ABSTRACT

Granular materials with low organic content are generally considered the preferred structural fill in the construction of mechanically stabilized earth (MSE) walls such as flyovers, bridge abutments etc. Due to scarcity of naturally available granular materials because of environmental regulations, efforts are in progress worldwide to explore possible reuse of a wide range of waste materials as substitutes. Coal ash is one such waste material. In the present study, an experimental investigation has been undertaken to experimentally assess the feasibility of using different types of coal ashes namely, bottom ash, pond ash and fly ash separately as structural fill in MSE walls as an alternative for natural soil.

Detailed geotechnical and electrochemical characterization of coal ashes have been carried out and results have been compared with locally available Yamuna Sand (reference material). Pullout test apparatus meeting the requirements of ASTM-D6706 has been designed and fabricated for the present study. Thereafter, pullout tests have been conducted to evaluate the pullout behavior of geogrids embedded in different coal ashes and reference material. The results have been compared with conventional fill materials (CFMs) reported in the literature. The influence of normal stress, percentage of fines in ash, under-compaction, geogrid from different manufacturing methods as well as of transverse members of geogrid on pullout behavior have also been studied. Efforts have been made to assess the suitability of predicting pullout behavior of geogrids embedded in coal ash using numerical simulations in PLAXIS 3D. Subsequently, the design and costs implications of using coal ashes as structural fill in the construction of MSE walls have been studied.

Bottom ash meets the gradation requirements for a structural fill of both national and international guidelines while pond ash and fly ash used in the present study satisfy only the requirements of national guidelines for structural fill. Both bottom ash and pond ash with less than 50 % of fines content meet the angle of shearing resistance and electrochemical

requirements of fill materials as per international guidelines when used with polymeric reinforcement. Fly ash meets the requirements of national guidelines only.

The pullout behavior of geogrids embedded in bottom ash and pond ash with less than 50 % of fines are comparable with those of CFMs. The pullout behavior observed in fly ash as well as mixture of bottom ash and fly ash with more than 60 % fines are on the other hand 30 to 40 % lower than bottom ash, reference soil and CFMs. Pullout resistance decreases by 30 to 70 % on under-compaction of coal ashes with larger reduction observed in fly ash.

The results obtained through numerical simulation match well with the laboratory tests and lie within ±10 to 20 % from experimental results.

MSE walls constructed with bottom ash as structural fill requires least amount of reinforcement due to its low unit weight and high shear strength. Pond ash with less than 50 % of fines require equivalent number of reinforcement layers as those by natural reference soil. Fly ash requires more reinforcement layers than natural reference soil due to its low angle of shearing resistance.

The results of present study encourage the construction industry for bulk utilization of bottom ash as an economical alternative to natural soil. Pond ash with less than 50 % of fines offers an alternative to natural soil. However, to ensure free drainage, it is recommended that few additional horizontal drainage layers of bottom ash/sand be introduced in the design to allow free flow of infiltrated water. Fly ash and mixture of bottom ash and fly ash with more than 60 % of fines is not suitable (by itself) for utilisation as structural fill without adequate design safeguards i.e. addressing the critical factors of providing intermittent drainage layers, decrease in pullout capacity due to under-compaction, and studying pullout behavior of geogrids embedded in saturated fly ash.