Determination of Geogrid Reinforced Ballast Behavior Using Finite Element Modeling

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Abstract : In some countries, such as China, Turkey, andseveralEuropeanUnionnations, the therailwaypavementstructuralsystem has recently undergonerapid growth as a vital element of the transportation infrastructure, particularlyfortheuse of high-speed trains. It is vitaltoconsiderthe High-SpeedInfrastructureDemandwhendevelopingandconstructingtherailwaypavementstructure. HSRL can create more substantial ldifficultiestotheballastorbaselayer of regularlyusedballastedrailwaypavementsthanstandardrailwaytrains. The deterioration of the theballastorbaselayermayleadtosubstructuredegradation, which might lead to safety concerns and catastrophicincidents. As a result, the efficiency of railways will be impactedbylargecargoesorhigh-speed trains. A railwaypavement construction can be strengthened using geosyntheticmaterials in theballastorfoundationlayer as a countermeasure. However, there is still a need in the literature to quantifytheinfluence of geosynthetic materials, particularlygeogrid, on the mechanical responses of railwaypavementstructuresto HSRL loads which is essential knowledge in supporting the selection of appropriate material and geogridinstallationposition. As a result, the purpose of this research is to see how a geogridreinforcementlayermayaffectthekeyfeatures of a ballastedrailwaypavementstructure, with a particular focus on the materialtypeandgeogridplacementpositionthatmayassistreducethe rate of degradation of the therailwaypavementstructuresystem. Thisstudyusesnumericalmodeling in a genuinerailwaycontexttovalidatethebenefit of geogrid reinforcement. The usage of geogrids in the railway system has been thoroughly researched in the technical literature. Three distinct types of geogrid installed at two distinct positions (i.e.,withintheballastlayer, betweentheballastandthesub-ballast layer) within a railwaypavementconstructionwereevaluatedunder a variety of verticalwheelloadsusing a three-dimensional (3D) finite element model. As a result, fouralternativegeogridreinforcementsystemsweremodeledtoreflectdifferentconditions in the ballastedrailwaysystems (G0: no reinforcement; G1: reinforcedwithgeogridhavingthelowestdensityandYoung'smodulus; G2: reinforcedwithgeogridhavingtheintermediateYoung'smodulusanddensity; G3: reinforcedwithgeogridhavingthegreatestdensityandYoung'smodulus). Themechanicalreactions of the railway, such as verticalsurfacedeflection, maximumprimarystressandstrain, andmaximumshearstress, werestudiedandcomparedbetweenthefourgeogridreinforcementscenariosandfourverticalwheelloadlevels (i.e., 75, 100, 150, and 200 kN). Differences in the mechanical reactions of railwaypavementconstructionsowingtotheuse of differentgeogridmaterialsdemonstratethebenefits of suchgeosynthetics in ballast. In comparison to a non-reinforcedrailwaypavementconstruction, thereinforcedconstructionsfeatureddecreasedverticalsurfacedeflection, maximum shear stress at the sleeper-ballast contact, and maximum main stress at the bottom of the ballast layer. As a result, addinggeogridtotheballastlayerandbetweentheballastandsub-ballast layer in a ballastedrailwaypavementconstruction has beenfoundtolowercriticalshearand main stresses as well as verticalsurfacedeflection.

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