ISSN (ONLINE) 2583-2506
http://publications.rayatbahrauniversity.edu.in
RBIJMR-Rayat Bahra International Journal of Multidisciplinary Research, Vol. 04, Issue 01, June2024

Utilization of Waste Foundry Sand and Crushed Waste Glass for Stabilization of Black Cotton Soil

Sudhanshu Chopra[1], Preet Pal Singh[1], Ajay[1] and Manmeet Kaur[2]

[1]*Department of Civil Engineering, Rayat Bahra University, Mohali - 140 104, India*
[2]*Department of Civil Engineering, Chandigarh University, Mohali - 140104, India*

Abstract: *In general, black cotton soil loses strength when it comes into touch with water and displays undesired engineering characteristics like shrinking and swelling. poor bearing capacity and increased compressibility as a result. Therefore, it is essential to improve the soil at a location. The strength of soil can be increased using a variety of techniques and stabilizers, such as fly ash, gypsum, and jute. Ash from rice husks. Used rubber tires, cement, lime, etc. In the current study, we improved the Black Cotton soil's characteristics by adding Crushed Waste Glass and Waste Foundry Sand as stabilizers. The black cotton soil that was used for this project comes from Maharashtra. By creating a mixture of soil, waste foundry sand, and crushed glass powder, the goal of this study is to increase the strength of the Black Cotton soil. To prepare specimens for investigating the qualities of soil, substitute 2%, 4%, and 6% of the original specimens. waste glass powder with different percentages (10%, 20%, and 30%) of waste foundry sand. To determine the soil mixture's optimal moisture content (OMC), maximum dry density (MDD), compressive strength, CBR value, and free swell index, tests such as the Modified Proctor Test, CBR Test, and Free Swell Index Test must be performed.*

Keywords: Black Cotton Soil, Crushed Waste glass, OMC & MDD, CBR test.

*Corresponding Author: Mr. Preet Pal Singh
e-mail: preetrihal@gmail.com

1. Introduction

Chalcogenides Black cotton soil, also known as black clay soil, is a type of expansive soil found in various parts of the world, including Nigeria, South Africa, India, the USA, Australia, and Israel. It is characterized by high swelling and shrinkage properties, making it a challenging material for construction engineers. The soil's high clay content, particularly montmorillonite, contributes to its significant volume changes, with swelling pressures as high as 8 kg/cm². During wet conditions, the soil swells, while it contracts and forms large cracks during dry seasons. These properties pose problems for construction, such as foundation heave, cracks in structures, and challenges in highway construction.

The engineering properties of black cotton soil, including its high compressibility and poor bearing capacity, make it necessary to improve its strength for construction purposes. Various methods and stabilizers have been explored to address these undesirable properties, such as the use of jute, gypsum, fly ash, rice-husk ash, cement, lime, and used rubber tires. In the context of the review paper, the focus is on the use of waste foundry sand and crushed waste glass as stabilizers to improve the properties of black cotton soil.

Waste foundry sand (WFS) and crushed waste glass (CWG) will be used in this project to assist stabilize the soil. Since they are both waste products, how to dispose of them is a global matter. Putting these wastes to good use will increase pollution in the environment and strengthen our efforts to preserve it. As business expands, many problems emerge, one of which is how to dispose of garbage in an effective and safe manner. Toxic waste is the source of many important environmental problems. Hazardous waste in the construction industry can therefore only be disposed of by using it.

1.1 Chemical Composition of Black Cotton Soil

Table 1.: Chemical Properties of Black Cotton Soil

Components	**Concentration (%)**
pH value	>7(Alkaline)
Organic Content	0.4 – 204%
CaCO3	1- 15%
SiO2	50- 55%
SiO2 , Al2O3	3- 5%
Montmorrilonite Mineral	30- 50%

1.2 Waste Foundry Sand

Sand that is thrown away or regarded as waste material after being utilized in foundries for metal casting processes is known as waste foundry sand. Superior silica sand, known as foundry sand, is usually used with a binder to

ISSN (ONLINE) 2583-2506
http://publications.rayatbahrauniversity.edu.in
RBIJMR-Rayat Bahra International Journal of Multidisciplinary Research, Vol. 04, Issue 01, June2024

form cores and molds for the casting of metal products. The silica withstands high temperatures, and the clay layer keeps the sand together. With over 35,000 foundries worldwide, 90 million tonnes are produced each year. Every year, the metal casting industry in India requires more than 100 million tonnes of foundry sand for production. Actually, foundry sands degrade over time to the point where mold can no longer form on them. As a result, every year, between 9 and 10 million tonnes of sand are dumped.

