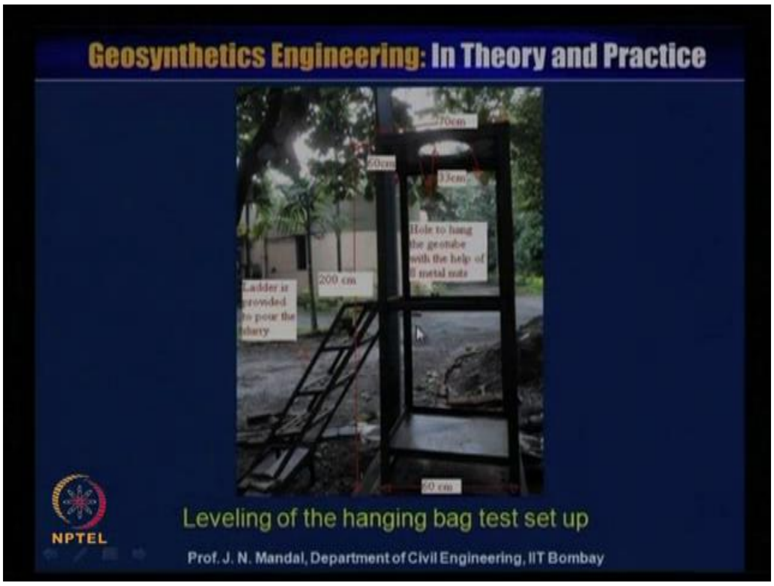

So, here you can see there are levelling of the hanging bag this is the set up, this is the frame and this is about 70 centimetre and this is a the circle is 33 centimetre and here this one is the 60 centimetre. This from top to bottom is 200 centimetre and this to here is 25 centimetre and here you can the pan and the here the hole to hanging the geotextile tube with the help of eight metal knots here. So, you can see later very clear picture about this eight metal knot here and how the geotextile tube is hanging from the top of this opening side of this frame and this is one ladder is used. So, this is provided to pour the slurry on the top of the geotextile tube, so you can climb up and can stand and can pour the slurry on to this to this open or to this geotextile tube.

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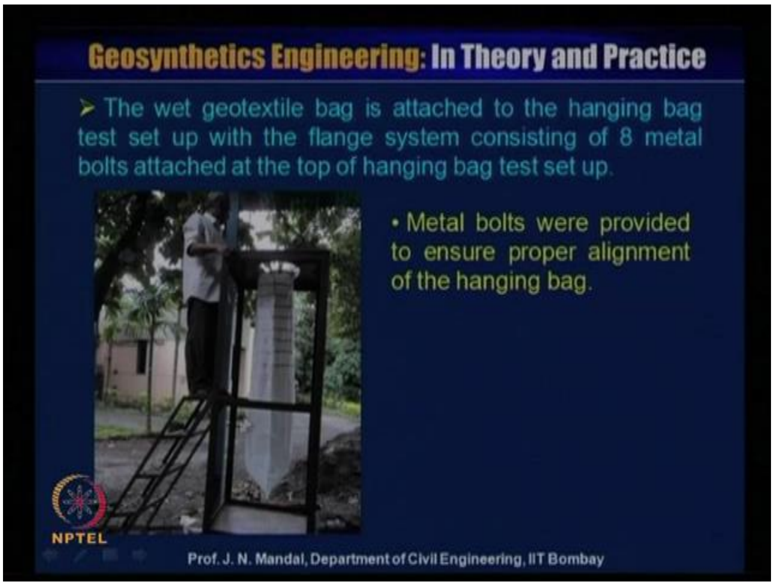

So, here you can see this student this went up and then he will be pouring this slurry into this tube, so this is the tube. So, this is the wet geotextile bag it attached here to the hanging bag test set up with the flange system consisting of eight metal here is the eight metal bolt attached at the top of the hanging bag test set up. Now, metal bolt were provided to ensure proper alignment of the hanging bag.

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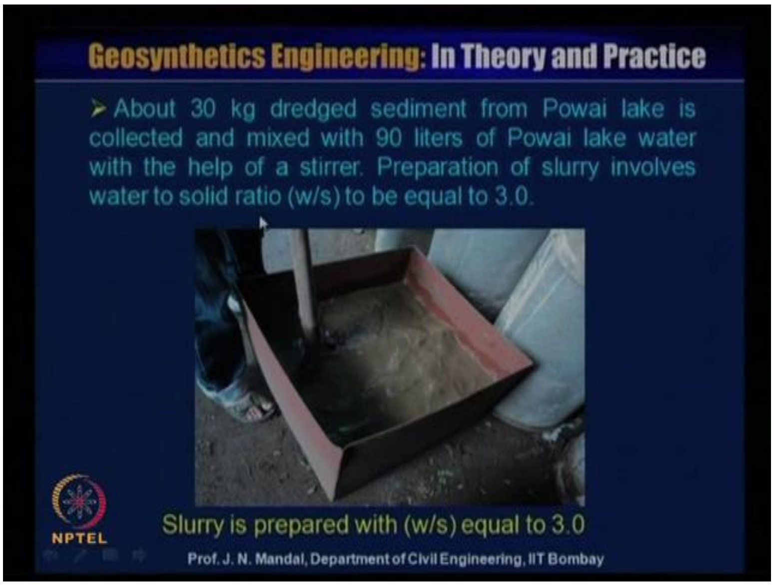

Next, after hanging the bag you require for the preparation of the slurry, so above 30 k g dredged sediment from Powai lake is collected and mixed with 90 litre of Powai lake water. With the help of a stirrer and preparation of the slurry involve water to solid ratio that means w by s should be equal to 3, so with this proportional this mixture has been made.

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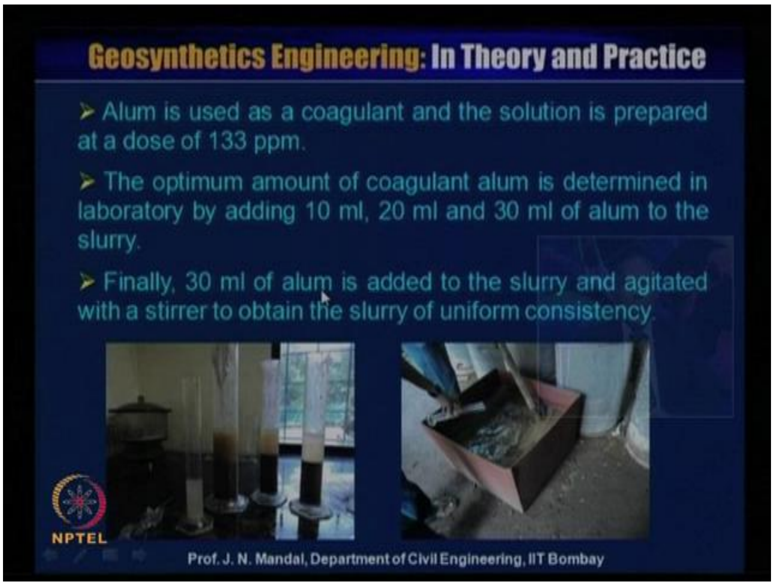

So, you have to prepare the slurry very carefully and then the alum is used as a coagulant and the solution is prepared at a dose of 133 p p m, the optimum amount of coagulant alum is determined in the laboratory by adding 10 m l, 20 m l and 30 m l of alum to the slurry. Finally, 30 m l of alum is added to the slurry and agitated with the stirrer to obtain the slurry of uniform consistency, this is very important that you should prepare the sample with the uniform consistency.

