ABSTRACT

The present investigation has been done to examine the performance of a cohesive subgrade mixed with shredded tyre scrap. A road named Jibantala-Taldi Road in South 24 Parganas District, West Bengal, measuring 12.45 km in length and 5.50 m in width, has been selected for this study. This road falls under the jurisdiction of the Public Works Department (PWD), Government of West Bengal.

Soil samples have been collected from the road site to determine the fundamental soil properties, while scrap tyres have been obtained from a local car garage in Jadavpur, Kolkata, West Bengal. The study involves conducting appropriate tests to observe changes in soil strength after mixing different sizes of scrap tyre (10mmX10mm, 15mmX15mm, 20mmX20mm, 25mmX25mm, 30mmX30mm) with soil at varying percentages ranging from 5% to 30% to identify the maximum improvement achievable. Various laboratory tests have been performed to assess critical soil properties, including: a) Grain size distribution b) Atterberg Limits c) Modified Proctor compaction test d) California Bearing Ratio (CBR) test. Soil-tyre mixtures have been prepared by combining road subgrade soil with shredded tyre scrap based on dry weight proportions. The soil-to-tyre ratios explored were 100:0, 95:5, 90:10, 85:15, 80:20, 75:25, and 70:30. To fulfill the objective of the study, two standard test methods have been conducted for soil-tyre mixtures: a) Modified Proctor test b) CBR test. Optimal results have been achieved with a 10% inclusion of 15mm x 15mm tyre scrap, enhancing the soaked CBR value by 164%, from an initial 3.36 to 8.90. In addition, a comprehensive traffic study, including an axle load test, have been carried out on the road to collect necessary data. The analysis of flexible pavement design considered two types of subgrade soil: normal soil and soil mixed with tyre scrap. This analysis followed the guidelines specified in IRC:37-2018 and considered two CBR values: one for normal soil and another for soil with tyre scrap. These findings guided the redesign of the pavement structure using IIT PAVE software, ultimately reducing the pavement thickness by 90mm and suggesting a more sustainable approach with scrap tyre materials.

Moreover, the construction of a new 30.0m road section incorporating these modifications allowed for in-field testing with Dynamic Cone Penetrometer (DCP) and Falling Weight Deflectometer (FWD). A FWD study has been conducted on a selected segment of the Jibantala-Taldi Road, including the newly constructed pavement with a subgrade modified using scrap tyres. Deflection measurements have been taken at various

intervals from the load cell, including 0 mm, 300 mm, 600 mm, 900 mm, 1200 mm, 1500 mm, and 1800 mm. These measurements have been used to calculate deflection bowl parameters, such as the Lower Layer Index (LLI), to assess subgrade deflection. The enhanced subgrade displayed a notable increase in stiffness and load-bearing capacity, evidenced by a 141% increase in the in-situ CBR value and a significant reduction in vertical deflections. The tests revealed a notable increase in subgrade stiffness and load-bearing capacity. These indices are instrumental in predicting the structural performance of in-service pavement layers and identifying homogeneous sections for condition assessment. Elastic modulus values have been determined and compared for both pavement types, following the guidelines outlined in IRC:115-2014. PLAXIS 3D Dynamic Finite Element (FE) modelling of the FWD test has been conducted to create an approximate simplified numerical model and use experimental data to validate the findings. A regression analysis, supported by MINITAB statistical software, demonstrated strong correlations ($R^2 = 0.84$, Adjusted $R^2 = 0.8163$) between the modified CBR and variables such as scrap tyre size, percentage, and existing pavement thickness.

This analysis confirms the effectiveness of the scrap tyre admixture in enhancing subgrade strength, offering a sustainable solution to improve road durability and performance. This approach provides valuable insights into the effective reuse of scrap tyre in civil engineering, highlighting its benefits for enhancing road durability and performance while advocating for environmentally friendly construction practices.

Keywords: *California Bearing Ratio (CBR); subgrade; Tyre Scrap; Falling Weight Deflectometer (FWD); Deflection; Elastic modulus*