

# Altering the Geotechnical Properties of Clayey Soil by using Scrap Rubber

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**Abstract:-** Altering the geotechnical properties by the addition of scrap rubber as a binding material in soil can be one of the method for soil stabilization. The production of scrap rubber tyres has been increased over the years in India. The scrap rubber material being left as a waste material can be later on used in soil so as to increase the properties of soil. Thus, it reduces the impact of rubber on environment. In current scenario the demand for infrastructures is increasing day by day. In some places the soil property is very loose and the foundation design is not suitable due to poor bearing capacity of soil. Hence we need to modify the property of soil. We are mixing the scrap rubber material in the powder form and chips form. These materials are mixed in different proportions and find the variation of these proportions in soil is identified. It is low cost method for altering the geotechnical properties of soil.

**Key words -** Clay soil, Waste crumb rubber tyre, unconfined compression test (UCS), standard proctor test (SPT).

## 1. INTRODUCTION

The production of scrap tyres has been increased over the years in India. The main objective is to increase the strength and to reduce the construction cost by using scrap rubber material. Scrap tyres can be used in several types either as powder or crumb or shredded or in chips form. The purpose of mixing the rubber material in soil mass is to improve its bearing capacity or stability and also reduce the settlement. The rubber tyre is a lightweight material. Since it is not easy to dispose the scrap rubber tyres, hence we can use it as a binding material for soil.

The generation of scrap tyres has been increased over the years in the world. The common practice used for disposal of the waste tyres such as stock piles, and fills and burning are considered as very dangerous to health of humans and ecological system. The main objective is to increase the strength and to reduce the construction cost by using scrap rubber material. The mixture of tyre shreds with in soil for highway bank construction can be a means of reusing tyres to handle economic and environmental applications, this also helps to solve geotechnical issues related to low shear strength of soil. This helps to solve the geotechnical properties of soil.

### Waste rubber tyre generation (global scenario)

A steady stream of large volumes of waste rubber tyres is generated annually by the increase in the numbers of all types of vehicles. This is very fast. The annual increase in

the number of tyres has become more severe in developed countries like UK, USA, INDIA, etc. due to expanding cities and ban on stockpiling and land filling of tyres in many countries. The waste rubber generation quantities of few developed and developing countries are listed in the following table.

Table – 1: Production of scrap rubber

S. No.	Country	Waste Generation	Reference
1	United Kingdom	475	2006, Reschner Kurt
2	USA	290	2009, Fikselet.al
3	Canada	240	2005, Pehlken et.al
4	France	398	2006, ETRMA
5	Germany	585	2006, Reschner Kurt
6	Italy	380	2006, ETRMA
7	Spain	305	2006, Reschner Kurt
8	China	239	2006, Zhao Shulanet.al
9	Sri Lanka	190	2003, Mathews

### Waste rubber tyre generation (Indian scenario)

India is one of the developing countries, In India there is a very fast annual increase in the number of vehicles leading to steady increase in the volume of consumption of waste rubber tyres day by day / year by year, it has been observed that the production of tyres and tube has been increased in every day/year. This following table are show annual consumption of waste tyre in India.

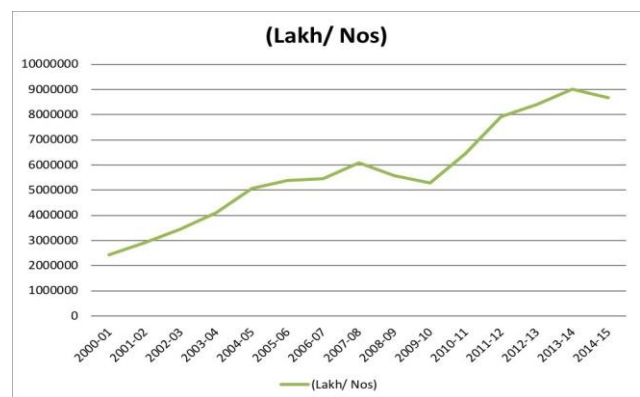


Table - 2: Chemical composition of waste tyres.

Constituents	Percentage
Rubber (natural & synthetic)	38
Fillers (carbon chalk, carbon black, silica)	30
Reinforcing materials (rayon, steel, nylon)	16
Plasticizers (resins& oil)	10
Chemical for vulcanization (zinc oxide, sulphur)	4
Chemical as antioxidants to counter ozone effects	1
Miscellaneous	1

Table - 3: classification of waste tyre according to particle size.

