

# Improvement of California Bearing Ratio Value of Soil by Addition of Quarry Dust and Plastic Strips

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**ABSTRACT:** Soil stabilization can be done in number of ways, but the stabilization using industrial wastes such as quarry dust and waste plastic strips is an economic method since the stabilizers used are waste materials, which are easily and cheaply available, hence an attempt is made to reduce the waste disposal problems up to some extent by utilizing these waste materials for engineering purposes. An experimental investigation is carried out to study the effect of quarry dust and waste plastic strips on strength properties of local soil. The properties of stabilised soil such as compaction characteristics, california bearing ratio were evaluated and their variations with content of quarry dust and waste plastic strips are evaluated. Addition of either optimum percentage (30%) of quarry dust and optimum percentage (1.5%) of waste plastic strips or optimum percentage of its combination to the soil has improved the strength characteristics of the subgrade.

**KEYWORDS:** CBR, UCS, MDD, OMC, Plastic Strips, Quarry dust.

## I. INTRODUCTION

Air pollution is a major environmental problem in the developing and developed countries of the world. Quarry dust is one of the frequently criticized nuisances due to its health and environmental implications on surrounding community. Due to the high demand for rubble and aggregates for construction purposes, rubble quarries and aggregate crushers are very common. Out of the different industrial wastes; quarry dust is one, which is produced in abundance. Quarry dust exhibits high shear strength, which is highly beneficial for its use as a geotechnical material. It has good permeability and variation in water content does not seriously affect its desirable properties. In this background, any attempt to utilize this waste in developmental activities is relevant.

The bottled water is the fastest growing beverage industry in the world. The general survey shows that 1500 bottles are dumped as garbage every second. Polyethylene terephthalate (PET) is reported as one of the most abundant plastics in solid urban waste. On an average, an Indian uses one kilogram of plastics per year and the world annual average is an alarming 18 kg. It is estimated that approximately 4-5 percent post-consumer plastics waste by weight of municipal solid waste (MSW) is generated in India and the plastic waste generation is more in other developed countries [9].

In this study, quarry dust was used to accomplish the physical stabilisation of local soil. Quarry dust (or screenings) is a by-product of rubble crusher units in the construction aggregate industry or quarries. In general, three types of mineral fines are produced, (namely; dry screenings, bag house fines and wet screenings or settling pond fines) Quarry dust is made up of the finer fraction of crushed stone that accumulates after primary and secondary crushing and separation. Literature study reported improvements in the compaction characteristics and california bearing ratio (CBR) of three soils namely; red earth, kaolinite and cochin marine clay, which were achieved by the addition of quarry dust.

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This study also presents simple way of recycling plastic water bottles in the field of civil engineering as reinforcing material. The plastic waste mixed soil behaves as reinforced soil, similar to fiber- reinforced soil. The concept of soil reinforcement has dramatically changed the function of soil as a construction material.

## II. EXPERIMENTAL WORK

Materials used in the study are soil, quarry dust and plastic bottle strips and the properties of those are shown in table

**Table 1: Properties of soil and quarry dust used in the present study**

Properties	Soil Values	Quarry dust
Specific gravity, G	2.52	2.85
Atterberg Limits; Liquid limit, $w_L$ (%) Plastic limit, $w_P$ (%) Plasticity index, $I_P$ (%)	46 26 20	NP
Compaction characteristics; Maximum dry density, $\gamma_{dmax}$ (kN/m <sup>3</sup> ) Optimum moisture content, $W_{OMC}$ (%)	15.70 21.10	20.60 12.20
Grain size distribution; Sand (%) Silt & Clay (%)	14.50 85.50	91.30 8.70
IS classification	CI	SW
CBR (soaked) (%)	2.51	7.37

**Table 2. Properties of waste plastic used in the present study**

Properties	Value
Thickness (mm)	0.1
Specific gravity	1.33
Density (gm/cm <sup>3</sup> ) (at 20 <sup>0</sup> C)	1.38

There are three different size of plastic strips were used by sieving the material.

