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Quarry Dust – A Key Player in Improving The Geo-Technical Properties of Subgrade Soil

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ABSTRACT :*Quarries and aggregate crushers are basic requisites for construction industry and quarry dust is a byproduct of rubble crusher units. Disposal of such wastes poses lots of geo environmental problems such as landfill disposal problems and environmental hazards. Geotechnical and mineralogical characterization of quarry dust and its interaction behavior with soils can lead to viable solutions for its large-scale utilization and disposal Utilization of Quarry Dust. Improvement in engineering properties of soil such as an increase the CBR value reduces permeability, increase the compressive strength and increase the shear strength. Stabilization of the Sub grade Soil by Adding Quarry Dust increases the durability of pavement subgrade and avoid pot holes in highway which is one of major failure as it reduces the plasticity soil and it also benefits the design cost of construction.Shear strength and compressive strength of the soil for various mix proportions of quarry dust have been determined and compared in this project. It has also been concluded with the right percentage of quarry dust to be added to the soil to get the best stabilization.*

Keywords:*Quarry dust, stabilization, shear strength, CBR value, sub grade soil*

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I. INTRODUCTION

1.1 Importance of Quarry dust

Quarry dust is a byproduct of the crushing process which is a concentrated material to use as aggregates for concreting purpose, especially as fine aggregates. In quarrying activities, the rock has been crushed into various sizes; during the process the dust generated is called quarry dust and it is formed as waste. So it becomes as a useless material and also results in air pollution. The Stabilization of soil is important in construction of foundations and highways as it improves the Engineering properties of soil like Compressibility, Permeability and Shear Strength. (1) Therefore, quarry dust should be used in construction works, which will reduce the cost of construction and the construction material would be saved and the natural resources can be used properly. Quarry dust has been used for different activities in the construction industry, such as building materials, road development materials, aggregates, bricks, and tiles. Quarry dusts are considered as one of the well accepted as well as cost effective ground improvement technique for weak soil deposits.(2)The Stabilization of soil is important in construction of foundations and highways as it improves the Engineering properties of soil like Compressibility, Permeability and Shear Strength. The present research work mainly deals with the influence of different replacement proportion of soil with quarry dust.

1.2 Applications of quarry dust

Construction Industry

This type of dust is getting popular in construction projects such as road construction, building houses and making bricks and tiles.Quarry dust is ideal for these jobs and is expected to be the future and likely replacement for sand in construction project, since river sand is fast becoming scarce and very expensive.

Highway Construction

This dust is widely used in the construction of roads projects, especially in the manufacture of slabs, and making retaining walls. It is also used filling roads before asphalting. It is believed that quarry dust makes stronger slabs and walls at construction site. Cheap Material for Home Builders Quarry dust uses is not limited to highway projects, in construction projects that involves homes building, it is fast becoming popular too. Partial replacement of sand with quarry dust will make good concrete that is well desired in residential construction. The final product is strong bricks, slabs or tiles that are produced at lower cost compare to using sand.
Saves Cost Demand for sand from river beds is on the increase, so is getting too expensive daily, a construction project that utilizes quarry dust come at cheaper cost and lesser pressure on market demand for sand.The shift in demand for sand in construction project is ongoing, and is not a surprise that this dust is the safe haven, with better innovation and inventions, it won't be something unimaginable to see quarry dust replacing sand in the construction projects.

1.3 Aim of the research

1. To determine the shear strength and compressive strength of the soil for various mix proportions of quarry dust.
2. To determine various index properties of soil with quarry dust.
3. To Stabilize the Sub grade Soil By Adding Quarry Dust.
4. 1.4 Scope of the research
5. To improve the engineering properties of soil such as an increase the CBR value, reduce permeability, increase the compressive strength and to increase the shear strength.
6. To increase the durability of pavement subgrade.
7. To decrease the thickness of subgrade.
8. To avoid pot holes in highway.
9. To reduce in plasticity of soil.
10. To eliminate the excavation material hauling or handling.
11. To benefit the design cost of construction.

II. METHODOLOGY

Mix proportions

The mixing of quarry dust is increasing 0-30% at an increment of 5%.The percentage of admixture mixed by weight of soil. Various percentage of mix proportions are in Table 2.1.

Table 2.1 Mix proportions of Quarry dust

Sl.no	Sub-base soil percentage	Quarry dust percentage	Sub-base soil percentage by adding quarry dust
1	100	0	100
2	95	5	100
3	90	10	100
4	85	15	100
5	80	20	100
6	75	25	100
7	70	30	100

Properties of Materials

Properties of Quarry Dust

Physical properties of quarry dust based on Indian Standard recommendations are determined andtabulatedin Table 2.2.

