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Effect of Crusher Dust-Geogrid Composite on Interface Shear Strength

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Abstract: *Modern geotechnical practice often uses technique of reinforced soil – a composite of soil and reinforcement mostly geogrids. In civil engineering application geogrid is widely use to reinforce embankment, retaining wall, roads and railway ballast. Therefore studying the geogrid soil interaction is important for any successful design. In this paper, a new type of geogrid has been evaluated for the interaction properties for different backfill soils using direct shear test. The test results are compared based on the type of sands and interface mechanical property. Two soils namely natural sand and crusher dust in combination with three different geogrids are tested at various loading conditions in direct shear test. High angles of internal friction of these materials are determined using direct shear, ranging from* $\phi = 55.92^\circ$ *to* 57.26° *while the crusher dust is characterized as* $\phi = 53.69^\circ$*. The addition of geogrid of three different sizes to the crusher dust led to an immediate increase in friction angle. By attaining high angle of internal friction, bearing capacity and reduction in total active earth pressure as that of sand, crusher dust can be used as an alternative material in geotechnical activities.*

Keywords: *Direct shear test, Geogrid, Interface shear strength, Reinforced crusher dust*

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I. Introduction

Modern building practice in construction of road, geotechnical construction of embankments, retaining structure and in improvement of foundation soil often uses the technique of reinforced soil. The soil is considered to be reinforced when the plane implants, mostly geo-synthetic sheets or geogrid are placed in it to create composite material with improved engineering properties. In reinforced soil structure, poor soil becomes usable and because of overall better properties of this composite. It is possible to build steeper slope of embankments often with lower prize and reduces space required for structure, improve behavior of structure under earthquake loading and also cost of construction is minimized. Conventional materials like natural soils, broken rock pieces, sand are popularly used in the construction of structures like roads, embankments, reclamation of grounds etc. Procurement of such materials in huge quantities have been becoming very difficult and presence of plastic fines in the soils causes excess deformations which proves to be costly for the maintenance of structures. Keeping this in mind and utilization of waste products in bulk quantities has been searched, from which crusher dust is selected as an alternate material in place of sand. If we introduce the flexible geo-synthetics in this fill material resulting in composite material. The sand and geo-synthetics are combined through friction. The result is monolithic mass that acts cohesively supporting its own weight and applied load. Differential settlement is eliminated and bearing capacity is eventually increased. Before using these materials as filling material it is necessary to check the behaviour of material for various parameters.In this study, it was aimed to observe shear strength behavior of crusher dust-geogrid interface. Two series of experiments were performed. In every series, behavior of shear strength under different testing conditions were investigated by varying geogrid aperture size.

1.1 Objectives of the Study

1. To investigate the effect of geogrid on shear strength parameters on different sands.
2. To study the performance of crusher dust as a geotechnical material.
3. To suggest the suitable combination of crusher dust and geo-grid.

II. Materials Used For Study

2.1 Backfill Materials

Two types of soils were used as backfill material in this study. Specifically, natural sand and Crusher dust and this have been used to evaluate the interface behavior with the same geogrid material. Before conducting the interface direct shear test, the physical properties of the soils were tested in the laboratory. The test of physical properties reveal that Crusher dust has effective diameter D_{10} of 0.071, D_{30} of 0.82, D_{60} of 1.6, the uniformity coefficient (Cu) of 22.53 and the coefficient of curvature of the gradation curve (Cc) of 5.91. The specific gravity of Crusher dust is 2.955. The water content of both the sand was less than 1% which corresponds to air dried condition. Figure 8 represents the gradation curve of the experimental soil. According to IS 2720 (Part-IV) 1985 engineering classification system, the crusher dust and natural sand are classified as poorly graded respectively. The major physical properties of the soils are listed in Table 1.

