Three-Day on-Field Training Program

On

Slope Stabilisation Measures for Railway Embankments on Lumding-Badarpur Hill Section

Date: 22 August to 24 August 2023

Organised by

Divisional Railway Manager (DRM), Lumding Division - North East Frontier Railway, Assam

&

National Institute of Disaster Management (NIDM), Delhi

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1. INTRODUCTION

The Lumding-Badarpur Hill Section stands as a vital railway artery in the northeastern state of Assam, India, operating under the Lumding Division and falling under the jurisdiction of the North-East Frontier Railways (NFR). This crucial rail link connects Lumding to Badarpur, spanning a distance of approximately 185 kilometers on a meter gauge. Notably, the Lumding Division serves six states: Assam, Tripura, Nagaland, Manipur, Mizoram, and Meghalaya.

The geographical expanse of the Lumding-Badarpur Hill Section traverses three districts in Assam—Hajoi, Dima Hasao (formerly North Cachar Hills), and Cachar. Of particular significance is the substantial stretch passing through the Dima Hasao district, a region known for its heightened vulnerability to frequent landslides and landslips. The district is often subject to the dual challenges of torrential rainfall and the consequent landslide events, turning them into recurrent disasters for the local populace.

The railway route, stretching across this dynamic terrain, assumes a critical role in the transportation network of the region. However, the susceptibility to landslides in the Dima Hasao district adds an additional layer of complexity to the operational and safety considerations associated with the Lumding-Badarpur Hill Section. The management of this rail link requires a keen focus on disaster preparedness and mitigation strategies to address the persistent threat posed by natural events, safeguarding both the infrastructure and the communities reliant on this vital transportation lifeline.

Altogether, the Lumding-Badarpur Hill Section not only serves as a crucial connector between Lumding and Badarpur but also embodies the intricate interplay between railway operations and the challenging, landslide-prone topography of the Dima Hasao district, necessitating a strategic and vigilant approach to ensure the reliability and safety of this essential transportation corridor.

In recognition of the heightened sensitivity of the Lumding-Badarpur Hill Section to geological challenges, the National Institute of Disaster Management (NIDM) collaborated closely with the Divisional Railway Manager (DRM) of Lumding Division within the North East Frontier Railway, Assam. Together, they orchestrated a significant three-day training program titled "Slope Stabilization Measures for Railway Embankments on Lumding-Badarpur Hill Section."

This noteworthy initiative unfolded over the course of three days, commencing on Tuesday and concluding on Thursday, specifically from August 22nd to August 24th. The training program was hosted at the prestigious DRM, Lumding Division – North East Frontier Railway in Assam.

The collaborative effort between NIDM and the DRM underscores the importance placed on addressing the unique challenges posed by the topography of the Lumding-Badarpur Hill Section. By organizing this comprehensive training program, stakeholders aimed to enhance the knowledge and skills of railway personnel involved in ensuring the stability of embankments in this geologically sensitive area.

The choice of dates and the esteemed venue reflect a commitment to a focused and strategic approach to the training, aligning with the urgency and significance of implementing effective slope stabilization measures along this critical railway route. This collaborative training initiative represents a proactive step towards bolstering the resilience of the Lumding-Badarpur Hill Section against potential geological hazards, contributing to the overall safety and reliability of the railway infrastructure in the region.

The training initiative titled "Slope Stabilization Measures for Railway Embankments on Lumding-Badarpur Hill Section" was designed with the primary objective of fortifying the resilience of the railway infrastructure in the face of the region's challenging and landslide-prone terrain. This comprehensive training program sought to empower railway personnel and stakeholders with essential knowledge and practical skills tailored to the unique topography of the Lumding-Badarpur Hill Section. The program aimed to enhance awareness about the geological sensitivity of the area and the associated risks, emphasizing the proactive implementation of slope stabilization measures. Through knowledge transfer sessions, hands-on exercises, and case studies, participants were equipped with a deeper understanding of geotechnical aspects, soil mechanics, and innovative engineering solutions relevant to embankment stability. Collaboration and coordination among stakeholders were emphasized, recognizing the integral role of a unified approach in addressing slope stability concerns. The training also focused on emergency preparedness, compliance with safety standards, and the adoption of sustainable practices to ensure the long-term stability and safety of the Lumding-Badarpur Hill Section's railway embankments. This initiative underscored a commitment to proactive risk mitigation, safeguarding both the infrastructure and the communities reliant on this critical railway corridor.

One of the key outcomes was the transfer of specialized knowledge to participants, providing them with a nuanced understanding of geotechnical aspects, soil mechanics, and innovative bio-engineering solutions particularly through Vetiver Grass Plantations tailored to the specific topographical challenges of the region. This knowledge transfer equipped railway personnel with the necessary expertise to identify, assess, and implement effective slope stabilization measures.

Figure: Lumding-Badarpur Hill Section

The program also played a crucial role in skill development, offering practical training opportunities that allowed participants to apply their knowledge in real-world scenarios. Through hands-on exercises, case studies, and simulations, participants gained the skills required to navigate the unique challenges posed by the Lumding-Badarpur Hill Section's landscape.

Another notable outcome was the promotion of collaboration and coordination among diverse stakeholders. By fostering a sense of unity among railway personnel, disaster management experts, and local communities, the training program encouraged a holistic and integrated approach to slope stability. This collaborative spirit is essential for the sustained success of any measures implemented along the railway embankments.

In terms of compliance and standards, the program ensured that participants were well-versed in the safety regulations and standards relevant to railway embankments. This knowledge is crucial for maintaining the integrity of the infrastructure and aligning with national and international safety benchmarks in railway engineering.

Lastly, the training program underscored a commitment to long-term sustainability. By encouraging the adoption of sustainable slope stabilization measures, the program aimed to minimize environmental impact and enhance the resilience of both the railway infrastructure and the communities it serves. This overarching outcome reflected a strategic and forward-looking approach to ensuring the enduring stability and safety of the Lumding-Badarpur Hill Section's railway embankments.

2. OBJECTIVES OF THE TRAINING PROGRAM

- To develop understanding of the slope material and slope mass characteristics along with geotechnical and geological engineering of the concerned locations.
- To enhance comprehensive knowledge on the engineering aspects of railway embankments, its design and the material characteristics.
- To impart sustainable & applicable solutions on the field by conventional and non-conventional methods for slope stability remediation.
- To establish a network among different relevant departments and organizations in order to enhance disaster management efforts.

