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Case Study For Railway Embankment On Slope Stability

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ABSTRACT

This case study used numerical modeling with the finite element method to analyze the slope stability of a 28-meter-high railway embankment. With a 25-ton axle loading, PLAXIS 2D CE V21 was used to calculate the factor of safety. SQ2 type soil, which has fines ranging from 12% to 50%, was used for the embankment and is abundant at the project site. Railway embankment modelling is done using field test data. The parameters of the various rail way track components were thoroughly examined. Put in place After the embankment was constructed, the results of the deformation and factor of safety were given.

In the analysis, soil models for the various embankment sections were incorporated. The Mohr-Coulomb soil model was used to model the subgrade, whereas the rail and sleeper were made of linear elastic. The element of safety was significantly impacted by the SQ2 type soil's effective cohesiveness. On failure, nonetheless, it exhibits significant deformation, for which blanket material was placed beneath ballasts. Adding turf on the side slopes improved stability even more. This study involved step-by-step modeling on PLAXIS 2D CE V21.

INTRODUCTION

The Project connects Hinterlands of Wardha, Yavatmal, Washim, Hingoli & Nanded Districts (Maharashtra) to the Mumbai – Howrah main Line at Wardha and Nanded–Nizamabad Line between Mugat (X-ing)- Maltekdi (X-ing) stations ahead of Nanded. Both Wardha and Nanded towns are of historical and religious importance. New rail link will contribute significantly to Socio- Economic development of the region, imparts Employment Generation & Goods Transportation.

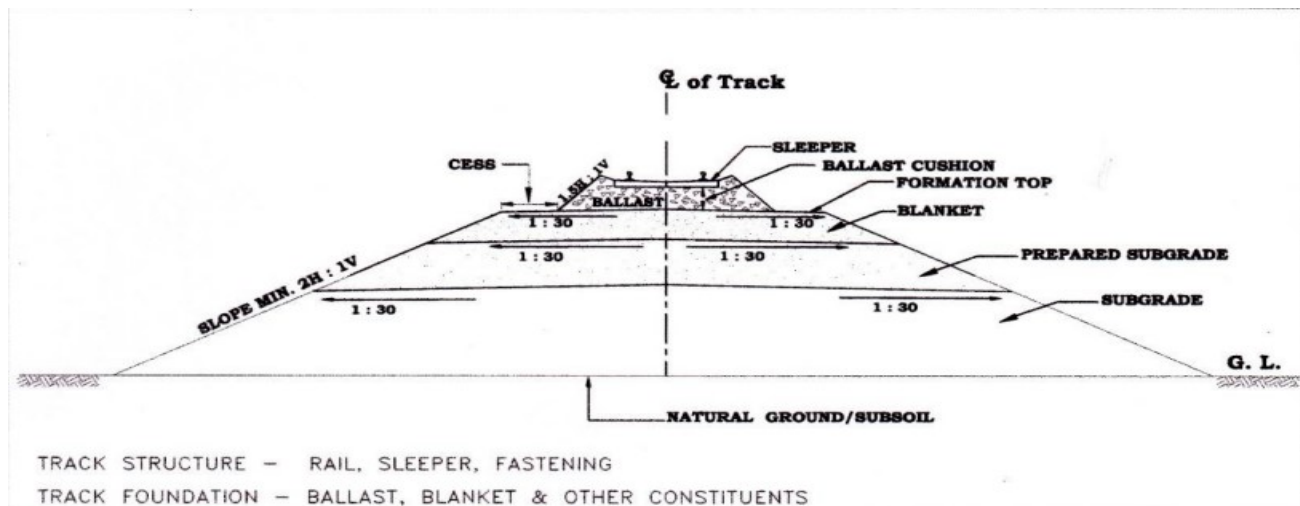
The Railway formation for this track is laid on bridges and earth embankment. To aligned track with ruling gradient the embankment at some section of this railway siding are as high up to 28 m from ground level to formation level. This Railway track has been designed to meet the loading requirement of 25Ton Axle loading with speed potential of 110 KMPH.

Track Gauge adopted is broad gauge (1676 mm) with rails of 60 Kg/m & 13.00m long 90 UTS Class-I rails at all locations.

