International Journal of Engineering and Advanced Research Technology (IJEART)
ISSN: 2454-9290, Volume-3, Issue-5, May 2017

Application of Fly Ash, Rice Husk Ash and Bentonite to Deminish the Permeability Value of Fine Sand

Joyanta Maity, Saurav Pal, Mainak Mukherjee

***Abstract*— To utilize and distribute the valuable water for drinking, agricultural and industrial purposes, it is necessary to store the available water in a planned environmental friendly manner. One of the most important ways to do so is being done by construction of cost effective dam at suitable location on the path of river which receives the major part of surface runoff from catchment area and discharge the same to the sea or lake. But to cut short the seepage loss from reservoir storage to permissible limit, it is essential to provide suitable core section in the earth dam, with material of very low permeability. Unfortunately soils of low permeability may not be available near the sites and large cost will be involved in transportation to bring impervious cohesive soil to the sites. Thus, costs effective method needs to be devised to use the locally available material of high permeability by modifying such soil suitably.**

In the present study, an experimental programme has been undertaken with the aim primarily to diminish the permeability value of locally available fine sands so that it can be used as core material of the earthen dam. Here, different percentages of fly ash, rice husk ash, and bentonite were used as admixture, to the sand and several permeability tests have been conducted on such mixed soil at respective OMC to determine the effect of such mixing on permeability value of the composite material and find the optimum percentage of mixing to effect minimum value of permeability.

***Index Terms*— Permeability, Seepage loss, Fly ash, Bentonite.**

I. INTRODUCTION

In India, most of the potable water is available from rains during monsoon but large part of this water flows out to sea through innumerable rivers from the hills and high lands. For utilizing and distributing this valuable water to different parts of the country, it is necessary to store this available water in a planned manner. This is being done by construction of large number of cost effective dam at suitable location on the path of the rivers. This location is generally in hilly terrain to suite the location and topographically advantages for construction of reservoir and distribution of water.

In many sites of earth dams, raw materials like gravel, rocks and sands are easily available at low cost. To control the seepage loss in earth dam, core of impervious soil is to be placed in suitable location in the cross section of the dam. In many sites, materials of very low permeability may not be present (Sherard et.al, 1963). Thus, for the construction of core material of the earthen dam, soil of very low permeability is to be brought to the site at a large transport cost. Even in many cases, it is not feasible to bringimpervious soils for use as core materials and earth dams have to be built for compulsion. Several such constructions of dams involving sands / gravels are reported elsewhere (Soroush et. al., 2011). If it is possible to decrease the permeability of local soil by mechanical means or by adding foreign materials in a small ratio, cost of construction may be diminished. For this purpose, an experimental programme was undertaken with the aim primarily to diminish the permeability value of fine sands by mixing different percentages of fly ash, rice husk ash, and bentonite, individually or in combination

II. OBJECTIVES AND SCOPE OF WORK

The main objective of the present investigation is to diminish the permeability value of fine sands by mixing fly ash, rice husk ash and bentonite individually or in combination to check whether these composite materials can be used as core material of the earthen dam.

The present study has been carried out initially by mixing different percentages of fly ash or rice husk ash with fine sand for this purpose. Standard proctor tests have been conducted to determine the optimum moisture content and corresponding maximum dry density for each sand-fly ash or sand-rice husk ash mixture combination. Thereafter, falling head permeability tests were conducted for each mixture combination at respective optimum moisture content. From these results, the optimum percentage of fly ash or rice husk ash to cause maximum decrease in permeability of the composite was obtained. After finding out the optimum percentage of fly ash and rice husk ash, 2% bentonite was then added to fly ash-fine sand and rice husk ash-fine sand mix at optimum percentage, and tested for permeability at respective OMC value.

III. MATERIALS AND TEST PROGRAMME

In the present investigation, locally available fine sands was used as soil medium and fly ash, rice husk ash and bentonite were chosen as admixtures to be added with fine sand to minimize the value of permeability. The physical properties of the fine sand was determined by conducting various laboratory tests as per IS code provision which are given in table 1.