Material	Size
Chips	<250mm
Shred	30-250mm
Granulate	1-30mm
Powder	<0.5mm

## 2. OBJECTIVE OF THE STUDY

- To alter the geotechnical properties of soil by using scrap tyres as a stabilizer.
- To determine the maximum dry density (MDD) & optimum moisture content (OMC) for the various mixture.
- To find the optimum amount of crumb rubber tyre that can be added, such that changes in properties are in favor to our requirement.
- Study the engineering properties of rubber and soil.
- To magnify the physical properties (Shear Strength, Water content, Compressibility) of the soil.
- To determine the change in OMC, MDD & shear strength with addition of different percentages of waste tyre rubber (0%, 5%, 10%, 15% and 20%).

## 3. SUMMARY OF LITERATURE REVIEW

- P. T. Ravichandran, A. Shiva Prasad, K. Divya Krishnan and P. R. Kannan Rajkumar Department of Civil Engineering, SRM University, Kattankulathur.

- Crumb rubber powder (CRP) mixed with both the soil showed improvement in CBR value with its addition up to 10% and there onwards decreased with further increase in crumb rubber powder.
- The permeability value shows rapid increase with the increase in crumb rubber content for the both the soils. The use of crumb rubber as a stabilizer introduces a low cost method for stabilization and it significantly reduces the waste tyre disposal problem that currently exists.

- A. Venkata Ratnam, Dr. D. S. V. Prasad, Civil

Engineering Department, B.V.C. Engineering College, AP.

- From the Standard Proctor Compaction test, it was calculated that the maximum dry density (MDD) reduced with the increase in percentage of crumb rubber and optimum MDD is 1.48KN/m<sup>3</sup>. This could be due to light weight nature of scrap crumb rubber waste.
- Cohesion(C) decrease with increase in CRP up to 7% and then increases with further increase in 9% of CRP. Soil+CRP+cement mixture showed an improvement in direct shear value up to 9% of CRP at 4% cement. Further the addition of cement to soil +CRP mix lead to a decrease in direct shear value.

- Umar jain, Vinod K Sonthwal, Department of civil engineering, NITTTR, Chandigarh, India.

- Added amount of rubber tyre had been varied in proportions of 4%, 6%, 8% and 10% by the weight of soil. Use of shredded rubber tyres in geotechnical engineering for enhancing the soil properties has received great attention in the current times.
- It is found that the 8% (25 mm×50 mm) of tyre content is the specific value where the CBR has got the improvement of 66.28% than in comparison of the plain soil.

- G. Ravi Kumar, K. Gayathri, Civil Engineering Department, QISIT, Ongole, AP, India.

- When the 10% of crumb rubber powder CRP are added in black cotton soil the shear strength of black cotton soil are increased. From the investigations, CBR value are increase in 10% of CRP are added to the soil.
- The addition of CRP in red soil when the shear strength of red soil are decreased. By the researcher investigation the use of rubber in red soil is not applicable for soil stabilization.

- Deepanshu Solanki, Dr. D.G.M Purohit, Department of Civil Engineering, M.B.M.E.C, J.N.V University, Jodhpur, Rajasthan, India.

- The shear strength is increased with the increasing the amount of scrap rubber up to 0.075percentage by the weight.
- The smaller grain size provides greater contact area and better surface frictional resistance between chips and clay.

## 4. RESEARCH METHODOLOGY

### Preparation of Sample

Specimens of parent soil and treated with 0, 5, 10, 15 and 20% by weight of rubber tyre scrap of various sizes were prepared at maximum dry density and optimum moisture content as per IS specification.

**Testing**

**Liquid Limit:** - it is a minimum water content at which the soil is flow with minimum water content.

**Apparatus:** - kesagrande liquid limit test, kesagrande type tool (clay), ASTM type tool (sandy clay)

In this test we are taking 450mm sieves and 120gm mixed water and massed it properly. And place the soil in to the cup now use the groove and tool which is divided the soil into two parts. Put the reading 0. Now gives the no of blows we are providing 25 no .of blows until the soil is fixed gain its original position. When it is fixed we removed the soil from tool into the cup in perpendicular possition. And put it in to the container and weight the soil. Now put the sample in the Owen until the soil is dry. And again weighting the dry soil sample and noted the reading. We are repeating the test two or three times. And from all these values we are draw a graph in x- axis or y- axis

**Plastic limit test:-**

Plastic limit of a soil is a water content at which the soil just began to crumble when rod in to a threaded approximately 3mm.