Table 2. : Chemical Properties of Foundry Sand

Components	Concentration (%)
Silica (SiO2)	87.91
Alumina Oxide (Al2O3)	4.70
Ferric Oxide	0.94
Lime (CaO)	0.14
Magnesium Oxide (MgO)	0.30
Sulphur Trioxide (SO3)	0.09
Sodium Carbonate	0.19
Potassium Oxide(K2O)	0.25
Titanium Dioxide (TiO2)	0.15
Strontium Oxide (SrO)	0.03
Loss on Ignition	5.15

1.3 Crushed Waste Glass (Cwg)

Glass is an amorphous, non-crystalline substance that is typically brittle & optically transparent. Drinking glassware & window panes are two common waste glass items. Soda-lime glass bottles, which contain 75% silica, chocolate, and similar chemicals, are another easily accessible trash glass product. It is primarily a non-biodegradable substance, and if

This huge amount may be used to build something instead of being thrown away. Currently, geotechnical works including building, foundation fills, and embankment construction require between 500,000 and 700,000 tonnes of sand.

Fig. 1.: Waste Foundry Sand

1.3 Chemical Composition Of Foundry Sand

handled improperly after being broken, it can injure people and animals. Due to the high permeability, strong crushing resistance, and restricted strain stiffness of broken glass, their application in geotechnical projects can be improved. It is desired to recycle most used glass into new glass. A excess of glass cannot, however, be utilised by glass manufacturers since the glass industry can only recycle color-sized and contamination-free waste glass.

CHEMICAL COMPOSITION OF GLASS

Components	Concentration

ISSN (ONLINE) 2583-2506
http://publications.rayatbahrauniversity.edu.in
RBIJMR-Rayat Bahra International Journal of Multidisciplinary Research, Vol. 04, Issue 01, June2024

	(%)
Silica (SiO_2)	74
Sodium Oxide (Na_2O)	13
Lime (CaO)	10.5
Alumina Oxide(Al_2O_3)	1.3
Others	1.2

Table 3: Chemical Properties of Glass

Fig.2: Crushed Waste Glass

2. Literature Review

B M Patil and K A Patil (2013) In 2013, B M and K A Patil carried out a study to find out how chemical additives and industrial waste affected the California Bearing Ratio (CBR) value of clayey soil. A soil's strength and load-bearing capacity are gauged by its CBR rating. The purpose of the study was to ascertain whether clayey soil could be stabilized and its CBR value increased by adding chemical additives and industrial waste. Potential ingredients for soil stabilization included chemical additives, which are compounds applied to change the properties of soil, and industrial waste, which can be a consequence of industrial activities. The study paper or article published by B M Patil and K A Patil will contain specifics on the research, including the types of industrial waste and chemical additives used, the testing procedures used, and the outcomes reached. Unfortunately, I am unable to offer more information on their research technique or particular findings as I do not have access to the particular paper. But generally speaking, the goal of research on chemical additives and industrial waste-based soil stabilization is to investigate practical, affordable ways to enhance the engineering qualities of soils, like strength, permeability, and compressibility. This research shed light on the viability and efficacy of modifying soil properties with these materials to improve its performance and prepare it for engineering uses such as building.

J. Olufowobi et.al.[2014]: This study evaluates waste glass's stabilizing impact on the soil associated with black cotton. Broken waste glass was gathered and ground into a suitable size for adding to black cotton soil in different amounts, such as 5%, 10%, 15%, and 20% cement (base) by weight of the soil sample. As a result, tests for atterberg limits, specific gravity, moisture content, and particle size distribution were performed in order to classify the soil according to the ASSHTO classification system. Following compaction, soil samples were tested for California bearing ratio both with and without the addition of broken glass. The maximum dry density value improved when crushed glass was added, and this improvement was accompanied by a progressive increase up to 5% glass crushed content before it began to fall and 15% crushed glass content.

Ashutosh Bhadoriya et.al.[2018]: This research examines the effects of different glass crushing proportions on black cotton soil parameters such as specific gravity, CBR, optimal moisture content (OMC), and mass dry density (MDD). broken glass was added to black cotton soil to boost its properties and compressive strength. The percentage of broken glass by dry weight of soil was determined to be 5%, 10%, and 20%.

