International Journal of Technical Innovation in Modern Engineering & Science (IJTIMES)
Impact Factor: 5.22 (SJIF-2017), e-ISSN: 2455-2585
Volume 4, Issue 09, September-2018

EXPERIMENTAL STUDY OF CRUMB RUBBER ADDITION ON SOIL PROPERTIES

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Abstract: With the development of a country the amount of waste generated increases. In the recent years, there has been a greater problem to deal with this increasing amount of waste. In the following study, an attempt has been made to deal with growing amount of rubber tire waste by utilizing crumb rubber as an additive with clayey soil in order to analyze its effect on soil properties. The Standard Proctor test and California Bearing Ratio (CBR) tests have been carried out on parent soil and soil mixed with varying percentage of crumb rubber. The results revealed a reduction in the value of OMC and MDD with increasing crumb rubber percentage whereas the CBR has shown an increasing trend till 10% addition of crumb rubber. Therefore, it is suggested that the waste crumb rubber tires can be safely used in the subgrade as a soil binder which will effectively hold the soil with increased strength values.

Keywords: Crumb Rubber, Clayey Soil., California Bearing Ratio, Standard Proctor, Optimum Moisture Content, Maximum Dry Density.

I. INTRODUCTION

In the present era, worldwide population has increased drastically over the years. Natural resources available are unable to satisfy the demand caused by the population growth. Thus, it becomes necessary to employ such techniques to make the best use of available resources. Civil engineering aspect of proper utilization includes land stabilization through which we can modify land's inferior engineering properties into land having adequate engineering properties. Construction on a land that has clayey soil appears to be difficult, as it have low strength and high compressibility when water content increases. This anomalous behaviour of clayey soil endangers the construction work over such soil. Instead of searching for a new adequate land, changing the properties of available land is more practical. Various methods such as compaction, soil reinforcement or drainage can be adopted to stabilize the soil. It can also be done by incorporate different admixtures such as fly ash, lime, cement, industrial waste etc. Incorporating waste material for soil stabilization appears to be an attractive solution, since it is cheaper and helps in waste management at the same time. Crumb rubber is one such waste material which has various properties that can be efficiently utilized for applications in civil engineering.

Table 1: Waste Rubber Tire Generations in the World

S. No.	Country	Waste Generation (MTY^{-1})	Reference
1.	Germany	585	Reschner Kurt, 2006
2.	United Kingdom	475	Reschner Kurt, 2006
3.	Spain	305	Rescher Kurt, 2006
4.	USA	290	Fiksel et al., 2009
5.	Canada	240	Pehelken et al., 2005
6.	China	239	Zhao Sulan et al., 2009
7.	Sri Lanka	190	Mathews, 2003
8.	South Africa	160	Mahlangu et al., 2009

II. LITERATURE REVIEW

Clayey soil exhibits peculiar alternate shrink-swell behaviour and therefore engineering properties of clayey soils are to be enhanced by carrying out soil stabilization to make them suitable for construction. R. Ayothiraman and Ablish Kumar Meena (2011) carried out experiments on soil and soil tire mixtures showed that maximum dry density reduced with increase of tire waste. Tire waste material mixed with soil showed improvement in CBR value with its addition up to 2% and there onwards decreased with further increase in tire content in unsoaked and soaked condition. Munnoli P. M. et al., (2013) studied crumb rubber powder effect on strength of soil subgrade. Standard Proctor test performed on black cotton soil showed OMC of 18% and MDD achieved was 2.34gm/cc further proctor test was repeated for different crumb rubber percentages. For samples compacted at OMC and MDD, CBR tests were performed. CBR test showed increasing trend till 10% of CRP and decreased as the percentage of CRP tire is increased. Ghatge Sandeep Hambirao and P.G. Rakaraddi (2014) carried out various tests on Shedi soil and found that Shedi soil shows an increase in California bearing ratio (soaked) from 2.63% to 13.79% which reduces pavement thickness by 66.66%. Increases in CBR value significantly reduce the total thickness of the pavement and hence the total cost involved in the project. P.T.