So, you have to check that what amount of the alum is to be added to the slurry in order that you can prepare a proper uniform consistency of the slurry. Here, you can see that this is the stirring and that they are preparing the slurry and this that how the sample at the bottom how the water have been collected and stored in a tube.

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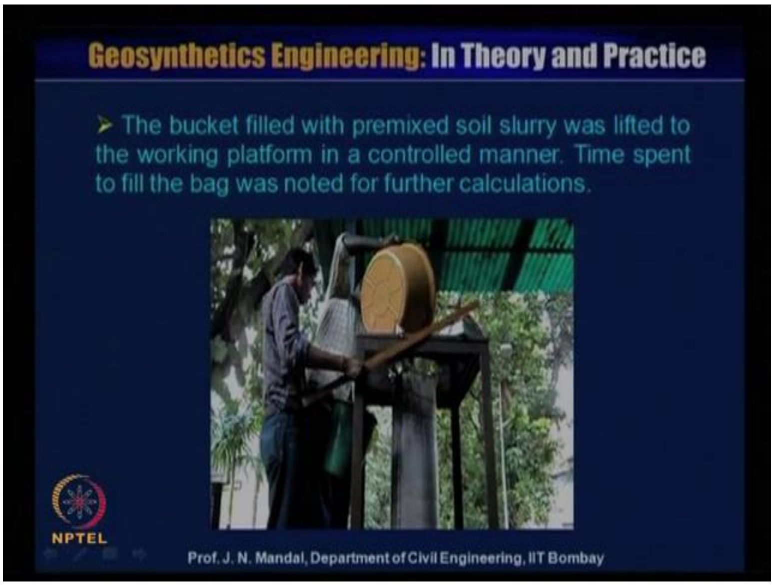

So, here this bucket filled with the premixed soil slurry was lifted to the working platform in a controlled manner and time spent to fill this geotextile tube was noted for further calculation. So, this is important because when you are pouring then you have to the measure the time that what time how much time it is required, because you are measuring the much water can discharge from the geotextile tube and at a particular time here students are pouring this slurry into this geotextile tube.

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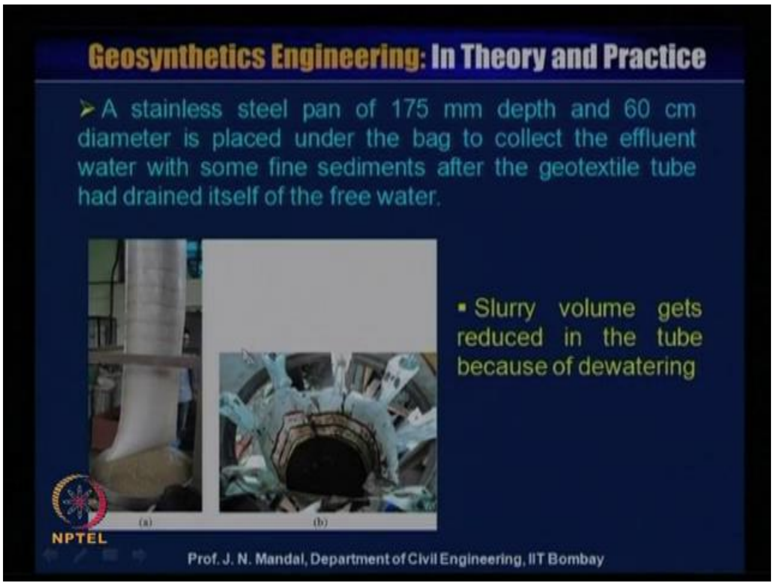

Now, a stainless steel plant the here the stainless steel plant of 175 millimetre depth and 60 centimetre of diameter is placed under the geotextile tube to collect that effluent water with some of the fine sediment after the geotextile tube had drained itself to the free water. So, slurry volume gets is reduced in the tube because for dewatering and here we can see that how this eight knots here is joined geotextile tube.

On the top these are the eight, one two three four five six seven eight and this geotextile tube is hanging. So, this is the slurry volume get you can see how it is reduced in the tube because of the dewatering and water is dewatering at the bottom. There is a span and you are collecting the drained water which is coming out from the geotextile tube.

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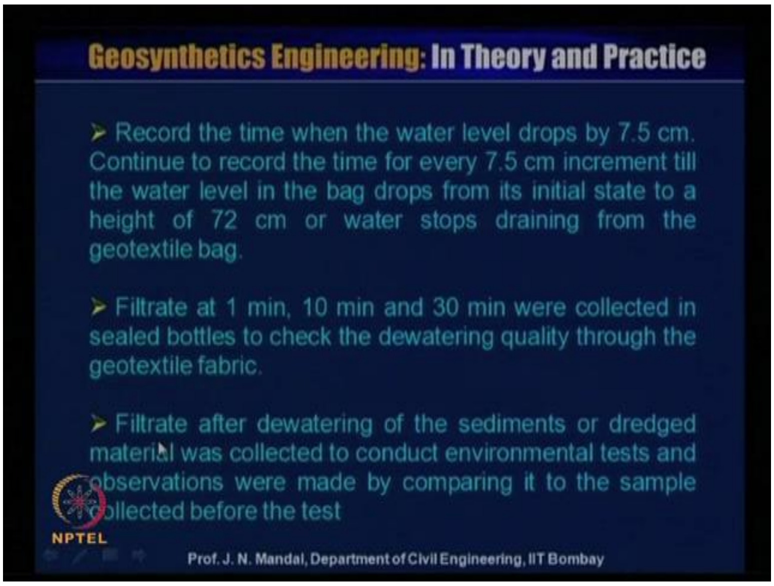

Now, record the time when the water level dropped by 7.5 centimetre and continue to record the time for every 7.5 centimetre increment till the water level in the bag drops from its initial state to a height of 72 centimetre or water stop draining from the geotextile bag. Now, filtrate at 1 minute, 10 minute and 30 minute were collected in the sealed bottle to check the dewatering quality through the geotextile fabric filtrate. After dewatering of the sediment or dredged material was collected to conduct the environmental test and observation were made by comparing it to the sample collected before the test.

