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Improvement in engineering properties of locally available black soil by fly ash and brick waste

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Abstract

Long-term performance of any construction and engineering project depends on the strength of the underlying soil. Unstable soil can cause significant problems for sub-structure and pavement. To improve its engineering properties, this extension represents a complete framework for removing this flaw of giant soil by adding fly ash and brick waste to the soil. The objective of this experimental study is to find out the possibility of using brick waste and large amounts of fly ash in the stabilization of available local soil available locally.
Soil stabilization is a very rapidly evolving technique. Soil improvement, in broader sense, is the change in any soil property and the treatment of land, which can be better in their induced purpose.
Fly ash can be easily obtained from coal combustion plants, whereas brick waste is easily available at demolition sites, to improve soil properties, several other mixtures or materials have been tried besides soil. These include limestone, cement, bitumen, industrial waste, water proof, entry, resins etc. 'Chemical stabilization' is a common word, which is usually used for above-mentioned mixture. The more widely used mixtures are fly ash, cement, brick dust, bitumen, industrial waste etc. And among them, the use of fly ash as a stabilizer is relatively more economical in India. It's available free of charge. In this research, fly ash added different percentage 0%, 4%, 8%, 12%, 16% 20% and brick waste to 4%, 8%, 12%, 16%, 20% of the soil weight. The results show that they have the ability to modify soil properties to meet the stabilization requirements.

Keywords: Fly ash, Brick Waste, Optimum Moisture Content, Max Dry Density, Liquid Limit

1. Introduction

Clay soil is classified into 2 groups. First group is presence of montmorillonite in sedimentary rocks while second group is igneous rocks, such as basalts of plateau of deccan.[1]

The soil for this research was collected from Indore (M.P.). Black cotton soil are soil which expands directly propositional to water content can also known as expansive soil. It is produce by chemical decomposition of basalt and trap. In this type of soil swelling and shrinkage is often occurred In some part of the soil excepting rest formed active and passive zone. This is highly unacceptable for roads, building and tall structure.[2]

In india black cotton soil (also known as regur & maan) are found in malwa region and extensive region of the deccan. These soil cover the huge area of country in different states.[3] Similar soil are also found in Australia, south Africa, Russia & Egypt. The name of black cotton soil has an agricultural origin. Most of these soil are dark in colour and are good for growing cotton due highly moisture content.[4]

These soils have great affinity towards moisture and are characterized by their highly swelling and shrinkage. A structure supported on such a soil undergoes vertical movement, which in most cases is non-uniform, leading to severe cracking and even to structure failure of the super structure shrinkage means reduction in volume when water content is reduced, shrinkage produce tensile stress within the soil leading to wide surface cracks in the soil reaching several meter in depth on saturation these soil become very weak and unstable and have very low bearing capacities.[5]

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If we will study on engineering properties and geotechnical properties on black cotton soil. The result obtained in research that very high liquid limit values, CBR values is very lows, free swell index limit is very high and other engineering properties are not suitable for construction project or civil engineering work.[6]

Expansive soil contain the highly active clay mineral in the form of montmorillonite due to which expensive soil swell upto 7% upon adding 1% of water, which may lead to unequal settlement of subsoil. This research represent a complete framework to overcome this drawback of expansive soil by adding fly ash and brick waste to expansive soil in order to improve its engineering properties.[7]

2. Past Researches

S. Lakshman Teja1, S.Shraavan Kumar and Dr. S. Needhidasan et. al. (2018) : They used construction and demolition waste like as brick residue. The brick residue is a waste product of construction waste was locally available near stabilization project. They performed tests like OMC test, MDD test, CBR test and UCS test to improve all geotechnical properties and behavior of sub base. It very well may be presumed that the soil treated with Brick residue can be used in soil as a soil stabilizer agent and minimize the settlement. From the economic analysis it is found that, a substantial save in cost of construction is possible by making use of two waste materials like Brick dust can be utilized to strengthen the Black cotton soil.[8]

Nikhil Tiwari, Sumit Shringi, Neha Chaudhary et. al. (2018) : he studied the utilization of brick dust & lime in the stabilization of the black cotton soil. In his research work he used lime as admixture. On the basis of study and experimental work he observed that the properties of black cotton soil effectively improved by use of different percentage of brick dust and lime contents. It was observed that the addition of 25% brick dust & 6% lime increases the unconfined compressive strength value. The CBR value increases upto 1000% with the use of lime and brick dust. It has been seen that differential free swelling list and liquid limit diminishes by including lime and burnt brick dust up to 25% brick dust & 6% lime.[9]

