Geosynthetics and Reinforced Soil Structures
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Lecture - 39
Case Study of the Construction of Airport Runway at Pakyong, Sikkim Using Geosynthetics

A very good morning students. Today's lecture will be given by Mr Ashish Gharpure, he is the chief operating officer from Maccaferri India, he will be talking to you on the construction of the airport at Gangtok, Sikkim. So, just from my understanding, these are Master students or B. Tech students and basic familiarity with reinforce soil. Even from technical or theoretical point of view, how we came up to design this kind of structure in India, which is unique in sound fashion.

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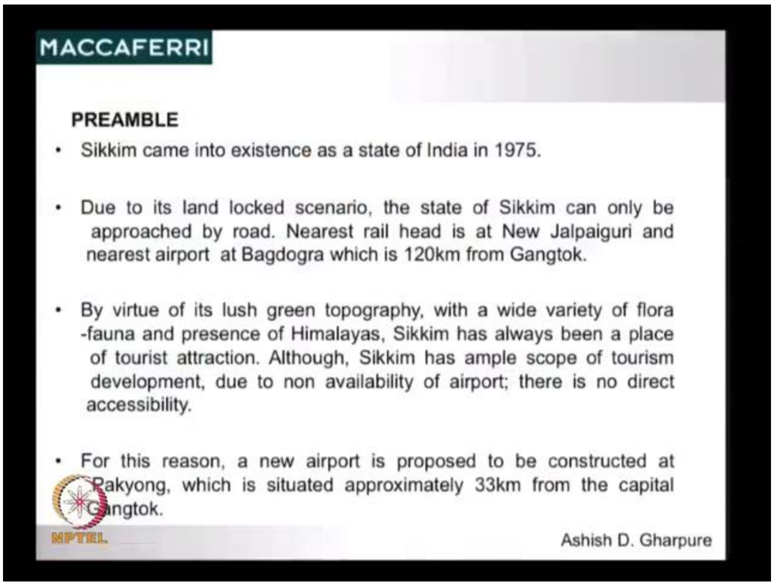

So, just to give a little background this project is in Sikkim, it is actually very late when Sikkim got into India. It was not from the beginning, from 1947 when we got our freedom. So, Sikkim became a part of India only in 1975 and very unique again feature of Sikkim is that probably only state which is surrounded by three different countries apart from India, so one side is Nepal, other side is China and the third side is Bhutan.

I will show you in the pictures also, there is no direct access to Sikkim, we had to go through West Bengal Jalpuguri or Bagdodra area and you get there very beautiful countryside and lot of potential for tourism. Hence, government decided to put a new airport in the area, this is the location of Sikkim.

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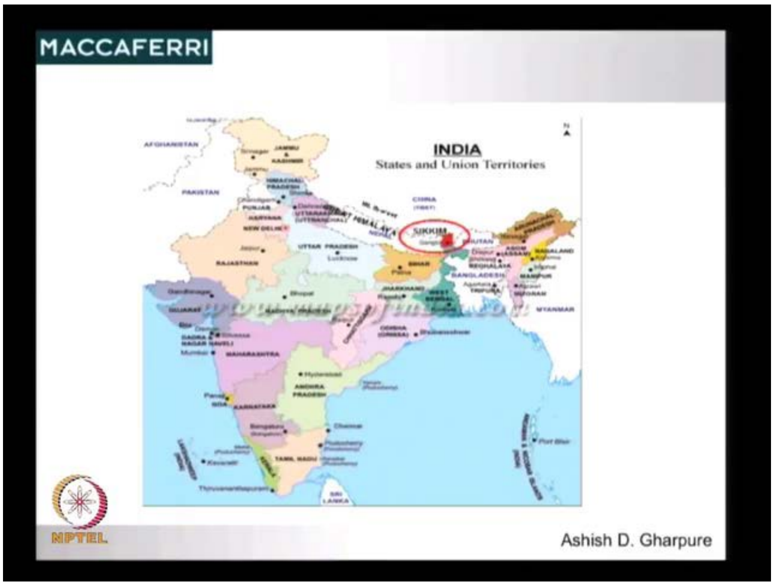

See, if you can see the point if at all you have it, so if you can see that red dot there, so it is surrounded by Nepal, China and Bhutan.

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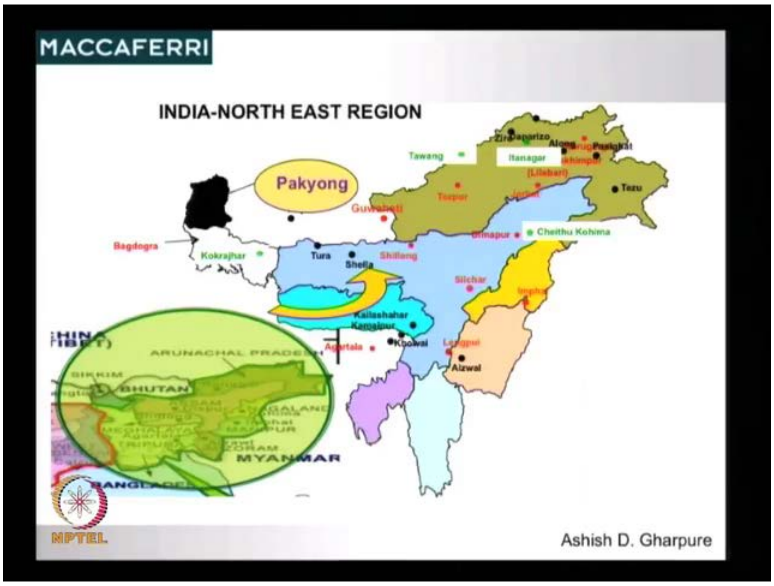

This is the detail.

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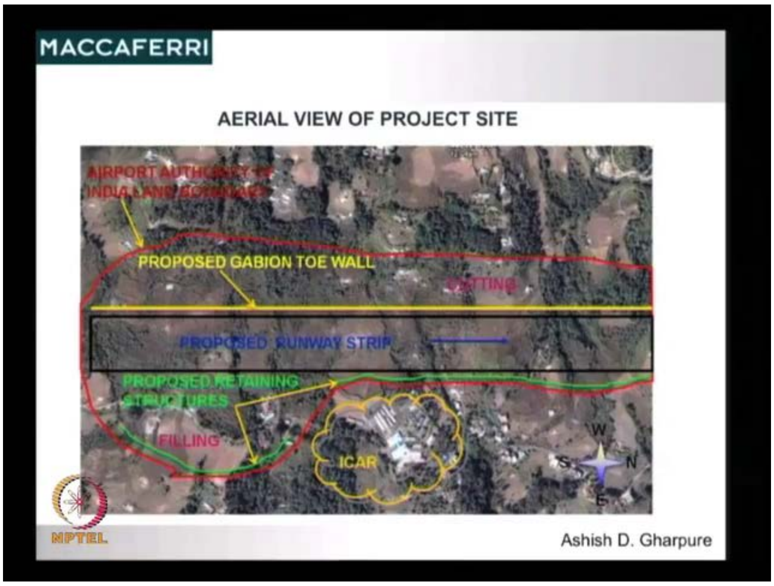

There is no access, but through this small portion of West Bengal and this is what is proposed as an airstrip into the region, since it is completely hilly region, and for airport, you actually require lot of flat land. It was difficult right from conceptual stage to build airport in the region and if you see the location, it is completely hilly location. From top to bottom, it is more like, this side is hilly area and slopes down like that and then they decided to put a strip in this direction.

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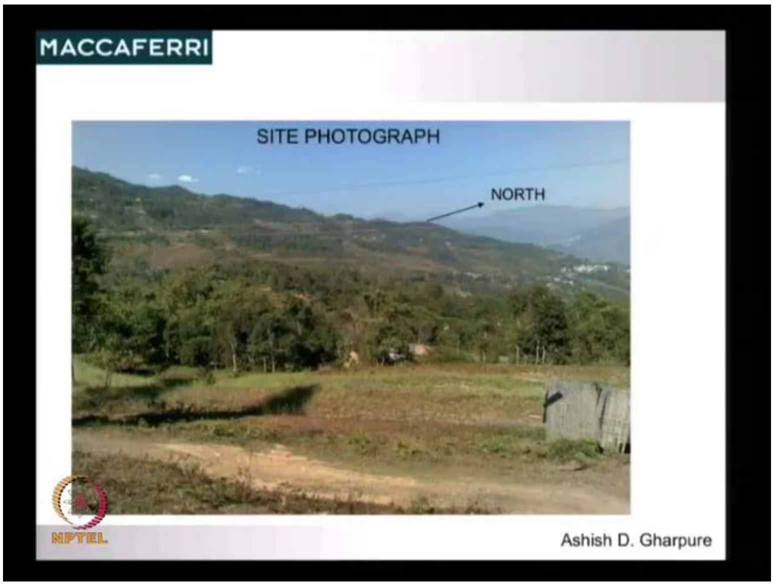

So, just a physical photograph, we closed from the lights, so that or because understand. So, this is the hill and this is the direction of the airport strip, airstrip actually, so runway is in that direction.

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See the contour, I mean just seeing and looking at these contours and terrain, you would not be able to believe that an airstrip can come in this location, which requires a flatter land.

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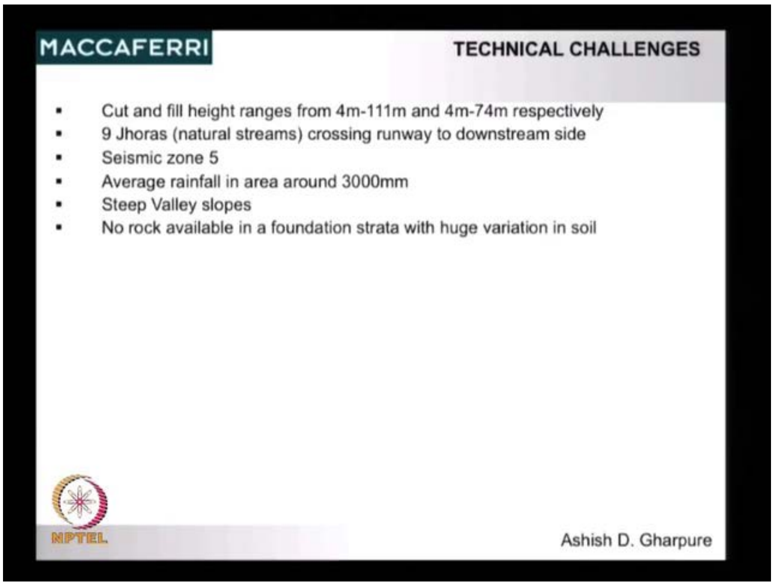

So, what were the technical challenges in this project is, the cut and fill height ranges from 4 meters to 111 meters of cut and fill side 4 meter to 74 meter. There were 9 Jhoras, Jhora is a local term for a natural stream, so 9 of these natural streams crossing the runway from uphill to downhill. This is in seismic zone 5, so highest seismic zone in the country.

