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Soil Stabilization With Brick Kiln Dust And Waste Fiber

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Abstract: ***Weak properties of soil create major problems in the construction sites of Afghanistan. This reduces the pavement performance life and increases the project cost. Therefore, the scope of this study is to stabilize soil with Brick Kiln Dust and Waste Fiber (Plastic Bottle Strip) for road, parking pavement base to decrease project cost and use sustainable material for proposed structure. Furthermore, use of brick kiln dust and waste plastic bottle reduces environmental defects around the country. For this study, the soil samples were collected from Bagrami site located in Kabul province of Afghanistan and preliminary laboratory tests performed to know about the properties of natural soil. Natural soil were mixed with additives i.e. brick kiln dust and waste plastic bottle strips. Local Soil was stabilised with BKD followed by the addition of plastic strip reinforcement. Laboratory experiments have shown the significant improvement in soil properties such as (MDD) ,Unconfined compression test (UCS) and California bearing ratio (CBR) with the addition of 20% BKD, which were further analysed by mixing plastic strips randomly and properties were enhanced substantially. The study shows that the properties of soil improved, therefore it is recommend to use brick kiln dust and waste plastic bottle with natural soil for base of pavement structure to increase pavement performance life, decrease environmental pollution, and decrease project cost with providing work opportunity for local people.***

Keywords: ***Brick kiln dust (BKD), Plastic Bottle fiber, California bearing ratio (CBR), Unconfined compression test (UCS)***

I. INTRODUCTION

The improvement of soil engineering properties has been recognised since long time, due to this many ancient cultures including Chinese and Romans utilised various techniques to improve soil suitability which has low shear strength and properties, these techniques have been continuing till present and people has been using different methods of soil stabilization. Therefore, buildings, roadways and many other structures have been constructed on stabilized soil base which has been provided proper performance and serviceability.

On the other hand, with rapid engineering construction works there is a need to find economical and easy way for construction purpose, therefore this issue is recently arise to use stabilizer for low strength soil, thus this subject became again popular trend as universal demand across the world and encourage professional to use the wasting as stabilizer for impairment of soil properties.

Furthermore, as the environment pollution has became a dangerous issue for many countries and it has been increasing day by day, thus people have been suffering from health problem and struggle with different kind of illness across entire world, due to many wastes such as various kind of fiber, fly ash, brick kiln etc. Therefore, it is necessary to find a proper solution for this issue, as the waste material are available everywhere. Using waste material as a stabilizer for low soil strength improvement will decrease project cost; improve soil strength, reduce volume of waste material from ground surface. Nevertheless, it has direct positive effect on decrement of pollution, within application of this assignment, the project performance life will be increased and engineers will be able to construct different project where the soil has low strength.

II. BACKGROUND

Mixing of Brick Kiln Dust with clay and red soil effectively changed the CBR result of clay soil increased significantly from 0.6% up to 6% and the CBR for red soil has improved from 2% to 21% (Depaa. Ra. B ,2013). Swelling shrinkage can be reduced with the use of Brick kiln dust, cement with clayey soil of clayey soil (Rajat et al. ,2017). Lime and brick dust has used with black soil, after performing the test, it has been found that, lime and brick kiln mixing with black cotton soil has positive result for stabilization. Therefore, within consideration of 35% (Percentage) of brick dust and 5% (Percentage) of lime given highly improvement in the properties of mentioned soil. Thus, it is preferable to use lime and brick kiln as soil stabilizer for low strength soil to improve its parameter to provide proper work durability (Tanveer Asif Zerdi et al. ,2016). Stabilization of expansive soil with fly ash and mixed up to 30%, for each 5 % increment Standard Proctor compaction tests, UCS and CBR were conducted, to find optimum percentage of fly ash for stabilization of expansive soil. (Akshaya Kumar, Sabat et al., 2016). With the optimum percentage of rice husk ash (RHA), fiber and lime. Optimum percentage of RHA is 10%, lime is 4% and polypropylene fiber is 1.5%. The length of Polypropylene fiber were considered to be 12 mm. Results were seen in terms of Soil engineering properties obtained with performance of Maximum dry density (MDD), Optimum Moisture Content (OMC), Unconfined Compressive Strength (UCS), Soaked California Bearing Ratio (CBR) and Swelling pressure. The results of tests have shown significant improvement in these properties (Sabat, Akshaya Kumar et al., 2010).

