Appraisal of Rock Flour as Frictional Fill Material for Use in Reinforced Earth Structures

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Abstract

The design and performance of reinforced soil structures is significantly influenced by the fill material. Particularly, reinforced earth retaining walls require frictional fills as they are free draining and mobilize higher friction coefficients with reinforcing elements. The frictional fill materials to be used in reinforced soil structures are river sand and moorum. Due to increased construction activities, the sources of sand and moorum are depleting at faster rate. Hence, the search for alternate fill material for use in reinforced soil structures has arised.

Keywords — *Rock flour, reinforced earth structures ,fill material ,Geotextiles, Modified direct shear test, pullout test.*

I. INTRODUCTION

The accumulation of industrial waste has posed a serious problem to the industrial growth and to human habitation. Disposal of industrial waste is covering vast track of valuable land. In this study an attempt has been made to evaluate the properties of industrial waste, crusher dust to use as fill material in the reinforced soil structures. Soil reinforcement is a recent and fast developing technique to improve soil behavior for variety of civil engineering works like earth retaining structures, slope stability, landslides protection works, pavements etc.., The reinforced materials commonly used ranges from metallic strips to polymer materials such as Geosynthetics, geotextiles, Geogrids .Any reinforced soil structure consists fill material ,reinforcing material and facing. The cost of reinforced soil structure is largely influenced by the cost of fill and hence, use of cost effective materials as alternative to conventional fill materials is present day requirement.

II. LITERATURE REVIEW

Ilangovan and Nagamani (1996) reported that Natural Sand with Quarry Dust as full replacement in concrete as possible with proper treatment of Quarry Dust before utilization.

Nagaraj and Bhanu (1996) have studied the effect of rock dust and pebble as aggregate in cement and concrete. It has been reported that crushed stone dust can be used to replace the natural sand in concrete.

Shankar and Ali (1992) have studied engineering properties of rock flour and reported that the rock flour can be used as alternative material in place of sand in concrete based on grain size data. Kanakasabai and Rajashekaran (1992) investigated the potential of ceramic aggregate can be used to produced lightweight concrete, without affecting strength.

Rao and Andal (1996) also have reported that sand can be replaced fully by rock flour without much loss of workability. Nearly 20% of rock is converted into rock flour while crushing rock into aggregate at stone crushing plants. Rock flour can be used as fine aggregate in place of conventional river sand, in concrete.

III. MATERIALS USED

A. *Rock Flour*

Rock flour is obtained from the quarries during the process of producing the aggregates from rocks. Rock flour has many useful properties of the stone that it comes from. Rock flour is being used as filler and cement aggregate sometimes it can also be used as the replacement for fine aggregates in the concrete. When used in concrete, the rock flour mixes in with larger aggregate to help form a specific texture. The Rock Flour posses good frictional characteristics so that they can be used as frictional fill material in the reinforced soil structures Total quantity of rock flour generated from the state of Andhra Pradesh is 23,21,820 tons per annum. The amount of rock flour produced at crushing plants is about 20% of weight of rock crushed. The districts of Visakhapatnam, Guntur, East Godavari, West Godavari, Prakasam and Ananthapur contribute to about 50% of the total rock flour generated from the state of Andhra Pradesh

B. *Geotextile:*

Geotextiles are fabric materials generally made up of polyester or polypropylene they are generally permeable in nature and used as reinforcement, filter, separate, protect or drain material along with soil.Geotextiles can be classified into three types: woven (resembling mail bag sacking), needle punched (resembling felt), or heat bonded (resembling ironed felt).Geotextiles composites are available with combination of geotextile with other geosynthetic materials.with the addition of geotextiles the engineering properties of the soil can be enhanced and we can yield better benefits in geotechnical and engineering design.

IV. RESEARCH METHODOLOGY

The test methods proposed for finding the characteristics of rock flour under study are mentioned.

