GEOTECHNICAL CHARACTERIZATION, STRENGTH AND FLEXURAL BEHAVIOR OF FLY ASHES STABILIZED WITH CEMENT AND RANDOMLY ORIENTED DISCRETE FIBERS

by

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Fly ash.

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V. Gay

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ABSTRACT

The quantity of fly ash produced worldwide is huge and keeps increasing every year. In India alone about 100 million tons of fly ash is being produced annually. There is a large gap between the rate of production and utilization of fly ash. The current rate of utilization of fly ash in India is around 23% as against, 3-4% during early 1990's. The utilization of fly ash in other major fly ash producing countries is also rather small. There is a great need to improve the scope of utilization of fly ash to minimize the problems associated with the vast accumulation of the material. With a view to improve the utilization of fly ash in India, the Government of India commissioned Fly Ash Mission (FAM), in 1994. Fly Ash Mission has identified ten different thrust areas to promote the utilization of fly ash. Of these, "Roads and embankments" and "Ash ponds and dams" are the major areas of geotechnical applications. The need of the present study arises from the requirement to improve the overall utilization of fly ash and in particular in applications related to geotechnical engineering. The scope of the present study is related to utilization of fly ash in geotechnical applications such as construction of embankments, fills and pavements where fly ash can be utilized in bulk quantities. Experiments were conducted on two Indian fly ashes, from Dadri and Rajghat thermal power plants.

The scope of work includes the study of following topics: (a) Physical properties and chemical composition; mineralogy and morphology; and geotechnical properties of the fly ashes; (b) Unconfined compressive strength (UCS) of cement-stabilized fly ashes and the influence of curing methods including controlled and ambient conditions of curing on the strength; (c) Geotechnical behavior of fly ashes mixed with randomly oriented polymeric fibers; (d) Behavior of fly ash-cement-fiber specimens under compressive and flexural loading; and (e) Mineralogical and morphological studies of fly ash-cement and fly ash-cement-fiber specimens.

In the first part of the study, experiments were carried out to characterize the Dadri fly ash. The physical properties such as specific gravity, specific surface area, and loss on ignition and the chemical compositions were determined. X-ray diffraction analysis and scanning electron microscopic studies were carried out to determine the mineralogy and morphology. Geotechnical characterization was carried out to understand the engineering behavior. The tests included grain size distribution, Atterberg limit tests, compaction tests, unconfined compression tests, direct shear tests, triaxial shear tests unconsolidated undrained (UU) and consolidated drained (CD), consolidation and permeability tests. The characteristics of the Dadri and Rajghat fly ashes are presented in Chapter 3.

Fly ash is rich in oxides and is pozzolanic in nature. The engineering behavior of fly ash can be improved by addition of suitable chemical stabilizers. The primary objective of the second part of the study is to evaluate the strength characteristics of the cement-stabilized Rajghat and Dadri fly ashes as pavement base course material and the influence of factors such as cement content, method of curing, and curing period, on the Unconfined compressive strength. The design mixes of cement-stabilized Rajghat and Dadri fly ashes were determined to comply with the strength criteria prescribed by Electric Power Research Institute (EPRI). Cement content varying from 4% to 18% and 4% to 15% were added to Rajghat and Dadri fly ashes respectively. The specimens were cured for different periods from 7 days to 3 years. Six different methods of curing, including controlled and ambient conditions, that simulated different field conditions were adopted. To evaluate the impact of seasonal curing on the UCS, specimens were cured during summer, monsoon and winter seasons also. Many times, the unit weight and water content of the compacted base courses in the field may slightly differ from the MDD and OMC of the material. Therefore, experiments were also conducted to study the effect of water content (optimum moisture content OMC, dry-of-OMC, wet-of-OMC) and dry unit weight (maximum dry density MDD, and 95% MDD) on the UCS of the cement-stabilized Rajghat fly ash specimens. X-ray diffraction and scanning electron microscopic studies were also performed to understand the micro structural changes and the reaction products formed due to cement stabilization. The results of the investigations on the cement-stabilized fly ashes are reported in Chapter 4.

Recent studies show that discrete fiber inclusion improves the geotechnical behavior of soils. Investigations on fly ash-fiber mixtures are relatively scarce. The third part of the experimental study was therefore carried out to investigate the influence of randomly oriented fiber inclusions on the geotechnical behavior of Dadri and Rajghat fly ashes. The geotechnical behavior of the raw fly ashes and fly ash-fiber mixtures have been compared. The deviator stress-axial strain behaviors in the UU and CD tests were represented by hyperbolic model and the different hyperbolic model parameters were determined. The results of the study are presented in Chapter 5.

No experimental study wherein fly ash-fiber specimens have been stabilized with high cement content that satisfies the strength requirements of pavement base courses is reported in literature. Therefore in the final part of the present study, experiments were carried out on Dadri and Rajghat fly ashes to investigate their compressive strength and flexural behaviors as cement-stabilized and fiber-reinforced base course materials. Dadri and Rajghat fly ashes were mixed, respectively with 15% and 18% cement content by dry weight. This stabilizer content was chosen to comply with the EPRI strength criteria. Polyester fibers, 6 mm and 20 mm long, and polypropylene fibers, 9 mm long, were used at 1% by dry weight of fly ash-cement mixture. The specimens were cured for different periods up to a maximum of 90 days. Unconfined compression tests and flexure tests were conducted on the cured specimens. A steel mold and accessories, required for the preparation of the flexure test specimens, were designed and fabricated. Flexure tests were carried out on fly ash-cement and fly ash cement-fiber beams. Portions of specimens were also scanned selectively to study the micro structural development. The results of the study on fly ash-cement-fiber specimens are presented in Chapter 6.

The conclusions of the various experimental studies are summarized at the end in Chapter 7.

CONTENTS

CHAPTER 2 GENERAL LITERATURE REVIEW

CHAPTER 3 GEOTECHNICAL CHARACTERIZATION OF FLY ASH