

GeoXchange

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Mapping India's Potential in Geosynthetics

The surge in the use of sustainable materials is resulting in increased traction in the size of the global geosynthetics industry.



JITIN MUKHEJA
GEOBRUGG INDIA

There are technologies and solutions that can cater to all needs of rockfall, landslides, debris flows, shallow landslides.



PRC ARIYARATHNE
THE INSTITUTION OF ENGINEERS,
SRI LANKA

Cut Slope Mitigation works between Ch 19+000 and Ch 20+000 of the Extension of Southern Expressway Project



MUJIB KATRAWALA
STRATA GEOSYSTEMS

The Indian market have adopted new technologies with open arms and have benefited immensely using them.



RK BHASIN
NORWEGIAN GEOTECHNICAL
INSTITUTE

Several hundreds of kilometres of road and rail tunnels have been built in Norway to combat major landslide and rockfall areas.

Protection/ Treatment works performed on the tracks of Shri Mata Vaishno Devi Ji Shrine, Katra, J&K

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THDC India Limited (A Govt. of India Enterprise), Rishikesh

Synopsis

This study provides the protection/ treatment works performed on the steep side hill slopes of Shri Mata Vaishno Devi ji Shrine tracks. The job of engineering applications and comparative analysis are done along with estimating the protection works. Because of the complex geological conditions of the steep slope, accidents such as shooting stones, slope instability, collapses have been experienced in the past. Therefore, state of the art technology viz. flexible treatment measures coupled with conventional measures have been adopted to tackle variety of complex issues on this track. The system deployed is performing to its expectation infusing confidence among the pilgrims.

1. Introduction

Shri Mata Vaishno Deviji Shrine is located on moderately steep hills of Lesser Himalyan terrain on the outer fringes of Katra town in J&K State. It is one of the most famous pilgrimage centres of North India, being visited by thousands of pilgrims every day. The shrine is approachable by road upto Katra town and further by walk, over a distance of about 14km through the moderate to steep side hills along the pathways. Initially only one pathway was available to cater the needs of the pilgrims. The old pathway takes off from Banganga, passes through Indraprasth, Adhkwari and Sanjhi

Chhat before culminating at Bhawan, where the sanctum sanctorum of Goddess Maa Vaishno Devi is located. Later, one more pathway was introduced from Adhkwari following a different route up to Bhawan. In order to avoid ups and downs on the route, a new pathway was excavated from Indraprastha onwards. It follows a consistent and gradual gradient until it joins the old pathway about a kilometer from Bhawan. Some portions of this track have experienced the problem of landslides and shooting stones originating from uphill slopes.

A separate track named (new track) is also excavated from the location of new rail bridge joining at Katra-Reasi highway, Katra to Ardhwari temple for transportation of pilgrims/ goods through ponies/ battery cars. This track is also experiencing the problem of slope instability and shooting stones originating from uphill as well as downhill slopes.

2. Engagement of THDCIL with Shrine Board of SMVD

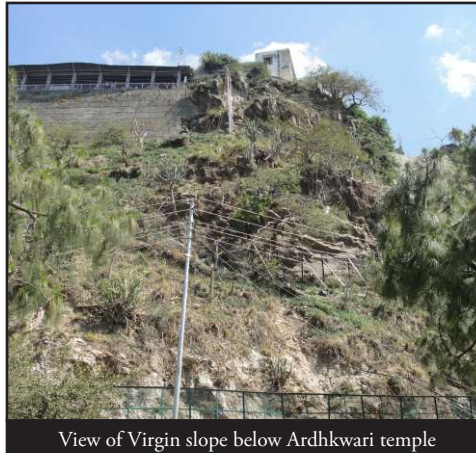
THDCIL has been engaged by the Shrine Board for undertaking all required studies and propose measures for treatment of the vulnerable portions of the hill slopes along the track between Katra and the Shri Mata Vaishno Devi Bhawan. This included conducting geological surveys, investigations and specific studies, designing stabilization interventions as

long-term measures to ensure against falling stones and landslides. On the recommendations of THDCIL, IIT Kanpur had carried out the work of Topography Survey and IIT Roorkee had done the Geological Mapping and Slope Stability Studies. Initially, after reconnaissance survey total of 24 nos. slide locations along the entire tracks were identified for treatment of slide prone/falling stone sites, which subsequently rose to 33 nos. including three no. locations falling on New Track. The identified locations have been planned to be treated in phases depending upon the vulnerability.

3. Approach

While designing the treatment measures on vulnerable slopes, "State of Art Technology" has been adopted. Since, major portions of this track involved problems of shooting stones, treatment of whole slope will not be prudent and cost effective. Therefore, for arresting the loose and shooting stones the cost-effective High-energy absorption Rockfall Barriers have been proposed and installed. In the recent years, advancement in slope protection/treatment measures has taken place worldwide, therefore some of those have also been adopted such as flexible Rockfall Barriers, High Tensile Steel Wire Mesh, High Tensile Steel Rolled Cable Net, Debris Flow Barrier etc.. Besides the advance treatment measures, conventional treatment measures such as Shotcrete, Cladding, Drilling and Grouting, Cable Anchors, Micro-piling etc. have also been deployed depending upon the requirements.