3. TRAINING SUMMARY

Day 1 (22.08.2023): Registration and Inauguration		
9:30 AM- 10:00 AM	Registration	**DRM, Lumding, Assam**
10:00 AM- 10:15 AM	Welcome Address	**DRM, Lumding, Assam**
10:15 AM- 11:00 AM	Context Setting and Overview of the Programme	**Prof. Chandan Ghosh** Head, RID, NIDM, MHA, Govt. of India
11:00 AM- 11:15 AM	Inaugural Session	**Mr. Prem Ranjan,** DRM Lumding
11:15 AM- 11:30 AM	Vote of Thanks	North East Frontier Railway Department
11:30 AM- 11:45 AM	**High Tea**	
11:45 AM- 13:00 PM	Landslides/erosion control measures by Bioengineering Solution	**Prof. Chandan Ghosh** Head, RID, NIDM, MHA, Govt. of India
13:00 PM- 14:00 PM	**Lunch Break**	
14:00 PM- 15:00 PM	Discussion/Problems based on case examples and experience sharing	**Dr Pradeep Kumar** Biostarts Ventures , Kolkata Prof. Ghosh along with Engineers from NFR
15:00 PM- 17:00 PM	Discussion on RDSO manual (2020), site selection followed by Vetiver grass plantation	**Dr Pradeep Kumar, Prof Chandan Ghosh and Team NFR**
Day 2 (23.08.2023): On-Field Training & Remediation measures		
9:30 AM- 11:00 AM	Field visits of the landslide effected areas, mitigation possibilities with Vetiver Grass, Geotextiles, Bamboo, local shrubs etc.	**Prof. Chandan Ghosh** Head, RID, NIDM, MHA, Govt. of India with experts and participants + Dr. Pradeep Kumar and Dr. Subir Sen & NFR field teams
11:00 AM- 11:15 AM	High Tea	
11:15 AM-13:00 PM	Continuation of previous Session	-
13:00 PM- 14:00 PM	Lunch Break	
14:00 PM- 17:00 PM	Continuation of previous Session	-
Day 3 (24.08.2023): Field Visit & Interaction		
9:30 AM-11:00 AM	Field Visit & Experience Sharing	Prof. Chandan Ghosh Head, RID, NIDM, MHA, Govt. of India + Dr Pradeep Kumar and Dr. Subir Sen & NFR field teams
11:00 AM- 11:15 AM	High Tea	
11:15 AM- 13:00 PM	Field Visit & Experience Sharing	Prof. Chandan Ghosh Head, RID, NIDM, MHA, Govt. of India + Dr Pradeep Kumar and Dr. Subir Sen & NFR field teams
13:00 PM- 14:00 PM	Lunch Break	

14:00 PM- 16:00 PM	Field visit	Prof. Chandan Ghosh Head, RID, NIDM, MHA, Govt. of India + Dr Pradeep Kumar and Dr. Subir Sen & NFR field teams
16:00 PM- 17:00 PM	Closing ceremony	NIDM & NFR

3.1: DAY 1 SUMMARY

The commencement of Day 1 unfolded with the welcoming address by DRM Subdivisional Officer Lumding. Following this, Professor Chandan Ghosh took the spotlight to provide context and articulate the purpose of the training program. The inaugural session then transitioned to Mr. Prem Ranjan, who spearheaded the proceedings as the DRM Lumding. Bringing the inaugural ceremony to a close, the North East Frontier Railway Department expressed gratitude and extended a vote of thanks to all participants and contributors. This marked the formal initiation of the training program, setting the tone for the informative sessions ahead.

Technical Sessions

Session 1: Prof. Chandan Ghosh, Head Resilient Infrastructure Division, NIDM

During the session, Professor Ghosh conducted a detailed exploration of a compelling case study, focusing on the treatment strategy employed to counteract landslides within a local community in Coorg. The discussion seamlessly expanded to provide a broader perspective on landslide control measures, with a particular emphasis on ground modifications implemented in the hills of Meghalaya. Drawing from his extensive expertise, Professor Ghosh delved into the intricacies of drain pipe implantation, inspired by practices observed in California, highlighting its crucial role in effectively addressing drainage issues associated with landslides. The session reached its zenith with a thorough examination of the attributes of vertiver grass, meticulously outlining its role and effectiveness in the realm of landslide mitigation. Professor Ghosh's expert lecture not only enriched participants' comprehension of nature-based solutions but also provided valuable insights into their practical application for the effective management and mitigation of landslides.

Session 2: Dr. Pradeep Kumar Bio starts Ventures, Kolkata

Within the session Dr. Pradeep delved into the case studies of slope stabilization in railways. He highlighted the following cases:

a. **Vegetative Stabilization in Switzerland:**

- **Challenge:** In Switzerland, where railway tracks traverse hilly and alpine regions, soil erosion and slope instability are concerns.
- **Solution:** Implementing vegetative stabilization through the strategic planting of grasses and vegetation to reinforce slopes and prevent erosion.
- **Outcome:** Natural stabilization of slopes, reduced soil erosion, and an aesthetically pleasing environment along the railway lines.

b. Gabion Walls in India:

- **Challenge:** In India, where railways traverse diverse terrains, some regions experience slope instability due to heavy rainfall.
- **Solution:** Construction of gabion walls—cages filled with rocks—along vulnerable slopes to prevent soil erosion and landslides.
- **Outcome:** Enhanced slope stability, reduced risk of landslides, and increased safety of the railway infrastructure.

Post Lunch Session

Prof. Ghosh and Dr Pradeep Kumar delved into the discussions highlighting the crucial aspects of slope stabilization for the North East Frontier Railway Corridor, focusing specifically on the implementation of the Research Designs and Standards Organization (RDSO) manual from 2020. The discussion commenced with a detailed exploration of the RDSO manual, emphasizing its relevance and guidelines for slope stabilization in railway infrastructure.

One key topic addressed was the meticulous process of site selection, a critical step in ensuring the effectiveness of slope stabilization measures. The RDSO manual provides comprehensive guidance on identifying suitable locations, taking into account geological factors, terrain characteristics, and potential risk factors for slope instability. The discussion highlighted the importance of aligning site selection with the unique challenges and conditions of the North East Frontier Railway Corridor.

Following the discourse on the RDSO manual, the session transitioned to a practical application—Vetiver grass plantation. This nature-based solution was explored as a sustainable and effective method for slope stabilization in the region. The discussion delved into the specific advantages of Vetiver grass, such as its deep and dense root system that helps bind soil, reduce erosion, and enhance slope stability. Practical insights into the plantation process, including considerations for terrain and climate specific to the North East Frontier Railway Corridor, were also covered.

By combining the guidance from the RDSO manual with the practical implementation of Vetiver grass plantation, the training program aimed to equip participants with a holistic understanding of slope stabilization tailored to the unique challenges of the North East Frontier Railway Corridor. The session fostered an integrated approach, aligning industry standards with nature-based solutions for sustainable and resilient railway infrastructure in the region.

