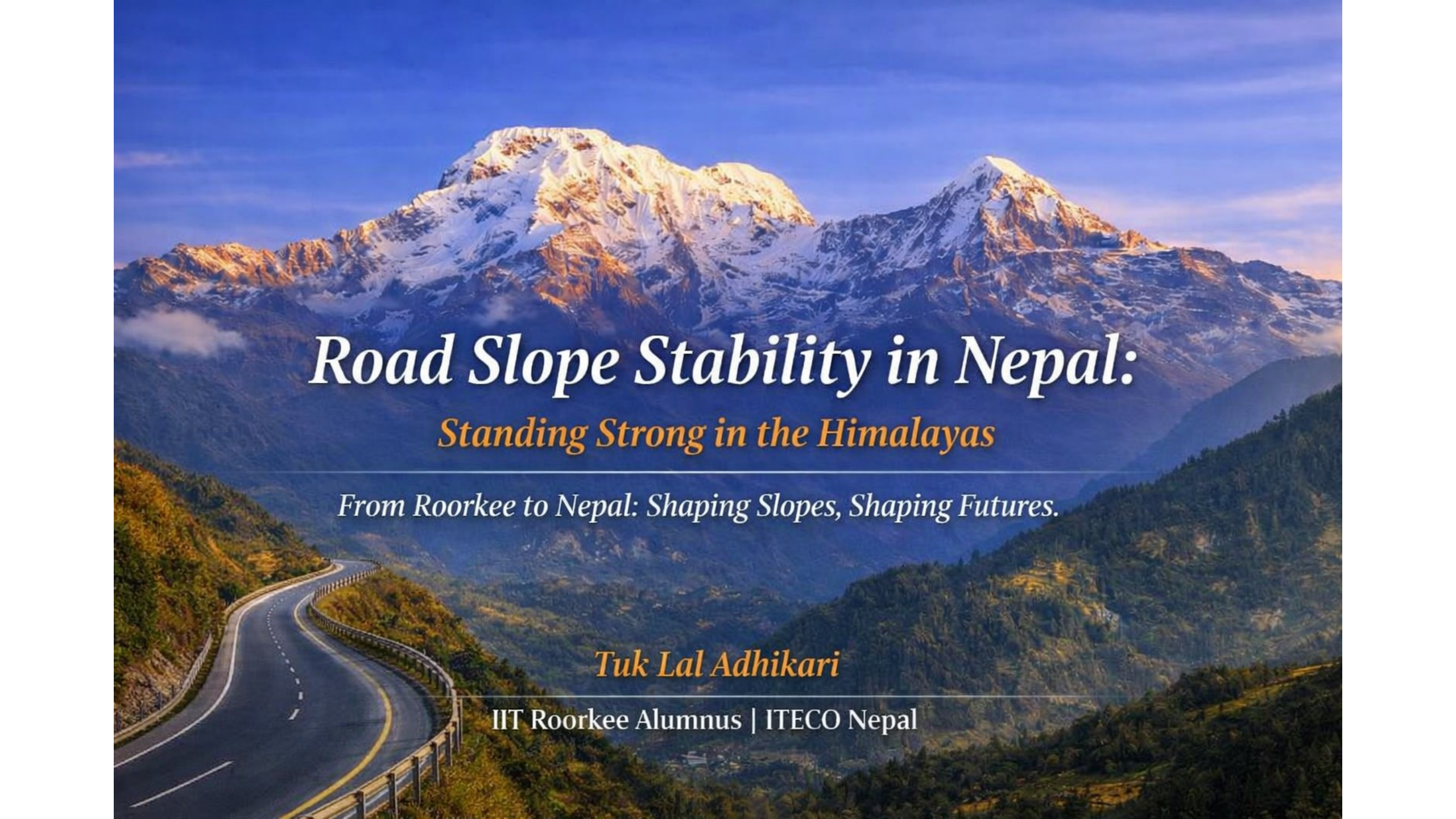




Road Slope Stability in Nepal: *Standing Strong in the Himalayas*

From Roorkee to Nepal: Shaping Slopes, Shaping Futures.

Tuk Lal Adhikari

IIT Roorkee Alumnus | ITECO Nepal

Content

Context

- Why Slope Stability Matters
- Himalayan Fragility
- Human Factors
- Nepal Road Network
- Historical Practices

Projects and Resilience

- Landmark Projects
- Charnawati Rehabilitation Project
- Araniko Highway
- Seismic Resilience

Leadership and Advances

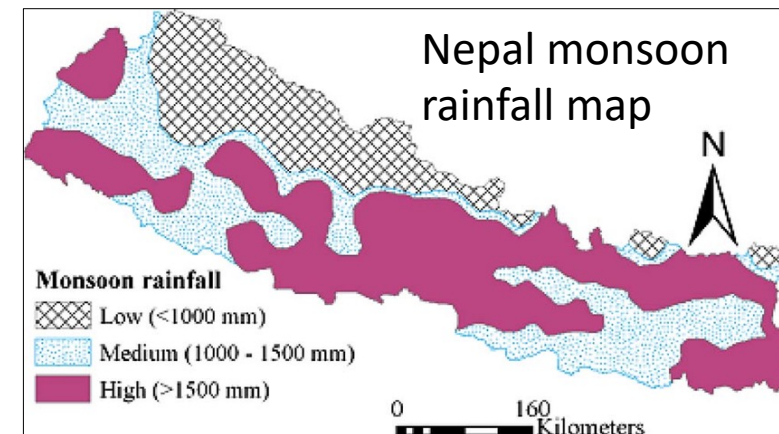
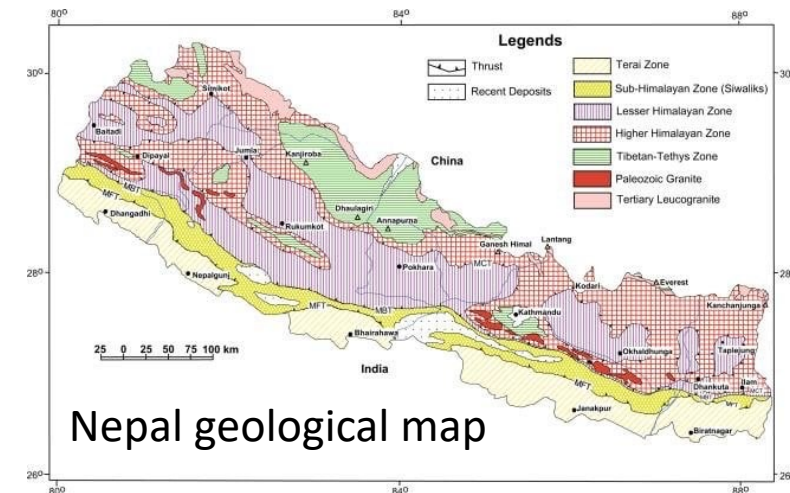
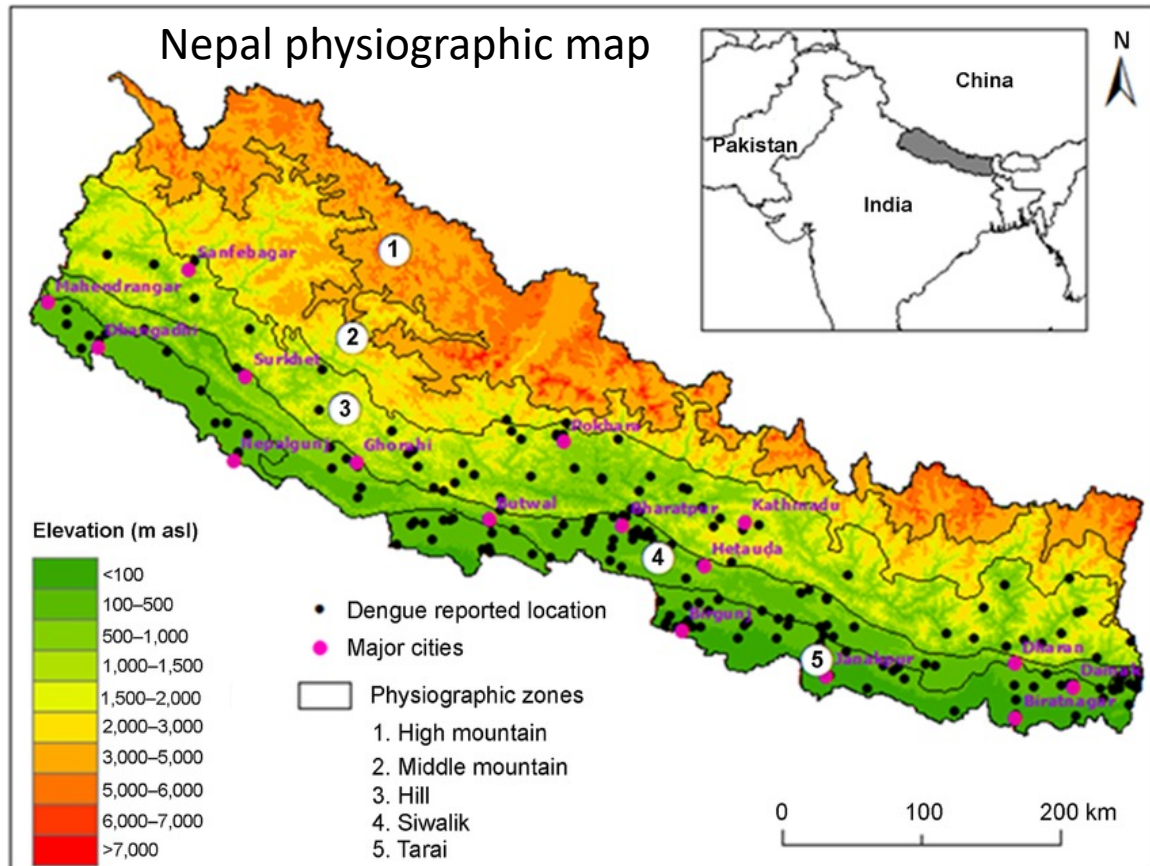
- Regional Leadership
- Technical Advances
- Nepal's Edge
- Technical References with Regional Impact