Table 1: Summary of the physical properties of Fine sand, Fly ash, Rice husk ash and Bentonite

Property	Fine sand	Fly ash	Rice husk ash	Bentonite
Specific gravity	2.58	1.962	1.235	2.85
Uniformity coefficient (C_u)	1.625	1.625	3.13	-
Coefficient of curvature (C_c)	0.895	0.831	0.817	-
Effective size, (D_{10})	0.16	0.08	0.075	-
MDD (gm/c.c)	1.605	1.44	1.28	1.195
OMC (%)	16.5%	31%	29%	39%
Permeability (cm/sec)	8.074×10^{-3}	4.56×10^{-6}	5.69×10^{-5}	5.3×10^{-9}
Liquid limit & Plastic limit	Non Plastic	Non Plastic	Non Plastic	82.5% & 51.5%

In this experimental study, Fly ash was collected from Titagarh Thermal Power Station in the district of North 24 Parganas, West Bengal whereas Rice husk ash was taken from Bethuadahari Rice Mill in the district of Nadia, West Bengal. Further, bentonite was purchased from Green field Eco solutions private limited, India. The physical properties of the Fly ash, Rice husk ash and Bentonite are given in table 1.

IV. METHODOLOGY

A systematic experimental programme was undertaken for fine sand - different admixture mix composite to determine the optimum percentage of admixtures to be added with fine sand for attaining minimum permeability values. The different mixture designation of different percentages of Fly ash and Rice husk ash with Fine sand are tabulated in table 2 and 3 respectively.

Table 2 Different mixture designation of fly ash and fine sand

Mixture designation	Soil type	Admixture type	% of admixture
SFA 050	Fine sand	Fly ash	5%
SFA 075	Fine sand	Fly ash	7.5%
SFA 100	Fine sand	Fly ash	10%
SFA 125	Fine sand	Fly ash	12.5%
SFA 150	Fine sand	Fly ash	15%
SFA 200	Fine sand	Fly ash	20%
SFA 250	Fine sand	Fly ash	25%
SFAB 2002	Fine sand	Fly ash & Bentonite	20% 2%

Table 3 Different mixture designation of rice husk ash and fine sand

Mixture designation	Soil type	Admixture type	% of admixture
SRHA 050	Fine sand	Rice husk ash	5%
SRHA 075	Fine sand	Rice husk ash	7.5%
SRHA 100	Fine sand	Rice husk ash	10%
SRHA 125	Fine sand	Rice husk ash	12.5%
SRHA 150	Fine sand	Rice husk ash	15%
SRHA 200	Fine sand	Rice husk ash	20%
SRHA 250	Fine sand	Rice husk ash	25%
SRHAB 2002	Fine sand	Rice husk ash & Bentonite	20% 2%

For this standard proctor tests were conducted to determine the optimum moisture content and corresponding maximum dry density for each combination of fly ash-sand or rice husk ash-sand mixture. Falling head permeability tests were conducted for each mixture combination at respective optimum moisture content to get the minimum permeability value. After determining the optimum percentage of fly ash or rice husk ash, 2% bentonite has been added to obtain maximum improvement in permeability values of different, mixture combination of sand-admixture.

V. RESULTS AND DISCUSSIONS

Several standard Proctor tests and falling head permeability tests were conducted in the laboratory for fine sand mixed with various percentages of 5%, 7.5%, 10%, 12.5%, 15%, 20% and 25% of fly ash or rice husk ash and the experimental results are presented here. The summary of the experiment results of fine sands mixed with Rice husk ash and Fly ash are given in table 4 and 5.