- i. Plastic strips retained between 20 mm and 10 mm size sieves designated as type I.
- ii. Plastic strips retained between 10 mm and 4.75 mm size sieves designated as type II.
- iii. Plastic strips retained between 4.75 mm and 1 mm size sieves designated as type III

## III. EXPERIMENTAL RESULTS

### Effect of quarry dust on soil

The variations in the geotechnical properties of soil are observed when different percentage of quarry dust is added to soil.

### Compaction characteristics of soil mixed with quarry dust

The variation in maximum dry density of soil with addition of quarry dust is shown in the figure 4.1 from the figure it is observed that with increase in percentage of quarry dust the maximum dry density (MDD) increases significantly,

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this is because of the increase in percentage of sand and high specific gravity of quarry dust. The maximum dry density of soil increased from 15.7 to 16.09, 16.87, 17.56, 18.05, 18.54 and 18.93 for the addition of quarry dust of 0%, 10%, 20%, 30%, 40%, 50% and 60% respectively. The experimental values are given in table 4.1 for addition of different percentage of quarry dust to the soil.

### California bearing ratio soil mixed with quarry dust

California bearing ratio test was performed after completion of four days soaking period on soil and quarry dust mixes compacted at their OMC at a strain rate of 1.25mm/min as per IS code provisions For the quarry dust of 0%, 10%, 20%, 30%, 40%, 50% and 60% the CBR values are 2.51, 2.99, 3.39, 5.66, 7.04, 8.02 and 10.19 respectively. The variation of CBR value is shown in the figure. At high CBR values, the particles offer more strength due to mobilization of frictional resistance under compression due to closer packing of particles.

Table 3 Experimental results of tests on soil with quarry dust

Sample soil : quarry dust	$\gamma_{dmax}$ (kN/m <sup>3</sup> )	OMC (%)	CBR (%)
00:0	15.70	21.10	2.51
90:10	16.09	20.15	2.99
80:20	16.87	19.00	3.39
70:30	17.56	18.30	5.66
60:40	18.05	17.00	7.04
50:50	18.54	15.50	8.02
40:60	18.93	15.00	10.19

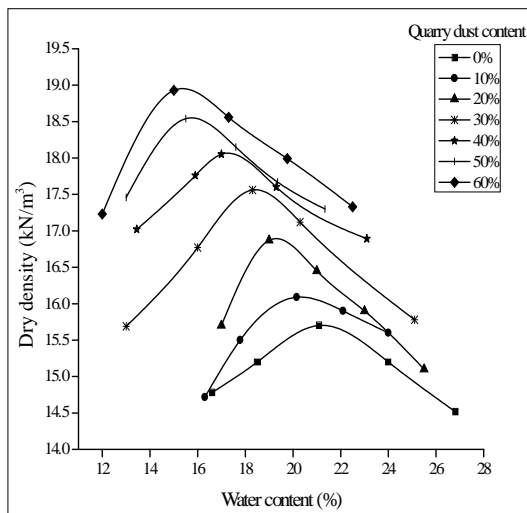
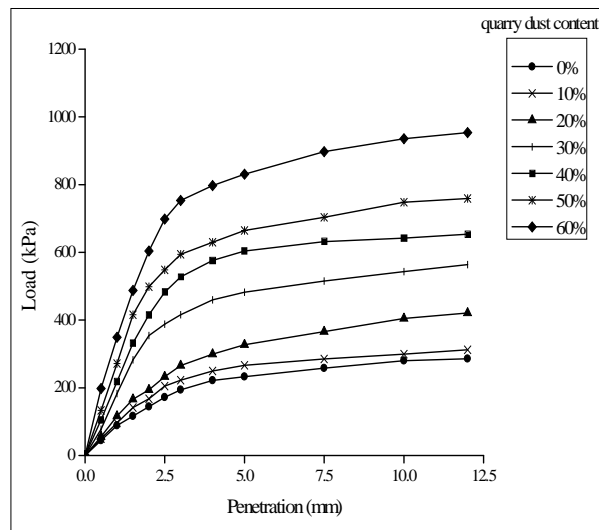


Figure 1 a) Dry density Vs water content for soil with quarry dust



b) Load Vs penetration curve for soil with quarry dust

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## II. EFFECT OF WASTE PLASTIC ON SOIL

Based on the experimental results, discussions have been made in this section. Effect of plastic content on compaction properties and effect of waste plastic content on CBR behaviors of soil alone and soil mixed with waste plastic strips have been discussed briefly.