Mono blocks PSC sleepers with density of 1660 nos./Km are being used on a cushion of ballast depth 350 mm. 400 mm depth Blanket material with negligible silt content is used just below ballast layer.

GEOMETRY

Formation width of 7.85 m for single track with side slopes of 2:1 in bank. For banks higher than 6m, a berm of 3m width will be provided on either side. Good soil will be used for making of formation. Blanketing – 40 cm on the top of the formation.



General Arrangement of Formation top

OBJECTIVE & SCOPE

The Objectives of the paper are given below:

Our goal with this case study is to accomplish the following outcome.

Evaluating the Safety Factor Using Just Gravity Loading

Evaluating the Safety Factor with 25T Axle Loading

In order to view the rainfall infiltration model,

To investigate the corresponding deformation for each situation.

LABORATORY TEST RESULTS

DEPTH BELOW GL(M)		TYPE OF SAMPLES	SPT N-VALUE	INSITU BULK UNIT T(g/cm ³)	DRY UNIT WT (g/cm ³)	INSITU WATER CONTENT (%)	LIQUID LIMIT %	PLASTIC LIMIT %	PLASTICITY INDEX, IP	IS CLASSIFICATION	SHEAR PARAMETERS			
FROM	TO										TYPE OF TEST	C (Kg/cm ²)	PHI, Φ [°]	SPECIFIC GRAVITY
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0.00	0.60	DS												
0.60	1.50	UDS		1.87	1.48	26.31				CH	UU	0.78	13	2.63
1.50	1.55	SPT	36		1.69		48.11	29.34	18.77	CH		1.67	19	2.62
1.55	3.00	UDS		1.92	1.50	28.12				CH	UU	0.81	15	2.64
3.00	4.50	SPT	37		1.71		49.16	30.11	19.05	CH		1.69	21	2.61
4.50	6.00	UDS		1.89	1.5	25.87					UU	0.97	18	2.65
6.00	7.50	SPT	50		1.89		35	19	16	CH		1.85	24	2.63
7.50	9.00	UDS												

After 9.0 m Grey BASALT ROCK Start

S.N.	PROPERTIES	TEST METHOD	TEST RESULTS
1	Sieve Analysis	IS:2720 Part 4	
	• Cobble(75+ to 300 mm size)		0%
	• Gravel(4.75+ to 75 mm size)		66.32%
	• Sand(0.075+ to 4.75 mm size)		26.78%
	• Silt & Clay(Below 0.075 mm size)		6.90%
2	Coefficient of Uniformity Cu		42.85
3	Coefficient of Curvature Cc		4.75
4	Modified Compaction	IS:2720 Part 8	
	• Optimum Moisture Content		9%
	• Maximum Dry Density		2.185 g/cm ³
5	Plasticity Characteristics	IS:2720 Part 5	
	• Liquid Limit		36.10
	• Plastic Limit		21.30
	• Plasticity Index		14.90
6	Laboratory Soaked CBR	IS:2720 Part 16	41.30%
7	Engineering Classification	IS:1498	GW-SW(Well Graded Clean Sand)

Properties	Top Soil	Bottom Soil
Bulk Unit Weight, γ_{unsat} kN/m^3	18.54	21.13
Saturated Unit Weight γ_{sat} kN/m^3	19.79	22.51
Young's Modulus (E_s) kN/m^2	65250	67000
Poisson's Ratio, ν	0.25	0.25
Drainage Condition	Drained	Drained
Effective cohesion, c' kN/m^2	95.12	95.11
Friction angle, ϕ' in degree.	18	18

MODELING BY PLAXIS 2D SOFTWARE

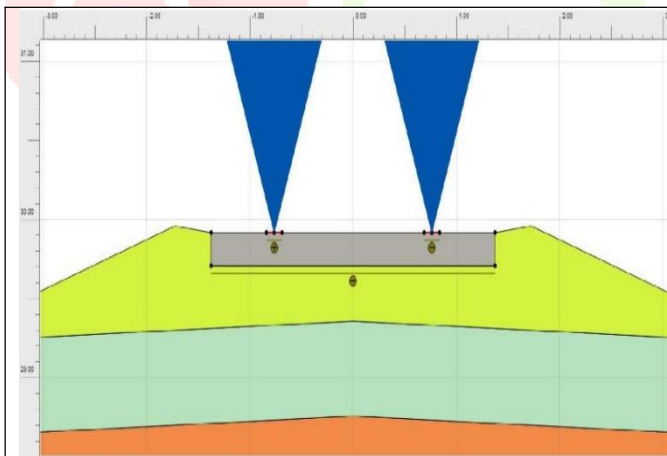
The axle loads, as calculated, are applied to the rail rolling surface's surface. The sleeper is only loaded by a portion of the vertical force. It is possible to calculate the vertical loads W that are applied to the sleeper.

