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An Experimental Study on Stabilization of Soil by Using Quarry Dust and Egg Shell Powder

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Abstract - *Soil is the foundation for any civil engineering structures.it is required to bear the loads without failure. In some places soil may be weak which cannot resist the oncoming loads in such cases soil stabilization is needed, the clay often is weak has no stability in heavy loading. The study involves replacing a varying percentage of soil with quarry dust and introducing eggshell powder for enhancing the properties and obtained the optimum mix proportion.*

In this experimental study we use eggshell powder and quarry dust to enhance the properties of soil, the test were carried out using various percentages of quarry dust like 8%, 16%, 24% and 32% as soil replacement and where max density value gained eggshell powder is added with a percentage of variation 4%, 8%, 12%and 16% to the weight of soil. The most appropriate percentage of quarry dust replacement and eggshell powder addition for black cotton soil and red soil was determined, which can be used to stabilize these soils for construction purposes. This experimental study provides valuable information for researchers and engineers in the field of soil stabilization.

The study was carried out through a series of laboratory tests, including sieve analysis Atterberg limits, compaction, unconfined compressive strength and California bearing ratio (CBR) tests.

Key Words: **Red soil, Black cotton soil, sieve analysis, atterberg limits, compaction, unconfined compressive Strength, California bearing ratio**

1.0 INTRODUCTION:-

Soil stabilization is the process of altering the properties of soil to improve its strength, Durability and resistance to deformation. It involves various techniques and methods that aim to enhance the soil's ability to support structures and withstand external forces such as traffic Loads, environmental changes, and natural disasters. The need for soil stabilization arises when the natural soil is not strong enough to support the intended use, such as building foundations, Roads, airports, and different infrastructure projects. Soil stabilization may be done with the aid of using adding different materials to the soil, such as cement, lime, fly ash, or chemical additives. The type of stabilizer used depends on the soil's characteristics, the desired engineering properties, and the project's requirements.

There are various methods of soil stabilization, which can be broadly categorized into mechanical, chemical, and physical methods. Mechanical methods involve adding materials such as gravel, sand, or geo-textiles to the soil to improve its stability. Chemical methods involve the addition of substances such as lime, cement, or fly ash to the soil to alter its chemical and physical properties. Physical methods involve the use of techniques such as compaction, grouting, or freezing to improve the soil's strength and stability.

Soil stabilization offers many benefits, including reducing construction costs, improving the performance of structures, and enhancing the safety and reliability of the infrastructure. It also minimizes the environmental impact by reducing the need for excavation and transportation of soil materials, which results in fewer greenhouse gas emissions and energy consumption.

2.0 OBJECTIVE OF THIS STUDY:-

This study aims to investigate the effectiveness of using quarry dust and eggshell powder as stabilizers for black cotton soil and red soil.

3.0 LITERATURE REVIEW:-

Lime stabilization: - In a study conducted by Mohammed et al. (2019) in Nigeria, varying percentages of lime (2%, 4%, 6%, and 8%) were added to black cotton soil. The study found that the addition of lime improved the soil's strength, with the highest strength achieved at 6% lime content.

Bitumen stabilization:- In a study by Masu et al. (2020) in Nigeria, varying percentages of bitumen (2%, 4%, and 6%) had been introduced to black cotton soil. The study found that the addition of bitumen improved the soil's stability, with the highest stability achieved at 6% bitumen content.

Organic stabilization:- A study by Karim et al. (2019) in Bangladesh investigated the use of rice husk ash (RHA) and cow dung ash (CDA) in stabilizing black cotton soil. The study found that a mixture of 8% RHA and 2A was the most effective in improving the soil's strength and durability.

Geogrid reinforcement:- In a study by El-Badawy et al. (2018) in Egypt, varying percentages of geogrid (0.25%, 0.5%, 0.75%, and 1%) were added to black cotton soil. The study found that the addition of geogrid improved the soil's strength and stability, with the highest strength achieved at a 1% geogrid content.

Quarry dust:- In a study by Abdu et al. (2021) in Nigeria, varying percentages of quarry dust (0%, 2.5%, 5%, 7.5%, and 10%) were added to black cotton soil. The an experimental study found that the addition of quarry dust improved the soil's strength, with the highest strength achieved at a 7.5% quarry dust content.

