Application of Sub-Ballast Embedded with Waste Rubber Tyres in Rail Infrastructure in Sri Lanka

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Abstract

Railway transportation has become one of the most popular modes for transporting freight and passengers all over the world due to factors such as increased road traffic on highways, urbanization, and population growth. Maintenance of rail tracks consumes a considerable cost. A ballast is introduced to bear loads, facilitate water drainage and prevent underlying vegetation from surfacing. While transferring the imposed loading uniformly to subgrade soil at a stress tolerable for the subgrade material, it provides the necessary degree of elasticity and resilience to absorb vibrations and shocks. However, ballast degradation is one of the major issues in the rail substructure due to excessive stresses and vibrations. Increasing the durability of the rail substructure will minimize the cost needed for maintenance and replacement. Geogrid and geocells can be placed below the ballast layer to prevent the frequent maintenance of the ballast layer. The three-dimensional cylindrical shape of the rubber tyre and the material properties match with the ground improved with geocells. Further, rubber tyre is a wasteland and cause numerous environmental and health hazards when dumped inappropriately. This research is a numerical study done with Finite Element Analysis using ABAQUS software. The traditional rail substructure, which contained the Ballast, Sub ballast, and Subgrade layers, is considered in the analysis. Proposed rubber tyres are embedded in the sub-ballast layer filled with sub-ballast material. 250kN and 350kN axle loads with the frequency of 10Hz dynamic load conditions are applied on the sleepers, considering the rail speeds in Sri Lanka. The impact of the sub-ballast embedded with filled rubber tyres subjected to cyclic loading is observed by varying the tyre sizes. Sizes of rubber tyres were selected based on the available wase quantity of such tyres in Sri Lanka. Sub-ballast embedded rubber tyre layer reduces the vertical stresses which are transferred to the subgrade, causing settlements. According to the results of the analysis, the most effective tyre size for reinforcement is 165/55R14 among the analyzed tyre sizes. The effectiveness of the tyre layer is increased with the decrease in the tyre section height. The number of rubber tyres that are needed to reinforce the 1km of rail track is also calculated in this study

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