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Stabilization of Black Cotton Soil by Using Waste Foundry Sand and Crushed Waste Glass

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ABSTRACT- Generally Black Cotton Soil exhibits undesirable engineering properties like shrinkage and swelling properties losses its strength, when come in contact with water. Thereby poor bearing capacity and higher compressibility. Thus the improvement of soil at a site is indispensable. There are many methods and stabilizers to improve the strength of soil like jute, gypsum, fly ash. Rice-husk ash. Cement, lime, used rubber tyres etc. In the present study, we added Waste Foundry Sand and Crushed Waste Glass as stabilizer to improve the properties of Black Cotton soil. Black Cotton Soil used in this project work is carried from Maharashtra. The objective of this study is to improve the strength of the Black Cotton soil by making Soil- Waste Foundry Sand and Soil- Waste Foundry Sand-Crushed Glass Powder mixture. Specimens is to be prepared to investigate the properties of soil out of these specimens are prepared by Replacing 2 %, 4%, 6% . Waste Glass Powder with varying percentage Waste Foundry Sand as 10%,20%, 30%.[4] Modified Proctor Test, CBR test and Free Swell Index test is to be conducted to analyze the Optimum Moisture Content (OMC), Maximum Dry Density (MDD) and compressive strength of soil mixture, CBR value and Free Swell Index.

KEYWORDS- Black Cotton Soil, Crushed Waste Glass, Strength of Soil, Modified Procter Test, BC Soil MDD,OMC,WFS, WGP,BC Soil Stabilization.

I. INTRODUCTION

Soil stabilization is defined as the engineering approach which is adopted to reduce the defects in soil such as compressibility, settlement as well as to enhance the engineering properties of soil by alteration of its physical properties. It can be done in two ways, first by mechanical stabilization, in which materials are added to the soil and second by chemical stabilization, in which chemical reactions occurs between the soil particles and additives.

Here, in this project, we will be performing soil stabilization with the help of waste foundry sand (WFS) and crushed waste glass (CWG)[4]. Both of these are waste products and their disposal is a big concern for the entire world. The beneficial use of these wastes will make the environment pollution so it will enhance our efforts to protect our environment.

Many issues arise from the growth of industry, one of which is the proper and efficient disposal of its waste. Many significant environmental issues are caused by toxic waste. Thus, the only way to dispose of hazardous waste in the building industry is to use it.

A. *Need of Soil Stabilization*

Depending upon the climatic and geographical condition of the areas, the soil properties vary from place to place. Soil present at some places are not able to provide sufficient strength to resist the upcoming load which can lead to damage and loss of both money and life, if we build structure on them first without going for soil stabilization and bearing capacity improvement. Following are some other reasons which justify the need of soil stabilization:

- Resistance against erosion.
- Provides greater soil stability on slopes or in other areas of this type.
- The cost of subgrade preparation by replacing poor soil with good soil content is higher than that of subgrade preparation by following various methods of soil stabilization.
- It prevents water from entering the soil in order to water-proof the soil, thereby preventing the soil from losing its strength.
- Reducing the shift in soil volume, either due to changes in soil temperature or moisture content

II. OBJECTIVES

Need of present research is to study the effect of using waste foundry sand and crushed waste glass to increase the load bearing capacity of the weak soil and increasing the engineering properties of soil. The soil often is weak and has no enough stability in heavy loading. The aim of this study is to review on the stabilization of the soil using low-cost material. Based on literature, foundry sand and waste glass is a low-cost and effective to soil stabilization.

The purpose of the current experimental investigation aims at the detailed study of stabilization modification of black cotton soil using waste foundry sand and crushed waste glass. The experiment used in this study includes compaction test, CBR, Free Swell Index test. This includes content collection, sample method, and tests done on them. Separate samples are prepared with different proportion of soil, waste foundry sand and crushed waste glass. Conducting a series of tests, optimum for mixed samples.

- To study the engineering properties of the Black Cotton soil for classification of soil, OMC, MDD, CBR and Swell Index.
- To study the engineering properties of BC Soil with replacing of WFS with Variation of (10%,20%,30%,40%) for OMC, MDD, CBR and Swell Index.
- To study the engineering properties of soil with optimized dose of Waste Foundry Sand with addition of Crushed Waste Glass Powder (2%,4%,6%,8%)
- To determination of optimum dose of Waste Foundry Sand and Glass Powder in combination.