Table 4 Summary of the experiment results for Rice husk ash and fine sand mixture:

Description	OMC	MDD (gm/c.c)	Permeability (cm/s)
Fine Sand	16.5	1.605	8.074×10^{-3}
Fine Sand + 5% RHA	19.1	1.59	3.23×10^{-4}
Fine Sand + 7.5% RHA	22.3	1.585	2.51×10^{-4}
Fine Sand + 10% RHA	25.4	1.58	2.02×10^{-4}
Fine Sand + 12.5% RHA	26.3	1.574	1.53×10^{-4}
Fine Sand + 15% RHA	27.8	1.57	1.09×10^{-4}
Fine Sand + 20% RHA	28.1	1.566	7.33×10^{-5}
Fine Sand + 25%RHA	28.3	1.56	6.95×10^{-5}
Fine Sand + 20% RHA + 2% Bentonite	30.7	1.57	$5.53X10^{-6}$

A) Compaction characteristics:

To determine maximum dry density and corresponding optimum moisture content, light compaction tests were conducted for different sand-admixture composites as per I.S. 2720 (Part VII) -1980. The variations of maximum dry density and optimum moisture content with percentage of ash are shown in figs. 1 and 2 respectively.

Table 5 Summary of the experiment results for Fly ash and fine sands mixture:

Description	OMC	MDD (gm/c.c)	Permeability (cm/s)
Fine Sand	16.5	1.605	8.074×10^{-3}
Fine Sand + 5% FA	19.2	1.601	2.62×10^{-4}
Fine Sand + 7.5% FA	21.5	1.595	1.97×10^{-4}
Fine Sand + 10% FA	24.4	1.59	1.41×10^{-4}
Fine Sand + 12.5% FA	28.5	1.588	1.01×10^{-4}
Fine Sand + 15% FA	29.0	1.585	5.61×10^{-5}
Fine Sand + 20% FA	29.5	1.582	6.88×10^{-6}
Fine Sand + 25% FA	29.8	1.58	6.62×10^{-6}
Fine Sand + 20% FA + 2% Bentonite	31.2	1.59	4.86×10^{-7}

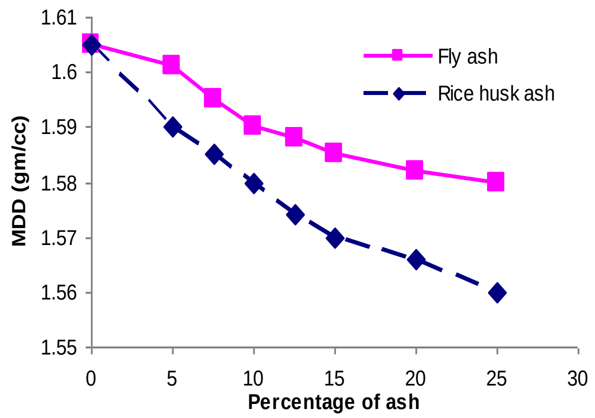

Fig. 1 Variation of MDD with percentage of ash

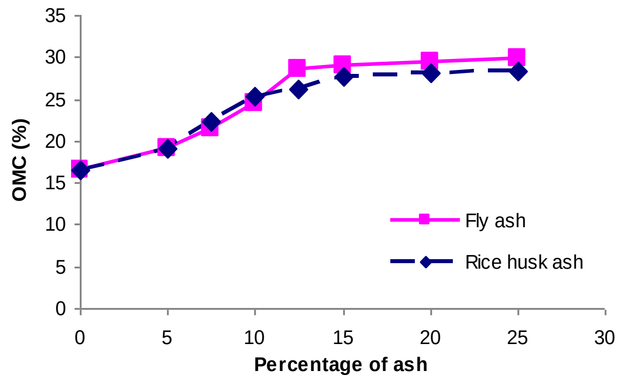

Fig. 2 Variation of OMC with percentage of ash

From the results it is evident that as the fly ash or rice husk ash content increases, the maximum dry density decreases and the optimum moisture content increases. The decrease in MDD is due to lower specific gravity of ash particles. On the other hand, the higher OMC value is due to need of hydration reaction for cementitious ash particles.

B) Permeability characteristics:

To determine the value of coefficient of permeability (K), Falling head permeability tests were conducted for different sand-admixture composites as per I.S. 2720 (Part XVII) -1986. The values of permeability for different sand-admixture composite are given in table. The variation of coefficient of permeability of different sand-admixture composites with fly ash content and rice ash content is shown in fig. 3. The results show that as the fly ash or rice husk ash content increases, the coefficient of permeability value decreases.