4.0 MATERIAL USED:-

Quarry dust:- Quarry dust is a waste material that is generated from the stone crushing industry, in this experimental study we collected the quarry dust from donabanda near kanchikacherla, Andhra Pradesh, India.

Eggshell powder:-Egg shell powder is a waste material obtained from hotels and school Canteen. ESP was received after the outer cover has been cleaned mechanically. It was kept in an open atmosphere for 1 week, the dried eggshell grinded to make it fine powder and sieve from 90-micron sieve.

Black cotton soil:- The black cotton soil used in this study was collected from perakalapadu village close to Kanchikacherla, Andhra Pradesh, India. The general properties of the soil were studied in the laboratory. The soil was tested for sieve analysis, specific gravity, liquid limit, plastic limit, optimum moisture content, maximum dry density, unconfined compressive strength and California bearing ratio.

S.no	Properties	I.S code	value
1	Sieve analysis	I.S code (1498:1970)	Sandy
2	Specific gravity	(I.S.2720 part III section I-1980)	2.66
3	Liquid limit	(I.S.2720 part v: 1985)	40%
4	Plastic limit	(I.S.2720 part v: 1985)	23%
5	Optimum moisture content	(I.S.2720 part VII:1974)	15.76%
6	Maximum dry density	(I.S.2720 part VII: 1974).	1.47%
7	Unconfined compressive strength	(I.S 2720 part 10: 1973).	1.89 kg/cm^2
8	California bearing ratio	(IS : 2720 (Part 16) – 1987)	8.87%

Red soil:-

The red soil used in this study was collected from west Ibrahimpatnam, Andhra Pradesh, India. The general properties of the soil were studied in the laboratory. The soil was tested for sieve analysis, specific gravity, liquid limit, plastic limit, optimum moisture content, maximum dry density, unconfined compressive strength and California bearing ratio.

S.no	Properties	I.S code	value
1	Sieve analysis	I.S code (1498:1970)	Sandy
2	Specific gravity	(I.S.2720 Part III section I-1980)	2.55
3	Liquid limit	(I.S.2720 Part v: 1985)	37
4	Plastic limit	(I.S.2720 Part v: 1985)	20
5	Optimum moisture content	(I.S.2720 part VII: 1974)	14.11
6	Maximum dry density	(I.S.2720 Part VII: 1974)	1.630
7	Unconfined compressive strength	(I.S 2720 part 10:1973)	2.43 kg/cm^2
8	California bearing ratio	(IS : 2720 Part 16) – 1987)	9.81%

5 METHODOLOGY:-

The clayey and red soil was replaced with four different percentage of quarry dust which were 8% 16% 24% and 32% by the weight of soil, where we get the maximum dry density of soil of that percentage of quarry dust replaced

to the soil and we again add egg shell powder with varying percentage of 4% 8% 12% and 16% to weight of soil, the various test are conducted are listed below.

1) Sieve analysis
2) Specific gravity
3) Compaction test
4) Atterberg limit.
   i) Liquid limit.
   ii) Plastic limit.
5) UCS
6) CBR

5.1 BLACK COTTON SOIL:-

Sieve analysis:-

Particle Size Distribution:-

Grain size analysis has been carried out as per the I.S. code of practice (I.S.1498:1970).As per the I. S code the given black cotton soil is classified as sandy soil.

Fig:-1 sieve shaker

Determination of Specific Gravity:-

The specific gravity of black cotton soil was determined according to IS: 2720 (part III, section-1) 1980. The specific gravity of black cotton determined as 2.66.

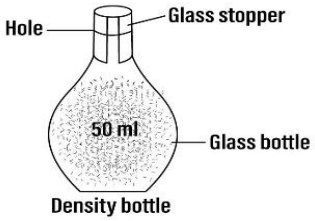

Fig:-2 density bottle

Compaction test:-

The moisture content, dry density relationships were found by using compaction tests as per IS: 2720 (part7) 1980. For this test, separately mixed black cotton soil and red soil with required amount of water and wet samples was compacted in proctor mould either in three or five equal layer using standard proctor rammer of 2.6 kg or modified proctor rammer of 4.5 kg. The moisture content relationship, Optimum moisture content (OMC) and Maximum dry density (MDD) were determined, Similarly compaction tests were conducted with different percentages of quarry dust replaced such as 0%, 8%, 16%, 24%, and 32% where get the maximum density value gained eggshell powder is added with a percentage of various 4% 8% 12% and 16% to the weight of soil and corresponding OMC and MDD were determined.