III. LITERATURE REVIEW

- Foundry sand's potential for use as a hydraulic barrier was examined by Abichou et al. in 2002 [1]. The study set out to determine whether special considerations were necessary while building hydraulic barriers with foundry green from a single or numerous sources, as well as to evaluate the validity of the laboratory results in a field environment. For this, experiments in the lab and on the ground were conducted. Testing the hydraulic conductivity of falling heads was done in a lab using flexible-wall permeameters. Tests were performed on the test pads during the field investigation after exposure to summer weather that caused desiccation and winter weather that caused freeze-thaw cycling. Green foundry sand that had been crushed was used to build three test pads. In order to gauge the hydraulic conductivity,. Two-stage borehole (TSB) permeameters, sealed double ring infiltrometers (SDRIs), and large block specimens were used to measure the hydraulic conductivity. Testing in the field and lab produced the same outcome. And it was determined that foundry sand must have a bentonite content larger than 6% (by weight), a plasticity index greater than 3 or a liquid limit greater than 20, and hydraulic conductivity less than 10-7 cm/s in order to be employed as a hydraulic barrier.
- In 2013, Ravi Kumar Sharma and Amrendra Kumar[2] assessed the effects of clayey soil mixed with foundry sand and fly ash on sub-grade properties. Clayey soil that is readily available in the area was used for the research, while Nahan Foundry provided the leftover foundry sand. The soil was designated as clay with medium plasticity in accordance with the ASTM classification system (CL). The fly ash was obtained as a byproduct of the burned gas' electronic precipitation. According to ASTM standards, the laboratory tests were carried out. Specific gravity tests, consistency limit tests, hydrometer analysis tests, CBR testing, and standard proctor exams are among the examinations that were carried out. Compaction tests were also performed on clay with optimal mixtures and foundry sand concentrations ranging from 10% to 50% and ideal mixtures were attained. For blends of clay and foundry sand, variations in the maximum dry density were seen. The maximum dry density of clay-foundry sand mixtures was found to increase with an increase in sand content up to 40% before decreasing. As the highest value of the maximum dry density was reached, the optimal moisture content continued to decline. During the CBR test, it was discovered that the addition of foundry sand and fly ash raised the soaking CBR value of clayey soil. From 2.44% for unstabilized soil to 5.10% for stabilised soil, the CBR value improved. The California bearing ratio serves as a foundation for designing flexible pavement subgrades. CBR values greater than 5.0 are typically regarded as adequate for the design of flexible. pavements with 1 million to 10 million standard axles per hour of traffic (MSA). As a result, it can be argued that clayey soil mixed with foundry sand and fly ash can be utilized successfully to build sub-grades. And ideal mixtures were attained. For blends of clay and foundry sand, variations in the maximum dry density were seen. The maximum dry density of clay-foundry sand mixtures was found to increase with an increase in sand content up to 40% before decreasing. As the highest value of the maximum dry density was reached, the optimal moisture content continued to decline. During the CBR test, it was discovered that the addition of foundry sand and fly ash raised the soaking CBR value of clayey soil. From 2.44% for unstabilized soil to 5.10% for stabilised soil, the CBR value improved. The California bearing ratio serves as a foundation for creating flexible pavement subgrades. CBR values greater than 5.0 are often regarded as adequate for the construction of flexible pavements. In general, a CBR value of 5.0 or above is regarded as adequate for the construction of flexible pavements with traffic intensity ranging from 1 million to 10 million standard axles (MSA). As a result, it can be argued that clayey soil mixed with foundry sand and fly ash can be utilised successfully to build sub-grades of roads with low traffic volume. Additionally, it was found that the O.M.C. of the clayey soil and foundry sand mixture decreased when foundry sand was added (up to 40% content), but increased afterward. This occurred because lower quantity of water required to lubricate the foundry sand particles which are coarser as compared to clay particles.
- Mohammed A., et al. (2016) [3] carried out the laboratory experiment to demonstrate the impact of crushed waste glass on cohesive soil's geotechnical properties. Because of the wide availability of waste glass in Iraq and simplicity to recycle it in crushed form, it was chosen as the additive to improve the soil properties. Variable amount (2, 4, 6 and 8%) of the crushed glass was put in the soil. For the composite sample (soil + waste glass), physical characteristics, strength parameters, and consolidation behaviour of cohesive soil were determined. In the lab, a number of tests were carried out, including consolidation and shear strength tests, sieving and hydrometer analysis, Atterberg's limits, compaction (optimum moisture content, maximum density), chemical tests, and Atterberg's limits. The addition of 4% crushed glass to cohesive soil is adequate and successful in