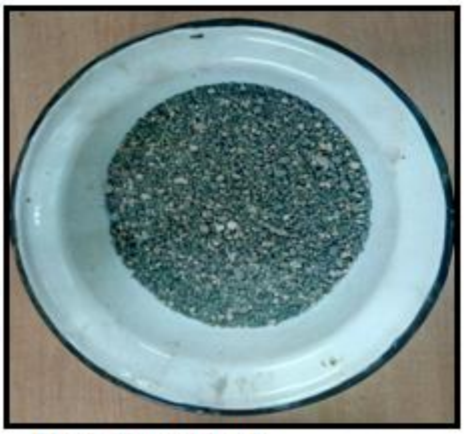
Fig. 1: Natural Sand


Fig. 2: Crusher Dust

Table 1- Properties of Crusher Dust

Sr. no	**Property**	**Crusher Dust**	**Natural Sand**
1.	Dry Density (λ_d)	23.2 kN/m^3	20.64 kN/m^3
2.	IS classification of soil	SP	SP
3.	Direct Shear Test a) Cohesion (C) b) Angle of internal of friction (ϕ)	 0 kN/m^2 53.69°	 0 kN/m^2 47.14°
4.	Specific Gravity	2.955	2.710

2.2 Geogrid Specimens

Three geogrids, of varrying aperture sizes i.e. 2.5cm x 3.2cm, 3.6cm x 3.0cm, 3.2cm x 3.2cm made up of polypropylene polyester fibres are used in this study. For performing experiments Macgrid was used. Here, Macgrid is geogrid manufactured by Maccaferri ind. pvt. ltd. Macgrid^{TM} is a geogrid for soil reinforcement, made from high molecular weight, high tenacity polyester multifilament yarns. The yarns are woven on tension in machine direction and finished with polymeric coating Macgrid^{TM} geo-grids are engineered to be mechanically and chemically durable and resistant to biological degradation.

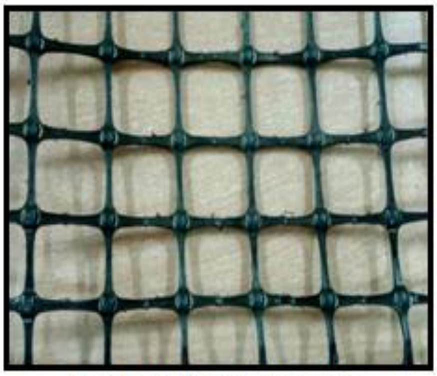
Fig. 3: GG1 (3.2cm*2.5cm)

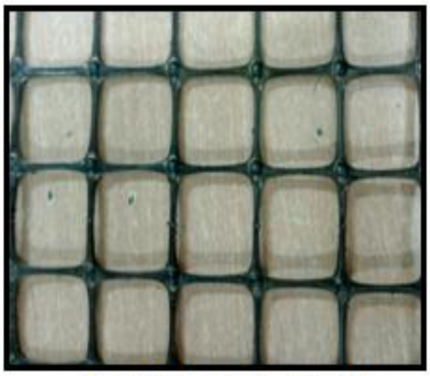
Fig. 4: GG2 (3.2cm*3.2cm)

Fig. 5: GG3 (3.6cm*3.0cm)

GG1 – Geogrid (3.2cm x 2.5cm)

GG2 – Geogrid (3.2cm x 3.2cm)

GG3 – Geogrid (3.6cm x 3.0cm)

Table 2- Physical Properties of Geogrid

Physical Properties	**GG1**	**GG2**	**GG3**
Specific wt. (g/m^2)	500	500	500
Aperture size	3.2cm*2.5cm	3.2cm*3.2cm	3.6cm*3.0cm
Percent open area (%)	61	71	73

Table 3- Mechanical Properties of Geogrid

Mechanical Properties	**GG1**	**GG2**	**GG3**
Ultimate tensile strength (KN/m)	20	20	20
Tensile strength at 2% strain	7	7	7
Tensile strength at 5% strain	14	14	14
Junction efficiency	93%	93%	93%

III. Methodology

Laboratory tests were conducted on crusher dust with and without geogrid. In order to evaluate the improvement in strength properties, physical and strength performance tests namely; specific gravity, sieve analysis and direct shear test were performed.