The average rainfall in the area is 300 millimeters, 3 meter, I am sorry 3000 millimeter, three meters of rainfall every year and very steep valley slopes and no rock available in foundation strata. This is completely soil hill, you may get some weathered rock if you dig deep, but again it is a very local like saying, there is no parent rock available in the area. So, if at all you look at that, the first thing comes in mind are, do we have risk in this? It is just a joke to put up that we have to do the risk analysis first to even build or think about whether we can build this kind of thing?

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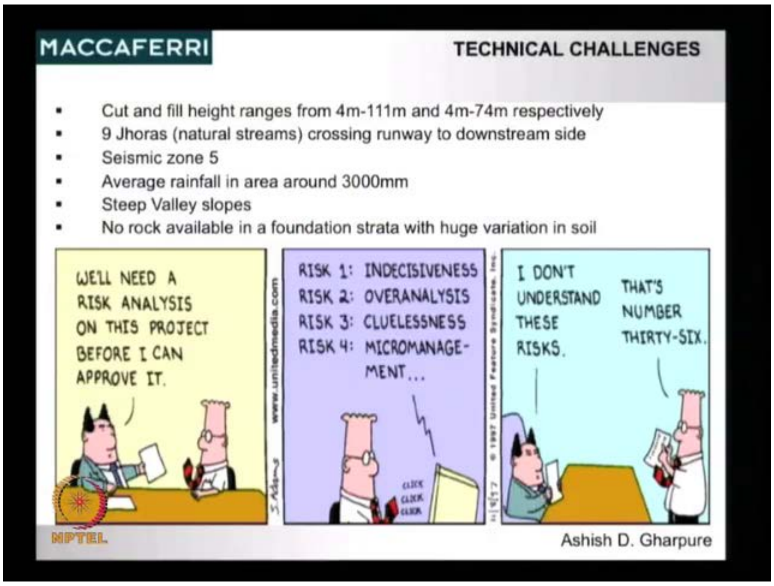

So, what kind of risk and obliviously this is a joke, but in the size of nest over analysis cluelessness or micromanagement, what kind of risk we can get in and the decision maker replies I do not understand the these risk. Again, we are listing that is number 36 in the list. So, there is lot of uncertainty what I am trying to convey here, lot of uncertainty we did not even know what kind of risk we are getting into by designing this kind of structure. Anyway, we went ahead and took that decision, so the runway strip was planned in north south direction and hills actually slope is from east to west or west to east.

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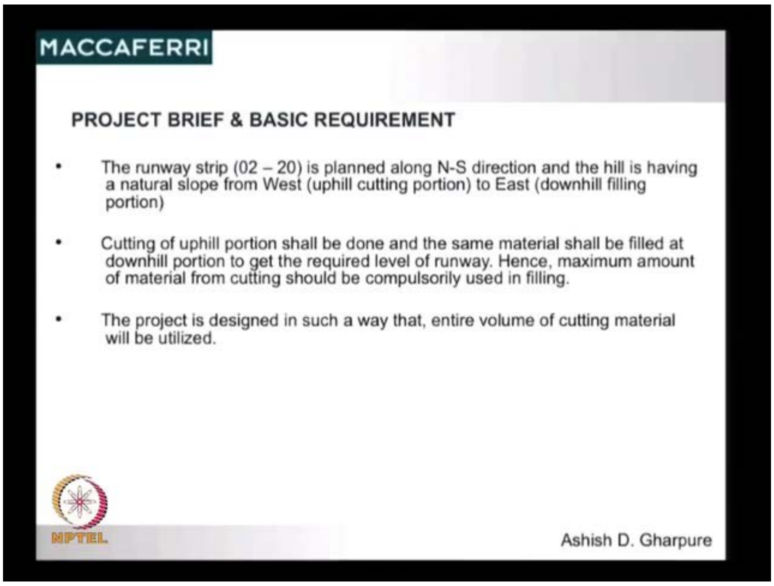

So, cutting of uphill portion will be done and then the same thing must be filled on the valley side, because that way will reduce the waste of material. We do not have to dump all the soil what we cut so that entire volume of cutting material will be utilized. So, in fact, the levels were set accordingly that the entire volume of cut will be utilized.

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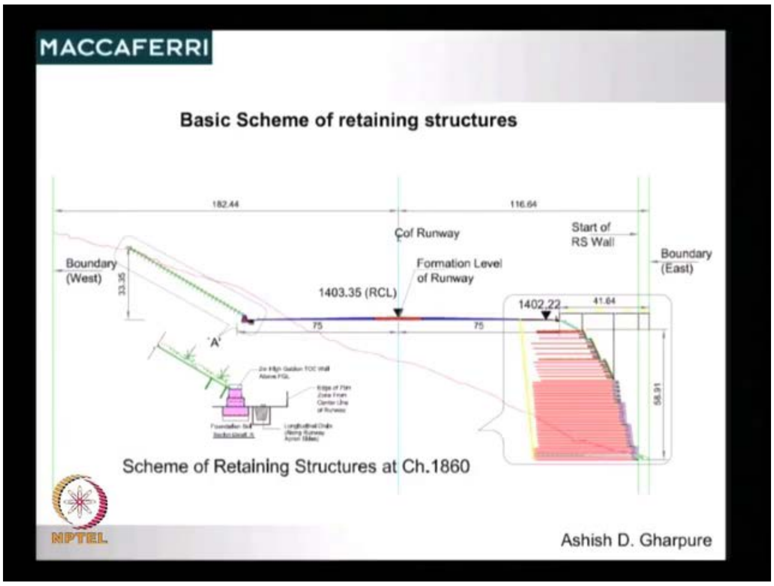

This is a conceptual sketch to start with, this red line what you see is kind of a cutline, this is a particular section, so you will not see the balance here, but so you will cut here, make the strip like that and fill this entire portion. Here, what we proposed is a reinforced soil wall and here in the cut section, this gabion to and some slope protection works.

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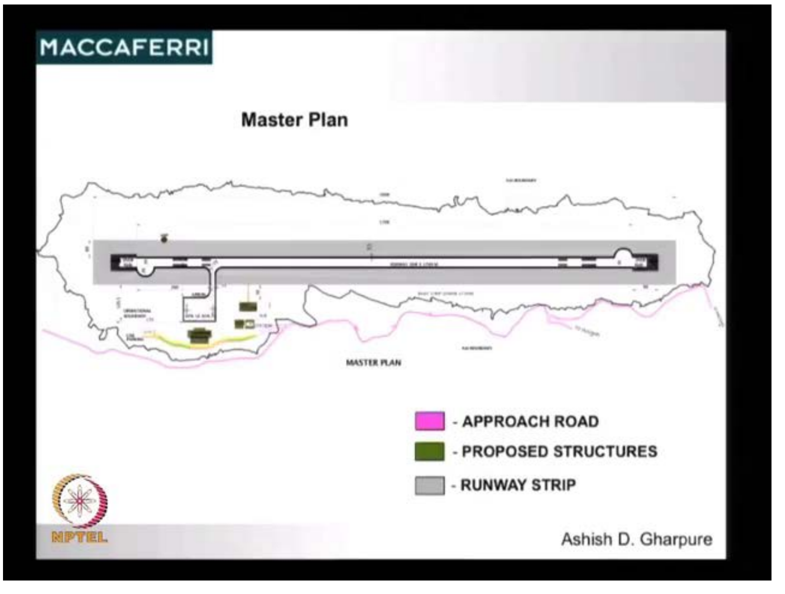

I will go to the scheme in detail later as well, so this was the master plan runway strip. The terminal building and elite structures and here what you see this is an approach road. So, this has to be maintained as well because this would have given us access to all this area. So, this has to be retained and then build a structure or flat structure in this. So, these are the proposed boundaries actually of the structures, so you had to go as per the contour. Hence, you will see the boundary was very not regular and this is the runway strip all across.

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This is what is a proposed terminal will look like, a small terminal I think 80 of 65, 65 seater ATR will land in this, because we could not go for a full size runway had to see this.

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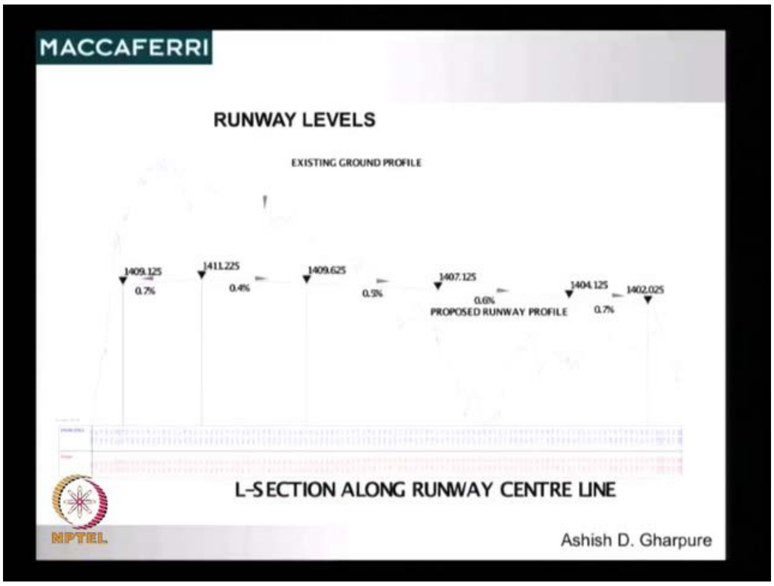

It is hard to see there actually is a complete cross section shown here, where it is difficult to see in here, so, anyway the cut and fill were balanced.

