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SOIL INVESTIGATION AND EFFECT OF STONE DUST ON GEOTECHNICAL PROPERTIES OF SOIL

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Abstract:- This projects deals mainly with soil investigation and analyze the effect of stone dust on some geotechnical properties of soil; a) Sequence and extent of each soil and rock stratum in the region likely to be affected by the proposed work; b)Bearing Capacity of the soil. c) The main objective of this study is to examine the change in the index properties of soil when stone dust is mixing with soil In this study stone dust by dry weight of soil was taken as 10%, 20%, 30%, 40% and 50% taken and mixed with the soil so as to examine the effect of mixing on OMC, MDD and CBR properties of soil. The objective of this study is to investigate soil and examine the effect of stone dust on some geotechnical properties of soil and also to determine the probable sub surface condition, assess the various engineering properties of soil .Adding 50% of stone dust is effective in decreasing optimum moisture content of soils which is advantageous in decreasing quantity of water required during compaction. The study also reveals the fact that with increase in the percentage of stone dust MDD of soil increases. Mixing of soils with stone dust is also found to improve its CBR. Adding only 30% of stone dust is found to increase the CBR of soil by nearly 50%.There is a great effect on specific gravity of soils on mixing stone dust with them. Adding 30% stone dust is found to be optimum in case of specific gravity In this research samples of soil were collected only from seven test pits, by increasing the number of sampling area in-depth investigation should be done in future. The dynamic characteristics of soils with relation to respond of soil to earthquake should be studied in future. The Correlation of the index property with shear strength parameters may also be done.

1.0 Introduction

The knowledge of subsoil conditions at a site is a prerequisite for safe and economical design of substructure elements. The field and laboratory studies carried out for obtaining the necessary information about the subsoil characteristics including the position of ground water table are termed as soil investigation. A well planned and properly executed site investigation programme will provide information about the stratography and physical properties of the soils at including ground water table and its fluctuations. These may be supplemented with geological studies and geological surveys along with the normal topographical survey. In view of the complexity of natural deposits, no single method of exploration is suited for all situations. The choice depends on the nature of sub soils, their extent, and the purpose of the exploration programme. In discussing the various methods of soil exploration, this project gives an overview for selecting depth, location and method of soil exploration for general types of buildings.

Stone dust is also a solid waste material that is generated from stone crushing industry which is abundantly available in India. **Soosan et al. (2001)** identified that crusher dust exhibits high shear strength and is beneficial as a geotechnical material. Stone dust is a material that possesses pozzolanic as well as coarser contents in it while other materials like fly ash possesses only pozzolanic property and no coarser soil particles. Significant improvement in the properties of soils is reported by different researchers by mixing it with stone dust. In this study stone dust by dry weight of soil was taken as 10%, 20%, 30%, 40% and 50% taken and mixed with the soil so as to examine the effect of mixing on OMC, MDD and CBR properties of soil.
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Fig.1.1. Satellite Map of Investigation Site

Although the temperature in Sihniwala, Dehradun can reach below freezing during severe cold waves, this is not common. Summer temperatures can reach up to 40°C for a few days, whereas winter temperatures are usually between 1 and 20°C. During the monsoon season, there is often heavy and protracted rainfall. In areas which have already been developed advantage should be taken of existing local knowledge, records of trial pits, bore holes, etc., in the vicinity of that area.

2.0 Theoretical Background

2.1 Literature:

M/s Hindustan Petroleum Corporation Limited (2010) proposed to conduct Soil Investigation at SS 6B Area in DHT project at Visakha Refinery, Visakhapatnam. Accordingly, land soil investigations were envisaged to evolve various soil/rock parameters in order to carry out engineering analysis and foundation design. In this connection, the soil investigation work was awarded to M/s J.J. Associates (VSKP) AETP Pvt. Ltd., Visakhapatnam vide Purchase order No. 9000163-OQ-10004 dated 11/2/2010 to carry out the land soil investigations at the proposed site. Broad objectives of the investigations were as follows:

(a) To evaluate the parameters of soil/rock at the proposed site.
(b) To assess the engineering parameters and to estimate the safe bearing capacity of soil.

