

Rockfall Mitigation on the Udhampur-Chenani Stretch of Jammu-Srinagar National Highway 44: Performance of Geosynthetic-Reinforced Embankments

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IIT JAMMU

Rockfall Protection Embankment (RPE)

Three dead in tragic rockfall incident near Pani Matha on Zojila Pass

A tragic accident occurred near Pani Matha Zojila when a heavy rock fell on an Alto car, resulting in the on-the-spot deaths of two individuals.

16 Jun 2024

Tribune India

Rockfall halts traffic on Ramban NH

The Jammu-Srinagar National Highway (NH) remained shut for hours due to heavy shooting stones in Ramban district on Monday.

17-Jan-2023

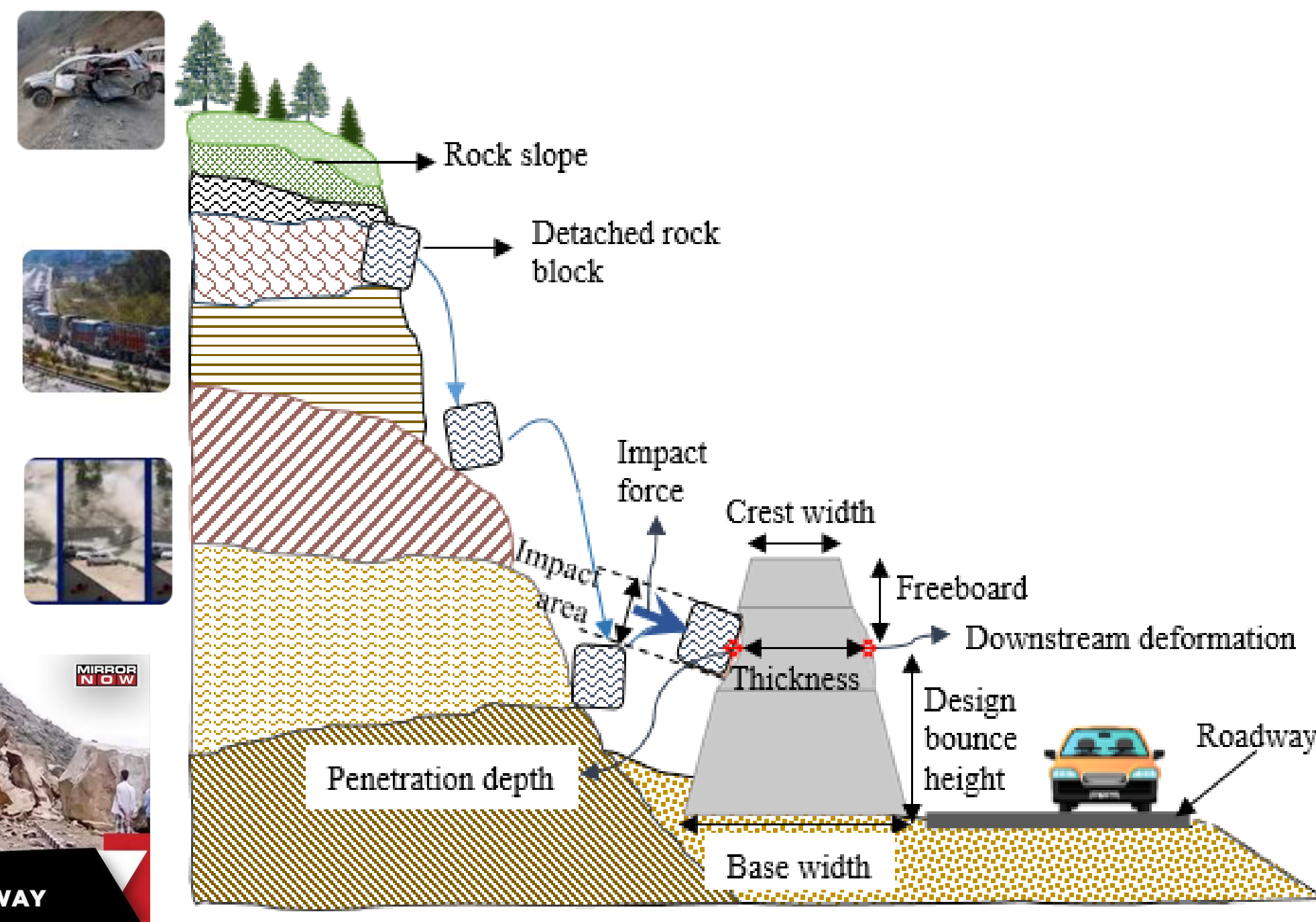
The Guardian

Nine dead after boulder destroys bridge in northern India ...

Video captures the moment a huge rockfall hit the Sangla valley in ... This article was amended on 26 July 2021 to correct the spelling of...

