Permeability Study of Sand with A Partial Replacement by Pond Ash

Ritesh Jain[1], Arvind Kumar Agnihotri[2]

[1]Research Scholar, Department of Civil Engineering, NIT Jalandhar. Punjab

[2]Department of Civil Engineering, NIT Jalandhar Punjab. India

ABSTRACT

Soil specially cohesion less material like gravel, sand and coarse silt cannot take even low stress in tension and fails instantaneously with large values of permeability. It can be attained by the various techniques available in Geotechnical Engineering for improving the mechanical and engineering properties of the soil. However, each technique has some limitations and suitability to get maximum improvement in the soil conditions with minimum effort. During the construction of embankments, abutments, earthen dams and other retaining structures a huge amount of soil is needed. It can be done by partially replacing soil with some alternative materials. The problem of disposing pond ash can be reduced by utilizing it in large or moderate quantities in various engineering works.

As compared to the natural soil, the weight of pond ash is very less and it has self-draining capability. It is necessary to know the strength characteristics of pond ash before its successful application in various fields. In the present study, the possibility of using pond ash with locally available sand for permeability study was investigated experimentally. Besides pond ash replacement as well as effect of fiber inclusion in the mixture of sand with pond ash was studied. It was found that it can act as a substitute for reduction in permeability of sand and at the same time gain in strength.

Keywords: Permeability, strength, fibers, sand, pond ash

1. INTRODUCTION

Pond ash is the by-product of thermal power plants, which is considered as a waste material and its disposal is a major problem from an environmental point of view and also it requires a lot of disposal areas. Actually, there are three types of ash produced by thermal power plants, viz. (1) Fly ash, (2) bottom ash, and (3) pond ash. Pond ash is collected by mechanical or electrostatic precipitators from the flue gases of power plant; whereas, bottom ash is collected from the bottom of the boilers. Then these two types of ash, mixed together, are transported in the form of slurry and stored in the lagoons, the deposit is called pond ash. Besides this steel, copper and aluminum plants also contribute a substantial amount of pond ash. Pond ash has silica, alumina and various oxides and alkalis as its constituents. It is fine grained and pozzolanic in nature. As compared to the natural soil, the weight of pond ash is very less and it has self-draining capability. It is necessary to know the strength characteristics of pond ash before its successful application in various fields. During the construction of embankments, abutments, earthen dams and other retaining structures a huge amount of soil is needed.

Due to rapid industrialization and the scarcity of availability of natural soil the scientists thought to utilize the waste products of power plants as a replacement to the natural soil. This will solve the environmental issues due to the deposition of the by-products and also reduce the scarcity of natural soil. At present scenario the use of pond ash in India in other fields is negligible. Only about 35% of the pond ash is being used commercially. It shows that in order to preserve the valuable natural soil it is necessary to utilize the pond ash to the maximum extent.

2. LABORATORY INVESTIGATION

The sample of pond ash was obtained from ash ponds of *guru nanak dev thermal power plant*, Ropar district Punjab. After burning of coal in thermal power plant, about 20% to 30% of ash is collected at bottom in the form of slurry. This slurry is deposited in the pond. After evaporation of water from slurry remaining ash in dry form is called as pond ash. The basic properties of pond ash are as given in table 1.

Table1: Properties of Pond Ash

Physical parameters	Values	Physical parameters	Values
Color	Light grey	Shape	Rounded/sub-rounded
Silt &clay (%)	41.6	Specific Gravity, G	2.10
Fine sand (%)	44.6	Plasticity Index	Non- plastic
Medium sand (%)	12.2	Optimum moisture content, %	26
Coarse sand (%)	1.6	Max. dry density (g/cm^3)	1.238

FIBERS: It is proposed to use commercially available poly-propylene fibers of length 6mm and 12 mm. The physical properties of fibers, as supplied by the manufacturer are in Table 2.

