Effect of Tire Chips on the Strength of Cement/Lime Stabilized Silty Soil

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ABSTRACT: In this study, High plasticity silt (MH) soil was tested. Initially cement and lime were added with soil, by pre determined quantities to stabilize the soil sample. The strength of samples were determined by conducting both soaked and unsoaked CBR tests. Tire chips were added to cement and lime stabilized soil samples separately, and variation of strength was measured. Addition of 15% cement under unsoaked condition gives maximum CBR strength to the soil. Under soaked condition CBR value was continuously increased with the increment of cement quantity. Addition of 4% lime under soaked condition and 6% lime under unsoaked condition gives maximum CBR strength to the soil. Addition of tire chips does not have a greater influence towards the strength increment of silty soil. In order to gain highest bearing strength for silty soil sample, cement stabilization is better compared with lime stabilization.

1 INTRODUCTION

The strength of soil can be improved by stabilizing using admixtures. The objective of using these admixtures is to provide additional artificial cementation to the soil. In the study, cement and lime were used for soil stabilizing.

Direct disposal of waste tires have been a global problem because both open dumping and burning may lead to problems such as land pollution, air pollution, ground water contamination etc. Therefore, it is an effective solution to use waste tire chips as soil stabilizing agent. In the research, 10mm x 20mm rectangular typical tire chips with 2mm thickness were added with both cement and lime stabilized soil separately to check the soil strength. Although lime and cement improve the strength of soil, our intention was to find the contribution of tire chips towards the strength of stabilized soil samples.

2 MATERIALS AND METHODS

The required amount of soil was collected from a road construction site at Pilimathalawa-Poththapitiya Road. Air dried soil samples were used for all experiments. The physical properties of soil are as follows.

Liquid Limit	= 68%
Plastic Limit	= 34%
Plasticity Index	= 34%
Average specific gravity	=2.68
British Soil Classification	=MH

The soil type was determined according to BS 1377: Part 02 (1990). Cone Penetration test was used to find the liquid limit. Wet sieving and hydrometer tests were carried out to determine particle size distribution and it was obtained as well graded soil. BS 1377 part 02 (1990) was followed for determining specific gravity. Optimum moisture content and maximum dry density of soil samples were determined by conducting Modified Proctor Compaction Test according to BS 1377: Part 04(1990). Optimum moisture content and maximum dry density were found to be 11% and 2010 kg/m^3 respectively.

To find the strength of stabilized soil samples, soaked and unsoaked CBR tests were conducted according to BS 1377: Part 04. Soil stabilization was done at the optimum moisture content of raw soil. The quantity of stabilization agent was varied according to predefined percentages by weight. The quantity of stabilization agent which gives highest CBR value at soaked condition and unsoaked condition was determined separately. These selected quantities were used to stabilize soil samples using tire chips.

In order to stabilize soil using lime, quick lime powder was added. Quantity of lime added was varied as 2%, 4%, 6%, and 8 % (by weight). Ordinary Portland cement was used for cement stabilization. Quantity of cement added was varied as 5%, 10%, 15% and 20 % (by weight). CBR tests were conducted under both soaked and un-soaked conditions.

To stabilize the soil using tire chips, 10mm x 20mm rectangular tire chips with 2mm thickness were prepared using waste tubes of bicycle tires. Quantity of tire chips added was varied as 1%, 3% and 5 % (by weight) to stabilize raw soil, lime stabilized soil and cement stabilize soil separately under soaked and unsoaked conditions. It was assumed that, no water absorbed by the tire chips.

3 RESULTS AND DISCUSSION

3.1 Soil Stabilization using Lime

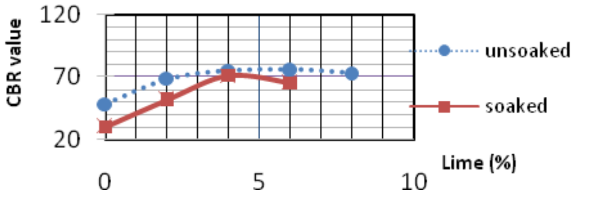

Fig. 1 Variation of soaked and unsoaked CBR values with lime %.

According to Fig. 1, unsoaked CBR values are greater than the soaked CBR values for lime stabilized soil.