The scope of work includes drilling of One (1) Land Boreholes at SS-6B Area. The scope also includes carrying out field tests like Standard Penetration Test (SPT) in boreholes, collection of disturbed and undisturbed soil samples and carrying out the relevant laboratory tests on collected soil samples. Considering the subsoil conditions prevailing at the site and based on field and laboratory investigation results, the following recommendations have been made for foundations of proposed constructions:

a) As Hard strata is met at shallow depth and taking both shear criteria & settlement criteria into consideration raft foundation/ isolated column footings should be adopted at the depths mentioned with the safe bearing capacities.

b) Filled up material if any should be removed and foundation should be from the natural ground level.

c) Plinth beams are to be provided to safeguard the structure against differential settlements if any.

d) Due to presence of sulphatesin water necessary precautions should be taken as per IS 456-2000.

e) Back Filling material should be Rubble Soling and well compacted in layers of 150mm below PCC.

Roobhakhshan and Kalantari (2013) conducted consistency limit, standard compaction test, unconfined compressive test and CBR test and concluded that there is remarkable influence on strength and CBR value at 1% lime + 6% waste stone powder for CBR and 7% lime + 6% waste stone powder for U.C.S which are optimum percentage.

Sabat (2012) conducted series of tests and concluded that addition of quarry dust decreases Liquid limit, Plastic limit, Plasticity index, Optimum moisture content, Cohesion and increases shrinkage limit, Maximum dry density, Angle of internal friction of expansive soil.

Satyanarayana et al. (2013) conducted plasticity, compaction and strength tests on gravel soil with various percentage of stone dust and found that by addition of stone dust plasticity characteristics were reduced and CBR of the mixes improved. Addition of 25-35% of stone dust makes the gravel soil meet the specification of morth as sub-base material.

Ali and Koranne (2011) presented the results of an experimental programme undertaken to investigate the effect of stone dust and fly ash mixing in different percentages on expansive soil. They observed that at optimum percentages, i.e., 20 to 30% of admixture, the swelling of expansive clay is almost controlled and there is a marked improvement in other properties of the soil as well. It is concluded by them that the combination of equal proportion of stone dust and fly ash is more effective than the addition of stone dust/fly ash alone to the expansive soil in controlling the swelling nature.

Bshara et al. (2014) reported the effect of stone dust on geotechnical properties of poor soil and concluded that the CBR and MDD of poor soils can be improved by mixing stone dust. They also indicated that the liquid limit, plastic limit, plasticity index and optimum moisture content decrease by adding stone dust which in turn increases usefulness of soil as highway sub-grade material

3.0 Proposed Work

3.1 Introduction

The sub-soil explorations are carried out in two stages, preliminary and detailed. The preliminary explorations consist of the geological study[16] of the site and site reconnaissance. During the site visit the study of local topography, excavations, cuttings, drainage pattern, and other natural features like streams, flood marks etc. will be useful. During preliminary investigation, geophysical methods[3] and tests are performed.

Detailed investigation[4] follows preliminary investigation and is normally carried out to variation determine the nature, sequence and thickness of various sub soil layers[2], their lateral variation, their physical properties and the position of ground water table. Borings and detailed sampling are usually undertaken to obtain this information. Various in-situ tests also form a part of the detailed investigation[1] program. Detailed soil exploration, can be limited in scope where the sub-soil layers are very erratic in distribution, the structure transmits light loads and is relatively unimportant and inexpensive or where a good record of subsoil details[1] already exists or where sound rock is available at shallow depth. Where the conditions are contrary to these, detailed soil explorations has to be quite expensive and elaborate.

3.2 Methodology:

3.2.1 Site Reconnaissance: Site reconnaissance would help in deciding future programme of field investigations, that is, to assess the need for preliminary or detailed investigations [22]. This would also help in determining scope of work, methods of exploration to be adopted, field tests to be carried out and administrative arrangements required for the investigation. Where detailed published information on the geotechnical conditions [19] is not available, an inspection of site and study of topographical features are helpful in setting information about Soil, rock and ground-water conditions. Site reconnaissance includes a study of local topography, excavations, ravines, quarries, escarpments; evidence of erosion or landslides, behavior of existing structures at or near the site; water level in streams, water courses and wells; flood marks; nature of vegetation; drainage pattern, location of seeps, springs and swamps. Information on some of these may be obtained from topographical maps, geological maps, pedological and soil survey maps, and aerial photographs [13].

