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Numerical Modelling of RDSO Designed Heavy Axle Load Embankment for Indian Railway in PLAXIS

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Abstract - *Indian Railway (IR) is currently upgrading its rail track infrastructure to meet the increasing demand for the high speed trains as well as higher freight capacity. Research Designs and Standards organisation (RDSO) has proposed some designs and manual for such high load capacity train embankments under Heavy Axle Load (HAL) segment. Currently there are many geotechnical numerical simulation and analysis softwares gobally, among which PLAXIS has its upright popularity and acceptance. Here in this paper we have analysed the RDSO HAL manual design of 32.5 T axle load with the help of numerical modelling in PLAXIS. This study shows that the designs made by RDSO for HAL and the numerical modelling in PLAXIS give very close results of deformations. Hence this paper recommends the use of PLAXIS for the in future designs and analysis of the Indian Railway (IR) embankment profiles.*

Key Words: Indian Railway, RDSO, Heavy Axle Load, PLAXIS, Railway Embankment

1. INTRODUCTION

Indian Railway is trying to cope with the transportation market competions, by upgrading its assets to the current technological advancements. In this scenario, the dedicated freight corridor was proposed and designed for the tranportation of heavier freight in competitive time. The designs were made by Research Designs and Standards organisation (RDSO) and published as RDSO HAL manual. This manual helps in designs of embankment formation, as guidelines and specification manual for the heavy axle load track designs of 25, 30, and 32.5 T axle load.

Heavy axle load designs help in carrying higher freight at comparatively higher speeds. Hence achieve impression of better performer in the competitive market. This is the idea behing developement of Dedicated Freight Corridor (DFC) in India.

As RDSO has done its work with all practical testing and analysis, this is the better oppurtunity to validate the results for certain softwares in the field of geotechnology for further use. By validating the software analysis, in future designs and developments will be much more easier and less tedious. Also it will give opportunity for the academic students to develope interests in this area, as on site testing is far from the scope of the academic institutes in such major topics of infrastructure.

PLAXIS is the globally recognised and widely accepted software by the geotechnical industry. Hence it will be much more importatant to check the results of this software in comparison to the RDSO given statistics. This will prove beneficial in the long run to the academic researchers and scholors for the further development of Indian Railway embankment formations with the help of PLAXIS alone.

1.1 Designs from the RDSO HAL manual

Following table shows the design values of the embankment from RDSO HAL manual. RDSO has developed this design values from various testing of materials, demo models in the laboratory and on field to the actual scale profile testing.

Table -1: Details of Track Model

Track Component	Details	Material Parmeters
Rail	Base Width = 150 mm Height = 172 mm Moment of Inertia (MOI) = 3055 cm^4 Base Area = 76.86 cm^2 Weight =60.34 Kg	E = 200 x 10^3 MPa μ = 0.30
Sleepers	Material = Concrete Base Width = 250 mm Height = 210 mm Top Width = 150 mm Length = 2750 mm MOI = 15290 cm4 Bottom bearing Area = 76.86 cm^2 Weight = 285.4 Kg Spacing = 60 cm	E = 30 x 10^3 MPa μ = 0.20
Ballast	Depth = 30 cm	E = 130 MPa, μ = 0.37
Blanket	Depth = 30 cm	E = 140 MPa
Subgrade 1. Top Soil 2. Middle Soil	 Depth = 70 cm Depth = 50 cm	 E = 100 Mpa E = 67 MPa
Bottom Soil	Depth = 150 cm	E = 50 MPa

As mentioned in the above table 1, the modelled geometry has 5 layers in the formation of the railway embankment namely ballast, blanket, top soil, middle soil, and bottom soil.

Formation stresses at various depths have been determined by various researchers. A study done by IIT, Delhi using Finite Element Analysis for 32.5T axle load is summarized. In the analysis, 60 kg rail section has been used which, modelled as

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rectangular section keeping the base width and the moment of inertia same. Thus, an equivalent height of rail section was calculated. The static wheel load of 243.75 kN (including dynamic augment of 1.5) was applied from the centre line. The elastic model was used for the analysis of the track.

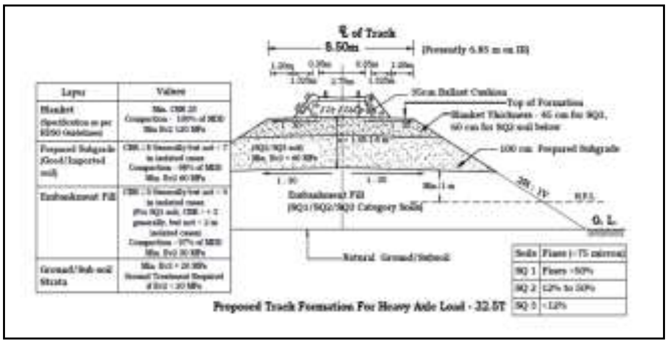

Fig -1: Proposed Track Formation for RDSO Heavy Axle Load – 32.5T

1.2 Assumptions

1. Materials such as soil, prepared subgrade, blanket, ballast, etc. are elastic.
2. Rail section has been assumed rectangular having same EI value as of the I –section
3. Due to symmetry only half of the track is modelled.
4. Elastic modulus of different material has been assumed as per specified value of CBR values of different layers.
5. Elastic modulus of other items such as rail, sleeper, ballast, and blanket has been taken as the available values in literature.