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So, here we can see that filter before the test that is dirty water at the left hand side on the other hand you can see after the dewatering of the sediment that is the clean water at the right side. So, you can directly add a very clean water when this slurry will passes through the geotextile material because we use lot of slurry and then you require for the very clean water. It takes lot of time and a lot of machinery manpower and the power is required to make the clean water, but here by the use of the geotextile tube, you can directly have a very clean water.

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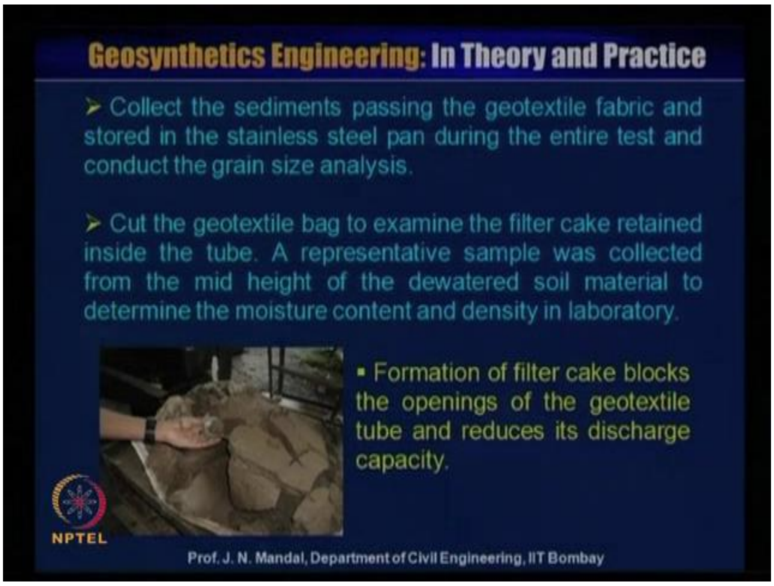

So, now collect the sediment passing the geotextile fabric and store in a stainless steel pan during the entire test and conduct the grain size analysis cut the geotextile bag to examine the filter cake retained inside the tube. Here, you can see that is cut it the geotextile tube and then this is the filter cake this is the formation of filter cake block the opening of the geotextile tube and reduce its discharge capacity. So, a representative sample was collected from the mid height of the dewatered soil material to determine the moisture content and the density in the laboratory you have to check what should be the moisture content what will be the density.

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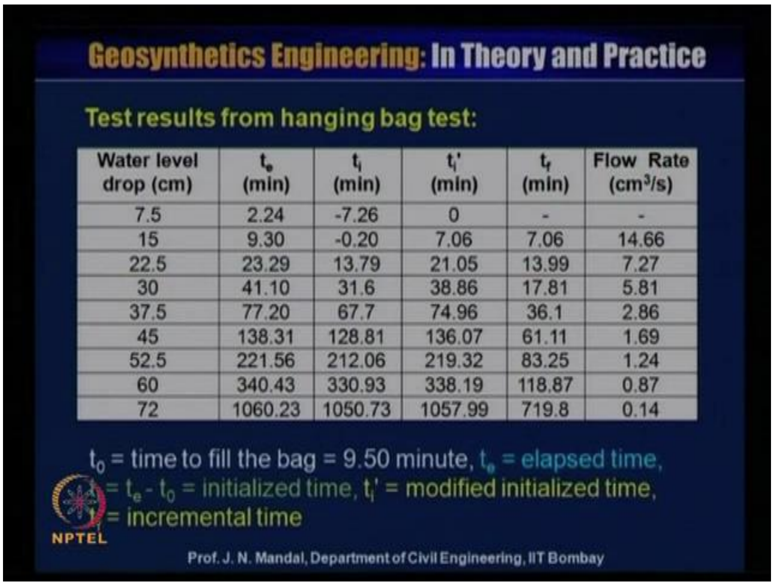

Water level drop (cm)	t_e (min)	t_i (min)	t_i' (min)	t_r (min)	Flow Rate (cm^3/s)
7.5	2.24	-7.26	0	-	-
15	9.30	-0.20	7.06	7.06	14.66
22.5	23.29	13.79	21.05	13.99	7.27
30	41.10	31.6	38.86	17.81	5.81
37.5	77.20	67.7	74.96	36.1	2.86
45	138.31	128.81	136.07	61.11	1.69
52.5	221.56	212.06	219.32	83.25	1.24
60	340.43	330.93	338.19	118.87	0.87
72	1060.23	1050.73	1057.99	719.8	0.14

Now, this is the some test result from the hanging bag test so water level as I say that you can start from 7.5 centimetre then 15, 7.5 meter interval and up to the 72 centimetre. So, you can continue and then you are measuring what is the elapsed time that is t e in minutes so when 7.5 it takes 2.24 minutes after that 15 centimetres it takes 9.30 minute. So, when the water level drop at 22.5 centimetres then that elapsed time is 23.29 when water level drop 30 centimetre then your elapsed time 41.10 minutes and when water level drop 37.5 centimetre, then the elapsed time 77.20 minutes. Now, when water level drop 45 centimetre then elapsed time 138.31 when water level drop 52.5 centimetre then elapsed time 221.56 minutes when water level drops 60 centimetre and elapsed time 340.43 minutes. At the end when water level drop 72 centimetres then elapsed time 1060.23 minutes.

So, we can see that how it takes time is increasing with the increasing the drop of the water level. So, from this also we have to calculate that what is t of i, so t i is the initialized time that means that will be the t e minus t 0. So, t 0 mean time to fill the bag it takes 9.50 minutes, I say that when you are filling the bag you should also note the time.

So, t 0 time to fill the bag 9.50 minute t i will be, so we have to calculate the t i, t i means t e minus t 0 that is initialization time. So, this t i will be equal to what is t 2.24 minus the t 0 is 9.50. So, 2.24 minus 9.50 which will give t of i is minus 7.26. So, next your 9.30 minus 9.50 is give minus 0.20. Now, next 23.29 minus 9.50 is give 13.79, then 41.10 minus 9.50 is 31.6, 77.20 minus 9.5 is 67.7 minutes. Then 138.31 minus 9.50 is 128.81 next 221.56 minus 9.50 is 212.06.

Next, 340.43 minus 9.50 is 330.93 and at the end 1060.23 minus 9.50 is 1050.73. So, you can calculate that what will be the initialized time, now what is t 1 dash that is modified initialized time. So, initially it is the 0 and next is 7.26 minus 0.20, so this is 7.26 this will be equal to 7 point, this is initially it is that it is the 0. So, this will be equal to 7.06, 7.26 minus 0.20 7.06, so minus minus plus, so this 7.06 now. Next, is this is 13.79 plus 0.20 that is minus 0 that means plus point 20 plus 7.06 will give 21.05 now.