IV. Experimental Investigation

Specific gravity and Sieve analysis tests are carried out as per IS 2720 (Part-II) 1964 and IS 2720 (Part-IV) 1985 respectively. Direct Shear test is carried out as per IS 2720 (Part-39/sec-I) 1977 in the following manner. A small scale direct shear testing device, as shown in figure 6. Which consists of fixed lower box and a moving upper shear box, has been used in this study. Both the shear boxes have same inside dimensions of 60 mm in length and 60 mm in width. The vertical load is applied to the backfill material through a loading plate below the lower shear box. A reaction plate is placed on the backfill in upper shear box. The applied shear force and horizontal displacement wehre are recorded using proving ring and dial gauge respectively.The geo-grid specimens were positioned on a sand base placed on the top of lower box (figure 4). Subsequently the specimen was folded to acquire grip and prevent slipage of geogrid during the test. In case of natural sand and Crusher dust the upper and lower shear box was filled by raining the sand from a height passing through two consecutive sieves. The dry unit weight of the sand mass in upper and lower box was 23.2 kN/m^3. The height of sand layer in upper and lower box is 2 cm. The upper and lower box was filled by the soil in three steps with same compaction energy for every step. Thus, density of backfill soil was kept almost constant. The direct shear tests were conducted using four different normal stresses of 0.5, 1, 1.5, 2 kg/cm^2. All the test involved applying the normal stress and monitoring the horizontal displacement. The maximum number of divisions obtained during the shear process was recorded as the peak shear strength. The same procedure was repeated for all maintained constant during shearing process. For two soils and three types of geogrid under different normal stress condition. Total 32 numbers of tests were performed in this study.

Fig. 6: Direct Shear Testing Machine

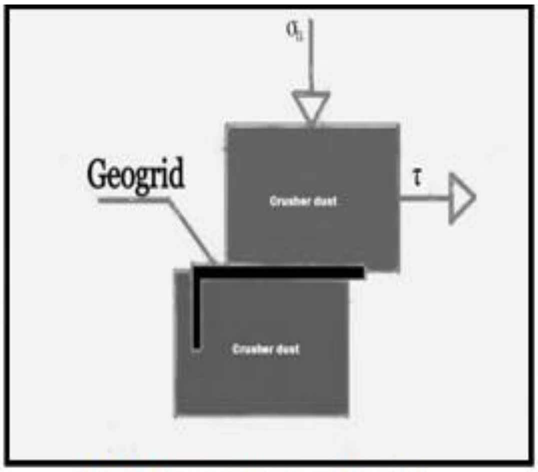

Fig. 7: Concept of Placing Geogrid

V. Results and Discussion

5.1 Specific Gravity of Crusher Dust and Natural Sand

Specific gravity of crusher dust and natural sand is carried out as per IS 2720 (Part-II) 1964

1. Specific gravity of crusher dust = 2.95
2. Specific gravity of natural sand = 2.71

5.2 Sieve Analysis of Crusher Dust

For grain size distribution of crusher dust and natural sand, sieve analysis tests have been performed. The coefficient of uniformity and coefficient of curvature are determined from fig. 1. The determined value for

1. Coefficient of uniformity (Cu) = 22.53
2. Coefficient of curvature (Cc) = 5.91

The determined values for coefficient of uniformity and coefficient of curvature of natural sand are 3.54 and 0.82 respectively.As per IS 2720: Part 4, as the values of Cu and Cc are 22.53 and 5.91 respectively the crusher dust is poorly graded.