With these discussions day 1 of the training program comes to an end.

3.2 DAY 2 SUMMARY

On the second day of the training program, participants engaged in field visits to areas affected by landslides. The delegation, comprising railway engineers, the North Frontier Railway (NFR) team, and representatives from the National Institute of Disaster Management (NIDM), directed their attention to specific locations susceptible to landslides. The targeted sites served as practical learning grounds for assessing the impact of landslides and exploring potential mitigation measures.

During the field visits, experts evaluated the feasibility of employing various solutions, including the strategic use of Vetiver Grass, Geotextiles, Bamboo, and local shrubs. These nature-based and sustainable approaches were considered for their efficacy in stabilizing slopes and reducing the risk of landslides along the railway corridor.

The collaborative effort involved in the field visits fostered discussions among experts, allowing for a comprehensive exploration of concerns and potential solutions for the identified vulnerable areas. This hands-on experience provided invaluable insights into the real-world challenges faced by the railway infrastructure and facilitated a dialogue on the most effective and context-specific strategies for landslide mitigation. The field visits thus played a crucial role in bridging theoretical knowledge with practical application, contributing to a more holistic understanding of effective slope stabilization measures for the railway network.

3.3 DAY 3 SUMMARY

On the third day of the training program, the focus remained on field visits, providing participants with extended exposure to landslide-affected areas. Concurrently, railway staff actively engaged in sharing their concerns related to landslides in railway zones, seeking expert intervention to address the specific challenges they encounter. This dynamic interaction evolved into a healthy and fruitful discussion, fostering a collaborative atmosphere where knowledge and practical insights were exchanged between the experts and railway personnel.

As the program reached its conclusion, certificates were conferred upon the participants in a formal ceremony. Professor Chandan Ghosh, Head of the Research and Information Division (RID) at the National Institute of Disaster Management (NIDM), took charge of the certificate distribution, acknowledging the successful completion of the training program by the participants.

4.DISCUSSION & FEEDBACK SESSION

The discussion and feedback session following the training program served as a crucial platform for participants to share insights, exchange experiences, and provide constructive feedback. The session commenced with an open forum where participants were encouraged to express their thoughts on the training content, methodologies employed, and the overall effectiveness of the program.

One of the key discussion points centered on the significance of the knowledge transfer component. Participants engaged in discussions on how the acquired knowledge about geotechnical aspects and innovative engineering solutions could be practically applied to address slope stability challenges in the Lumding-Badarpur Hill Section.

The session also delved into the practical aspects of skill development. Participants discussed the hands-on exercises and simulations, providing valuable insights into how these activities enhanced their practical understanding and preparedness to implement slope stabilization measures. This discussion highlighted the tangible impact of the training on the participants' skill sets and their readiness to tackle real-world challenges.

Emergency preparedness emerged as a significant point of discussion, with participants exchanging ideas on the development of contingency plans and the implementation of early warning systems. Insights were shared on how to integrate these measures seamlessly into existing railway operations, ensuring a swift and organized response in the face of unforeseen events.

Feedback on the training program's compliance and standards component provided an opportunity for participants to discuss the importance of aligning with safety regulations and standards. The discussion delved into how adherence to these standards is essential not only for the safety of the railway infrastructure but also for maintaining public trust and confidence in the reliability of the Lumding-Badarpur Hill Section.

5. CLOSING CEREMONY

In the closing ceremony, Mr. C.S. Pradip Kumar, along with Prof. Chandan Ghosh, Head of the Resilient Infrastructure Division at NIDM, took a moment to express profound gratitude to all the dignitaries, speakers, trainers, participants, and support staff who played integral roles in the resounding success of the training program. Their words of appreciation resonated throughout the venue, serving as a heartfelt recognition of the collective effort and unwavering commitment that had been poured into making the program not only informative but profoundly impactful.

The esteemed dignitaries highlighted the collaborative spirit that had been the cornerstone of the entire training initiative. They emphasized the significance of teamwork and shared dedication in achieving the program's goals, recognizing that the success of such an endeavor is built on the collective wisdom and commitment of all involved. The acknowledgment extended beyond the participants to include the valuable contributions of speakers who shared their expertise and trainers who imparted crucial skills.

The final note of gratitude echoed the sentiment that this training program was not just a learning experience but a collaborative journey toward enhancing the stability and safety of the Lumding-Badarpur Hill Section. As the dignitaries conveyed their appreciation, they reinforced the importance of such collaborative efforts in fostering resilience and sustainability within the railway infrastructure. This closing ceremony served as a fitting tribute to the collective achievement and a reminder of the enduring impact that thoughtful collaboration can have in addressing complex challenges.

6. KEY TAKEAWAYS

- Discussed the comprehensive understanding of Slope Stability Principles in hilly terrains.
- Discussed the Site-Specific Challenges related to the topography, soil types, and geological conditions in the region.
- In support of this, NFR engineer presented several erosion and slope failures that are being faced and some of the mitigation measures taken up so far with reference to the Halflong railway that was affected in May 2022.
- Elaborated the multifaceted techniques for Slope Stabilization across hilly terrains.
- Consultation with participants, including NFR officials and railway construction agencies emerged with definite site-specific solutions
- Delved into the understanding of Bio-engineering application measures as a best suited technology.
- Encouraged the promotion of Vetiver Grass for Slope Stabilization.

- A pilot site at Lumding division was planted with Vetiver grass on 2nd and 3rd day, which was followed by the experience sharing and plan for further action with few vulnerable site noted during site visit.

7. ABOUT THE ORGANIZATION

About National Institute of Disaster Management (NIDM)

The National Institute of Disaster Management (NIDM) was constituted under an Act of Parliament with a vision to play the role of a premier institute for capacity development in India and the region. The efforts in this direction that began with the formation of the National Centre for Disaster Management (NCDM) in 1995 gained impetus with its re-designation as the National Institute of Disaster Management (NIDM) for training and capacity development. Under the Disaster Management Act 2005, NIDM has been assigned nodal responsibilities for human resource development, capacity building, training, research, documentation, and policy advocacy in the field of disaster management. Both as a national Centre and then as the national Institute, NIDM has performed a crucial role in bringing disaster risk reduction to the forefront of the national agenda. The Institute believes that disaster risk reduction is possible only through promotion of a "Culture of Prevention" involving all stakeholders. The Institute works through strategic partnerships with various ministries and departments of the central, state, and local governments, academic, research and technical organizations in India and abroad and other bi-lateral and multi-lateral international agencies. NIDM is proud to have a multi-disciplinary core team of professionals working in various aspects of disaster management. The Institute provides training in face-to-face, on-line, and self-learning mode as well as satellite-based training. In-house and off-campus face-to-face training to the officials of the state governments is provided free of charge including modest boarding and lodging facilities. NIDM provides Capacity Building support to various National and State level agencies in the field of Disaster Management & Disaster Risk Reduction. The Institute's vision is to create a Disaster Resilient India by building the capacity at all levels for disaster prevention and preparedness.

