

## ABSTRACT

---

The energy is the driving force of human inventions which make our day to day activities easier and effortless. The outmost demand of the energy compels us for the exertive utilization of the fossil fuel (coal, oil, natural gas) in order to meet the demand. Among all the fossil fuel available, the coal is the most abundantly available fossil fuel in India. Because of its availability and reasonable cost, it has been primarily utilized for the electricity production followed by steel & iron industries and cement & chemical industries. In India, the production of coal in the year 2021-22 was found to be 778.19 million tonnes (MT) which was increased by 8.67% as compared to the previous year. Also, the ash content potential of the Indian coal is around 35-45%. Taking this ash content percentage into account, the total amount of coal ash produced must be between 272.37 to 350.19 MT in the year 2021-22 and this is projected to cross 1000 MT by the upcoming decades. These generated coal ashes consist of a higher percentage of fly ash than that of the bottom ash, i.e., approximately 70-80%. In India, the amount of fly ash produced over a period of 25-year is approximately 3335.9 MT, of which only 55% (1834.83 MT) have been used and the remaining 45% (1501 MT) is still in their unutilized form. The generated ash usually dumped in slurry form near to the thermal power plant that causes scarcity of the valuable agricultural land. The dependency on the non-renewable energy resources will take another 2-3 decades to eliminate considering the current rate of development of the renewable resources.

The production of large amounts of coal ash and its land requirements for disposal is an alarming situation for the present scenario. Also, the very limited

fraction of it has been utilized in different sectors like cement, brick, soil stabilization, mine filling etc. Its bulk utilization is the major point of concern and that can only be possible by broadening its application area such as; embankment fill material, subgrade/sub-base material, foundation material for construction etc. 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). Contributing to this objective, a comprehensive experimental program has been planned in the present study.

In the present study, an attempt has been made to examine the insight behaviour of the fly ash and local soil collected from Renukoot (U.P), India and IIT(BHU), Varanasi campus respectively. Also, the implementation of coal ashes is generally done over the existing soil and follows the stratification of multiple layers. In order to simulate the realistic field condition, the interaction between the fly ash and local soil has also been investigated in the stratified form. Furthermore, along with the comprehensive physical, geotechnical, and chemical assessment, the dynamic behaviour of the homogeneous and stratified soil-ash deposits have been examined under large and small-strain conditions. A set of 105 strain-controlled cyclic triaxial test were performed under consolidated undrained conditions for dynamic behaviour and liquefaction study. In addition, the influence of independent parameters such as relative compaction, frequency of loading, effective confining pressure, shearing strain has been incorporated for the wider assessment of the shear modulus ( $G$ ) and damping ratio ( $D$ ) of the material. Furthermore, normalized modulus reduction and damping ratio curves of all the homogeneous and stratified soil-ash deposits have been plotted using the results of the cyclic triaxial and bender element tests.

The present fly ash contains a higher fraction of sand (61.52%) size particles followed by silt (33.19%) and clay (5.29%). Similarly, local soil is composed of maximum silt (81.77%) size particles followed by clay (16.11%) and sand (2.12%). Since, both the soils are satisfying the desirable condition of well graded soil, hence classified as well graded silty sand (fly ash) and silt of intermediate plasticity (local soil). In the same way, the outcome of the standard Proctor test shows that local soil has higher maximum dry density and lower optimum moisture content and vice-versa for fly ash. Also, significant improvement in the shear strength parameters of the considered local soil through a soil-waste layered system was observed in the saturated drained and undrained condition. From the dynamic study, the stratified soil-ash shows higher shear modulus than that of the fly ash and local soil for a shear strain of 0.3% & 0.6% and beyond 0.6%, it shows the comparable shear modulus as compared to the homogeneous one. Similarly, the damping ratio of the stratified soil-ash and local soil is slightly higher than that of the other soil, although the damping ratio of the fly ash is equivalent to that of the sand and clayey soil. Based on the results, it is highly recommended to use the asymmetric hysteresis loop (ASHL) approach, especially under large strain conditions irrespective of the soil type. In addition, the liquefaction assessment using energy method reveals that the energy required for liquefaction is dependent on all the considered parameters, whereas it is independent of the cycle needed to liquefy. From the experimental investigation, this can be concluded that the stratified soil-ash deposit shows enhancement in shear strength parameters (cohesion: 55-69 kPa & internal friction: 25-35°) and CBR value (Unsoaked: 13-30% and Soaked: 1.5-4.5%). Similarly, it shows high dynamic shear modulus (G: 2-8 MPa) that ultimately improve the liquefaction resistance. In the same way, the stratified soil exhibits reduction in

pavement thickness as compared to local soil. But with geosynthetic reinforcement a significant reduction in pavement thickness between 19-32% has been observed for different traffic loading conditions. According to the performance, this layered arrangement can be recommended as a subgrade or fill material under moderate seismic conditions.