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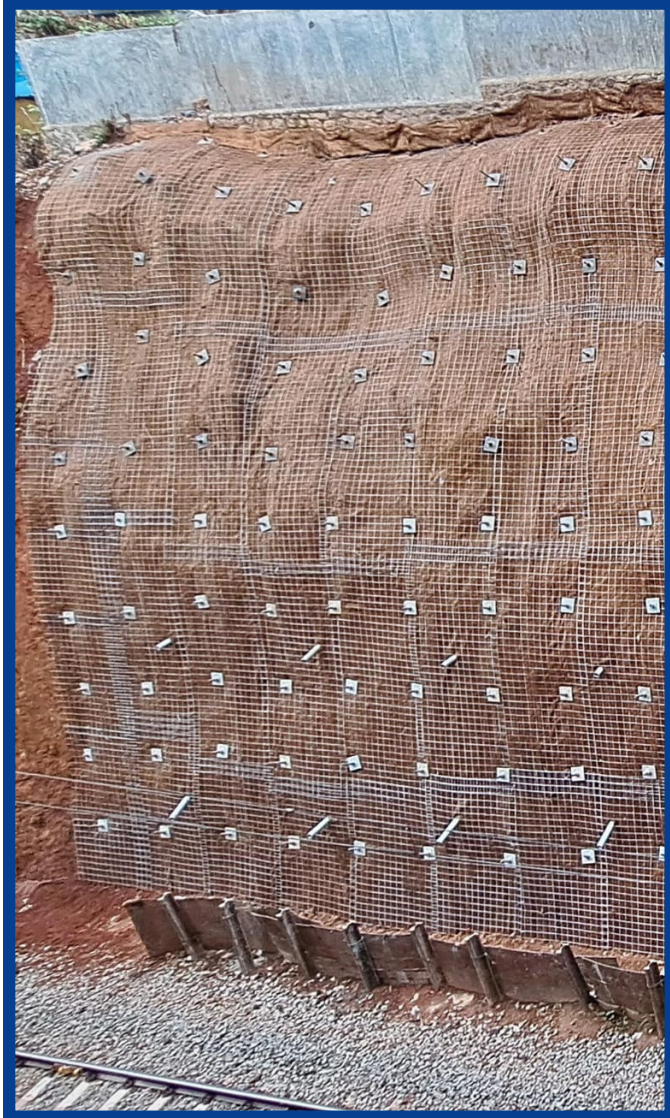
CASE STUDY

SLOPE PROTECTION BETWEEN PARASSALA AND ERANIEL WITH SELF- DRILLING ANCHORS.



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SLOPE PROTECTION BETWEEN PARASSALA AND ERANIEL WITH SELF- DRILLING ANCHORS.

SITE DESCRIPTION

The case study delves into the analysis of slope protection and remedial measures for two significant areas along the railway line connecting Parassala railway station in Kerala to Eraniel Railway Station in Tamil Nadu, India. This project falls within the purview of the Thiruvananthapuram Division-Engineering Department, Southern Railway. The objective is to ensure the efficient operation of the railway lines by stabilizing and protecting specific stretches. The details of the slope locations, along stability analyses and recommended remedial actions, are provided in subsequent sections.

Figure 1 Site Conditions of Location 1

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Figure 2 Site Conditions of Location 2

GEOLOGY

The geological makeup of Location 1 consists mainly of Khondalite and Charnockites Group, whereas Location 2 is predominantly made up of sandy silt/clayey sand originating from the Quaternary Formation, which is renowned for its unconsolidated structure. To evaluate stability, geotechnical parameters are established via bore log tests carried out onsite. Subsequently, soil samples, disturbed during collection, undergo a series of laboratory analyses to gauge their distinct characteristics.

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FIELD AND LABORATORY TESTING

The Standard Penetration Test (SPT) is a common geotechnical investigation method used to assess the subsurface soil conditions. It involves driving a split-spoon sampler into the ground at regular intervals and recording the number of blows required to penetrate the soil. SPT results aid in designing foundations for construction projects.

Figure 3 SPT test being performed at site.

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LOCATION 1

According to the borehole log data, the slope section contains Laterite soil up to a depth of approximately 8.5 meters. Beyond this depth and up to 15 meters, highly weathered laterite rock is encountered. The Rock Quality Designation (RQD) percentage of the strata is indicated as nil, and the solid core recovery ranges from 3% to 10%.