26-Jul-2021

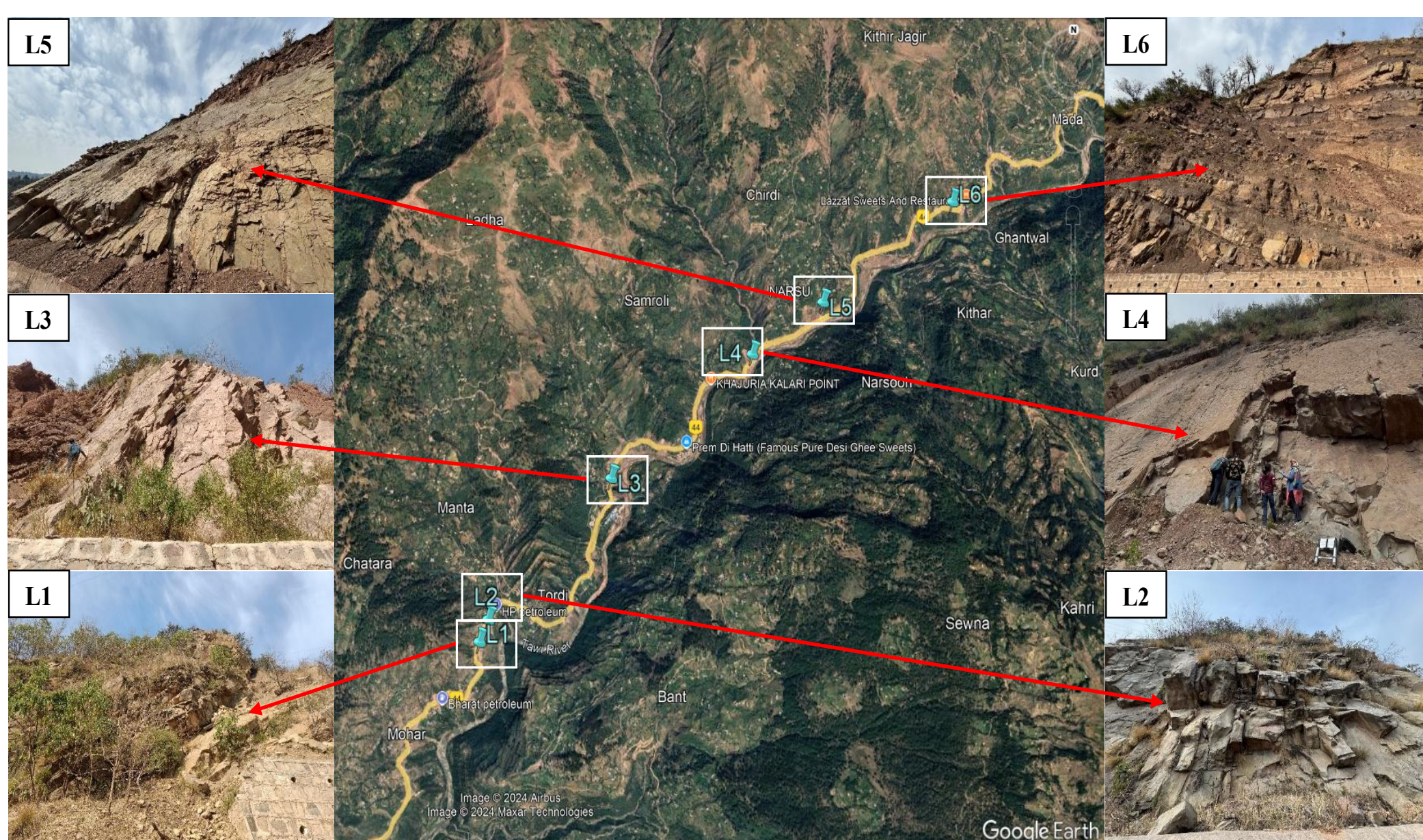
YouTube



Objectives

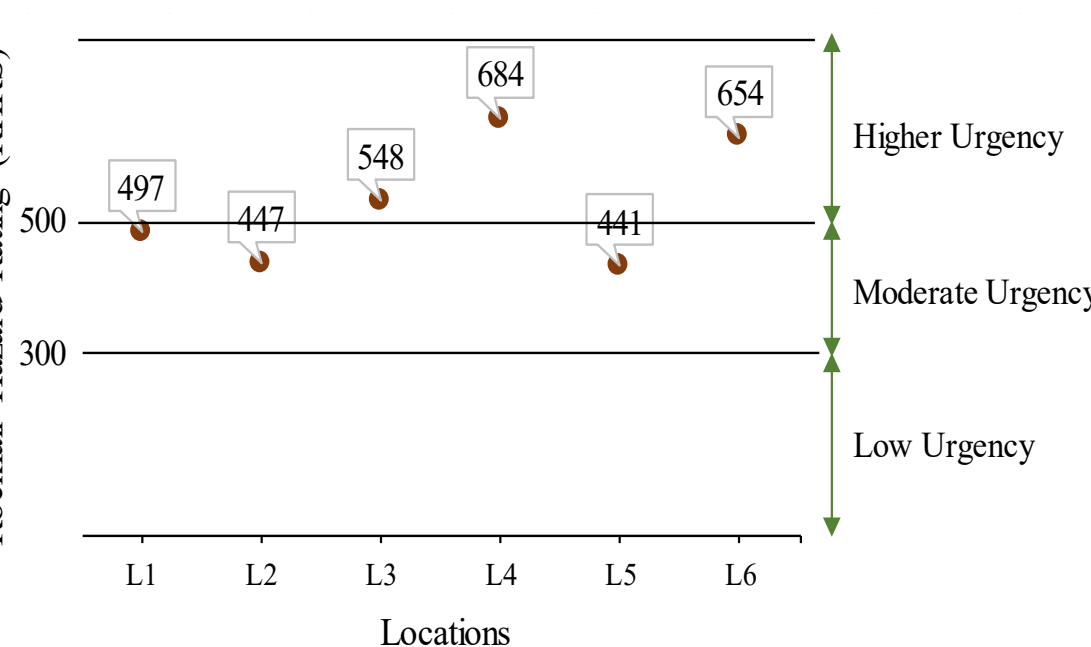
- To assess the rockfall vulnerability of 40 km stretch of Jammu-Srinagar National Highway NH-44 through detailed field investigations, structural geological assessments, and geomechanical characterization methods
- To analyze the trajectory of falling rocks at selected sites using lumped mass modelling and the influence of irregular rock shapes on rockfall trajectories using rigid body modelling
- To propose a comprehensive design methodology for rockfall protection embankments (RPEs) based on site-specific rockfall hazard conditions
- To investigate the impact performance of RPE under downward, horizontal, and upward impacts
- To evaluate the effectiveness of RPE under higher energy level impacts and at different impact locations
- To propose site-specific design improvements for RPE systems suitable for steep rockfall-prone areas