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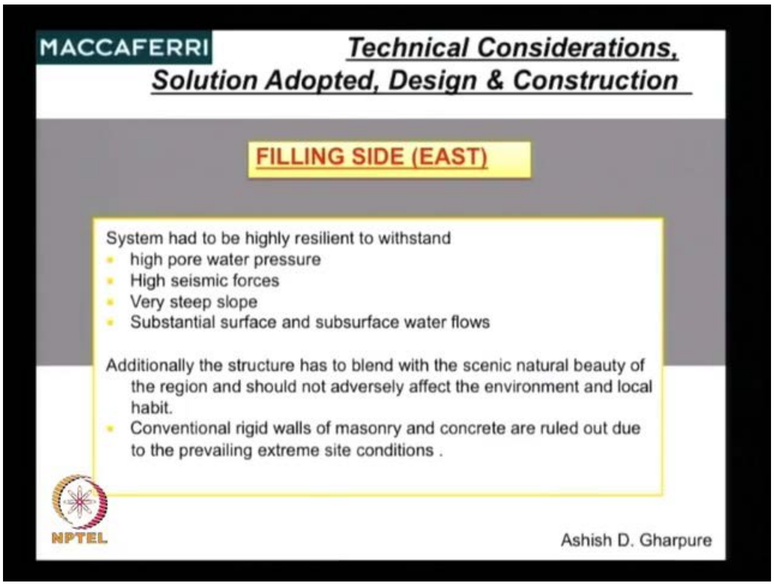

So, this is the filling side, what were the technical considerations and solutions adopted, so filling side we had these issues with we had to deal with. There could be high pore water pressure, very high seismic force, very steep slopes and very substantial surface and subsurface flow.

In fact, just to let you know whenever you do construction whether it is a highway or anything in hilly area, you know we always say three things you had to take off and these three things are drainage, drainage and drainage. If you take care of drainage, your 90 nine percent issues are solved. Structure is a supporting thing, but the basic thing at the back of your mind should be drainage, how to give the water outlet. If water is not released properly, you will have problems in all types of structures. So, keep that in mind you know, whenever you go into design in hilly areas, drainage is the most important thing I will hammer that point probably couple of times in this presentation.

So, anyway apart from that, the structure has to blend with the natural scenic beauty also. You cannot make an eye source structure in such a beautiful countryside where everything is green. The only location where you do not see green is a man made structure, otherwise this countryside is completely green. We wanted that merging to the environment should happen and conventional rigid walls and concrete.

I mean one thing that not only that they do not merge with the surrounding, but they are eyesore, I mean ascetic wise there are not good and plus they are rigid. So, in this kind of country, where you are building a structure of 78,80 meter, you expect lot of settlement and if you build a rigid structure on top of that soil, then you expect lot of cracks and plus the cost is always a concern.

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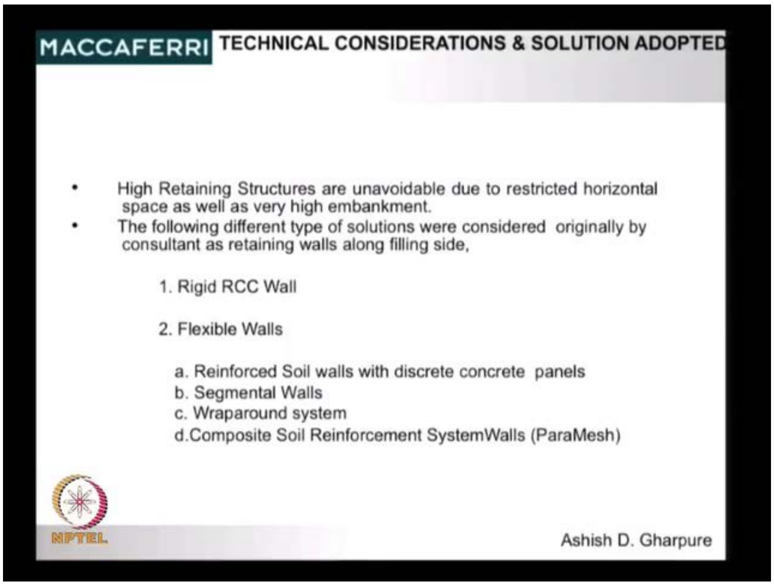

So, while going through the design in process we did consider it, but the more trust was given for flexible walls. So, we did consider reinforced soil wall with discrete concrete panels segmental walls wraparound system or a composite soil reinforcement system, we call it Paramesh.

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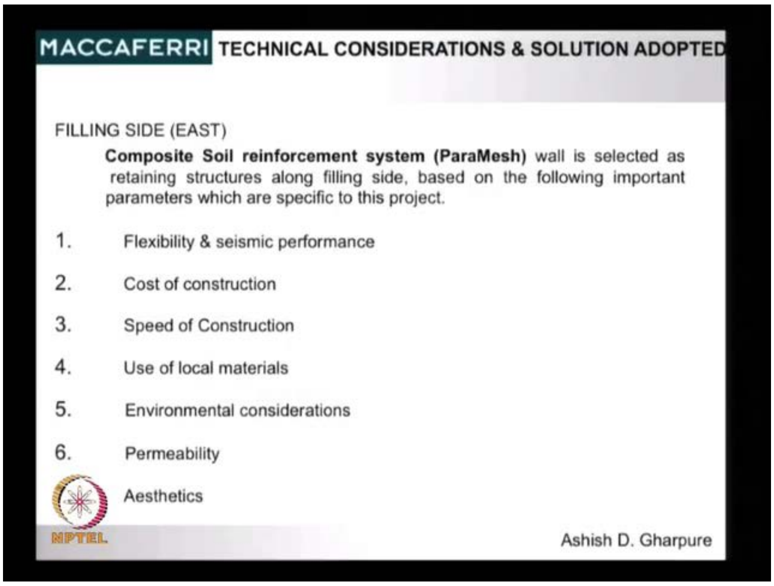

Eventually, we decided to go with the last option which was paralink. These are the reasons one is that it is flexible and its seismic performance is very good any instantaneous load this polymeric materials are good. Creep sustained load they have creep issues, but instantaneous load like seismic effects are in loads. There are very good the cost of construction you would not believe, but original proposal was 1,300 crores which were brought down to 300 crores. With this structure, this 1,300 crore because originally they taught about r c c wall, I do not, but who taught to me it is a non starter right at the beginning. It will take me one minute to a discard that kind of structure.

Speed of construction was very rapid, you do not had to wait. You know concrete structure, you had to build then wait for strength to gain and then you go for next layer and so on. So, speed of construction was parallel as you are building the wall you are filling at the back everything is going parallel, so you there is no practical practically no waiting in time.

Use of local materials as we mentioned, entire fill was through the cut area material, so we use lot of local materials and cut area materials also included boulders. So, we depending on the quantity, we were getting from the cut side we filled the gabions into a gab ,sorry the strong cetirol gabion wall and built that also the stones were not available in high quantities. Hence, we did not go for any bulky structure or anything it is just a facia.

Environmental consideration, this type of structure what I am going to show next, you will see that these are green structures that you can grow actually vegetation into the structure. Unlike in a concrete wall or rigid walls were the roots of vegetation can actually crack the structure or widen the cracks here. They further reinforce the structure if the vegetation is there it will just grip all the stones or the soil behind it and increase in strength permeability again going back to the same point drainage is the main aspect. So, entire facia we made it draining, so there is no construction which is blocking the water from flowing out. Then attics it was a green and very nice looking structure in couple of next slides you will see

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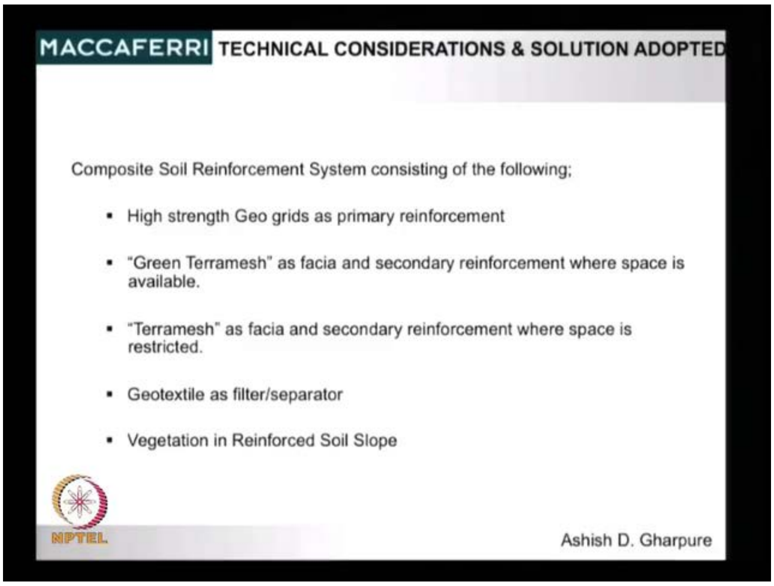

So, what we used is a very high strength geogrid and again that everything was selected as per the need. Why very high strength, because when you are cutting there is lot of issues with what should be the size to fill at the back, they maybe boulders coming which are bigger in size. Now, if you have your reinforcement placed very closely these boulders may influence the function of a geogrids. So, we wanted to place the geogrids at very high spacing, if you go for higher spacing, you need higher strength material.

Hence, we used a very high strength material and we went even up to two meter of spacing and there is a way to do it. Obviously, of facia has to be retained and I will come to that in a while. Then we used green terramesh as facia again for the green look that we wanted at the outer surface and we also use these facias, whether green terramesh or terramesh.

Terramesh is with a gabion facia and green terramesh is completely green facia and both had a tail attached to it, which we call secondary reinforcement. This is just to retain the facia then we use geotextiles as a filter and separator, obviously with lot of flow taking place through the structure. The major concern was soil particles should not migrate along with the flow and then you will have a subsidence. So, lot of use of geotextile is to protect any migration of a soil particle then vegetation in reinforce soil slope some deliberate plantation were made.