A. Characterisation of Rock Flour for Selected Quarry

The rock flour for the study has been collected from a quarry located at Kurnool. The quantity of rock flour present in the state of Andhra Pradesh is estimated by gathering information from quarries located across the state. Laboratory experiments namely I.S heavy Compaction test, Grain size analysis, Direct shear test, Permeability and CBR tests are proposed to know the characteristics of the rock flour. The effect of saturation on shear parameters is also included in the study.

B. Determination of Friction Coefficient of Rock Flour

The direct shear tests are conducted on the rock flour in order to determine the friction coefficients of the rock flour. The procedure suggested by Hussaini and Perry is used for the direct shear tests. The tests are conducted on rock flour prepared at OMC & MDD conditions and saturated conditions. The tests are conducted for at least three normal stress values. The tests are conducted by using both the woven and non-woven geo textiles.

C. Characteristics of Parent Rock

As the toughness and frictional characteristics of the rock flour mainly depends on the parent rock characteristics A study on geology of parent rock is conducted in order to find out the characteristics of the rock flour It is proposed to compare the results obtained for rock flour under study to rock flour of other parent rocks available from previous works. Finally the results of the study are summarized and appraisal of rock flour as a fill material in soil structures has been done.

V. DETAILS OF WORK

The laboratory experiments are planned by keeping in view about the specific scope of work, the properties of rock flour, parent rock of rock flour and properties of woven and non-woven geotextiles were determined from the test results.

Table5.1 Engineering properties of rock flour

S.No	Engineering Property	Value	
1	Specific Gravity	2.65	
2	Grain Size Analysis	Before compaction	After compaction
	(a) Gravel Size (%)	11.7	11
	(b) Sand Size (%)	85.6	85.8
	(c) Fines (%)	2.7	3.2
	(d) Coefficient of Uniformity	9.58	11.5
	(e) Coefficient of Curvature	1.00	1.06
	(f) D_{10}, (mm)	0.24	0.20
3	Plasticity Characteristics		
	a) Liquid limit (%)	NP	
	b) Plastic limit (%)	NP	
4	IS Classification	SW	
5	Compaction Characteristics (IS Heavy compaction)		
	(a)Maximum Dry Unit Weight(kN/m^3)	20.6	
	(b)Optimum Moisture Content (%)	6.5	

6	Shear Strength Parameters (a) Dry Condition (i) Cohesion (kN/m^2) (ii) Angle of Internal Friction (b) Wet Condition (i) Cohesion (kN/m^2) (ii) Angle of Internal Friction	 0 47° 0 43 °
7	Coefficient of Permeability (cm/s)	2.5×10^{-3}
8	CBR Value (%)	30

Table 5.2 Engineering Properties of Geotextiles

S.No	Property	Woven Geotextiles	Non-Woven Geotextiles
1	Mass per unit Area(g/m2)	133	524
2	Thickness (mm)	0.33	1.92
3	Compressibility (mm/kPa)	0.01	0.025
4	Tensile Strength(kN)	1.6	0.07
5	Elongation (mm)	21.6	20.0
6	Strain (%)	21.6	20.0

A. Interfacial Shear Parameters Of Rock Flour Sample With Geotextiles

1) Modified Direct Shear Test

Modified Direct Shear Tests are conducted on the rock flour sample in OMC and MDD condition and also in wet Condition to evaluate the shear parameters cohesion and the angle of interfacial friction with Woven and Non-Woven Geotextiles. During the test a wooden piece is placed as a rigid material in the lower half of the shear box the Geotextile is placed on it. In the upper half of the shear box, rock flour is placed by compacting at OMC and MDD condition

2) Pullout Test

Pullout tests are conducted on the rock flour samples along with the woven and non-woven geotextiles at OMC and MDD conditions to evaluate the interfacial friction with woven and non-woven geotextile and the pullout strength. The test is performed as per ASTM D-6706(2001).