3.2.2 Ground-Water Conditions: The ground-water level fluctuates [19], and will depend upon the permeability of the strata and the head causing the water to flow. The water level in streams and water courses, if any in the neighborhood, should be noted, but it may be misleading to take this as an indication of the depth of the water table in the ground. Wells at the site or in the vicinity give useful indications of the ground-water conditions [19]. Flood marks of rivers may indicate former highest water levels. Tidal fluctuations may be of importance. There is also a possibility of several water tables at different levels, separated by impermeable strata, and some of this water may be subject to artesian head [12].

3.2.3 Enquiries Regarding Earlier Use of The Site: In certain cases, the earlier uses of the Site may have a very important bearing on proposed new works. This is particularly so in areas where there have been underground workings, such as worked-out ballast pits, quarries, old brick fields, coal mines and mineral workings. Enquiries should be made regarding the location of shafts and workings, particularly shallow ones, where there may be danger of collapse [13], if heavy new structures are superimposed.

3.2.4 Number and Disposition of Trial Pits : The disposition and spacing of the trial pits and borings should be such as to reveal any major changes in thickness, depth or properties of the strata over the base area of the structure and its immediate surroundings. The number and spacing of bore holes or trial pits will depend upon the extent of the site and the nature of structures coming on it. For a compact building site covering an area of about 0.4 hectare, one bore hole or trial pit in each corner and one in the center should be adequate [13]. For smaller and less important buildings even one bore or trial pit in the center will suffice. For very large areas covering industrial and residential colonies, the geological nature of the terrain will help in deciding the number of bore holes or trials pits. Cone penetration tests may be performed at every 50 m by dividing the area in a grid pattern and number of bore holes or trial pit decided by examining the variation in the penetration curves [13,19].

3.2.5 Boring (Auger Boring) : An auger may be used for boring holes to a depth of about 6 m in soft soil which can stand unsupported but it may also be used with lining tubes, if required .Mechanically operated augers are suitable for gravelly soils or where a large number of holes are to be made [12].

Fig.3.1. A view of Test Pit

Fig.3.2. Hand Auger

3.2.6 Depth of Exploration: The depth of exploration required depends on the type of proposed structure, its total weight, the size, shape and disposition of the loaded areas, soil profile, and the physical properties of the soil that constitutes each individual stratum[19,22]. Normally, it should be one and a half times the width of the footing below foundation level. In certain cases, it may be necessary to take at least one bore hole or cone test or both to twice the width of the foundation. If a number of loaded areas are in close proximity, the effect of each is additive. In such cases, the whole of the area may be considered as loaded and exploration should be carried out up to one and a half times the lower dimension. In weak soils [19], the exploration should be continued to a depth at which the loads can be carried by the stratum in question without undesirable settlement and shear failure. In any case, the depth to which seasonal variations affect the soil should be regarded as the minimum depth for the exploration of sites. But where industrial processes affect the soil characteristics, this depth may be more [1,12,19].

3.2.7 Simulation & Observations:

3.2.7.1 Sampling

Samples are of two types:

a) Disturbed Samples -These are taken by methods which modify or destroy the natural structure of the material though, with suitable precautions, the natural moisture content can be preserved. Disturbed samples of soils [19,22] may be obtained in the course of-excavation and boring. The taking of disturbed samples of clay may result in the remolding of the material and may render it unsuitable for shear strength measurements unless it is required for fill. Such samples are suitable for mechanical analysis and tests for index properties. These samples may not be truly representative, especially when taken from below the ground-water level. This is more so in the case of gravels containing a portion of fine sand, since the finer fractions tend to be washed off the sampler by the water. For procuring true samples, where possible, the ground-water level may be lowered by means of pumping from filter wells before procuring samples, or special type of samplers used [22].

b) Undisturbed Samples -These are taken by methods which preserve the structure and properties of the material. Such samples are easily obtained from most rocks, but undisturbed samples of soil can only be obtained by special methods. Samples shall be obtained in such a manner that moisture content and structure do not get altered. These may be attained by careful protection and packing, and by the use of a correctly designed sampler [7].
In the present work, a test pit of one meter depth was dug in the ground with the help of a hand auger. Disturbed samples were collected during the excavations from three consecutive layers of the pit. Finally, different tests were performed on the sample [1-2].

3.2.8 Grain Size Distribution of All Samples Collected from Boreholes

The oven dried samples of soil is separated into two fractions by passing it through 4.75mm IS Sieve. The portion passing through the sieve is analyzed by fine analysis using the IS Sieve Nos. 2.36mm, 1.18mm, 600, 300, 150 and 75 microns. The portion retained on this sieve is analysed by coarse analysis using IS Sieve Nos. 100, 60, 20, 10 and 4.75mm [19,22].