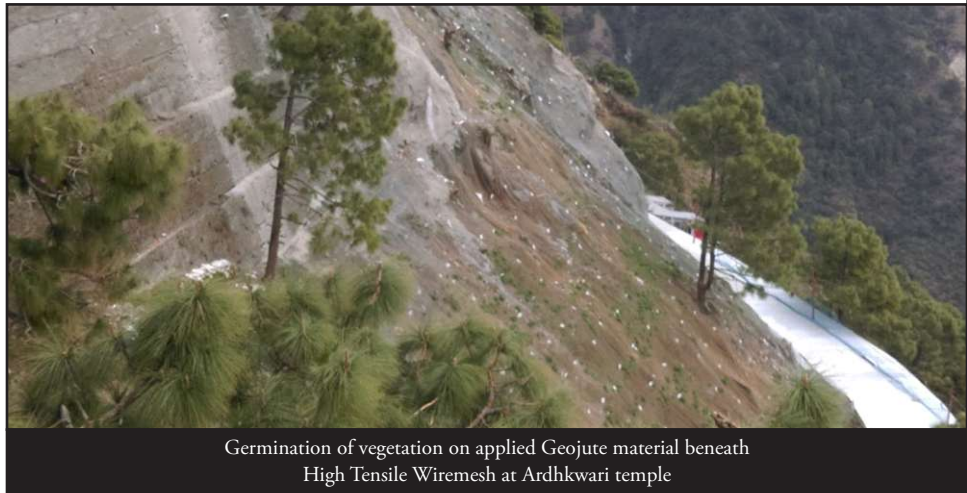
In Ist phase, five (5) out of thirty three locations were treated. The treated 5 critical locations during Ist phase lies on alternate track from Ardhkwari temple which is designated as location no. 03 (below Ardhkwari temple, from Ch. 5.275 to 5.330 km), location no. 07 (from Ch. 0.925km to Ch. 1.00km), location no.14 (from Ch. 3.850km to Ch. 4.250 km), location no.16 (from Ch. 5.075km to 5.375 km) and location no.17 (at Bhawan).



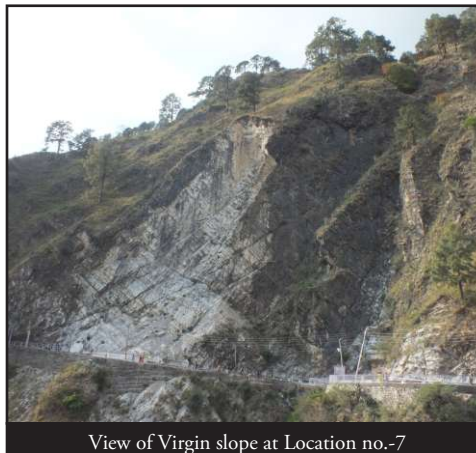
View of Virgin slope below Ardhkwari temple



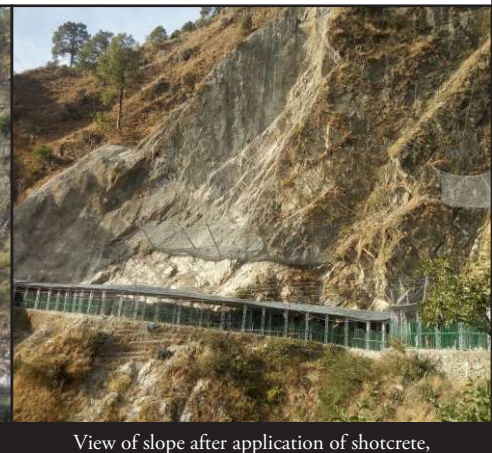
View of slope after receiving treatment of CC cladding, HT Rolled Cable Net below Ardhkwari temple



Germination of vegetation on applied Geojute material beneath High Tensile Wiremesh at Ardhkwari temple



View of Virgin slope at Location no.-7



View of slope after application of shotcrete, rockfall barriers at Location no.-7



View of Virgin slope at Location no.-14



View of Virgin slope at Location no.-16



View of High Tensile Steel Rolled Cable Net at Location no.-14



View of Installed Rockfall Barriers at Location no.-16



View of Installed Rockfall Barriers, Location no.-17



View of Virgin slope at Location no.-17



Due to heavy and continuous rain, a massive landslide occurred on the track between elevator point and gate No. 5 at Bhawan during construction of a new Bhawan at the dismantled aged Durga Bhawan.



