ISSN 2362–0412

ABS-128

Effect of Particle Size and Shape on the Breakage Characteristics of Ballast Aggregates Used in Sri Lankan Railway Tracks

P.V.S.M. Nayanajith[1], J.P. Tharaka[1], H.G.S. Mayuranga[1]*

[1] Department of Civil and Environmental Engineering, University of Ruhuna, Hapugala, Galle

**Corresponding author:* sushan.m@cee.ruh.ac.lk

Ballast breakage is one of the most critical factors affecting the long-term performance, stability, and maintenance needs of Sri Lankan railway tracks. The durability of ballast is strongly governed by its individual particle properties, particularly size and shape, which control how particles resist compressive stresses and fracture under loading. However, the influence of these two parameters on breakage behavior has not been comprehensively studied for ballast aggregates used in Sri Lankan railway tracks. Consequently, this research presents an experimental and numerical investigation aimed at quantifying the effects of particle size and particle shape on the breakage characteristics of railway ballast used in Sri Lanka. Ballast samples were collected from the Department of Railways, Sri Lanka, and categorized into four size ranges between 20 and 63 mm. Shape categorization was carried out using flakiness and sphericity values derived from 3D-scanned particle geometries. Representative particles from each size and shape group were tested through single-particle crushing tests under displacement-controlled conditions to determine peak load capacity, force-displacement response, and tensile strength. Discrete Element Method (DEM) models of the single-particle crushing test were developed using 3D-scanned ballast particles and calibrated against laboratory results to numerically simulate particle breakage. The findings highlight significant effects of both particle size and shape. Larger particles recorded higher peak loads but lower tensile strength due to internal flaws and stress concentration, reflecting a significant impact from particle size. Flaky-shaped particles exhibited substantially weaker mechanical resistance and more brittle failure modes compared to cubical-shaped particles of the same size. DEM simulations accurately reproduced these trends, confirming the dominant influence of size and shape on particle breakage. Overall, the results emphasize the importance of controlling both size distribution and shape quality to minimize breakage and improve the long-term performance of ballast aggregates.

Keywords: Ballast breakage, DEM modelling, Particle shape, Particle size, Single-particle crushing test