improving the geotechnical soil qualities, it was determined after examining the results of the laboratory tests. . Addition of glass leads to increase in both soil shear strength and bearing capacity. The increase in friction angle and decrease in cohesion between soil particles caused the shear strength parameter to change. Since, the glass is a granular material, its behaviour showed reduction in specificgravityandliquidlimitwhileincrementintheplasticlimitwithincreaseofadditive. Additionally, because of the increased soil additive, there was a noticeable decrease in the ideal moisture content and an increase in the dry density. The composite soil displayed reduction in compressibility and swelling.

- Prashant, et al. (2016) [4] looked into the possibility of stabilising the subgrade using leftover foundry sand. The fines of foundry sand passing through 10 mm sieves were used as stabilising material in this example. A number of tests were performed on the soil when foundry sand was mixed in different percentage. The percentage of foundry sand added to the soil varied (5%, 10%, 15%, and 20%) depending on the weight of the soil. A series of tests were conducted, including the CBR test, direct shear test, liquid limit, plastic limit, ideal moisture content, and maximum dry density. To correctly assess the impact of the addition of foundry sand on the parameters of soil, graphs for each percentage fluctuation were plotted. It was observed that the liquid limit went on decreasing with the addition of foundry sand and hence, it helped to reduce the drying shrinkage of the clayey soil which in turn will help to reduce the crack width of the soil. When foundry sand, a non-cohesive material, was added to the soil, the cohesion of the soil was reduced, and the ideal moisture content was reduced to 10%.The CBR value of soil continued on growing, it increased from 8.9 to 18.21 with rise in the amount of foundry sand. A considerable improvement in angle of friction was also noticed from 22 degrees to 28 degrees with the addition of foundry sand. Overall, it was all round improvement in the soil’s properties with the addition of foundry sand.
- According to research by H. Canakci et al. (2016) [5], using soda-lime glass powder waste with clay has a substantial impact on the soil's strength. The used soda and lime glasses were broken down and put through a 75-millimeter screen before being combined with clay in various amounts of 3%, 6%, 9%, and 12% of the soil's dry weight. Standard proctor tests, the test for Atterberg limits, the California bearing ratio (CBR) test, and the test for unconfined compressive strength were all carried out. Based on the test findings, it was determined that soda lime glass powder can enhance clay soil's engineering features as well as MDD (maximum dry density), OMC (optimum moisture content), and Atterberg limits. As the percentage of additive was increased, the maximum dry density of soil increased. When 12% soda lime glass powder was combined with clay soil, there was a 5.49% maximum dry density increase. In addition to this, there was a significant drop in optimum moisture content was observed due to increase in the percentage of soda lime glass powder. The largest percentage decrease in optimum moisture content was 21.6 % when 12 % soda lime glass powder was mixed with clay soil. The reason behind this decrease could be that the absorption capability of glass is much less than that of clay. During Atterberg limits test, it was clearly evident that the values of plasticity index for the sample decreased owing to rise in the percentage of soda lime glass powder. The biggest percentage drop in plasticity index was to 44.05% when clay soil was combined with 12% soda lime glass powder. Due to a rise in the additive's content, soil value's CBR value also rose. The largest percentage increases of CBR value was 140 % when clay soil was mixed with 12 % soda lime glass powder. Also, it was observed that the edoema decreased as the percentage of soda lime glass powder increased. There was a considerable rise in the UCS values at 6% of soda lime glass powder, it was found that the UCS values increases 519 kPa at 3 days, 583 kPa at 7 days and 723 kPa.