**Testing:** - we are taking 50 gm. of soil sample and passing it from 425 micron sieve from the prepaid sample in the evaporating dish. Now add the still water in to the soil sample mixed it throwly.so that the soil mass is plastic enough to be used .prepaid the ball weight of 8gm. out of this soil mass press the ball on the glass plate and rolled it with the fingers . So, that a threaded is uniform diameter is formed. The rate of rolling should be between 18-19 stokes per/minutes. Continue the rolling until the threading having a dia of 3ml and taking the reference to the metallic rod again make a ball of the thread and rolled it again to a threaded. We continue this process until the thread is crumbling .collect the sample of pieces of crumble soil thread in a container of non-weighting determine he moisture content as per standard procedure,  
 Water content (w) =  $w1-w2/w1-w2*100$

**MDD Test (maximum dry density test), OMC (Optimum Moisture Content of Soil):-**

To determine the relationship between water content and dry density of given soil and then to determine optimum moisture content and maximum dry density. This can be measured by mainly two methods standard Proctor Compaction Test and Modified Proctor. Both the test helps to determine the optimum moisture content that is required for a soil to attain maximum compaction  
 Optimum Moisture Content (OMC) This function of soil is tested through the site investigation process. The Optimum moisture content (OMC) or Optimum Water Content (OWC) is the moisture content at which the soil attains maximum dry density.

**Dry density of soil using core cutter test: -**

For this test we are calculating.

- Stability analysis.
- Bearing capacity.
- Degree of compaction.

**Mixing Proportion**

The scrap rubber tyre mixed in various proportions can be represented as in table number 4.

Table - 4: Various proportions of sample used.

Sample	Soil (%)	Scrap rubber tyre (%)
A	100	0
B	95	5
C	90	10
D	85	15
E	80	20

**5. EXPERIMENTAL OBSERVATION**

The soil specimen of the parent soil was taken. Soil specimen replaced with 0, 5, 10, 15 and 20% of scrap rubber tyre by the weight.

Description of Sample	Properties	Scrap rubber tyre percentage				
		0%	5%	10%	15%	20%
Soil + Scrap rubber tyre (retained on 425µ)	OMC in %	25	23.2	22.4	21.1	19.4
	MDD in gr/cc	1.60	1.574	1.561	1.476	1.458
Soil + Scrap rubber tyre (retained on 300µ)	OMC in %	24	23.3	22.9	21.0	20.7
	MDD in gr/cc	1.60	1.58	1.534	1.48	1.455

Table - 5: Index properties of Sample.

Physical Properties	Sample	
	Result	Scrap rubber tyre
Specific Gravity	2.58	Passing from 600µ sieve & retained on 425µ sieve
Plastic Limit	42	
Liquid Limit	24	
Plasticity Index	16	Passing from 425µ sieve & retained on 300µ sieve
Maximum Dry Density (MDD)	1.59	
Optimum Moisture Content (OMC)	25	

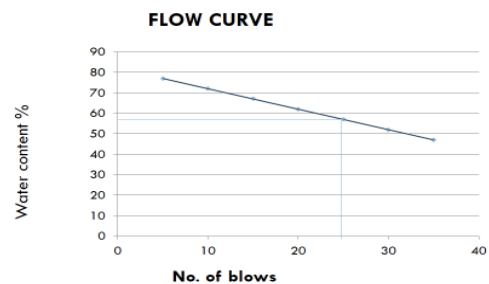
**6. RESULTS**

**Liquid Limit Test**

The test was done on the clayey soil first. The process of testing was followed as discussed earlier. Put 250 gm sample, passed 425 mm sieve, into dish. Add distilled water into the soil.

Place a portion of the paste in the cup of device. Trim it to a depth of 1 cm.

Rotate the cup at two revolutions per second till length of about 13 mm by flow, and record the number of blows, N.



THE LIQUIDITY OF THE SOIL SAMPLE IS 57%

**Standard Proctor Test**

Weight of empty mould = 4340gm. Volume of empty mould = 1000cc.

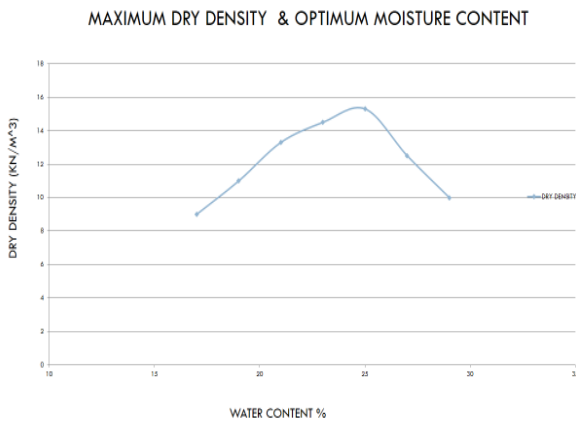
Results obtained are listed below in Table 6

