International Journal of Engineering Sciences Paradigms and Researches (IJESPR)
(Vol. 32, Issue 01) and (Publishing Month: July 2016)
(An Indexed, Referred and Impact Factor Journal)
ISSN: 2319-6564
www.ijesonline.com

GEOSYNTHETIC REINFORCED DOUBLE LAYER SYSTEM WITH POND ASH OVERLAIN BY SAND

Flora Das
Aryan Institute of Engineering & Technology, Bhubaneswar

ABSTRACT

Pulverised fuel ash, delivered in colossal amounts by nuclear energy stations, causes ecological perils and require enormous land region for removal. The bearing limit of feeble lake debris can be expanded by putting a granular course of required thickness on top of the lake debris fill. The heap bearing limit can be expanded further and the thickness of the granular course can be diminished by giving a layer of geosynthetic at the interface of the two layers. In the current review, the bearing limit conduct of a rectangular burden under static pressure on the outer layer of a twofold layer framework with the granular sand layer underlain by lake debris with a layer of geosynthetic at the interface are introduced.

Two sorts of lake remains and various kinds of both polymeric geogrids and coir woven geotextiles have been utilized the review. The outcomes acquired from the heap tests at various thicknesses of the sand layer with and without various sorts of geosynthetic support have been introduced.

The outcome shows that lower thickness of sand layer with geosynthetics at the interface perform better compared to that with thicker sand layer without support. The adequacy of coir woven geotextiles for twofold layer soil framework is featured.

Keywords: Bearing capacity, geosynthetic, geogrids and coir geotextiles.

INTRODUCTION

Pulverised fuel ash, the by-product of thermal power plants is considered as solid waste and its disposal is a major problem from environment point of view and also it requires lot of disposal areas. Utilization of pond ash to the maximum possible extent is a worldwide problem. To solve the problem, pond ash can be used as a subgrade material for road construction. There are two types of ash produced by thermal power plants, viz., fly ash and bottom ash. These two ash mixed together are transported to the ash pond and this deposit is called pond ash. The decreasing availability of good quality soil for subgrade has led to the increased use of pond ash, whose bearing capacity is relatively low. The bearing capacity of a weak pond ash subgrade can be increased by placing a granular course of required thickness on top of the compacted pond ash subgrade. The load bearing capacity can be increased further by providing a layer of geosynthetics at the interface of the two soil layers. The thickness of the top granular course can be further reduced by intrusion of geosynthetic layer at the interface.

BACKGROUND

Numerous studies on the bearing capacity of double layered soil systems have been reported by different researchers by taking different types of subgrade and base course material and reinforcements. Meyerhof (1974) has proposed a theory for the ultimate bearing capacity of sand layer overlying a clay layer in an undrained condition. Brown et al (1985) conducted a series of tests to study the effectiveness of a polypropylene geogrid in improving the performance of pavement, such as resistance to rutting, reflective cracking and fatigue cracking. They also reported that the geosynthetic reduced the rut depth by 20 % to 58 %. Sheo Gopal (1993) conducted the static loading tests in a model with Delhi silt as subgrade (270 mm) and different thicknesses of WBM with non-woven geotextiles and geogrid at the interface. Dixit (1994) conducted the static loading tests on a model by varying the base course, subgrade material reinforced with and without a non-woven geotextile, a woven geotextile and a geogrid at the interface with WBM as base course (100 mm thick) and kaolinite as subgrade (270 mm thick). Khing et al. (1994) also conducted tests for the ultimate bearing capacity of a surface strip foundation supported by strong sand of limited thickness underlain by weak clay with a layer of geogrid at the sand-clay interface. Dutta (2002) and Venkatappa Rao, G. and Dutta, R. K. (2002) conducted static loading tests on a model by using kaolinite clay subgrade (270 mm thick) and sand layer (75 mm thick) as base course. He used 4 types of coir woven geotextiles at the interface of the base course and the subgrade. The results of this study show that, a) the reinforcing effect of geosynthetic with small base course thickness is relatively better compared with that of the model with a higher thickness at higher deformation levels b) the behaviour of the models with geosynthetics, having 40% smaller thickness of base course is better than that of an unreinforced model, c) significant improvement occurs in the bearing pressure at a given vertical deformation with geosynthetic.