Similarly, 31.6 minus 13.79 plus 21.05 will give 38.86, now 67.7 this minus 31.6 plus 38.86 give 74.96. Similarly, 128.81 minus 67.7 plus 74.96 will give 136.07 like that you can continue and you can obtain at the end that is 1057.99. So, this is the t f is the final, so this is the t f final is this is 7.06 and after that this is 21.05 minus 7.06 will give that what is 13.99.

Similarly, 38.86 minus 21.05 will give 17.81 similarly, 17.496 minus 38.86 will give the 36.1. Similarly, we can continue and we can calculate what should be the incremental time. So, you know that at this water level drop and you are also at the same time you are you are measuring that how much water has been collected from the geotextile tube at a particular time, so from that you can calculate what will be the flow rate.

So, here that flow rate at this level is 13.66 centimetre cube per second. Then gradually, you can see that flow rate is reducing 7.27 centimetre cube per second 5.81 centimetre cube per second, 2.86 centimetre cube per second, 1.69 centimetre cube per second, 1.24 centimetre cube per second, 0.87 centimetre cube per second and 0.14 centimetre cube per second. So, you can see that what will be the water level drop is water level drop also is increasing and whereas, this flow rate is also gradually is decreasing because for sedimentation or precipitation of the slurry itself.

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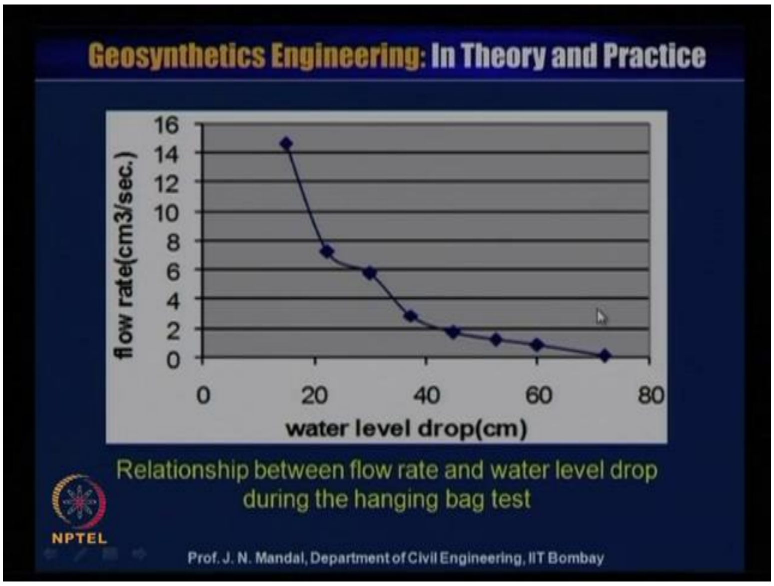

So, from this table, so you can draw a correlation between the flow rate in centimetre per cube versus water level drop in centimetre. So, this is the figure has shown the relationship between the flow rate and water level drop during the hanging bag test. So, from this table and if you substitute this value that is the flow rate value you can see starting from 14.66 and the water level drop is 7.5 15 and this is the water level this is 14.6 and then 15 you can see somewhere here. So, this is the flow rate versus the water level like that you can substitute this value for the water level drop 22.5 then your flow rate is 7.27 like this 7.27.

You will be getting this point and then again for 5.81 that is in thirty water drop 5.81 then you can see water drop about thirty. Similarly, for this 37.5 and this is flow rate is 2.86, 37.5 and flow rate is 8 and like this you can continue and you can have a correlation between the water level and the flow rate. So, from this curve you have observe that how the flow rate is decreasing with increasing the water level and after a certain drop it has went up to the 72 centimetre and 0.14 flow.

So, this is almost 72 and 0.14 flow this is almost that flow is diminishing, so there will be almost negligible flow. So, you can obtain a relationship between the flow rate and the water level drop here how the flow rate is decreasing with increasing the water level dropped.

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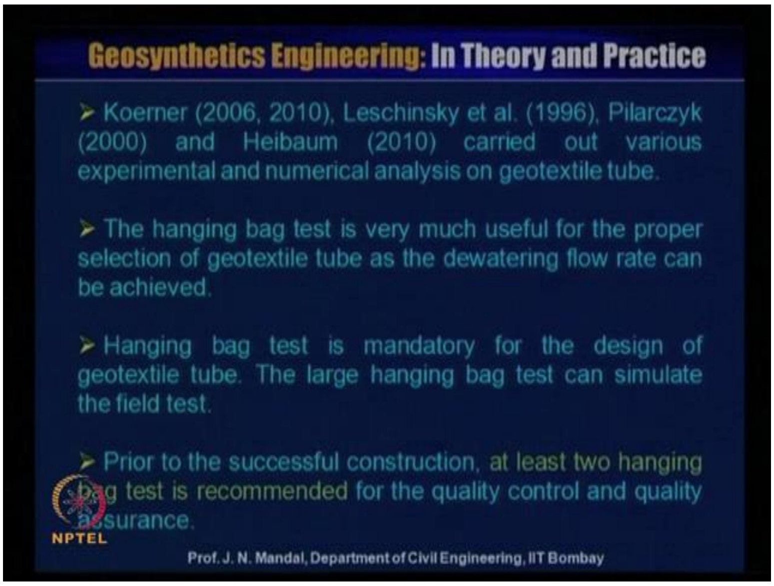

Now, Koerner 2006 and 2010 Leschinsky et al 1996 and Pilarczyk 2000 and the Heibaum 2010 carried out the various experimental and numerical analysis on geotextile tube. We have also performed some numerical analysis also on geotextile tube, this hanging bag test is very much useful for the proper selection of geotextile tube as the dewatering flow rate can be achieved. So, hanging back test its mandatory for the design of the geotextile tube the large hanging bag test can simulate the field test prior to the successful construction. At least two or three hanging bag test is recommended for the quality control and the quality assurance.