Ravichandran et al., (2016) investigated in this work the possibility of using crumb rubber powder was an additive to improve the strength of soft soil. Two types of problematic clay soil are stabilized with the various percentages of crumb rubber (5%, 10%, 15% & 20%). The strength properties of stabilized soil were improved by increasing percentage of crumb rubber up to 10% is studied by the CBR tests. With the addition of crumb rubber of 10% shows the improvement of CBR value of soil is 161% and 130% in soil A1 and A2.

III. MATERIALS USED

a) Clayey Soil :

Soil used in the experiments has been used which is locally available in Jammu & Kashmir and is of mountainous clayey origin. The soil that has been collected from the site has been powdered into small fines so that lumps are completely eliminated and then placed under a cover so that moisture content of the soil is preserved. The liquid limit of the soil is determined by reading the water content corresponding to 25 blows on the flow curve. The Specific Gravity of soil was calculated using Pycnometer as per IS: 2720 (Part III/Sec-1) (1980). Various index properties of the soil under investigation are as shown in Table 2.

Table 2: Index Properties of Parent Soil

S. No.	Parameters	Results
1.	MDD (gm/cc)	1.61
2.	OMC (%)	20.6
3.	Liquid Limit (%)	51.3
4.	Plastic Limit (%)	24.4
5.	Plasticity Index (%)	29.4
6.	Specific gravity	2.5

b) Crumb Rubber:

Crumb rubber used for the study was obtained from Jai Durga Enterprises, Jammu.

- Material : whole tire crumb rubber powder
- Composition : 40 mesh (420 microns)
- Standard package : 20 kg

Table 3: Composition of Crumb Rubber Powder

S. No.	Parameters	Results
1.	Ash Content %	09±1
2.	Acetone %	09±2
3.	Moisture %	0.01
4.	Carbon black %	22±1
5.	Specific gravity %	1.15±0.5
6.	RHC (By difference) %	55±5
7.	Fibers & Irons	NIL

IV. EXPERIMENTAL INVESTIGATION

Standard Proctor Test

This test involved a detailed investigation of the compaction characteristics of the parent soil and the blended sample with varying percentage of crumb rubber, in order to obtain the optimum moisture contents and maximum dry densities. The optimum moisture contents thus obtained was used in preparing samples for California Bearing Ratio test. This test confirms to IS: 2720 (Part 7) - 1980.

California Bearing Ratio Test

CBR test was developed by California Department of Transportation. CBR test is penetration test meant for the evaluation of subgrade strength of roads and pavements. The results obtained by these tests are used with the empirical curves to determine the thickness of pavement and its component layers. This is the most widely used method for the design of flexible pavement. This test confirms to IS: 2720 (Part 16) – 1987.

CBR tests were carried out on parent soil as well as blended soil samples. The proportion of CRP remained same as in compaction test. Samples were prepared for both unsoaked and soaked conditions.

V. RESULTS

Standard Proctor Test

Standard Proctor Test on parent soil shows maximum dry density (MDD) of 1.6lgm./cc at optimum moisture content (OMC) of 20.6% .With the addition of 6% CRP, MDD decreased to 1.59gm/cc and OMC decreased to 20.1%. Further observations were made at 8%, 10%, 12%, 14%, 16% and 18% addition of CRP and MDD were found to be 1.55gm/cc, 1.56gm/cc, l.5lgm/cc, l.48gm/cc, 1.43gm/cc and l.42gm/cc respectively while the OMC decreased to 19.7%, 19.4%, 19.2%, 19.3%, 18.8%, and l8.2% respectively

Table 4: Standard Proctor Test Values for Different Percentage of CRP

%CRP	**0**	**6**	**8**	**10**	**12**	**14**	**16**	**18**
MDD (gm/cc)	1.61	1.59	1.57	1.56	1.51	1.48	1.43	1.42
OMC	20.6	20.1	19.7	19.4	19.2	19.3	18.8	18.2

