ABSTRACT

Municipal solid waste (MSW) management is a leading challenge for humans currently. As we not only have to deal with the daily generated waste but also must find the solutions for already generated waste which still lying somewhere on the earth's surface. Landfilling which use to be the most viable option to get rid of our waste is no longer an acceptable disposal option left. Poor waste management and increasing waste generation have become environmental and health hazards. Now, this piled-up waste from decades in these landfills causes an alarming situation and can’t be ignored. Other than sanitary landfills there are numerous unsanitary landfills and open dump sites which create more dangerous situations in the environment. One of the ways to deal with it could be extracting the waste from the landfills and recirculating the material and land cost in the economy, through enhanced landfill mining techniques. The most abundantly excavated material from sanitary landfills or open dump sites is the municipal solid waste (MSW) fine fractions which consist of more than 50% of the waste composition. These fine fractions also called “MSW fines/soil-like material” have the potential to be used as a bulk replacement for construction/geomaterials. Before this material can be used in bulk in fields as geomaterials in structures, it is important to check the behaviour of the considered material under realistic loading conditions (monotonic or dynamic). The heterogenic characteristic of the MSW is the major factor that influences all the other parameters and makes this material more unpredictable and challenging to reuse. The material characteristic of the MSW is very specific to the site it has been collected (origin of the waste), so it requires specified pilot projects to deal with the waste locally. The data from these pilot projects can be

further helpful to predict or model general geotechnical parameters (static or dynamic). Contributing to this objective a comprehensive experimental program has been planned. The MSW fines (particle size less than 4.75 mm) which contribute to the major portion of the decomposed waste and closely resemble the soil have been the focus of the study. The sample was collected from the local site Ramana in Varanasi. After segregation and processing, about 60% of waste was characterized as MSW fines. The basic physical, chemical, and geotechnical characterization of the waste categorize the MSW fines as lightweight, non-plastic silty sand-type material with good shear strength properties (cohesion and friction angle from 31.37 to 42.19 kPa and 26.69° to 30.74°, for relative compaction of 95 to 99% respectively) with an organic content of 5.9% and slight acidic behaviour. The study on MSW fines has been continued under static and cyclic loading conditions for unreinforced and reinforced categories. A set of 100 strain-controlled cyclic triaxial tests under consolidated undrained conditions were performed to study the cyclic behaviour of the considered MSW fines. The sensitivity of different parameters (relative compaction, effective confining pressure, cyclic shear strain, and loading frequency) on dynamic properties (dynamic shear modulus (G) and damping ratio (D)) of the MSW fines was evaluated. The MSW fines were reinforced with randomly distributed fibers which were also part of the waste collected from another site Karsada, Varanasi. These fibers were mixed to the MSW fines in 0.5, 1, 2, 4, 8, and 10%. The static and dynamic strength of the composite mix was evaluated to find the optimum percentage of fiber content in the mix. Through static strength tests, the optimum fiber content can be decided as 8%. But, the improvement in dynamic shear strength can’t be seen as governed by the dynamic shear modulus of the material. The inclusion of fibers enhances the damping parameter of the MSW fines and can be used as shock absorbers but does not help in excess pore water pressure dissipation. It can be concluded from the results that under static conditions, these waste fibers work satisfactorily and can be used as backfill or embankment material but has limited applications in high seismic zones.

Moreover, the small-strain shear modulus of unreinforced and fiber-reinforced MSW fines was evaluated through the laboratory bender element apparatus. The data evaluated from the laboratory tests were further used to develop empirical correlations for the unreinforced and fiber-reinforced MSW fines. Based on the experimental test results, the excess pore water pressure (r_u) model for the fiber-reinforced MSW fines was established. A cubic polynomial model was applied to correlate the normalized small-strain shear modulus (G_R/G_{UR}) and normalized shear strength (τ_R/τ_{UR}) of the reinforced and unreinforced MSW fines. Nonlinear models were fitted for the normalized shear modulus and damping ratio with cyclic shear strain for both the unreinforced and reinforced MSW fines. Further, the dynamic shear modulus data obtained from the cyclic triaxial tests of the unreinforced and reinforced MSW fines was used for the prediction model of MSW fines (dynamic shear modulus) through two machine learning techniques, i.e., Artificial neural network (ANN) and Gaussian process regression (GPR). The GPR model predicts better results for the dynamic shear modulus of unreinforced and reinforced MSW fines. The sensitivity analysis of the considered parameters on the dynamic shear modulus of MSW fines also correlated with the experimental results.