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"Experimental Study on Stabilization of Highly Plasticclay with sea sand and Flyash for Shallow Foundation"

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ABSTRACT

The foundation of any structure is resting on the soil. So the soil is the basic for foundation of every structure. Therefore it's essential to bear the load of structure without any failure. Different regions having different types of soil and those soils have different index properties, engineering properties and different behaviours. Some types of soil have problematic behaviors so due to that it's may not be suitable for foundation of heavy structures or any infrastructure developments. Due to the excessive presence of montmorillonite, problematic soil is responsible for volumetric variations with changes in moisture content. The process of improving the qualities of expansive soil and making it stable to handle the load operating on it is known as soil stabilisation.Cement, fly ash, bagasse, coir fibre, bitumen, and other stabilisers and admixtures are used to stabilise the soil.. This paper represents the experimental study of sea sand and fly ash as different admixture to refine the index properties and engineering properties of highly plastic clay soil of Surat city. This paper includes the soil stabilization by sea sand, fly ash and its combination as replacement of soil with 15%, 20% and 25% by weight and analyzing the safe bearing capacity as per Indian Standards.

Keywords: High Plastic Clay, Soil Stabilization, Safe Bearing Capacity, Sea Sand, Fly ash

INTRODUCTION

For any construction project, the soil is one of the most critical and fundamental media. Before a project can get off the ground, a site feasibility analysis for geotechnical projects is vital. Before the design process begins, a site survey is normally conducted to learn about the subsoil features and make a choice about the project's location. Design load and function of the structure, type of foundation to be used and bearing capacity of the subsoil is the geotechnical design criteria that have to be considered during site selection. The strength and durability of any structure depend on the strength properties of the soil. Stabilization of disturbed soils in geotechnical engineering applications such as pavement structures, roadways, building foundations, channel and reservoir linings, irrigation systems, water lines, and sewer lines to prevent damage from soft soil settlement or the swelling and shrinking action of highly plastic clay soils (expansive soils).Highly plastic clay soils are weak and have low index and engineering property values. So various methods are used to improve its properties, such as surface compaction, drainage methods, vibration methods, pre-compression and consolidation, grouting and injection, mechanical and chemical stabilisation, soil reinforcement, geosynthetics, and other methods.(1)

The expansive soil occurs all over the world. India has a large tracks of expansive soils known as Black Cotton soil (BC soil or Highly plastic clayey soils) it, covering about 0.8 million sq.km which is about 20% of total area. Gujarat, Madhya Pradesh, Maharashtra, Andhra Pradesh, Karnataka and Tamil Nadu having these clayey soils.(2) These soils undergo volumetric changes with the increase in moisture content. This is due to the presence of the mineral montmorillonite(3). The types of structures likely to get damaged are foundation, retaining walls, Pavements, runway of airport, side walk, canal beds and linings. It is great challenge to civil engineers for the construction of building structures and roads over it.

Sea sand and fly ash were used to stabilise the soil in this experimental study. The basic properties of soil have been discovered. The free swell index, liquid limit, plastic limit, optimum moisture content, and maximum dry density, as well as the triaxial compression test (unconsolidated undrained) of soil, were all examined. Laboratory tests were conducted on various proportions of stabilizers lime (15%,20%,25%) sea sand (15%,20%,25%) and combination of both (15%,20%,25%) by weight of soil. The fly ash, Sea sand and clayey soil are mixed fully oven dry weight basis in the suitable requirement proportions.And based on the engineering properties Safe Bearing Capacity (SBC) is calculated for each mix proportions.Finally, we expect to see improved results after stabilising high plastic clayey soil with Sea sand and Fly ash, as compared to normal high plastic clayey soil.

MATERIALS AND METHODOLOGY

Laboratory testing methods:
A series of laboratory tests were performed to determine the preliminary characteristics of the soil, followed by the addition of Sea Sand and Fly Ash in various quantities to determine the change in soil properties. Laboratory test includes grain size analysis (IS:2720-4-1985), Atterberg's limits (IS:2720-5-1985), swelling potential (IS:2720-40-1985), standard Proctor test (IS:2720-7-1980), triaxial test (IS:2720-11-1980).