Table 6: Standard Proctor Test Values for Different Percentage of CRP

%CRP	0	5	10	15	20
MDD	15.3	14.7	14.2	13.6	13.1
OMC	25	23.2	21.9	18.8	17

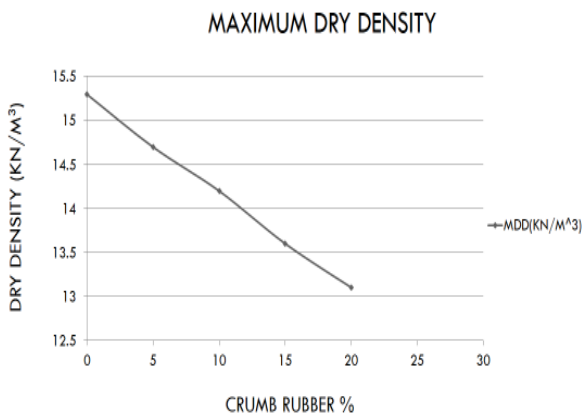
**Standard proctor test on soil**

The test was done on the clayey soil first. The Maximum Dry Density was found to be 1.72 g/cc at Optimum Moisture Content of 20.8%. The process of testing was followed as discussed earlier.

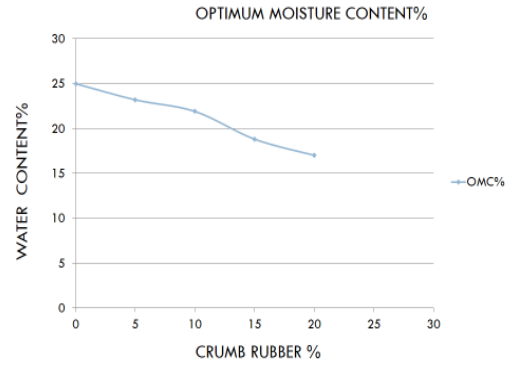


**Standard proctor test on blended soil**

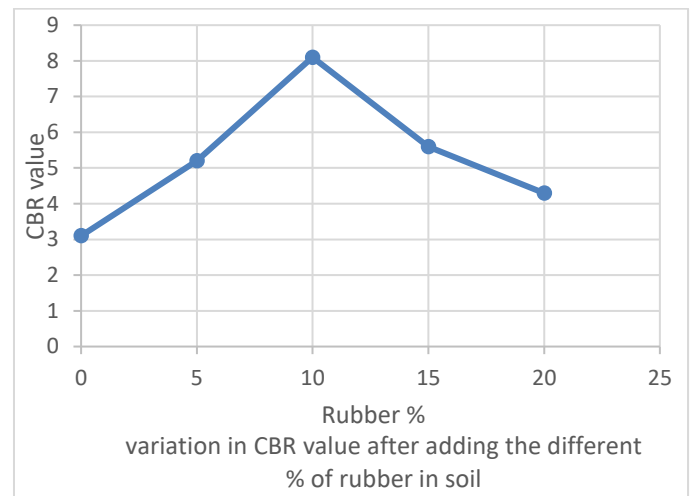
The process described earlier was repeated for all the samples



It can be observed that the increase in percentage of crumb rubber decreases the MDD



It can be observed that the increase in percentage of crumb rubber decreases the OMC



**7. CONCLUSION**

- After investigation of the test results are presented in table and figures of plotted graphs, following conclusion were drawn about the experimental study.
- The optimum moisture content (OMC) will be varies about 17% to 20% due to addition of scrap rubber tyre as form of shredded rubber content .The shear strength increased with the increasing amount of rubber up to 20 percentage by its weight.
- Strength was increased and thus it can be used for further constructions and in constructions of roads, bridge, and foundation work.
- The percentage reduction in liquid limit and plasticity index was about 50% & 54% when 4% CRP was added.
- Results of tests conclude that involvement of chips scrap (waste) rubber tyre strips in clay with proper amounts improved strength and shapeless behavior of sub grade soils. For scrap rubber tyre contemplated soil, the value of Unconfined Compressive Strength (UCS) is greater in compare to parent soil.
- For soil treated with 20% of scrap rubber tyre (Retained - 425 μ – scrap rubber tyre passing through 600μ and retained on 425μ IS sieve), and the highest unconfined compressive strength (UCS) value of 68KN/m<sup>2</sup> has been observed.
- The scrap rubber tyre chips using to reduce the environmental impact of scrap rubber tyre waste.

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