Table2: Physical Properties of Fibres

Property	Values	Property	Values
Colour	White	Specific Gravity	0.91
Cut length	6mm, 12mm	Equivalent diameter (µm)	32-55
Denier (d)	1.5	Water absorption (%)	85.22
Tensile Strength (MPa)	600	Acid resistance	Excellent
Melting Point (°C)	>250	Alkali resistance	Good

Standard modified proctor compaction tests were performed in the laboratory to obtain maximum dry density (MDD) and optimum moisture content (OMC) for sand alone and a combination of sand and pond ash with various proportions as follow:

Table 3: Details of modified proctor compaction tests

Sand(%)	Pond Ash (%)	Sand (%)	Pond Ash (%)
100	-	80	20
90	10	50	50

For each test on mixture care was taken to mix the various proportions thoroughly in dry state prior to addition of water so as to ensure proper and uniform mixing of fibers and sand and pond ash. For each combination of sand and pond ash fibers were added @ 0%, 0..25%, 0.5%, 0.75% and 1% by weight to the mix and constant head permeability tests were performed in accordance with IS 2720 part 17-1986 for vertical permeability cases. The sample sizes were of 600 mm length, 300mm width and 300mm height. At the optimum moisture content (OMC) and maximum dry unit weight, the tests were performed. The tests were performed under no load conditions as well as under different loading conditions@ 9kN, 18 kN, 27kN, 36kNand 45 kN without any reinforcement and with fibre reinforcement of 6mm, 12mm and mix of 6mm and 12mm fibres(in equal proportions).

3. RESULTS AND DISCUSSION

The equivalent coefficient of permeability of soil–geosynthetics system was determined by varying the percentage of fibers and mixture of sand and pond ash. Fig. 1 presents variation of equivalent coefficient of permeability with normal stress for sandy soil and pond ash in a proportion of 90% and 10%. With an increase in normal stress a decrease in equivalent coefficient of permeability of the soil can be noted. Considerable increase in the equivalent coefficient of permeability of soils with the inclusion of fibers can be noted from Fig. 1. However, increase in equivalent in-plane permeability calculated at all normal stresses was found to be higher for higher percentage of fibers and higher stress level. The variation of equivalent coefficient of permeability has been studied for five levels of loading conditions for soil mix.