Table 2.2 Physical properties of Quarry Dust

Property	Quarry dust	Natural sand	Test method
Bulk density(kg/m3)	1720-1810	1460	IS 2386(part-3)-1963
Absorption(%)	1.20-1.50	Nil	IS 2386(part-3)-1963
Moisture content(%)	Nil	1.50	IS 2386(part-3)-1963
Fine particles<0.075mm(%)	12-15	6	IS 2386(part-3)-1963
Sieve analysis	Zone 2	Zone 2	IS 383-1970

Index properties

Index properties are the properties that are used to identify the types of soil Various properties of materials such as specific gravity ,liquid limit and plastic limit are determined for various percentages of substitution of quarry dust.

Specific gravity test

Specific gravity test was conducted for various percentage of substitution of Quarry Dust using the pycnometer method and the results are tabulated from tables 2.2 to table 2.7.

Table 2.2 Specific gravity results for 0% admixture

Trail	Empty weight of pycnometer in (gm)	Weight of pycnometer+soil in(gm)	Weight of pycnometer+soil+water in(gm)	Weight of pycnometer+water in(gm)	Specific gravity (G)
1	661	960	1545	1380	2.231
2	660	958	1558	1390	2.292
3	678	976	1596	1433	2.207
				G=	2.243

Table 2.3 Specific gravity results for 5% admixture

Trail	Empty weight of pycnometer in (gm)	Weight of pycnometer+soil in(gm)	Weight of pycnometer+soil+water in(gm)	Weight of pycnometer+water in(gm)	Specific gravity (G)
1	656	957	1551	1412	1.858
2	664	966	1522	1402	1.659
3	672	973	1574	1422	2.020
				G =	1.845

Table 2.4 Specific gravity results for 10% admixture

Trail	Empty weight of pycnometer in (gm)	Weight of pycnometer+soil in(gm)	Weight of pycnometer+soil+water in(gm)	Weight of pycnometer+water in(gm)	Specific gravity (G)
1	656	956	1572	1412	2.142
2	664	962	1555	1402	2.055
3	672	973	1557	1422	1.813
				G =	2.000

Table 2.5 Specific gravity results for 15% admixture

Trail	Empty weight of pycnometer in (gm)	Weight of pycnometer+soil in(gm)	Weight of pycnometer+soil+water in(gm)	Weight of pycnometer+water in(gm)	Specific gravity (G)
1	1	556	954	1582	1412
2	2	664	962	1559	1402
3	3	672	973	1578	1422
				G =	2.172

Table 2.6 Specific gravity results for 20% admixture

Trail	Empty weight of pycnometer in (gm)	Weight of pycnometer+soil in(gm)	Weight of pycnometer+soil+water in(gm)	Weight of pycnometer+water in(gm)	Specific gravity (G)
1	656	955	1587	1412	2.411
2	664	963	1531	1402	1.758
3	672	972	1572	1422	2.000
				G =	2.056

Table 2.7 Specific gravity results for 25% admixture

Trail	Empty weight of pycnometer in (gm)	Weight of pycnometer+soil in(gm)	Weight of pycnometer+soil+water in(gm)	Weight of pycnometer+water in(gm)	Specific gravity (G)
1	656	956	1554	1412	1.898
2	664	963	1508	1402	1.549
3	672	972	1564	1422	1.898
				G =	1.782

Table 2.8 Specific gravity results for 30% admixture

Trail	Empty weight of pycnometer in (gm)	Weight of pycnometer+soil in(gm)	Weight of pycnometer+soil+water in(gm)	Weight of pycnometer+water in(gm)	Specific gravity (G)
1	**656**	**956**	**1563**	**1412**	**2.013**
2	664	962	1580	1402	2.483
3	672	973	1579	1422	2.090
				G =	2.195

Table 2.9 Specific gravity results for Quarry dust

Trail	Empty weight of pycnometer in (gm)	Weight of pycnometer+soil in(gm)	Weight of pycnometer+soil+water in(gm)	Weight of pycnometer+water in(gm)	Specific gravity (G)
1	656	957	1551	1412	1.858
2	664	966	1522	1402	1.659
3	672	973	1574	1422	2.020
				G =	1.845

Liquid limit test

Liquid limit is the minimum water content at which soil tends to flow as liquid. It the change of state of soil from liquid state to semi solid state. Liquid limit test is conducted for various percentages of quarry dust and reported in table 2.10 to 2.16.