Loading Calculations,

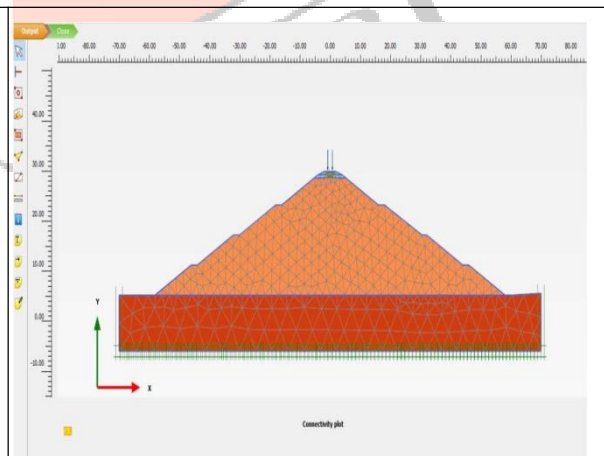
$$\text{Axle Loading} = 25 \text{ T (Dynamic) Augment Factor} = 1.5$$

$$\text{Augmented Dynamic Loading} = 37.5 \text{ T}$$

$$\text{Wheel Loads on each rail} = 18.75 \text{ T or } 187.5 \text{ kN.}$$



Application of Wheel Load as point Load on Rail Model as Linear platelement

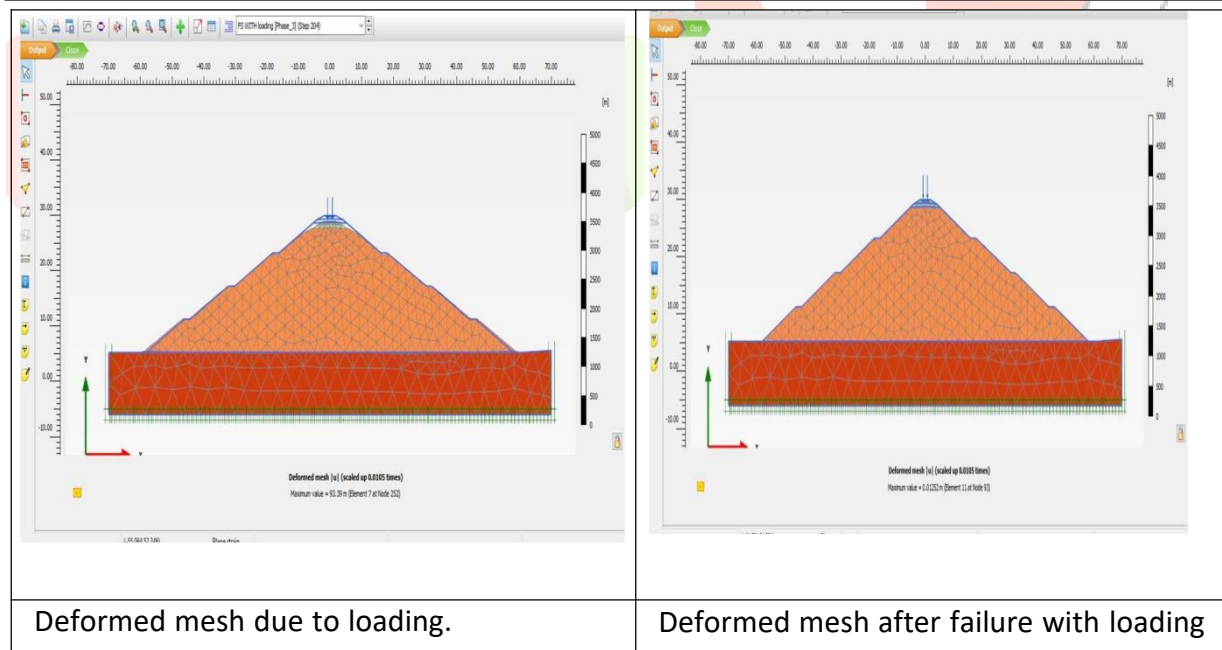
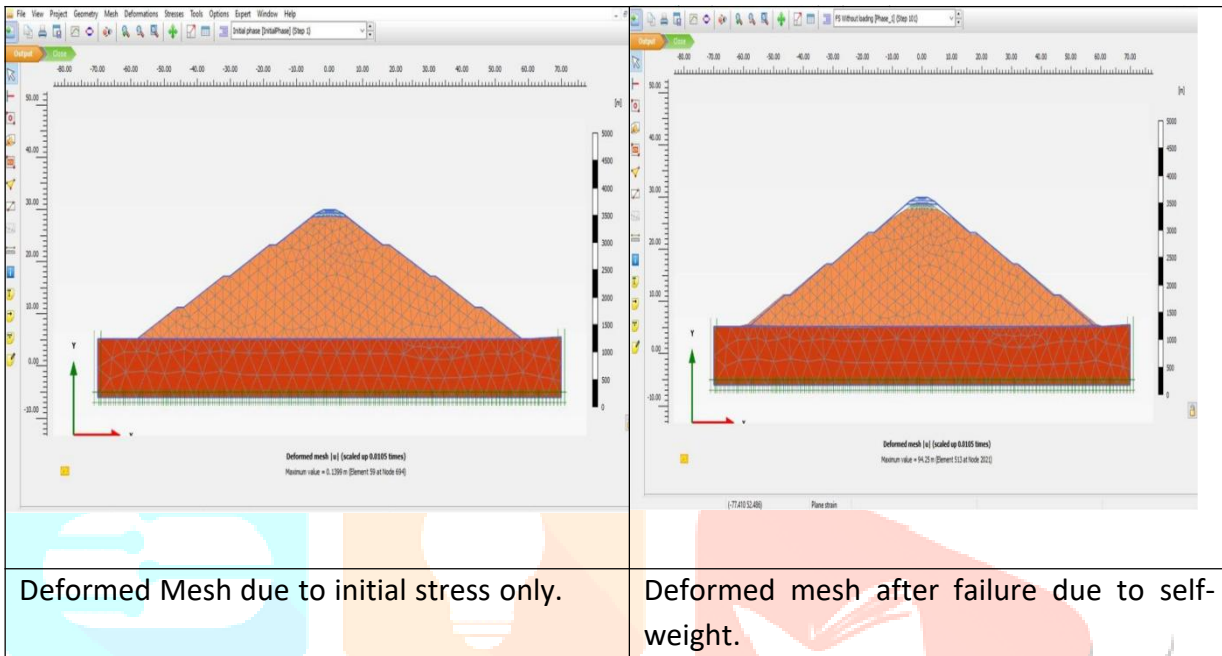


Generated Mesh for finite elements

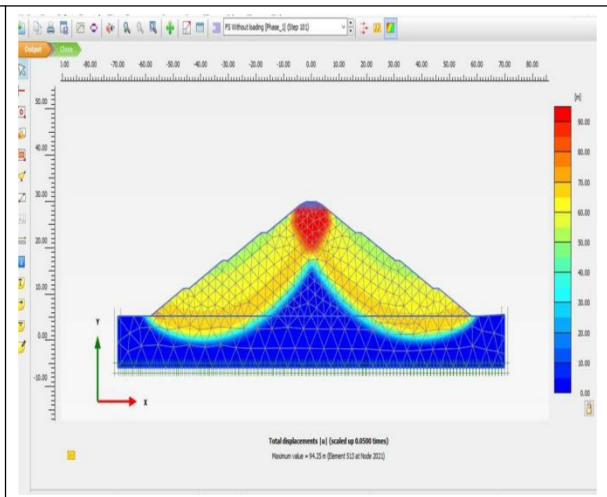
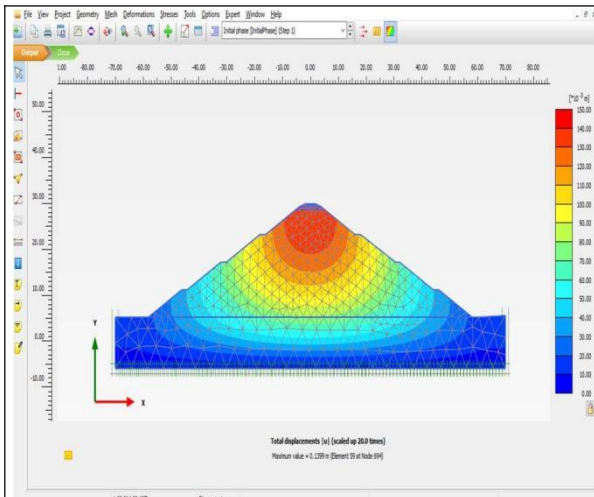
OUTPUTS FROM PLAXIS ANALYSIS