PRESENT STUDY

In the present study, the bearing capacity behaviour of a rectangular load under static compression on the surface of the sand layer underlain by pond ash with a layer of geosynthetic at the interface are presented. Two types of pond ashes and five different types of geosynthetics (2 types of polymeric geogrids and 3 types of coir woven geotextiles) have been used the study. The results obtained from the load tests at different thicknesses of the sand layer with and without different types of geosynthetic reinforcement have been presented. In the present study the effects of the above parameters on both bearing capacity of rectangular load at specified settlement and ultimate bearing capacity have been made. Bearing capacity ratio is used to compare the performance of reinforced and un-reinforced pond ash.

The results show that lower thickness of sand layer with geosynthetics at the interface perform better than that with thicker sand layer without reinforcement. The effectiveness of coir woven geotextiles for reinforcement in double layer soil system is highlighted.

GEOMETRIC PARAMETERS

A rectangular load of width „B" being supported on SAND layer of variable thickness overlain on compacted pond ash with and without geosynthetics reinforcement layers as shown in Figure 1.

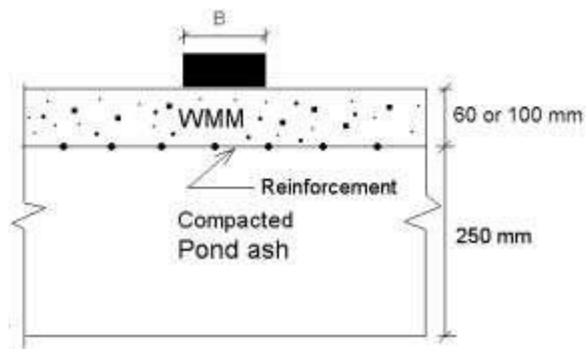

Figure 1. Typical arrangement for test series with SAND and pond ash with reinforcement at the interface

MATERIALS

For the present study, pond ash was selected as the subgrade medium and sand as granular medium along with different types of geosynthetics (both polymeric geogrids and coir woven geotextiles) as the reinforcement material.

Pond Ash

Pond ash was procured from the ash pond of the Captive Power Plant (CPP) of National Aluminum Company Ltd. (NALCO), Angul, Orissa, India. From the ash pond two samples of pond ashes were collected. First one from near the slurry disposal point which is coarser in nature and second one far away from the slurry disposal point which is finer in nature. The detail properties are shown in Table 1. These two samples of pond ash are code named as „NC" and „NF‟‟ for our study.

Table 1: Properties of pond ash

Physical properties		NF	NC
Grain Size	Gravel (> 4.75mm)	0	0
	C.Sand (4.75-0.475mm)	2	4
	F.Sand (0.475-0.075mm)	40	76
	Silt (0.075-0.002mm)	56	19
	Clay (< 0.002mm)	2	1
Specific gravity		2.02	2.48
Liquid limit (%)		48	33
Plastic limit (%)		Non-plastic	Non-plastic
Maximum dry density (kN/m^3)		10.7	13.6

Optimum moisture content (%)	34.5	25.2
Angle of internal friction (Deg.) at MDD	31	36

Sand

The sand used in this study is a local sand from Badarpur quarry, near Delhi. It is weathered quartzite sand, from which fines were removed by washing. It is a medium sand with sub-angular particles. The physical characteristics of the sand are summarized in Table 2.

Table 2: Physical characteristics of sand

Local name	Badarpur sand
Gradation	Medium grained uniform quarry sand
Maximum particle size (mm)	1.20
Minimum particle size (mm)	0.07
Maximum dry density (kN/m^3)	16.70
Minimum dry density (kN/m^3)	12.30
Maximum void ratio	1.12
Minimum void ratio	0.56
Specific gravity	2.66
Relative density adopted (%)	70

Reinforcements

The geosynthetic reinforcements used for the study are of polymeric and natural fibre coir. The two types of polymeric biaxial geogrids used are of rigid and flexible types as shown in Figures 2(a) and 2(b) respectively. These geogrids were code named „GGR" and „GGF" respectively. The detailed dimensions and mechanical properties of the geogrids are given in Table 3. The three types of coir woven geotextile used for the study are shown in Figures 3(a) to 3(c) respectively. These coir geotextiles were code named „CWA", „CWB" and „CWC" respectively. The detailed dimensions and mechanical properties of these coir geotextiles are given in Table 4.

