INTERNATIONAL JOURNAL OF GEOMATICS AND GEOSCIENCES
Volume 4, No 3, 2014



Research article ISSN 0976 – 4380

# Study on Effect of Crumb Rubber on Behavior of Soil

Shiva Prasad.A[1], P.T.Ravichandran[2], R.Annadurai[3], P.R.Kannan Rajkumar[4]
1- PG Student, 2 – Professor, 3 – Professor and Head, 4 – Asst. Professor (Sr.G)
Department of Civil Engineering, Faculty of Engineering and Technology,
SRM University, Kattankulathur, Chennai, Tamil Nadu, India
ptrsrm@gmail.com

## ABSTRACT

A major problem associated with socio-economic development of a country is waste disposal. Safer disposal of rubber tyre waste has become a challenging job. This paper presents the stabilization of soils using crumb rubber at varying percentages (5%, 10%, 15% and 20%). The soil properties, compaction and unconfined compression strength were used to gauge the behavior and performance of the stabilized soils. From the tests conducted on the two soils, it was observed that maximum dry density and optimum moisture content decreases with increase in percentage of crumb rubber on soils. The UCS value increased with increase in percentage of crumb rubber and the maximum values were observed at 10% and 15% for the soil sample S1 and soil sample S2 respectively.

**Keywords:** Crumb rubber, UCS, OMC, MDD.

## 1. Introduction

The industrial revolution made mind-blogging changes in the trade and transport sector. Developing countries like India mainly depend on the transportation sector for their economical growth. There is a continuous development and growth in the usage of motor vehicles. The growth and usage of motor vehicles have not only caused noise pollution, air pollution etc. but also has created problems in discarding the tyre's. Rubber does not decompose and as a result, an economically feasible and environmentally sound disposal method has to be found out. One of the common and feasible ways to utilize these waste products is to go for construction of roads, highways and embankments. If these materials can be suitably utilized in construction of roads, highways and embankments then the pollution problem caused by the industrial wastes can be greatly reduced. Huge amount of soil is used in the construction of roads and highways but sufficient amount of soil of required quality is not available easily. Utilization of various industrial wastes such as crumb rubber as a soil replacement not only solves environmental problems but also provides a new resource for construction industry.

## 2. Literature review

Engineering properties of clayey subgrade soils may need to be improved by adopting some sort of stabilization methods so as to make them suitable for construction. Stabilization of pavement subgrade soils has traditionally relied on treatment with lime, cement, or waste materials such as flyash, slags, Silica Fume, etc. Many researchers are looking for alternative materials for soil stabilization. Studies have been conducted with the crumb rubber to observe the characteristics of crumb rubber when mixed with soil. Baykal et al., (1992) mixed clay and fly ash samples with used tyre obtained from retarding industry and hydraulic conductivity tests were conducted using water gasoline as permeates. The strength of soil-tyre chip mixture decreases once the rubber content exceeds 30% in the mixture because soil-tyre chip mixture behaves less like reinforced soil and more like a tyre chip mass with sand inclusion (Foose, 1996). Falling head permeability tests were conducted on rubber mixed soil samples and it was observed that when water permeated through samples, a slight increase in hydraulic conductivity was observed. Lee et al., (1999) also determined the shear strength and stress strain relationship of tyre chip and a mixture of sand and tyre chips. They found out the stiffness and strength properties for tyre sheds and rubber sand mixture. Rao and Dutta, (2001) conducted studies on sand mixed with rubber chips. Compressibility tests and triaxial tests were conducted. The stress strain relations and strength parameters were studied. It was found that the value of internal friction and effective cohesion of sand increased with increase in percentage of rubber up to 15%. The aim of this study was to investigate the possibility of the utilization of industrial waste crumb rubber to stabilize soils.

## 3. Materials and methods

The experimental study was carried out on two soil samples S1 and S2 collected at a depth of 0.7m below ground level. The basic tests performed includes test for Specific Gravity (IS:2720, Part-III), Atterberg's limits (IS:2720, Part-V & VI), Grain Size distribution (IS:2720,Part-IV), Compaction characteristics (IS:2720, Part-VII) and UCS (IS:2720, Part-X).The geotechnical properties of soils tested in the laboratory are tabulated in Table – 1. The particle size of crumb rubber used to stabilize the soil in this study was ranging from 425micron to 600micron. Specific gravity of crumb rubber obtained with a pycnometer test ranges from 0.8 to 0.9.