Black cotton (BC) soil properties with different percentage 2%, 4%, 6% of waste Plastic bottle strips improved to analysis engineering properties. The composition of this stabilization was black cotton soil, lime, and waste Plastic strip. At the CBR value of the Black cotton soil is increased with mixing of optimum content of lime and waste plastic bottle strips. Within consideration of this study it will be possible to use plastic strip as soil stabilising agent for improving of soil engineering properties. Finally, it would be concluded that, CBR percentage of black cotton soil increased with 4% waste plastic and it decreased with mixing of 6% plastic waste with the same soil. It concluded that 4% plastic and 5 % lime content is the optimum content of stabilizers used in stabilisation of the BC soil (N VENKATA HUSSAIN REDDY et al. 2017).

III. INVESTIGATION MATERIAL

A. SAMPLE LOCATION

The study has been carried out for Bagrami District which is about 15 Km away from Kabul City Capital of Islamic Republic of Afghanistan. Bagrami is the 22nd district of Kabul province which has located in eastern fringes of mentioned province. The exact study location was Bagrami 2nd project, 1st road in the right side with station 0+095 Km and soil sample were collected at a depth of 0.5 to 1m from ground surface. The history of purposed area shown that, the water table was high in lost period, even this area was waterlogged, hence the soil which was taken for investigation was wet soft bright grey silt colour with weak condition, the visual observation of the site has shown that, the soil has weak properties, thus it is necessary to construct heavy structure or it is also possible to stabilize natural soil to obtain require strength for specific project.

B. PROPERTIES OF NATURAL SOIL

The study has been done based on American Society for Testing and Materials (ASTM), therefore the natural soil is ML (Silt) and its LL is less than 50 as well as its PI is below from 4, furthermore the soil particle does not have gravel and also the visual observation shown the material has wet soft bright grey silt, due to this it has seem the soil has weak properties and it needs to stabilized and improved its characteristic. see Table 1.

Sr. No	Description of Properties	Result
1	Specific gravity	2.651
2	Atterberg's limit: a) Liquid limit LL (%) b) Plastic limit PL (%) c) Plasticity Index PI (%)	 31.0 27.4 3.65
3	Standard Proctor Compaction Test: a) Optimum Moisture Content (OMC), % b) Maximum Dry Density (MDD), Kg/m^3	 16 1775
4	Natural Moisture Content (NMC), %	21.92
5	Bulk Density of Material, Through FDT	1.913
6	California Bearing Ratio (CBR) %	4.97
7	Unconfined Compression Strength (UCS), Kpa	171.5
8	Soil Group Symbol	ML
9	Soil Group Name	Silt

Table 1: Natural Soil Properties

C. BRICK KILN DUST (BKD)

For this study, brick kiln dust has been taken from brick production factory located in Northern Side of Kabul City of Afghanistan, after collection of brick kiln dust, the preliminary experiments such sieve analysis, Atterberg Limit and Classification have been performed, the result of test shown the brick kiln dust is course grain size material, based on ASTM it classified with ML (SW - SM), Well-grade Sand with Silt material.

D. FIBER (PLASTIC BOTTLE)

For this study waste fiber used as a second stabilizer for soil properties improvement, for this research the aspect ratio (length/diameter) is 12mm and 4mm with content of 0.25, 0.5, 0.75, and 1.0 percentage has mixed with natural soil, at the end natural soil + 20 % brick kiln dust with above content has mixed and required tests performed.

Figure 1: Natural Soil, Brick Kiln Dust and Plastic Bottle Strip

E. MIXING PROPORTIONS

For improvement of natural soil properties, below additives see Table 2 added with natural soil.