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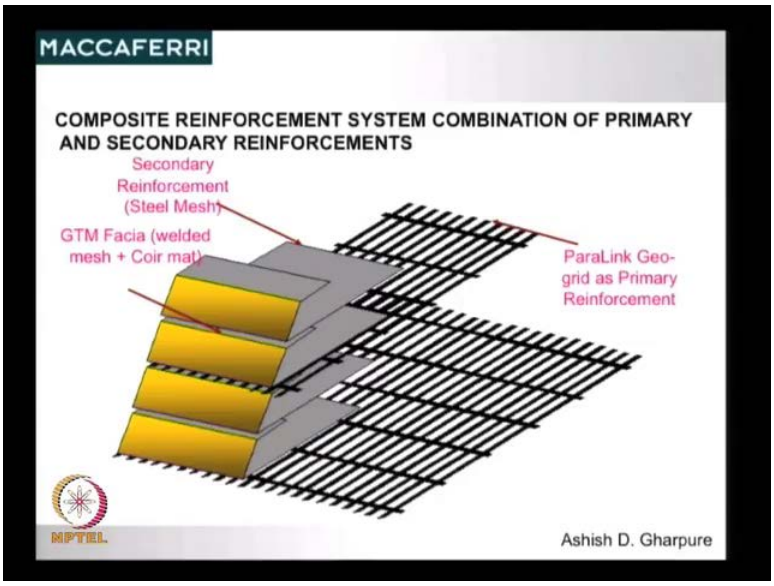

So, this is the green terramesh structure I was talking about, so these are the units which are we call it secondary reinforcement. We call it steel mesh and the facia is the green facia wielded mesh with coir mat, this coir is preceded or you can do hydro ceding later also, and then it grows green. It will be in touch with the soil behind, so immediate contact of soil. So, these were and this is the very high strength geogridthe particular grid is called paralink.

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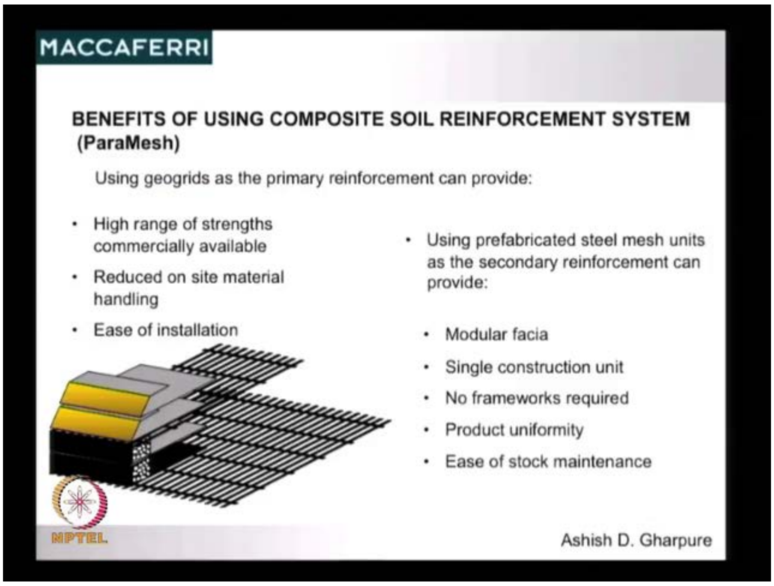

Then we also talked about using gabion facias this is the gabion facia unit and here also the tails are attached, these are the primary, the secondary reinforcement. So, again high range of strengths is commercially available and this reduces the handling at site as well, so by placing it at 2 meter distance. If you place it every say couple of inches as then you have to roll out every 6 inch, every one foot or something this material lot of handling. So, if you use very high strength material the handling reduces and remember we are talking about 70 meter high structure. So, even the length of this reinforcement was approximately 50, 60 meters, so you are rolling 50, 60 meter every foot is not a practical solutions.

So, another consideration for very high strength geogrid and it was easy to install I mean you just roll it out. It has its own self weight, it will not bend, and it will not have a memory to roll back or something. So, it was very easy to roll out there are a couple of materials in polymeric materials range where this kind of geogrids have memory. Memory in the sense, when you try to roll out or you try to roll back, so very difficult to handle.

So, again selection criteria was the geogrid should be such that once you roll out, you do not have to mess around with it and just to keep it down and the self weight and unrolling properties were considered. Then this facia has modular type of units, so it was 2 meter wide only and this length is around 3 meter. So, there is a modular you just pickup and keep placing side by side and keep connecting them, so then this reinforcement secondary reinforcement is a continuous from the facia. So, practically there is no joint here or here it is monolithic with the facia with these kind of things, when wielded panels are used here or a gabion facia used.

You do not have to put any support structure of form work in a wrap around system, if you have studied that you need to have some support. Otherwise, it will keep on bulging and de shaping whereas, this type of structure have its own slope or vertical faces, so you do not have to put any form works product uniformity from outside. It will all look same this is also a mesh, this is also a mesh and where we are using gabions that is also a mesh. So, aesthetically it will be all same from outside is of stock maintenance again, it is a modular unit, so you do not have to worry which unit to put where it is all same the codes.

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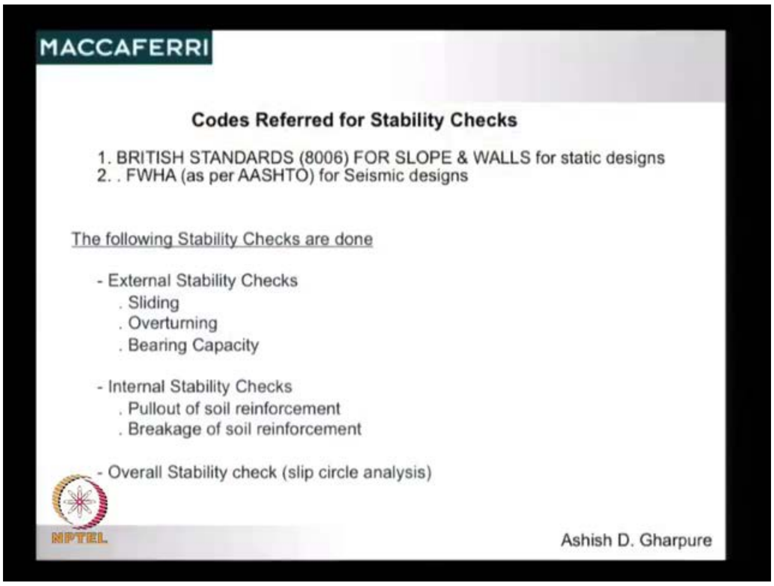

We referred is British standard 8006 for slopes and walls for static design because BS has a limitation, it does not talk much about seismic design. Hence, we went with Federal Highway or AASHTO design for seismic analysis. We checked obliviously the normal checks of any reinforce soil wall, its external stability check on sliding overturning and bearing capacity internal stability checks on pullout of soil reinforcement and breakage of soil reinforcement.

Then we also did in overall stability check again this also becomes very important in hilly areas, for normal reinforce wall which are on the flat land like flyovers and all global stability is not you know that important. You still need to run the checks, but in hills it becomes extremely important that you run that. In fact, lot of our designs were guided by overall stability rather than anything else because deep circle the slip circle was pretty deep.

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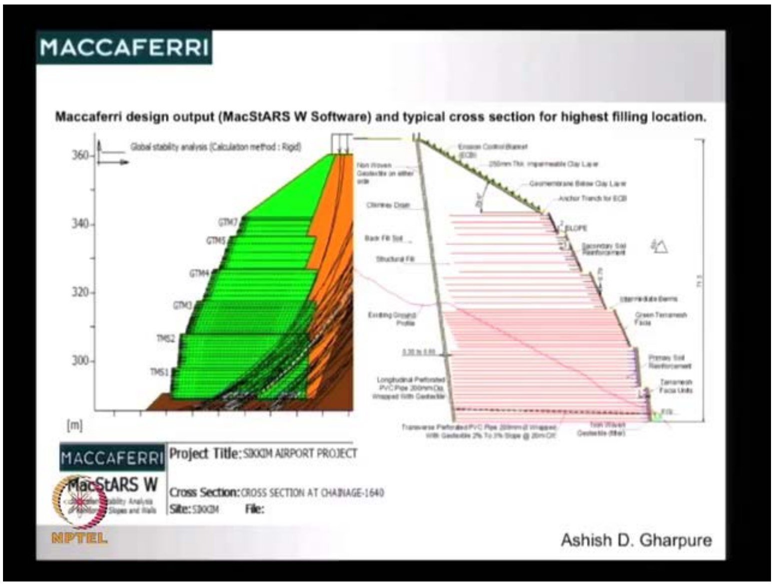

This is just to show how we ran the analysis, so this was modeled in software called Macstars, its Maccaferri's internal software. Maccaferri's stability analysis of reinforce soil that is the long form of Macstars and this is how we run slip circles, and you can go pretty deep with that you can generate thousand of circles. I still remember that during my M. Tech days, that it was only one problem was given for stroke stability analysis where we had to do it by hand and with probably four slides.

We were already exhausted doing the calculations and thank god, lots of software's today are available, and they can run thousands of slip circles very quickly. If you see you know these are the spacing and as you go on the top, we even reduce the grid further. So, at the bottom, it was approximately 0.5 to 1 meters spacing, at the top it became almost 2 meters spacing. This you can see was the line before we started excavation work when we excavated it back and then build this wall.

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So, having explained that now I will just run through couple of pictures of these areas. So, there are four different sections we identified, so we call it wall one wall two wall three wall four different chain ages.

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So, these were the initial ground conditions.

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Started cutting it, building this gridding.

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This is the initial gabion facia layers.

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This is the main reinforcement lane.

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This is the structure built.

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This is the Jhora coming out, we are yet to build at the point when we took this picture, we are yet to build a drop structure, but in couple of next slides you will see that.