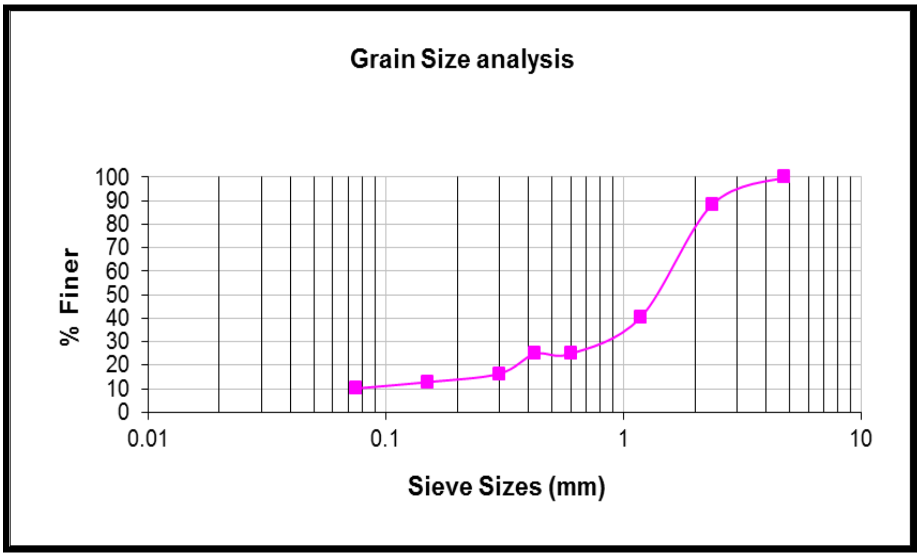

Fig. 8: Sieve analysis of Crusher Dust

5.3 Interface Shear Strength

The shear strength of a soil geogrid interface is an essential parameter of slope stability analysis where slip surface run along the geogrid. The relationship between interface shear strength and normal stress at the interface is generally considered to be linear and defined by equation (1).$\tau_f = C + \sigma \tan\phi$….(1)Where the τ is the soil-geogrid interface shear srength; C is the interface cohesion; σ is the stress normal to the interface; and (δ) is interface frictional angle

5.3.1 Interface Shear Strength of Crusher Dust-Geogrid Composite

The interface shear strength is find out according to (IS 2720-Part 13-1972) and the values are tabulated in tables 4, 5 and 6.

5.3.1.1 Crusher Dust + Geogrid of Size 3.2 cm*2.5 cm

Table 4- Data sheet for Interface shear strength of Crusher dust

Sr. no	**Normal stress (kg/cm^2)**	**Maximum shear force (kg)**	**Shear stress (kg/cm^2)**	**Shear strength (kg/cm^2)**
1.	0.5	20.096	0.4971	1.6162
2.	1.0	53.38	1.0902	
3.	1.5	78.50	2.1369	
4.	2.0	100.48	2.7408	