Figure 4 Bore Log Sample for Location 1.

LOCATION 2

Based on the borehole log data, the slope section consists of Laterite soil up to a depth of approximately 5 meters. Below this depth, heavily weathered laterite rock is encountered. The RQD percentage of the strata is reported as nil, with solid core recovery varying between 4% and 7%.

Figure 5 Bore Log Sample for Location 2.

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STABILITY ANALYSES AND REMEDIAL MEASURES

LOCATION 1

The slopes along the stretch exhibit highly weathered strata predominantly consisting of sandy silt/clay with gravel. The entire slope is densely vegetated, indicating significant weathering. Dense vegetation is particularly observed in areas with heavy rainfall, as rainfall enhances soil fertility and provides ample water supply.

In the absence of anchors, the Limit Equilibrium Analysis revealed a Factor of Safety of 0.493, falling significantly below the safety threshold. However, upon incorporating anchors into the analysis, the Factor of Safety increased substantially to 2.440. Similarly, when Finite Element Analysis was conducted at this location without anchors, the Strength Reduction Factor (SRF) was calculated to be 0.69, below the critical SRF. After installing anchors, the SRF value increased to 1.73, surpassing the minimum safe value. Consequently, as part of the remedial measures, 32mm diameter SDA with a length of 7 meters and a spacing of 1.25 meters in both plane and out-of-plane directions were installed.

To address erosion and facilitate vegetation growth, Non-woven Coir mats were installed, supplemented by welded steel wire mesh to further stabilize the slope. Additionally, perforated PVC pipes were installed for drainage purposes to mitigate Excess Pore water pressure.

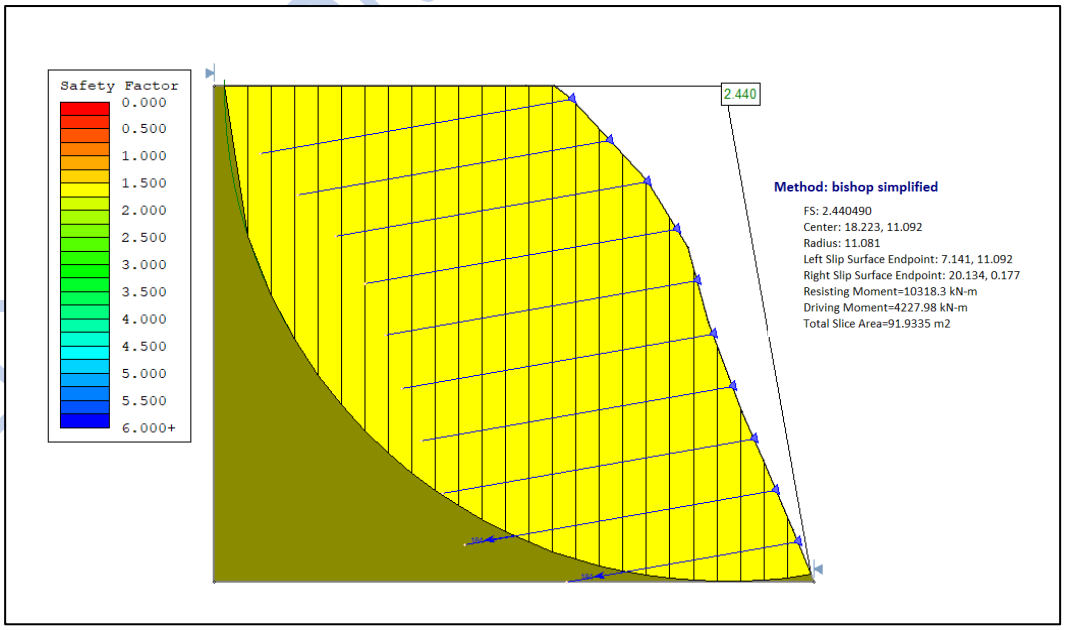

Figure 6 LEM analysis of location 1 with anchors.