Ajeet Rathee et.al.[2018]: The project aims at determining the noticeable change in the behavior of soil after blending in with some admixture. For this purpose, broken glass was taken as admixture in different balance up to 20% the total weight by mass before mixing the soil with this admixture some basic properties of soil like grade of soil, moisture content, specific gravity and Atterberg’s limit were to be determined. After determining the basic properties two main two tests of this project namely proctor compaction test and California bearing ratio test were performed on soil with adding crushed glass and without adding crushed glass.

Mohammed A., et.al. (2016). The 2016 laboratory study by Mohammed A. and associates examined the effects of crushed glass debris on cohesive soil's geotechnical characteristics. Examining the effects of broken waste glass addition on different cohesive soil engineering properties was the aim of the study. The research paper or publication written by Mohammed A. and colleagues will contain a detailed description of the study's unique findings and methodology, as well as the outcomes attained. I'm sorry, but I am unable to provide more details about their research methodology or particular findings without access to the relevant paper. Generally speaking, though, studies looking at how cohesive soil qualities are affected by crushed waste glass are investigating the material's potential as a stabilizer or addition. The impact of adding broken waste glass on cohesive soil metrics such compressibility, permeability, compaction properties, and shear strength is evaluated by researchers. These studies yield information about the acceptability and efficacy of using crushed waste glass to enhance cohesive soil performance and engineering behavior in a range of geotechnical applications.

Babatunde, et. al. (2019): In their 2019 study, Babatunde and associates investigated stabilizing black cotton soil with the partial substitution of powdered glass. Investigating how adding glass powder affected the stability and engineering qualities of black cotton soil was the goal of the study. I can give a general summary of the goals and possible results related to the use of powdered glass as a partial replacement for black cotton soil stabilization,

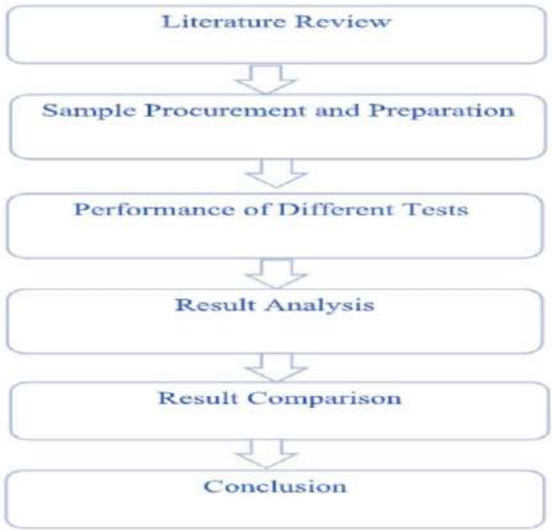
ISSN (ONLINE) 2583-2506
http://publications.rayatbahrauniversity.edu.in
RBIJMR-Rayat Bahra International Journal of Multidisciplinary Research, Vol. 04, Issue 01, June2024

even though I don't have access to the specific article by Babatunde and colleagues in 2019. Because of its high flexibility and expansive tendency, black cotton soil presents volume variations that might be problematic in building. Often, stabilization techniques are used to improve its engineering properties and lessen its undesired traits. In this investigation, some of the black cotton soil was replaced in part with glass powder. The purpose of adding glass powder is to alter the characteristics of the soil, making it stronger, less pliable, more compacted, and less susceptible to volume fluctuations. The powdered glass, which can have come from glass waste or glass production operations, might stabilize the soil by acting as a pozzolanic substance. The study's exact conclusions would shed light on how well powdered glass works to partially replace black cotton soil stability. The study may have looked into factors like the ideal replacement proportion of glass powder, how it affects soil strength, compaction characteristics, permeability, or other pertinent engineering aspects. These results would advance knowledge of how black cotton soil can be made more stable and effective in geotechnical engineering applications by using powdered glass.

2.1 Need of Soil Stabilization

The soil qualities differ from location to location based on the climate and topography of the area. Certain types of soil are not strong enough to withstand the impending load, and if we build structures on top of them without first stabilizing the soil and increasing its bearing capacity, we risk causing damage and losing both money and lives. Here are some further justifications for the necessity of stabilizing the soil:

- Resistance to the erosion process.
- Increases soil stability in places of this kind, such as slopes.
- Subgrade preparation including the replacement of deficient soil with good soil content is more expensive than subgrade preparation involving the use of other soil stabilization techniques.