Vakkapatla Laxmi Durga, DR. D.S.V. Prasad et. al. (2017) : they used brick dust waste and lime for stabilization of black cotton soil in this research work. Firstly, He is used different percentages of brick dust waste with black cotton soil. Than he is used different percentages of lime with black cotton soil. And finally take best combination of soil + lime + brick dust waste. Black cotton soil after stabilization the required CBR value of 8% according to IRC: 37-2012 is achieved by stabilizing with replacement of BC soil by 50% BP + 4% lime and 30% BP + 1.5% lime. From the above discussion it can be concluded that the BP can effectively utilized with BC soil in improving the soil CBR values. The use of Brick Powder resulted in utilization of demolition wastes and found to be economical for local area. This will results in the utilization of rejected black cotton soil in construction. From the results, it is concluded that impact of Brick Powder and Lime is positive.[10]

Mohammad Iqbal Malik, Aasif Iqbal, Jansher Manzoor, Towseef Iqbal, Hamid Nazir et. al. (2017) : in this investigation they are used waste brick powder with soil. This research studied shear strength and CBR properties of Lacustrine soil in natural state and after replacement of the soil by waste brick powder as 10%, 20%, 30% and 40% by weight. These dirt examples were tried for compressive quality and CBR esteem for 7 days of age and were contrasted and ordinary soil test without blend. The tests demonstrate most extreme unconfined compressive quality addition of 150% and greatest Tri-axial compressive quality increase of 165% for blend with 30% substitution of soil by brick powder concerning regular soil. CBR Value likewise demonstrated adequate increment from 1.34 % to 11.5% for blend with 30% of brick powder. The issue of transfer of brick powder as a waste is tended to and thus evading landfill.[11]

Hairulla and Philipus Betaubun et. al. (2016) : They used brick waste to find out the unconfined compressive strength to stabilization of soft soil. He is using different percentages of brick waste like as 0%, 10%, 20%, 30% and 40% in soft soil and find out the UCS value at 3days, 7 days, 14days and 28days curing period. Before the soft soil balanced out with brick wastes, the UCS is 1.44 kg/cm2. After the soft soil balanced out with the blend and furthermore considered with some different percentage, the Results is 90% Pure Soft Soil (PSS) + 10% Bricks Waste (BW) = 1.54 kg/cm2, 80% Pure Soft Soil (PSS) + 20% Bricks Waste (BW) = 1.87 kg/cm2, 70% Pure Soft Soil (PSS) + 30% Bricks Waste (BW) = 2.01 kg/cm2, 60% Pure Soft Soil (PSS) + 40% Bricks Waste (BW) = 1.89 kg/cm2. The abatement (reduce) of Unconfined Compression Strength in 40% (after blended with the Bricks Waste is because of the air hole found in the test, hence the score is lower than in the 30% degree of blend. This outcome is acquired dependent on the Unconfined Compression Strenhth of 28 days of restoring time, consequently the Brick Waste blend utilized in the soft soil is 30%.[12]

C.Rajakumar, T.Meenambal et. al. (2015) : he studied the utilization of coal ash in the stabilization of the expansive soil. In his research work he used coal ash as an admixture. Experimental work has been carried out with 10%, 20%, 30%, 40%, 50% and 60% of coal ash content. On the basis of past research and experiment basis he concludes that the properties of expansive soil effectively improved of geotechnical properties by use of different percentage of coal ash contents. It was conclude that the addition of 40% flyash or coal ash increase the UCS strength from 84.60 kn/m2 to 290.748 kn/m2. CBR value was reported to be increased by 6.693% to 10.193% in addition of 30% of fly ash or coal ash. Liquid limit value and plasticity index value decreases with increases the coal ash or fly ash. The results is shows that the 30% coal ash or fly ash is useful for geotechnical applications.[13][14]