For more programs please visit: https://nidm.gov.in/

About North East Frontier Railway, Lumding Division

The Northeast Frontier Railway (NFR), one of the 19 railway zones within the Indian Railways network, operates with its headquarters situated in Maligaon, Guwahati, Assam. Tasked with managing and expanding the rail network across the Northeastern states, as well as certain districts in eastern Bihar and northern West Bengal, the NFR plays a pivotal role in connecting and facilitating transportation in this region.

The Northeast Frontier Railway is divided into 5 divisions:

The operational structure comprises divisions, each overseen by a Divisional Railway Manager—an officer of Senior Administrative Grade equivalent to a Joint Secretary to the Government of India. The centralized headquarters and decentralized divisional setup work in tandem, assisting the General Manager in the efficient administration of railway operations. Several departments, including engineering, mechanical, electrical, signal & telecom, operations, commercial, safety, accounts, security, personal, and medical, are led by officers of Senior Administrative Grade / Higher Administrative Grade. These departments collectively provide technical and operational support to the divisions, ensuring the seamless functioning of train operations.

Among the five railway divisions under the Northeast Frontier Railway zone, the Lumding railway division holds a prominent position. Established on May 1, 1969, and headquartered in Lumding, Assam, this division serves a crucial role in the railway network of India. The Lumding railway division oversees and coordinates railway operations in its jurisdiction, contributing significantly to the overall connectivity and transportation infrastructure in the state of Assam.

For more information please visit:

https://nfr.indianrailways.gov.in/view_section.jsp?lang=0&id=0,6,655,659,848

ANNEXURE I: PROGRAM SCHEDULE

"SLOPE STABILISATION MEASURES FOR RAILWAY EMBANKMENTS ON LUMDING-BADARPUR HILL SECTION"

PROGRAMME SCHEDULE

VENUE: DRM, Lumding Sub Division, North East Frontier Railway, Assam

DATE: 22nd – 24th August 2023; (Tuesday – Thursday)

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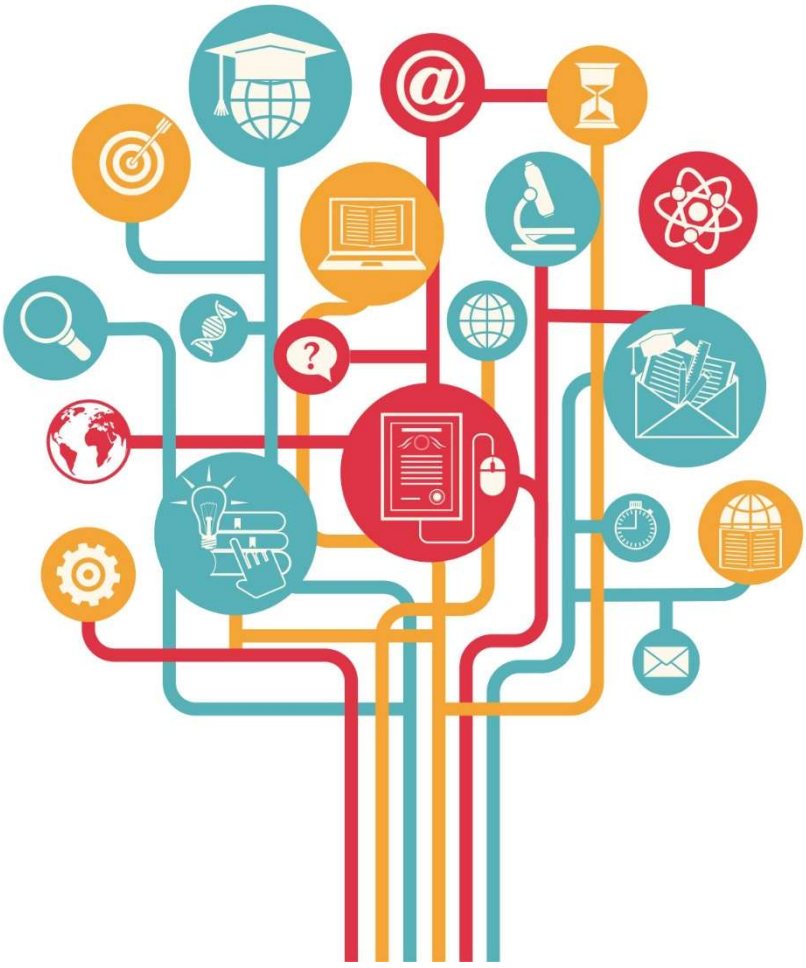
13:00 PM- 14:00 PM	Lunch Break	
14:00 PM- 16:00 PM	Field visit	Prof. Chandan Ghosh Head, RID, NIDM, MHA, Govt. of India + Dr Pradeep Kumar and Dr. Subir Sen & NFR field teams
16:00 PM- 17:00 PM	Closing ceremony	NIDM & NFR



ANNEXURE II: CONCEPT NOTE

Three-Day on-Field Training Program

On

Slope Stabilisation Measures for Railway Embankments on Lumding-Badarpur Hill Section

Organised by Divisional Railway Manager (DRM), Lumding Division -
North East Frontier Railway, Assam

&

National Institute of Disaster Management (NIDM), Delhi

Date: 22 August to 24 August 2023

Venue: DRM, Lumding Division – North East Frontier Railway

Overview

The Lumding-Badarpur Hill Section is a crucial railway route located in the North-Eastern state of Assam, India under the Lumding Division. It connects the section from Lumding to Badarpur on a meter gauge and is associated with North-East Frontier Railways (NFR). The Lumding Division serves in six states, namely Assam, Tripura, Nagaland, Manipur, Mizoram, and Meghalaya. The route network between Lumding-Badarpur Hill Section spans approximately 185 kilometres in total. The section falls under three districts of Assam viz; Hajoi, Dima Hasao (formerly known as North Cachar Hills) and Cachar. A majority of this section passes through Dima-Hasao district which is known to be extremely prone to recurrent landslide and landslips (Martha et al., 2021). Torrential rain and associated landslide events are frequent affair causing disaster in the region. (Figure 1)

Aim

The intent of this on-field face-to-face training is to provide practical solutions to mitigate the recurrent slope failures along the Lumding-Badarpur Hill Section, North East Frontier Railway by using multi-dimensional approach for long-term stability.