IV. METHODOLOGY

A. Methodology List of Laboratory Test to be Conducted

On the black cotton soil mixed with waste materials (glass powder and foundary sand.) at varying proportions. 27 Table 1: Test to be conducted on the black cotton soil: Sr. No. Name of the Test Parameter

- Determinations of the consistency of soil (As per IS: 2720:Part 5) Liquid Limit, Plastic Limit
- Determination of the MDD & OMC relationship by the use of modified proctor test. (As per
- IS:2720: Part 7) Maximum dry density and Optimum moisture content.
- Determination of load-penetration curve by the use of CBR test. (As per IS:2720:Part 16) California Bearing Ratio Test values.
- Determination of UCS of black cotton soil (As per IS: 2720:Part 10) Unconfined Compressive
- Strength. Test to be conducted on the black cotton soil mixed with waste materials. The waste materials glass powder and foundry sand to be mixed to the black cotton soil with varying percentages the following test are conducted.

B. Proposed Methodology

Methodology consists of the following steps and are followed in the given below order(figure 1).

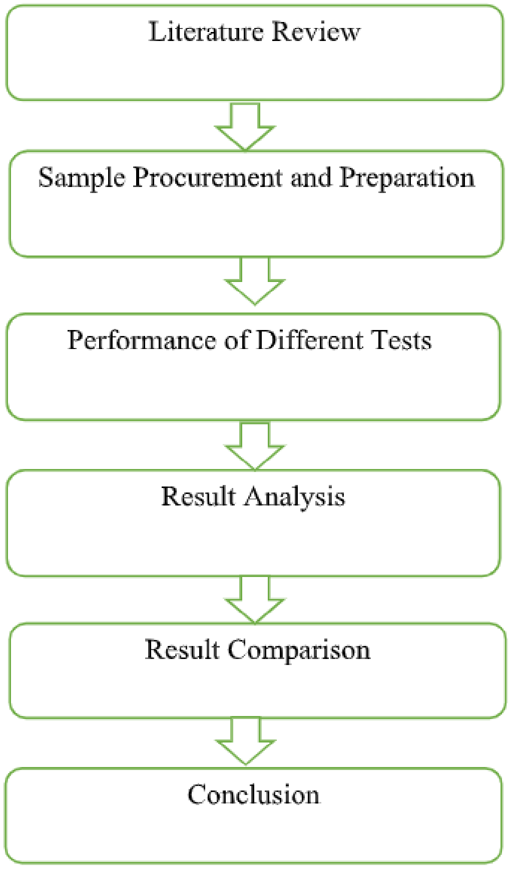

Figure 1: Proposed Methodology

Laboratory work will be carried out in two stages:

- On the collected natural soil sample without addition of waste materials (glass powder and foundary sand)
- Name of the Test Define Parameter
- Determination of the MDD & OMC relationship by the use of modified proctor test. (As per IS:2720: Part 7) Maximum dry density and Optimum moisture content
- Determination of load-penetration curve by the use of CBR test. (As per IS:2720:Part 16) California Bearing Ratio Test values 28
- Determination of UCS of natural soil (As per IS:2720:Part 10) Unconfined Compressive Strength.

V. RESULTS AND DISCUSSION

An attempt was made in this research study to use the Waste Foundry Sand (WFS) and Waste Glass Powder (WGP) for stabilization of Black Cotton (BC) soil through extensive laboratory experiments. In order to analysis their physical properties, such as the liquid limit and plastic limit, the soil samples were examined. Using a Modified Proctor test, the BC soil MDD and OMC were obtained. The soil was mixed with various percentages of WFS and WGP after analyzing the physical properties of BC soil, and then the Free Swell Index and CBR values were calculated. The main objective of this investigation was to carry out systematic research on the impact of WFS and WGP on BC soil stabilization.

A. Analysis of the Results of Engineering Properties of Stabilized Soil

1) Optimum Moisture Content and Maximum Dry Density

BC soil samples of Waste Foundry Sand and Waste Glass Powder have been tested for the study of MDD and OMC using the Modified Proctor Test at varying moisture content values. As follows, the results are illustrated.