Closing Slides

- Innovations / Transfer of Knowledge
- Conclusions and Alumni Contribution

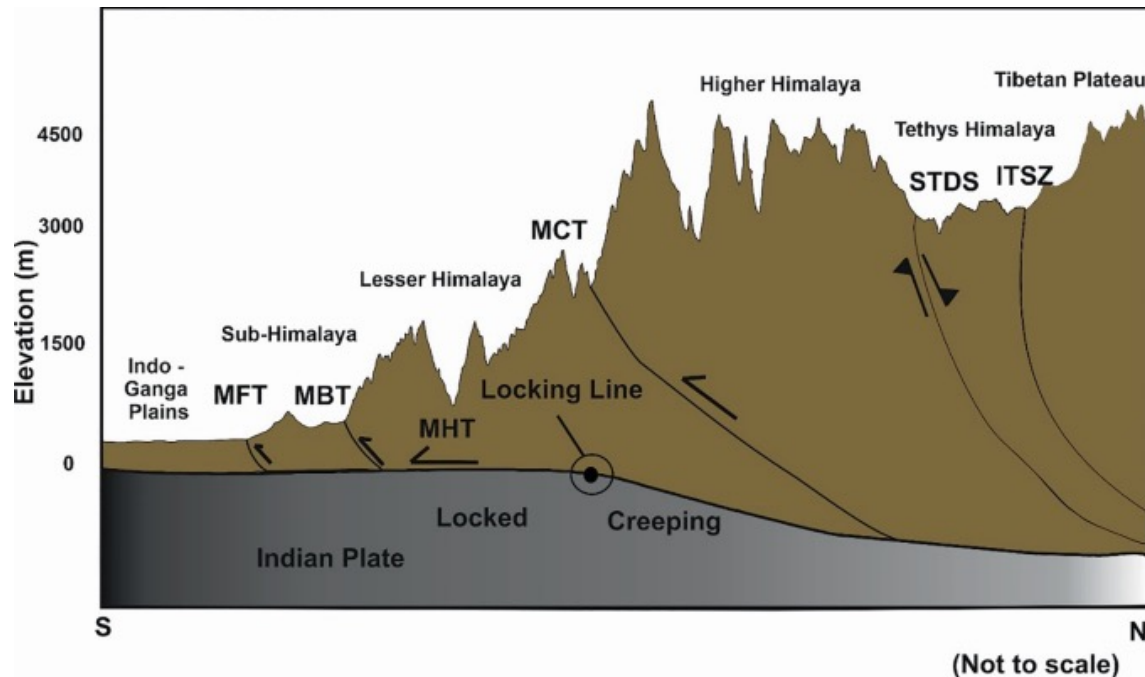
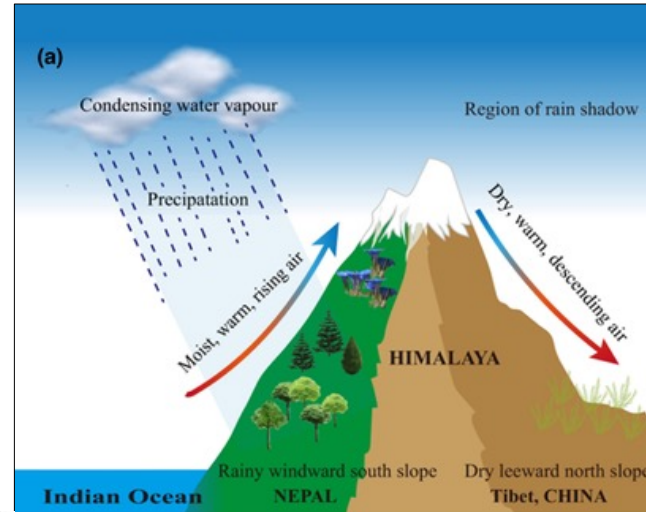
Why Slope Stability Matters?

- ❑ Most of Nepal's hills/mountains are landslide-prone
- ❑ Monsoon rainfall + fragile geology = high risk
- ❑ Slope stability is central to resilience



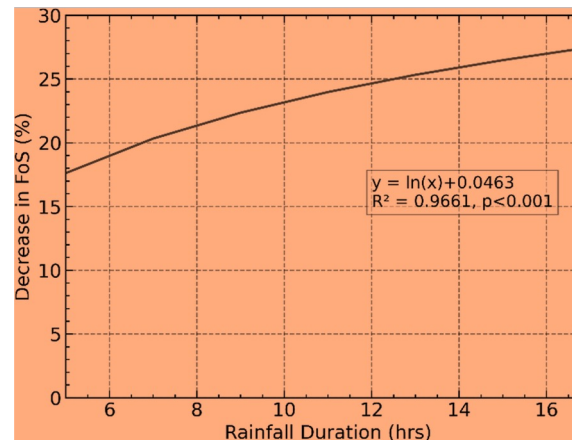
Himalayan Fragility

- ❑ Young Himalayas, tectonic uplift, seismicity
- ❑ Steep slopes, soft soil, intense rainfall
- ❑ Natural susceptibility to landslides

