

CASE HISTORY

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ROCKFALL PROTECTION WORKS ALONG THE PATHS OF SHRI MATA VAISHNO DEVI JI SHRINE, KATRA, JAMMU & KASHMIR

KATRA, JAMMU & KASHMIR, INDIA



At the Heart of GeoHazard Mitigation Activity

Rockfall Protection

Client:	Products used :
SHRI MATA VAISHNO DEVI SHRINE BOARD (SMVDSB)	• ROCKFALL BARRIER 3000 kJ
Main contractor:	
SHIVA STRUCTURE PVT. LTD.	
Manufacturer & Supplier:	Year of construction
TECHFAB (INDIA) INDUSTRIES LTD.	2023

Project brief & Problem Description:

Shri Mata Vaishno Devi Ji is one of the most revered pilgrimage sites in Hinduism, located in the Trikuta Mountains of Jammu and Kashmir. The sacred journey of approximately 13 kilometers from Katra to the Vaishno Devi Temple is a spiritual trek for millions of devotees every year. However, the region's unique topography, situated in Seismic Zone V and at an elevation of 1,765 meters, makes it highly susceptible to natural hazards such as earthquakes, rockfalls, landslides, and extreme weather conditions. These factors have posed significant risks to the safety of pilgrims.

In response to the increasing frequency of rockfalls and landslides, particularly after the 2013 flood disaster in Uttarakhand, the Shri Mata Vaishno Devi Shrine Board (SMVDSB) initiated a phased project in 2014 to address these hazards. The project aims to mitigate risks and enhance the safety of pilgrims by stabilizing and protecting 33 vulnerable locations along the trek route. Phase I and Phase II focused on stabilizing 12 locations, while Phase III, currently underway, focuses on eight additional locations between Adhkwari and Mata Vaishno Devi Bhawan.

The Rockfall Mitigation works at Location 6 of Phase III, located at Chainage 0.700 km to 0.775 km, are of particular importance. This stretch, part of the 14-kilometer trek, has seen a growing incidence of falling stones and landslides, endangering lives. The topography, consisting of limestone and Siwalik rocks, combined with seismic activity, makes the area highly vulnerable. Therefore, advanced techniques such as high-energy absorption rockfall barriers, high-strength steel wire mesh, rolled cable nets, shotcrete, and various concrete applications (e.g., grouting, anchoring) are being employed to stabilize the slopes and prevent future occurrences.

The ultimate goal of this project is to safeguard both the pilgrims and the natural environment of the Trikuta Hills by employing state-of-the-art technologies, ensuring the safety and continuity of this sacred journey for years to come.