2. Numerical modelling in PLAXIS

Finite element analysis was carried out by using PLAXIS software. The PLAXIS is two dimensional programe, developed for the analysis of reinforced ballast embankment, foundation construction, etc

Geometry of model is axisymmetric, hence only half right hand side is drawn. All geometry is modelled using 15-node linear strain quadrilateral elements. After selecting particular geometry, selecting default mesh generation which will automatically generate mesh for selected portion. There is also provision of editing mesh size, shape according to model.

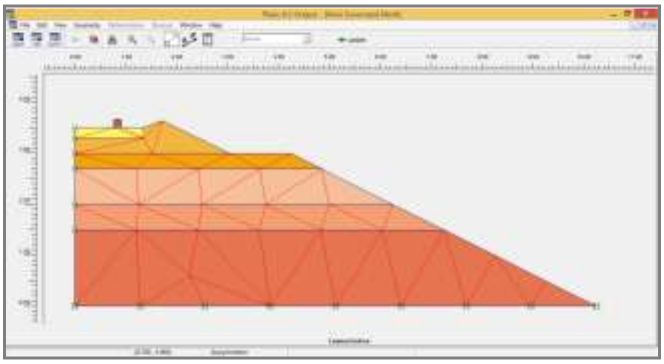

Fig -2: Geometry of Railway Ballast Embankment

PLAXIS has various material models in its library for the different soil conditions and other materials like rail, sleeper, etc. Hardening Soil (HS) model, Mohr-Coloumb (MC) model, and Linear Elastic (LE) model are the best suited for our case of analysis. But as RDSO has verified and assumed the conditions of elastic property of we have used Linear Elastic (LE) model only. Also drained or undrained conditions of each layer was specified.

Material properties used were completely with reference from the RDSO manual. Properties like unit weight (γ, kN/m^3), modulus of elasticity (E, Mpa) and poisson's ratio (μ) were of main importance for the analysis.

3. Result and Discussion

After thorough testing of the modelled geometry using PLAXIS, we obtained certain results for the deformations of the layers.

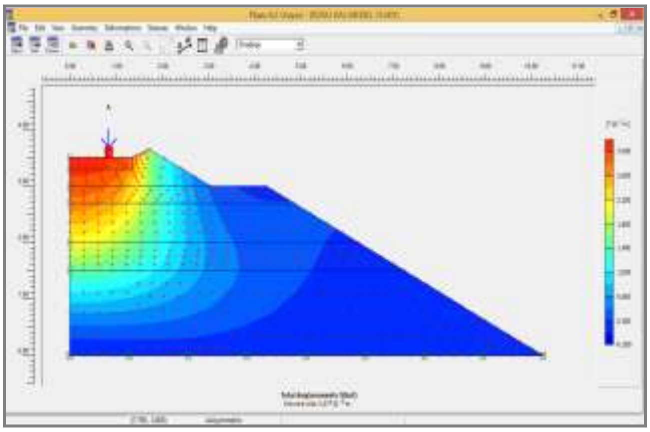

Fig -3: Displacement of Embankment Formation After Load Application

Following table 2 shows, the displacement value at the top of each layer in the modelled geometry of the specific selected node (exactly under the rail and load application).

Also displacement values directly given in the RDSO HAL manual are mentions for the reference.

Table -2: Comparative results from RDSO manual and PLAXIS analysis

PARAMETERS	RDSO MANUAL	PLAXIS
Displacement at top of ballast (mm)	2.67	2.721 (Node 454)
Displacement at top of blanket (mm)	2.30	2.027 (Node 407)
Displacement at top of top soil (mm)	2.12	2.27 (Node 417)
Displacement at top of middle soil (mm)	1.64	1.632 (Node 375)
Displacement at top of bottom soil (mm)	1.27	1.191 (Node 319)

Following is the graphical representation of the results RDSO Manual and PLAXIS Analysis, which shows the very close results of the displacements for the respective layers.

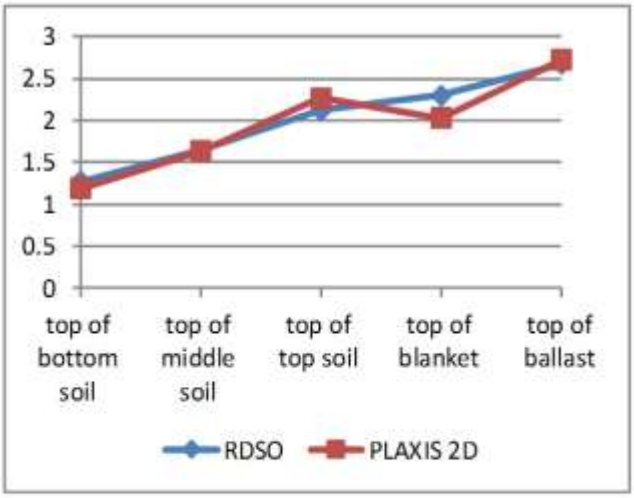

Chart -1: Comparative Graph between Results of RDSO Manual and PLAXIS Analysis

4. CONCLUSIONS

From above analysis and results, we conclude that the displacements obtained from the RDSO manual and PLAXIS analysis are very much close. Hence PLAXIS can be used in the development of Indian Railway's rail embankment formation. Results obtained are the outcome of thorough literature review of IR and PLAXIS, which are beneficial for rapid design generation. There will be less requirements of actual on site testings due to use of PLAXIS, so more analysis and detailed study can be performed with this software.

At last, PLAXIS will save time, energy, materials, less involvemenent of resourses as well infrastructure in such high level projects of development of Indian Railways.

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BIOGRAPHIES

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