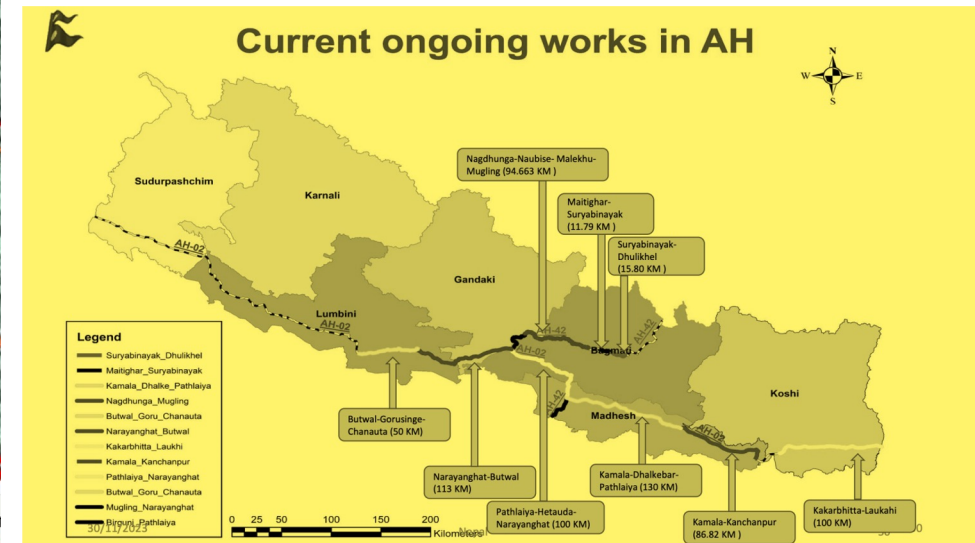
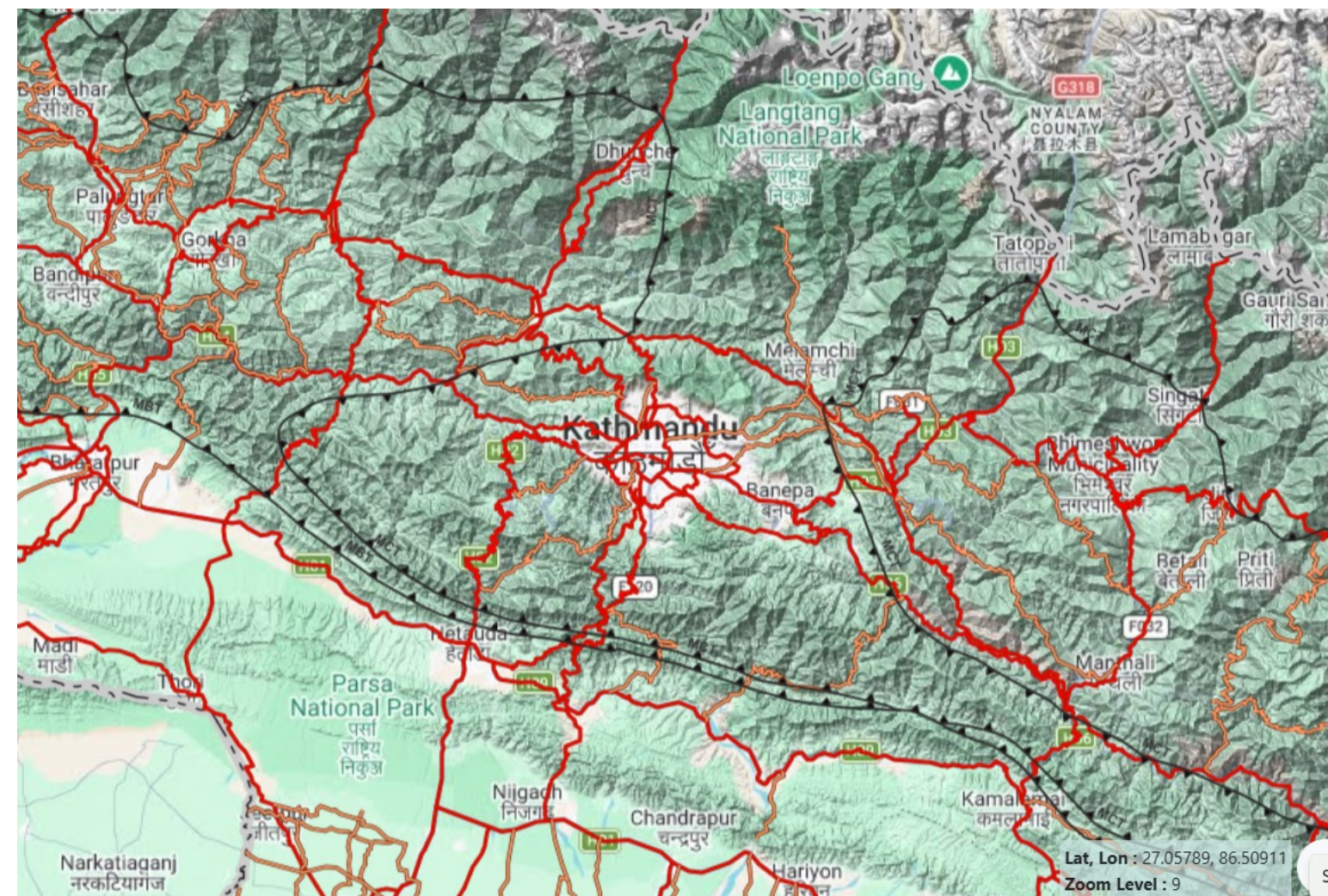


Human Factors

- ❑ Haphazard road cutting and slope excavation
- ❑ Unplanned settlements and deforestation
- ❑ Weak drainage and poor construction practices



Nepal Road Network



Historical Practices

- ❑ Gabion walls and bioengineering vegetation
- ❑ Early stabilization methods, low-cost but limited
- ❑ Foundation for later geotechnical advances



Landmark Projects

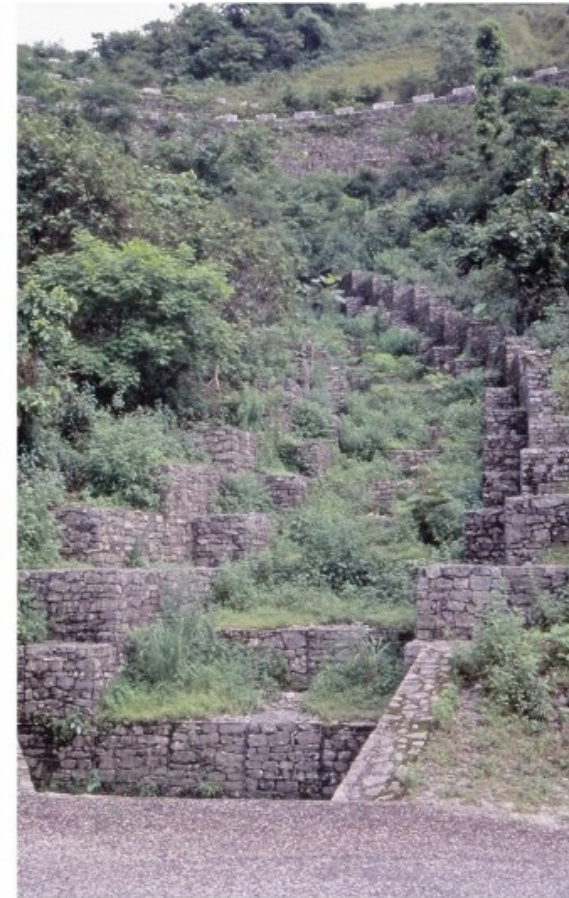
- ❑ Dharan–Dhankuta Road: environment-friendly construction
- ❑ Lamosangu–Jiri Road: pioneering Landslide Infestation, Design and Implementation of slope stabilization, river training, drainage and bioengineering
- ❑ Set precedent for slope management



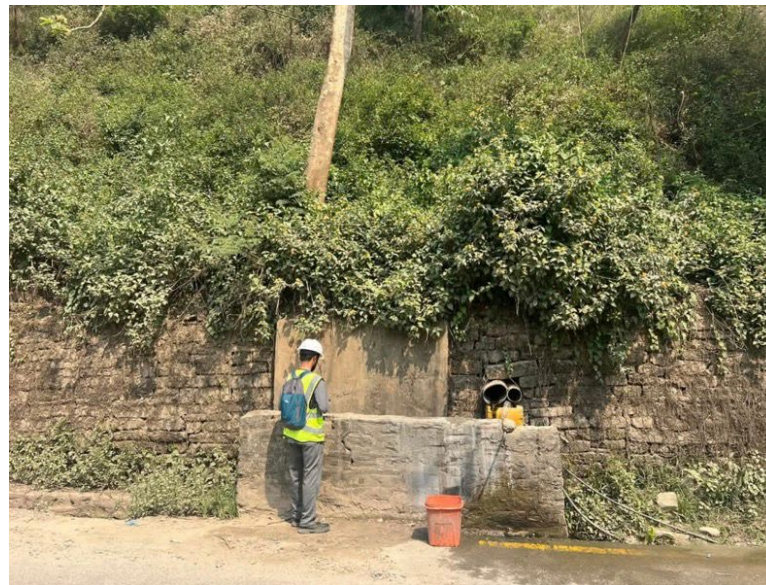
a) Gabion retaining walls to support unstable slopes



b) Extensive use of gabion retaining walls to support road fill and revetments to protect cut slopes