Photo 1 : A Partial view of Location No - 06

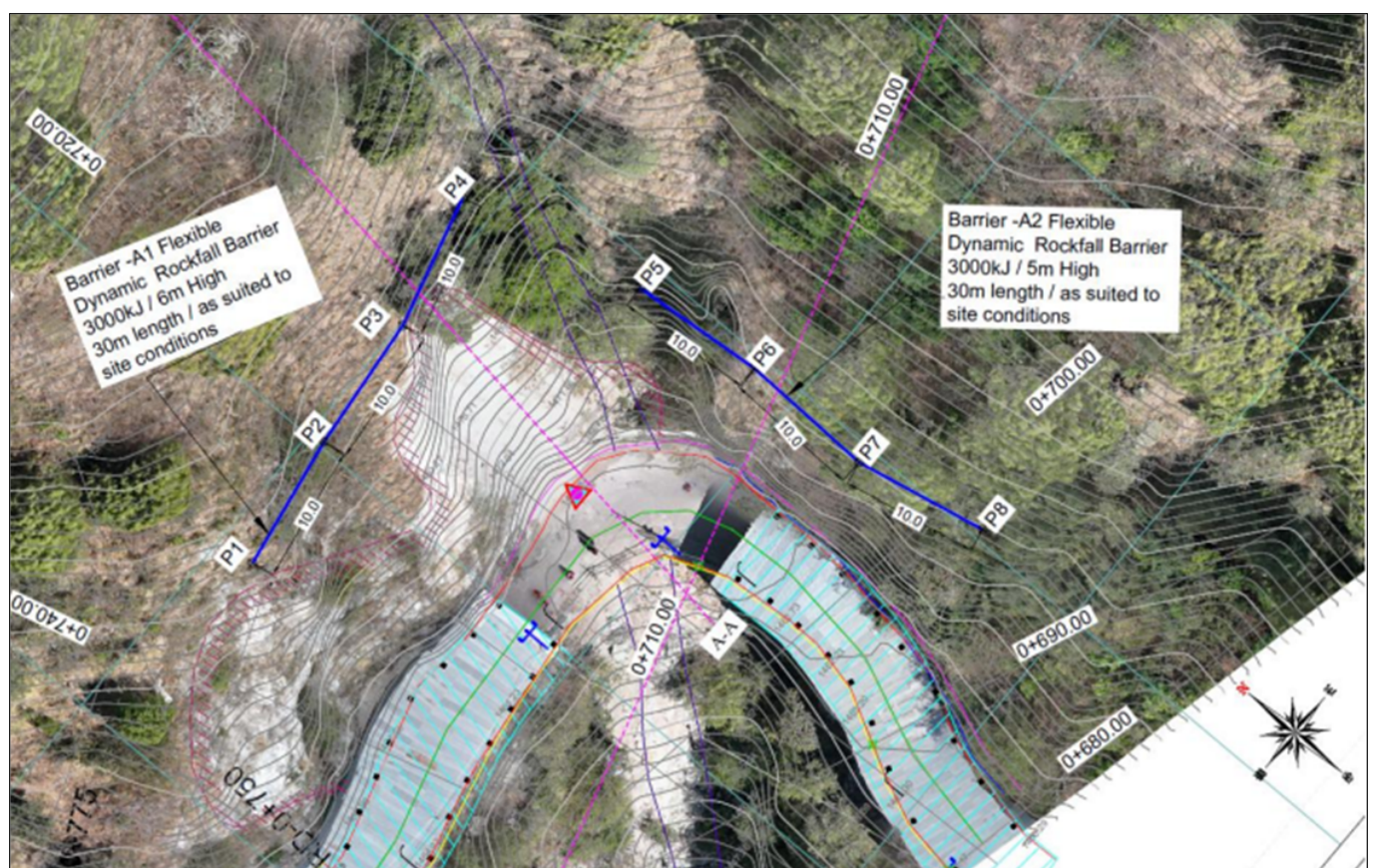
Solution Proposed:

To protect the pathway from falling stones along the trek to Mata Vaishno Devi Bhawan, TechFab India proposed a robust solution involving the installation of two sets of rockfall barriers - Set A1 and Set A2. Set A1 consists of a 6.0 meter high, 3000 kJ barrier, covering a stretch of 30 meters, while Set A2 comprises a 5.0 meter high, 3000 kJ barrier, also covering 30 meters. These barriers are strategically placed to absorb the kinetic energy of falling rocks and prevent them from reaching the pathway.

The design process incorporated rockfall simulations to determine dynamic parameters such as bounce height and translational velocity of falling rocks. Using the 95th percentile of the rockfall distribution, the simulations ensured that the barriers were designed to withstand the most severe scenarios. Furthermore, partial safety factors were incorporated into the design to account for uncertainties and mitigate associated risks.

The rockfall barriers were evaluated based on crash tests stipulated by EAD 340059-00-0106 (formerly ETAG 027), ensuring compliance with commercial standards for performance and safety. The selected barriers were favored for their versatility, cost-effectiveness, and rapid construction compared to traditional concrete barriers, making them an ideal choice for the challenging site conditions.

To maintain the integrity and effectiveness of the barriers, TechFab India recommends regular inspections, maintenance, and cleaning of the barriers after each rockfall event, as well as the replacement of any damaged components, to ensure ongoing protection for the pilgrims.