Table 5.3 Engineering properties of rock flour Interfacial Shear Parameters of Rock flour with Geotextiles from Modified Direct Shear Tests

Interfacial Shear Parameters	Woven Geotextiles		Non-Woven Geotextiles	
	OMC&	Wet	OMC &	Wet
Angle of Interfacial Friction	41°	39°	39°	38°

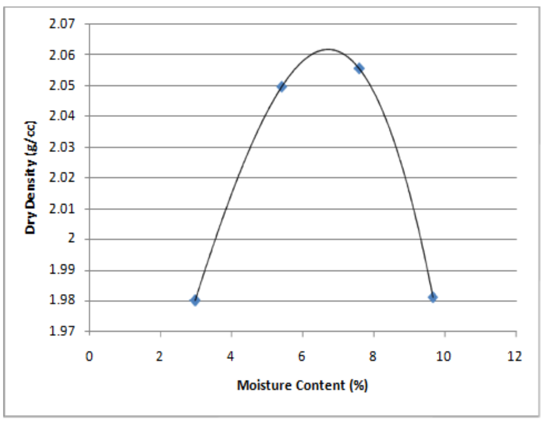
Table 5.4 Friction Coefficient of Rock Flour with Geotextiles

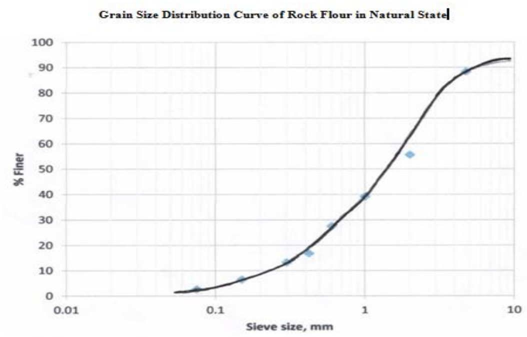
Reinforcing Material with Rock Flour	Friction coefficient	
	OMC & MDD Condition	Wet Condition
Woven geotextile	0.87	0.81
Nonwoven geotextile	0.81	0.78

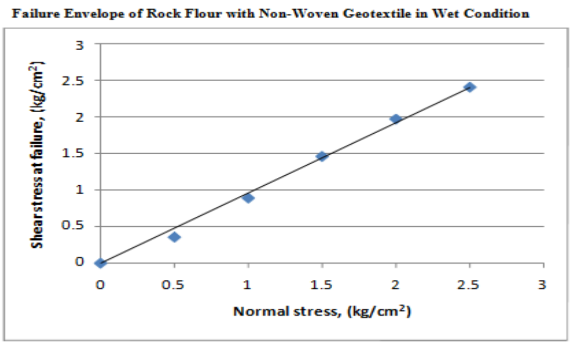
Table 5.5 Interfacial shear parameters of Rock Flour with Geotextiles from Pull out

Interfacial Shear Parameters	Woven Geotextiles	Non-Woven Geotextiles
	OMC & MDD Condition	OMC & MDD Condition
Adhesion	0	0
Angle of Interfacial Friction	38°	35°