View of restored track at Durga Bhawan by construction of RCC Cladding and 100T capacity Cable Anchors

In IInd phase, 7 other identified locations designated as location no. 4 (100m from western end of tunnel on way to Bhawan, at Ardhkwari), 12 (from Ch. 3.25Km to Ch. 3.75km), 15 (from Ch. 4.650Km to Ch. 4.975km), 25 (Bhairon track, from Ch. 2.175Km to Ch. 2.225km), 31 (slope near Tarakote Police Chowki), 32&33 (2 nos. Nalas crossing the new track originating from locations 5 & 7 on alternate track), lies on all the existing tracks were treated. The executing agency for the Ist & IInd phase of the project was a consortium of M/s Pioneer Foundation Engineers, India and M/s Geobruigg AG, Switzerland.



View of Virgin slope at Location no.-4



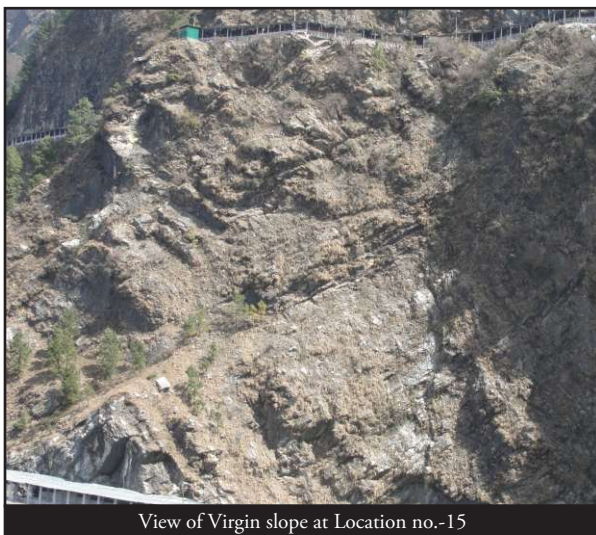
View of slope after treatment measures with CC cladding, HT Wiremesh, HT Rolled Cable, Shotcrete Location no.-4



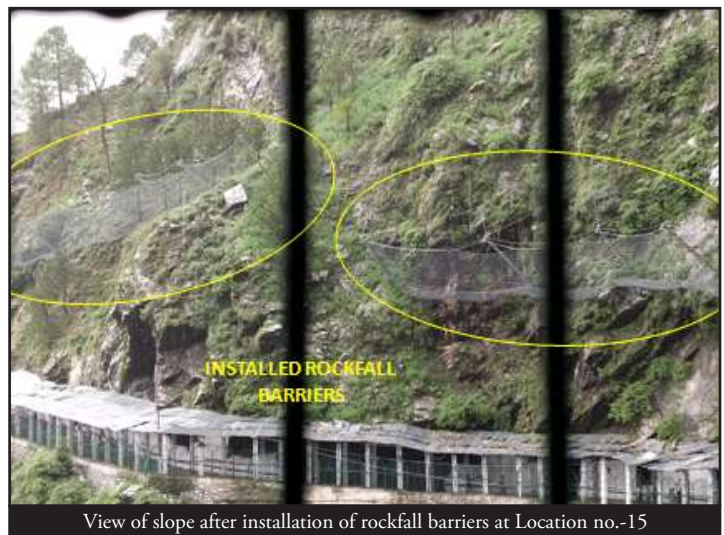
View of Virgin slope at Location no.-12



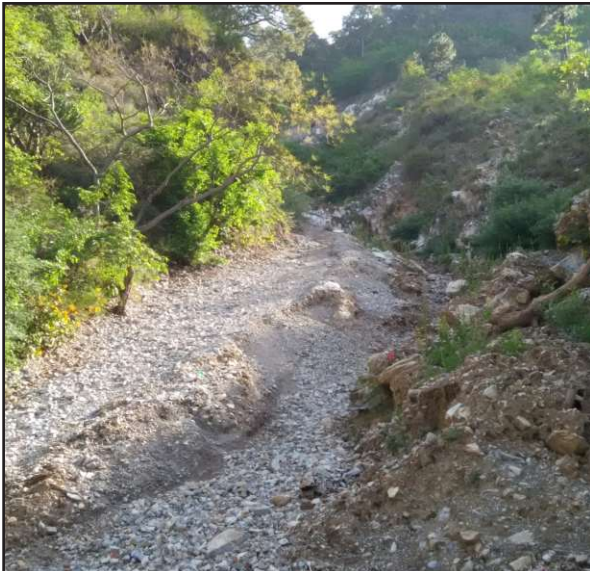
View of slope after installation of rockfall barriers at Location no.-12