Materials sources and properties:

a. Soil:The Disturbed soil sample was collected from 6m depth from existing ground level from Vesu area,Surat. The table 2.2.1 shows the index properties and engineering properties of soil. Based on the experiment data the soil is classified asHighly plastic clayey soil.
b. Fly Ash: Fly ash is a fine powdery particle made primarily of silica that is produced when finely ground coal is burned in a boiler to generate power.The Fly Ash is collected from Sayan Check-post, Surat. The source of Fly Ash is the Reliance Thermal power plant The chemical composition and physical composition of Fly ash is summarized in Table 2.2.2.
c. Sea Sand: The Sea Sand was collected from about 0.5-1 m below the ground level at Dumas Beach Surat. The Physical Properties of Sea Sand is summarized in Table 2.2.3

Table 2.2.1 - Index properties and Engineering properties of soil

Sr.No.	**Property Name**	**Value**
1.	Grain size distribution (%)	
	I. Silt + Clay	88.29
	II. Sand	11.59
	III. Gravel	0.11
2.	Liquid Limit (%)	68.74
3.	Plastic Limit (%)	37.02
4.	Plasticity Index (%)	31.72
5.	Soil Classification (IS 1498)	CH
6.	Specific Gravity	2.56
7.	Differential Free Swell	110
8.	Maximum Dry Density (gm/cc)	1.66
9.	Optimum Moisture Content (%)	19.00
10.	Shear Parameter	
	I. Cohesion (C) (Kg/cm^2)	0.128
	II. Angle of Internal Friction φ(°)	7
11.	Safe Bearing Capacity (kN/m^2)	102

Table 2.2.2 - Physical Properties and Chemical Properties of Fly ash

Sr.No.	**Property Name**	**Value**
1.	Physical Properties	
	I. Fineness by Blaine's permeability method (specific surface area) (m^2/kg)	324.67
	II. Sieving on 45-micron residue (%)	12.49
	III. Moisture (%)	1.42

2.	Chemical Composition		
	I.	Silica (SiO2)	52.58
	II.	Alumina (Al_2O_3)	23.12
	III.	Iron oxide (Fe_2O_3)	7.21
	IV.	Lime (CaO)	25.28

Table 2.2.3 - Physical Properties of Sea Sand

Sr.No.	Property Name	Value
1.	Particle size distribution (%)	
	Sieve diameter(mm)	Percent Finer (%)
	10.0	100.00
	4.75	100.00
	2.36	100.00
	0.600	99.82
	0.075	4.52
2.	Fineness Modulus	0.490
3.	Liquid Limit (%)	29.48
4.	Plastic Limit (%)	NP
5.	Plasticity Index (%)	NP
6.	Specific Gravity	2.97
7.	Differential Free Swell	Nill

Soil Mix Proportions for Stabilization:

The stabilization of soil is done with nine various mix proportions by weight of soil with additive Sea Sand and Fly Ash.

Table 2.3.1 - Mix Proportions for soil Stabilization

Sr.No.	Mix Proportions
1.	85% Soil + 15% Flyash
2.	80% Soil + 20% Flyash
3.	75% Soil + 25% Flyash
4.	85% Soil + 15% Sea Sand
5.	80% Soil + 20% Sea Sand
6.	75% Soil + 25% Sea Sand
7.	85%Soil+7.5%SeaSand+7.5%Flyash
8.	80% Soil +10%SeaSand+10%Flyash
9.	75%Soil+12.5%SeaSand+12.5%Flyash

Safe Bearing Capacity:

For Determination of SBC the IS 6403-1981 "Code of Practice for Determination of bearing capacity of shallow foundation" is used. Thefollowing equation for the net ultimate bearing capacity for general shear failure.(4)

$q_{nu} = CN_cS_cd_ci_c + q\ (Nq\text{-}1)S_qd_qi_q + 0.5\gamma BN_\gamma S_\gamma d_\gamma i_\gamma W'$