- In an effort to water-proof the soil and keep it from losing its strength, it keeps water out of the soil.
- Decreasing the shift in soil volume brought on by variations in the moisture or temperature of the soil

3. Methodology

3.1 Methodology List of Laboratory Test to be Conducted

On the black cotton soil combined in different amounts with waste materials (foundry sand and glass powder). Test to be carried out on the soil of the black cotton: Senior No. Test Parameter Name. The different exams taken in order to receive an engineering Geotechnical characteristic of soil:

- Specific Gravity
- Liquid Limit
- Plastic Limit
- Modified Proctor test
- California Bearing Ratio test

The soil mixed with waste items and black cotton will be tested. The following tests are carried out using waste materials, glass powder and foundry sand, combined in different ratios with black cotton soil. Following are the results obtained from the various tests conducted on the black cotton soil

Table 4: Engineering Properties of Black Cotton Soil

S. No.	Parameters		Results
1.	Modified compaction test	MDD (gm/cc)	1.732
		OMC (%)	22.80
2.	Liquid limit (%)		66.52
3.	Specific Gravity		2.13
4.	Plastic limit (%)		38.20
5.	Plasticity index (%)		28.32
6.	Indian soil classification		CH

3.2 Proposed Methodology

The phases in the methodology are as follows, which should be followed in the order indicated below (figure 3)

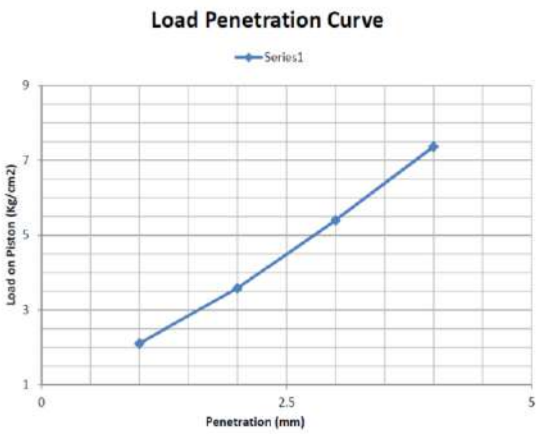


Fig.3: Proposed Methodology

4. Results and Discussion

This study attempted, via a series of in-depth laboratory tests, to stabilize Black Cotton (BC) soil using Waste Foundry Sand (WFS) and Waste Glass Powder (WGP). Examining the soil samples allowed for the investigation of their physical characteristics, including the plastic and liquid limits. The BC soil OMC and MDD were measured using a Modified Proctor test. The Free Swell Index and CBR values were computed after the soil was combined with varying proportions of WFS and WGP following an analysis of the physical characteristics of BC soil. Researching WFS and WGP's effects on BC soil stabilization methodically was the primary goal of this study.

4.1 California Bearing Ratio (CBR) Test

ISSN (ONLINE) 2583-2506
http://publications.rayatbahrauniversity.edu.in
RBIJMR-Rayat Bahra International Journal of Multidisciplinary Research, Vol. 04, Issue 01, June2024

The California bearing ratio test, which is based on calculations made in a lab on BC soil in various combinations for the study of California soil bearing ratios, has been used to test the soil samples reinforced with waste foundry sand and waste glass powder for optimal moisture content and maximum dry density. The results are shown in the following manner.