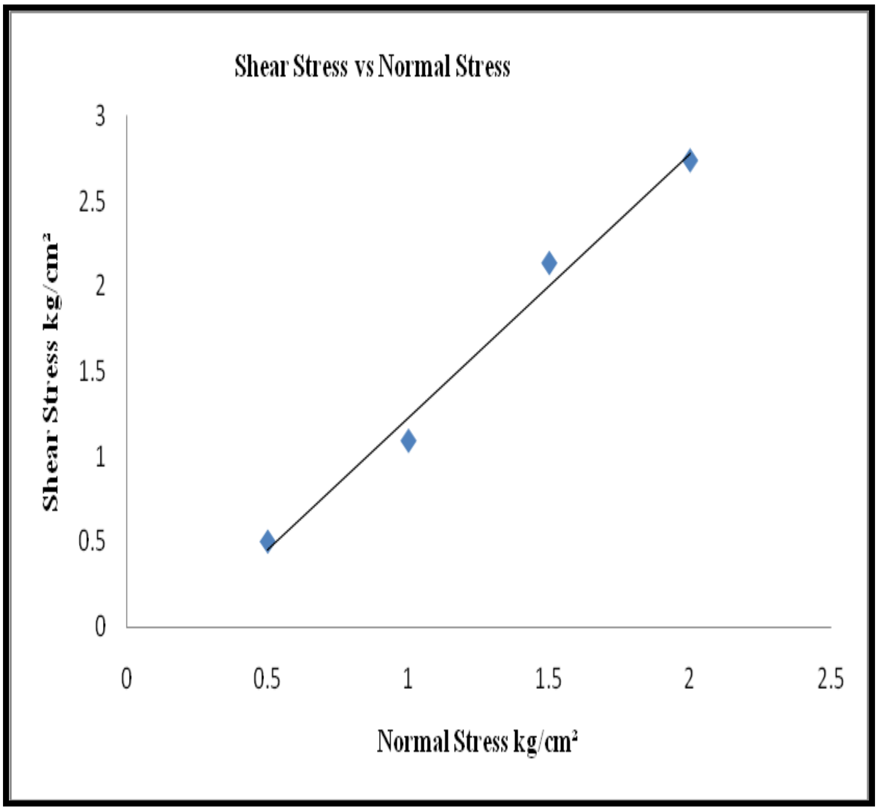

Fig. 9: Variation between normal stress and shear stress

Cohesion (C) and Interface friction angle (δ) are 0 and 57.26º.

5.3.1.2 Crusher Dust + Geogrid of Size 3.2 cm*3.2 cm.

Table 5- Data sheet for Interface shear strength of Crusher dust

Sr. no	**Normal stress (kg/cm^2)**	**Maximum shear force (kg)**	**Shear stress (kg/cm^2)**	**Shear strength (kg/cm^2)**
1	0.5	27.946	0.7762	1.9275
2	1.0	58.718	1.6310	
3	1.5	80.38	2.2328	
4	2.0	110.52	3.070	

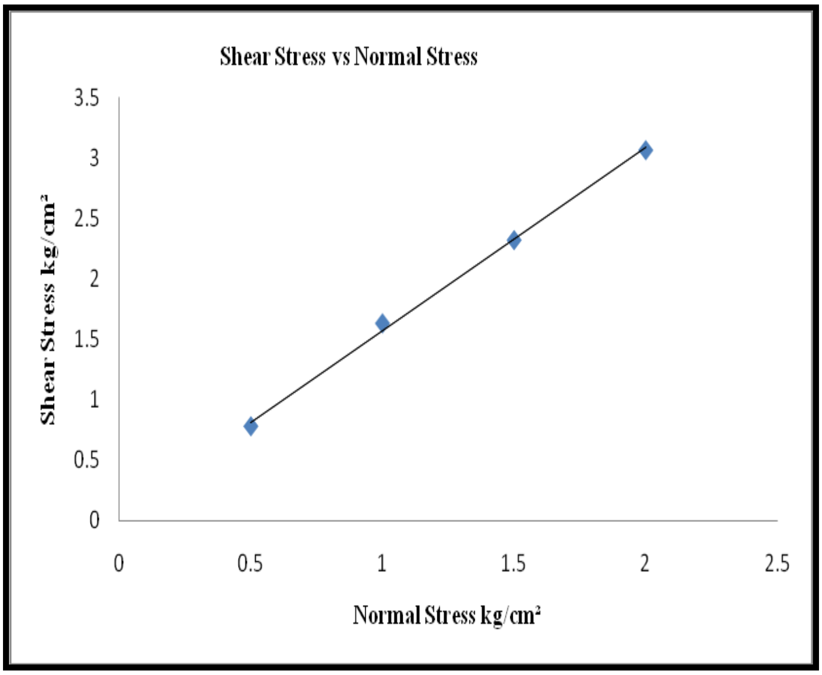

Fig. 10: Variation between normal stress and shear stress

Cohesion (C) and Interface friction angle (δ) are 0 and 56.56º.

5.3.1.3 Crusher Dust + Geogrid of Size 3.6 cm*3.0 cm

Table 5- Data sheet for Interface shear strength of Crusher dust.

Sr. no	Normal stress (kg/cm^2)	Maximum shear force (kg)	Shear stress (kg/cm^2)	Shear strength (kg/cm^2)
1.	0.5	20.096	0.5582	1.7553
2.	1.0	53.38	1.4827	
3.	1.5	78.50	2.1805	
4.	2.0	100.48	2.7911	