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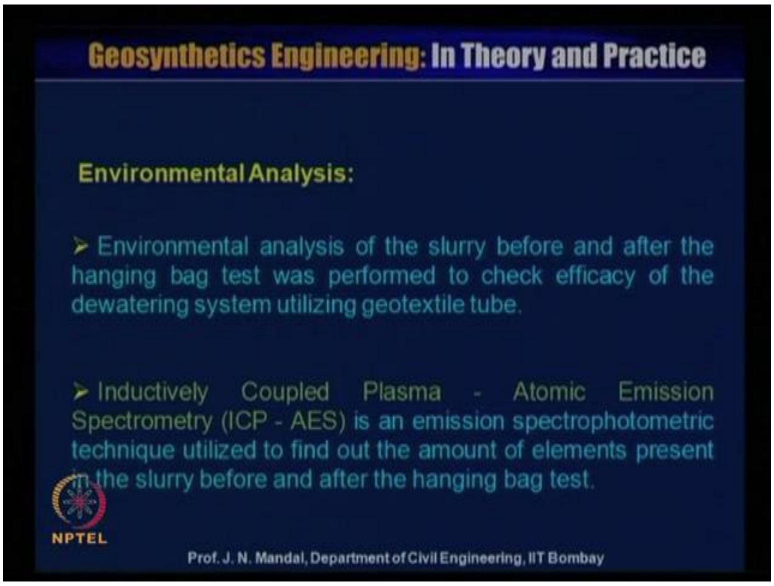

Now, from this test we have also performed that some environmental analysis. So, environmental analysis of the slurry before and after the hanging bag test was performed to check the efficacy of the dewatering system utilizing geotextile tube. So, inductively coupled plasma atomic emission spectrogram ICP-AES is an emission spectrophotometric technique utilized to find out the amount of element present in the slurry before and after the hanging bag test.

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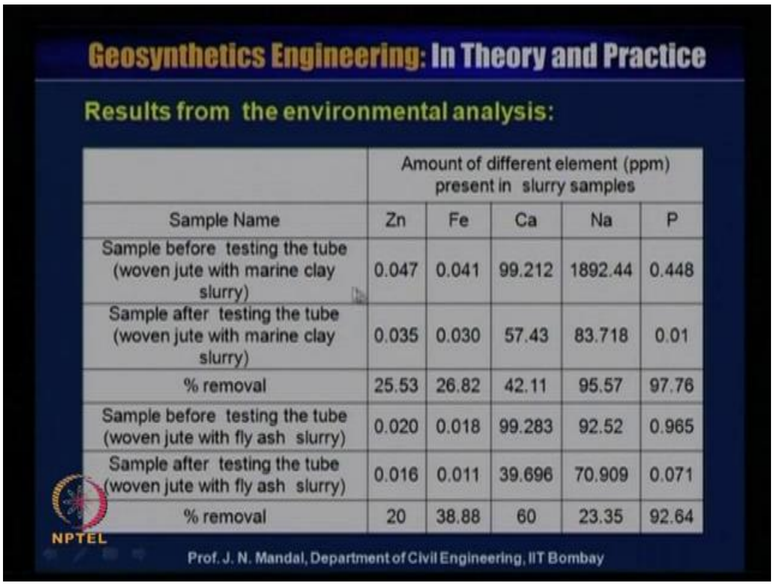

	Amount of different element (ppm) present in slurry samples				
Sample Name	Zn	Fe	Ca	Na	P
Sample before testing the tube (woven jute with marine clay slurry)	0.047	0.041	99.212	1892.44	0.448
Sample after testing the tube (woven jute with marine clay slurry)	0.035	0.030	57.43	83.718	0.01
% removal	25.53	26.82	42.11	95.57	97.76
Sample before testing the tube (woven jute with fly ash slurry)	0.020	0.018	99.283	92.52	0.965
Sample after testing the tube (woven jute with fly ash slurry)	0.016	0.011	39.696	70.909	0.071
% removal	20	38.88	60	23.35	92.64

So, these are the result from the environmental analysis this is amount of the different in p p m present in the slurry sample. This is the sample name the sample before testing the t woven jute with the marine clay you can see that zinc 0.047 iron 0.041 and calcium 99.212, sodium 1892.44 and potassium 0.448. Similarly, sample after testing of the geotextile jute woven jute with the marine clay slurry is zinc 0.035 iron 0.030, calcium 57.43 and sodium 83.718 and phosphorous 0.01.

So, percentage of removal is zinc 25.53 percentage and iron 26.82 percentage calcium 42.11 percentage sodium 95.57 percentage and phosphorous 97.76 percentage. Now, sample before testing tube woven jute with the fly ash slurry zinc 0.020 iron 0.018 and calcium 99.283, sodium 92.52 and phosphate 0.965. Sample after testing of geotextile tube woven jute geotextile with the fly ash slurry, that zinc 0.016, iron 0.011 and calcium 39.696 and sodium 70.909 and phosphorous 0.071. So, you can see percentage of removal zinc 20 percentage iron 38.88 percentage and calcium 60 percentage and sodium 23.35 percentage and the phosphorous 92.64 percentage.

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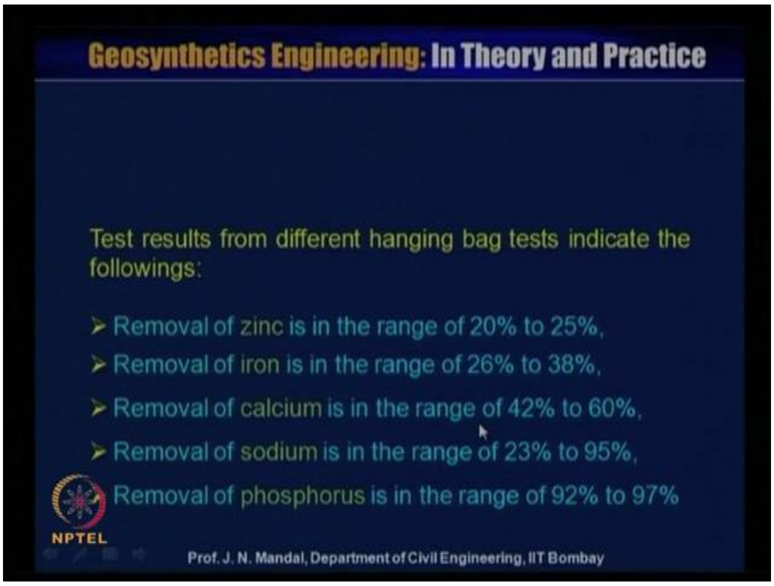

So, from the test result from different hanging bag tests indicate the following the removal of zinc is in the range of 20 to 25 percentage. Removal iron in the range of 26 to 38 percentage removal of calcium in the range of 42 percentage to 60 percentage. Removal of sodium in the range of 23 percentage to 95 percentage and removal of phosphorous is in the range of 92 to 97 percentage.