View of Virgin slope at Location no.-15



View of slope after installation of rockfall barriers at Location no.-15



View of debris flows on the crossing nalas at Location no.- 32 &33



View of gabion channel at Location no.-32 &33



View of debris flow crossing nalas at Location no.- 32 &33

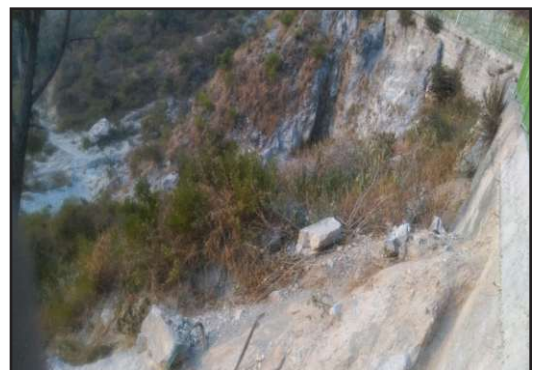


Installation of Debris Flow Barrier at Location no.-32 &33



VIEW OF DEBRIS FLOW BARRIER

Installed Debris Flow Barrier at Location no.-32 &33



View of Virgin slope at Location no.-31 (Tarakote Police Chowki)

Rockfall protection and landslide Mitigation Work on NH 222 at Malshej Ghat in Maharashtra

By Geobrugg India

Introduction

Malshej Ghat is a mountain pass in the Western Ghats range in the Kalyan-Ahmednagar Road of Maharashtra, India. The site is nestled in the lofty rugged hills of the Western Ghats. Malshej Ghat, with average height of 700 m is situated in Thane district near the borders of Thane and Ahmednagar districts. It is at 130 km north of Pune and 154 km from Mumbai towards northeast. The presence of tourist spot and resort at the top attracts a lot of tourists too. Due to its unique location, along with proximity to the western coast, it receives heavy rainfall during better part of the year on a very busy road frequented by public transportation buses connecting the cities. Hence, it is known for landslides during monsoons.

After initial visits and site investigation, critical points were identified and have been treated with suitable Geohazard solutions, tackling cases of Slope failures, rock-shooting from atop the slopes onto the roads and channelized movement of Debris Flow. This has led to reduced instances of roads and traffic getting interrupted.

Since the area is a part of western Ghats, the strata here is predominantly rocky (made up of Basalt), surrounded by steep slopes of great heights overlooking the roads. Therefore, movement of rocks from any height poses a grave danger to the vehicles going below. Many projects regarding different protection systems have been carried out during many years.

Under the leadership of Mr. Christophe Balg, who is also the General Manager for Geobrugg Asia Pacific and Africa, Geobrugg India Pvt. Ltd. had a wonderful opportunity to offer and supply a wide array of products at this location.

The complete installation was carried out by M/s Pioneer Foundation Engineers Pvt. Ltd. during different phases over subsequent years. Pioneer Foundation Engineers is a Mumbai based turnkey solutions providing organization led by Chairman and Managing Director - Mr. Asif Kazi.

The in-house facilities such as to carry out aerial surveys through drones, LiDAR surveys, mapping, geotechnical investigations provide an extra competitive edge in completing geotechnical studies and thus arriving at suitable designs.



1. QUAROX® Plus (2014)

This solution was installed to protect the road from the falling rocks off a 120m high overhanging slope, over a tourist spot. Due to its location at a turn and the dense traffic of tourists gathering below at the temple, it was a very dangerous spot in case of even a small stone falling from the top.

As a solution, the whole height of the overhanging portion of the slope was covered with high-tensile steel rolled cable net, QUAROX® Plus.

QUAROX® Plus consists of a primary mesh (QUAROX® 0/6.5/275, strand diameter - 6.5mm), paired with a secondary mesh (DELTAX® G80/2- wire diameter 2mm) to arrest the smaller rocks. Around 1,700 sqm. of QUAROX® Plus was installed to protect the slope and work carried out by technicians with full-body harness and rope access.



2. RXE-8000 H6 and SPIDER® S3-130 (2017)

Past occurrences of huge boulders as large as 5m falling onto the highway road from heights, warranted the installation of a Rockfall barrier with great absorption energy.

RXE-8000, a barrier capable of withstanding impact energies up to 8000 kJ, and SPIDER® S3-130, a high-tensile steel spiral rope net that kept loose rock masses in check. The two solutions were installed together to stop the rocks from hitting the road and to stabilise the slope below the barrier. The rockfall barrier (6 m height) was installed in two segments of 50m each and around 1,250 sqm. of SPIDER® net was installed.





3. RXE-5000, TECCO® G65/4 and SPIDER® S3-130, DELTAX® (2018)

Torrential rainfalls were seen previous year and led to slopes collapsing and Rocks getting dislodged at multiple locations. At a protection measure, RXE-5000 (5000 kJ rockfall barrier) was installed (5 m height) in two locations in 60m and 70m spans, along with more in other places. Excessive erosion caused a slope to start collapsing. So high-tensile steel wire mesh, TECCO® G65/4, a slope solution, was installed up to 1,050 sqm. to arrest the falling slope. Apart from these, SPIDER® S3-130 was also installed a slope located on a blind turn, to protect the road below. The quantity used was 3,500 sqm in addition to a secondary mesh, DELTAX®.







4. VX100-H4 (2019)

At one location, there was a channelized flow of debris from top of the hills, as an aftermath of heavy rainfall. This channelized flow violently took everything that was in the way, along with rocks, trees etc and washed it on the highway with a massive hit to the infrastructure below. This problem required special solution, Debris flow barrier VX100-H4 (100 kN/sqm pressure capacity, Height 4m) was installed in the channel to curb the flow of debris in flow, while allowing water to pass through the bottom.