Maximum unsoaked CBR value =76.25%
Corresponding Lime percentage =6%
Maximum soaked CBR value = 71.25%
Corresponding Lime percentage = 4%

Table 1. Variation of CBR values with the increment of lime percentage.

Lime %	CBR value	
	Unsoaked	Soaked
0	48.25	30.5
2	68.75	52.13
4	75.25	71.25
6	76.25	65.25
8	73.25	-

According to Table 1, 6% and 4% lime quantities were used to stabilize the soil sample under unsoaked and soaked conditions respectively, to check the effect of tire chips.

3.2 Soil Stabilization using Cement

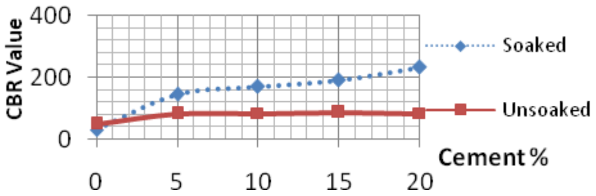

Fig. 2 Variation of soaked and unsoaked CBR values with cement %.

According to Fig. 2, soaked CBR values are greater than the unsoaked CBR values for cement stabilized soil. This is controversial when compared with results obtained for lime stabilized soil and raw soil. This may happened due to the hydration reaction of cement.

Maximum unsoaked CBR value = 85.48%
Corresponding cement percentage = 15%
Maximum soaked CBR value = 233.00%
Corresponding cement percentage = 20%

Table 2: Variation of CBR values with the increment of cement percentage.

Cement %	CBR value	
	Unsoaked	Soaked
0	48.25	30.50
5	81.40	144.50
10	82.75	169.00
15	85.48	190.50
20	82.58	233.00

According to Table 2, 15% cement quantity was used to stabilize the soil sample under both soaked and unsoaked conditions to check the effect of tire chips.

3.3 Effect of tire chips on raw soil

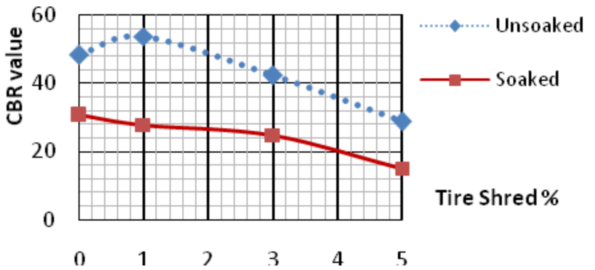

Fig. 3 Variation of soaked and unsoaked CBR values of raw soil with tire chips %.

According to Fig. 3, unsoaked CBR values are greater than the soaked CBR values.

Maximum unsoaked CBR value = 53.75%
Corresponding tire shred percentage = 1%
Maximum soaked CBR value = 30.50%
Corresponding tire chip percentage = 0%

Due to the addition of tire chips, soaked CBR value continuously reduced. Under unsoaked condition, 1% tire chip addition gives maximum CBR strength to the soil.

Table 3: Variation of CBR values and percentage CBR value reduction with the increment of tire chip percentage.

Tire %	CBR value		% CBR value reduction	
	Unsoaked	Soaked	Unsoaked	Soaked
0	48.25	30.50	–	–
1	53.75	27.75	-11.4	9.0
3	42.25	24.75	12.4	18.9
5	28.75	14.88	40.4	51.2

According to Table 3, Maximum percentage reduction of CBR value was experienced at an addition of 5% tire chips. With the increment of tire chip percentage, soaked CBR value continuously decreased.

3.4 Effect of Tire Chips on Lime stabilized Soil

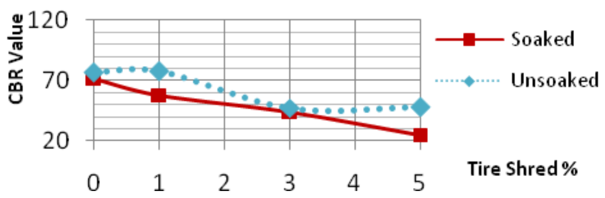

Fig. 4 Variation of CBR values of lime stabilized soil with tire chip %.

According to Fig. 4, unsoaked CBR values are greater than the soaked CBR values.
Maximum unsoaked CBR value = 77.50%
Corresponding tire chip percentage = 1%
Maximum soaked CBR value = 71.25%
Corresponding tire chip percentage = 0%

Table 4: Variation of CBR values and percentage CBR value reduction in lime stabilized soil with the increment of tire chip percentage.