3.2.9 SOIL : The soil for this study was procured from the campus of Shivalik college of engineering & Technology, Dehradun, Uttarakhand, India. The material was extracted from 60cm below the ground surface. Index properties of the soil were determined as per IS codes and are presented in Table-1. The soil is classified as **CL** [12,19,22].

Table 3.1 Shows Index properties of soil dust

S.No.	Property	Value
1.	Natural Moisture Content (%)	11.11
2.	Particle Size distribution	
3.	Sand (%)	23.6
4.	Silt (%)	61.4
5.	Clay (%)	15
6.	Specific Gravity	2.40
7.	Liquid Limit (%)	19.5
8.	Plastic Limit (%)	7.14
9.	Plasticity Index (%)	12.86
10.	OMC (%)	16.5
11.	MDD (g/cm^3)	1.76
12.	CBR Soaked (%)	1.95

3.2.10 Stone Dust: Stone dust for this study was purchased from Pal Stone Industry, Halduchaud, Uttarakhand, India. Index properties of the stone dust were determined as per IS codes and are presented in Table-2.The stone dust is classified as SP. Stone dust was randomly mixed with soil samples in 10%, 20%, 30%, 40% and 50% of the dry weight of soil [1-3].

Table 3.2 Shows Index Properties of Stone Dust

S.No.	**Property**	**Value**
1.	Natural Moisture Content (%)	9.11
2.	Particle Size distribution	
3.	Sand (%)	97.1
4.	Silt (%)	2.9
5.	Specific Gravity	2.76
6.	Liquid Limit (%)	NP
7.	Plastic Limit (%)	NP
8.	Plasticity Index (%)	NP
9.	OMC (%)	11.5
10.	MDD (g/cm^3)	1.97
11.	Angle of internal friction (degree)	35
12.	Cohesion (kN/m^2)	0.07
13.	CBR Soaked (%)	11.5
14.	CBR Unsoaked (%)	26.28

3.2.11 Liquid Limit and Plastic Limit test: Liquid limit of the soil is determined by Casagrande method using Casagrande type mechanical liquid limit apparatus. Plastic limit is determined as per the standard procedure [5].

3.2.12 Natural moisture content: Natural moisture content of the soil is determined by oven drying method as per IS: 2720 Part – II, 1969. Weights are taken to an accuracy of 0.001g [8].

3.2.13 Bulk & Dry density : Bulk density and dry density of the undisturbed soil samples are evaluated as per IS: 2720 [6]

3.2.14 Compaction Test: Compaction Test gives the Optimum Moisture Content of the soil. The degree of compaction of a soil is measured in terms of its dry density [8].

3.2.15 Triaxial shear Test: If the encountered strata is stiff in consistency, careful attention is made to extract sample from the tube. The test is conducted as per part of IS 2720.

3.2.16 Specific Gravity Test: Specific gravity test is conducted on the soil fraction passing through 425 micron I.S. sieve by density bottle method or by pycnometer. All weights are taken to an accuracy of 0.001 gr. and the tests were conducted at 27°C [4].

4.0 Chapter-4 Result And Discussion

4.1. Grain Size Analysis Soils having particles larger than 0.075 mm size are termed as coarse grained soils. In these soils more than 50% of the total material by mass is larger than 75 micron. Coarse grained soil may have boulder, cobble, gravel and sand[13].Sieves are wire screens having square openings. Different standards such as Indian, British and US designate the sieves differently. According to the Indian standard Code IS: 460-1962, the sieve number is the mesh width expressed in mm for large sizes and in microns for small sizes. Sieves vary in size from 80 mm to 75µ. The representative soil sample is separated into two fractions by sieving through the 4.75 mm I.S.sieve. The fraction retained on this sieve (+4.75 mm) is called the gravel fraction which is subjected to coarse sieve analysis. A set of sieves of size 80 mm, 20 mm, 10 mm and 4.75 mm is required for fractioning of gravel fraction. The material passing 4.75 mm sieve (-4.75 mm) is further subjected to fine sieve analysis. The set of I.S. sieves for fine sieve analysis consists of 2.36 mm, 1.18 mm, 600 µ, 300 µ, 150 µ and 75 µ sieves [9].