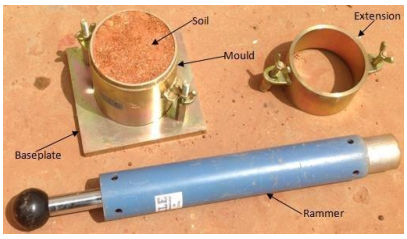

Fig:-3 proctor compaction test

Compaction test result value at various percentage Replacement of BCS by quarry dust.

Replacement of BCS by quarry dust for Various percentages	OMC In %	MDD In g/cc
Soil 100%+ quarry dust 0%	15.76	1.47
Soil 92 %+ quarry dust 8%	17.89	1.56
Soil 84%+ quarry dust 16%	19	1.59
Soil 76 %+ quarry dust 24%	**18.68**	**1.65**
Soil 68%+ quarry dust 32%	11.53	1.60

Compaction test result value for Optimum Replacement of BCS by quarry dust+ Addition of ESP by various percentages.

Optimum Replacement of BCS by quarry dust+ Addition of ESP by various percentages	OMC %	MDD g/cc
Soil 76%+ quarry dust 24%+4% ESP	20	1.67
Soil 76 %+ quarry dust 24%+8%ESP	16.50	1.75
Soil 76%+ quarry dust 24%+12% ESP	10	1.7

Liquid limit:-

The liquid limit of black cotton soil and red soil was determined according to I.S:2720 (part V 1985). The liquid limit of black cotton soil was found to be 40% and liquid limit of red soil found 37% there were test also conducted with the replacement and introduction of quarry dust and egg shell powder with respective to compaction test results.

Fig:-4 casagrand apparatus

Liquid Limit result value at various percentage Replacement of BCS by quarry dust.

various percentage Replacement of quarry dust	Liquid limit
Soil 100%+ quarry dust 0%	40%
Soil 92 %+ quarry dust 8%	43%
Soil 84%+ quarry dust 16%	45%
Soil 76 %+ quarry dust 24%	**48%**
Soil 68%+ quarry dust 32%	42%

Liquid Limit result value for Optimum Replacement of BCS by quarry dust+ Addition of ESP by various percentages.

Optimum percentage Replacement of quarry dust+ Addition of ESP by various percentages	Liquid limit
Soil 76%+ quarry dust 24%+4% ESP	48%
Soil 76 %+ quarry dust 24%+8%ESP	56%
Soil 76%+ quarry dust 24%+12% ESP	56%

Plastic Limit:-

The plastic limit of black cotton soil and red soil was determined according to IS: 2720 (part V 1985). The plastic limit of black cotton soil was found to be 23% and red soil 20% there were test also conducted with the replacement and introduction of quarry dust and egg shell powder with respective to compaction test results.

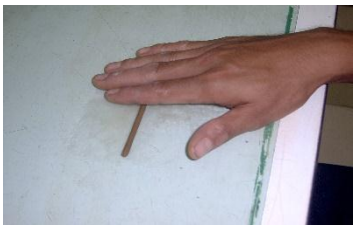

Fig:-5 Plastic Limit

Plastic Limit result value at various percentage Replacement of BCS by quarry dust.

various percentage Replacement of quarry dust	Plastic limit
Soil 100%+ quarry dust 0%	23%
Soil 92 %+ quarry dust 8%	24%
Soil 84%+ quarry dust 16%	26%
Soil 76 %+ quarry dust 24%	**27.27%**
Soil 68%+ quarry dust 32%	28%

Plastic Limit result value for Optimum Replacement of BCS by quarry dust+ Addition of ESP by various percentages.

Optimum percentage Replacement of quarry dust+ Addition of ESP by various percentages	Plastic limit
Soil 76%+ quarry dust 24%+4% ESP	31.4%
Soil 76 %+ quarry dust 24%+8%ESP	34.28%

Soil 76%+ quarry dust 24%+12% ESP	35.7%

Unconfined compressive strength:-

The black cotton soil and red soil Unconfined compressive strength is the load per unit area at which an unconfined cylindrical specimen of soil will fail in compression test. The unconfined compressive test has been carried out as per I.S code of practice (I.S 2720 part 10:1973). There were test also conducted with the replacement and introduction of quarry dust and eggshell powder with respective to compaction test results.