5. RXE-10000 and RXE 8000 (2020)

Malshej Ghat will be the first site in India to witness the installation of a whopping 10,000 kJ rockfall barrier, RXE 10000, that is a world record for a rockfall barrier. It will be a 50m long and 7m high barrier, to arrest heavy sized boulders. Apart from this, RXE-8000 was installed in two locations totalling up to 100m here.



Excerpts from Innovative Landslide Mitigation & Debris Flow Mitigation Techniques by Geobrugg India's Perspective.

Moderator: Now, I have to ask all the panelists about lessons. Are there any lessons that you have learnt from events like flash floods, the cloudburst specially in Uttarakhand or the horrific mudslide in Maharashtra in 2014, or some more recent landslides in Kerala. Lots of people lost their lives in these events. So, what are your views regarding these? And ofcourse you can add if you have anything to say about the Char Dham Road Project in Uttarakhand which is under construction. Where hillslopes are being cut to widen the roads. So are we taking enough precaution, are we implementing enough precaution measures to mitigate any landslides in future? That's quite a lot on your plates. If you could enlighten us with your views. Maybe we can start with Jitin Mukheja?

Jitin Mukheja:Yup. If we talk about the mitigation solution and the available technology to combat the effects of the flash floods and debris flow. You must understand what is the first difference between the flash flood and the consequent problems that it carries along. In flash floods we might not be aware that it usually happens within a very short span of time like 4 hours or 5 hours and within 3 hours it collects all types of debris, mud or the wooden log and whatever comes its way. And we cannot estimate the type of volume it is carrying. We cannot estimate what type of flow it will be. Will it be totally granular or will it be totally muddy. In order to be prepared for such kinds of problems we need to identify the geographical area. If we take the example of Uttarakhand then there we know what kinds of geology is there and what type of flash floods are happening. We need to segregate the type of problem and then we need to find out the right solution. If we just talk about flash floods it is rather



GSM based satellite could also show the possibility of landslide or flash flood. That would be enough for local authorities to evacuate the place so that precious human lives can be saved as the properties can't be moved in a short span of time. The char Dham, was a learning curve. As a civil engineer, I feel helpless while traveling on these roads. We are cutting the steep mountains and we are cutting it steeply. We are cutting it to 60, 70, 80 degrees, cut off 5 meters to 25 meters. I would just say cross your fingers and pray that this slope doesn't come down. The requirement to educate ourselves in this field is immense. The DPR stage. The fund for protection measures is usually considered extra. For a civil engineer when you look for the building construction the foundation cost is hardly 10% or 15%, the investigation cost could be even lesser than that but if you spend that amount you could optimize a lot of things in the same year. The protection cost could be x amount but if we put that protection cost on roads or maybe the infrastructure that could be protected for many years and you will reduce the maintenance cost. It has to be a balance between the initial investment and the maintenance cost. That's the way it needs to go.

Moderator: I agree. I have to, fortunately, ask Dr. Ratnakar Mahajan to express his views about what we are discussing. About the authorities and how updated they are, what actions they are taking, how updated the DPR are. And also while you answer I would like you to add some comments about some of your landmark projects, specifically the one that you are currently doing in Uttarakhand. How are those performing and whether the objectives have been met with?

Dr. Ratnakar Mahajan: Thank you for merging two questions, that helps me link the project and the answer to the question. I think when we talk about the works that are being done now, as I explained earlier there are a lot of things to be done as usual. There is always something you see which is being done

but you think it could be done better. We as humans, always try to improve. When I compare it to the past, yes, there have been improvements. I feel it is a part of one of the stakeholders. It is our responsibility also to make sure that the technologies we think are appropriate to be incorporated. One of the projects, which was the Birahi landslide, which was through the ministry of road transfer highways, where the contractor was RG Buildwells, and Maccaferri was the technology partner. Now being the technology partner, the best way to approach these kinds of problems, is to first visit the site. Indian terrain, especially Himalayan Terrain it has to be dealt with a multidisciplinary approach. You must know about geotechnical engineering. The most important part is the geology. The next being how one does the investigation. If this is the landslide where are you going to do the investigation? It is a multi-dollar question. The Birahi landslide which looks to be stable in 2006, with some disturbance in 2011 started to show signs of constant disturbance in the year 2016. We combined the investigation of geotechnical investigation, geophysical investigation and geological report to understand the full terrain. The important part in any landslide is water. Water is both a friend and an enemy. It can be an enemy for a geotechnical engineer. To add optimum moisture you can compact the soil to 95-98%. But if you have excess water it can create havoc. The soil losses strength. If water goes inside rocks, it acts like a lubricant. If you drain out this water effectively you can stabilize the landslide properly. This aspect has brought a difference. As a stakeholder, we have brought a difference in the landslide treatment. A proper drainage plan was prepared. As a geotechnical engineer, we tend to see the mechanics point of view. But keep in mind with proper drainage we can eliminate most of the problem out. Proper drainage at the toe of the hill and around the hill is to be done. Then of course, the kind of geology is supposed to be studied. In addition to that, this is the first time when the instrumentation of the project has come out as a part of

the tender. It helped in measuring the pressure, loads, to check the movement of strata. And this is like a cross-section. Earlier there were conventional walls that were replaced with suitable reinforced soil. That's how the structure is put in place. The project is complete now, and the client is satisfied. Things are moving in a good direction. As a stakeholder, we need to do our part. Be a part of this work and incorporate these details.