The Deformed mesh, total deformation, contour of shear stress shear strain and factor of safety are presented as output with and without loading to study the location and slip surfaces.

Deformation in Mess:-

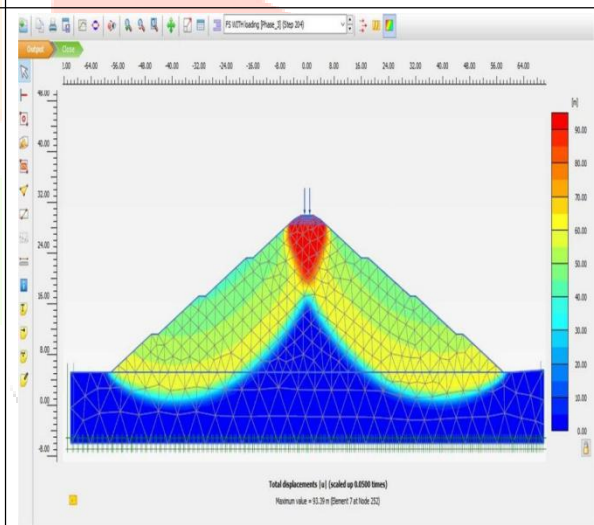
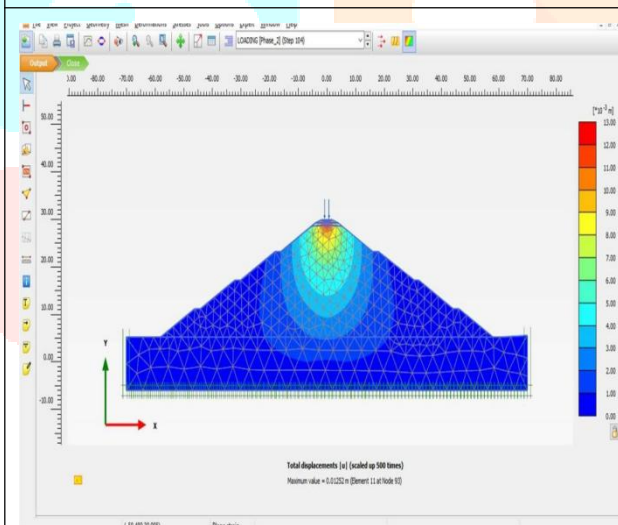


Total Displacements:



Total Displacement at initial phase due to self-weight.