**Table 1:** Geotechnical properties of soil

| **Parameter** | | **Value** | |
|---|---|---|---|
| | | **Sample S1** | **Sample S2** |
| Specific Gravity | | 2.1 | 2.3 |
| Particle Size Distribution | Sand, % | 3 | 6 |
| | Silt, % | 27 | 35 |
| | Clay, % | 70 | 59 |
| Liquid Limit , % | | 74 | 56 |
| Plastic Limit, % | | 36 | 20 |
| Plasticity Index, % | | 38 | 36 |
| Shrinkage Limit, % | | 4.8 | 5.9 |
| Compaction Characteristics | Maximum Dry Density,(kN/$m^3$) | 15.3 | 15.2 |
| | Optimum Moisture Content, % | 25 | 26 |
| Unconfined compressive strength, kN/$m^2$ | | 142 | 100 |

### 3.1 Compaction characteristics

The compaction tests were carried out on virgin soil and soil- crumb rubber mixtures. The Standard Proctor tests were conducted as per IS 2720 (Part-VII) on soil S1 and S2 with crumb rubber mixtures to determine its compaction characteristics, namely, the optimum moisture content (OMC) and maximum dry density (MDD). The soil is mixed with various amounts of crumb rubber of 5%, 10%, 15%, and 20%, by weight of soil and standard proctor test were conducted on these mixtures. The compaction curve obtained from the tests for different percentage of soil 2- crumb rubber mixtures is shown in Fig. 1. The OMC and MDD values obtained for both the soils mixed with crumb rubber (5%, 10%, 15% and 20%) are summarized in Table 2.

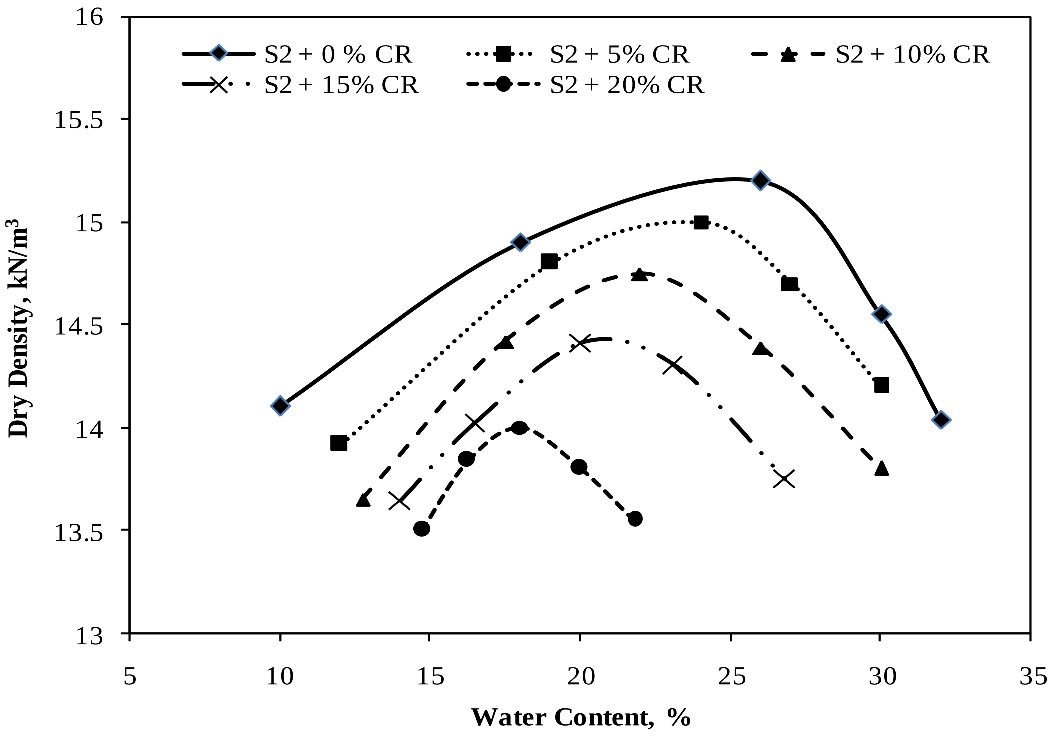


**Figure 1:** Compaction curve for soil 2 - crumb rubber mixtures

From the Figure 1 and Table 2, it can be observed that for both the soils, the maximum dry density of soil-crumb rubber mixtures decreases significantly with an increase of percentage of crumb rubber. This is due to the light weight nature of crumb rubber in comparison with soil. Similarly the OMC also decreases with the increase in percentage crumb rubber in the soil. This may be due to the negligible water absorption capacity of the crumb rubber.