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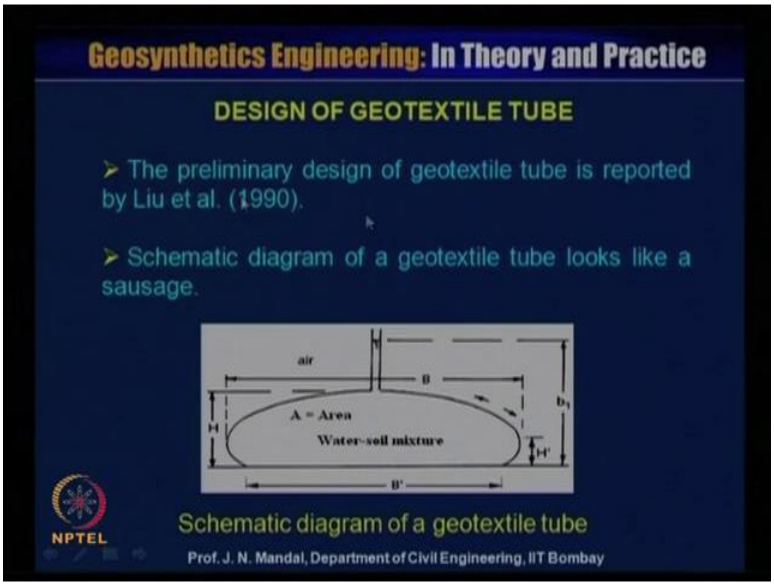

Now, this is the portion is shown the design of geotextile tube, the preliminary design of geotextile tube is reported by Liu et al 1990 and schematic diagram of geotextile tube looks like a sausage. So, this is the schematic diagram you can see that this is the area of the weighted soil mixture and this is the white that this is the slurry is pour into this.

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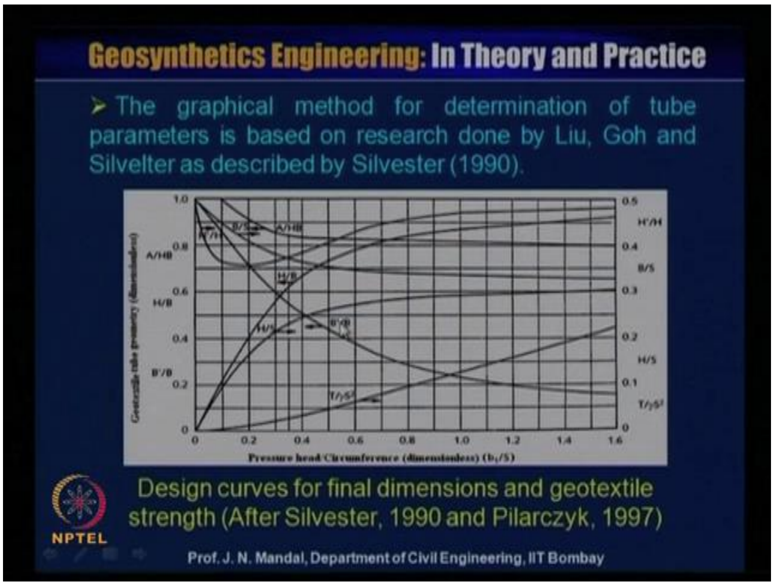

So, from this you can establish this design curve for final dimension of the geotextile strength this is after Silvester 1990 and Pilarczyk 1997. So, this is a graphical method for the determination of geotextile tube parameter is based on the research done by the Liu goh and the Silvester as described by the Silvester 1990. So, in this this is the pressure head and the circumference well that is the dimensionless that is b 1 by s in the x axis and this is the geotextile tube geometry this also the dimension.

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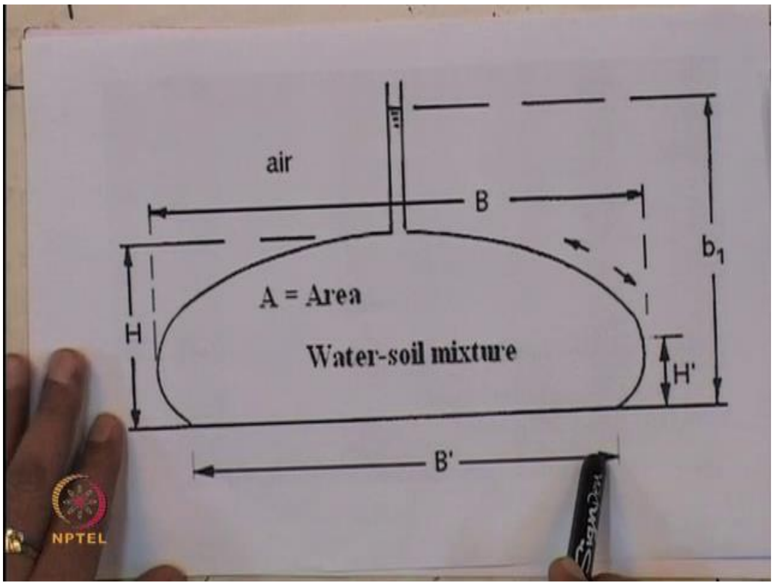

So, if it is that if this is A like A surface type this is water soil mixture this is and this distance is equal to B dash because what you see in the elliptical form when you will apply load, it will be in the sausage like this. So, this portion is B dash and the initial it was A B and from here to here this is the b 1 and this is the H of dash and this is this height is equal to H, so in this also this graph which I am also showing here.

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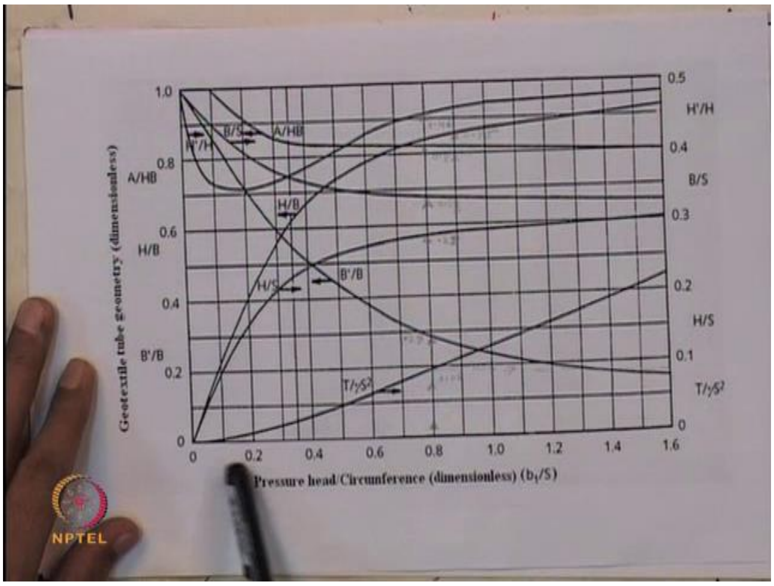

This is axis is the pressure head versus circumference that is the dimensionless that is b 1 by s, that means this is the this is the b 1 by s. So, that is slurry and this the portion geotextile tube geometry that is also dimensionless and this is the area this I should showed what is H and what is B which you can also see that this is the H and this is the B. So, you can have the A by H B, you can have H by B, you can have B dash by B that B dash means this is B dash, this is B dash and this is B. So, B dash by B, so all this arrow are showing this curve for B dash by B this curve shown H by B, this curve show A by H B.