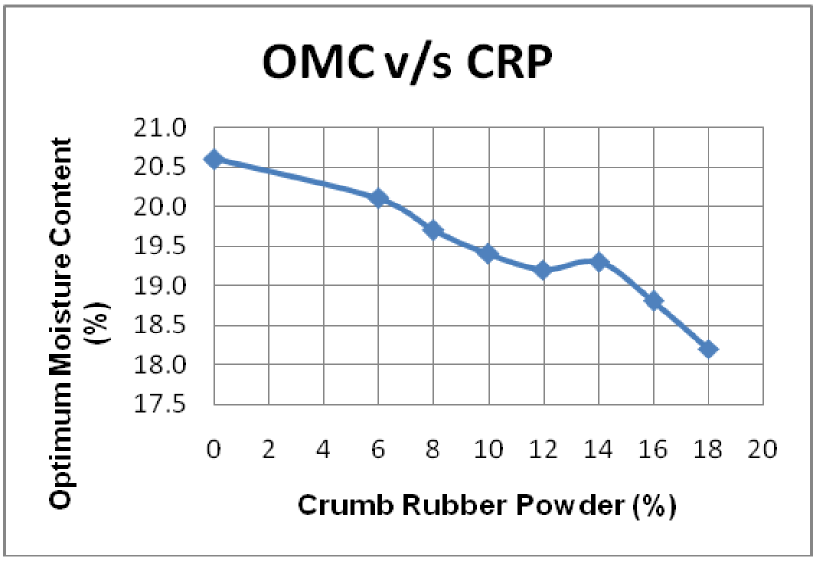

Fig 1: Variation of Optimum Moisture Content with CRP Percentage

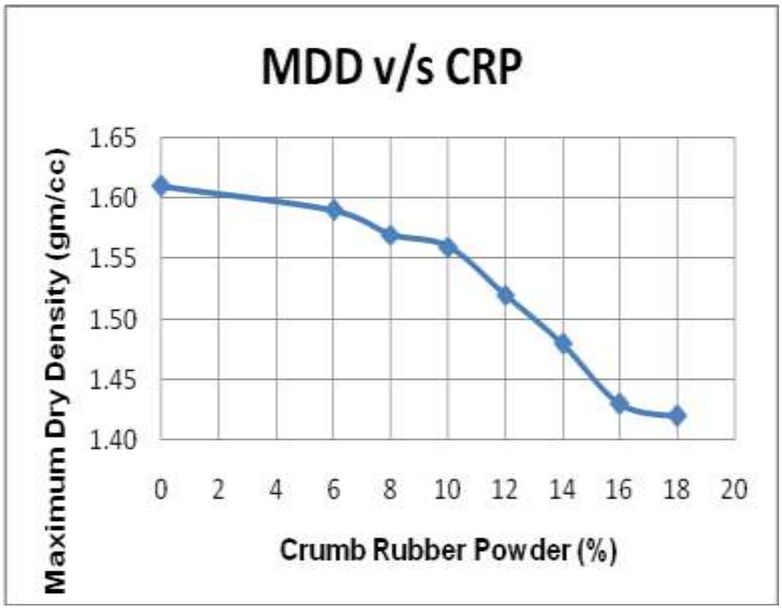

Fig 2: Variation of Maximum Dry Density with CRP Percentage

California Bearing Ratio Test

Tests were performed on soil samples with same ratio of crumb rubber powder as in case of standard proctor test at respective Optimum Moisture Content. Results have shown CBR values for parent soil under unsoaked condition as 4.12 and under soaked conditions (4 days) as 2.85. Addition of 6%, 8%, 10%, 12% and 14% crumb rubber powder to soil resulted in CBR values of 3.96, 4.14, 4.44, 3.91, 2.74 under unsoaked condition and 2.56, 2.71, 2.91, 2.62, 1.73 for the same varying percentage of crumb rubber powder for soaked condition respectively. CBR values were obtained from comparing the load required for 2.5mm and 5mm penetration on soil to the standard load. The present study revealed that addition of 10% crumb rubber with the clayey soil has shown better performance with CBR value.