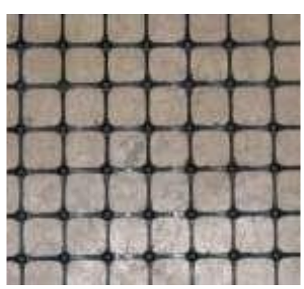

Figure 2(a): Biaxial rigid geogrid Type GGR

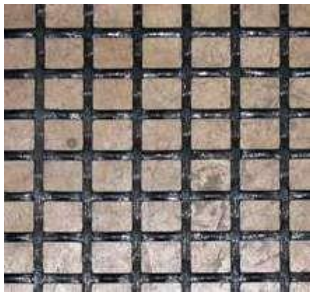

Figure 2(b): Biaxial flexible geogrid Type GGF
Figure 2: Geogrid Types

Table 3: Properties of geogrids

Properties	Rigid Geogrid (GGR)	Flexible Geogrid (GGF)
Polymer	Polypropylene	Polyester with epoxy coating
Mass per unit area (gsm)	520	550
Peak tensile strength (kN/m)	50	80
Strain at break (%)	18	19
Aperture size(mm ×mm)	32 × 32	24 × 28

Figure 3(a): Coir geotextile Type CWA

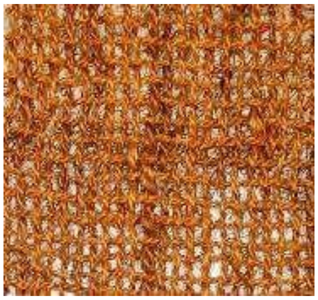

Figure 3(b): Coir geotextile Type CWB

Figure 3(c): Coir geotextile Type CWC

Figure 3: Coir geotextile Types

Table 4: Properties of coir geotextiles

Properties	Coir geotextile type		
	CWA	CWB	CWC
Aperture size (mm × mm)	25 × 25	10.0 × 12.5	7 × 4
Thickness (mm)	6.7	8.1	9.6
Mass per unit area (gsm)	360	610	1335
Peak tensile strength (kN/m)	10	19	38
Strain at break (%)	21	22	37

EXPERIMENTAL ARRANGEMENT

The bearing capacity tests were conducted in a rectangular box measuring 750 mm (length) × 300 mm (width) × 400 mm (depth). The tank was made up of 12 mm perspex sheet. The tank was reinforced with a frame made up of mild steel angles so that there will be no lateral yielding of the box during compaction and loading. The inside walls of the box were polished and a thin coating of grease were applied to minimize friction as much as possible. The rectangular load used for the study was made of wood of size 75 mm (width) ×296 mm (length) × 50 mm (height). On the top of the wooden block a ribbed steel plate was placed during loading such that there is no bending of the footing during the loading process.

The pond ash was pulverized in the laboratory and mixed with predetermined amount of water. For uniform moisture distribution the moist pond ash was placed in several plastic bags and put in airtight containers during the test periods. The moisture content was checked in regular intervals and the corrections were made if found required.

Before the actual loading test, trial compactions were carried out in layers of 50 mm and densities were found out by core cutter method at different depths of the tank. The compaction of different layers was done by using a heavy proctor hammer. A wooden plank of the size of the tank was used above the fill and the hammer was dropped on it for predetermined number of blows for a specific layer. A plastic sheet was placed between the soil and the wooden plank so that it will act as a moisture barrier, to prevent the moisture from the soil to get absorbed by the wooden plank while compaction. The number of blows was changed for different layers. It was decided to start the bottom most layers with 60 numbers of blows distributed over the whole area of the tank and the number of blows increased to 80 numbers as the top most layers is placed. After the trial tests it was found that the pond ash „NC‟ was compacted to a dry density of 12.7 kN/m3 i.e. 93.5 % of MDD. Similarly for „NF‟ the dry density achieved was 9.6 kN/m3 i.e. 89.7% of MDD.