Robert Brooks, F.ASCE, Felix F. Udoeyo, A.M.ASCE and Keerthi V. Takkalapelli et. al. (2010) : in this study program, he used fly ash and lime stone dust in different percentages. The improvement includes a decrease in plasticity value and an expansion in California bearing proportion value. The CBR of extensive soil treated with 3 percent, 6 percent, and 9 percent lime stone residue were higher than that of the control (untreated soil) test by 80.0%, 140.0%, and 173.0%, separately. Likewise flyash powder treated with 15 percent and 25 percent flyash slag were higher than that of the control by 40% and 60%, individually. Soil treated with a mix of 15% flyash cinder and 3% lime stone residue likewise shown more prominent CBR estimations of about 170% than the control.. The unconfined compressive strength of expansive soil treated with a blend of 3% lime stone dust and 15% fly ash also exhibited greater UCS value of about 928 kpa, 928 kpa and 1712 kpa at 1, 7 and 28 days respectively. When we increasing the percentage of fly ash the value of UCS strength is decress.. According to the above results the 15% fly ash and 3% lime stone dust is best combination for stabilization of expansive soil and utilization for civil engineering and geotechnical applications.[15][16]

Mohanty SK, Pradhan PK and Mohanty CR et. al. (2018) : In this investigation, The effect of waste flyash and lime on ground improvement tech. are discussed here.. The different amount of lime content and flyash content were added for stabilization of clay type soil. With the addition of flyash, the liquid limit percentage and Plasticity index percentage of soils gradually reduce with the increase of fly ash content. Maximum reduce is being observed at 30% fly ash content. Also, the addition of lime to the soil-fly ash mixture reduced the L.L. and P.I. further . it reduce the FSI 100% when bland 30% fly ash and 4% lime content added. The OMC value and MDD value of soil-fly ash mixed samples are increased and decreased respectively with the increase of fly ash content. maximum CBR of (soil + fly ash) observed at 30% fly ash content. At 30% fly ash content, the 4 days soaked CBR of expansive soil is increased by 126%. Again the increase value of soaked CBR (30% lime + 4% FA) . Likewise, for a given lime content, the CBR estimations of soil-fly ash powder lime are expanded with the expansion of soaking periods. With 30% fly ash residue and 4% lime residue, the 4-days soaked CBR of expansive type soil increment by 724% when weigh with expansive type soils. Adjustment by expansion of fly ash remains with or without lime is observed to be progressively successful if there should arise an occurrence of very broad soil.[17][18]

Shubham Maheshwari, S.S.Goliya et. al. (2016) : in this research work they used fly ash and lime for stabilization of black cotton soil. He is mainly focused on geotechnical properties of black cotton soil. In this research they added 25% fly ash, the liquid limit of plain soil is 77.5%. after addition of 25% fly ash the results is decreases. The liquid limit is obtained 67.5%. similarly the plasticity indexvalue on plain soil is 36.7% , after addition of fly as the value decreses 18.56%. but the plastic limit increase. The plastic limit value on plain soil is 40.8%. when added fly ash the value is increase 48.92%. finally It reveals that by addition of 25% fly ash with 2% of lime blend the liquid limit and plasticity indexreduced by 14.83% and 47.22% respectively whereas increase in plastic limit by 14.28%. By addition of 25% fly ash with 3% lime the liquid limit and plasticity indexreduced by 19.63% and 62.56% where as increase in plastic limit by 18.97%. By addition of 25% of fly ash with 4% lime the liquid limit and plasticity indexreduced by 22.58% and 70.21% where as increase in plastic limit by 20.26%. There is increase in CBR value with normal 4 days soaking is 55.44% more than the plain soil.[19][20]

Satyendra singh rajput & R.K. yadav et. al. (2015) : they are used fly ash in black cotton soil in different percentages. In this research they focused on engineering property of soil like as L.L. value, P.L. value, P.I. value, O.M.C value., M.D.D value., & C.B.R. value. Fly-ash remains is included amount of fly-ash included 10% (FA) + 90%(ES), 20% (FA) + 80%(ES), 30% (FA) + 70%(ES), 40% (FA) + 60%(ES), 50% (FA) + 50%(ES) and the adjustment in list properties and designing properties is inspected. It has been discovered that huge variety in liquid limit percentage, plasticity indexpercentage, and swelling indexpercentage. In far reaching soil, liquid limit value percent diminished from 55.2% to 36.3% and plasticity index percent diminished from 27.1% to 18.1% , differential free swell (DFS) likewise decreased from 52% to 14% separately. the compaction test outcomes indicated increment in ideal dampness content (OMC) from 19% to 23% and decrees (MDD) from 1.63g/cc to 1.52g/cc. the greatest CBR value come at 20% fly-ash.[21][22][23]