Site Investigation



40 km stretch of Jammu-Srinagar national highway NH-44

Rockfall Hazard Rating System (RHRS)



Laboratory Testing of Materials

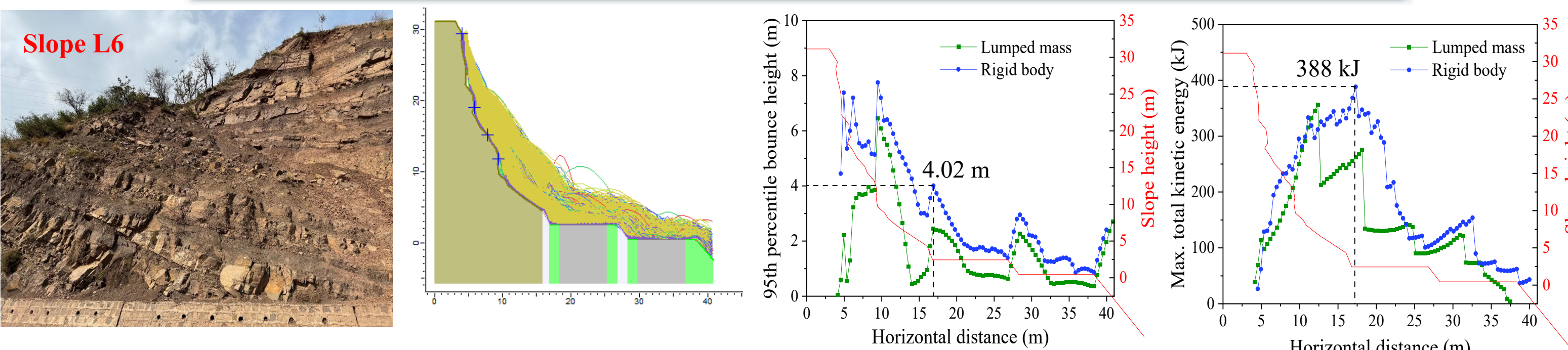
Slope no.	Dry density (kg/m ³)	Porosity	Point load index (MPa)	Uniaxial Compressive Strength (MPa)	Elastic modulus (GPa)	Secant modulus (GPa)	Poisson's ratio
L1	2364.5	0.0769	2.57	66.06	24.649	30.709	0.173
L2	2594.8	0.0222	6.79	30.21	17.685	17.239	0.439
L3	2608.3	0.0456	10.45	51.17	37.334	36.877	0.224
L4	2588.6	0.0234	7.5	42.4	17.831	22.739	0.158
L5	2496.8	0.0845	3.51	56.66	22.726	23.551	0.264
L6	2595.0	0.0344	10.31	86.85	51.097	40.687	0.132

Properties	Site 4	Site 6
Specific gravity	2.705	2.63
Maximum dry density (kN/m ³)	19.4	19.2
Minimum dry density (kN/m ³)	16.7	16.4
C _u	5.84	10.47
C _c	1.41	1.056
D ₁₀ (mm)	0.085	0.075
Classification	SP-SM	SW-SM
Angle of internal friction (°)	43	46