Objectives

- To develop understanding of the slope material and slope mass characteristics along with geotechnical and geological engineering of the concerned locations.
- To enhance comprehensive knowledge on the engineering aspects of railway embankments, its design and the material characteristics.
- To impart sustainable & applicable solutions on the field by conventional and non-conventional methods for slope stability remediation including Nature-Based Solutions.

- To establish a network among different relevant railway departments in order to enhance disaster management efforts.

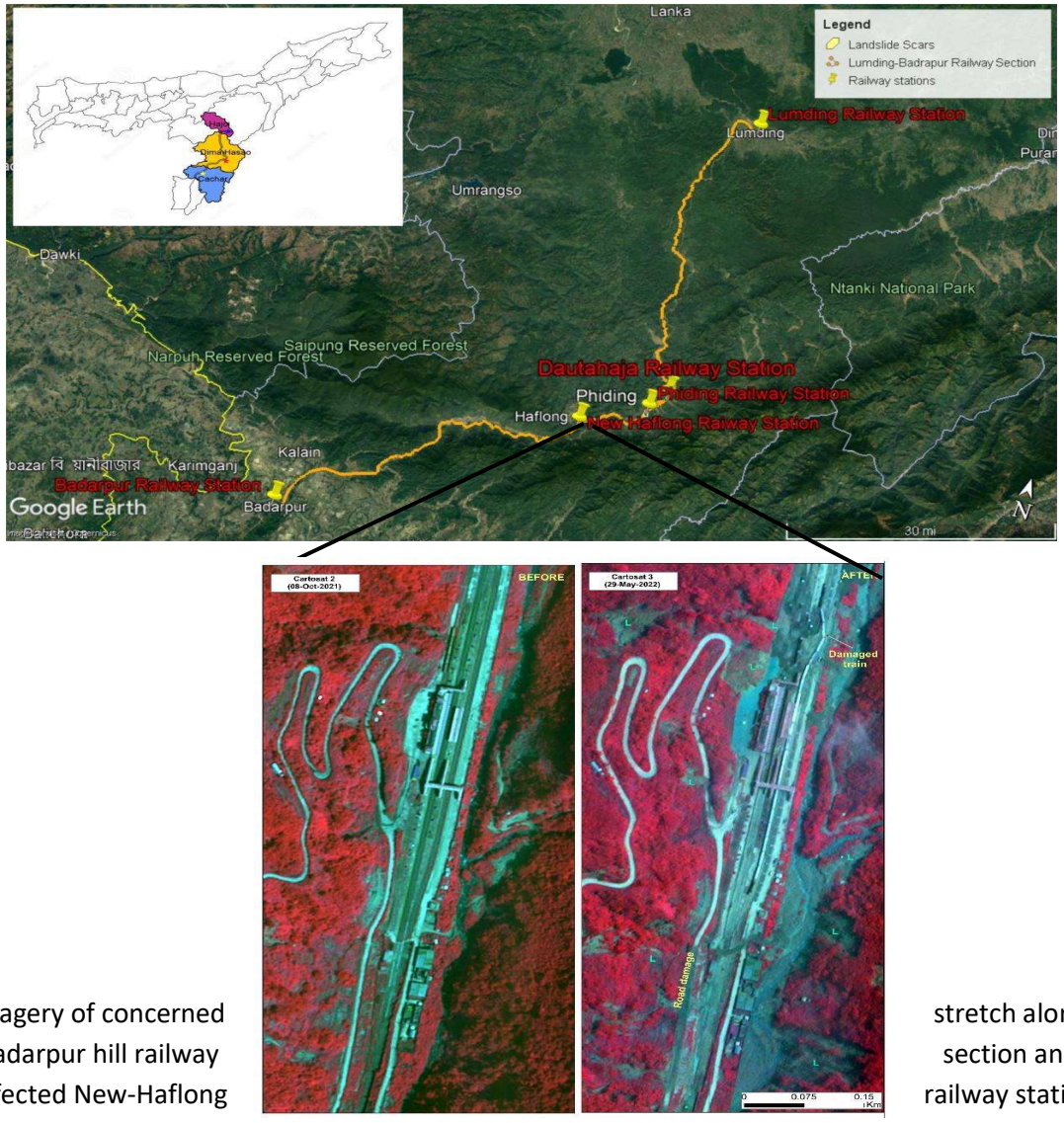


Figure 1: Imagery of concerned stretch along Lumding-Badarpur hill railway section and landslide affected New-Haflong railway station (Courtesy: ISRO)

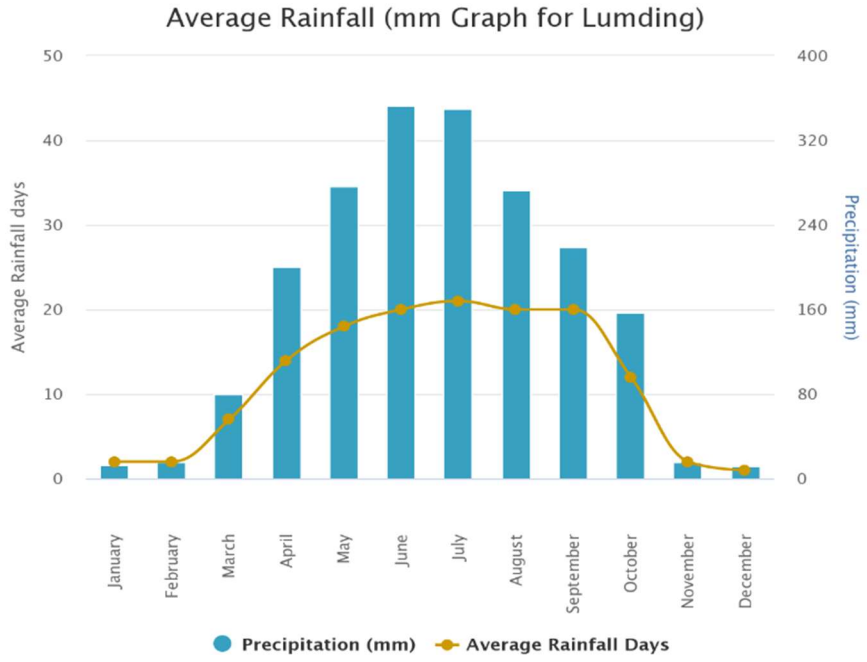
Geology & Geography

The regional geology comprises of carbonaceous shale, sandstone and limestone of Renji formation with mudstone, sandstone, siltstone, ferruginous sandstone of Bokabil formation. The location has Tipam and Disang formation of sandstone where most of the landslide had occurred (Gupta & Biswas, 2000). The young alluvium overlying on the top of these formations are scattered which range from clayey loam to sand and silt. Structurally, discontinuities serves for planar type failure. The folded sequence of rocks are weak with faults and lineation making it a very fragile location for any engineering construction. The geographical area

encompasses the southern plains of the Brahmaputra River, the plains of the Barak Valley, the hilly terrain of North Cachar Hills, Karbi Anglong, Nagaland, Manipur, Mizoram, and Tripura, characterised by the presence of dense forests.