Sr. No	Natural Soil %	Brick Kiln Dust %	Plastic Strip %
Step – 1: Natural Soil			
1	100.0	0.00	0.00
Step – 2: Natural Soil with BKD			
1	95.0	5.00	0.00
2	90.0	10.0	0.00
3	85.0	15.0	0.00
4	80.0	20.0	0.00
5	75.0	25.0	0.00
6	70.0	30.0	0.00
Step – 3: Natural Soil with Plastic Bottle Strip			
1	99.75	0.00	0.25
2	99.50	0.00	0.50
3	99.25	0.00	0.75
4	99.0	0.00	1.00
Step – 4: Natural Soil with Brick Kiln Dust and Plastic Bottle Strip			
1	79.75	20.0	0.25
2	79.50	20.0	0.50
3	79.25	20.0	0.75
4	79.00	20.0	1.00

Table 2: Material-Mixing Proportion

IV. RESULT AND DISCUSSION

A. TEST FOR NATURAL SOIL AND BRICK KILN DUST

a. ATTERBERG LIMIT TEST

The test has performed based on ASTM D- 4318 with 200-gram oven dray soil sample which has passed through No – 40 sieve and mixed with demineralized water in the glass plate different percentage of brick kiln dust, the result shown that the Plastic index decreased.

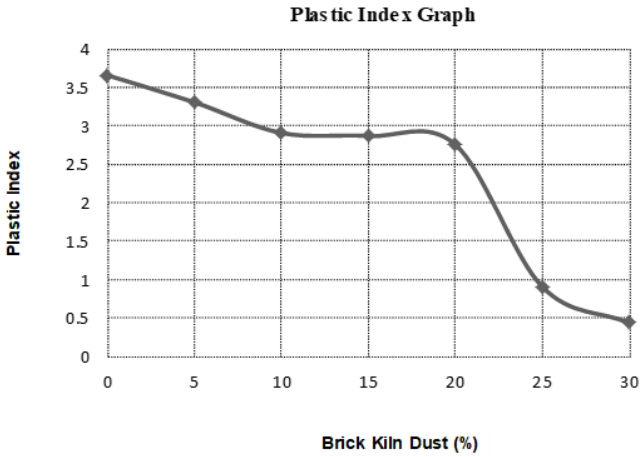


Figure 2: Plastic Index Graph for Natural Soil and BKD

b. MAXIMUM DRY DENSITY (MDD) TEST

MDD increased with mixing of 20 % brick kiln dust, and then it decreased with mixing of 25 and 30 % BKD.

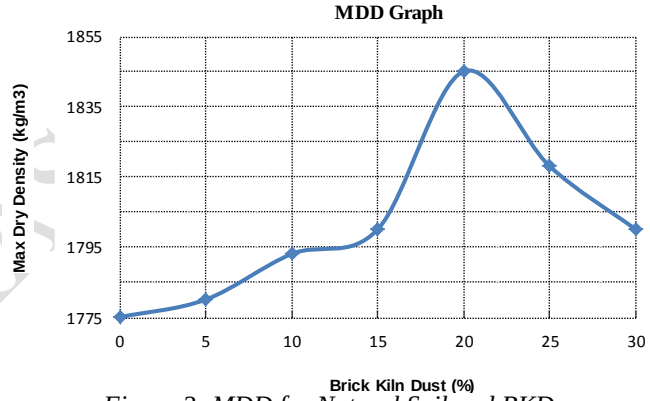


Figure 3: MDD for Natural Soil and BKD

At the same time Optimum Moisture Content (OMC) determined for natural soil with brick kiln dust. Finally, OMC decreased up 20 % BKD, then OMC increased.

c. CALIFORNIA BEARING RATIO (CBR) TEST

Soil CBR increased with mixing of 20 % BKD and then it decrease with mixing of 25 and 30 % brick kiln dust.

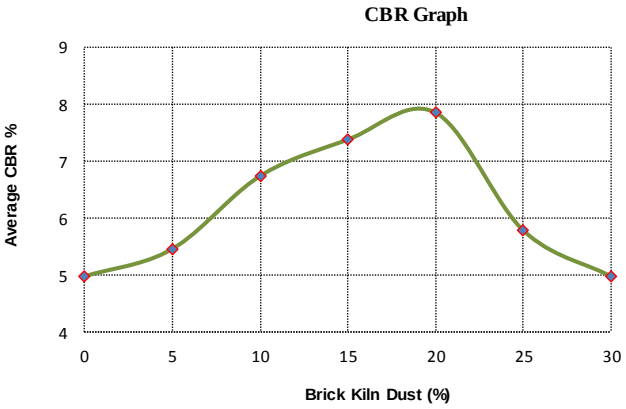
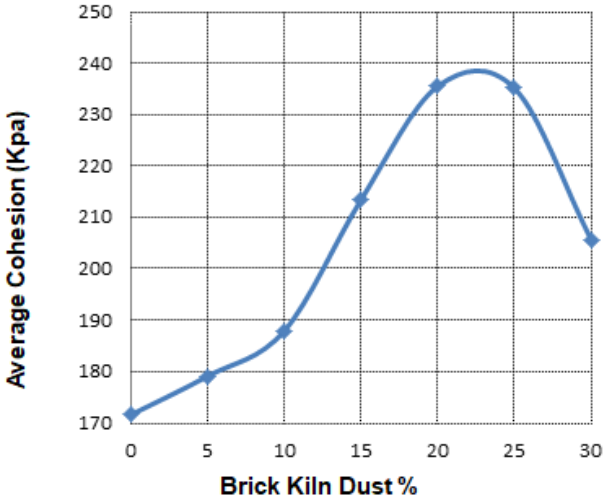