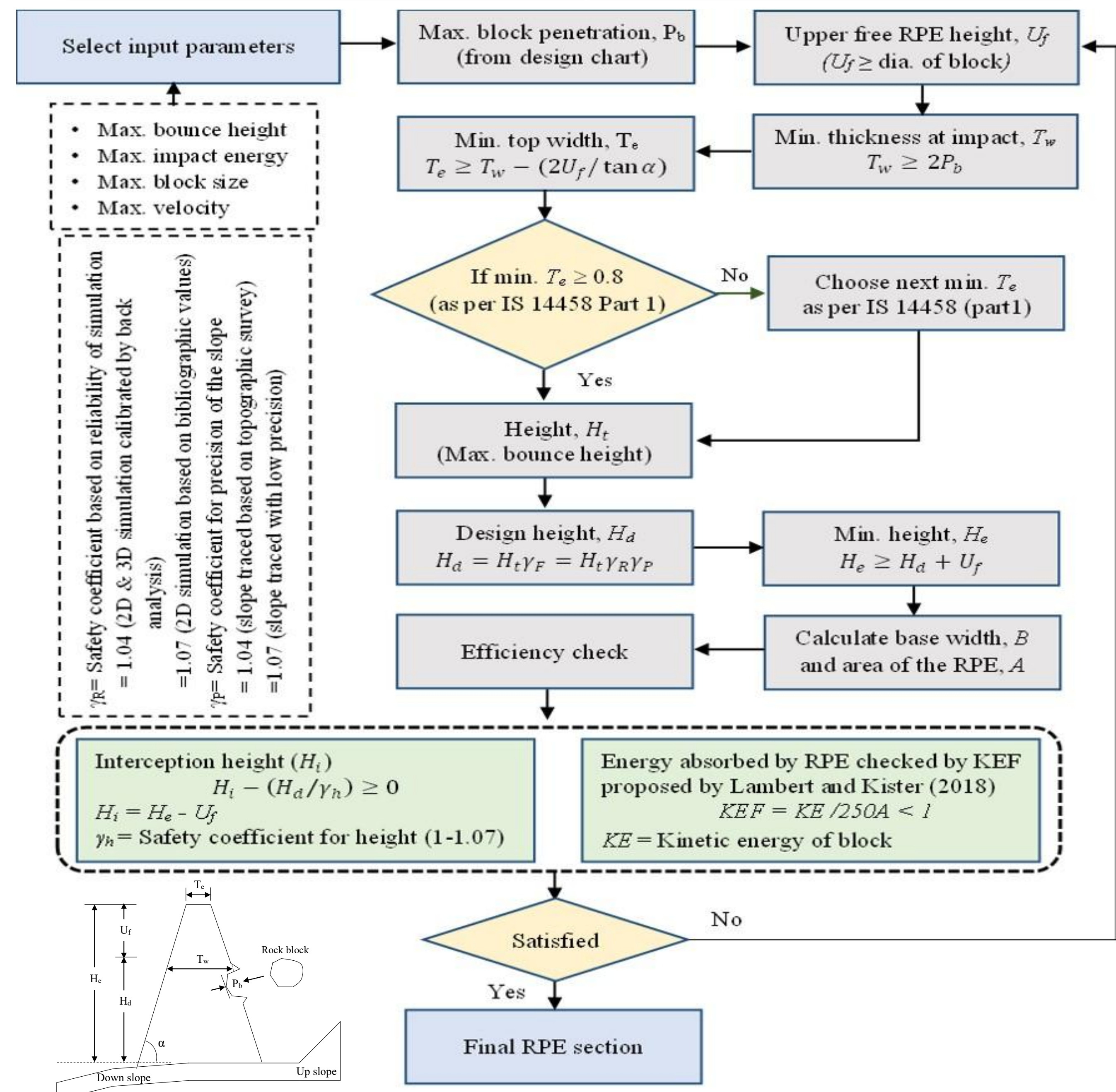
Properties	Values
Mass per unit area (g/m ²)	570
Longitudinal ribs Width (mm)	8.4
Thickness (mm)	1.27
Transverse ribs Width (mm)	6.5
Thickness (mm)	1.2
Junction thickness (mm)	1.3
Aperture opening (mm)	21x25
Percent opening area (%)	43.24

Strain rate	Elasticity modulus, E (MPa)
5 mm/min	14.407
10 mm/min	17.24
Strain rate	Secant modulus, M (MPa)
5 mm/min	10.4
10 mm/min	12.34