Table 2.10 Liquid limit results for 0% admixture

No Of Flows	Weight Of the Empty Container in (Gm)	Weight Of the Container + Wet Soil In (Gm)	Weight Of the Container + Dry Soil In (Gm)	Water Content (Gm)	Weight Of Dry Soil in (Gm)	% of Water Content
179	29	44	40	4	11	36.36
75	30	37	36	1	6	16.67
23	29	40	37	3	8	37.50

Table 2.11 Liquid limit results for 5% admixture

No Of Flows	Weight Of the Empty Container in (Gm)	Weight Of the Container + Wet Soil In (Gm)	Weight Of the Container + Dry Soil In (Gm)	Water Content (Gm)	Weight Of Dry Soil in (Gm)	% of Water Content
171	27	35	31	4	4	100
60	28	36	34	2	6	33.33
28	30	35	33	2	3	66.67

Table 2.12 Liquid limit results for 10% admixture

No Of Flows	Weight Of the Empty Container in (Gm)	Weight Of the Container + Wet Soil In (Gm)	Weight Of the Container + Dry Soil In (Gm)	Water Content (Gm)	Weight Of Dry Soil in (Gm)	% of Water Content
190	28	35	34	1	6	16.67
107	28	34	33	1	5	20
44	28	35	34	1	6	16.67

Table 2.13 Liquid limit results for 15% admixture

No Of Flows	Weight Of the Empty Container in (Gm)	Weight Of the Container + Wet Soil In (Gm)	Weight Of the Container + Dry Soil In (Gm)	Water Content (Gm)	Weight Of Dry Soil in (Gm)	% of Water Content
105	28	37	36	1	8	12.5
44	28	40	39	1	11	9.09
18	28	36	35	1	7	14.29

Table 2.14 Liquid limit results for 20% admixture

No Of Flows	Weight Of the Empty Container in (Gm)	Weight Of the Container + Wet Soil In (Gm)	Weight Of the Container + Dry Soil In (Gm)	Water Content (Gm)	Weight Of Dry Soil in (Gm)	% of Water Content
162	26	35	33	2	7	28.75
132	26	35	33	2	7	28.57
73	26	32	30	2	4	50.00

Table 2.15 Liquid limit results for 25% admixture

No Of Flows	Weight Of the Empty Container in (Gm)	Weight Of the Container + Wet Soil In (Gm)	Weight Of the Container + Dry Soil In (Gm)	Water Content (Gm)	Weight Of Dry Soil in (Gm)	% of Water Content
186	25	34	32	2	7	28.57
113	26	35	33	2	7	28.57
42	29	44	40	4	11	36.36

Table 2.16 Liquid limit results for 30% admixture

No Of Flows	Weight Of the Empty Container in (Gm)	Weight Of the Container + Wet Soil In (Gm)	Weight Of the Container + Dry Soil In (Gm)	Water Content (Gm)	Weight Of Dry Soil in (Gm)	% of Water Content
206	32	43	41	2	9	22.2
123	28	41	38	3	10	30.00
39	27	39	37	2	10	20.00

Plastic limit

Plastic limit is minimum water content at which the soil pat produces the visible cracks when threaded into 3mm diameter rods. It can also be defined as the change of state from semi solid state to solid state .plastic limit values for different percentage of substitution of quarry dust is shown in table

Table 2.17 Plastic limit values for different percentages of admixtures

% of admixture	Plastic limit value
0	6.25
5	7.02
10	9.09
15	17.14
20	36.3
25	37.0
30	37.5

2.2.3 Compaction test

The Proctor compaction test is a laboratory method of experimentally determining the optimal moisture content at which a given soil type will become most dense and achieve its maximum dry density. Diameter of mould is 10cm , Height of mould is 12.73cm and Weight of hammer =2.6kg .Tests are conducted for various percentages of substitution of Quarry dust and represented in table 2.18

Table 2.18 Optimum moisture content and maximum dry density of soil with percentages of Quarry dust

% of admixture	Optimum moisture content	Maximum dry density
0	10	2.01
5	10	2.03
10	10	2.04
15	10	2.03
20	10	1.99
25	10	2.01
30	10	1.93

III. RESULTS AND DISCUSSIONS

1. The addition of quarry dust decreases the Plastic limit Liquid limit, Plasticity index goes on decreasing and plastic limit and shrinkage limit goes on increasing with increase in percentage of lime in expansive soil-quarry dust mixes.
2. The addition of quarry dust decreases the OMC and increases the MDD of the expansive soil. OMC goes on increasing and MDD goes on decreasing with increase in percentage of lime in expansive soil-quarry dust mixes and up to 5% of lime content the MDD of expansive soil-quarry dust mix is greater than that of virgin soil .
3. The addition of quarry dust to expansive soil decreases the cohesion and increases the angle of internal friction. With the addition of lime to soil-quarry dust mixes, the cohesion and angle of internal friction value increases up to 5% addition of lime and decreases with further increase in lime content. iv. Addition of lime makes the soil-quarry dust mixes durable. The percentage reduction of UCS is lowest at 5% lime addition
4. Maximum dry density is maximum for 10% of substitution of Quarry dust which could be useful to achieve maximu compaction.

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