Figure 4: CBR Graph for Natural Soil and BKD

B. UNCONFINED COMPRESSION STRENGTH (UCS) TEST

The average cohesion increased with mixing of 20 % BKD and then it has decreased.

Figure 5: Cohesion Graph for Natural Soil and BKD



C. TESTS RESULT FOR NATURAL SOIL WITH 20 % BKD AND BOTTLE WASTE PLASTIC STRIP

Natural soil with 20 % Brick Kiln Dust (BKD) and 0.25, 0.5, 0.75 and 1.0 % of bottle plastic strip mixed and perform below tests.

a. MAXIMUM DRY DENSITY (MDD)

MDD experiment has performed for different condition, due to this MDD increased from 1775 kg/m3 to 1845 kg/m3 with mixing of natural soil and 20 % brick kiln dust, and then it decreased up to 1800 kg/m3 with mixing of 30 % BKD. In the second stage MDD performed for soil and plastic strip and it has increased form 1775 kg/m^3 to 1799 kg/m^3 with mixing of 0.5 bottle plastic waste, after that it has decreased. Finally, natural soil mixed with 20 % fixed amount of brick kiln dust and 0.25, 0.5, 0.75 and 1.0 % plastic bottle strip, and MDD increased 1775 kg/m^3 to 1808 kg/m^3. At the end it has decreased up to 1760 kg/m3, in addition MDD decreased from 1845 kg/m3 to 1808 kg/m3 which has obtained from natural soil and brick kiln dust with compare to plastic bottle strip. Similarly, Optimum Moisture Content (OMC) tests has performed and it has decreased from 16.00% to 14.80 % for natural soil and of 20 % brick kiln dust, and then it decreased up to 15.70 % with mixing of 30 % BKD. In the second stage, OMC performed for soil and plastic strip and it increased from 16.00 % to 17.40 % with mixing of 0.5 bottle plastic waste, after that it has decreased. Finally, natural soil mixed with 20 % fixed amount of brick kiln dust and 0.25, 0.5, 0.75 and 1.0m % of plastic bottle strip, due to this OMC increased up to 16.5 % with mixing of 0.25% plastic bottle strip , then it decreased to 16 %, after that once again it increased.

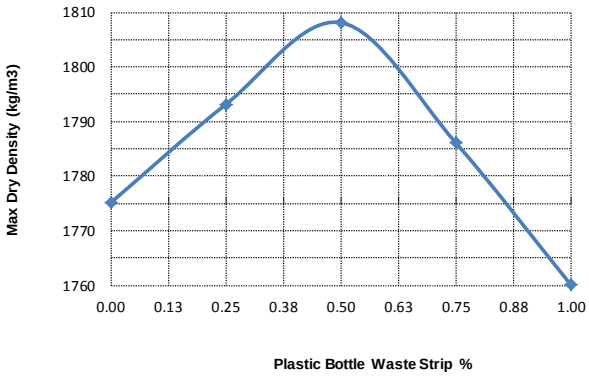


Figure 6: MDD Graph for Natural Soil with 20 % BKD and Bottle Plastic Strip

b. CALIFORNIA BEARING RATIO (CBR)

California Bearing Ration (CBR) tests has been conducted for natural soil, and result obtain 4.97 %, then 5, 10, 15, 20, 25, 30, BKD added with natural soil and the result improved up to 7.86 % with mixing of 20 % BKD, then it deceased up 4.97 %. In the second step, natural soil mixed with plastic bottle strip, thus the result improved with mixing 0.25 and 0.5 % of plastic bottle strip from 4.97 up to 6.58%, and then it has deceased up to 5.94 and 5.29 with mixing of 0.75 and 1.0 % of plastic strip respectively. Finally, natural soil with 20 % of BKD and plastic bottle strip mixed and the result improved up to 8.5 % with mixing of 20 % BKD and 0.5 plastic trip, then it decreased to 5.45 with mixing of 1.0 % plastic bottle strip.

