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GRADING EFFECT ON BEHAVIOUR OF RAILWAY TRACK BALLAST

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Ballast is the main structural component of railroad sub structures. In general, ballast aggregates are uniformly graded and angular in shape. The function of ballast is to transform loads to the subgrade efficiently and to provide sufficient drainage. Track deformation by settlement and degradation of ballast has been identified as the main problems in maintaining the desired geometry of a rail track in lateral and horizontal directions. The particle packing degree, which is governed by ballast gradation, influences the ballast performance since it determines the distribution of aggregate particles within the ballast structure and hence the interaction of aggregates in distribution of the applied stresses. Various ballast gradations are in use all over the world. In this study the deformation of ballast under constant static load increments was examined using a cubical triaxial apparatus. Three sides of the apparatus were fixed and the other side was free to move laterally to simulate the confinement provided by the surrounding ballast at field. The samples were selected to reflect the upper, middle and lower limits of world ballast specifications; American Railway Engineering and Maintenance-of-way Association (AREMA) No 4 to represent the upper bound (UB) and Australian Lower Bound (LB) for the lower limit while AREMA LB and Australian UB representing the middle. In the apparatus a 275 mm thick compacted ballast layer was laid on top of a well-compacted 75 mm thick sub-ballast layer and 50 mm thick clay layer to simulate the sub grade. All ballast samples were compacted according to Rodding procedure specified in ASTM C29-97. Axial load was applied via a circular rigid plate. The load and settlement data was acquired by a data acquisition system. Load increments were applied until a maximum pressure on the ballast surface was close to 0.5 N/mm^2 which equals the pressure exerted on ballast underneath the sleeper by a train at 80 km/hr with 25 Tonne (Appx.245kN) axel load. The associated settlement of ballast showed rapid initial deformation at initial loading steps indicating rearrangement of particles. This rearrangement of aggregate skeleton increased the ballast density and thereby, reduced the rate of vertical deformation due to subsequent increment of loading. This stage, the settlement is mainly due to minor particle breakdown by failure of sharp edges and further rearranging of particles. This is characterized by small fluctuations of the load settlement curve. During the latter part of the loading, deformation tends to be large with sudden settlements indicating major particle breakdowns by crushing, shearing or tensile failure depending on the location of particles inside the ballast skeleton. This is characterized by rapid and large fluctuations in the load settlement curve. With further increase of loading, the ballast sample showed slow but large deformations. Out of four ballast samples, Australian UB has the most well-graded ballast distribution and exhibited lesser deformation than the others while more uniformly graded AREMA LB showed significant settlement. AREMA UB and Australian LB showed almost equal load settlement behaviour showing the effect of parallel gradation. The results of this study confirm the influence of ballast gradation on the amount and the rate of settlement. The behaviour of AREMA UB and Australian LB reveals that track performance could be further optimized using parallel gradation techniques while maintaining proper hydraulic conductivity.

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