IMPROVEMENT OF POND ASH WITH GEOSYNTHETICS

by

GOUTAM KUMAR POTHAL

Department of Civil Engineering

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DEDICATED

TO

MY FAMILY

CERTIFICATE

This is to certify that the thesis entitled "**IMPROVEMENT OF POND ASH WITH GEOSYNTHETICS**" submitted by **Mr. Goutam Kumar Pothal** to Indian Institute of Technology Delhi, for the award of degree of Doctor of Philosophy is a record of the bonafide research work carried out by him. **Mr. Goutam Kumar Pothal** has worked under my supervision for the submission of this thesis, which to my knowledge has reached the requisite standard.

This thesis, or any part thereof has not been submitted to any university or any institution for the award of any degree or diploma.

Dr. G. Venkatappa Rao
Professor
Department of Civil Engineering
Indian Institute of Technology Delhi
New Delhi – 110016
INDIA

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Goutam Kumar Pothal

(GOUTAM KUMAR POTHAL)

ABSTRACT

Pond ash, produced in huge quantities by thermal power plants, require large land area for disposal and causes environmental hazards. The application potential of pond ash as a structural fill material for developing low lying areas to construct infrastructure development projects on it is the prime objective of this thesis. The major disadvantage of its low being capacity can be improved by applications of geosynthetics reinforcements. The possible improvement of compacted pond ash with different types of geosynthetics and other geotechnical behaviour of reinforced pond ash are examined in this thesis through a comprehensive laboratory study. India, being the largest producer of coir fibre, a special emphasis is given to the use of coir geotextiles, as a reinforcement to improve the pond ash fills.

The research programme included

1) A study of the improvement in bearing capacity of compacted pond ash reinforced with both polymeric geogrids and natural fibre coir geotextiles by carrying out model tests with a strip footing.
2) A study of the improvement in the strength of double layered system WMM layer and the sand layer underlain by compacted pond ash with application of coir geotextile and polymeric geogrids at their interface and to compare the results for their potential use in pavements.
3) A study of the triaxial behaviour of compacted pond ash reinforced with natural fibre coir geotextile in layers and compares the results with that of polymeric counterparts.

4) A study of the improvement of settlement behaviour pond ash with loading under natural condition by inclusion of prefabricated vertical drains by large scale model tank tests.
5) Analyze and develop a mathematical model to predict the ultimate bearing capacity improvement factor of the reinforced pond ash.

Chapter 1 of the thesis gives the introduction to the present work along with a brief description to the environmental problems with the rising ash production in the country and natural fibre coir geotextiles. In Chapter 2, the available relevant literature has been reviewed. The test equipments and setups used are described along with the detailed procedures and test programme in Chapter 3.

The behaviour of pond ash reinforced with different types of geosynthetics including two polymeric geogrids and three coir woven geotextiles is presented in Chapter 4. The behaviour of unpaved road system with reinforcement at the interface is presented in Chapter 5. Studies on triaxial behaviour of reinforced pond ash with layers of geosynthetic reinforcement are included in Chapter 6. The improvements in the consolidation settlement behaviour of the pond ash with and without prefabricated vertical drains have been presented in Chapter 7. Mathematical model developed by multiple regression analysis based on the model test data for prediction of ultimate bearing capacity ratio is presented in Chapter 8. An overall summary of the work carried out and the salient conclusions drawn are highlighted in Chapter 9.

Tests were conducted in model tank of 750 mm × 300 mm × 400 mm size with a 75 mm wide strip footing, with two types of compacted pond ash reinforced five geosynthetics as reinforcements. From the test results presented in Chapter 4, it is concluded that the ultimate bearing capacity of the reinforced models increased significantly with inclusion of any type of geosynthetics. The ultimate bearing capacity ratio is found to depend upon the parameters like the length of the reinforcement layer (b), the depth of the reinforcement layer below the base of the footing (u) and the number of reinforcement layer (N) for all types of reinforcements. The performance of the coir woven geotextiles is found to depend on the physical properties like mass per unit area and aperture size and mechanical properties like tensile strength and initial slope of the tensile stress-strain curves.

Load tests were also conducted on the model tank with two types of pond ash as subgrade (250 mm thick) and wet mix macadam or sand as base course (100 mm and 60 mm thick) under unreinforced condition. Tests were also carried out under reinforced condition with the geosynthetics at the interface of the compacted pond ash subgrade and wet mix macadam or sand as base course layer. Based on these results presented in Chapter 5, it was found that the ultimate bearing capacity of the reinforced double layer model increased significantly with inclusion of both polymeric geogrids and coir woven geotextiles at the interface of both the WMM and sand base courses and pond ash subgrade. The ultimate bearing ratios of coarser pond ash type NC are better than the finer pond ash type NF. As expected, the performance of the coir woven geotextiles is quite different from that with polymeric geogrids. The improvement with the rigid polymeric geogrid type GGR is better than that with the flexible polymeric geogrid type GGF for both the types of pond ash subgrades. This can be attributed to the higher stiffness and better friction at the interface of the former. The performance of with the coir woven geotextiles with both the types of pond ash subgrades, clearly depended on their respective physical and mechanical properties. The coir woven geotextile type CWC exhibited the best improvement followed by that with type CWB and CWA.

Drained Triaxial compression tests have been conducted on two types of pond ash under unreinforced and reinforced condition with different layers of geosynthetics reinforcements. From the results presented in chapter 6, it was generally concluded that the strength of the unreinforced specimens of both the types of pond ash increased significantly with inclusion of both polymeric geogrids and coir woven geotextiles. There is an increase in the value of ϕ' by as much as 6^o to 8^o for both the types of pond ash with all the types of reinforcements. For both the pond ash types, the value of c' increased with an increase in the number of reinforcement layers. The stress-strain relationships follow the hyperbolic variation as per Kondner's procedure.

Large scale tests were carried out in a model tank in order to qualitatively assess the in-situ performance of the prefabricated vertical drains (PVDs) in ash ponds. From the test results presented in Chapter 7, it is observed that there are significant improvements by the pond ashes in terms of total settlements and moisture content by the use of PVDs.

A mathematical model was developed to predict the ultimate bearing capacity of reinforced pond ash by multiple regression analysis. The experimental data obtained from 90 model tests on the two types of pond ash and the five types of geosynthetics with varying parameters like b, u, d and N were used to develop a mathematical model by multiple regression analysis.

The application of the above results in typical field situations is mentioned below.

1. The bearing capacity of compacted pond ash can be improved by providing different layers of geosynthetics reinforcements including both polymeric and coir geotextiles and can be used advantageously as a fill material in construction of many infrastructure projects and to save valuable soil.
2. The inclusion of coir woven geotextiles in compacted pond ash improves the strength behaviour and consequently the bearing capacity of a double layered system. With the use of a reinforcement layer the required depth of base course can be reduced upto 40 %, which not only reduces the cost of construction but also the application of natural fibre coir geotextile in rural roads as reinforcement will be an eco-friendly approach.
3. PVDs can be suitably used for rehabilitation of pond ash deposits.

The thesis ends with suggestions for further work.

CONTENTS