**Table 2: MDD and OMC of soil-crumb rubber mixtures**

| Soil | Crumb Rubber (CR), % | Compaction characteristics ( Std. Proctor) | |
|---|---|---|---|
| | | Max. Dry density (kN/m$^3$) | Water content (%) |
| **S1** | **0** | 15.34 | 25 |
| | **5** | 14.74 | 23.5 |
| | **10** | 14.34 | 22 |
| | **15** | 13.70 | 19 |
| | **20** | 13.25 | 17 |
| **S2** | **0** | 15.20 | 26 |
| | **5** | 15.00 | 24 |
| | **10** | 14.75 | 22 |
| | **15** | 14.41 | 20 |
| | **20** | 14.00 | 18 |

### 3.2 UCS value of soil-crumb rubber

UCS tests were conducted as per IS: 2720 (Part-X) on both the soil samples S1 and S2 with various percentages of crumb rubber to determine the UCS value and to evaluate the suitability of soil stabilized with crumb rubber. The UCS tests were conducted on soil sample-crumb rubber mixture prepared at an OMC and MDD obtained corresponding to that particular soil-crumb rubber mixture. The soil was mixed with crumb rubbers of 5%, 10%, 15% and 20% by weight of soil and UCS test were conducted on these soil- crumb rubber mixtures. The stress – strain curve obtained from the UCS tests for different percentage of soil1 + crumb rubber mixtures is shown in Fig. 2. The UCS value of the soil and soil+ crumb rubber mixtures were determined from the stress – strain relationship and are summarized in Table 3. The variation of UCS value with varying percentages of crumb rubber is shown in Fig. 3.

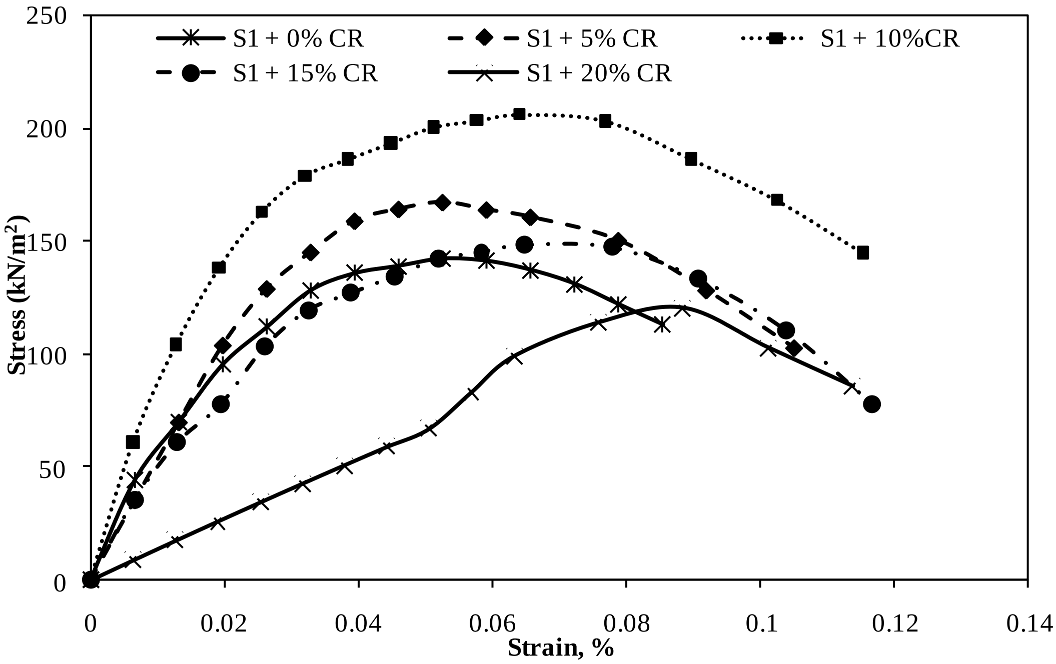


**Figure 2:** Stress – Strain curve from UCS tests for soil S1 + crumb rubber

It can be inferred from Table 3 and Fig. 3 that the improvement in UCS value in stabilized soil S1 is 45% with 10% addition of crumb rubber, whereas in soil S2 the percentage improvement is 80% with 15% addition of crumb rubber. The optimum value of crumb rubber content evaluated is 10% and 15% for the soil S1 and S2 respectively, beyond which the addition of higher percentage of crumb rubber make the soil + crumb rubber mixture more compressible with lesser load.