On the other hand, this arrow indicates this is the curve, this is the curve. So, this side also may be H dash by H B by S H by S and also you can have T by gamma S square. So, this indicate this is T by gamma S square in this, this curve then that means you have to use this curve on this direction and this is the curve B by S means you have to take the data on this direction whereas, H dash by H dash curve is like this. That means you have to select the data from this side H dash by H and if it is A H by B you have to select the data on this side that means this is the curve. Similarly, if you want to select B by B dash curve then you have to select the data from this side, if you this is the H by S curve if you want to select the data H by H on the this side.

Similarly, T by gamma S square, so this is the curve, so you have to select the data from this type. So, this design chart is very helpful, so I think that you should follow that how you can, you can take this different value for the design of the geotextile tube.

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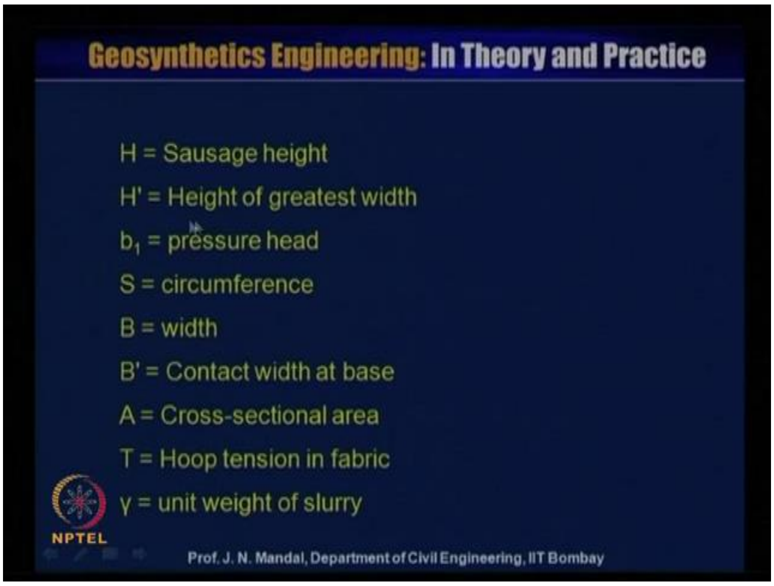

I will show you here that I say that H is equal to that sausage height H dash is equal to height of the greatest width and b 1 is the pressure head. S is equal to circumference, B is equal to width, B dash is equal to contact width at the base A cross sectional area T hoop tension in the fabric and gamma unit weight of the slurry.

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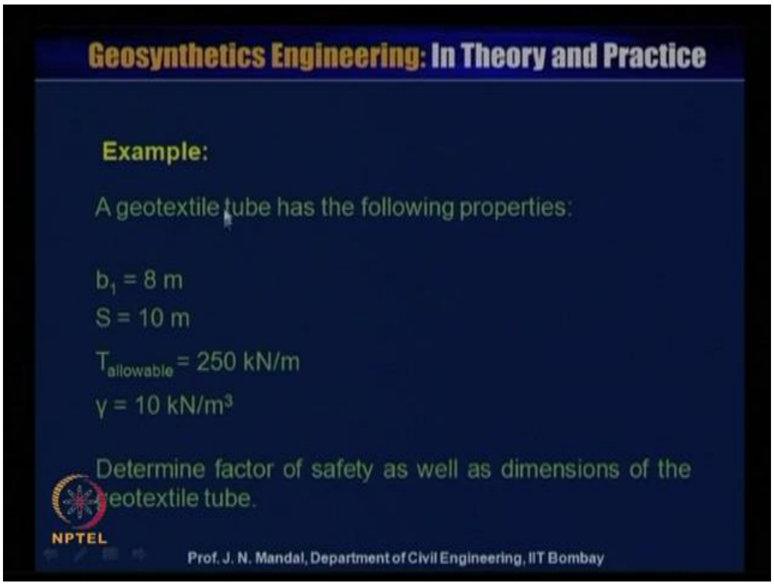

So, this is one small example a geotextile tube has the following property b 1 is 8 meter and S is 10 meter and T allowable is given 250 kilo Newton per meter, gamma 10 kilo Newton per meter cube. So, determine the factor of safety as well as the dimension of the geotextile tube.

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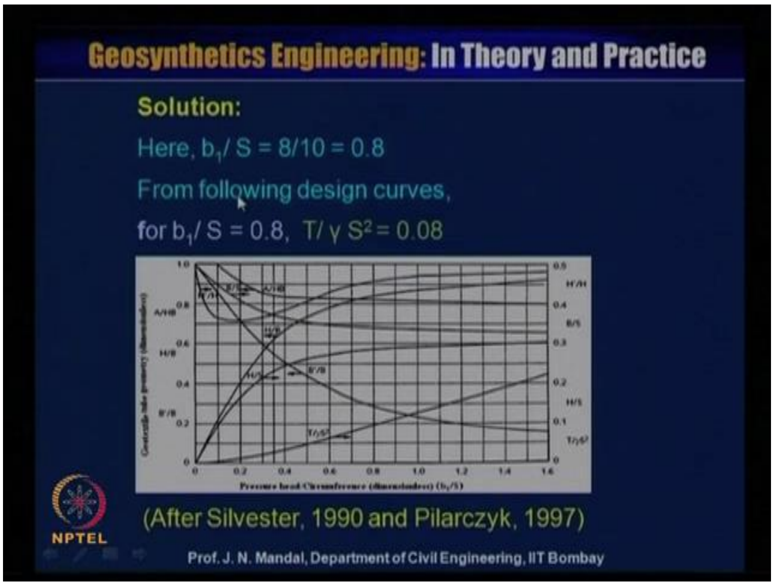

So, here is the solution, when b 1 by S you know b 1 is 8 S is 10, so 8 by 10 0.8. So, from the following design curve, so we can see that for b 1 by S is 0.8 you can see that this is b 1 by S and b 1 by S is 0.8 when it is 0.8 and you require T by gamma S this is the curve. So, when b 1 is this 0.8 and this is the curve T by gamma s, so T Y by gamma S you can move in the horizontally. So, you can have this value T by gamma S is equal to 0.08. So, you will have 0.08, so here also shown that T by gamma S square is equal to 0.08.