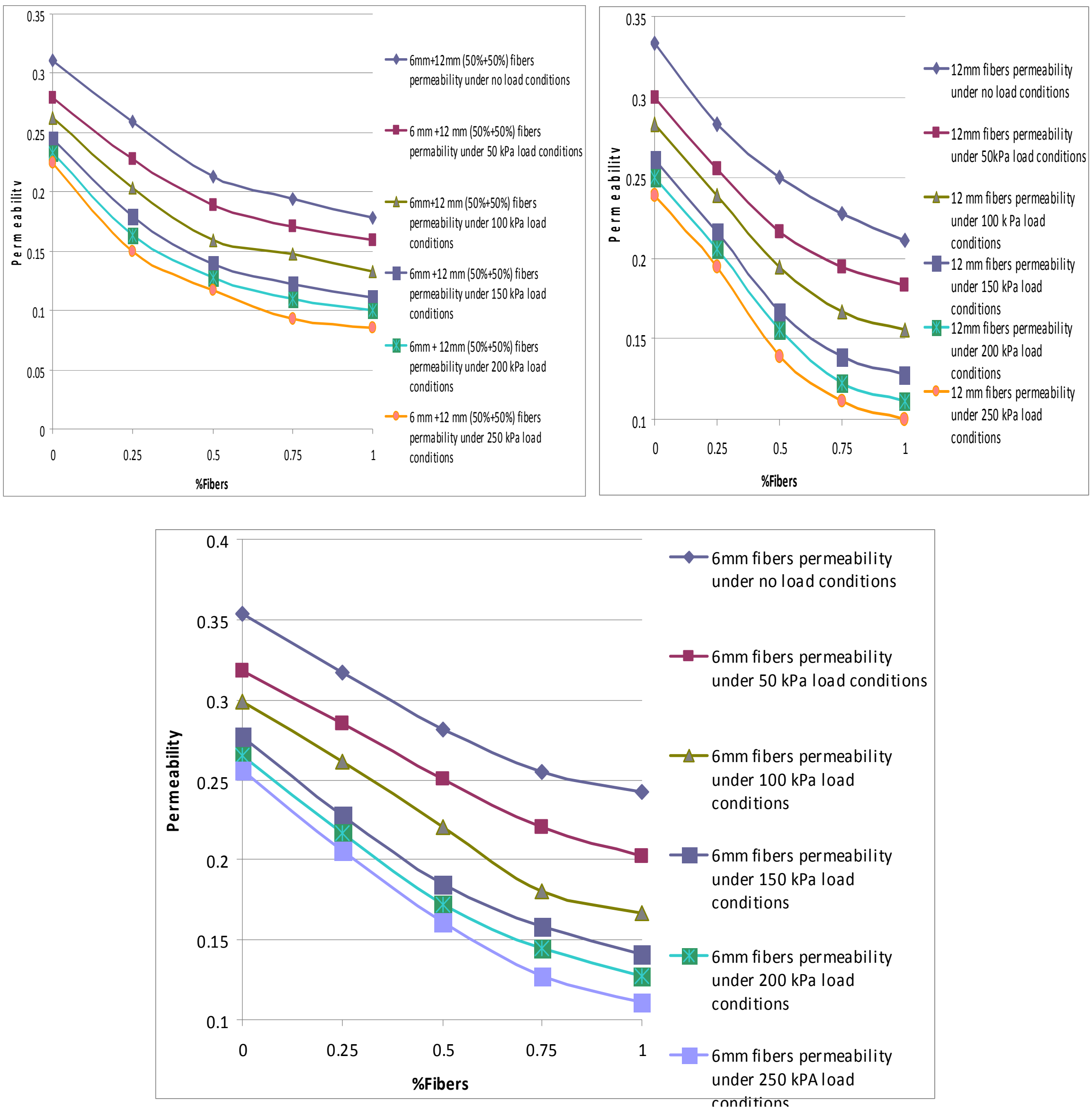


Fig.1: Permeability of sand and pond ash in the ratio of 90%:10% with various fibers