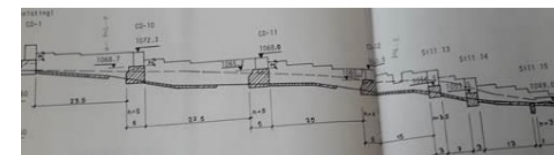
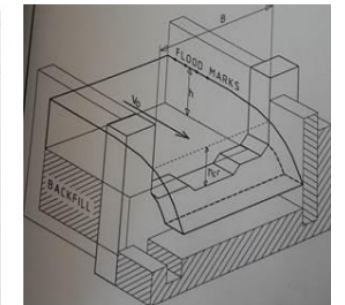
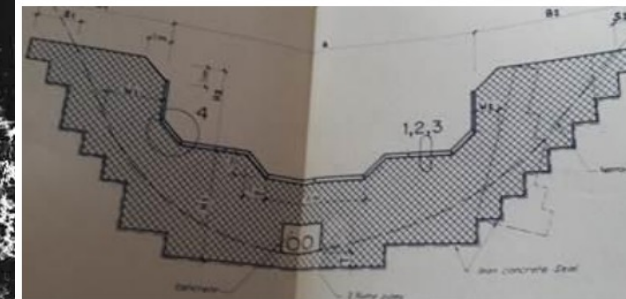
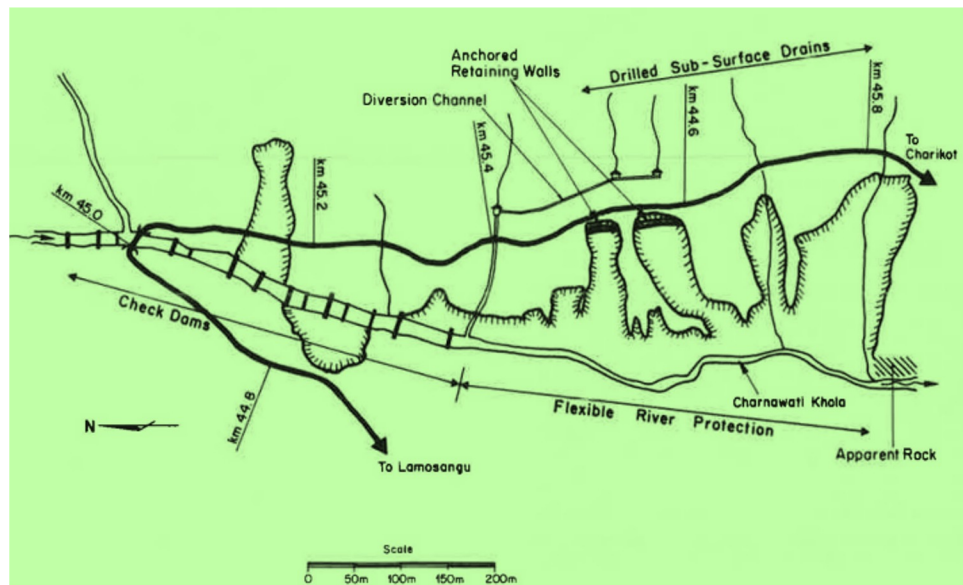
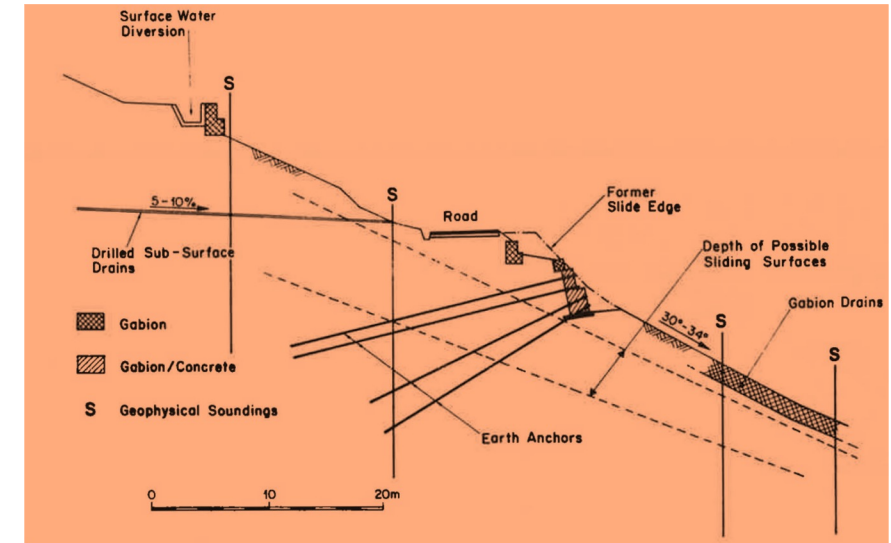


c) Continuous gabion cascade protecting central drainage line from scour



Charnawati Rehabilitation Project

- ❑ Introduced French drains, soil nails, anchored walls
- ❑ Integrated river protection and slope stabilization
- ❑ Milestone in innovative geotechnical works

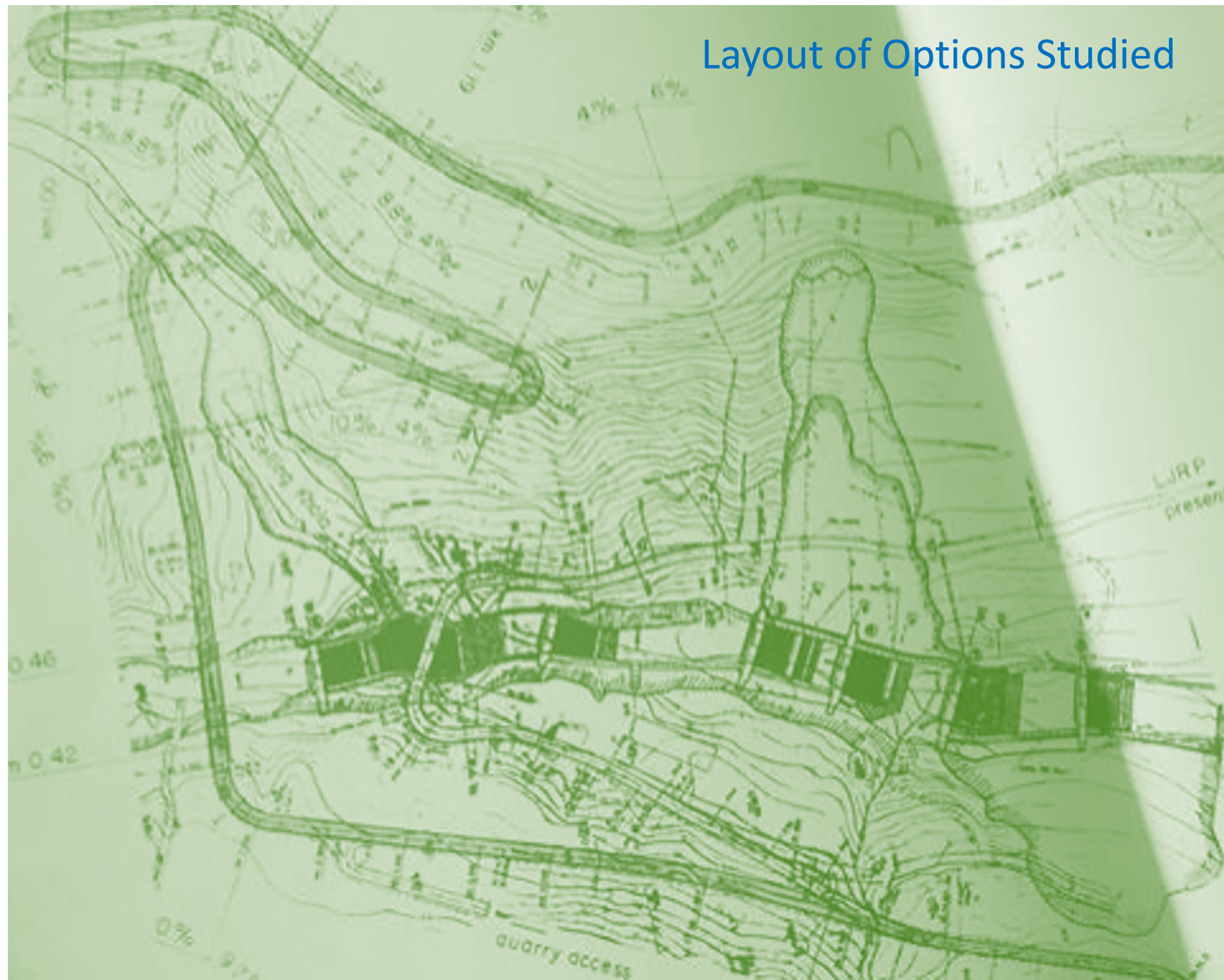


Disaster at Charnawati Valley

31 July – 01 August 1987



Layout of Options Studied





Concrete Armor Bands

Design based on hydraulic model test conducted at FAW (Flussbau und Wasserbau) at ETH Zurich, Switzerland

Topography and boulders were modeled in scale 1:40 for varying discharges up to 120 cumecs.