Where,q_{nu} = Net ultimate bearing capacity

C =Cohesion(Kg/cm²)

N_c, N_q, N_γ =Bearing capacity factors

S_c,S_q,S_γ= Shape factors

d_c,d_q,d_γ= Depth factors

i_c,i_q,i_γ= Inclination factors (4)

For this experimental study the design criteria is fixed out that mention in following table 2.4.1

Table 2.4.1 - Design Criteria of shallow foundation

Shallow Foundation	
Type of Foundation	Rectangular

Width of Footing (m)	3
Length of Footing(m)	4
Depth of Foundation (m)	6
Depth of Water Table (m)	-
Dry Density (gm/cc)	1.64
Correction Factor for water table (W')	0.5
Factor of Safety (FOS)	2.5

Table 2.4.2 - Data based on IS-6403-1981

Shallow Foundation

Shape factors for Rectangular footing	
Sc	1.15
Sq	1.15
Sγ	0.70
Depth factors (dc,dq,dγ)	Depend on value of φ
Bearing capacity factors (Nc, Nq, Nγ)	Depend on value of φ
Inclination factor (ic,iq,iγ)	1

RESULTSAND DISCUSSION

Table 3.1 - Test results of clayey soil with various Percentages of Fly Ash additive

Sr.No.	Property Name	85% Soil + 15% Flyash	80% Soil + 20% Flyash	75% Soil + 25% Flyash
1.	Liquid Limit (%)	62.73	48.27	42.11
2.	Plastic Limit (%)	32.40	24.98	21.88
3.	Plasticity Index (%)	30.33	23.29	20.23
4.	Soil Classification (IS 1498)	CH	CI	CI
5.	Specific Gravity	2.55	2.59	2.56
6.	Differential Free Swell (%)	75	84	70
7.	Maximum Dry Density(gm/cc)	1.62	1.62	1.54
8.	Optimum Moisture Content (%)	24.2	23.71	24.80
9.	Shear Parameter			
	III. Cohesion (C) (Kg/cm²)	0.409	0.132	0.2
	IV. Angle of Internal Friction φ(°)	7	13	14
10.	Safe Bearing Capacity (kN/m²)	244	229	300

The effect of Fly Ash addition in various Percentagesshowing the change in Index and Engineering properties of soil as shown in Table 3.1.The optimum mix from SBC, we can say it is (75+25) mix of soil+ fly ash. For the derived proportion, the angle of internal friction is also improved, which the leads to improvement of strength of soil..

Table 3.2 - Test results of clayey soil with various Percentages of Sea Sand additive

Sr.No.	Property Name	85% Soil + 15% Sea Sand	80% Soil + 20% Sea Sand	75% Soil + 25% Sea Sand
1.	Liquid Limit (%)	41.59	39.19	38.26
2.	Plastic Limit (%)	22.87	19.40	18.97
3.	Plasticity Index (%)	18.72	19.79	19.29
4.	Soil Classification (IS 1498)	CI	CI	CI
5.	Specific Gravity	2.58	2.63	2.61
6.	Differential Free Swell (%)	51	49	41
7.	Maximum Dry Density(gm/cc)	1.69	1.77	1.72
8.	Optimum Moisture Content (%)	20.3	15.83	19
9.	Shear Parameter			
	I. Cohesion (C) (Kg/cm²)	0.274	0.102	0.190
	II. Angle of Internal Friction φ(°)	12	17	18
10.	Safe Bearing Capacity (kN/m²)	301	324	550

The effect of Sea Sand addition in various PercentagesShowing the change in Index and Engineering properties of soil as shown in Table 3.2 by addition of Sea Sand the soil Classification is change High Plastic to Medium Plastic

Clay soil and the free Swell index is also decrease with increase the Sea Sand Percentage. The value of Angle of Internal Friction is increase with the increase in the sea Sand percentage.