Moderator: Wonderful to know that things are moving in the right direction with the right people in place.

Audience Question: In India, we don't have enough standardized guidelines or courts for the industry like Europe has the ECA. Do you foresee an operational change in the industry with India formulating courts and having a governing body?

Dr. Ratnakar Mahajan: I think if we look at the different bodies which make the guidelines of standards in India like the European Indian Standards or the Indian Road congress or RDSO, especially for sticking to the landslides. There are some beautiful documents from the Indian Road Congress about hill road manuals as well as landslide mitigation measures in hilly areas. There are very good documents. Whenever we see these guidelines as an engineer we must read the first two pages where it is usually mentioned that these are guidelines, which are guidelines but you need to practice as per the site condition. Like if we see the European guidelines, most of the guidelines are open and not restricting certain things. And the same things have to be practiced. Some guidelines are in making by the Indian Road Congress. They are making guidelines on some hill road Manurewa that is getting revised. We should practice the Indian guidelines and in the absence of Indian guidelines, we can adopt the best available practices worldwide. I would say, yes we are developing in guidelines but it doesn't stop us from doing the work and we can continue doing that.

more challenging to collect all the water that is coming from the flash floods. And there could not be any such solution where you can install something which only collects water. So the majority of the problem coming from a flash flood is about 70% of it is water and it's mainly rain water. Which combines with the rivers or streams or the gullies and then the problem begins to expand. So if we need to filter out the solid parts then there is a solution. You can identify what sorts of gullies are there, what sorts of installation techniques are there and how much area you have in hand. And talking about the available parameters in hand, how many investigations have been done already, do we have a stable foundation or not. So we have to penetrate into the depth of the problem by finding out the available data in hand and then you have to find out what type of techniques are really available in the market today. We cannot say that A company or B manufacturer or a C organisation have everything and they can tackle all sorts of natural hazard problems. It won't be totally correct but it won't be totally wrong to say that nothing can be done about it. Definitely measures can be taken. But if we specifically speak about flash floods it's more problematic just to catch them. And if we speak about debris flow problems or just landslides or shallow landslide problems then definitely specifically something can be done about it. We have to estimate the right quantity, we have to go into the historical data, how much problems have been happening in the past, we have to take care of the occurrences which have been happening again and again in that year in that particular area. So, you have to have collective data without that proper engineering cannot be done.

Moderator: Sure. We will come back to you about your views on investigation and some of the projection measures later in the discussion. Do you have anything to say on the specific examples I mentioned, such as the events recently in Uttarakhand or the mudslide or the devastating landslide in several parts of Kerala this year as well as two years back, do you have anything to say on that? Also on projects like the Char Dham Project or some other projects. So, do you have anything to say on that?

Jitin Mukheja: If we specifically talk on such events these were mostly triggered by heavy rainfall. And most of the cities were devastated only because of the floods. So much water enters into the cities from be it a plain city, Kerala or be it a hilly area, Uttarakhand. We need to have a proper channel, a proper dam system and a proper drainage system in whatever infrastructure we are talking about. Be it a plain city or a hilly area. The solutions that we are talking about here are the mitigation solutions and these specifically cater to very specific problems. In general the floods cannot be estimated and they cannot be quantified. And we cannot estimate the quantity of a flood. We can only take examples and we can estimate them from historic events. Say, something which happened in 2014 in A,B,C years it could double or triple the quantity. We do not know the return volume of that particular event. So floods is something which is still a very tricky challenge.

Moderator: And yet we have to plan. These days what is

happening is clients are increasingly asking for project lives of 100 years and more. We have to predict the climate change that we have seen from experience. Now we have to predict those. Who could have predicted in 2019 what 2020 would be like? It's a challenge at our hands. But as somebody who provides solutions and services, you are I believe are ready with the protection measures and solution. But you also need a more holistic approach in which things are predicted more realistically. The solutions are site specific. But also a holistic approach to look at the entire thing. (moderator moves to Arushi Bhalla).

I'll ask Mr. Jitin Mukheja that there are certain prediction measures which require some space at the toe of the slope which means for new and existing projects you might have to increase the write-off way. Or you have an option of not doing that and perhaps providing more expensive slope treatments. So which of these should be given the importance to minimize the landslide events?