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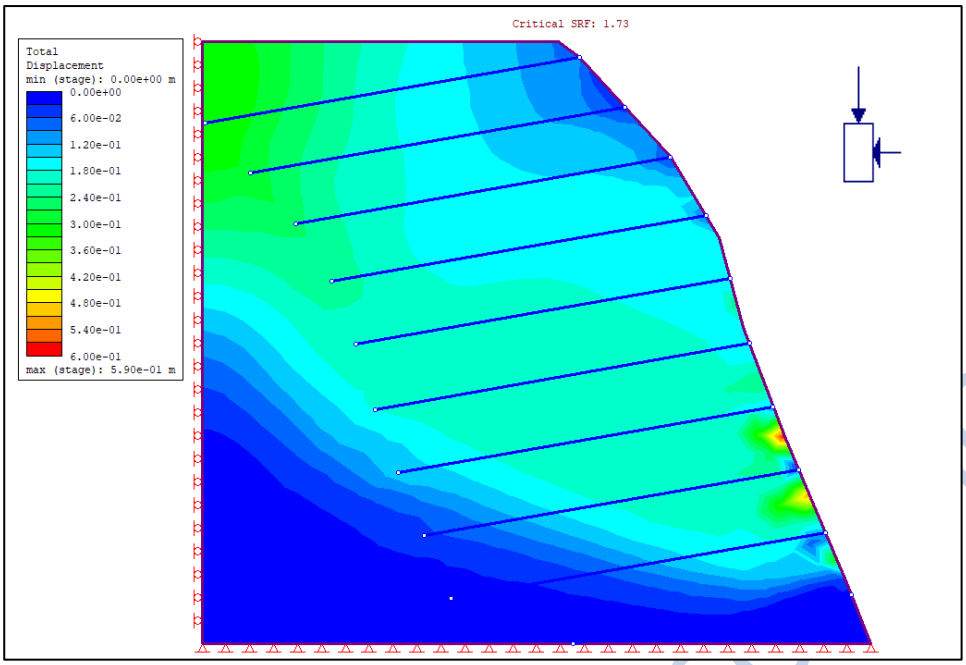

Figure 7 FEM analysis of location 1 with anchors.

LOCATION 2

The area designated as Location 2 features a slope that has undergone weathering. Increased vegetation growth in this area contributes to biomechanical weathering, a process that slowly decomposes rock into soil. Borehole log data reveals that the slope comprises Laterite soil extending to a depth of around 5 meters, below which lies heavily weathered laterite rock.

In the absence of anchors, the Limit Equilibrium Analysis yielded a Factor of Safety of 1.306, which fell below the safety threshold. However, after conducting the analysis with anchors, the Factor of Safety increased significantly to 2.338. Similarly, in the Finite Element Analysis conducted at this location without anchors, the Strength Reduction Factor (SRF) was calculated to be 1.25, below the critical SRF. After installing anchors, the SRF value increased to 1.55, surpassing the minimum safe value. As part of the remedial measures, 32mm diameter SDA with a length of 7 meters and a spacing of 1.25 meters in both plane and out-of-plane directions were installed.

To address erosion and encourage vegetation growth, Coir mats were installed, complemented by welded steel wire mesh to enhance slope stability further. Additionally, perforated PVC pipes were installed within the slope to facilitate drainage and mitigate Excess pore water pressure.