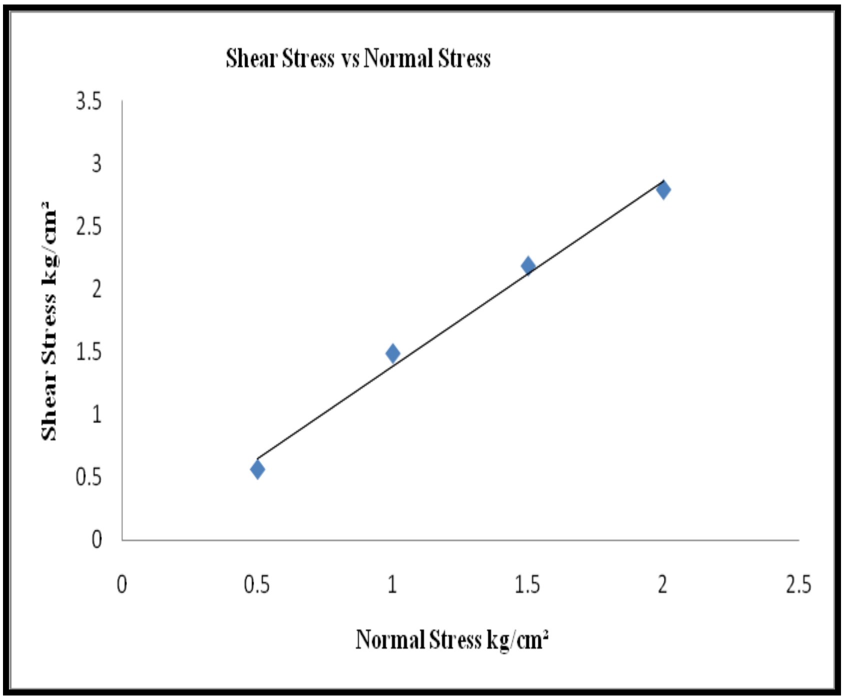

Fig. 11: Variation between normal stress and shear stress

Cohesion (C) and Interface friction angle (δ) are 0 and 55.92º.

5.3.1.4 Natural Sand + Geogrid of Size 3.2 cm*3.2 cm

Table 6- Data sheet for Interface shear strength of Natural Sand

Sr. no	Normal stress (kg/cm^2)	Maximum shear force (kg)	Shear stress (kg/cm^2)	Shear strength (kg/cm^2)
1.	0.5	36.738	1.0205	1.7945
2.	1.0	52.438	1.4566	
3.	1.5	74.418	2.0671	
4.	2.0	94.828	2.6341	

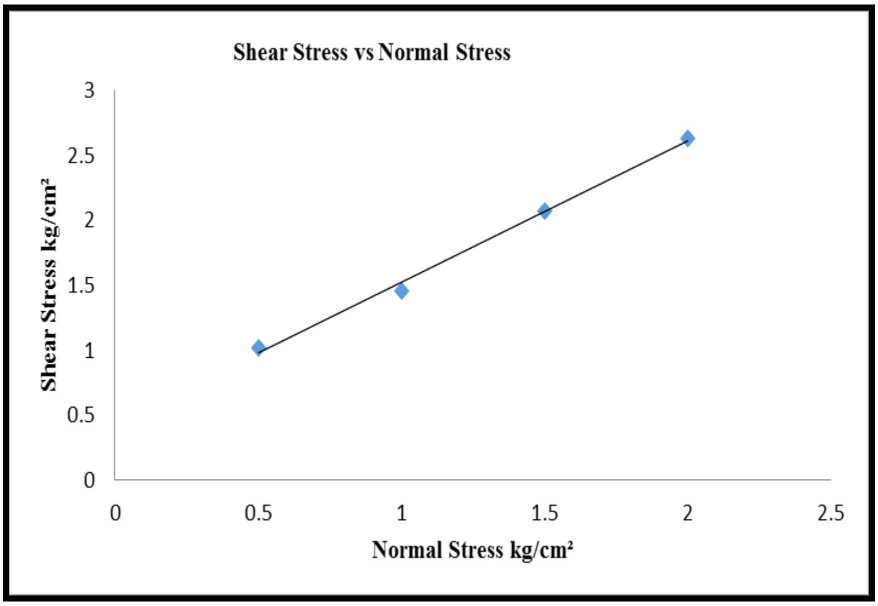

Fig. 12: Variation between normal stress and shear stress

Cohesion (C) and Interface friction angle (δ) are 0 and 47.47º.