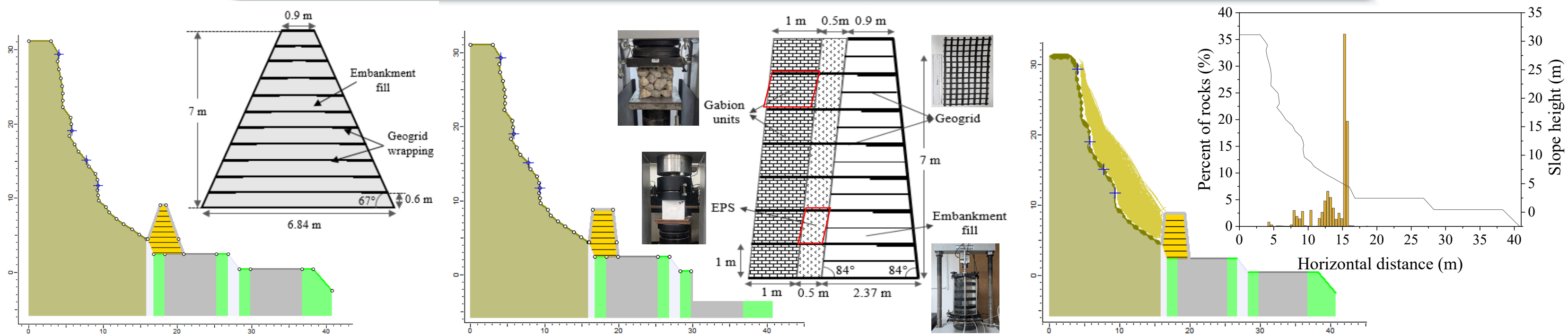
Rockfall Trajectory Analyses



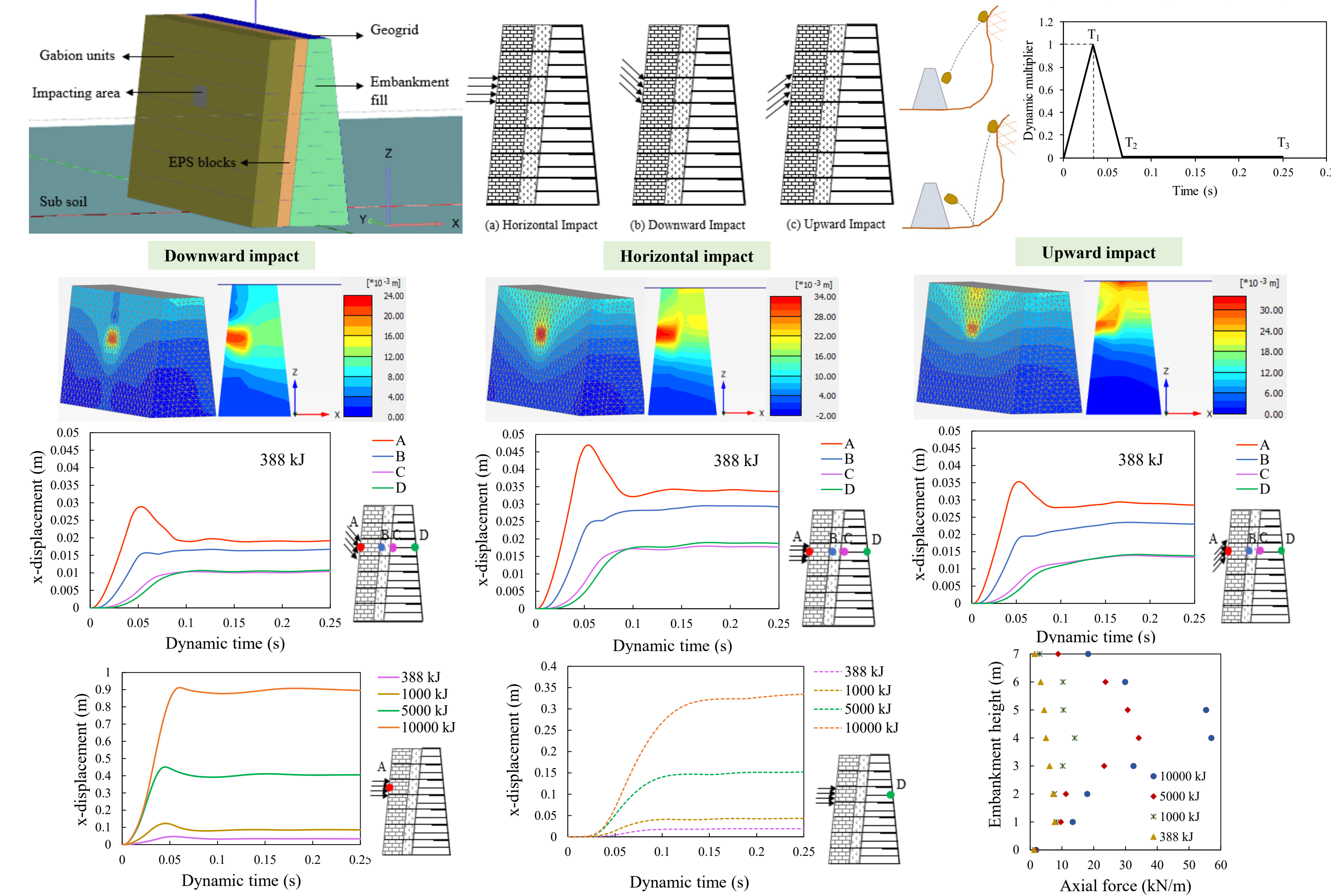
RPE Design Steps



RPE Designed



Dynamic Analyses in FEM Platform



Conclusion

- RPE undergoes the highest deformation under horizontal impact loading compared to downward and upward impact scenarios. This highlights that the horizontal impact condition represents the most critical loading scenario for RPE design.
- The shock absorption capacity of the designed RPE section is between 5000 kJ to 10000 kJ, based on the observation tensile stresses induced on the geogrid reinforcements at this impact energy exceed the allowable tensile strength of the geogrids.

Fundings

- 2021-2023: SRG Project titled "Landslide Mitigation Structures: Investigations on geosynthetics-reinforced barriers impacted by rockfall." funded by SERB.
- 2021-2024: NFS SEED Grant Project titled, "Experimental and Numerical Investigations on Resilience of Geosynthetic-Reinforced Embankments for Mitigation of Rockfall Impacts" funded by IIT Jammu (30 lakhs).
- 2021-2022 Vritika Event titled "Numerical investigation on the behaviour of geosynthetics-reinforced embankment under dynamic impact force of rockfall" funded by Accelerate Vigyan, SERB