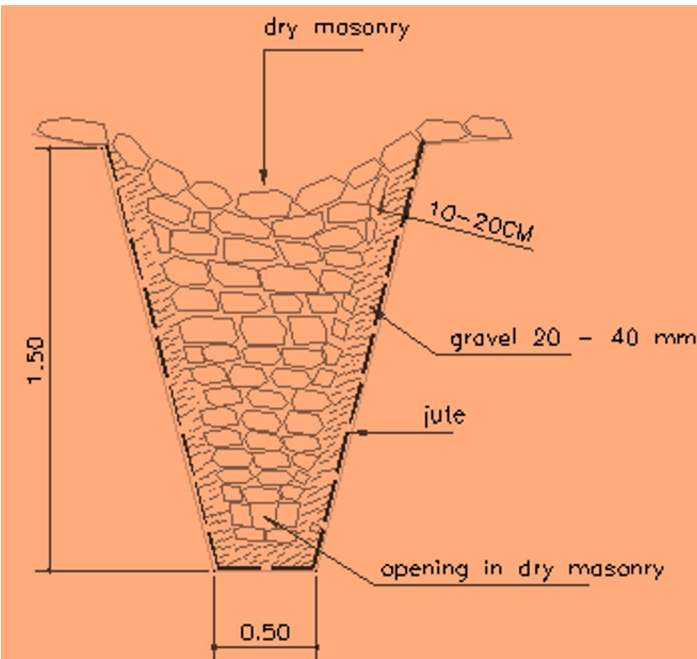




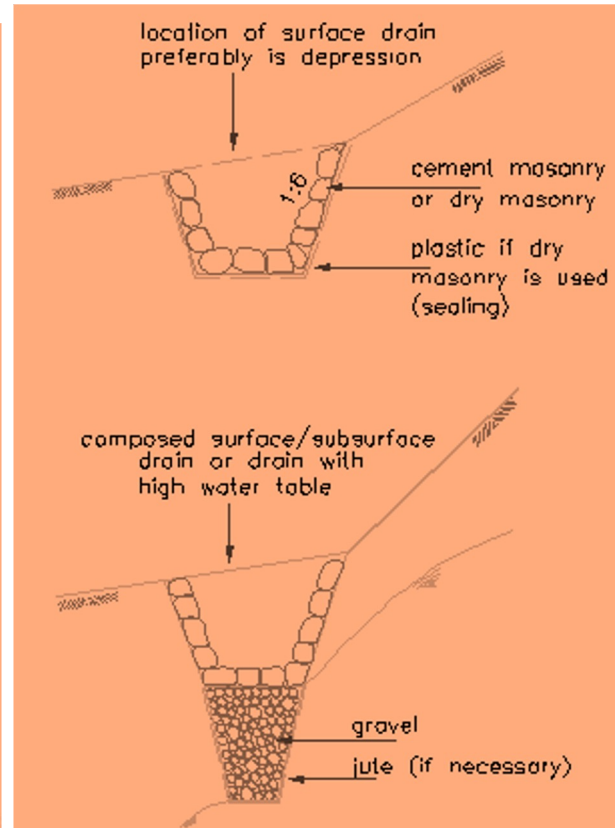
Status
Charnawati
of Works



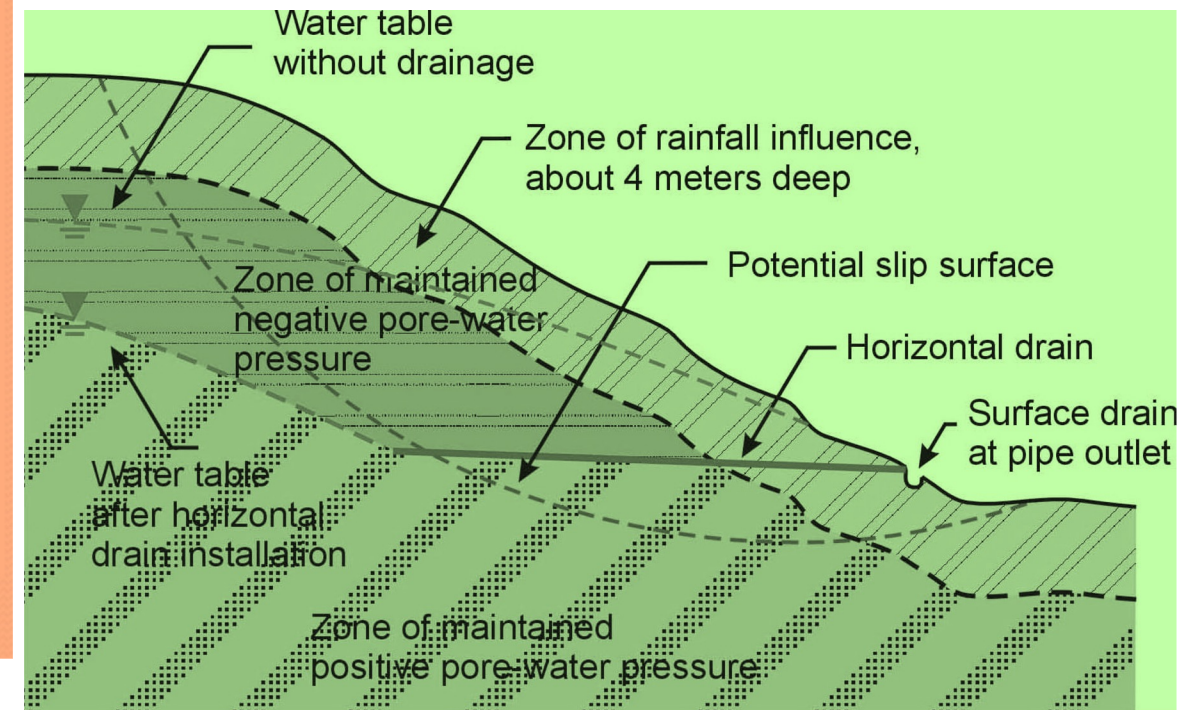
Drainage Measures



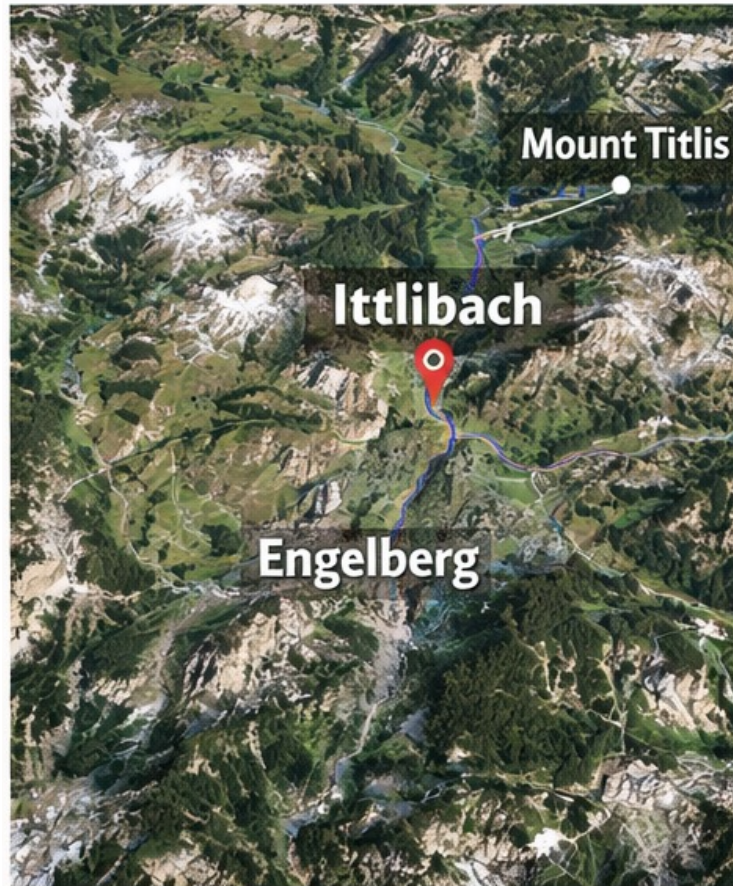
French Drain



Lined Catch Drain



Charnawati, Nepal vs Ittlibach, Switzerland

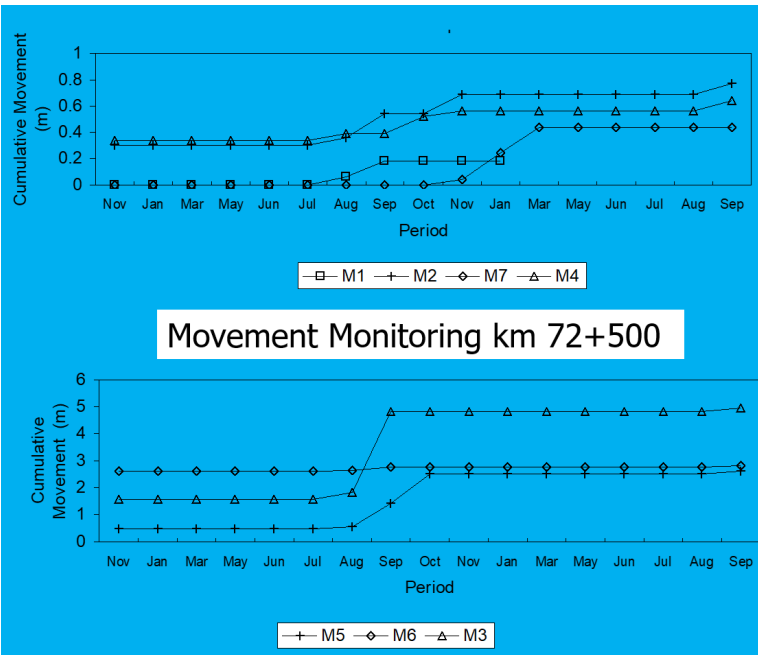
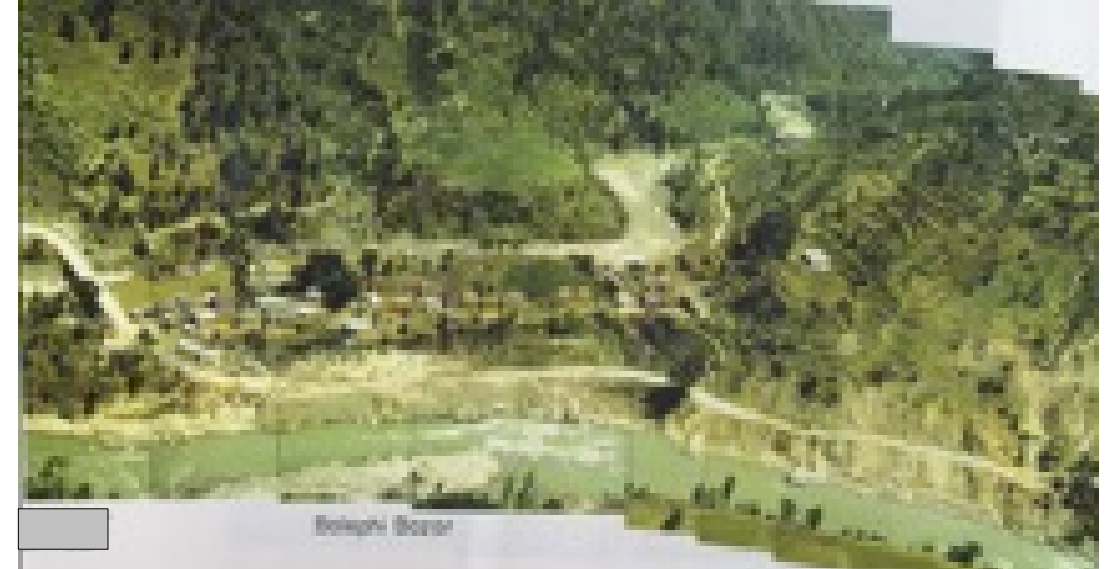


- Both debris flow events happened in 1987