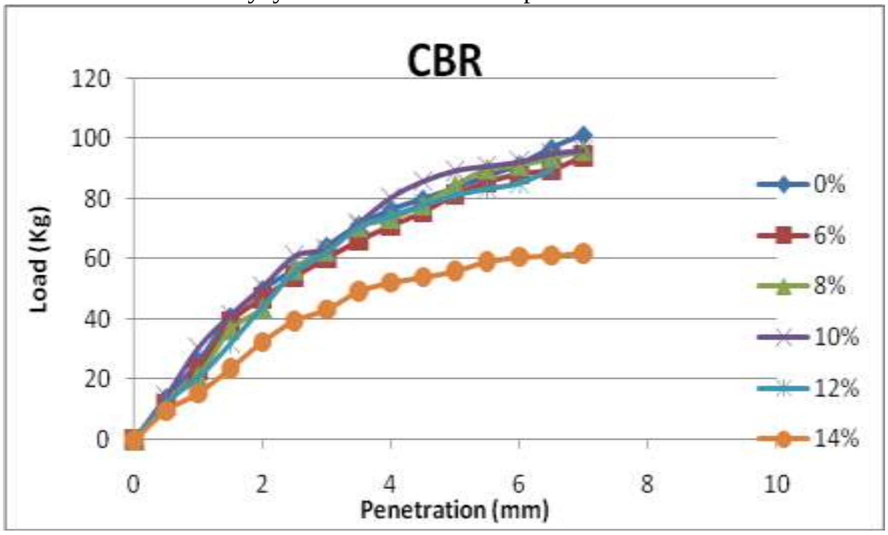

Fig 3: Load v/s Penetration Curve for Unsoaked condition

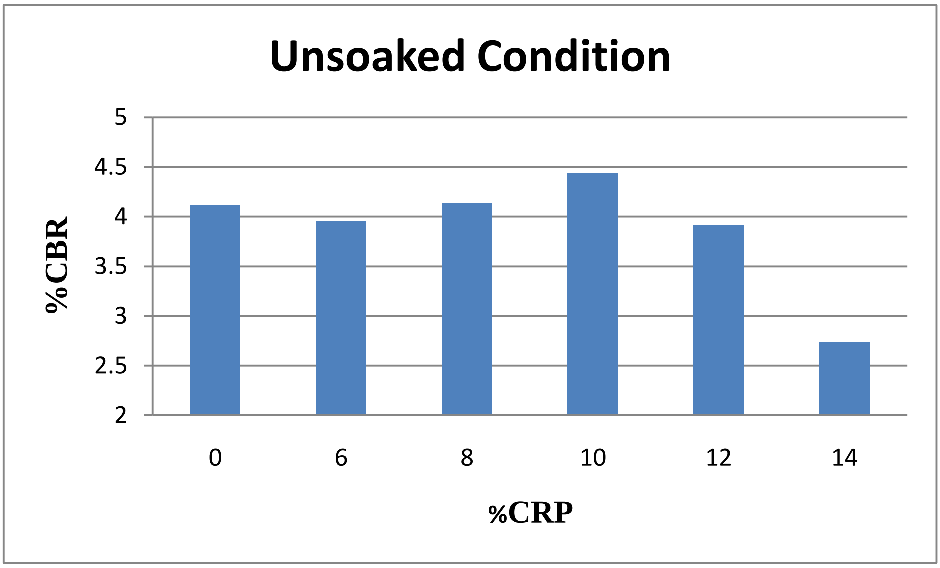

Fig 4: Variation of CBR with %CRP for Unsoaked condition

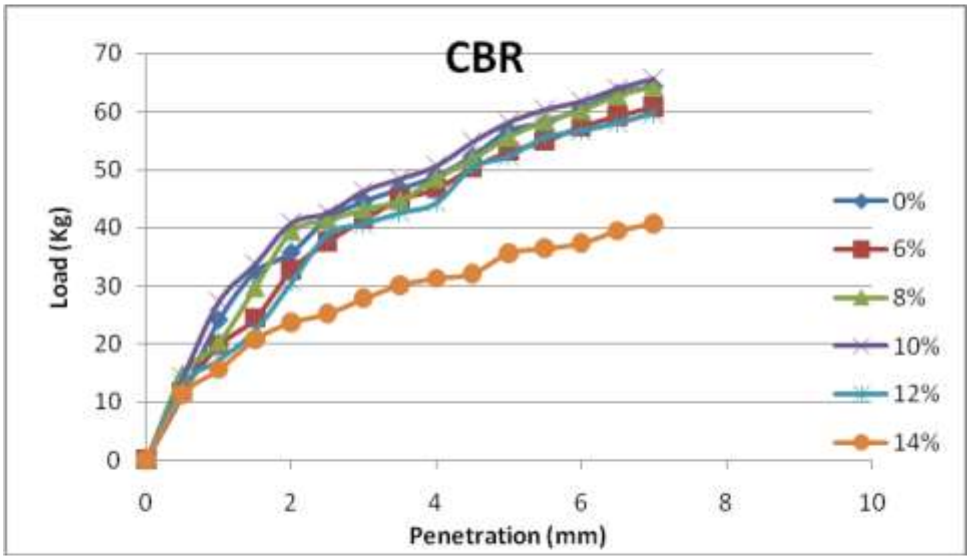

Fig 5: Load V/s Penetration Curve for Soaked condition

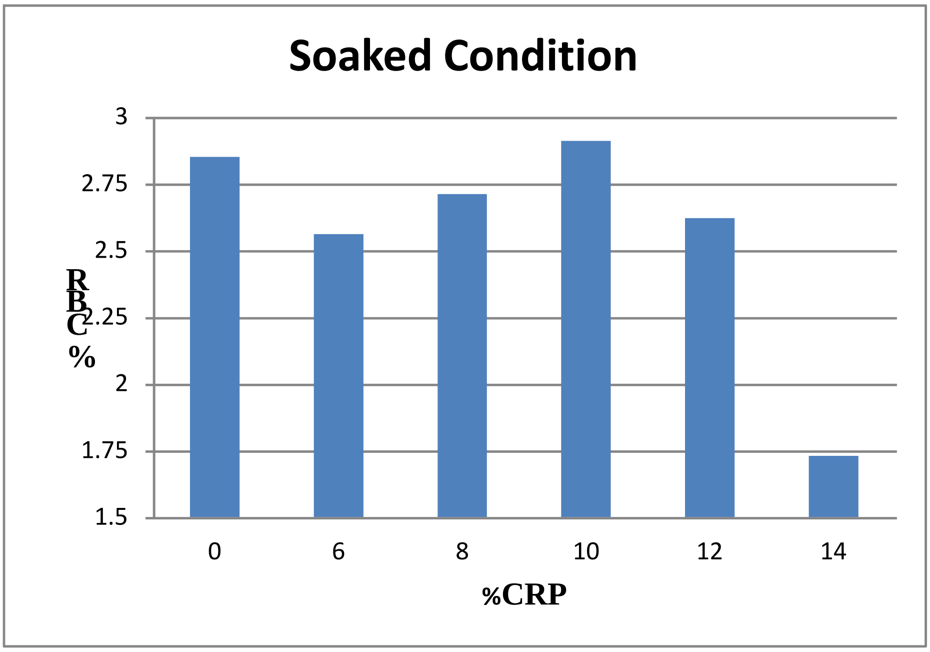

Fig 6: Variation of CBR with %CRP for Soaked condition

VI. CONCLUSIONS

Following conclusions can be drawn from the results obtained through experimental investigation

- It was observed that the OMC and MDD values of soil decreased with increase in crumb rubber powder percentage. Since, it does not absorb water, OMC decreased for the mix.

- Since the compaction was carried out immediately after mixing and rubber is inert material which does not reacts with soil, therefore, no chemical reaction is expected in this process of hydration. The reduction in MDD with increasing CRP content might be the result of the replacement of soil particles by rubber particles in a given volume; they partially filled the voids between the soil particles and prevented them from coming into a closer state of packing, and their lower specific gravity resulted in less density of soil rubber mix.

- CBR tests have shown increasing trend till 10% of CRP and decreased as the percentage of CRP was increased to 12% and 14%. The CBR value at 10% for unsoaked condition is 4.44 which is highest and also higher to the control CBR (4.12) without CRP. The CBR value at 10% for soaked condition is 2.91 which is highest and also higher to the control CBR (2.85) without CRP. Therefore, it is concluded that addition of CRP has the characteristics of increased strength values, and also solves the problem associated with disposal of waste rubber tire to some extent.

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