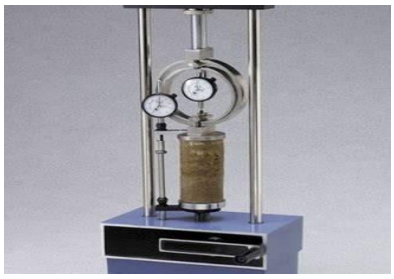

Fig:-6 unconfined compressive strength

UCS result value at various percentages Replacement of BCS by quarry dust.

Replacement of BCS by quarry dust for Various percentages	UCS kg/cm²
Soil 100%+ quarry dust 0%	1.89%
Soil 92 %+ quarry dust 8%	2%
Soil 84%+ quarry dust 16%	2.29%
Soil 76 %+ quarry dust 24%	**2.57%**
Soil 68%+ quarry dust 32%	2.43%

UCS result value for Optimum Replacement of BCS by quarry dust+ Addition of ESP by various percentages.

Optimum Replacement of BCS by quarry dust + Addition of ESP by various percentages	UCS kg/cm²
Soil 76%+ quarry dust 24%+4% ESP	2.89%
Soil 76 %+ quarry dust 24%+8%ESP	3.027%
Soil 76%+ quarry dust 24%+12% ESP	2.94%

California bearing ratio:-

The California Bearing Ratio (CBR) test is a standardized laboratory test used to determine the relative strength of a material such as soil, aggregate, or pavement subgrade. These test measures the pressure required to penetrate a soil sample with a standard piston at a standard rate, and then compares the result to the pressure required to penetrate a standard material (typically crushed rock or gravel) under the same conditions. The ratio of the pressure required for the soil sample to the pressure required for the standard material is known as the California Bearing Ratio, and it provides an indication of the strength and bearing capacity of the soil. The CBR test is commonly used in civil engineering and road construction to design and evaluate pavement subgrades and base courses.

Fig:-7 California bearing ratio

CBR result value at various percentage Replacement of BCS by quarry dust.

Replacement of BCS by quarry dust for Various percentages	CBR
Soil 100%+ quarry dust 0%	8.87%
Soil 92 %+ quarry dust 8%	9.7%
Soil 84%+ quarry dust 16%	9.92%
Soil 76 %+ quarry dust 24%	10.09%
Soil 68%+ quarry dust 32%	10.02

CBR result value for Optimum Replacement of BCS by quarry dust+ Addition of ESP by various percentages.

Optimum Replacement of BCS by quarry dust+ Addition of ESP by various percentages.	CBR
Soil 76 %+ quarry dust 24%+4% ESP	11.74%
Soil 76%+ quarry dust	12.37%

24%+8%ESP	
Soil 76 %+ quarry dust 24%+12 %ESP	10.00%

6.0 RED SOIL:-

Sieve analysis:-

Particle Size Distribution:-

Grain size analysis has been carried out as per the I.S. code of practice (I.S.1498:1970).As per the I. S code the given red soil is classified as sandy soil.

Determination of Specific Gravity:-

The specific gravity of red soil was determined according to IS: 2720 (part III, section-1) 1980. The specific gravity of red soil was found to be 2.55.

Compaction:-

Compaction test result value at various percentage Replacement of Red soil by quarry dust.

Replacement of Red soil by quarry dust for Various percentages	OMC in%	MDD g/cc
Soil 100%+ quarry dust 0%	14.11	1.630
Soil 92 %+ quarry dust 8%	17	1.71
Soil 84%+ quarry dust 16%	**16.84**	**1.75**
Soil 76 %+ quarry dust 24%	12	1.70

Compaction test result value for Optimum Replacement of Red by quarry dust+ Addition of ESP by various percentages.

Optimum Replacement of Red by quarry dust+ Addition of ESP by various percentages.	OMC in %	MDD in g/cc
Soil 84%+ quarry dust 16%+4% ESP	17.27	1.80
Soil 84%+ quarry dust 16%+8%ESP	11.53	1.82
Soil 84%+ quarry dust	12.17	1.86
16%+12% ESP		
Soil 84%+ quarry dust 16%+16% ESP	8.6	1.77

Liquid limit:-

Liquid Limit result value at various percentage Replacement Red soil by quarry dust.