- Model tested at FAW, ETH, Zurich
- Mitigation measures similar: check dams, guide walls, debris flow barriers, bioengineering

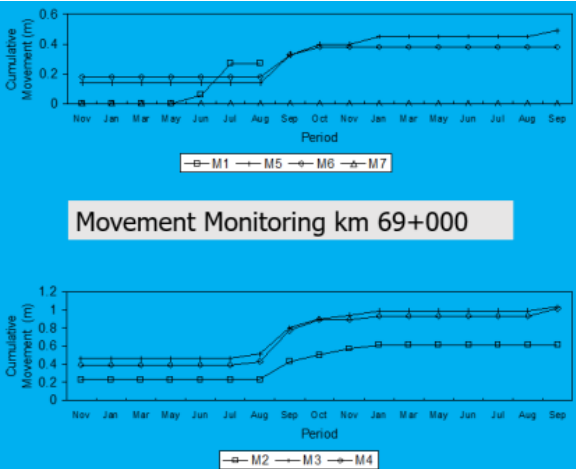
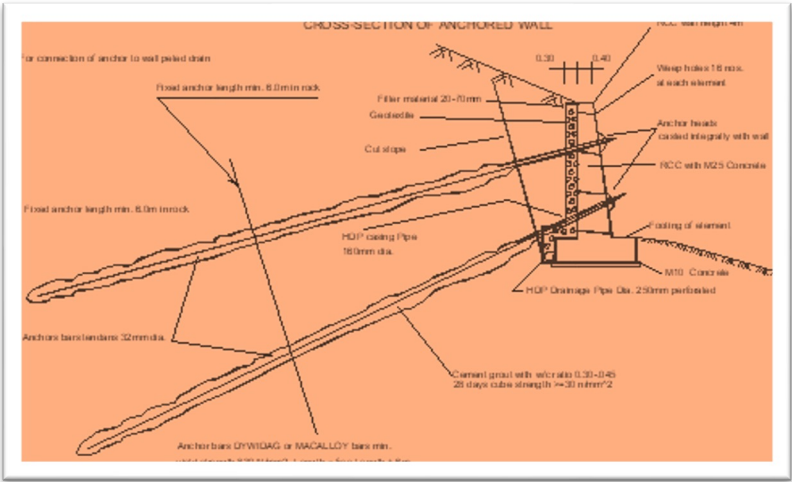


Araniko Highway

- ❑ Ten slides stabilized during 1991-93
- ❑ French drains, horizontal drains, soil nails and gabions extensively used
- ❑ Solutions showed resilience in Gorkha Earthquake 2015