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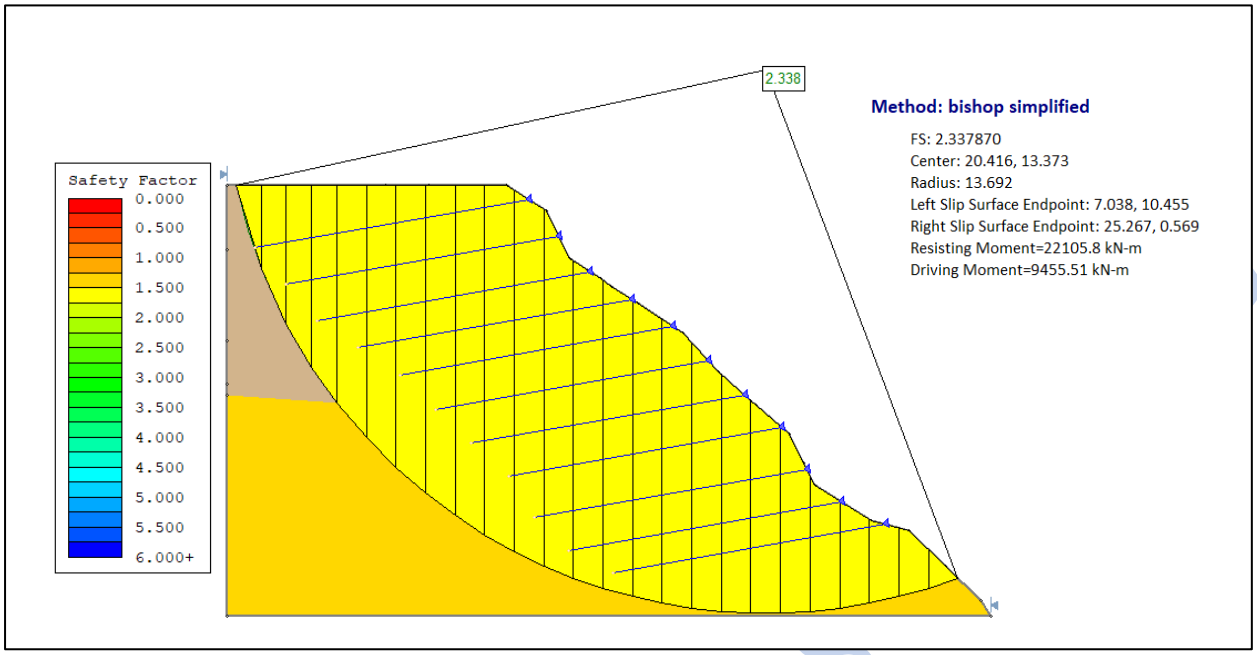

Figure 8 FEM analysis of location 1 with anchors.

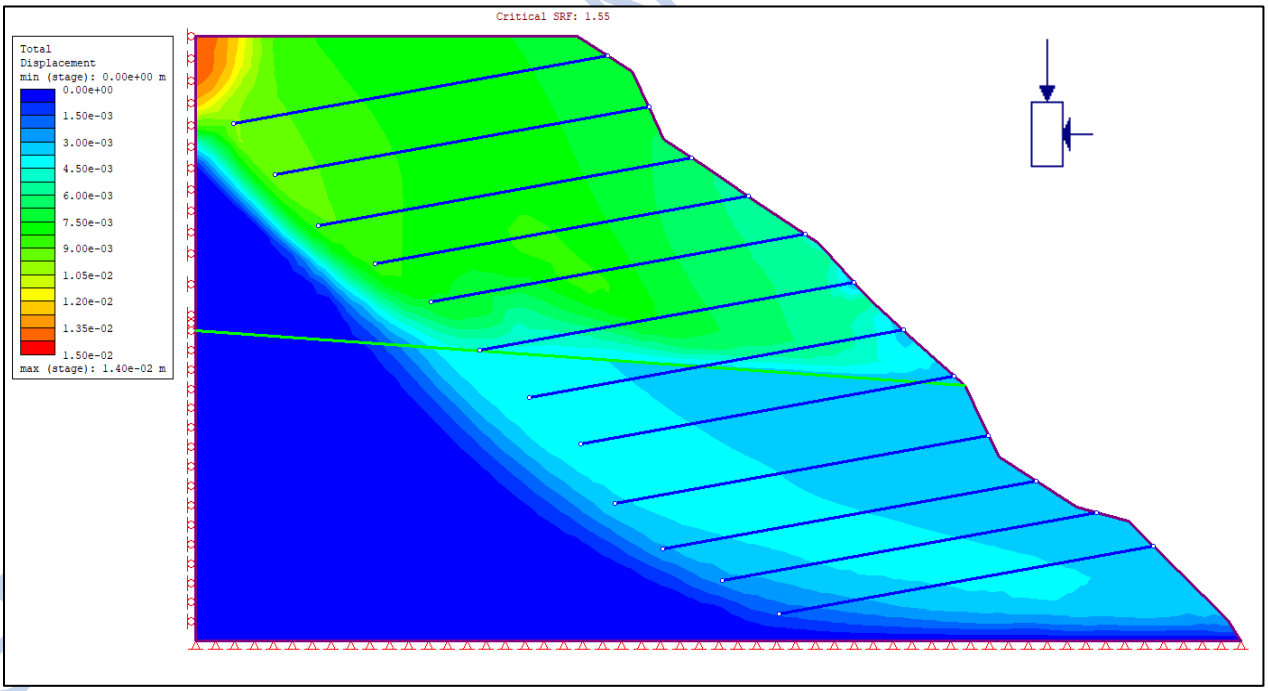

Figure 9 FEM analysis of location 1 with anchors.