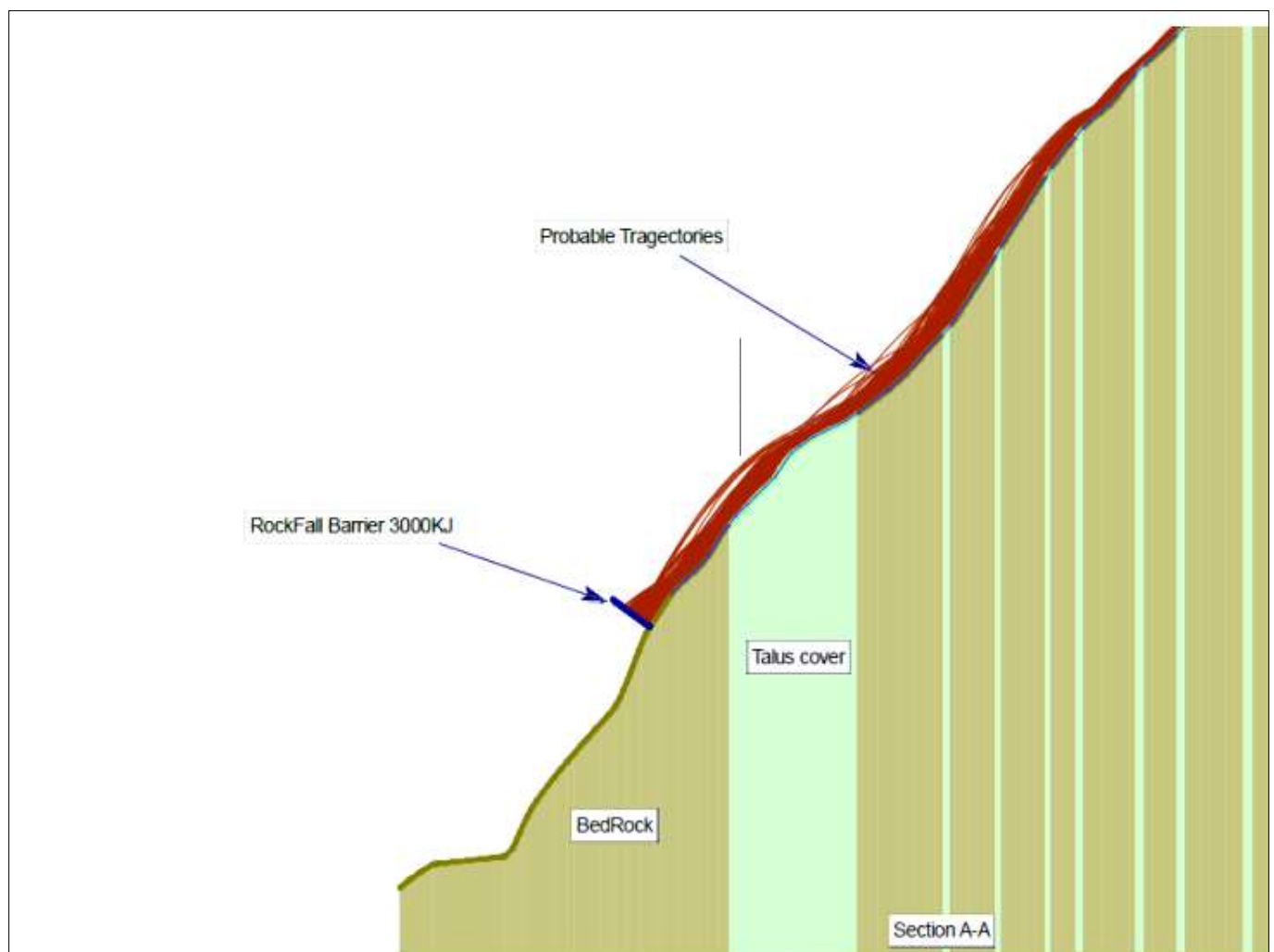
Plan of Proposed Rockfall Protection Measures

Design Approach of Rockfall Barriers:

Numerous simulations were conducted along cross-sections to analyze statistically significant rock detachment volumes based on on-site observations. The slope profile was modeled using survey drawings in specialized software, incorporating standard deviations in both x and y directions. Key slope properties, such as coefficients of restitution (normal and tangential), dynamic friction, rolling resistance, and vegetation area, were assigned to the model.

The design was carried out for two sections: Section A-A for Set A1 and Section 710 for Set A2. The software-generated model included a probable detachment path (seeder) with specified rock shape, mass, density, and number of throws, enabling the simulation of potential rock trajectories. Detachment zones were strategically located in critical areas to ensure comprehensive data. Trajectory analysis revealed rockfall paths, and the optimal barrier location was determined based on these findings and site feasibility considerations.

The design ensured that the barrier was capable of absorbing energy, containing rock debris, and withstanding multiple rockfall events. Simulations were conducted using the 95th percentile of bounce height and translational velocity to account for extreme scenarios. Safety factors were incorporated into the design to address uncertainties in real-world conditions. Barrier performance was evaluated against crash tests stipulated by EAD 340059-00-0106 (formerly ETAG 027), ensuring that the barrier met commercial standards and effectively mitigated rockfall hazards.



Barrier Analysis at Section-AA



Conclusion:

The selected rockfall barrier system was chosen for its versatility, cost-effectiveness, and rapid construction, offering significant advantages over traditional solutions like concrete barriers. Its design not only ensures effective energy absorption and rock containment but also provides long-term durability with minimal maintenance. The project, including the installation of other protective measures, was successfully completed in November 2023 and continues to function as intended, effectively preventing further rockfall incidents. This system has proven to be a reliable and sustainable solution, enhancing the safety of pilgrims along the trek and contributing to the overall stability of the site.

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