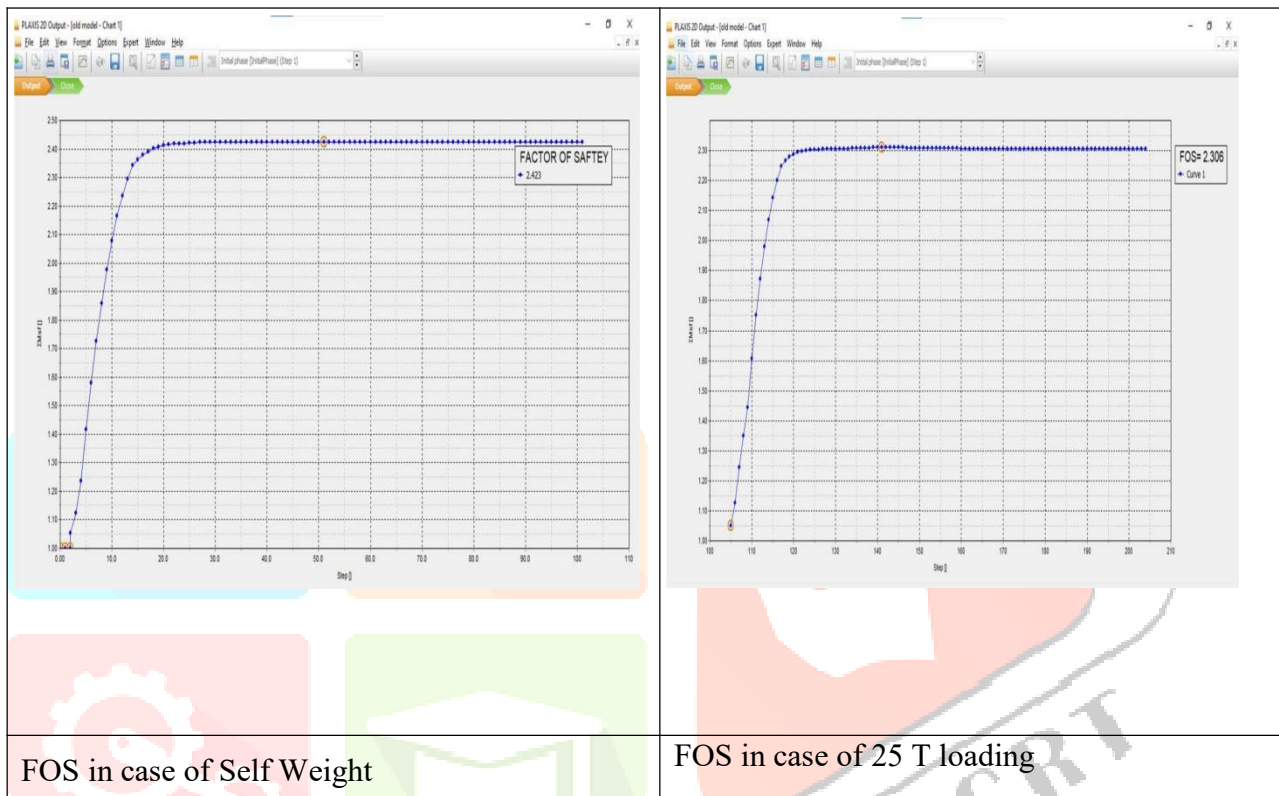
Total Displacement after failure for FOS without any loading



Total Displacement after loading.

Total Displacement after failure for FOS with loading

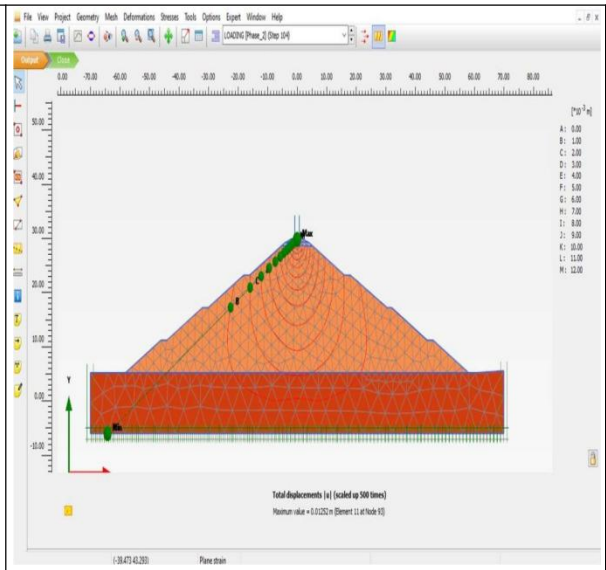
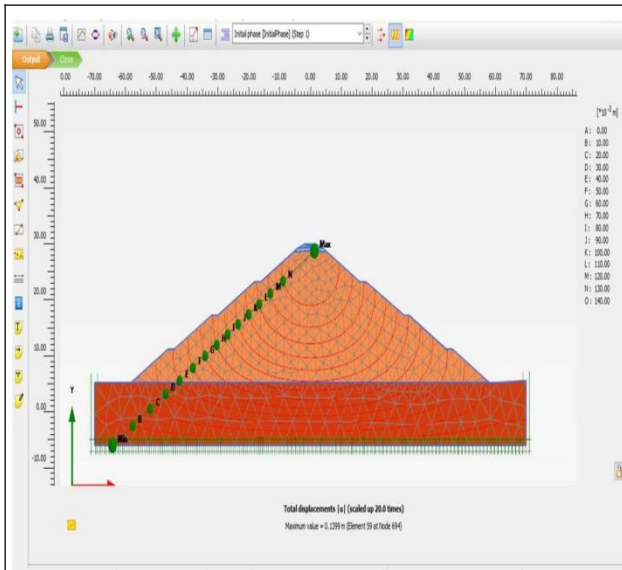
Analysis for Factor of Safety:-