Climate & Rainfall

Rainfall varies considerably in the region with total average of about 1965.2 mm annually. Rainfall is heavy during the months from May to September, but it is not evenly distributed throughout the district. Climate condition is also not uniform. Temperature ranges from 33°C in summer to 5°C in winter in Dima Hasao district. Cachar receives an average annual rainfall of more than 3,000mm. The climate is Tropical wet with hot and wet summers and cool winters. The climatic condition of Hajoi district is humid which rises to extreme levels. Maximum temperature during winter is about 25°C and minimum is 11°C. The mean daily maximum temperature during summer is 34°C and the minimum is 24° C.



Natural Disasters in Assam

Landslide: Assam state experiences recurrent landslides, especially, along railway corridor sections. The majority of incidences occur due to incessant rainfall during the monsoon season. Assam has witnessed several significant landslides over the years. Several districts, including Dima-Hasao, Karbi Anglong, and Goalpara, were affected by landslides in 2012. Mandardisa to Damcherra railway stretch was critically hit by several landslide events (Times of India, 2012). Dima Hasao expericed landslide in 2016 with road and railways shut for several days. During 2020 monsoon season landslides occurred in the districts of Dima Hasao, Karimganj, Hailakandi, and Cachar. Year 2022 was worst hit by landslides in the Lumding -Badarpur hill stretch accounting for 61 locations severely affected (India.com, 2022).

Earthquake: Assam's tectonic activities are characterized by the presence of several active faults, including the Main Boundary Thrust (MBT) and the Kopili Fault, which contribute to the seismic activity in the region. In the past notable earthquake events such as 1897, 1930, 1941, 1950, 1988 marked 6.0 or more in Richter scale created mass devastation include loss of property and fatalities as reported CNDM.

Flood: Assam's extensive river network makes it susceptible to floods and erosion, which hampers development. The Brahmaputra and Barak Rivers, with over 50 tributaries, contribute to monsoon floods. Assam's flood and erosion problem is the most severe and unique in the nation. Rastriya Barh Ayog (RBA) estimates that 31.05 Lakh Hectares, or 39.58 % of Assam's total land area is flood-prone as compared to 10.2% flood-prone of entire country. Floods impact 9.31 Lakh Hectares annually. Major incidences of flooding occurred in 1954, 1962, 1972, 1977, 1984, 1988, 1998, 2002, 2004, 2012, 2013, 2015-2020 and 2022. It is estimated that around Rs. 200 Crores annual losses is burdened on the state of Assam.

Another issue to Assam economic losses is the erosion of river bank of Brahmaputra. The drainage streams constantly breach the river embankment engulfing greater than 7% of the state landmass. This include new area every year under the threat with more and more of irrigable land loss.

Wind: According to Assam State Disaster Management Authority the onset of the South West Tropical Monsoon is typically characterized by robust wind patterns, cloudy atmospheric conditions, intermittent thunderstorms, instances of hailstorms, and occasional cyclonic activity occurring from April to May. Frequent afternoon thunderstorms, referred to as *Bordoicila*, are observed. The onset of a substantial precipitation event typically commences in the month of June. Occasionally, these cyclones exhibit a highly destructive nature, resulting in significant human casualties and extensive property damage (Figure 2)

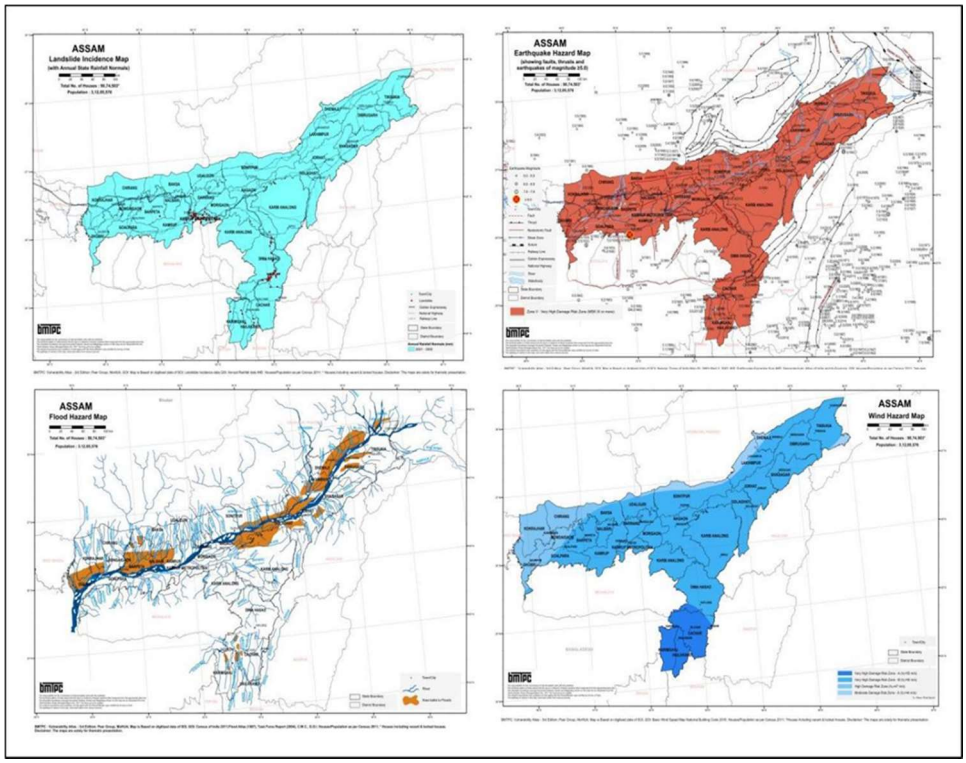


Figure 2: Natural Disaster map of Assam (Courtesy: BMTPC)

Landslide events along Lumding-Badarpur Hill Section

- ***Year 2022***

Torrential rainfall occurred from 11th to 18th May 2022 resulting in several landslides in the region. Lumding-Badarpur Hill Section, leading to a disruption in train services and causing significant damage to the railway infrastructure. The 3-day downpour from 11th to 13th created a substantial increase in pore pressure in the slope material thereby decreasing its shear strength resulting in major landslides. Silchar-Guwahati express train was engulfed including uprooting the railway track by a landslide at New Haflong station stranding more than 1000 passengers from 14th and 15th May 2022 (Bhattacharjee, 2022). The presence of friable rocks such as shale, siltstone, flaggy sandstone and slope steepness are prime reason for occurrence of landslides (Roy et al., 2022) (Figure 3).