Mohammad Iqbal Malik, Aasif Iqbal, Jansher Manzoor, Towseef Iqbal, Hamid Nazir et. al. (2017) : they used brick powder in black cotton soil in different percentages and they mainly focused on lacustrine soil for changed the engineering properties of soil. This research studied shear strength and CBR properties of Lacustrine soil in natural state and after replacement of the soil by waste brick powder as 10%, 20%, 30%and 40% by weight. These dirt examples were tried for compressive strength test and CBR result test for 7 days of age and were contrasted and ordinary soil test without blend. The tests demonstrate most extreme unconfined compressive quality increase of 150% and greatest Tri-axial compressive quality addition of 165% for blend with 30% substitution of soil by brick powder concerning normal soil. CBR Value additionally demonstrated adequate increment from 1.34 % to 11.5% for blend with 30% of brick powder.[24][25][26]

3. Material and Methodology

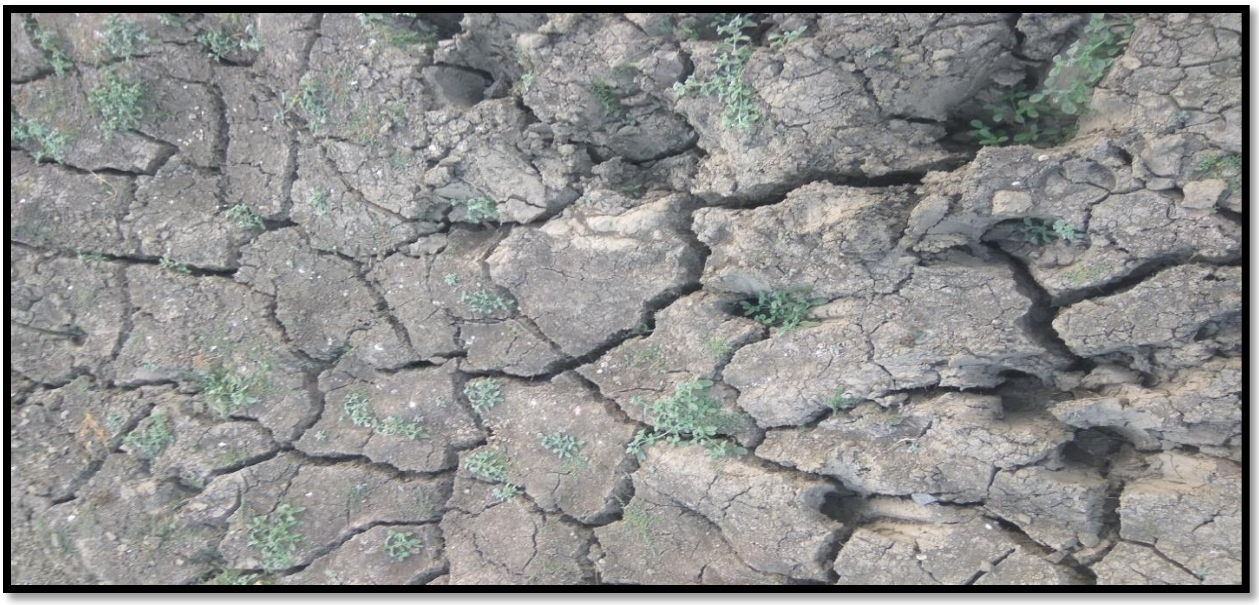

Fig- 1. Black Cotton Soil Used in This Study.

Table- 1 Engineering properties of expansive soil sample are tabulated below-

Serial No.	Property	Results
1.	Specific Gravity	2.50
2.	Liquid Limit (%)	56.3%
3.	Plastic Limit (%)	28.09%
4.	Plasticity Index(%)	28.22%
5.	Soil Classification	CH
6.	Free Swell Index (%)	47%
7.	Optimum value of Moisture Content(%)	15%
8.	Maximum Dry Density gm/cc	1.63
9.	C.B.R (soaked) (%)	0.901
10.	U.C.S (Unconfined Compressive Strength) (kn/m2)	68