FOS in case of Self Weight

FOS in case of 25 T loading

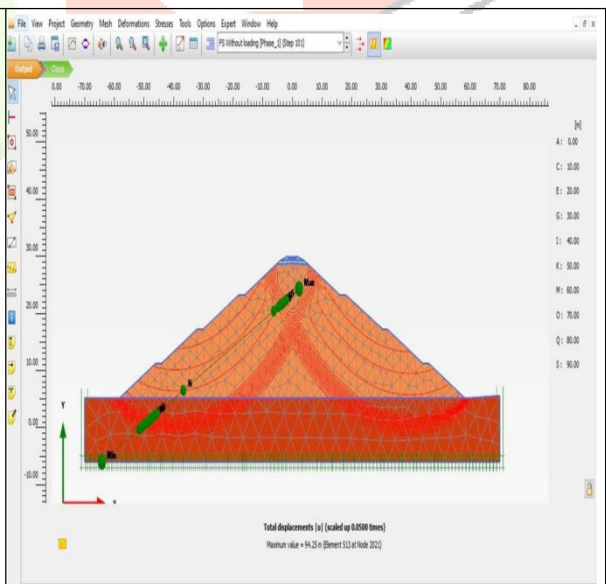
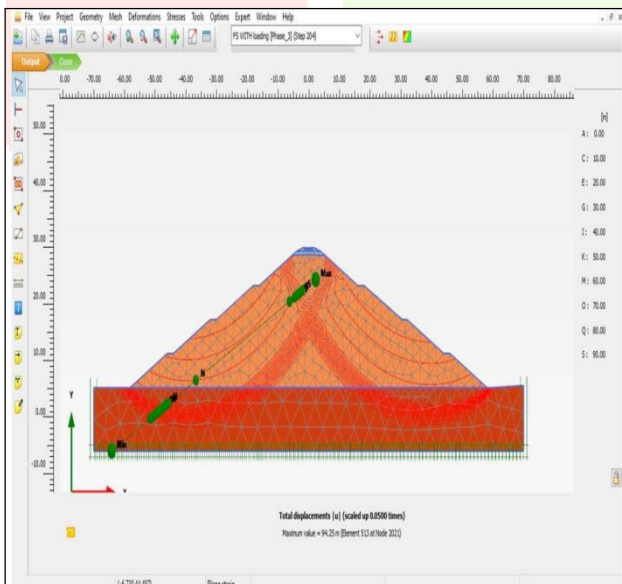
Contour Lines of Shear Stress-Strain:-



Contour Line of Shear Stress-Strain due to initial stress

Contour Line of Shear Stress-Strain due to loading

CONTOUR OF SLIP SURFACE:-



CONTOUR OF SLIP SURFACE due to initial stress

CONTOUR OF SLIP SURFACE due to loading

Effect of Loading:-

PARAMETERS	INITIAL PHASE	WITH LOADING
FACTOR OF SAFETY	2.423	2.306
EXTREME TOTAL DISPLACEMENTS (M)	0.1399	0.01252

CONCLUSIONS

The following conclusions may be drawn from parent study:-

A case study using PLAXIS 2D CE V21 was conducted to analyze the slope stability of the railway embankment.

For railway development, the deformation and safety factor were examined in SQ2 type soil both with and without a 25 T axle loading. While the factor of safety was approximately 2.306, the railroad track's deformation and settling exceeded the basic guidelines set by Indian Railways.

Railway settlement should be 10 mm/10year, according to RDSO. The outcome revealed that the greater cohesiveness of the SQ2 type soil in the formation was the cause of the higher factor of safety.

Further scope of study is to study the stability analysis against rainfall infiltration.

As the result table show that settlement is exceeding the prescribe allowable limit further counter measures such as geosynthetics have to be studied next.

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