Jitin Mukheja: I have already experienced such problems in live events a few years back. So first of all I'll go to the very root of the problem that is the design part. Whenever we are doing some kind of design we always go with the drawings first. For example the typical cross section. So whenever we are receiving PCS for any site and it says it's a 55 degree slope it's never implemented at site and in reality it's not even close to 60. So it's either 70 or 75 and the slope cutting is always the heaviest part and it's the most expensive part and most people are shrugging off this kind of responsibility off their shoulders so that they don't have to invest a lot of money and they can go with some kind of short term solutions just to get on with the work quickly. If you try to increase the write off way it involves more earth work, more cost involvement, more dumping of the material. Not just the cost is there but where you dump the material. These are very small problems which are not realised or understood by a layman. He won't understand where the contract is going to dump the material, how we are going to organize the transport, how much money is involved in the Earth work. Every cubic meter is very costly. And all this goes to the record books and into the costing part and every cubic meter counts. So just increasing the write off way by one metre is very costly. So this is the commercial part and then comes the technical part which is the approval. Example, you are not approved and you seek permission from the authorities or clients even if you are ready to make investment then it takes time. You have to go to the environmental department, forest department and if there are trees and forests involved then forget about it. Write-off is something that you just cannot take against. Then comes a solution that just you have to work with what is available in hand. Go with the techniques or the existing write off way even if it is a 70 or 75 degree slope, sometimes it's totally a vertical slope. Look for what options are available. And thankfully we have options. Example, if I am belonging to a company and if we have worked on such slopes or steep slopes or vertical slopes or not, and yes we have worked. So we know such techniques are available if people are ready to invest in solutions for long term stability then yes it can be done. But if you go to the loop of

taking permission and approval, I've seen people wasting years and still not getting it. So this is the major problem.

Moderator: Yes, your answer contains many many aspects which we can discuss the whole day. Brings me, some of the points that you made should not be there if the detailed projects reports are done properly. It gives me an inkling that perhaps we need to do something there, something better than what we have been doing. So I'll come back and ask questions specific to that. Because when you talk about a certain angle of the slope and I believe the design is done based on the stability which might be 46, 53, 55 degrees and how is it possible that the contractor comes back with the approval of the authority and asks to change it to 70, 75 degrees. We have many examples where the projects are stuck now. There is something that needs to be done in the part of the authorities as well as consultancies those are engaged for this. So we will come back and ask such uncomfortable questions but we can see a very bold panel of speakers already.

I go back to Mr. Jitin Mukheja and ask you about your views on the sustainable solutions and the specific products that you have which in your opinion will provide maximum safety from landslides in the mountain terrains.

Jitin Mukheja: There are technologies available and the type of solutions that we have, can cater from all needs of rock fall, landslides, debris flows, shallow landslides. So, we first need to understand the type of problem which is existing over there, then you take out the historical data and then find out the magnitude of the problem. And how much it has been affecting the local community and area. First we have to take out the design parameter and all the information available but, in our cases 90% of the time it is not available with the authorities. Then you have to make a plan where you can include the design investigation into your solution. Unless you do an investigation you cannot arrive at a proper design. Most of the time if the client knows about the area, and knows their job then they would provide you information. And even if they don't have it they will arrange it for you. They will question you and ask you everything they need to know. That is a very healthy sign that the client is taking interest and accepting the solution in wherever he is investing the money. So when we see that kind of proactive attitude from the people it is a healthy sign that he is interested in all sorts of technology and he is ready to accept that. Coming to the available technologies you can have solutions that can protect you from shallow landslides and debris flow. You have to understand the volume and type of the debris flow. And do a proper design that is sustainable for at least 50 to 60 years, 75 or a 100 years. You have to understand the return channel and return volume of the event which is going to happen again. For example, in case of a debris flow problem it could happen in different surges. And it won't happen in a single surge. There is a possibility that multiple debris flows are happening in a span of 2 days. Or there could be 10 surges happening together. This kind of event can happen in one monsoon or may not happen in 10 years. you have to understand the return period when it can happen again, what type of volume it will bring back, in what

kind of forest it is located, what type of gully or torrent it has taken. Just go through all the details and analyze everything and just arrive with the solution. I think we have this kind of solution which can cater to such needs for a very long time. This is one part of technical design which can take care of the impact pressure in both static and dynamic conditions. And then there is sustainability in terms of corrosion life. If the product is not giving up just because it is corroded and it's not the fault of the dynamic or the static load and just the fault of the corrosion. You need to have such kinds of solutions taking care of the problem and the aspects from A to Z covering everything.

Moderator: Do you have enough landmark projects in India which could set a benchmark for future landslide mitigation projects?

Jitin Mukheja: We have got numerous examples. When we started our operation with the Geo group in India about 10 years ago, not everybody was very well aware about the solutions which are there. Maccaferri was already present but still a lot of people and the market were unaware of the type of solutions which were there. If we speak about the situation in 2020, I cannot even begin to explain to you how many people are there. Every person has set up their own shops right now. There are many suppliers and designers. And now because of this the awareness is also spreading. Almost everybody is there with a solution.