Figure 3: Landslide inundated the New Haflong railway station on 14 May 2022

- ***Year 2016***

Heavy rains in Dima Hasao caused landslides at several places, including its headquarters in Haflong occurred on 16 May near Hathkali. In April 2016, the Dima Hasao district witnessed a major landslide triggered by heavy rainfall. This event led to 100 meters of railway track in Phiding in Dima Hasao to wash away (The Economic Times, 2016).

Figure 4: Landslide scar near Hatkhali railway station

- ***Year 2012***

Unprecedented rainfall took a toll on the commute services on 26 June. The crucial rail link between Lumding and Badarpur, which is also the lifeline for Tripura, suffered extensive damage due to landslides at various locations. The rail track had been washed away at 23 critical locations and one tunnel had collapsed, in addition to the damage to several bridges (Indian Red Cross Society, 2012).

Figure 5: Landslide Scar near between Daotuhaja and Phiding Railway stations

Railway Infrastructure

The Lumding-Badarpur Hill section essentially require fundamental development of their railway transport infrastructure. Railway system continues to be the predominant means of transportation, functioning as the fundamental infrastructure for the communication network, encompassing both economic and strategic importance. Food-grains, salt, oil, sugar, cement, coal, steel, fertilizer and other essential items to Barak Valley, Tripura and Mizoram. Around 3000 passenger travel regularly from the Lumding division. The movement of the route remains affected by natural hazards in the region.

Figure 6: Railway track affected by rainfall-induced landslide along on 14 May 2022. (Roy et al., 2022; The Federal, 2022)

Impact on Infrastructure

- The occurrence of the landslide resulted in the temporary cessation of train services along Lumding-Badarpur Hill section. The diversion of trains between Lumding and Badarpur necessitated the utilisation of alternative routes and cancellation leading to chaos and inconvenience to passengers.
- Significant destruction to the infrastructure, including the railway tracks, bridges, and signalling systems have been reported resulting in economic losses.
- The alteration of land use as a result of slope deformation, thus posing a potential hazard for future landslides and requiring the modification of pathways.

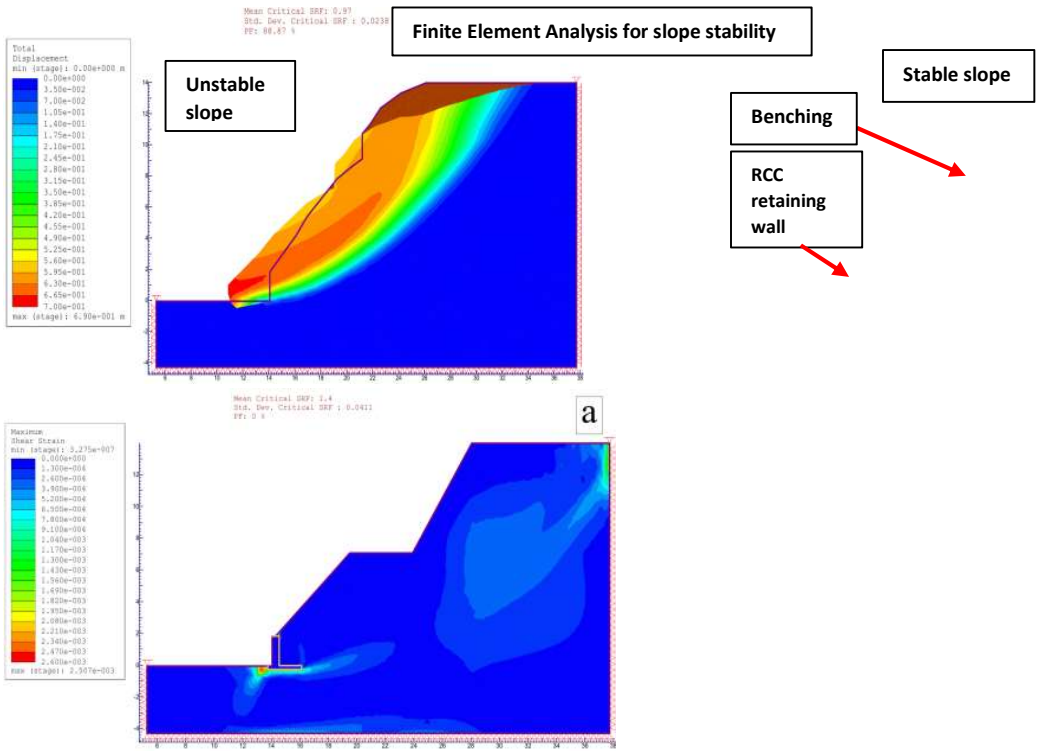
Developments in railway infrastructure

- Railway to implement IDS (Intrusion Detection System) for real time alerts on landslide for which vibration sensors in combination with optical fibre cable will be laid in trench depending on geotechnical inputs and site condition (ANUBHAV, 2023).
- Alert system on a hand-held device for prompt action by Loco pilots.

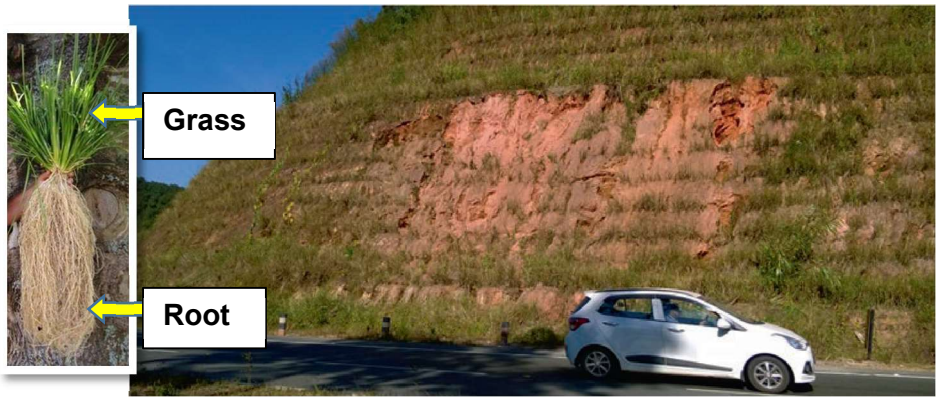
Landslide mitigation measures

The mitigation measures are as accordance with Guidelines/ Specification provided by Research Designs & Standards Organisation (RDSO), Ministry of Railways, Govt. of India (2020).

1. Proper field investigation of its engineering geology and geotechnical aspects such as rock mass characterisation, structural geology, rock and soil properties, shear strength, weathering properties and numerical modelling of slopes (Finite Element Analysis & Distinct Element Analysis) will be u up for systematic assessment of sliding at site specific scale.