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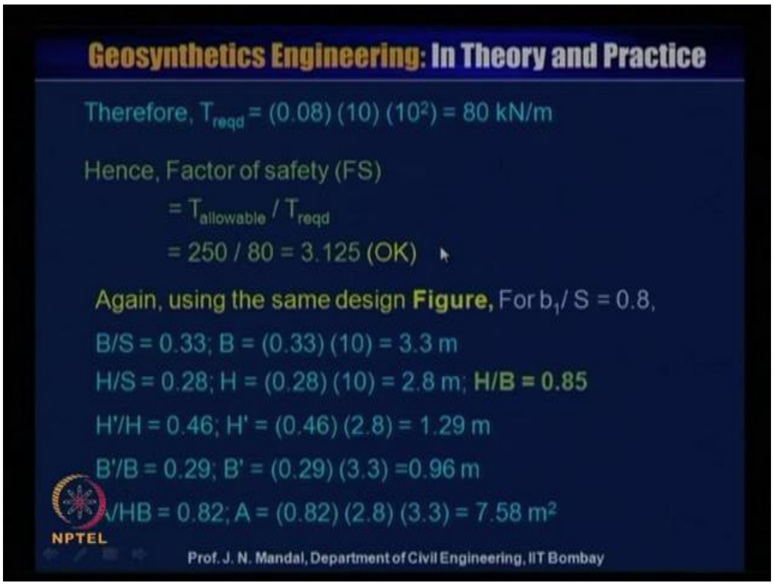

Similarly, that means T required will be you know that this is gamma 10 and this also S also is the 10. So, this is 10 square that means this will give 80 kilo Newton per meter, so T required geotextile strength required 8 kilo Newton per meter. Hence, factor of safety will be equal to T allowable by T required that mean 250 that is T allowable is given this divided by T required 80 that means 3.125 is again using the same design figure for b 1 by S when 0.8. So, you can calculate b 1 by S is 0.8 for example, B by S is S 0.33, so b 1 by S is 0.8 and because I show you that suppose this is 0.8, b 1 by S, so this curve b 1 by S, so this is B by S that means this curve, so B by S in this direction. So, this will give you about that 0.33, 0.33.

So, B will be equal to 0.33 into 10 that means 3.3 again H by S, so this is for 0.8. So, H by S will be this direction, H by H is equal to 0.28 somewhere here, so H will be equal to 0.28 into 10 that mean 2.8 meter again H by B. You can see here that H by B in this direction, so this is 0.8 H by B in this direction that means this will give about 0.85 H dash by H. So, H dash by H is this, so H dash by H is we can move here. So, you can have 0.46 that mean H dash will be 0.46 into H is 2.8 that will be 1.29 meter again B dash by B in this direction.

So, B dash by B in this direction here, so B dash by B will be equal to equal to 0.29, so B dash will be 0.29 into 3.2 then 0.96 again that A by H B. So, A by H B will be equal to

0.82 here, so 0.82 here, so this will be A will be equal to 0.82 into H is 2.8 into 3.3, it will give 7.58 meter square, so you are having this all this value.

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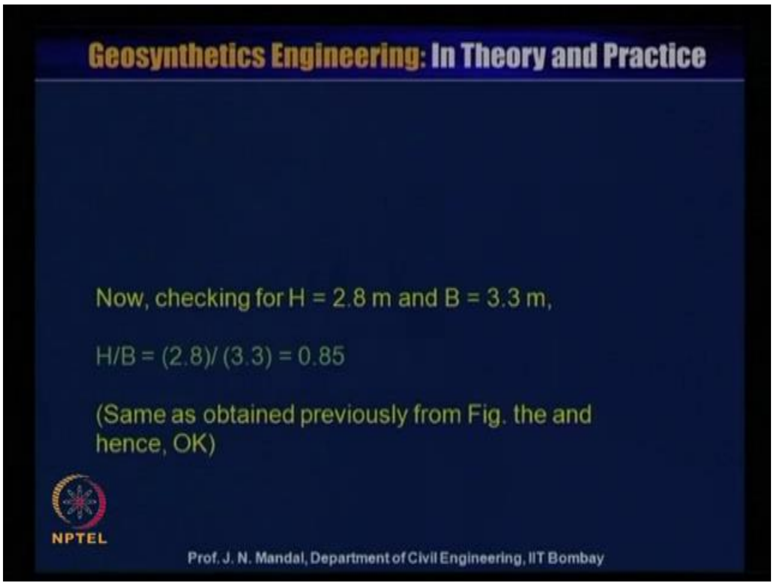

Ultimately, you have to check for A H is equal to 2.8 and B is equal to 3.3 meter and what you are obtaining from this curve. So, you can see from this earlier this that what is H by B you can have 0.85, H is 2.8 and you can H is 2.8 and B this is this is the B you can have this is B is equal to 3.3. So, you can see H by B 2.8 by 3.3 which will give 0.85 that means from you can also check that H by B will give you that value of 8.5 here. So, we can have that H by B value that means this is 0.85 and this is the H B by B curve, so this will give also that 0.85. So, same result you can obtain previously from the figure.

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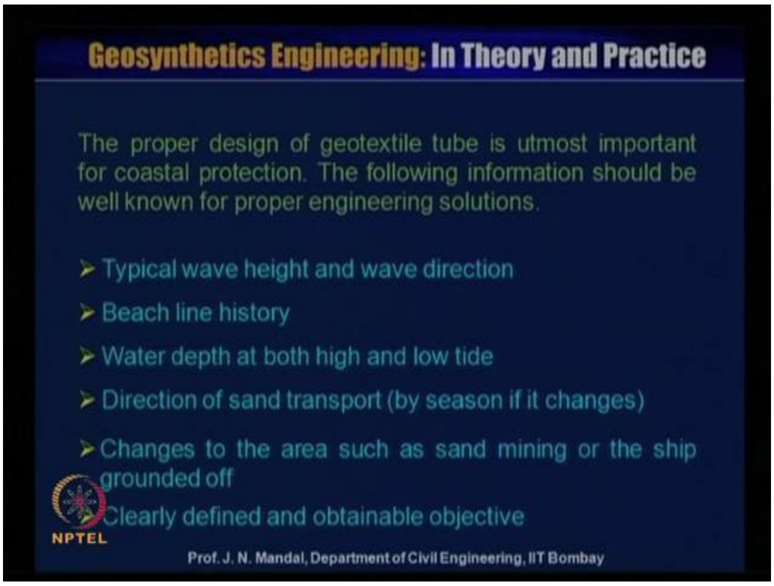

Now, the proposed design geotextile tube is utmost important for coastal protection, the following information should be well known for proper engineering solution typical wave height and the wave direction and beach line history is very important. Otherwise some structure also fail and water depth at both high and the low tide and the direction of the sand transport that is by season.

If it is changes and changes to the area, such as sand mining or the ship grounded off clearly defined and obtainable objective. So, one has to be taken care for the proper use of the geotextile tube for dewatering for the fine grained soil. This is also very hot area and this is a cutting edge research topic and many unknown like that what will be the fate of pollution in case of the hazardous material.

Then what will be the microorganism in case of the bio solid and decontamination with the geotextile tube can occur, if the proper additive are including during the filling of the geotextile tube. So, this is very important, one should go for the minimum three geotextile tube test to select the proper kind of the geotextile material for the proposed project. With this I finish my lecture today, please let us hear from you any question.

Thanks for listening.