4.2 Values Soaked CBR for Soil with Different Percentage of WFS

Table 5: Values Soaked CBR For Soil With Diff. % Of WFS

S. No.	Percentage of WFS	CBR (%)
1	0	2.11
2	10	3.58
3	20	5.40
4	30	7.37

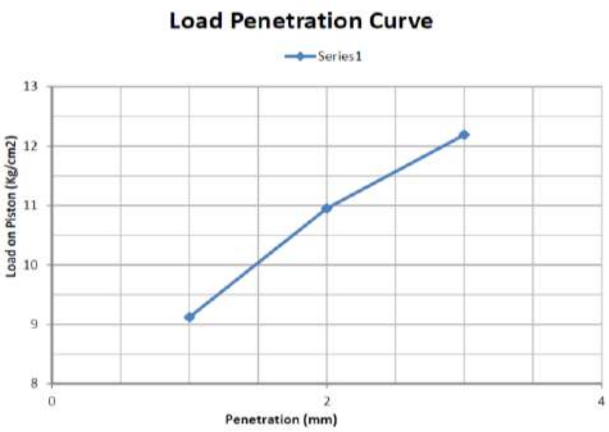


Fig.4: Load- penetration graph for the soil with diff. % of WFS

4.3 Values Soaked CBR for Soil with Different Percentage of WFS and WGP

Table 6: Values Soaked CBR For Soil With Diff. % Of WFS And WGP

S. No.	Percentage of waste material with soil (WFS + WGP)	CBR (%)
1	30% + 2%	9.12
2	30% + 4%	10.95
3	30% + 6%	12.19

Fig.5: Load- penetration graph for the soil with diff. % of WFS & WGP

5. Conclusions

The waste products, such as glass and foundry sand, that are thrown away in large quantities annually all over the world. Not only do these materials occupy landfill space, but they also lose out on possible uses. We have attempted to use these waste materials in soil stabilization through our study. It gives us a means to use these waste materials profitably and efficiently in the various branches of civil engineering, in addition to solving the problem of how to dispose of them. Studies have been done in which the individual applications of crushed waste glass and waste foundry sand for soil stabilization have been studied. The purpose of our study is to examine their combined application as stabilizing agents in black cotton soil. Glass and foundry sand both function well as stabilizers since silica is a substantial component of both materials. In order to complete the literature review for this thesis topic, several publications written by various researchers were examined. These researchers have stabilized soil by using a combination of waste products and foundry sand. In order to obtain the appropriate stabilizing quality and strength, they have also recommended the ideal proportion of crushed glass, foundry sand, and other waste materials. As such, this project must be completed using the references from their works, and the outcomes will be compared to the desired and anticipated outcome. Additionally, we will recommend the proportion or quantity that must be utilized in both crushed glass and foundry sand in order to attain the highest level of efficiency.

References

[1] Shiva Kumar, Vidyaranya, Shravan Bharadwaj, Prathibha and Yuvaraj, (2016), Soil Stabilization Using Waste Plastic Strips, Int. J. Recent Scientific Res., **7 (5)**, pp.11356-11358.

[2] Mousa Attom, (2018), The use of waste glass material to control soil swelling pressure, Proceedings of Int. Conf. on Technological Challenges for Better World.

[3] Canakci, Hanifi, A. L. Aram, and Fatih Celik, (2016), Stabilization of clay with waste soda lime glass powder, Procedia engineering **161**, pp.600-605.

[4] Al-Neami, Mohammed A., et al., (2015), Remediation of cohesive soils using waste glass, Int. Conf. of Technology and Science. Catholic Academic-Freiburg, Germany.

[5] Bhimani, Dushyant Rameshbhai, et al., (2013), Used Foundry Sand: Opportunities For development of Eco-Friendly Low Cost Concrete.

[6] S. S. Razvi, Shaikh Sujahat, Syed Adnan, Khan Aasim, Ughade Ravi and Mohammed Saud, (2017), Stabilization of Soil by Foundry Sand with Fly-Ash, Int. J. Innovative Res. in Science, Engg. and Technology, **6 (5)**; ISSN (Online): pp.2319-8753, ISSN (Print): 2347-6710.

[7] Sarde, Urmila S. Stabilization of Black Cotton Using Waste Foundry Sand & RBI Grade 81.

[8] Alhassan M, (2008), Potentials of Rice Husk Ash for Soil Stabilization", AU J.T. **11(4)**, pp.246-250.

[9] Ifetayo O, Pretorius C J, (2018), Engineering Properties of Black Cotton Soil Stabilized with Plantain Peel Powder, Int. Conf. on Industrial Engg. and

Operations Management Pretoria / Johannesburg, South Africa, October 29-November 1.

[10] Babatunde O. A1, Sani J. E1, Sambo A.H, Black Cotton Soil Stabilization using Glass Powder, https://www.researchgate.net/publication/333547655.

[11] K. Subash, S. Sukesh, R. Sreerag, (2016) Stabilization of Black Cotton Soil using Glass and Plastic Granules, IJERT, ISSN: 2278-0181, **5 (4)**.

[12] Parihar S. N., Garlapati K. V., Ganguly R., Stabilization of Black Cotton Soil Using Waste Glass, https://link.springer.com/referenceworkentry.

[13] Alhassan M., (2008) Potentials of rice husk ash for soil stabilization. AU JT **11(4)**, pp.246-250.

[14] Brooks R. M., (2009), Soil stabilization with flyash and rice husk ash. Int J Res Rev Appl Sci **1(3)**, pp.209–217.