4.1.1 Calculations:

Sample 1**:** Mass of soil sample taken for the analysis = 1 kg

Table 4.1. Observation Table of Grain Size Analysis of Sample 1

Sieve no.	Mass of sieve (gm)	Mass of sieve + soil (gm)	Mass of soil retained (gm)	Cumulative mass of soil retained (gm)	Cumulative % of soil retained	%Finer (passing)
4.75mm	400	490	90	90	9	91
2.36mm	390	460	70	160	16	84
1.18mm	390	470	80	240	24	76
600µ	350	400	50	290	29	71
300µ	360	470	110	400	40	60
150µ	360	740	380	780	78	22
75µ	340	520	180	960	96	4
Pan	480	520	40	1000	100	0

Grain size distribution curve

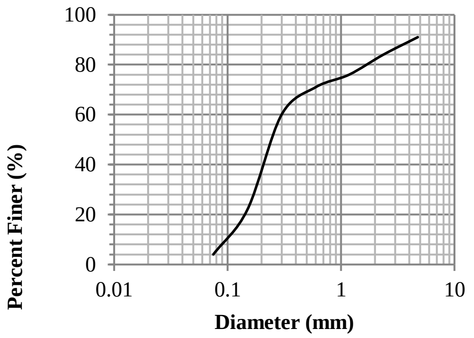

Fig.4.2. Grain Size Distribution Curve of Sample 1

Sample 2 : Mass of soil sample taken for the analysis = 1 kg

Table 4.2. Observation Table of Grain Size Analysis of Sample 2

Sieve no.	Mass of sieve (gm)	Mass of sieve + soil (gm)	Mass of soil retained (gm)	Cumulative mass of soil retained (gm)	Cumulative % of soil retained	%Finer (passing)
4.75mm	400	470	70	70	7	93
2.36mm	390	440	50	120	12	88
1.18mm	390	460	70	190	19	81

600µ	350	390	40	230	23	77
300µ	360	490	130	360	36	64
150µ	360	850	490	850	85	15
75µ	340	450	110	960	96	4
Pan	480	520	40	1000	100	0

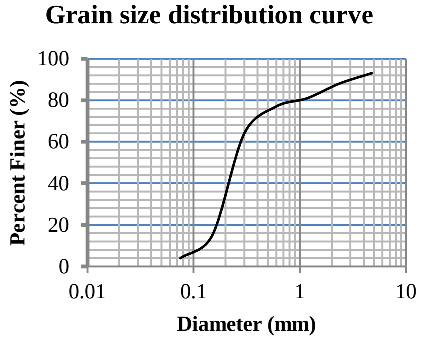

Fig.4.3. Grain Size Distribution Curve of Sample 2

Sample 3: Mass of soil sample taken for the analysis = 1 kg

Table 4.3. Observation Table of Grain Size Analysis of Sample 3

Sieve no.	Mass of sieve (gm)	Mass of sieve + soil (gm)	Mass of soil retained (gm)	Cumulative mass of soil retained(gm)	Cumulative % of soil retained	%Finer (passing)
4.75mm	400	450	50	50	5	95
2.36mm	390	430	40	90	9	91
1.18mm	390	440	50	140	14	86
600µ	350	390	40	180	18	82
300µ	360	400	40	220	22	78
150µ	360	920	560	780	78	22
75µ	340	520	180	960	96	4
Pan	480	520	40	1000	100	0

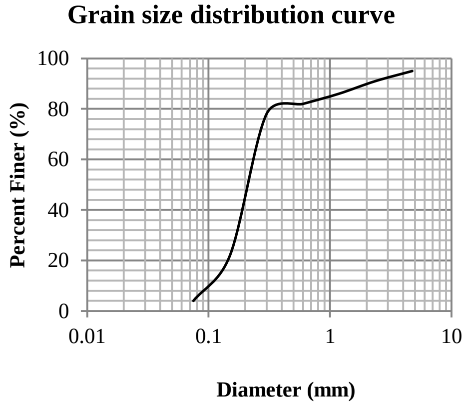

Fig.4.4. Grain Size Distribution Curve of Sample 3

5.0 Conclusion

The objective of this study is to investigate soil and examine the effect of stone dust on some geotechnical properties of soil and also to determine the probable sub surface condition, assess the various engineering properties of soil .