Results for Interface Shear strength:

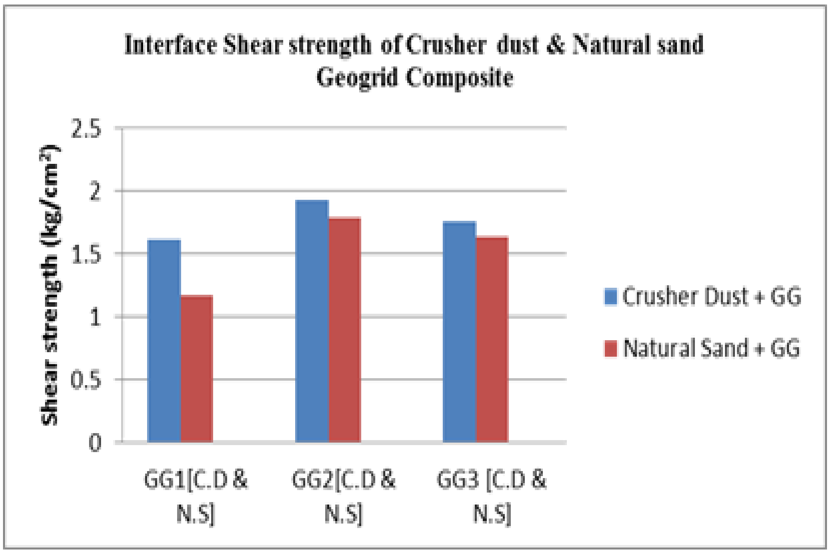

Fig. 13: Comparison of interface shear strength of crusher dust-geogrid composite

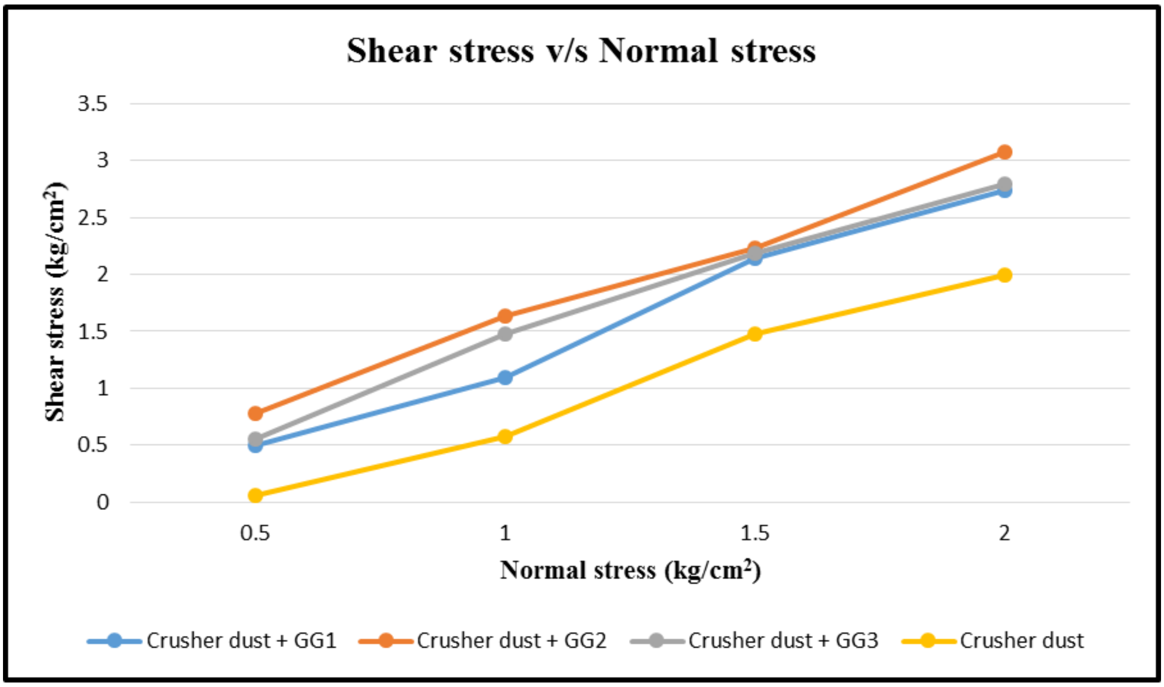

Fig. 14: Variation in cohesion (C) and interface friction angle (δ) of crusher dust-geogrid composite