Araniko Highway 69 km



Seismic Resilience

Stabilized Slides Located Within Zone of Gorkha Earthquake 2015

❑ Lamosangu-Jiri Road

❑ Charnawati

Rehabilitation Project

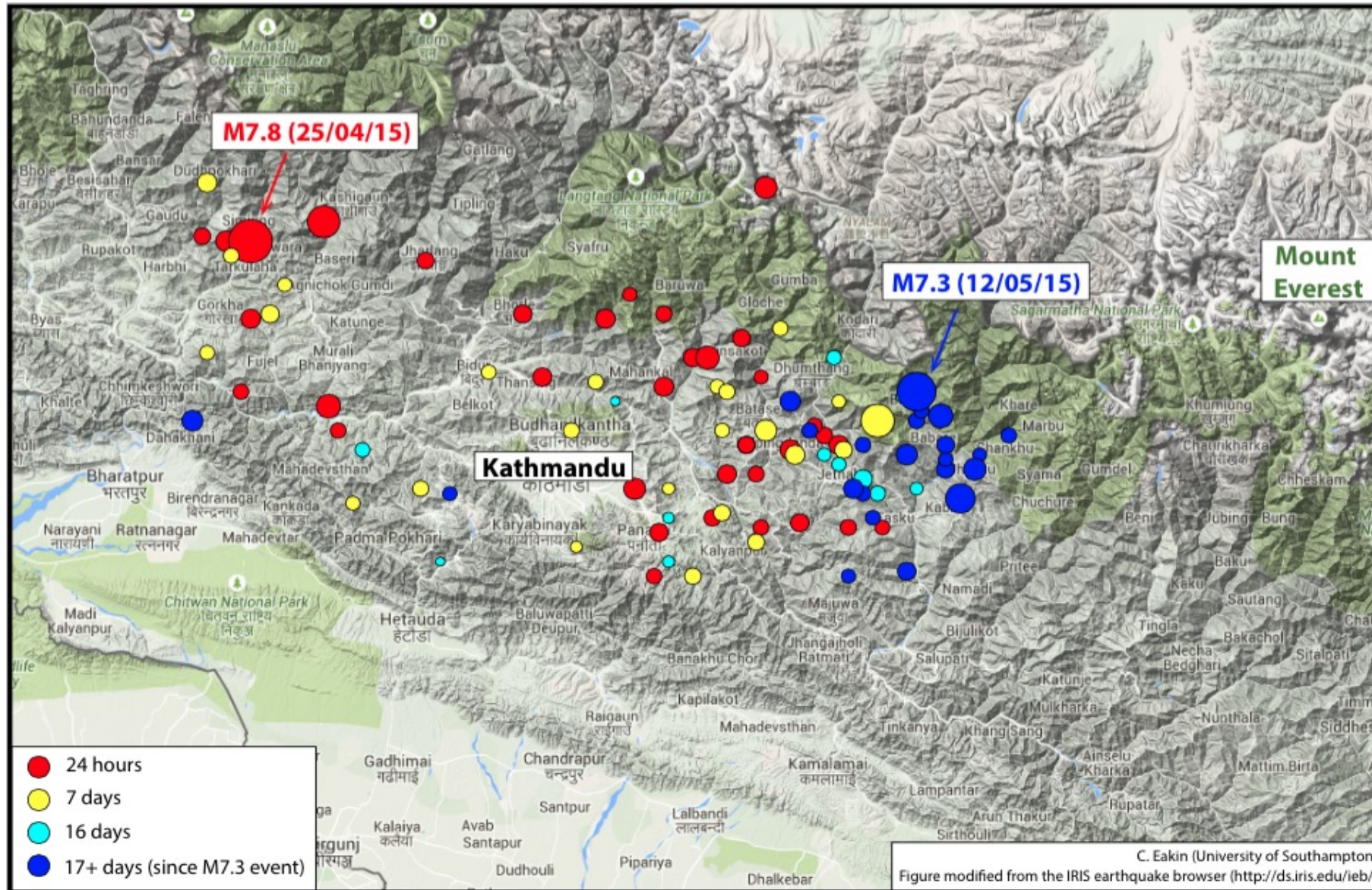
❑ Arniko Highway (km 62-87)

❑ Thankot-Naubise Road

❑ Tribhuwan Rajpath

❑ Prithvi Highway
(Naubise-Mugling)