Moderator: Do you also cooperate with the National Disaster Management Authority (NDMA) in creating awareness about these techniques?

Jitin Mukheja: Yes, ofcourse, we are always in constant touch with them. We always organize seminars and awareness exhibitions. Now because of Covid we are taking the help of the online platform. In the past also we were always organising seminars and exhibitions, inviting esteemed people from such communities who are willing to understand and take initiative in this field. They are always a part of this plan.

Moderator: Yeah, the only thing is that you can't install those prediction measures online. You have to visit. One last question in these series, how do you approach a landslide problem? When somebody approaches you and asks you to study the landslide and propose a system for mitigation. What are your responses and what sort of investigation is required?

Jitin Mukheja: It is a pretty standard course. The simple protocol is that you have to first visit the site. Unless you see the site physically you can never estimate the type of problem that is there. Make a site visit, have an interaction with the client. If the client is knowledgeable about the problem, and if he is ready to give the solutions in the form data which he has already collected, that's very useful. If not then we definitely suggest them to have a technical investigation done. Just to understand the type of soil and rock and the type of depth, type of unstable slope which is there. We just need to understand the type of parameter and input we need for our design. We just prepare that

check list and collect the data and then come back to the designing part. And get it full-proofed checked by the third party if that is the requirement of the authority. I think that's a safe measure. You cannot rely on one guy. So if that is the requirement you can get it checked from the IIT or someone who has knowledge in the Geo technical department. If everything is done and everything is in place then that solution will be accepted by the authority. Then they go forward on how they want to go ahead with the solution.

Moderator: Okay. Great.

Next question is in your opinion what are the actions that the Indian Government agencies like the NHIDCL, border road organisation, etc that they are taking for the prevention of the landslides in our country? Also, if you can answer how updated are the DPR consultants while proposing the systems in the project reports and tender documents that they prepare?

Jitin Mukheja: Let's say 5 or 6 years back the situation was totally different. Now it is very friendly at the moment. Organisations like NHA, NHIDCL, DRO are actually now pushing into this field. I see a lot of projects coming up in hilly areas like north east, northern, eastern and southern part of India wherever they are problems related to the mountainous regions. Because these are neighbouring countries these are crucial areas in terms of border safety. You must have a proper infrastructure road so there is a better connectivity of the army and we feel fully secure. They are preparing a lot of tunnels, taking a lot of actions at the moment and providing proper safety in these areas. So definitely the technology is spreading through them and these authorities

are taking proper measures wherever required. I don't think there is any problem we are facing in terms of accepting these technologies related to natural hazard solutions. I feel there is full acceptance by these government organisations now.

Moderator: That's wonderful to know. What about the DPR consultants, are they updated enough to include those systems?

Jitin Mukheja: Yes, DPR consultants who are preparing reports for clients, a few years back they were also unaware, and there were not many agencies who were doing such types of tutorials or sessions for them. Unless you google you won't be aware of the right technologies. That was a few years back. But now if there are 1000 DPR Consultants, for example in Delhi also there are 500 consultants who are already aware about it. Everybody is fighting so that they get the job. Everybody is aware.

Moderator: That's wonderful to know. The picture that you are portraying looks very good.

Audience Questions: Any handy instruments to get the idea of the depth of the first layer?

Jitin Mukheja : No, unless you do the proper geotechnical investigation, I don't think there is any handy instrument that can give you an accurate analysis. The depth may vary from changes. You just need to go through a proper analysis and such devices won't give you the accurate data. And just knowing about the unstable layer thickness won't give you the correct idea. We need to actually find what lies beneath that.

The screenshot shows an Airmeet webinar interface. The main window displays five participants in a grid:

- Neha Bajaj** (Host): Founder and Editor in Chief, GeoXchange, Gurgaon, India.
- Dr. Ratnakar Mahajan** (Speaker): Technical Manager ISEAP, Maccaferri, Gurgaon, India.
- Arushi Bhalla** (Speaker): MD, Encordio, Delhi, India.
- Jitin Mukheja** (Speaker): Deputy General Manager, Geobrugg India Pvt. Ltd., Gurgaon, India.
- Manoj Verman** (Speaker): Tunneling & Rock Engineering Expert, Independent, Gurgaon, India.

The sidebar on the right shows audience questions:

- Open Questions:**
 - Jitender Sharma, Business Manager, P&G Geohazard Solutions Pvt. Ltd.** • Posted 02:56 pm: What type of sensors can be used for monitoring of systems installed for landslide mitigation? Is there any criteria to specify the number of such sensors and are these sensors adaptable to site conditions like high or low temperatures?
 - Abhinav Godayal, Geotechnical Engineer, Spar Geo Infra Pvt Ltd.** • Posted 03:50 pm: Any sensors for checking freeze and thawing. For example to check deflection underneath railway tracks in snow areas with temperature variations.
- Buttons:** Ask a question, Exit.