From table 4 and 5, it is observed that permeability of fine sand decreases to great extent on addition of either of fly ash or rice husk ash initially, but with increase in percentage of either of fly ash or rice husk ash, value of permeability does not decrease significantly any further (Fig. 3). To decrease the value of permeability to a greater extent, 2% bentonite was further added. This has resulted nearly 10 times decrement in the value of the permeability (Table 4 and 5).

Thus, addition of Bentonite at a small percentage with fly ash-fine sand or rice husk ash-fine sand combination at the optimum percentage causes drastic decrease in value of permeability. Similar observations are also reported elsewhere (Das, 1998).

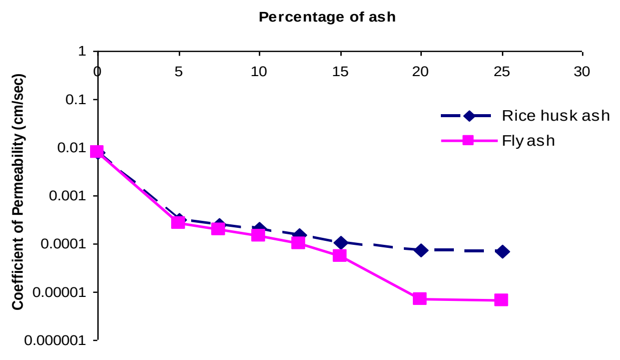

Fig. 3 Variation of Coefficient of permeability with percentage of ash

VI. Conclusion

On the basis of systemic experimental investigation on compaction characteristic and permeability characteristic of fine sand mixture different types of admixtures like fly ash, rice husk ash and bentonite of varying percentages, following conclusions can be drawn.

1. As the percentages of Rice husk ash increases, the maximum dry density of fine sand-rice husk ash mixture composite decreases whereas the optimum moisture content increases. The similar result is also obtained for the case of fine sand-fly ash mixture composite.
2. The Co-efficient of permeability (k) value of fine sand-fly ash mixture composite decreases with the increase of fly ash content up to a maximum value after that it seems to attain a constant value. The similar result is also obtained for the case of fine sand- rice husk ash mixture composite.
3. With addition of small amount of bentonite the value of permeability for both fine sand- fly ash mixture composite and fine sand- rice husk ash mixture composite decreases to a great extent. The improved permeability values may be applicable for material of construction of core of earth dams.

References

[1] Das, B.M.(1998), "Principle of Geotechnical Engineering" 4th Ed. *PWS Publishing Company*, Boston, MA, USA.

[2] IS 2720 (Part VII) -1980, Determination of Water content – Dry density relation using light compaction, *Bureau of Indian Standards*, New Delhi, India.

[3] IS 2720 (Part XVII) -1986, Determination of Permeability, *Bureau of Indian Standards*, New Delhi, India.

[4] Sherard, J.L., Woodward, R.J., Gizienski, S.J. and Clevenger, W.A. (1963) "Earth and Earthen dam, Engineering Problem of Design and Construction", *John-Wiley and Sons*, New York.

[5] Soroush, A., Shourijch, P.T. and Mohammadinia, A., (2011) "Controlling internal origin in earth dams and their foundation", *Proc. of Indian Geotechnical conference*, Kochi, Vol – 1, pp. 64 - 71.

Joyanta Maity, PhD (JU) is Assistant Professor of C.E. Dept., Meghnad Saha Institute of Technology, Kolkata. He is actively engaged in teaching both PG and UG Civil Engineering students for more than a decade. His research interests include ground improvement techniques, use of alternative materials and use of natural geofibers in Civil Engineering. He has published more than 35 papers in different national and international conferences and journals.

Saurav Pal, ME (JU) is an Assistant Professor of C.E. Dept., Meghnad Saha Institute of Technology, and Kolkata. He is actively engaged in teaching both PG and UG Civil Engineering students. His research interests include advanced transportation planning and non-conventional methods of pavement design, i.e. Mechanistic Empirical approach based design on basis of IRC 37:2012 guidelines.

.**Mainak Mukherjee,** B.Tech student, of C.E. Dept., Meghnad Saha Institute of Technology, Kolkata.