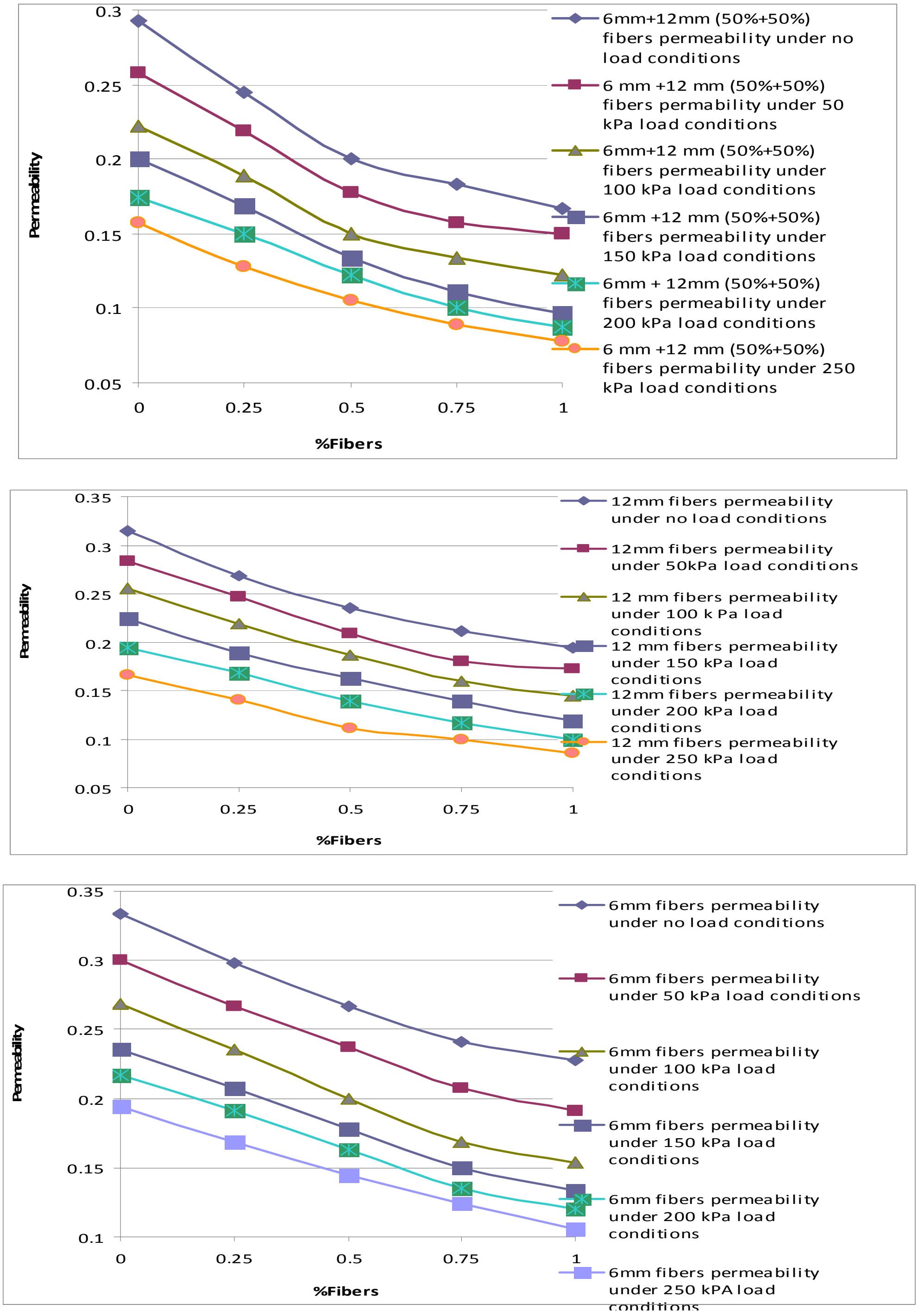
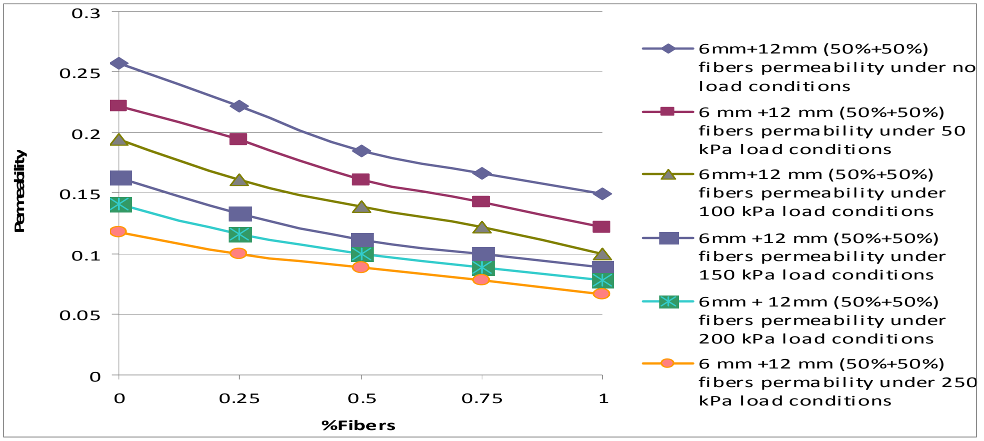
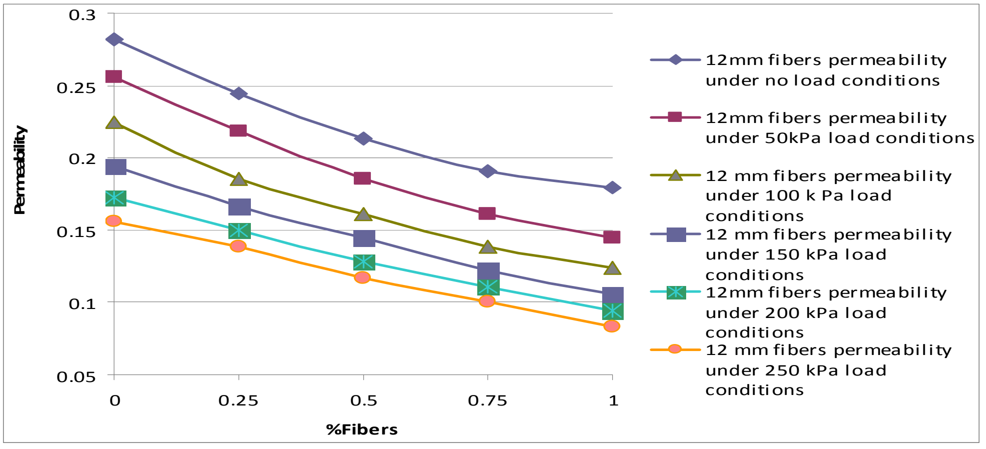