V. Conclusion

Based on the experimental work carried out in the present study the following conclusions are drawn for investigation of Crusher Dust-Geogrid composite properties.

1. Interface friction angle (δ) of Crusher dust-Geogrid composite is higher than angle of internal friction (ϕ) of crusher dust.
2. Crusher dust particles are similar to sand particles and offer more shear strength.
3. Interface friction angle is increases with decrease in geogrid aperture size.
4. Maximum increase in shear strength of crusher dust-geogrid composite is 46%.
5. Best suitable combination of crusher dust-geogrid composite is crusher dust with geogrid of aperture size (3.2cm*3.2cm).

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References

[1]. A. Cancelli, P. Rimoldi and S. Togni, "Frictional Charac-teristics of Geogrids by Means of Direct Shear and Pull-out Tests," Proceedings of the International Symposium on Earth Reinforcement, Kyushu University, Fukuoka

[2]. C.A. Bareither, T.B. Edil, C.H. Benson and D.M. Mickelson, Geological and physical factors affecting the friction angle of compacted sands, Journal of Geotechnical and Geoenvironmental Engineering, 134 (10), 2008, 1476-1489.

[3]. Chia-Nan Liu, Jorge G. Zornberg, M.ASCE; Tsong-Chia Chen, Yu-Hsien Ho, and Bo-Hung Lin (2012),"Behavior of Geogrid-Sand Interface in Direct Shear Mode," American Society of Civil Engineering (ASCE) Volume 4 (2012) PP 42-47

[4]. E. M. Palmeria and G. W. E. Milligan, "Scale and Other Factors Affecting the Results of Pull-Out Tests of Grids Buried in Sand," Geotechnique, Vol. 39 No. 3, 1989, pp. 511-524.

[5]. G. M. Ayininuola, O. A. Agbede and S.O. Franklin, Influence of calcium sulphate on subsoil cohesion and angle of friction. Journal of Applied Sciences Research. 5(3), 2009, 297 – 304.

[6]. Krunoslav Minazek, Zeljana Kopic, Mensur Mulabdic (2011), "Simple Procedure of Geogrid-soil Interaction Efficiency Assesment", International Journal of Advanced Civil Engineering Research. ISSN 1330-3651(2011) pp. 1- 11

[7]. Mohammad Saleh Ahmadi and Parastoo Nikbakht Moghadam(2017) ,"Effect of Geogrid Aperture Size and Soil Particle Size on

[8]. Geogrid-Soil Interaction under Pull-Out Loading", Journal of Textiles And Polymers. Vol. 5, No. 1, January 2017 PP .25

[9]. M.Y. Shah, Sawmi Saran, S. Mittal (2013), "Effect of Geogrid Reinforcement on Hyperbolic Stress Strain Behavior of Sand: An Experimental Investigation", International Journal of Science and Research (IJSR), India Online ISSN: 2319-7064 Volume 2 Issue 1

[10]. P. V. V. Satyanarayana, N. Pradeep, N. Nandhini (2013) , "A study on the Performance of Crusher dust in place of sand and red soil as A subgrade and fill material", ISOR Journal of Mechanical and Civil Engineering (IOSR-JMCE) , Volume 9 PP 53 – 57.

[11]. Satyanarayana P.V.V, Sai Chaitanya VarmaN, Krishna ChaitanyaD. Ganga Raj (2016),"A Study on Performance of Crusher Dust in Place of Sand as A Sub-Grade and Fill Material in Geo-Technical Applications", International Journal of Advanced Civil Engineering Research. Volume 1, Number 1 (2016) pp. 1- 11

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