After 5 layers of the pond ash layers were compacted, it was overlain by a sand layer with a layer of reinforcement at the interface. The depth of pond ash in the model tank was kept as 250 mm and the overlying sand layer was kept as 100 mm or 60 mm for the un-reinforced condition and 60 mm for the reinforced condition. The details are summarized in Table 5. At the first stage the pond ash was compacted to a depth of 250 mm in 5 layers of 50 mm each. After the preparation of the pond ash layer, a geosynthetic reinforcement of size 745 mm × 295 mm was laid over this. A sand course of 100 mm or 60 mm for un-reinforced and reinforced case respectively was laid over the reinforcement layer. The 100 mm sand layer was laid in 3 layers, 40 mm each for the first two layers and 30 mm for the final layer. The 60 mm sand layer was compacted in 2 layers of 30 mm each with the number blows remaining same at 100 per layer. All the layers were compacted by the plate tamping technique using a wooden plate of 745 mm × 295 mm and the modified proctor hammer.

Table 5: Plan for model test

Pond Ash	Sand Layer Thickness (mm)	Reinforcement Details			No. of Tests
	0	Unreinforced			2
NC	100	Unreinforced			2 × 2
NF	60				= 4
		Reinforced	Polymeric	Coir	2 × 1 × 5
			GGR	CWA	= 10
	60		GGF	CWB	
				CWC	
		Total =			16

For loading, an automatic Universal Testing Machine (UTM) used. The UTM was a constant strain rate machine and was capable of constant strain rates in the range of 0.01 mm/min to 500 mm/min and a 50 kN load cell. The machine was connected to a computer where the load and settlement was recorded. The load applied to the footing at a constant strain rate of 1.0 mm/min and the settlement and corresponding increase in load was recorded at a settlement interval of 0.5 mm. The setup is shown in Figure 4.

The load bearing tests were repeated at random and the results obtained were found to be varying between 5 %.

Figure 4: The load test on progress

TEST RESULTS

Bearing Capacity

Unreinforced Pond Ash

The ultimate bearing capacities have been calculated as per Vesic (1963). The ultimate bearing capacity (q_u) of unreinforced pond ash type NC was found to be 283.6 kPa at a settlement (s_u) of 6.7 mm where as the ultimate bearing capacity (q_u) of unreinforced pond ash type NF was found to be 247.1 kPa at a settlement (s_u) of 6.1 mm.

Unreinforced Pond Ash with Sand

It is observed that the q_u of unreinforced model increased from 422.2 kPa to 504 kPa with an increase of sand thickness from 60 mm to 100 mm. Similarly, the q_u values for pond ash type NF changed from 428.7 kPa to 525.3 kPa.

Pond Ash with sand Reinforced at the Interface

With intrusion of different types of geosynthetics at the interface of pond ash and sand, the values of q_u and s_u increased, for both NC and NF type of pond ashes as presented in Tables 6 and 7. The value of qu for pond ash type NC with reinforcement type GGR was 660.4 kPa, whereas it was 648.9 kPa with GGF type reinforcements.

Similarly, with coir geotextiles type CWA, CWB and CWC, the q_u increased to 532.4 kPa, kPa and 620.4 kPa at s_u values of 12.6 mm, 13.3 mm and 14.5 mm respectively. Similar observations for pond ash type NF, both for unreinforced condition with different thicknesses of SAND layer i.e. 100 mm and 60 mm and reinforced condition with different types of geosynthetics with constant thickness of SAND layer i.e. 60 mm, have been presented in Table 7.

Table 6: Comparison between ultimate bearing capacity (q_u) of pond ash type NC with different thickness of sand and reinforcements at interface

Thickness of WMM (mm)	Reinforcement type		q_u (kPa)	Settlement (s_u)	BCR_u
100	Unreinforced		504.0	12.1	1.19
60	Unreinforced		422.2	9.3	-
	Reinforced	GGR	660.4	12.4	1.56
		GGF	648.9	11.2	1.54
		CWA	532.4	12.6	1.26
		CWB	575.1	13.3	1.36
		CWC	620.4	14.5	1.47

From the last column of Table 6, it is observed that the ultimate bearing capacity ratio (BCRu) was only 1.19 with an increase in the thickness of SAND layer from 60 mm to 100 mm on NC type of pond ash as subgrade. But keeping the thickness of the SAND layer same at 60 mm and providing a layer of geosynthetics at the SAND-pond ash interface, the BCRu value increased to 1.56 and 1.54 respectively for GGR and GGF types of polymeric reinforcements. With the coir geotextile types CWA, CWB and CWC, the BCRu values obtained were 1.26, 1.36 and 1.47 respectively. The behaviour is similar in respect of pond ash type NF as evident from the last column of Table 7.