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So, started building, one thing which is not clear in the sketch, but since we build this we had to protect the toe of the structure also, this was the road in front. So, we also built a toe wall to protect the toe of the main structure.

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So, it will look like this, so this is just a small gabion wall maybe foundation depth is approximately one and half meter below this. Then it was filled back so that it can protect the toe erosion, toe erosions is one of the main concerns on this type of hills the structure.

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Now, you can see when this was built, you can see the number of layers a small set offs were given when the structure was built and even each layer has just, take 1 inch of edge as you built.

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So, this is wall two, now on another location.

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Grading work here, the green terremesh structure installation.

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You can see in couple of months it started growing green.

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You can see the height of it, how high it is going.

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Rolling compaction and the vegetation started coming in 2011.

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Complete structure is now looking at this; it will look like more natural hill rather than any constructed wall.

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This is wall three.

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Again, wall under construction.

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Here, the unique thing is the bottom part is gabion aphasia and the top part is green terremesh. We expected the see the consideration for choosing, whether gabion or green terremesh was also constrains of right of race gabion. We can make more or less vertical green terremesh has to be yet around 65 degrees slope case of depending on the land availability. How much water percolation is expected because most of the water will percolate through gave here, structure here without disturbing the green derivation at the top.

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Now, the same structure, so this in this same structure this after construction. Now, you can see also gave stepped we are constructed so that whatever water comes out from all the Jhoras, where given in outlet and this was out let structure.

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It completely says, it even this look like an natural hill.

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Now, this is wall for the last area.

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Preparation of bed and you can see that what kind of risk we were taking.

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Also lot of dwelling is the areas, which have to be protected.

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If you see the construction feature that we do not build, you know complete section vertical there has to be stepped structure otherwise the difficult to control.

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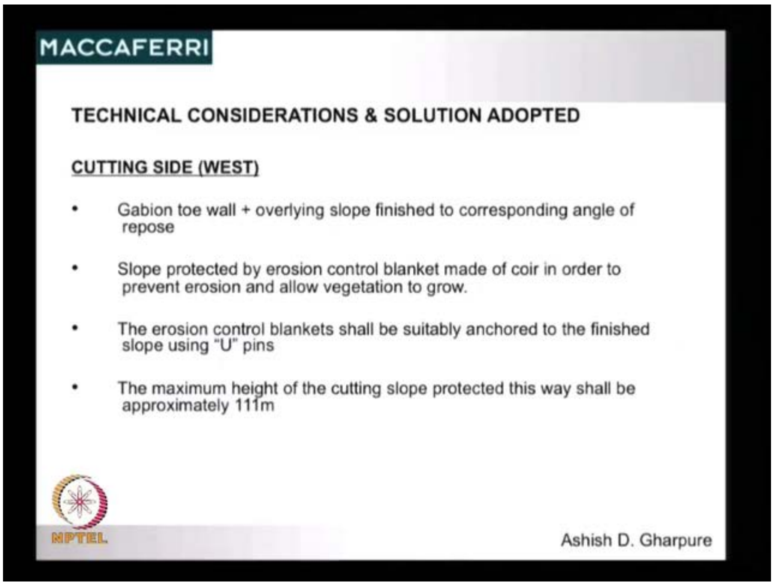

Now, on the cutting side what were the consideration and how we build a Gabion toe wall again, because drainage was very important pretoria and we covered it with an erosion control blanket made up of coir. This blankets where you, now made to hug the surface, because then only the grass grows faster in it. We used U pin which has to be hammered down so that this square matrix gets close to the surface and remains in touch with the surface soil. Maximum height of cut slopes is approximately 11 meter.

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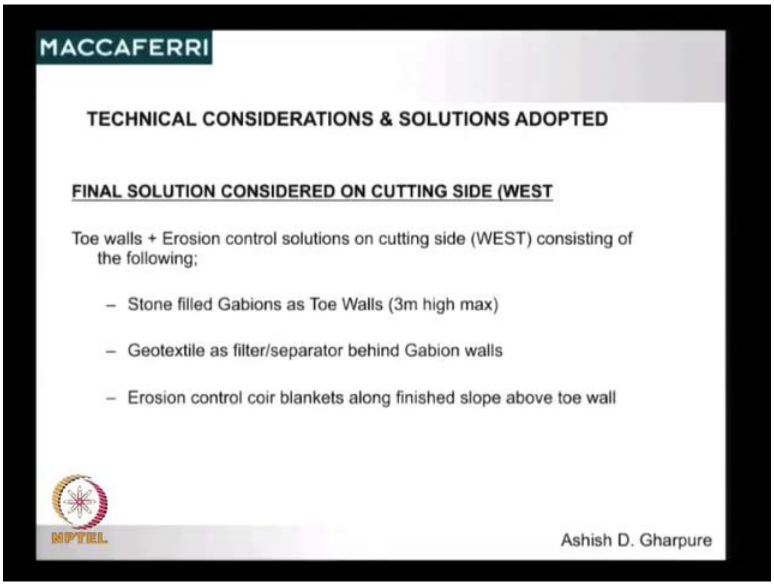

So, typical gabion toe walls were 3 meter and there is always a geotextile filter behind the gabion wall, mention to arise the soil particle migration and erosion control blankets.

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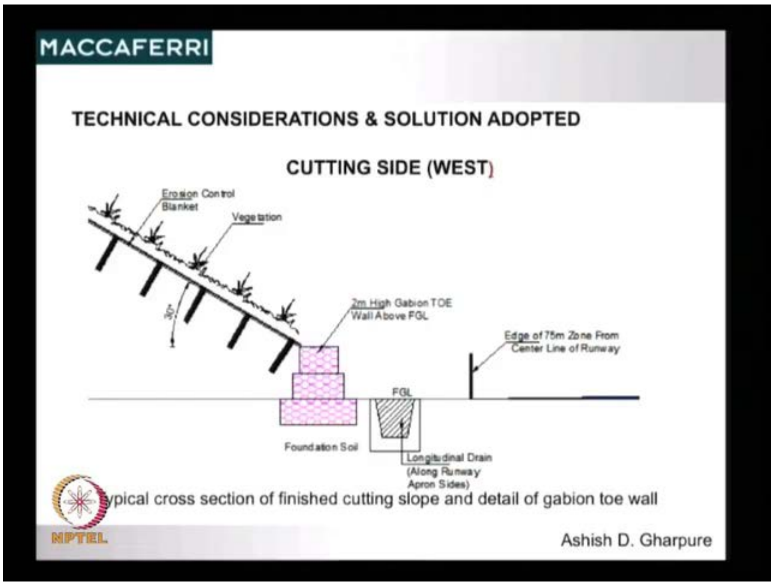

On the toe walls, it was the solution.

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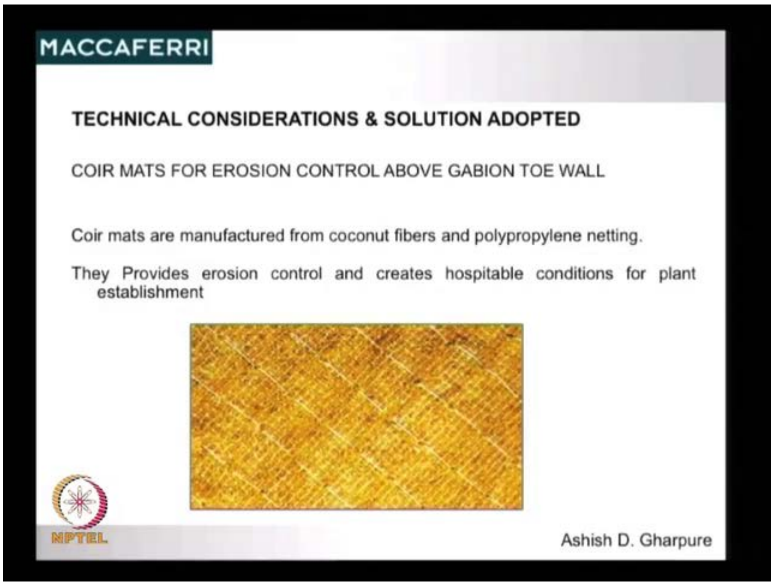

This is the coir blanket, so itsmove on withpolymeric thread also he has to give enough strength.

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This is how it is laid on the slopes.

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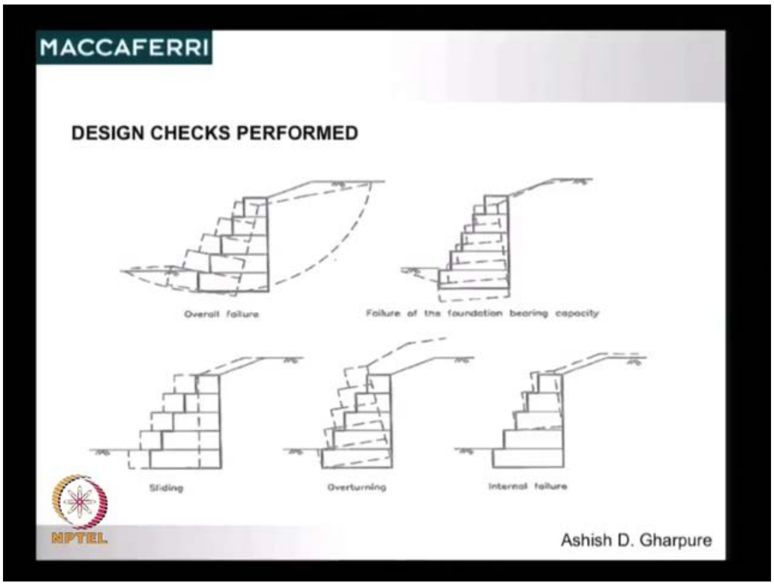

For Gabion wall, again we run similar checks as for any gravity wall in case of the check what we do is again over all failure is always a part of design, then foundation for bearing capacity sliding failures over turning failures and additional test. What we do, which you normally do not do with any other gravity wall is any internal sliding failure because there are modular structure that could be sliding failures at some inter layer as well.