[15] Canakci H, Kaki A A, Celik F (2016), Stabilization of clay with waste soda lime glass powder, Proc Eng (Elsevier), **161**, pp.600–605.

[16] Thakur, A., Thagunna, P., Devi, R. T., Thounaojam, A., & Senagah, A. (2023), Experimental Study for Stabilizing Properties of Black Cotton Soil by use of Geogrid and Admixture, J. Biomechanical Science and Engg., https://doi.org/10.17605/OSF.IO/A4E39.

[17] Indiramma, P., & Sudharani, C. (2008). International Journal of Emerging Technology and Advanced Engineering Variation of Properties of an Expansive Soil Mixed with Quarry Dust and Fly Ash. In Certified Journal (Vol. 9001). www.ijetae.com.

[18] Yilmaz, F., & Yurdakul, M. (2017). Evaluation of marble dust for soil stabilization. Acta Physica Polonica A, 132(3), 710–711. https://doi.org/10.12693/APhysPolA.132.710

[19] Joe MA, Rajesh AM (2015) Soil stabilization using industrial waste and lime, IJSRET **4(7)**, pp.799-805.

[20] Hashmie N., Gunagi P., Belagal P., Manoharan S., "Utilisation of Recycled Glass Powder for the Stabilization of Black Cotton soil by Alkali Activation", iopscience.iop.org/article.

[21] Seco, A., Ramírez, F., Miqueleiz, L., & García, B. (2011). Stabilization of expansive soils for use in construction. Applied Clay Science, **51(3)**, 348-352. https://doi.org/10.1016/j.clay.2010.12.027.

[22] Sharma, A. K., & Sivapullaiah, P. V. (2016). Ground granulated blast furnace slag amended fly ash as an expansive soil stabilizer. Soils and Foundations, **56(2)**, pp.205-212. https://doi.org/10.1016/j.sandf.2016.02.004

[23] Sharma, R., Gupta, G., Nimbark, G., Gupta, C., & Tiwari, S. (n.d.). Impact of Stone

Mine Waste on Sub Grade Characteristics of Expansive Soil.

[24] Shyam Singh, P., K, Y. R., & Author, C. (2014), Effect of Marble Dust on Index Properties of Black Cotton Soil. http://www.ijerst.com/currentissue.php

[25] Oluwafemi Ifetayo, Jan-Harm C Pretorius, "Engineering Properties of Black Cotton Soil Stabilized with Plantain Peel Powder", the International Conference on Industrial Engineering and Operations Management Pretoria / Johannesburg, South Africa, October 29 – November 1, 2018

[26] Kumar Shiva, Vidyaranya, Bharadwaj Shravan, Prathibha and Yuvaraj, (2016), Soil Stabilization Using Waste Plastic Strips, IJRSR, **7 (5),** pp.11356-11358.

[27] Ishrat Mairaj, Stabilization of Black Cotton Soil by Using Waste Foundry Sand and Crushed Waste Glass, https://doi.org/10.55524/ijircst.2023.11.2.5

[28] B. B. Y. Thakur, (2020), Effect of Marble Dust on Index Properties of Black Cotton Soil.

[29] Brajesh Mishra, A Study on Engineering Behavior of Black Cotton Soil and its Stabilization by Use of Lime, IJSR) ISSN (Online): 2319-7064 Index Copernicus Value (2013): 6.14.

[30] Soil Mechanics And Foundation Engineering by Dr.K.Arora

[31] Soil Mechanics and Foundation Engineering by B. C. Punmina.

[32] IS 2720 (Part 2)-1973, "Determination of Water Content".

[33] IS 2720 (Part 3/Sec 1)-1980, "Determination of Specific gravity".

[34] IS 2720 (Part 5)-1985, Determination of Liquid Limit and plastic Limit.

[35] IS 2720 (Part 7)-1980, Determination of Water Content-Dry Density Relation using Modified Proctor Compaction.

[36] IS 2720 (Part 16)-1987, Determination of CBR.

[37] IS 2720 (Part 40)-1977, "Determination of free swell index of soils".

[38] Urmila S. Sarde, (2018), Stabilization of Black Cotton Soil Using Waste Foundry Sand & RBI Grade 81 IOSR J. Mechanical and Civil Engg. (IOSR-JMCE) **15 (6)** Ver. III (Nov. - Dec. 2018), pp-59-61.