Table 7: Comparison between ultimate bearing capacity (q_u) of pond ash type NF with different thickness of sand and reinforcements at interface

Thickness of sand (H) (mm)	Reinforcement type		H/B	q_u (kPa)	Settlement (s_u)	BCR_u
100	Unreinforced		1.33	356.4	7.4	1.07
60	Unreinforced		0.8	332.4	7.1	-
	Reinforced	GGR	476.4	476.4	8.9	1.43
		GGF	443.6	443.6	7.8	1.33
		CWA	348.4	348.4	8.1	1.05
		CWB	364.4	364.4	8.3	1.09
		CWC	380.6	380.6	8.8	1.14

Discussion

To facilitate a comparison, bearing capacity ratios (BCR) at different deformations have been presented in Figure 5 for pond ash type NC and in Figure 6 for pond ash type NF respectively. It is evident that for all types of geosynthetics there is an increasing trend with deformation. The BCR value raised sharply to about 1.5 at a settlement of about 12 mm for pond ash type NC with both the types of polymeric geogrids after which the slope became flatter reaching a value of 1.6 at a settlement of 20 mm. Whereas the value of BCR with the coir geotextiles remained about the same at 1.1 up to a settlement of 9 mm after which the coir geotextiles type CWC took the steepest slope reaching a value of 1.54 at a settlement of 20 mm, followed by CWB at 1.42 and CWC at 1.27. Similar observations could be made in respect of pond ash type NF.

International Journal of Engineering Sciences Paradigms and Researches (IJESPR)
(Vol. 32, Issue 01) and (Publishing Month: July 2016)
(An Indexed, Referred and Impact Factor Journal)
ISSN: 2319-6564
www.ijesonline.com

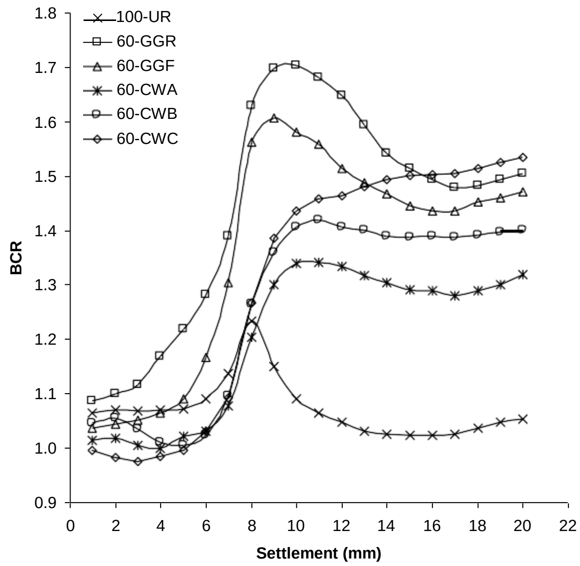

Figure 5: Bearing capacity ratio vs. settlement of pond ash type NC with and without reinforcements