2. Rockfall and debris fall can be ceased using modified ditch design based on site specific condition.
3. Slopes potential of having toe sliding can be installed with RCC retaining wall. Channelling of percolated water by weep holes can be done.
4. Surface run-off water should be directing out from the vulnerable slope.
5. Use of Soil nails /Rock bolts for anchorage can be done. Also wherever possible soil slope trimming and slope benching with vetiver grass plantation can be implemented according to the site condition.



Use of Vetiver grass in the cut-slope – affordable and naturally stabilised

Nailing of slope – requires high skills and site specific measures

6. Use of Geotextiles as drainage cum reinforcement along with Vetiver grass – require great skills in identifying the site and portended danger if not implemented properly

Conventional structural work and vetiver planting in progress, November 2012

Same site totally stabilized, May 2014

Casis erosion project in Congo-Brazzaville where at least 900,000 vetiver slips were used

KM 61/3-4

Issues

Bank erosion up to edge of the sleeper. Toe area collapsed

Probable solution

- Refilling of the Scarp with debris followed by covering of soil.
- Benching of the embankment. (IS 14680: 1999)
- Plantation of Vetiver grass.

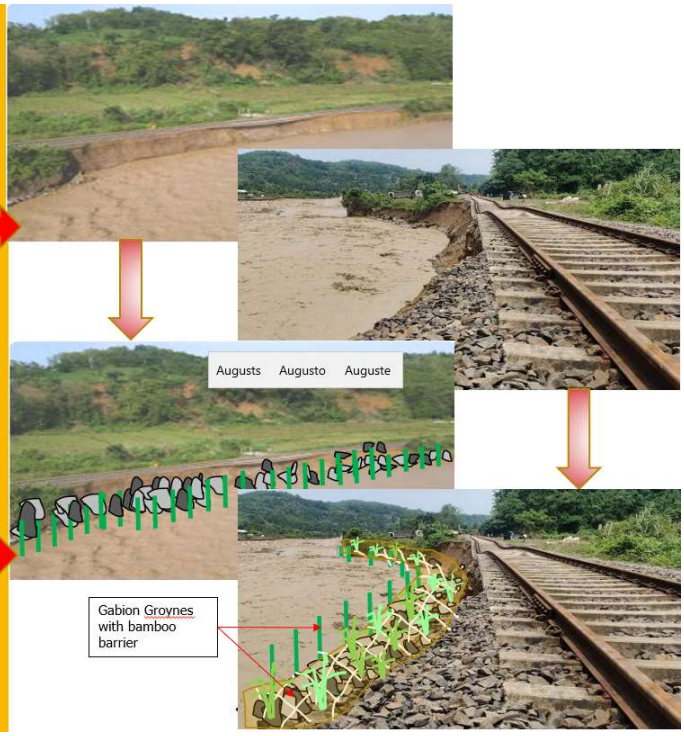
KM 66/2-4

Issues

Intense river bank erosion with embankment failure.

Probable solution

- Gabion structure along the toe of the embankment. (IS 14262: 1995)
- Use of Geogrid. (IS 14680:1999)
- Refilling of embankment overlaying the Gabion Groynes.
- Bamboo logs installation to stabilize Groynes.
- Plantation of Vetiver grass



Target Group

The targeted groups for the upkeep and maintenance of critical railway and road infrastructure in the North East Frontier Railways encompass a diverse group, including engineers and staff from various organizations. This collective effort involves dedicated professionals from North East Frontier Railways, NHIDCL (National Highways and Infrastructure Development Corporation Limited), NHAI (National Highways Authority of India), PWD (Public Works Department), and Brahmaputra Board. Together, these individuals contribute their expertise and efforts to ensure the optimal functioning and resilience of essential transportation networks, vital for the connectivity and development of the region.

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ANNEXURE III: PHOTO GALLERY

ANNEXURE IV: POST TRAINING IMPACT

This visual narrative serves as a compelling testimony to the tangible impacts of the training program, highlighting the transformative influence of informed strategies on landscapes and their ability to mitigate environmental challenges. The flourishing Vetiver Grasses stand as a vivid testament to the program's effectiveness in not only addressing but also remedying the ecological vulnerabilities inherent in the slopes. This visual story captures the journey from knowledge acquisition to on-the-ground application, showcasing how a well-informed approach can yield concrete and sustainable results. The thriving Vetiver Grasses symbolize not just the growth of vegetation but the resilience and vitality instilled in the very fabric of the environment through strategic interventions—a powerful illustration of the positive ripple effects generated by informed ecological restoration efforts.

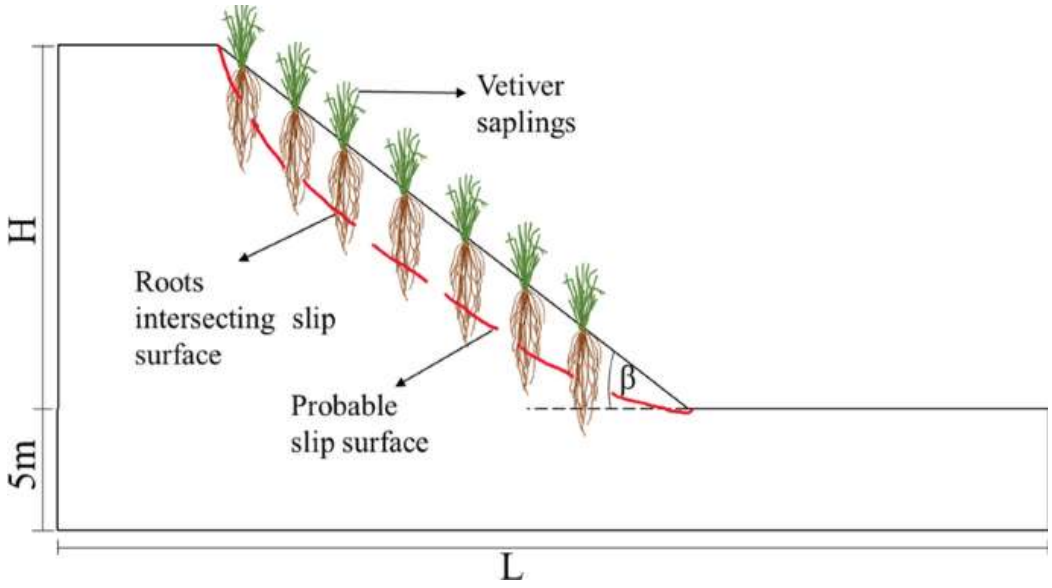

Figure: Schematic diagram for Vetiver Grass Plantation

ANNEXURE V: LIST OF PARTICIPANTS

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