Table 1: MDD and OMC values for soil with different percentage of WFS

S. No.	Percentage of WFS	OMC (%)	MDD (g/cc)
1	0	22.80	1.732
2	10	20.40	1.749
3	20	19.60	1.751
4	30	19	1.769

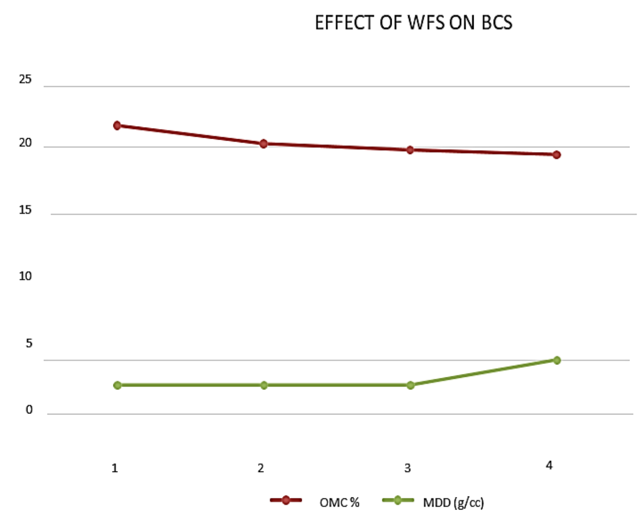

Figure 2: OMC and MDD values for the soil with WFS

Table 2: OMC and MDD values for soil with optimized 30% WFS and WGP contents

S. No.	Percentage of waste material with soil (WFS + WGP)	OMC (%)	MDD (g/cc)
1	30%+2%	21.80	1.775
2	30%+4%	22.60	1.779
3	30%+6%	23	1.721

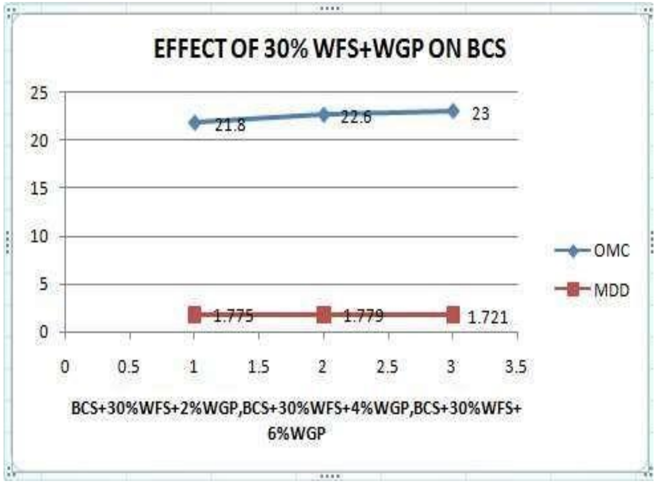

Figure 3: OMC and MDD values for the stabilized soil

In order to research the impact of replacing waste material with soil on the relationship between OMC and MDD, waste materials have been mixed with soil in different amounts, thus reducing the optimum moisture content and increasing the overall dry density with the addition of waste.

2) California Bearing Ratio (CBR) Test

The soil samples reinforced with Waste Foundry Sand and Waste Glass Powder have been tested for optimum moisture content and maximum dry density using the California bearing ratio test as calculated in the laboratory on BC soil in various combinations for the study of California soil bearing ratios. As follows, the results are illustrated.

Table 3: Values soaked CBR for soil with different percentage of WFS

S. No.	Percentage of WFS	CBR (%)
1	0	2.201
2	10	3.301
3	20	4.508
4	30	6.602

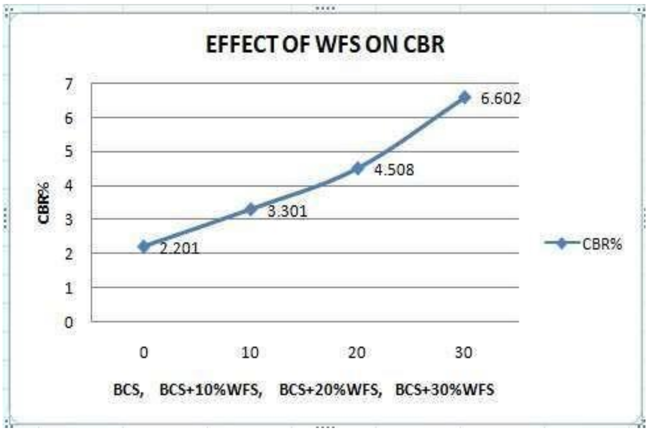

Figure 4: Variation of CBR for Soil and different percentage of WFS

Table 4: Values of Soaked CBR for 30% WFS and varying percentage of WGP contents.