### 2.1 Effect of waste plastic strips on compaction properties of soil

Optimum moisture content (OMC) and maximum dry density (MDD) relations from standard proctor compaction tests for soil alone and soil mixed with waste plastic strips are summarized in Table 4.

**Table 4 Experimental values of compaction tests of soil and CBR mixed with plastic strips**

Size of plastic strip	Plastic strip content (%)	OMC (%)	MDD (kN/m <sup>3</sup> )	CBR (%)
Type I Retained between 20mm and 10 mm size sieves	0	21.1	15.7	2.51
	0.5	20.99	15.62	2.83
	1	20.8	15.58	3.15
	1.5	20.46	15.41	4.53
	2	20.1	15.3	3.02
	2.5	19.88	14.98	1.86
Type II Retained between 10 mm and 4.75 mm size sieves	0	21.1	15.7	2.51
	0.5	21	15.6	2.75
	1	20.89	15.55	3
	1.5	20.6	15.398	3.48
	2	20.2	15.25	2.2
	2.5	19.9	15.09	1.78
Type III Retained between 4.75 mm and 1 mm size sieves	0	21.1	15.7	2.51
	0.5	21.08	15.58	2.75
	1	20.95	15.49	2.9
	1.5	20.7	15.26	3.16
	2	20.3	15.09	2.12
	2.5	20	14.859	1.7

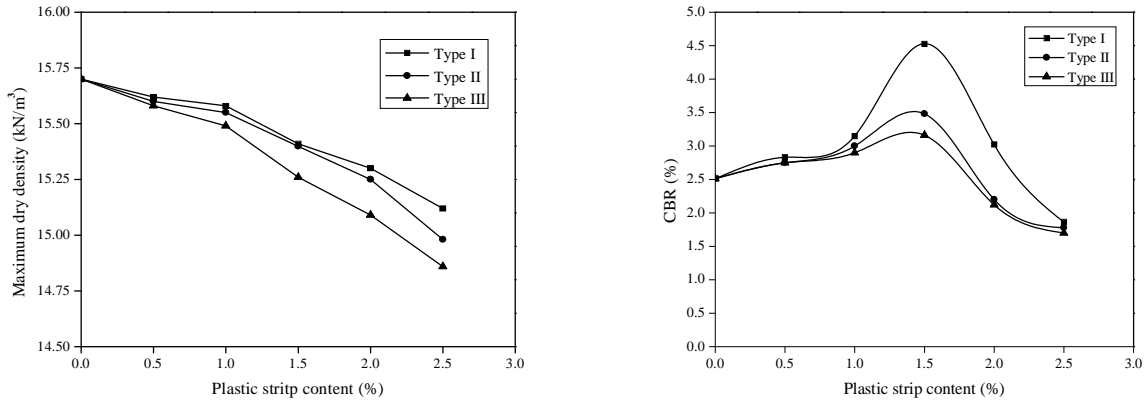


Figure 2 a) Variation of maximum dry density of soil with plastic strip content

b) CBR vs plastic strip content

### Effect of combination of quarry dust and plastic strips on soil

In order to obtain maximum strength, the soil is tested by adding 30% of quarry dust and 1.5% Type I plastic strips. From the results it is found that there is increase in strength by adding optimum percentages of both quarry dust and waste plastic strips. Figure 4.14 shows the dry density *V/s* optimum moisture content for soil alone, soil with quarry dust, soil with plastic strips and combination of soil plus quarry dust plus plastic strips. For the combination of soil plus 30% quarry dust plus 1.5% plastic strips the maximum dry density (*MDD*) and optimum moisture content (*OMC*) are 17.1 kN/m<sup>3</sup> and 18% respectively. Figure 4.15 shows the variation of *CBR* with soil alone, soil with quarry dust and soil with plastic strips and combination of soil plus quarry dust plus plastic strips. For the combination of soil plus 30% quarry dust plus 1.5% plastic strips the *CBR* value is 7.95, which is 3.17 times more than normal soil.