Publications

- Shreya Maheshwari, Riya Bhowmik, and Sabatino Cuomo (2024), Impact Performance of Unreinforced and Geogrid-reinforced Rockfall Protection Embankment. *Geosynthetics International*, 32, 321-341. <https://doi.org/10.1680/jgein.23.00159>
- Shreya Maheshwari, and Riya Bhowmik (2024), Performance Assessment of a Protection Embankment Designed for a Rockfall-Prone Slope along Lesser Himalayas of Jammu and Kashmir, India. *Natural Hazards*, 121, 4095-4133. <https://doi.org/10.1007/s11069-024-06959-6>
- Shreya Maheshwari, Riya Bhowmik, and Manojit Samanta (2025), Mechanics and Modelling Approaches of Rockfall: A Comprehensive Review for Hazard Mitigation in Hill Roads. *Arabian Journal of Geosciences*, 18, 45. <https://doi.org/10.1007/s12517-025-12189-2>
- Utkarsh Gautam, Riya Bhowmik, and Shreya Maheshwari (2025), Performance Assessment of Geofam-Soil Cushion of a Rock-Shed Tunnel Designed for a Rockfall-Prone Slope Along Jammu-Kashmir National Highway, India. *International Journal of Geosynthetics and Ground Engineering*, 11, 8. <https://doi.org/10.1007/s40891-025-00613-2>