S. No.	Percentage of waste material with soil (WFS + WGP)	CBR (%)
1	30% + 2%	8.252
2	30% + 4%	9.902
3	30% + 6%	10.39

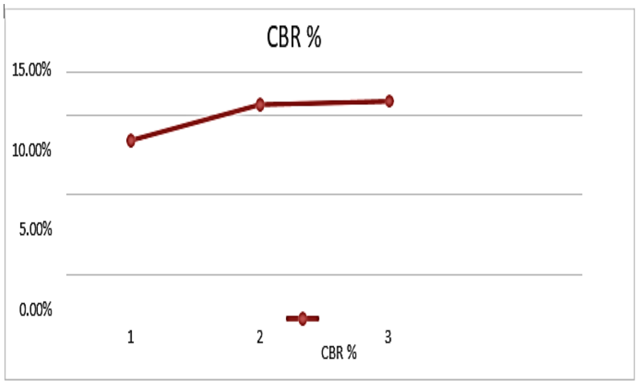

Figure 5: Variation of CBR for soil, WFS and different percentage of WGP

B. *Interpretation of Results*

1) Optimum Moisture Content (OMC) and Maximum Dry Density (MDD)

The comparison of the optimum moisture content and maximum dry density of the plain soil with the stabilized soil as obtained below.

Table 5: Comparison of OMC and MDD of plain soil with reinforced soil

S. No.	Sample	OMC (w) %	Comparison (%)	MDD (γd) g/cc	Comparison (%)
1	Plain Soil	22.80	-	1.732	-
2	Soil + 10% WFS	20.40	-10.5	1.739	0.404
3	Soil + 20% WFS	19.60	-14.03	1.751	1.27
4	Soil + 30% WFS	19	-16.66	1.769	2.13
5	Soil + 30% WFS + 2% WGP	21.80	-4.38	1.775	2.48
6	Soil + 30% WFS + 4% WGP	22.60	-0.877	1.779	2.71
7	Soil + 30% WFS + 6% WGP	23	.875	1.720	-1.096

California Bearing Ratio (CBR) of Plain BC Soil with STABILIZED Soil

The comparison of the CBR of the plain BC soil with the stabilized soil as obtained below.

Table 6: Comparison of CBR of plain BC soil with stabilized soil

S. No.	Sample	CBR (%)	Comparison (%)
1	Plain Soil	2.201	-
2	Soil + 10% WFS	3.301	49.977
3	Soil + 20% WFS	5.508	104.81
4	Soil + 30% WFS	6.606	199.95
5	Soil + 30% WFS + 2% WGP	8.252	274.92
6	Soil + 30% WFS + 4% WGP	9.902	349.88
7	Soil + 30% WFS + 6% WGP	10.39	372.05

Free Swell Index of plain BC soil with Stabilized soil

Table 7: Comparison of Free Swell Index of plain BC soil with stabilized soils

S. No	Sample	Swell Index	Comparison
1	Plain Soil	62.5%	-
2	Soil + 10% WFS	48.38	-22.59
3	Soil + 20% WFS	42.85	-31.44
4	Soil + 30% WFS	33.3	-46.94
5	Soil + 30% WFS + 2% WGP	30.76	-50.784
6	Soil + 30% WFS + 4% WGP	27.27	-56.368

VI. CONCLUSION

The waste materials like foundry sand and glass which are discarded in massive amount every year all over the world. These materials not only take up the space in landfills but also their potential of being utilized is wasted. Through this study, we have tried to utilize these waste materials in soil stabilization. It provides us with a way to not only resolve the disposal problem of these waste materials but also to effectively and economically utilize them in the different fields of civil engineering. Research works have been conducted where both waste foundry sand and crushed waste glass has been used separately for the purpose of soil stabilization. Our study encompasses both of them to be used as stabilizing agent combinedly in black cotton soil. Since, both foundry sand and glass contain silica as their major constituent, they definitely prove to be a good stabilizing agent. In this thesis project, literature review has been done by studying a number of papers published by multiple researchers. These researchers have used foundry sand along with different waste materials for the purpose of soil stabilizing. They have also suggested the optimum percentage of waste foundry sand, crushed waste glass and other waste materials which can be used to achieve desired strength and quality of stabilization. Thus, by taking the reference from their works, this project has to be performed and the results thus obtained will be compared with the expected and desirable result. In addition to this, we will be suggesting the percentage or amount in which both foundry sand and crushed glass will have to be used to achieve maximum efficiency.

CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

REFERENCES

[1] Abichou, Tarek & Benson, Craig & Edil, Tuncer. (2000). Foundry Green Sands as Hydraulic Barriers: Laboratory Study. Journal of Geotechnical and Geoenvironmental Engineering - J Geotech Geoenviron Eng. 126. 10.1061/(ASCE)1090-0241(2000)126:12(1174).

[2] Barriers: Field study." Journal of geotechnical and geoenvironmental engineering 128.3 (2002): 206- 215.z

[3] Dr.Ravi Kumar Sharma, Amrendra Kumar, "Compactionand Sub-gradeCharacteristics of Clayey Soil Mixed withFoundry Sand andFly Ash", International Journal of Engineering Research & Technology,Vol. 2 Issue 10,October – 2013IJERT ISSN: 2278-0181.

[4] Mohammed A. Al-Neami, Kawther Y.H. Alsoudany, Aram A. Dawod and Elaf A. Ehsan,"Remediation of Cohesive Soils Using Waste Glass",Conference of the International Journal of Arts & Sciences, CD-ROM. ISSN: 1943-6114: 09(01):125–138 (2016).

[5] Prashant Kumar, Prof. M.C.Paliwal,Prof.A.K.Jain, "Stabilization of Sub Grade Soil By Using Foundrysandwaste", International Journal Of Engineering Sciences & Research Technology,ISSN: 2277-9655.

[6] H. Canakci, A. Al-Kaki, F. Celik,"Stabilization of clay with waste soda lime glass powder",Procedia Engineering, ELSEVIER, Vol. 161, pp. 600-605, 2016.

[7] Ajeet, Shikha Sachan, Dheeraj Sharma, Varun Yadav, Shubhanshu and Manvendra Sharma, "Stabilization of Soil by Foundry Sand Waste with Fly-Ash",International Research Journal of Engineering and Technology (IRJET), Volume: 05 Issue: 05 | May-2018, e-ISSN: 2395-0056, p-ISSN: 2395-0072.

[8] Shiva Kumar,Vidyaranya,Shravan Bharadwaj, Prathibha and Yuvaraj, "SOIL STABILIZATION USING WASTE PLASTIC STRIPS", International Journal of Recent Scientific Research, Vol. 7, Issue, 5, pp. 11356-11358, May, 2016

[9] Dushyant R.Bhimani,JayeshkumarPiroda and Jaydevbhai J. Bhavsar, "A Study on Foundry Sand: Opportunities for Sustainableand Economical Concrete", GRA - GLOBAL RESEARCH ANALYSIS, Volume: 2, Issue: 1, Jan 2013 ISSN No. 2277-8160.

[10] Prof. S.S. Razvi,Shaikh Sujahat, Syed Adnan, Khan Aasim, Ughade Ravi and Mohammed Saud, "Stabilization of Soil by Foundry Sand withFly-Ash", International Journal of Innovative Research in Science, Engineering and Technology, Vol. 6, Issue 5, May 2017, ISSN(Online): 2319-8753, ISSN (Print): 2347-6710.

[11] Urmila S. Sarde, "Stabilization of Black Cotton Soil Using Waste Foundry Sand &RBI Grade 81", IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)e-ISSN: 2278-1684, p-ISSN: 2320-334X, Volume 15, Issue 6 Ver. III (Nov. - Dec. 2018), PP 59-61.

[12] Adebisi Ridwan, Taiwo Kanmodi and OlufikayoAderinlewo, "Comparative Assessment of Rice Husk Ash,Powdered Glass And Cement As Lateritic Soilstabilizers", The Civil Engineering Journal,Article no. 163-2016.