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CONCLUSION

The slope protection measures recommended are based on thorough numerical modelling derived from comprehensive geotechnical data analysis. These recommendations are carefully tailored to address the specific challenges posed by the terrain. By integrating insights from the numerical modelling process, we have identified and implemented effective solutions such as Self-Drilling Anchors, Perforated PVC Drainage pipes, non-woven coir mat, and welded steel wire mesh. This approach ensures that the slopes are adequately stabilized, thus safeguarding the integrity of railway lines, trains, and ensuring the safety of passengers.

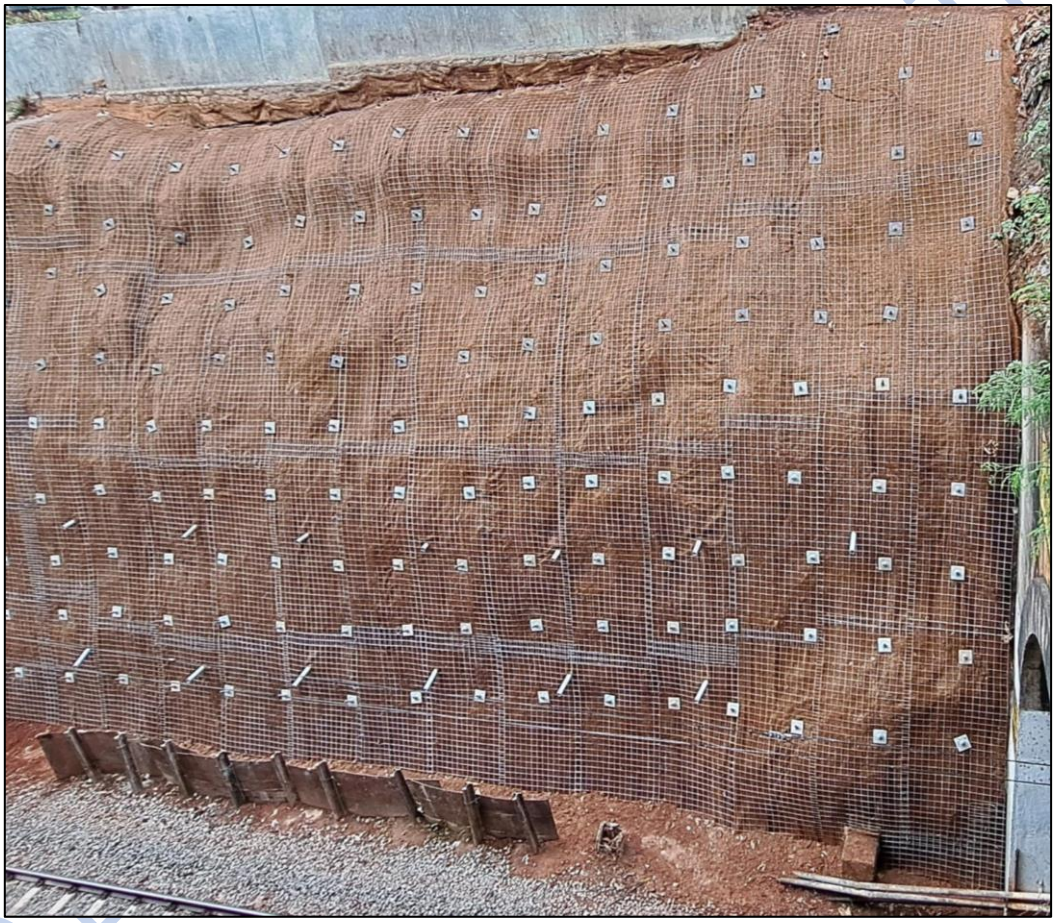

Figure 10 Site after the execution of remedial measures (LOCATION 1).

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Figure 12 Site after the execution of remedial measures (LOCATION 1).

Figure 11 Site after the execution of remedial measures (LOCATION 2).

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