Replacement of Red soil by quarry dust for Various percentages	Liquid limit
Soil 100%+ quarry dust 0%	37%
Soil 92 %+ quarry dust 8%	45.0%
Soil 84%+ quarry dust 16%	**45.6%**
Soil 76 %+ quarry dust 24%	42.5%

Liquid Limit result value for Optimum Replacement of Red soil by quarry dust+ Addition of ESP by various percentages.

Optimum Replacement of Red soil by quarry dust+ Addition of ESP by various percentages.	Liquid limit
Soil 84%+ quarry dust 16%+4% ESP	48%
Soil 84 %+ quarry dust 16%+8%ESP	49%
Soil 84%+ quarry dust 16%+12% ESP	53.1%
Soil 84%+ quarry dust 16%+16% ESP	52%

Plastic limit:-

Plastic Limit result value at various percentage Replacement of red soil by quarry dust.

Replacement of Red soil by quarry dust for Various percentages	Plastic limit
Soil 100%+ quarry dust 0%	20%
Soil 92 %+ quarry	22.22%

dust 8%	
Soil 84%+ quarry dust 16%	**26.31%**
Soil 76 %+ quarry dust 24%	25%

Plastic Limit result value for Optimum Replacement of Red soil by quarry dust+ Addition of ESP by various percentages.

Optimum Replacement of Red soil by quarry dust+ Addition of ESP by various percentages.	Plastic limit
Soil 84%+ quarry dust 16%+4% ESP	28.57%
Soil 84 %+ quarry dust 16%+8%ESP	29%
Soil 84%+ quarry dust 16%+12% ESP	29.166%
Soil 84%+ quarry dust 16%+16% ESP	31.03%

Unconfined compressive strength:-

UCS result value at various percentage Replacement of Red soil by quarry dust.

Replacement of Red soil by quarry dust for Various percentages	UCS kg/cm²
Soil 100%+ quarry dust 0%	2.43
Soil 92 %+ quarry dust 8%	2.60
Soil 84%+ quarry dust 16%	**2.87**
Soil 76 %+ quarry dust 24%	2.79

UCS result value for Optimum Replacement of Red soil by quarry dust+ Addition of ESP by various percentages.

Optimum Replacement of Red soil by quarry dust+ Addition of ESP by various percentages.	UCS kg/cm²
Soil 84%+ quarry dust 16%+4% ESP	3.066
Soil 84 %+ quarry dust 16%+8%ESP	3.40
Soil 84%+ quarry dust 16%+12% ESP	3.55
Soil 84%+ quarry dust 16%+16% ESP	3.32

California bearing ratio:-

CBR result value at various percentage Replacement of Red soil by quarry dust.

Red soil in % and replacement of quarry dust in %	CBR
Soil 100%+ quarry dust 0%	9.81%
Soil 92 %+ quarry dust 8%	9.99%
Soil 84%+ quarry dust 16%	**10.27%**
Soil 76 %+ quarry dust 24%	10.16%

CBR result value for Optimum Replacement of Red soil by quarry dust+ Addition of ESP by various percentages.

Optimum Replacement of Red soil by quarry dust+ Addition of ESP by various percentages.	CBR
Soil 84%+ quarry dust 16%+4%ESP	11.32%
Soil 84%+ quarry dust 16%+8%ESP	12.49%
Soil 84%+ quarry dust 16%+12%ESP	13.43%
Soil 76 %+ quarry dust 16%+16%ESP	11.91%

CONCLUSION:-

- The effectiveness of utilization of the quarry dust and egg shell powder as a stabilizer which improving the properties of black cotton soil and red soil.
- The combination of quarry dust and egg shell powder is more effective than the addition of

quarry dust or egg shell powder along for the improvement of properties of soil.

- The optimum mix proportion was found to be 76% soil+24% quarry dust + 8%Egg shell powder for Black cotton soil.
- Liquid limit value is increased by 40%.
- Plastic limit value is increased by 49%.
- For this optimum mix proportion MDD is increases by 19.04%and OMC is increased by 4.69%.
- The CBR value is increased by 39.45%.
- The UCS value is increased by 60%.
- The optimum mix proportion was found to be 84% soil+16%of quarry dust+12% of eggshell powder for Red soil.
- Liquid limit value is increased by 43.51%
- Plastic limit value is increased by 56%.
- For this optimum mix proportion MDD is increases by 14.11% and OMC is decreased by 15.94%.
- The CBR value is increased by 36.90%.
- The UCS value is increased by 46%.

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