Table 3.3 - Test results of clayey soil with various Percentages of Sea Sand and Fly Ash additive

Sr.No.	Property Name	85%Soil+ 7.5%SeaSand+7.5%Flyash	80% Soil +10%Sea Sand+10%Flyash	75%Soil+ 12.5%Sea Sand+ 12.5%Flyash
1.	Liquid Limit (%)	47.29	43.24	40.58
2.	Plastic Limit (%)	28.61	24.88	27.08
3.	Plasticity Index (%)	18.68	18.36	13.50
4.	Soil Classification (IS 1498)	CI	CI	CI
5.	Specific Gravity	2.62	2.55	2.56
6.	Differential Free Swell (%)	40	45	25
7.	Maximum Dry Density(gm/cc)	1.66	1.68	1.66
8.	Optimum Moisture Content (%)	20.41	20.07	20.40
9.	Shear Parameter			
	I. Cohesion (C) (Kg/cm²)	0.04	0.478	0.357
	II. Angle of Internal Friction φ(°)	21	15	16
10.	Safe Bearing Capacity (kN/m^2)	431	533	491

The effect of Sea Sand and Fly Ash addition in various Percentagesshowing the changes in Index and Engineering properties of soil as shown in Table 3.3 by Combination of both additives the soil Classification is change from high plastic to Medium plastic clay and the Plasticity Index is also decrease as compare to above both Mix Proportions. The maximum SBC is achieving in 10% sea sand and 10% Fly ash Mix Proportion.