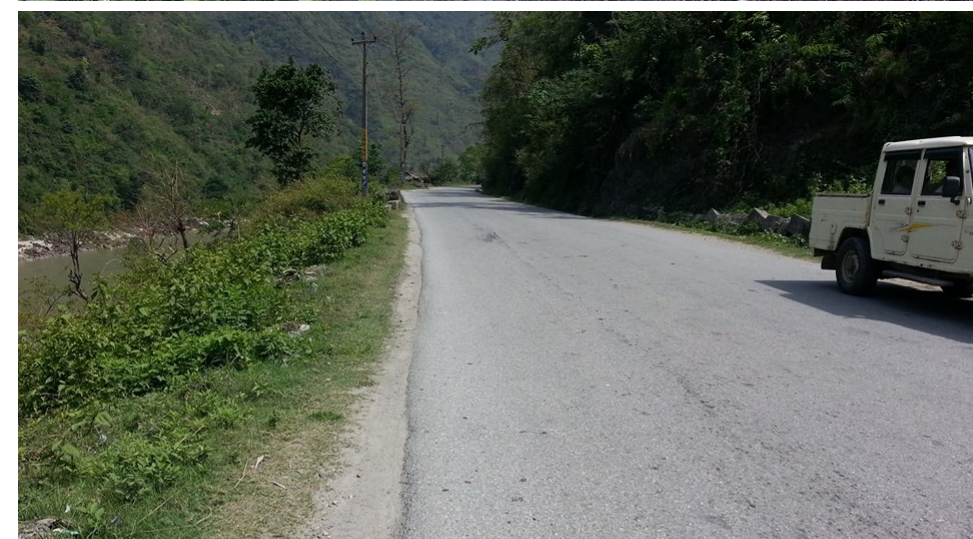
❑ Narayanghat-Mugling Road



Narayanghat-Mugling Road



km 17
Anchored
Retaining
Wall



Tribhuwan Rajpath



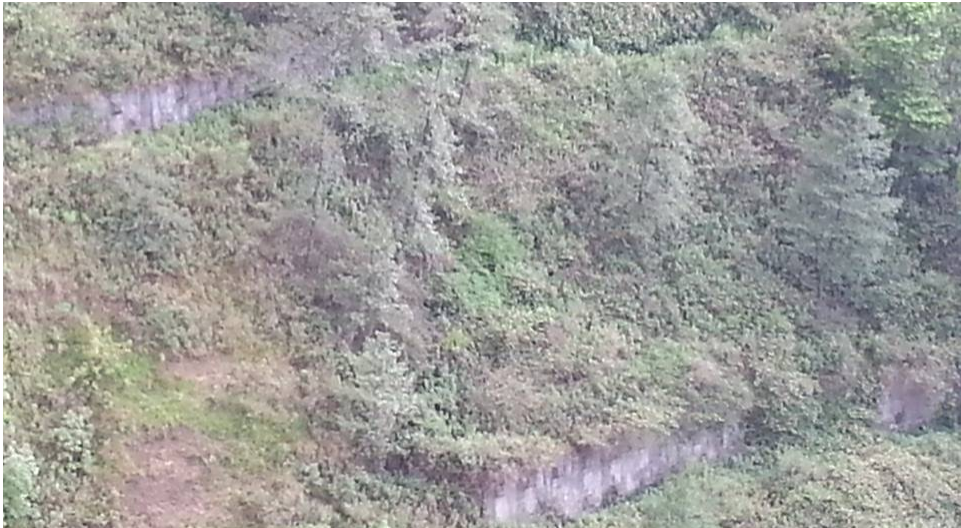
Lamidanda
Landslide
Protection
Works



Thankot-Naubise Road



Khatripauwa Landslide
TN10A



Prithvi Highway



Krishnabhir
Landslide

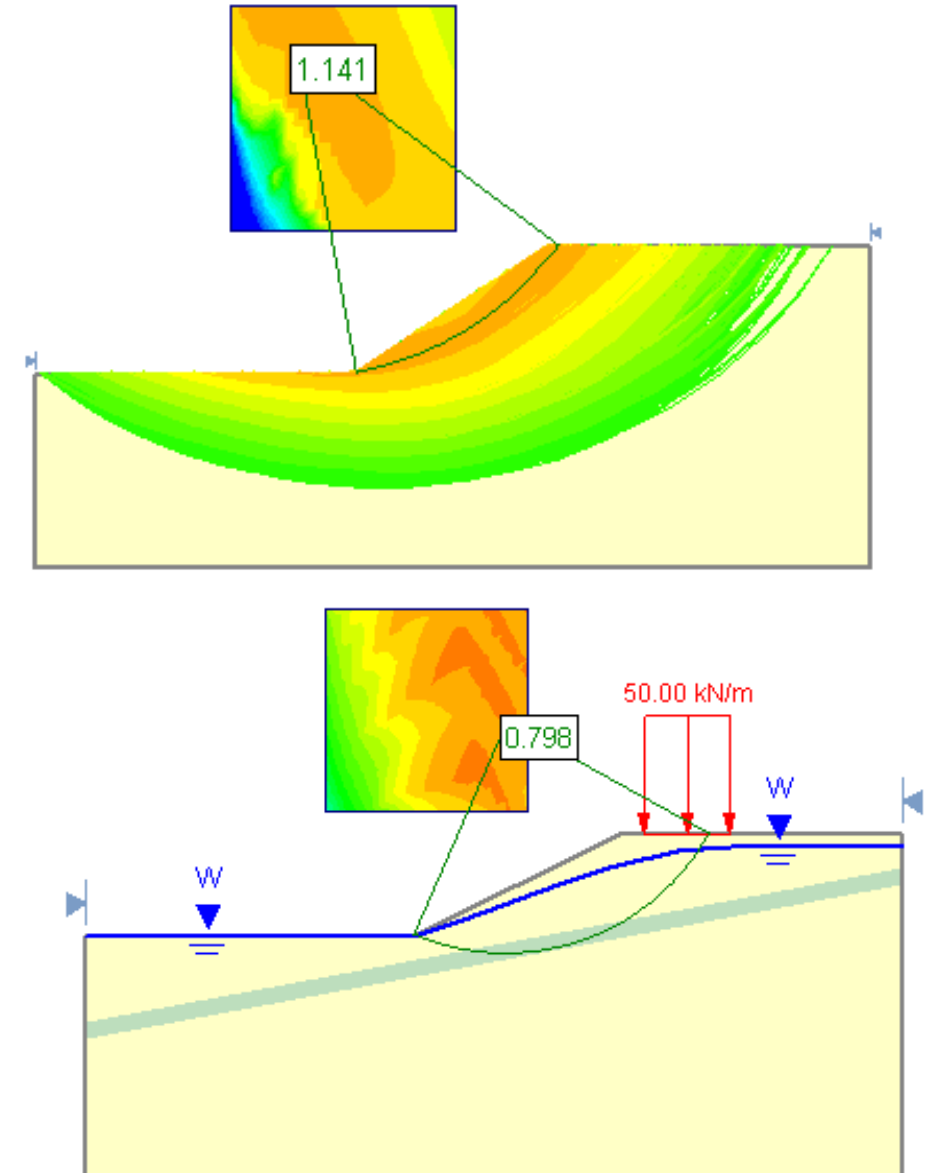


Regional Leadership

- ❑ Bhutan Lateral Highway: Nepalese experts exported anchored walls, horizontal drains, geophysical investigation techniques and bioengineering measures
- ❑ Techniques replicated in J&K and Mizoram of India and Bhutan
- ❑ Nepal stands high as a regional reference:
 - Bioengineering Handbook and Reference Manuals (two volumes) are benchmark documents in the Region
 - Mountain Risk Engineering Handbook (two volumes) are among the most comprehensive references in HKH region
 - “Guide to Slope Protection Work” and “Roadside Geotechnical Problems: A Practical Guide to Their Solution” are unique hand books published by DOR, Nepal
 - Charnawati Rehabilitation Project and Araniko Highway have served as the field laboratory to showcase Nepal’s successful slope stabilization solutions for numerous international trainings conducted by ICIMOD, WB and GON
 - Applied drainage, soil nails and bioengineering solutions have performed excellent and shown resilience in seismic event like Gorkha Earthquake 2015 of Mw 7.8
 - Geo-Environment and Social Unit initiatives in DOR, Nepal
 - Blend of bioengineering and geotechnical solutions, not one solution

Technical Advances

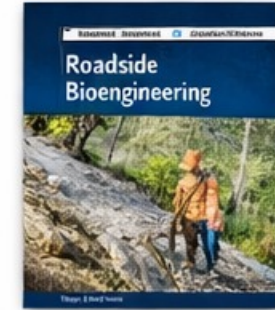
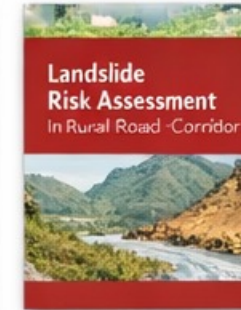
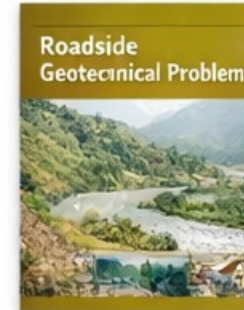
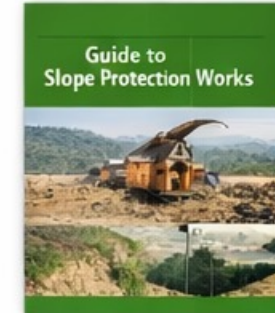
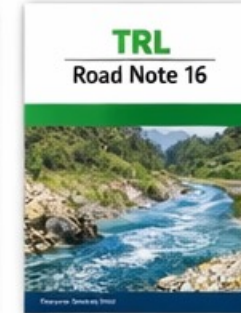
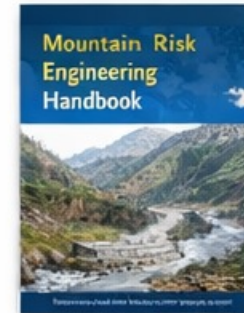
- ❑ Nepal has demonstrated state-of-the-art tools and techniques in slope stability management:
 - Limit Equilibrium Method with Slide or other software
 - Finite Element Method with shear strength reduction with RS2 or Plaxis software
 - GIS-based landslide susceptibility mapping
- ❑ Nepal's Edge:
 - Fusion of bioengineering + geotechnical measures
 - Affordable, sustainable, regionally admired
 - Unique model for mountain roads



Technical References with Regional Impact

Document	Highlights	Regional Impact
Mountain Risk Engineering Handbooks (ICIMOD, 1991)	Two volumes: <i>Background and Applications</i> . Edited by B. Deoja, M. Dhital, B. Thapa, A. Wagner. Includes case studies from Arniko Highway and Lamosangu–Jiri Road.	Benchmark for HKH region; widely cited in mountain risk engineering research.
TRL Road Note 16 (1997)	<i>Principles of Low-Cost Road Engineering in Mountainous Regions, with Special Reference to the Nepal Himalaya</i> .	Adapted globally for mountain road construction; shaped Nepal’s environmentally sensitive road policies.
Guide to Slope Protection Works (DoR Nepal, 2016)	Practical manual for engineers; integrates drainage, bioengineering, and geotechnical measures.	Official guideline for Nepal’s Department of Roads; replicated in Bhutan and India.
Roadside Geotechnical Problems: A Practical Guide (DoR Nepal, 2007; updated 2023)	Developed with DHV Consultants, CMS Nepal, and ITECO Nepal. Provides solutions for landslide-prone corridors.	Institutional strengthening tool; supported by World Bank and Japan’s Quality Infrastructure Partnership.
Landslide Risk Assessment in Rural Road Corridor (DFID, 2001–2003)	Guidelines for hazard mapping and risk assessment in Nepal and Bhutan.	Equipped planners with rapid mapping techniques; improved rural road safety.
Roadside Bioengineering Handbooks (Nepal–UK Road Maintenance Project, 1990s)	Reference Manual and Site Handbook; detailed methods for vegetation-based stabilization.	Regional benchmark; trained engineers across HKH countries.
Small-Scale Drainage and Bioengineering Measures for Slope Stabilization (2023)	Combines vegetation with civil structures; cost-effective solutions for shallow-seated instability.	Admired for affordability and sustainability; replicated in community-based projects.

Innovations & Knowledge Transfer in Slope Stability



☑ Replication & Resilience

- Technologies replicated across SRN.
- Resilient during the 2015 Gorkha Earthquake.

☑ Knowledge Transfer

- Manuals & handbooks as regional benchmarks.
- Dissemination from projects to academia & industry.

☑ Future Commitment

- Import, adapt & scale proven technologies.
- Embed knowledge transfer in every project design.

Nepal's Edge = Innovation + Knowledge Transfer → Regional Leadership

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Standing Strong in the Himalayas

From Roorkee to Nepal: Shaping Slopes, Shaping Futures.

Conclusions

- Stabilization/mitigation measures survived the Gorkha earthquake
- Minor damages manageable with recurrent/emergency maintenance
- Measures performed well over 20–30 years lifespan
- Knowledge transfer enabled Nepalese experts/contractors to design & implement
- Replication across SRN roads and beyond Nepal

Alumni Contribution

- Knowledge transfer & mentorship for young engineers
- Pride in Nepal's leadership in slope stabilization
- Inspiration for advanced studies in geotechnical engineering
- Acknowledged Alumni: Beni Madhav Lekhak, Sandip Shah, Basu Dev Pokhrel, Om Raut, Niaz Ahmad, Uttam Amatya, Mohan Ratna Shakya, Shiv Shankar Karki, Tuk Lal Adhikari etc.
- Acknowledged Institutions: SDC, WB, ADB, USAID, ICIMOD, DOR, DoLI, MoEWRI, ITECO Nepal

Thank you for your attention!