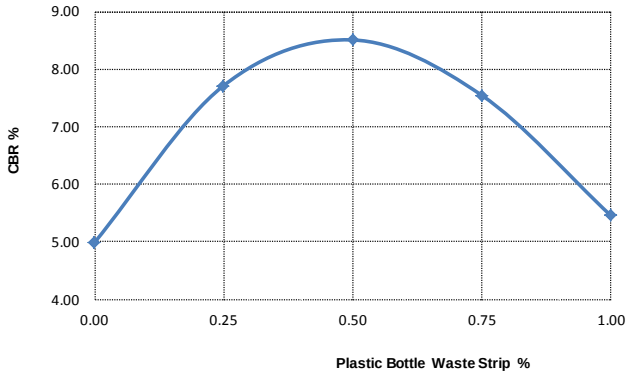


Figure 7: CBR Graph for Natural Soil with 20 % BKD and Bottle Plastic Strip

c. UNCONFINED COMPRESSIVE STRENGTH

UCS experiment has performed for different condition, at the result it increased from 171.50 Kpa to 235.40 Kpa with mixing of 20 % brick kiln dust and then it decreased with mixing of 30 % BKD. In the second stage UCS performed for soil and plastic strip and it has increased form 171.50 kPa to 174.00 kPa with mixing of 0.5 bottle plastic waste, after that it has decreased. Finally, natural soil mixed with 20 % fixed amount of brick kiln dust with 0.25, 0.5, 0.75 and 1.0 % of plastic bottle strip, due to this soil increased from 171.50

Kpa to 237.10 Kpa, and then it has decreased up to 170.00 kPa. At the end UCS decreased from 235.4 kPa to 174.00 kPa which has obtained from natural soil and 20 % brick kiln dust with compare to plastic bottle strip.

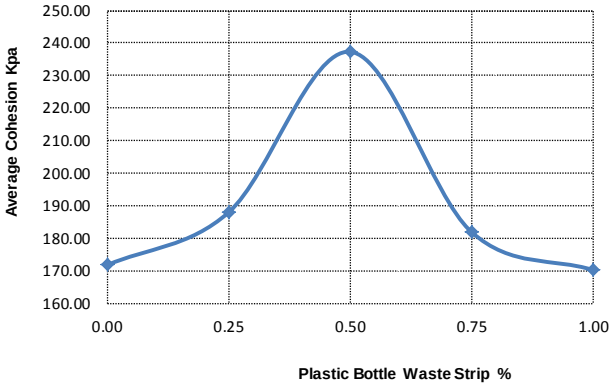


Figure 8: UCS Graph for Natural Soil with 20 % BKD and Bottle Plastic Stri

V. CONCLUSION

Laboratory experiment were carried out to investigate the MDD, OMC, UCS and CBR behaviour of soil samples mixed with brick kiln dust and plastic strips.

- ✓ Addition of 20 % fixed amount of brick kiln dust and 0.5 % plastic bottle strip increased MDD from 1775 kg/m^3 to 1808 kg/m^3.
- ✓ OMC increased from 16 % up 16.9 % with the addition of 20 % fixed amount of brick kiln dust and 0.5 % plastic bottle strip.
- ✓ CBR improved from 4.97 % up to 8.5 % with mixing of natural soil with 20 % BKD and 0.5 % of plastic strips, after that it decreased with mixing extra plastic waste.

UCS has increased 171.50 kPa to 237.10 kPa with natural soil, 20 % brick kiln dust and 0.5 % plastic bottle strip, after that It decreased from 181.70 kPa to 170.00 kPa with mixing of 0.75 and 1.0 % plastic bottle strip and 20 % BKD.

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