Studies on Use of Shredded Tyre Chips as Aggregates in Ordinary and Encased Stone Columns

With industrialisation there has been an ever-increasing scarcity of the land/ground of appreciable ultimate carrying capacity. The technique of ground improvement by the construction of stone columns is widely accepted to stabilize soft ground. However, stone aggregates, being a natural resource, has been depleting due to over-utilisation. In this study the use of an alternate material, i.e. shredded tyre chips, as an aggregate in stone columns is explored. The present study emphasizes the behavior of stone columns made of different mix proportions of stone aggregates and shredded tyre chips. The load-settlement behavior of ordinary as well as encased columns made of such aggregates is studied under quick and slow loading conditions through model tests. The columns are encased with geonet when the quick loading tests are performed. For the slow loading tests, the encasements include geonet, galvanised wire mesh, and steel nails. To understand the bulging behavior of columns, numerical analysis was performed with Plaxis 3D software. Comparative analysis of the behavior of columns for the respective mix proportions is carried out to understand the effect of rate of loading. Finally, the efficiency of the ordinary and encased columns is obtained with respect to ordinary conventional columns i.e. 100S columns both for quick and slow loading. From the efficiency factor, the optimum amount of tyre chips that can replace stone aggregates in the stone column is determined. The results obtained from the model experiments report that under quick loading, the ordinary columns made of a greater proportion of stone aggregates exhibit higher load carrying capacity. For the geonet encased columns in quick loading tests, the load carrying capacity of the composite ground is further enhanced. Also, comparison of the efficiency with respect to Ayothiraman and Soumya (2015) helps to infer that smaller diameter columns perform better than larger diameter column. When the columns are subjected to slow loads, the load carrying capacity increases further. Moreover, the encased capacity of most of the columns under slow loading is higher than the $Q$ value due to the draining away of pore water from the clay bed over considerable time. The efficiency plot of the ordinary and encased columns concludes that up to 50% replacement of the stone aggregates with shredded tyre chips by volume is possible for
geonet-encased columns. For the galvanised wire mesh and steel nails reinforced columns, almost 70% of the stone aggregates can be replaced with shredded tyre chips by volume. From the numerical analysis of ordinary and encased column under quick loading, it is seen that with encasement of the columns, the aggregates exhibit a significantly higher modulus of elasticity and hence the stiffness of columns improve. The ordinary columns composed of the dominant proportion of stone aggregates bulge predominantly closer to the ground surface while the bulging increases and becomes uniform over the entire depth for columns containing a greater quantity of tyre chips (more than about 30%). For the encased columns, the bulging is negligible for columns composed of mix proportions with dominant volume of stone aggregates (up to about 70%), but for the columns composed of more than 30% shredded tyre chips, the bulging behavior is similar to that of ordinary columns composed primarily of stone aggregates. Moreover, the encased columns behave similar to that of conventional columns which only leads to the fact that such columns composed primarily of tyre shreds behave similar to conventional columns when provided with suitable encasement. Thus, with respect to the bulging behavior of columns, partial replacement of tyre chips with stone aggregates by about 30-70% is possible with proper encasement of desired stiffness.