ANALYSES AND EXPERIMENTAL INVESTIGATIONS OF RAILWAY TRACKS WITH AND WITHOUT GEOSYNTHETIC REINFORCEMENT

by

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To

My Family

CERTIFICATE

This is to certify that the thesis entitled "**ANALYSES AND EXPERIMENTAL INVESTIGATIONS OF RAILWAY TRACKS WITH AND WITHOUT GEOSYNTHETIC REINFORCEMENT**" being submitted by **Mrs. Sowmiya Chawla (nee L.S)** to the **Indian Institute of Technology Delhi** is a record of bonafide research work carried out by her under our supervision and guidance. The thesis work, in our opinion, has reached the standard fulfilling the requirements for **DOCTOR OF PHILOSOPHY** degree. The research report and results presented in this thesis have not been submitted, in part or full, to any University or Institute for the award of any degree or diploma.

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ABSTRACT

Railroad track is one of the few geosynthetic applications where a geosynthetic is used for multiple functions, namely, reinforcement, separation, filtration and drainage. In the present study, static and cyclic tests are performed on full panel railway track models laid on compacted soil subgrades. Tests are performed on model tracks with two different thicknesses of subballast layer and laid on two different subgrade soils, namely, Dhanaury clay and Delhi silt. Model tracks were adequately instrumented to record induced stresses and displacements in the track. Model tracks were reinforced with geogrid or geotextile or both at suitable interfaces. Track condition after a heavy rainfall was simulated. The models reinforced with geogrid at ballast-subballast interface were found to be more effective in reducing the tie displacements, ballast and subballast strains, and subgrade displacements as compared to the models reinforced with geotextile at subballast-subgrade interface for tracks with Dhanaury clay as subgrade. On the other hand, the models reinforced with geotextile gave better performance in terms of reduced tie and subgrade displacements as compared to the models reinforced with geogrid for tracks laid on Delhi silt subgrade.

In the present study, finite element analyses are carried out by using a commercially available finite element software code, MIDAS/GTS (Midas manual 2013). The analyses are carried out using three different sets of constitutive relationships for different track layers: (i) Non-linear analysis- Different track layers are simulated using hyperbolic Duncan Chang model, (ii) Straight analysis- Subgrade soil is simulated using elasto-plastic, Mohr-Coulomb, total stress (undrained) relationship but ballast and subballast are simulated using effective stress (drained), Mohr-Coulomb relationship and

(iii) Coupled analysis- Subgrade soil is simulated using a coupled pore water pressure-stress, time-dependent formulation under an elasto-plastic, Mohr-Coulomb constitutive relationship but ballast and subballast are simulated using effective stress (drained), Mohr-Coulomb relationship.

The constitutive parameters of the different track materials and interfaces used in the analyses are calculated from laboratory tests (triaxial tests and interface tests). Assessment of predictive capabilities in terms of vertical stress and displacement of the analyses is carried out by detailed comparisons with other numerical models and measured field test results. Model test results were extended to the field by performing a detailed parametric study of the track responses using coupled analysis for a typical reinforced prototype track with a practical range of track variables. Subgrade modulus (E_{sg}) and subballast thickness (d_{sb}) were found to be the most influential track parameters on the overall track responses. The next most important track parameters were shear strength parameters (c'_{sg} and ϕ'_{sg}) of the subgrade soil, stiffness of geogrid and coefficient of permeability of the subgrade soil. Water table fluctuation and consolidation time had significant influence on the pore water pressure development at the top of subgrade soil. Practical implications of predicted parametric trends are discussed.

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