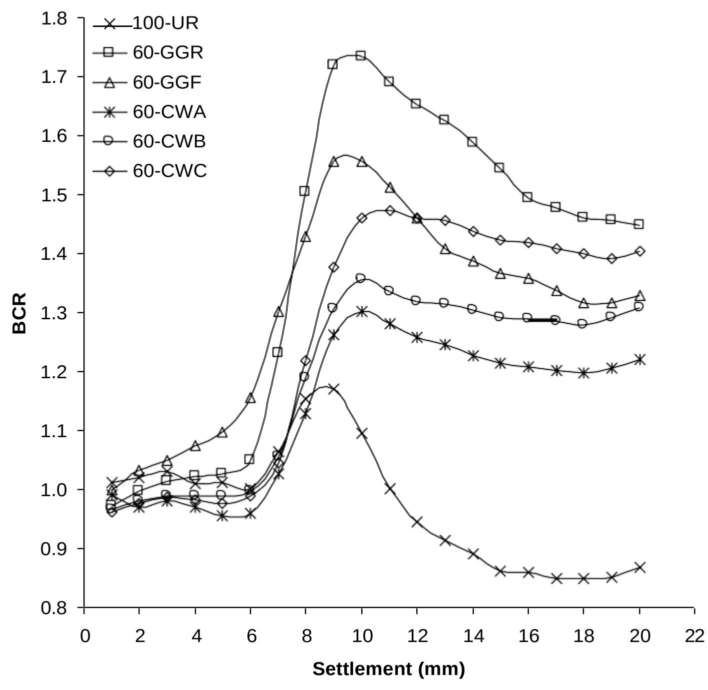

Figure 6: Bearing capacity ratio vs. settlement of pond ash type NF with and without reinforcements

Biodegradability

Previous studies at IIT Delhi (Singh et al., 2006) clearly indicated that the coir hardly degrades in one year and the life expectancy can be up to a decade. Hence, the potential of coir geotextile, if not same, is comparable to the polymeric materials.

CONCLUSIONS

Based on the test results presented in this chapter, the following conclusions may be drawn.

The performance of double layer model with SAND base course and compacted pond ash subgrade is better than the single layer model of pond ash only. The ultimate bearing capacity of the former is greater.

The ultimate bearing capacity of the unreinforced double layer model depends on the thickness of SAND base layer.

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 SAND course and pond ash subgrade.

The performance of the coir woven geotextiles is quite different from that with polymeric geogrids.

The performance of 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.

For SAND base course and pond ash subgrade the improvement with polymeric geogrids is exhibited even at very low settlements whereas that with coir woven geotextiles occurred only after a settlement of about 8 mm. This could be attributed to the higher strength at lower strains of the former.

The coir geotextile reinforced double layer model of sand and pond ash did not exhibit any improvement up to a settlement of 8 mm. but beyond this settlement of the improvement with the coir woven geotextiles for both types of pond ash types is quite significant. At a settlement of 14 mm and beyond, the double layer model with coir woven geotextile type CWC outperformed the polymeric geogrids.

The results with double layer models with coir geotextiles are encouraging for their potential use in low cost roads which can tolerate larger settlements (or rutting in repeated loading).

REFERENCES

1. Brown, S.F., Brunton, J.M., Hughis, D.A.B. and Brodrick, B.V.,1985, "Polymer Grid Reinforcement of Asphalt." Proc., Asia of Asphalt Technology, 54, 18-41.
2. Dixit. A., 1994, "Behaviour of Model Pavements with Geosynthetics." Unpublished Ph.D Thesis submitted to Indian Institute of Technology Delhi, New Delhi, India.
3. Dutta, R.K., 2002, "Alternate Low Cost Material in Ground Improvement." Unpublished Ph.D Thesis submitted to Indian Institute of Technology Delhi, New Delhi, India.
4. Khing, K.H., Das, B.M., Puri, V.K., Yen, S.C. and Cook, E.E., 1994, "Foundation in Strong Sand Underlain by Weak Clay with Geogrid at the Interface." Geotextiles and Geomembranes, 13, 199-206.
5. Meyerhof, G. G., 1974, "Ultimate Bearing Capacity of Footings on Sand Layer Overlying Clay." Canadian Geotechnical Journal, 11 (2), 223-229.
6. Sheo Gopal, 1993, "Behaviour of Model Pavements with Geosynthetics under Repetitive Loading." Unpublished Ph.D Thesis submitted to Indian Institute of Technology Delhi, New Delhi, India.
7. Singh, R.M. and Venkatappa Rao G., 2006, "Sustainable development: Durability of natural geotextiles as erosion control product." Proc., 5th ICEG Environmental Geotechnics, Thomas Telford, London, 1060 – 1067.
8. Venkatappa Rao, G and Dutta, R.K., 2002, "Testing and Application of coir based Geotextiles." Proc., Seventh International Conference on Geosynthetics, 22-27 Sept, France, 955-958.