**Table 3:** UCS values of soil and soil-crumb rubber

| Soil | UCS Value (kN/m$^2$) | | | | |
|---|---|---|---|---|---|
| | Crumb Rubber, % | | | | |
| | **0** | **5** | **10** | **15** | **20** |
| **S1** | 142 | 167 | 206 | 147 | 120 |
| **S2** | 100 | 144 | 173 | 180 | 129 |

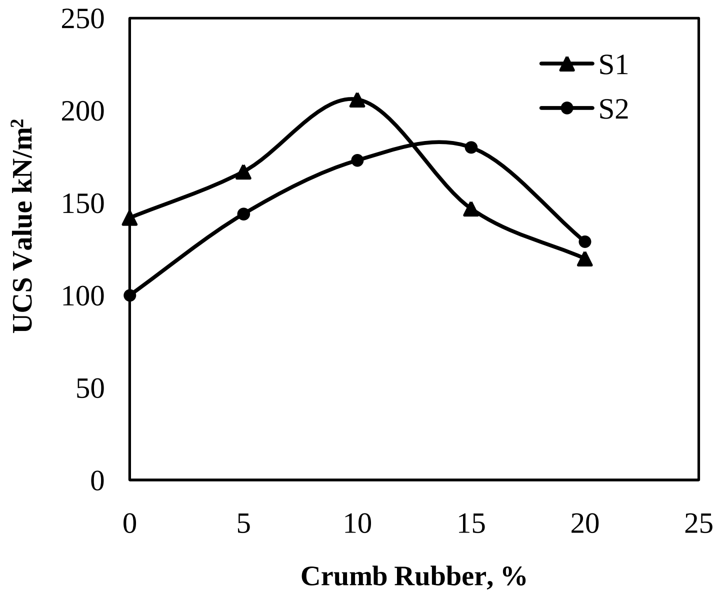


**Figure 3:** Variation of UCS values with % of crumb rubber on soil S1 and S2

## 4. Conclusions

1. From the Standard Proctor Compaction test, it was observed that the maximum dry density reduced with the increase in percentage of crumb rubber for both the soils S1 and S2. This could be due to light weight nature of crumb rubber waste.

2. Waste crumb rubber-soil mixture showed an improvement in UCS value for both the soils S1 and S2 upto 10% and 15% addition of crumb rubber respectively. Further the addition of crumb rubber to soils lead to a decrease in UCS values.

3. The percentage improvement in UCS value of soil S1 stabilized with 10% of crumb rubber was 45% and soil S2 stabilized with 15% of crumb rubber was 80%.

4. In view of industrial waste management, crumb rubber can be disposed safely in road embankments as a fill material. However, it is recommended to study the influence of crumb-rubber chemicals on the soil to know its environmental impact.

## Acknowledgment

The authors wish to thank Nano Technology Research Centre, SRM University, Kattankulathur for the help in SEM analysis.

## 5. References

1. Bayka I, G., Yesiller, N. and Koprulu, K, (1992), "Rubber-Clay Liners Against Petroleum Based Contaminants", Environmental Geotechnology, pp 477-481.

2. Foose, G.J., Benson, C.H. and Bosscher, P.J., (1996), “Sand Reinforced with Shredded Waste Tires”, Journal of Geotechnical Engineering, 122(9), pp 760-767.

3. IS: 2720 (Part III) – 1987, Methods of test for soil: Determination of specific gravity, Bureau of Indian Standards, New Delhi.

4. IS: 2720 (Part IV) – 1985, Methods of test for soil: Grain size analysis, Bureau of Indian Standards, New Delhi.

5. IS: 2720 (Part V) – 1985, Methods of test for soil: Determination of liquid limit and plastic limit, Bureau of Indian Standards, New Delhi.

6. IS: 2720 (Part VI) – 1972, Methods of test for soil: Determination of shrinkage factors, Bureau of Indian Standards, New Delhi.

7. IS: 1498-1970, Classification and identification of soils for general engineering purposes, Bureau of Indian Standards, New Delhi.

8. IS: 2720 (Part VII) – 1987, Methods of tests for soil : Determination of water content-dry density relation using light compaction, Bureau of Indian Standards, New Delhi.

9. IS: 2720 (Part X) – 1973, Methods of tests for soil: Determination of unconfined compressive strength, Bureau of Indian Standards, New Delhi.

10. Lee, J. H., Salgado, R., Bernal, A., and Lovell, C. W. (1999), "Shredded tires and rubber-sand as lightweight backfill", Journal of Geotechnical and Geo environmental Engineering .., 125(2), pp.-132–141.

11. Rao G.V and Dutta R.K (2001), "Utilisation of shredded tyres in highway engineering", Proceedings of the International seminar on sustainable development in road transport, New Delhi, pp 257-268.