Fig.2: Permeability of sand and pond ash in the ratio of 80%:20% with various fibers





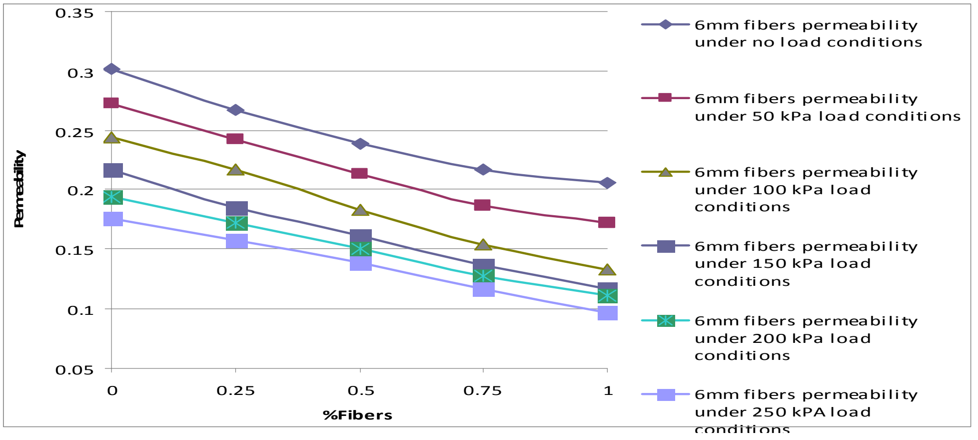


Fig.3: Permeability of sand and pond ash in the ratio of 50% :50% with various fibers

The equivalent coefficient of permeability of soil–ash system was observed to increase with increasing number of pond ash for the soil mix of Sand: Pond ash :: 80% and 20%. (Fig. 2), due to the increased bonding of fibers pond ash and soil mix. Significant difference of increase in the equivalent coefficient of permeability was also observed for a mix of Sand: Pond ash :: 80% and 20%. (Fig. 3), Similar tests were conducted with Sand: Pond ash :: 80% and 20%. (Fig. 4) and Sand: Pond ash: 80% and 20%. (Fig. 5). Moreover, with an increase in normal stress, equivalent coefficient of permeability of soil–ash mix was found to decrease gradually for all the tests with various combinations of fibers. To some extent, this was observed in the present study through readings obtained from dial gauges placed on top of the loading plate.

CONCLUSIONS

The computed values of equivalent coefficient of perm abilities at zero normal stress for all the tests are higher than the measured values. The measured coefficient of permeability of soil–pond ash mix system appears to be a function of fibers mixed in the soil mix and the overburden stress of the soil acting on it. However, further work in this direction is warranted in the direction of strength of soils with and without fibers.

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