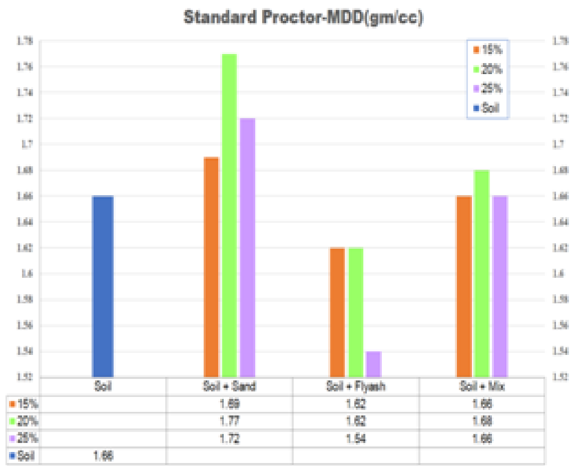

Chart 3.1- Standard Proctor - MDD

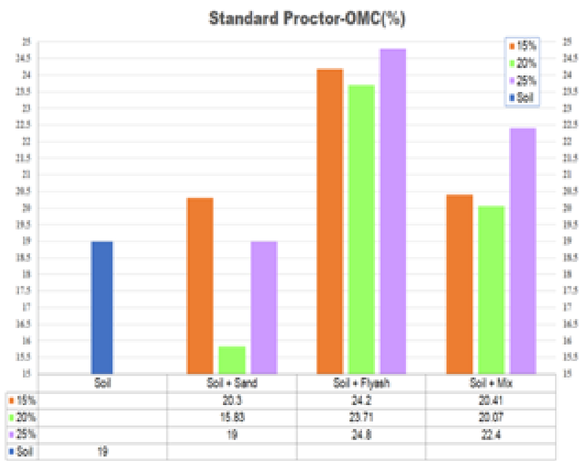

Chart 3.2 - Standard Proctor - OMC

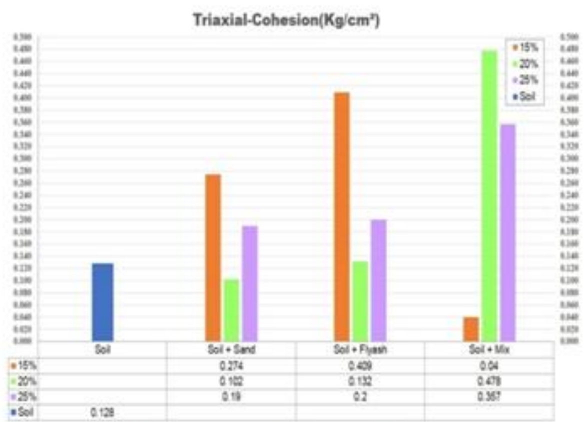

Chart 3.3– Triaxial- Cohesion

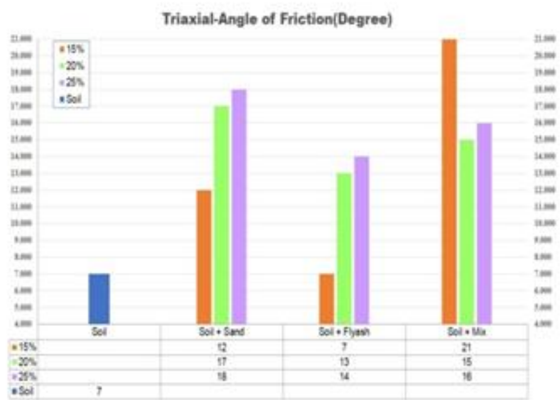

Chart 3.4- Triaxial – Angle of Friction

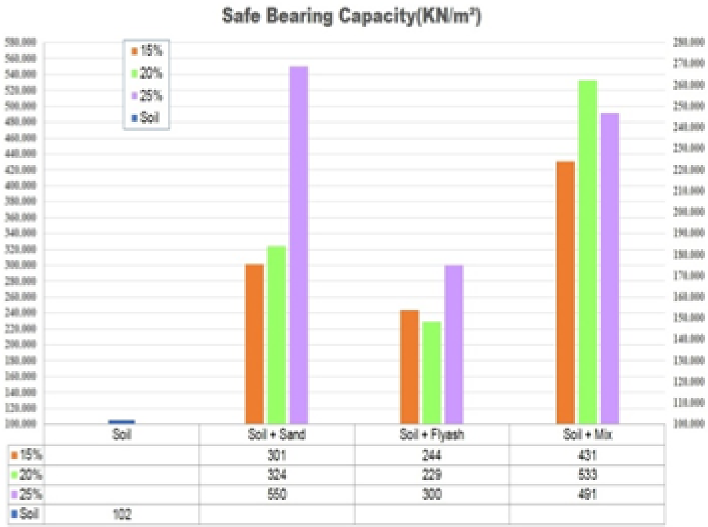

Chart 3.5 - Safe Bearing Capacity of Soil

The above tables and Graphs are shows the variation in results after adding the Sea Sand the Fly Ash in various percentages for Stabilization of the soil.

CONCLUSION

The soil in this project is not suitable for constructing a high rise building (G+7) due to its poor engineering properties, as determined by a laboratory investigation conducted on the soil. As a result, the soil received the additives (Sea Sand and Fly Ash). The following conclusions were drawn from the above data and observations...

I. The additive is sourced from natural and man-made resources for use in soil stabilisation.

II. OMC of the Highly Plastic soil has decreased from 19% to 15.83% and Maximum Dry Density (MDD) increased from 1.66 gm/cc to 1.77gm/cc with the addition of 20 % Sea Sand into the Highly Plastic soilfrom the graph 3.1 and 3.2 by addition of Fly ash the MDD is decrease and the OMC is increase.

III. In addition of Sea Sand and Fly ash the soil classification is change high plastic to medium plastic clayey soil and the plasticity index and Free Swell index is reducing by addition of 12.5% sea sand and 12.5% fly ash in soil.

IV. Addition of Fly Ash in soil shows improvisation in soil Properties. The plasticity index is decreasing with increasing the percentage of fly ash. Various percentage of fly ash makes different effect on SBC. As 15% of fly ash having SBC of 244kN/m^2 .Similarly, 25% Fly Ash with soil having SBC 300kN/m^{2}the fly ash particles are finer than the clay particles due to finer particle size it increasing the value of cohesion in soil. It might not be necessary that more percentage of Fly Ash will increase SBC. Study has maximum percentage usage of Fly Ash is 25%.