Table 2 Test results of proctor field density on natural soil

Water added in percentage	10%	12%	14%	16%	18%	20%
Volume of Mould (cm3)	1000	1000	1000	1000	1000	1000
Weight of Mould in (kg)	4.482	4.482	4.482	4.482	4.482	4.482
Weight of Mould + compacted soil (kg)	5.700	5.770	5.840	5.900	5.930	5.910
Bulk Density (gm/cc)	1.68	1.75	1.82	1.88	1.91	1.89
Water content (%)	10	12	14	16	18	20
Dry Density	1.54	1.57	1.61	1.63	1.63	1.57

Table 3 Classification of sub-grade soil according to strength

Serial no.	Sub-grade classification	CBR (soaked) (%)
1.	Extremely Weak	<1
2.	Weak	1-2
3.	Medium	2-5
4.	Normal	5-10
5.	Strong	10-30
6.	Extremely strong	>30

4. Experimental results and discussion

4.1 Plastic Limit Results

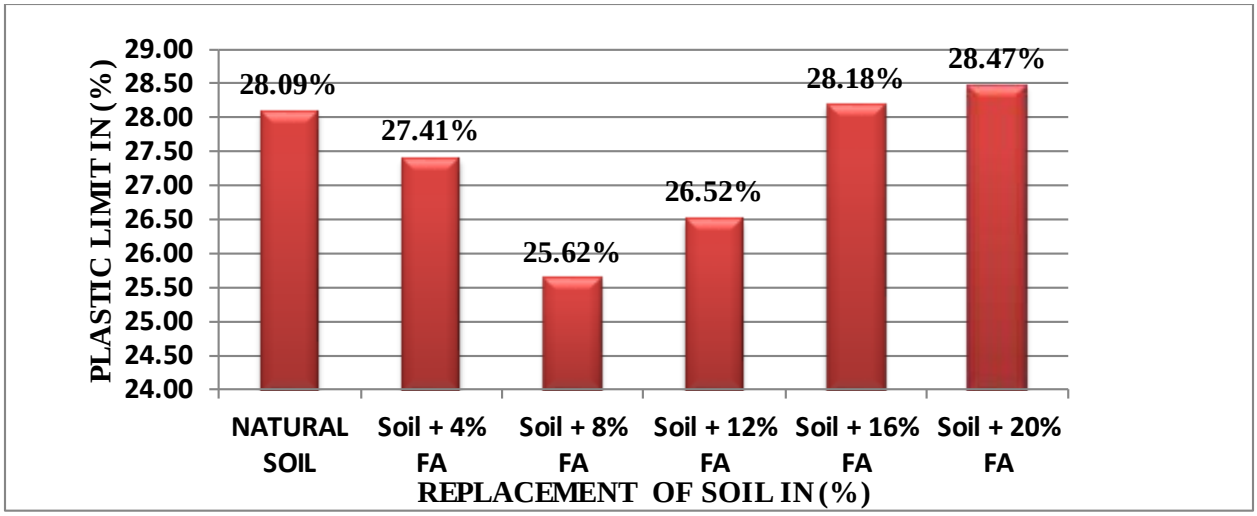

Fig 2. Chart showing the variation of Plastic Limit for different soil + FA composition