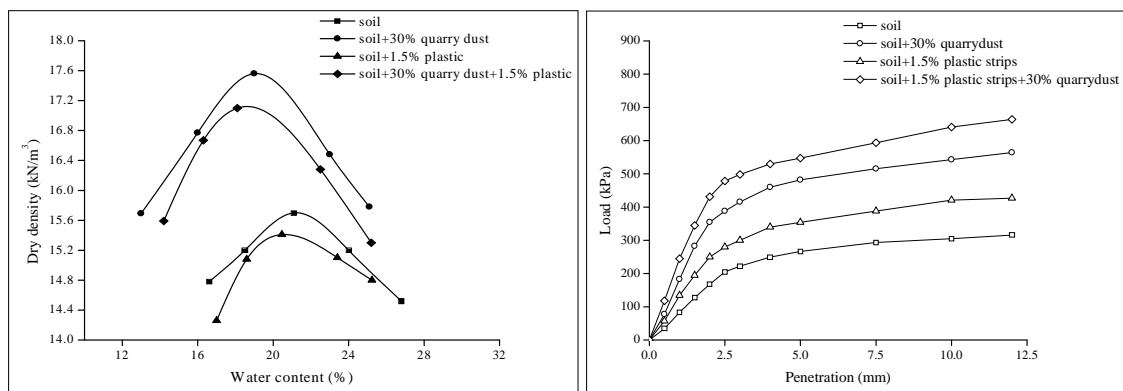


Figure 3 a) Dry density Vs moisture content for soil, with quarry dust, soil with plastic and its combination

b) Load Vs penetration curve for soil, soil with quarry dust, soil with soil plastic and combination of plastic and quarry dust with soil.

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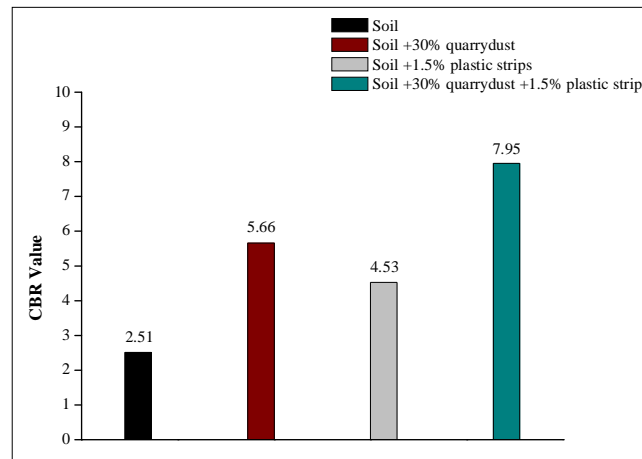


Figure 4 Variation of CBR value

## IV. CONCLUSION

Based on the present study, the following conclusions are drawn.

1. The addition of quarry dust decreases the OMC and increases the MDD of the soil and also CBR value of soil increased. The experimental results of compaction tests indicate that maximum dry density (MDD) of plastic reinforced soil decreases with increasing plastic strip content. There is marginal decrease in the optimum moisture content (OMC).
2. For soil admixed with only quarry dust, the optimum combination is found to be 70% soil and 30% quarry dust. The soaked CBR value of this mix is found to be 5.66, which is 2.255 times more than CBR value of soil alone. For soil admixed with only waste plastic strips, the optimum combination is found to be 1.5% plastic strips of size retained between 20mm and 10mm size IS sieves. The soaked CBR value of this mix is found to be 4.53, which is 1.8 times more than CBR value of soil alone.
3. For soil admixed with quarry dust and plastic, the proportion which yielded max CBR value was found to be 70% soil, 30% quarry dust and 1.5% plastic strips. The soaked CBR value of this combination was 7.95, which is 3.167 times more than soil alone.
4. There is increase in CBR value with addition of quarry dust and plastic strips and the increase in strength with addition of optimum percentage of quarry dust and waste plastic strips are more compared to only quarry dust and plastic strips with soil.
5. The reinforcement benefit increases with an increase in size and percentage of plastic strip content up to certain limit, and beyond that it reduces its strength.
6. This study has attempted to provide an insight into the CBR behaviour of quarry dust and waste plastic (PET) strip mixed soil for use in subgrade in constructing rural roads, utilizing some portion of the waste in this way will reduce the quantity of the waste requiring disposal. More so the disposal in this way will be in an environmental friendly manner.

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