5.1 Conclusion:

A number of laboratory tests were performed on soil samples taken from different depths of test pit and from the results of these laboratory tests, the following conclusions have been drawn:

a) The soil at this site is mainly composed of fill material.
b) Nature of the soil is sandy with some portion of clay (Sandy Loam).
c) No rock was observed up to 1 m depth of the pit.
d) Gravels and Boulders were not at all present in the soil.
e) Calculaton of geotechnical properties of soil.
f) The Safe Bearing Capacity of the soil at 1m depth for 1m wide square footing has been determined. If the load on the footing is less than the safe bearing capacity, then that footing is safe from shear failure. Otherwise, other appropriate footing will be used.
g) Adding 50% of stone dust is effective in decreasing optimum moisture content of soils which is advantageous in decreasing quantity of water required during compaction.
h) The study also reveals the fact that with increase in the percentage of stone dust MDD of soil increases.
i) Mixing of soils with stone dust is also found to improve its CBR. Adding only 30% of stone dust is found to increase the CBR of soil by nearly 50%.
j) There is a great effect on specific gravity of soils on mixing stone dust with them. Adding 30% stone dust is found to be optimum in case of specific gravity.

5.2 Future work:

In this research samples of soil were collected only from seven test pits, by increasing the number of sampling area in-depth investigation should be done in future. The dynamic characteristics of soils with relation to respond of soil to earthquake should be studied in future. The Correlation of the index property with shear strength parameters may also be done.

6.0 References

1. **A.S Bshara, Y.K. Bind and P.K. Sinha,** “Effect of Stone Dust on Geotechnical properties of Poor soil,”Int. Journal of Civil Engineering and Technology (IJCIET), vol. 5, issue 4, pp. 37-47, 2014.
2. **Ali, M.S. and Koranne, S.S. (2011).** Performance Analysis of Expansive soil Treated with Stone Dust and Fly Ash. EJGE, vol.16, 973-982.
3. **Casagrande, A. and Fadum, R.P. (1939-40).**“Notes on soil testing for engineeringpurposes.” Soil Mech., series No.8, Publication from Graduates School of Engineering, No. 268, Hardward University, Cambrige
4. **IS:2720-Part 3 Sect 1-1980**, “Determination of specific gravity-Fine grained soils”.
5. **IS: 2720- Part 5 1970**, “Determination of liquid and plastic limits”.
6. **IS:2720- Part 29 1975**, “Determination of dry density of soil in place-by the core cutter method”.
7. **IS: 2720 Part IV (1965)**. Methods of Test for Soils: Grain Size Analysis.
8. **IS: 2720 Part IV (1965)**. Determination of moisture content dry density relation using light compaction.
9. **IS:2720, Part VII,** “Methods of Test for Soils, Determination of Water Content-Dry Density Relation Using Light Compaction Method,” Bureau of Indian Standards, New Delhi, India, 1980.
10. **IS: 2720, Part 4,** “Grain Size Analysis,” A publication of Bureau of Indian Standards,ManakBhawan, New Delhi, India, 1985.
11. **IS:2720, Part16,** “ Laboratory Determination of CBR,” A publication of Bureau of Indian Standards,ManakBhawan, New Delhi, India, 1987
12. **Meyerhof, G.G. (Dec. 1951).** “The ultimate bearing capacity of Foundation”. Geotechnique, vol. 2, No. 4, London.
13. **M.S. Ali, and S.S. Koranne,** “Performance Analysis of Expansive soil Treated with Stone Dust and Fly Ash,” EJGE, vol.16, pp. 973-982, 2001
14. **Resenquist, I.T. (1959)**. “Physicochemical properties of soils: Soil-water System”, Jour. Soil Mech. Found. Div. Vol. 85, No. SM-2 Part-1, Proc. Paper 2000, ASCE
15. **Roobhakhshan, A. and Kalantari, B. (2013).** Stabilization of Clayey Soil with Lime and Waste Stone Powder. Int. Journal of Scientific Research in Knowledge, vol. 1, issue 12, 547-556.
16. **SP 36-2 (1988):** Compendium of Indian Standards on Soil Engineering: Part-2 Field Testing of Soils For Civil Engineering Purposes.
17. **Skempton, A.W. and Bishop, A.W. (1950).**“The measurement of shear strength of soil”Geotechnique, vol. 9, London.
18. **Soosan, T.G.; Jose, B.T. and Abraham, B.M. (2001).** Use of Crusher dust in embankment and highway construction. Proc. Indian Geotechnical Conference, December, Indore, 274-2.