So, all those test we do and coming to the third main structure design which is drainage. The entire drainage has to be planned, otherwise it will run in trouble and this is ours pet normally not learnt in during you college days or something no way. Nobody will tell you how to design for drainage, yes you do check for water pressure and you know that calculation that has to be a holistic plan in mind. How the water is going to come and how it is going to go out you have to flow along with the water to get an exit, and a safe exit I would say.

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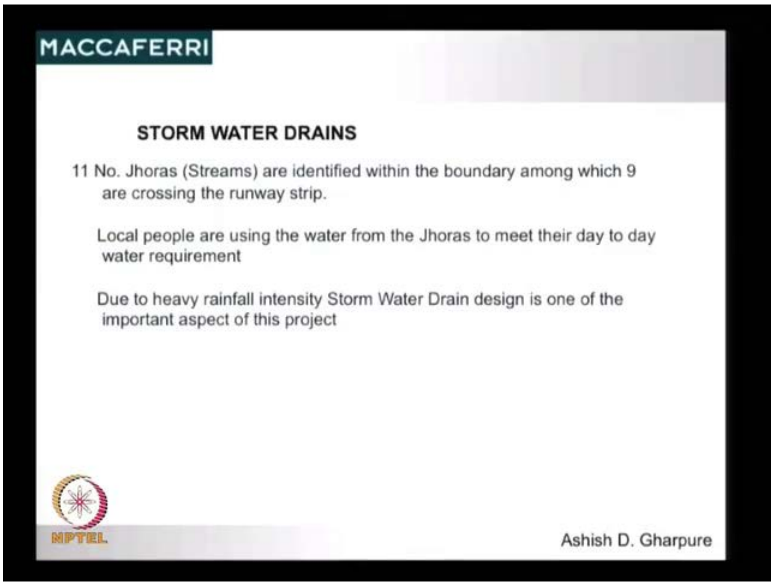

So, there were actually a total eleven Jhoras, but 9 where actually crossing the run way strip and we cannot stop and completely divert them as well reason being that people where using this Jhoras for their daily water requirements. The intensity was very strong water design, I mean it will if you try to merge it the size will become unreasonable.

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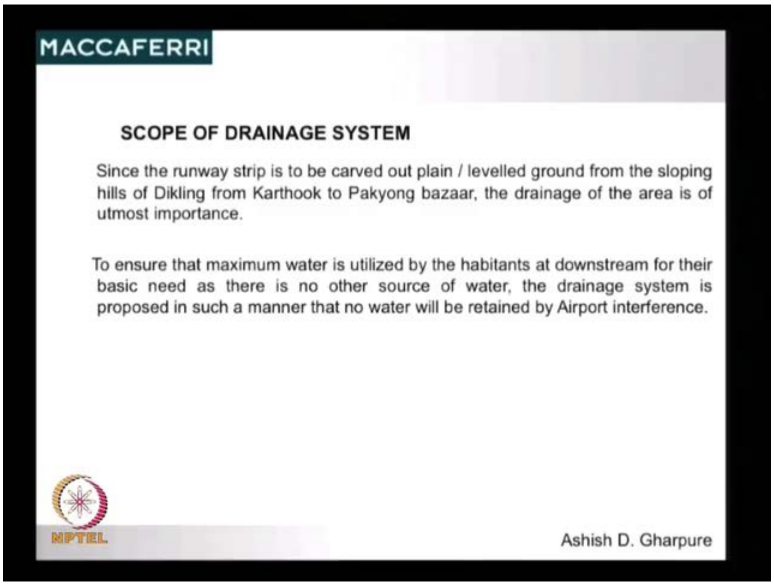

So, what we planned for that uphill people and downhill people should not get affected with whatever we plan, and hence it has to be a more plastic plan given, the areas where it was affecting the whole plan.

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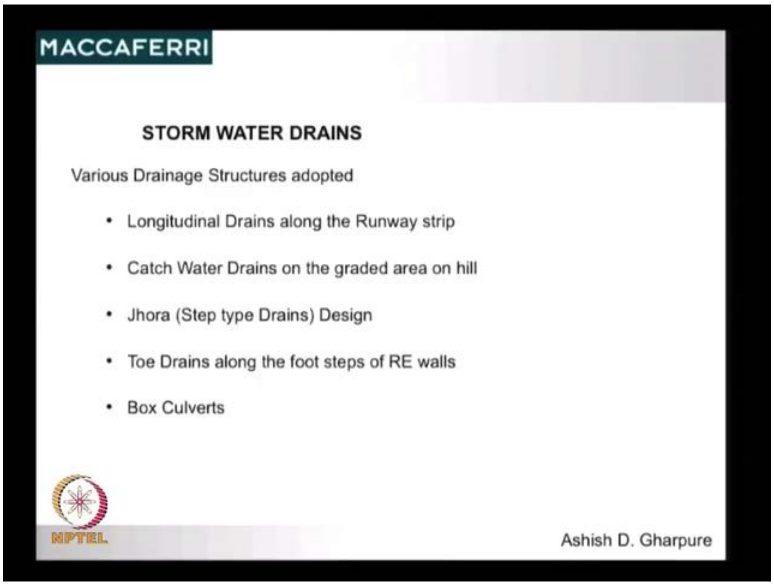

So, this drainage plan included longitudinal drains, catch water drains, Jhoras or the main stream which were coming to drains and box culverts.

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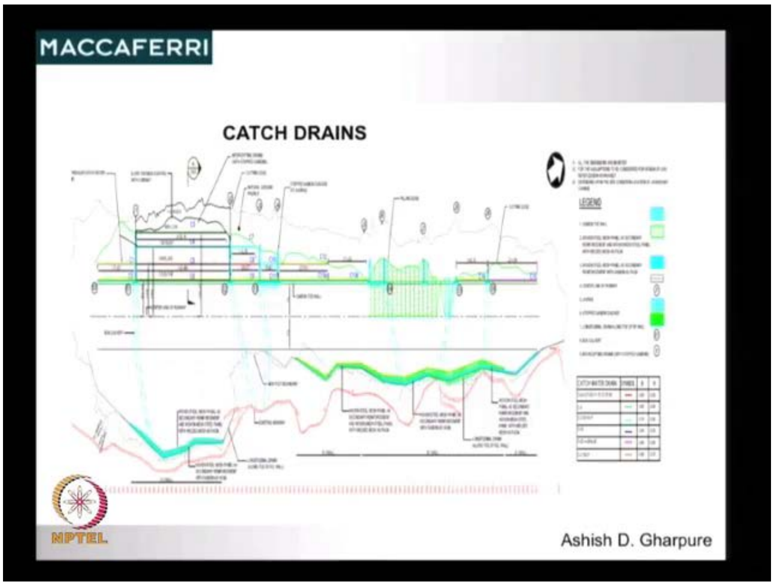

Let me show you, so again its provably hard to see the light, but these where the the blue one what you are seeing are the Jhoras which were coming into the area and the what we did is instead of nine we made it 4 you know merge couple of Jhoras together. So, we do not have to make too many structure also for drainage plan and then we crossed at 1, 2, 3 and 4 location is this small dotted line. I think it difficult to see in light, but and then as they got the out let, then we planned the complete detailed outlet structures as well.

Now, again as I said drainage plan is complete like how you will catch the water which is coming from this area not only Jhoras, I am talking even the surface run off. How will you arrest them, how will you guide them, how will you get in? So, all of these were arrested through a stepped structure taken down merge with y, a longitudinal drain and then at intermittent locations taken out from the other sides.

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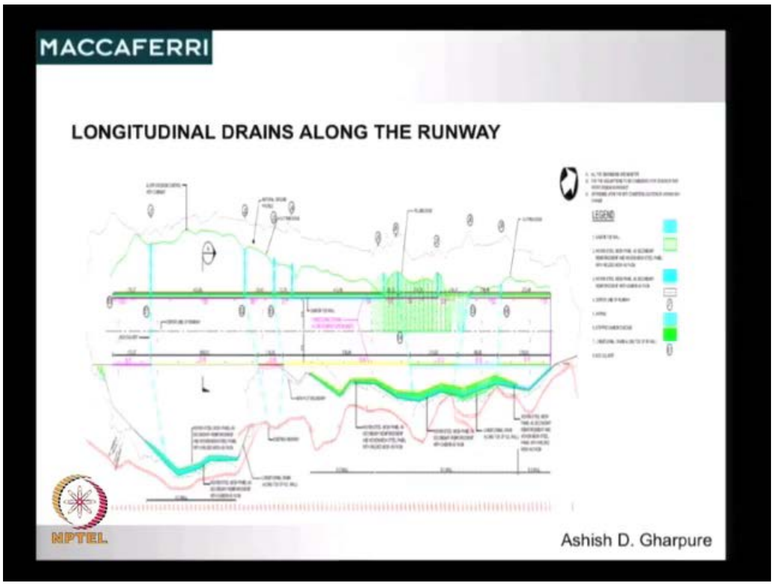

Is it any clear here, same thing.

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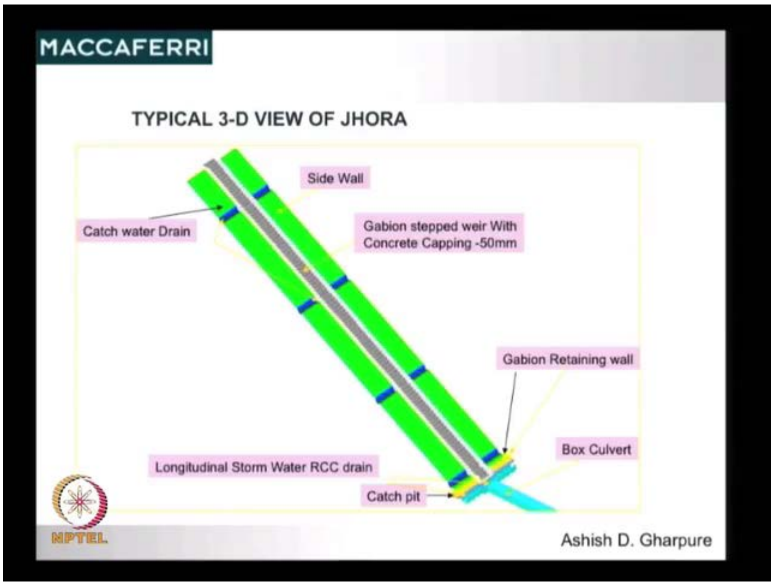

So, just a schematic, it is to the scale, so actually it is not very cleared, but I will explain it that these are the slopes and the green thing is we are assuming that after the coir matrix, it will go green. These blue things are catch water drains, so anything flowing on the slopes will get into this. It will get guided to these stepped Gabion structure, there are number of catch water drains which will come and connect to this Gabion drop structure, all this stepped here then it will get down and then there is a longitudinal drain. So, we calling it catch pit where all the water comes and then enters into these box culverts.