V. The addition of Sea Sand with soil reduces the Plasticity index and swelling characteristics of soil. The percentage of sea sand is increase the MDD of soil is increasing and the value of OMC is decreasing as per this study. As Sea sand is coarser then the clay particles hence the angle of internal friction is improves so the value of SBC is increasing. By the addition of 25% of sea sand in high plastic soil noticeable increase the SBC about 550 kN/m^2. It might not be necessary that more percentage of Sea Sand will increase SBC. Study has maximum percentage usage of Sea Sand is 25%. By more increment in Sea Sand the soil might be behave like Non-Plastic soil so that is not suitable for foundation of structure.

VI. Combining the sea sand and fly ash up to 10% in High Plastic soil improves the SBC of soil. From the study sea sand (10%) and fly ash (10%) mix proportion can be used to improve the strength of high plastic clay.

BIBLIOGRAPHY

[1]. K.R.Arora, Dr.Soil Mechanics and Foundation Engineering. s.l. : Standard Publishers, 7TH REPRINT 2019,Edition.
[2]. Maheshwari G.Bisanal, Ravikumar Badiger.Study on Stabilization of Soil Using Sea. s.l. : International Journal Of Innovative Research In Science,.
[3]. Dr. B.C.Punamia, Ashok Kumar Jain & Arun Kumar Jain.Soil Mechanics and Foundations. s.l. : Laxmi Publications, Sixteenth edition (1 January 2017).
[4]. Code of practice for determination of bearing capacity of shallow foundations[CED 43: Soil and. 1981.

REFERENCES

[1]. IS: 2720 (part 1) – 1977, Bureau of Indian Standards
[2]. IS: 2720 (part 3-sec-1) – 1980, Bureau of Indian Standards
[3]. IS: 2720 (part 5) – 1985, Bureau of Indian Standards
[4]. IS: 2720 (part 7) – 1980, Bureau of Indian Standards
[5]. IS: 2720 (part 11) – 1993, Bureau of Indian Standards
[6]. IS: 2720 (part-40) – 1977, Bureau of Indian Standards
[7]. IS: 1498-1970, Bureau of Indian Standards
[8]. IS:6403-1981, Bureau of Indian Standards
[9]. Dr.K.R.Arora, Soil Mechanics and Foundation Engineering
[10]. Dr.B.C.Punamia, Ashok Kumar Jain &Arun Kumar Jain, Soil Mechanics and Foundations
[11]. Narayan V Nayak, Foundation Design Manual
[12]. American Society for Testing and Materials. (2008). ASTM C618 Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete.
[13]. S. Andavan , Mohamed Hassaan, "Study On Flyash Soil Stabilization" published on International Journal of Pure And Applied Mathematics Volume 119, 2018,
[14]. Raghunandan M H , Lakshmi C "Study on Soil-Admixture Stabilization using Cement, Fly ash, Rice husk and Stone dust " published on International Research Journal of Engineering and Technology (IRJET).
[15]. MaheshwariG.Bisanal, RavikumarBadiger "Study on Stabilization of Soil Using Sea Shell and Bitumen Emulsion" , International Journal Of Innovative Research In Science, Engineering And Technology
[16]. Murat Aziz Ozdemir "Improvement in Bearing Capacity of a Soft Soil by Addition of Fly Ash" , International Conference on Transportation Geotechnics.
[17]. Dr. P. D. Arumairaj and A. Sivajothi, EJGE Vol. 15 [2011], Bund.J, had investigated "Effect of Saline water on Expansive Soils''
[18]. J. Prabakaraetal, "Influence of fly ash on strength behaviour of typical soils", Construction and Building Materials, vol. 18, 2004, pp. 263–267.
[19]. Gyanenetal, "Laboratory Study on Soil Stabilization Using Fly ash Mixtures", International Journal of Engineering Science and Innovative Technology, vol. 2, issue. 1, Jan. 2013.
[20]. Chang, A. C., Lund, J. L., Page, L. A., &Warneke, E. (1977). Physical Properties of Fly Ash Amended Soils. Journal of Environmental Quality 6 (3)., 267-270.