4.2 Liquid Limit Results

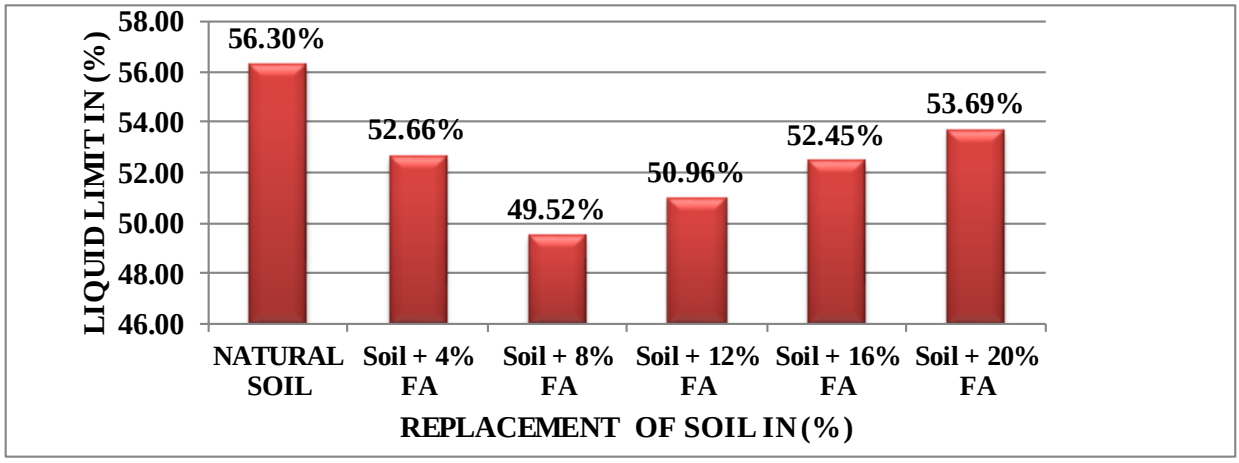

Fig 3. Chart showing the variation of Liquid Limit for different soil + FA composition

4.3 free swell index results

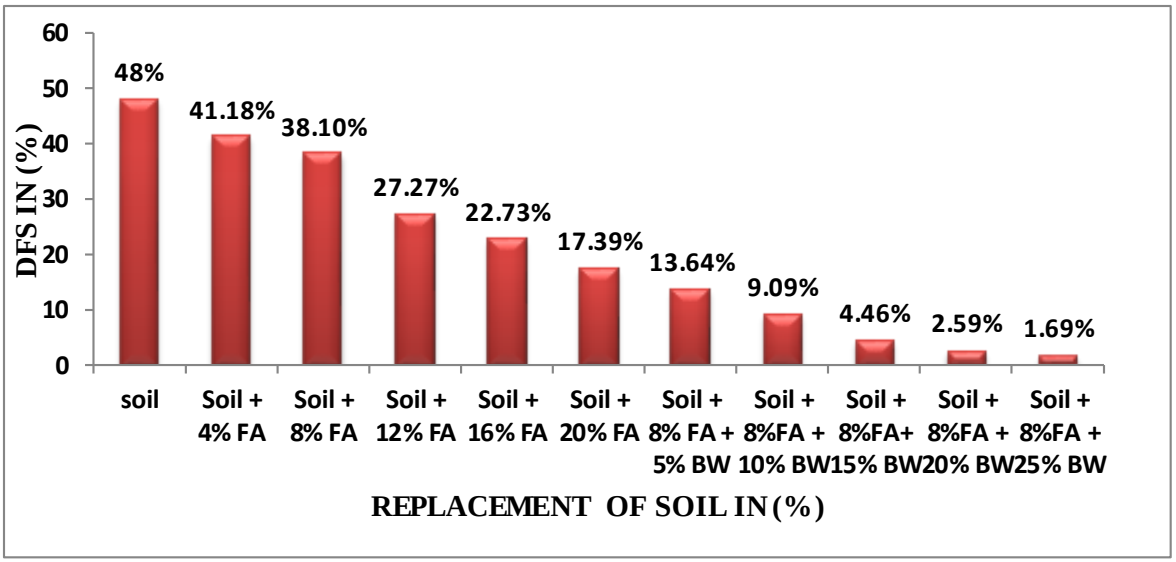

Fig 4. Chart showing the variation of DFS for different soil + FA composition + BW composition

4.4 Plasticity index Results

Table 4. P.I. results of soil Mixed with different percentage of Fly Ash

Serial no.	Soil sample	Plasticity Index(%)
1	Natural Soil	28.21
2	Soil + 4% Fly Ash	28.26
3	Soil + 8% Fly Ash	23.9
4	Soil + 12% Fly Ash	24.45
5	Soil + 16% Fly Ash	24.27
6	Soil + 20% Fly Ash	25.22

5. Conclusion

From the study carried out following significant observations have been made. The effect of additions of brick waste to soil fly ash mix.

1. According to above results the combination of 8% fly ash reduce the liquid limit from 56.29% to 49.52%.
2. Plastic limit of black cotton soil decreasing from 28.08% to 25.62% with addition of 8% of fly ash.
3. According to above result the 8% fly ash is found the best combination for mixed it with brick waste.
4. OMC decreased from 17% to 15% at 8% replacement of fly ash and 15% replacement of brick waste with soil. A slight increase is noted in maximum dry density and high amount of decrement in free soil index is observed.
5. Liquid limit decreased from 56.28% to 39.60% at combination of 8% replacement of fly ash and 15% replacement of brick waste with soil.
6. It was found that fly ash and brick waste complement each other and mixed together gives better results.

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