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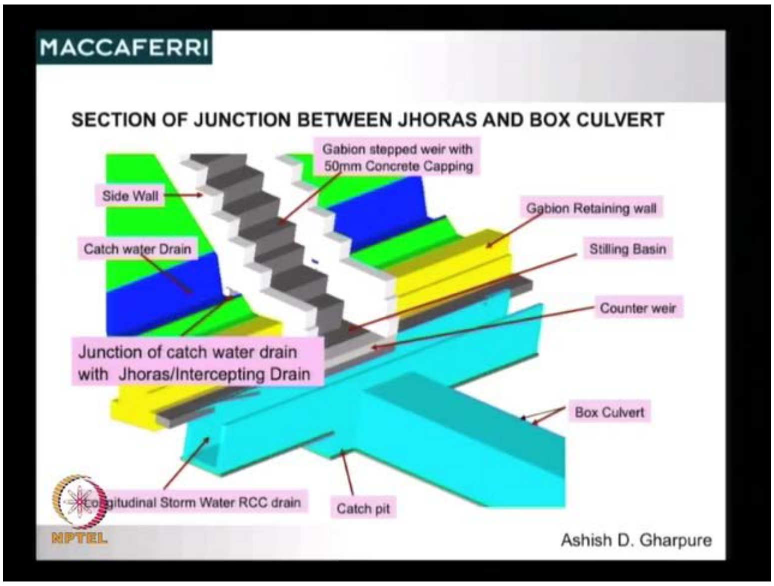

Then goes across the air strip, further details of it again the sketch is bit tried, but sorry to will come down in steps here gather in these, and come inside these box culverts and cross for the air strip.

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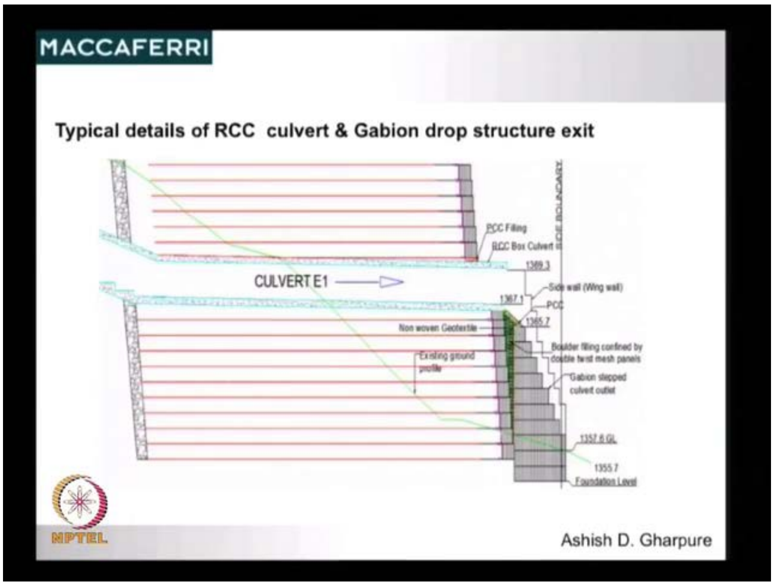

This is how it will cross and since it was crossing the entire air stripped, and there is complete wall at the other end. So, it has to cross the wall as well so again the details how the culvert E will cross the wall this will create kind of a discontinuity. It adds to the strength of the structure because any slip circle will also cut this box structures it adds, but we had to be very careful that the things below by the time fully compacted it.

So, we do not expect much settlement and then we also design in such a way that even for minor settlement; the concrete will take the strength. You know the strength will be enough, so that it will take care and then as it comes out again proportionally non made, but basically it will stepped down on Togabi on here and drain out.

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This is this structure in reality, so this box is coming out, it is getting dot here. This is purely for energy deception because if it falls directly, it will erode the complete base of the structure. So, this is an energy dissipation structure and then it will be taken into the natural Jhoras. If Jhoras are very sound at the base and not getting eroded, then they are left untouched, if Jhoras are also eroding, we had designed to put a matrix there, so it will protect the erosion.

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So, this is another structure, earlier one picture you must have seen it just hanging there. So, this was after we built the structure and again there was an underground structure to take it cross the road and then drain it off.

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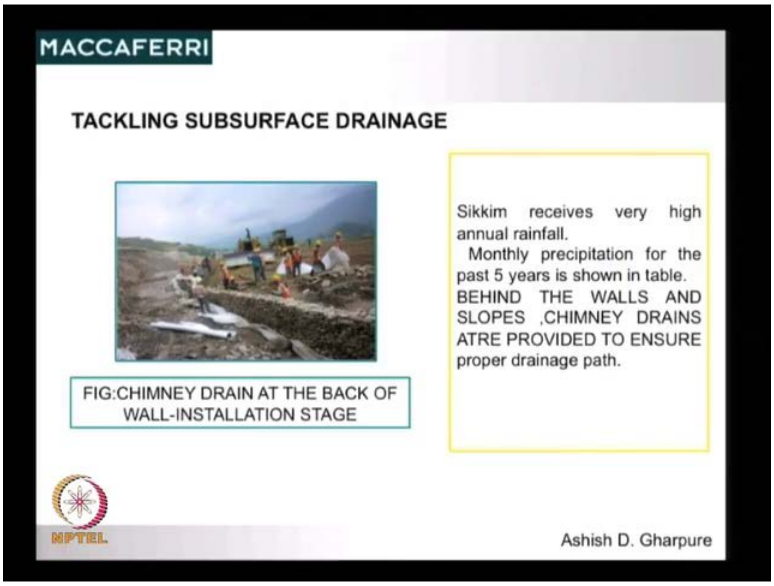

So, very find details on the set, tackle the sub surface drainage which is also one of the major part. We actually, behind the reinforcement build the complete chimney drain and this is the chimney drain in progress where geotextile filter was rapped. In fact, lot of small stone pieces which were coming during the excoriation, we selected those pieces, and build a chimney drain and completely going down, and then perforated water pipe, so connected to take it out.

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Now, these are the pictures on a different faces of the construction.

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So, this is final beta ling how this geotextile is put behind.

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How the green terremesh in it, look just behind this aphasia, we do not compact too much it just some basic compaction because if you over compacted to 95 or 98 percent, the vegetation does not grow. A second thing is this vegetated soil, so there may be some clay percentage in it behind around one and half feet or 2 feet. We mentioned that we just use normal vegetated soil and anything behind that this structure fill again taken from hills in drains relation.

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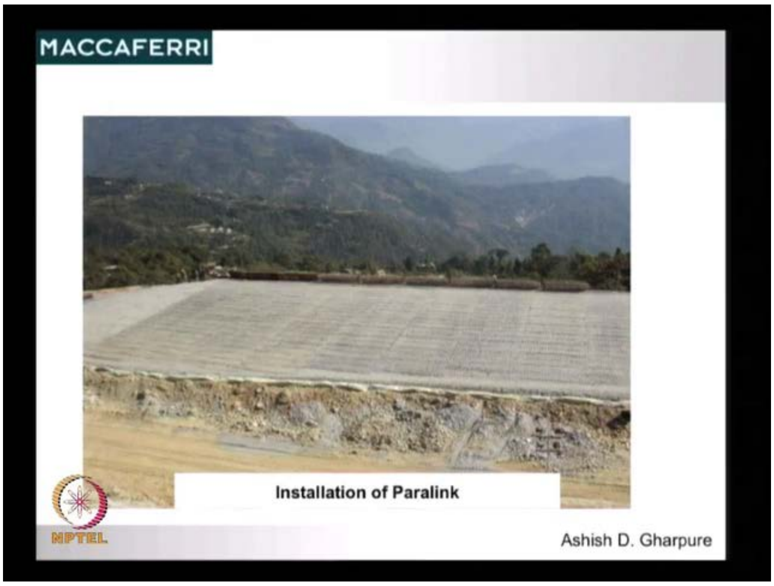

Now, this shows complete thing aphasia, the main reinforcement and can you see the chimney drain at the back of it this chimney drain will intercept all the sub surface water, take it down and take it out through a perforate pipe.

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So, this is that geogrib, a close look up Paralink and you know we can debate a good practice, not good practice of this kind of stones in the field or in the filth, but this was necessity. It could not have been dumped or could not have crushed all of the stones. The only thing we told them that not put directly on Paralink, it should have been put after 6 inch fill is done, so dare that it does not affect the performance of Paralink.

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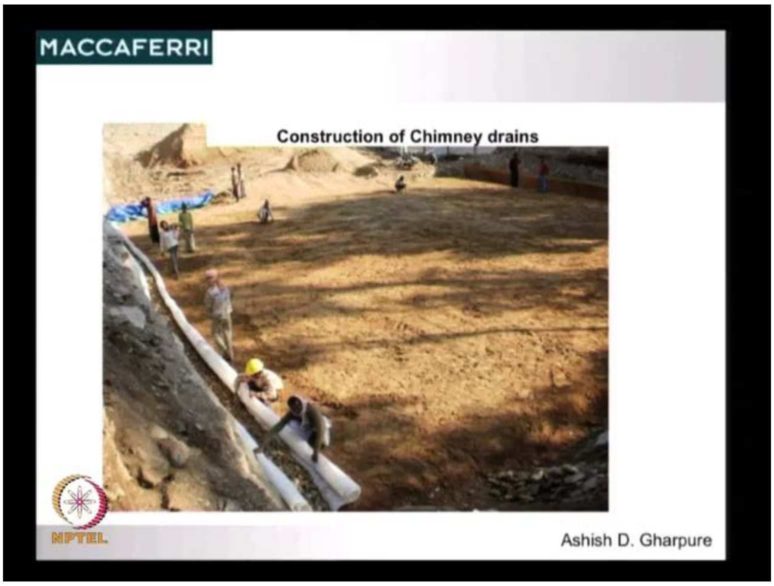

Again, you can see the chimney drain construction.