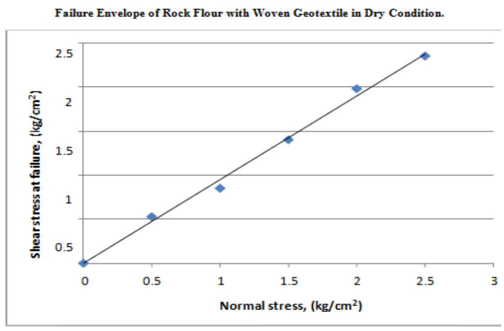
Compaction Curve of Rock Flour

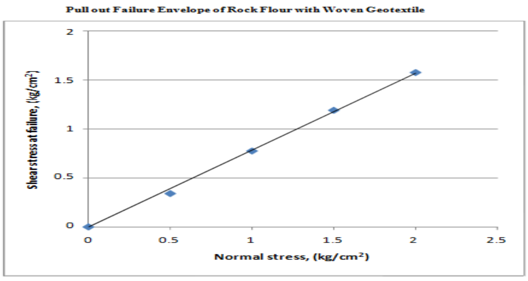


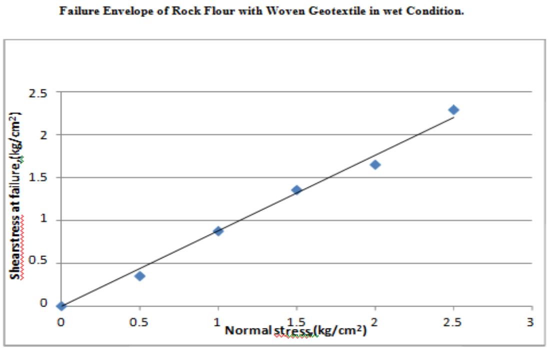


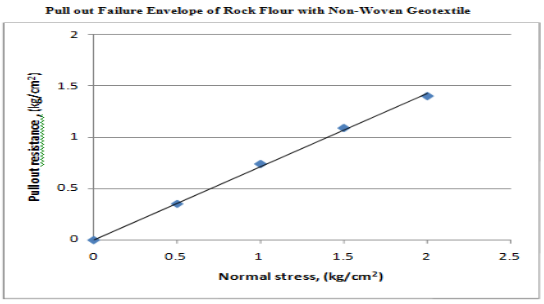


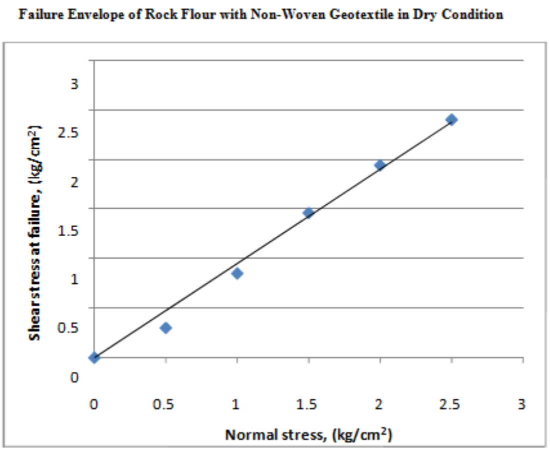
3) Graphs for Direct Shear Test

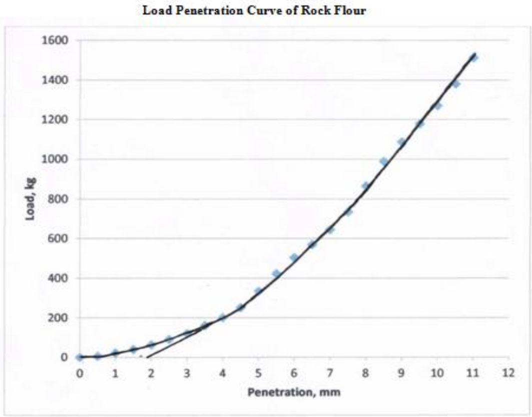












VI. CONCLUSIONS

- The equivalent IS classification symbol for rock flour under study is well graded sand.
- The rock flour is coarse grained material with more sand size particles with good frictional and drainage characteristics (k = 2.5X10-3cm/s).
- Rock flour has higher angle of internal friction (Ø = 43) compared to coarse sand.
- Rock flour mobilized 86 to 93% of angle of internal friction as interfacial friction angle with geotextiles.
- The friction coefficient reduced by 6.8 percent from OMC and MDD state to wet condition in respect of a woven geotextiles where as the friction coefficient reduced by 3.5 percent from OMC and MDD state to wet condition in case of non woven geotextiles.
- The frictional coefficient mobilized by rock flour with woven geotextile is relatively more than that of non-woven geotextile.
- The friction coefficients mobilized by rock flour with geotextiles is higher than that mobilized by sand (about 10 - 20%).
- Rock flour under study satisfied the requirements of frictional fills for use in construction of reinforced soil structures.

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