Tire %	CBR value		% CBR value reduction	
	Unsoaked	Soaked	Unsoaked	Soaked
0	76.25	71.25	–	–
1	77.50	58.00	-1.6	18.6
3	47.00	43.75	38.4	38.6
5	48.00	24.63	37.0	65.4

According to Table 4, soaked CBR value continuously reduced. Under unsoaked condition, 1% tire chip addition gives maximum CBR strength to the soil. Maximum percentage reduction of CBR value was experienced at 5% tire chip addition. With the increment of tire chip percentage, soaked CBR value continuously decreased. The reduction of soaked CBR values were significant compared with the reduction of unsoaked CBR values.

3.5 Effect of Tire Chips on cement stabilized soil

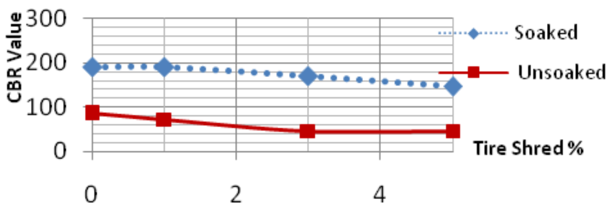

Fig. 5 Variation of CBR values of cement stabilized soil with addition of tire chips

According to Fig. 5, soaked CBR values are greater than the unsoaked CBR values.
Maximum unsoaked CBR value =85.48%
Corresponding tire chip percentage = 0%
Maximum soaked CBR value =190.50%
Corresponding tire chip percentage = 0%, 1%

Table 5 Variation of CBR values and percentage CBR value reduction in cement stabilized soil with the increment of tire chip percentage

Tire %	CBR value		% CBR value reduction	
	Unsoaked	Soaked	Unsoaked	Soaked
0	85.48	190.50	–	–
1	73.00	190.50	14.6	0.0
3	45.75	169.25	46.5	11.2
5	46.75	146.00	45.3	23.4

According to Table 5, unsoaked CBR values were continuously decreased. Under soaked condition, CBR value corresponding to 1% tire chip addition was equal to the CBR strength gained by cement stabilized soil without adding tire chips. Therefore, no CBR strength gain of tire chips addition. The percentage reduction of CBR value due to tire addition is significant under unsoaked condition when compared with the soaked condition.

4 CONCLUSIONS

- The quantity of Ordinary Portland cement added to the raw soil was varied as 5%, 10%, 15% and 20% by weight, to stabilize the raw soil. Due to that, initial CBR strength of raw soil was increased from 65% to 80% under unsoaked condition. For soaked condition, initial CBR strength of raw soil was increased from 370% to 660%.
- The quantity of lime added to the raw soil was varied as 2%, 4%, 6% and 8% by weight, to stabilize the raw soil. Due to that, initial CBR strength of raw soil was increased from 40% to 50% under unsoaked condition. For soaked condition, initial CBR strength of raw soil was increased from 70% to 135%.
- The addition of tire chips does not have any influence towards the increment of CBR strength of silty soil under soaked condition.
- The addition of 1% tire chips has increased the CBR strength of raw soil and it has continuously reduced with the increment of tire chip percentage under unsoaked condition.
- The addition of tire chips does not have any influence towards the increment of CBR strength of lime stabilized silty soil under soaked condition.
- The addition of 1% tire chips have increased the CBR strength of lime stabilized silty soil and it has continuously reduced with the increment of tire chip percentage under unsoaked condition
- The addition of tire chips does not have any influence towards the increment of CBR strength of cement stabilized silty soil under both soaked and unsoaked conditions.
- Considering these stabilization techniques lime stabilization is more economical. But the CBR value increment is relatively low.
- Although cement stabilization is costly, it improves the CBR strength of silty soil in significant amount.
- It is not effective to add 10 mm×20 mm tire chips to improve the strength of silty soil sample.

5 RECOMMENDATIONS

- For a selected site which has relatively weak silty soil and if the borrow pits are located far away, it is economical to do the cement stabilization within the site without replacing the existing soil.
- For silty soil which has moderately higher strength, lime stabilization is more economical, because lime is cheaper than cement.

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