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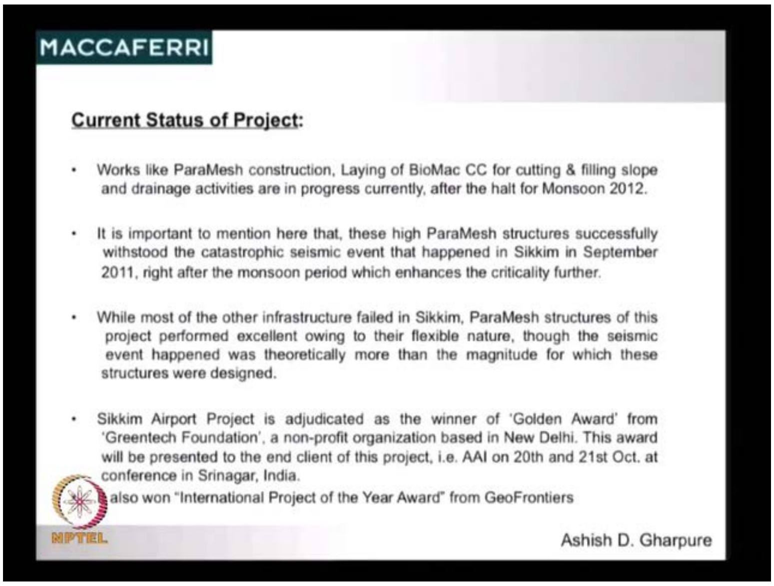

So, coming to the last part the current status of the project, around 55 meter vertical height maximum height is already built. We had to go 20 more meter fill it, so all the construction has started from October first during rainy season. We do not work and there is pretty good rainy season, in fact the work window in Sikkim, one of the challenge provably I forgot or I did not mention. The work window was only 4 to 5 months in a year; it is a rain forest, it continuously rains.

So, the rains start somewhere in April and it goes right up to October, it is also different season to start the work. So, you get practically good season is November December January, Feb, March onwards spring shower starts, may be you can continue March a bit and April onwards you have to completely stop. Now, post monsoon 2012, we have just started working there and all the construction activities are this paramesh structure what we called it actually withstood that 6.56. You know rector scale earthquake, which had come last year, if you are all in touch with news in Sikkim, there was a good earthquake in 2011, 6.5.

Actually, I have seen it practically that all the road structure there was completely broken and this withstood that not a single distress point in the structure. So, that was highlight and yes this airport project has won the golden award from Genentech foundation, a nonprofit organization foundation in India. It has also won international project of the year award from ground engineering, sorry I have mentioned geo frontier sit is actually ground engineering award for project of the year. So, this is an international award, there were approximately 7, 8 structures in the race and they still considered this as one of the best structure in got the award for that.

The special feature which I want to highlight here is that we went ahead with a belief that we can do it that was the game changer actually, because people are thinking it is simply not possible I mean this is a steep slope hill. How will you build a structure which is so high never done before? Just to let you, all know that the highest structure people know in reinforced soil work is approximately 30 meter odd, 30 to 40 meter, probably that range highest structure and this was almost double of that, so there was again this dilemma whether we will be able to do that or not.

Second thing is when we propose that in order to cost optimize and take advantage of local soil. These 2 meters spacing, when we propose people were faring that the codes do not allow, by the way 2 meter spacing the codes allow only 0.8 meter spacing. Then, we came up with this idea of you know putting secondary reinforcement, and then putting main reinforcement behind which may have a higher. The whole idea of that 0.8 meter reinforcement started because the fascia will not be stable. So, we made fascia stable by using introducing secondary reinforcement, and then we made the whole structure stable using a primary high strength with a 2 meters spacing of the geo grid.

The federal highway people, Professor Dauletinsky and Jim Collins, all those people visited actually because they now want to relook their codes why that 0.8 meter cannot be amended to higher value. So, they want to see the performance of the structure and in fact, they have taken up one work in Delaware or somewhere, where it will be monitored and seen that whether a high spacing can also work. So, it is belief in engineering which actually converted into project of this size. So, with that I will conclude if any questions I will be more than happy to answer, thank you. I saw the five minutes blinking.

Student: So, sir what was the experience about homogeneity of the material.

Actually, very good question, when actually, probably not very clear in the picture, but when we cut the whole hills, you know it was more like a collage. Those soil properties were varying every probably 4, 5 meter vertically as well as horizontally. In fact still remember, we were taking it as a joke when we got the geo technical report, I will not name the agency because just to keep the confidentiality of the firm. In geotech report, they had mentioned in the Bohr lock description that soil is something like this, that it is yellowish brown to black with reddish tint and you know the wording was such that you put any soil.

It will match that wording where it was giving all the colors in one sentence and varying and everything. So, it was black, it was yellow, it was brown, it was red, everything we be started laughing when we saw the report and obviously it should not be the practice for any geo tech report, but when we actually cut the ground, you will get all this variation. It is not true for one spot description, but it was true that there were yellowish soils, there were reddish soil, there were blackish soil, and there were brownish soil. We were bit worried on the blackish soil, whether it contains organic material or something. So, when I went to the field, I actually smelled and saw that now it was still good soil.

The good part is all the soils, so much of variation in color and probably mineralogy, but we got very consistent result on cohesion and friction angle very surprising to our slight variation here and there. It was all with plasticity index lower than what we had prescribed was 15 percent; we want to take advantage of this kind of soil, so we design. We did go with not average property fluid did go with conservative mode that is lowest expected property. So, we design the structure with 28, but practically 28 degree, but practically we are consistently getting above 30 friction angle, so any other question.

It was another unfortunate part of typical government projects, since it was not planned, they had no budget for monitoring part and we had been chasing the main consultant which is Mot Macdonell. We submitted a complete detailed plan on monitoring, but somehow it did not go throughway. They are monitoring today is just a crude method of taking a level and you know marking a spot and seeing whether settlements are there or not.

Unfortunately, no instrumentation was done in spite of giving a complete detailed plan on that, but there are settlements and within expected range. We are achieving consistently 95 percent plus, in fact you know some of the field mistakes like we are somewhere achieving even 100 plus in the sense because the bench mark remains one particular soil. As you have other soils more dense soil coming or heavy soil coming it was going, now the monitoring part is very consistent and people are working very seriously on that. In fact, if we have just I will draw one thing, just to highlight a point, so this is right when you have this.

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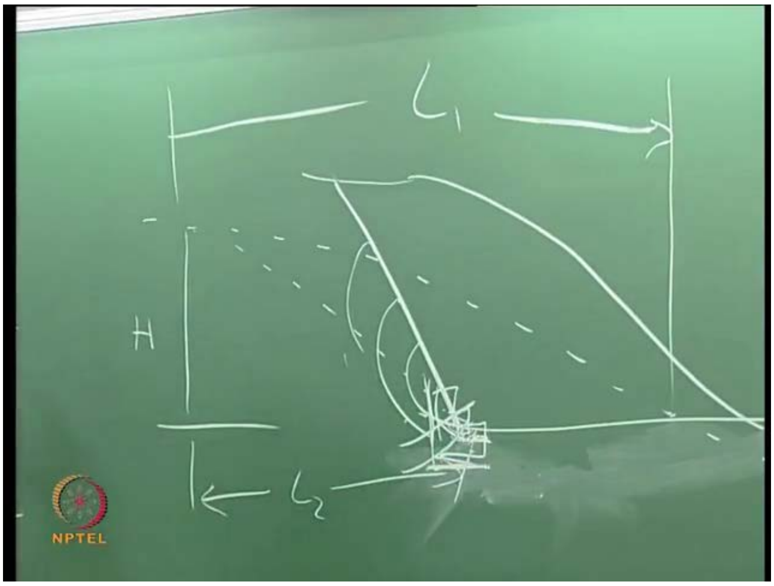

You know cut like that and then you want to build you cut, sorry this was typical profile I am just trying to prove a point. This was the original ground and then when you cut it and fill it this becomes profile, what happens is look at this point this was subjected to this much of load soil load. It is being taken off right this material here down in the foundation, this was not subjected to any load and it will get the maximum height of load. So, this is where you know the monitoring is necessary that you have this kind of situation then obviously your settlement will be lowest here or lowest right.

In fact, you may expect some heaving here because you have cut it down entire portion, so there will be some heaving and here where nothing was there no preloading was there. You have maximum height of structure right there, you will have maximum settlement. So, there is always this possibility of this overturning due to settlement and that is why that batter or the stepped structure is almost must, otherwise this complete turning. This is not because of soil pressure anything, this is just because of differential settlement here the settlement would be different here; it would be different in that moment.

Second thing you know, imagine the water line initially usually it follows ground profile a bit, it will be something like that and it will come out here right this is sub surface. Now, when you cut it and alter the whole geometry, what will happen is this will start going like imagine if this I am using same point just for explanation. If this was length initially with the same head of water, your hydraulic gradient earlier was H by L, when you cut the surface. I am taking same level, now at this point of your hydraulic gradient will be if this is L 2 it is H by L 2.

Now, L 2 being very small, you have sudden increase in hydraulic pressure at this point why the tow valve was necessary and why it has to be, I am just giving bit details that you have sudden increase in hydraulic gradient. This point most all time, if you have seen any cut in any hills the initiation point is here and the reason is this right sudden increase in hydraulic gradient. You will have lot of exit gradient pressure, here the soil particle will migrate, and there will be a collapse like this, then second, third and the whole hill will collapse.

These points necessity, that there has to be a god heavy gabion tow with a geo textile filter at the back and at the bottom so that any soil particle migration because of high sea pressure will not be there and right in front of gabion wall. We put a drainage structure and took the water out, so again importance of drainage in this kind of structure all right anything else. I think my time is over, so I will conclude.