

# STUDY ON USE OF PLASTIC WASTE IN ROAD CONSTRUCTION

Mercy Joseph Poweth<sup>1</sup>, Solly George<sup>2</sup>, Jessy Paul<sup>3</sup>

Professor, Department of Civil Engineering, M.A. College of Engineering, Kothamangalam, India, Pin-686666<sup>1</sup>

Professor, Department of Civil Engineering, M.A. College of Engineering, Kothamangalam, India, Pin-686666<sup>2</sup>

Professor, Department of Civil Engineering, M.A. College of Engineering, Kothamangalam, India, Pin-686666<sup>3</sup>

**Abstract:** The population growth, industrialization, consumerism and technological development have led to uncontrollable accumulation of waste. Proper waste disposal is of great importance in both rural and urban areas. This study discussed the suitability of plastic waste materials for pavement construction. The waste is mixed in different proportions to the soil sample and their influences on geotechnical properties were studied. The results of the tests indicated that plastic alone is not suitable for pavement subgrade. When quarry dust was added along with soil plastic mix, it maintains the CBR value within the required range.

**Keywords:** plastic waste, pavement, CBR Value

## I. INTRODUCTION

The rate of production of waste has increased tremendously in almost all parts of the world in the past few decades. The quantities of these waste that are accumulating, are causing serious disposal problems. The conventional methods of disposal are found to be inadequate. Due to population growth, industrialization, consumerism and technological development there has been a tremendous increase in the rate of production of waste. Every year, 7.2 million tonnes of hazardous waste is produced and its disposal is becoming a major issue and about one km<sup>2</sup> of additional landfill area is needed every year. Indian government spends about Rs 1600 crore for treatment & disposal of these wastes. In addition to this, industries discharge about 150 million tonnes of high volume low hazard waste every year, which is mostly dumped on open low lying land areas. In this scenario, the conventional waste disposal methods are found to be inadequate. Through this project, a small attempt has been made at deducing a new method of waste disposal. This paper aims at proposing a new method of disposal of plastic, quarry dust and tyre waste by using them in the sub grade soil of pavement. The Main objective of this study are safe and productive disposal of wastes - plastic, quarry dust and tyre, study of index properties and CBR values of variable mixes of soil and waste and suitability of soil-waste mix in sub grade. This paper aims at proposing a new method of disposal of plastic, quarry dust and tyre waste by using them in the sub grade of pavements. A series of laboratory tests including specific gravity, grain size analysis, Atterberg's limits and CBR test were conducted for this purpose. The results of the tests are presented and discussed in this paper.

## II. EXPERIMENTAL STUDY

### MATERIALS USED

**Soil:** The soil sample for the experimental work was collected from Kothamangalam, Ernakulam District. The results of the laboratory tests conducted for soils are shown in Table 1. The test were carried out as per IS Code specifications.

**Plastic:** Plastic waste was collected from Star polymers-waste plastics processing unit, Perumbavoor, Ernakulam District. The plastic waste used for the experiments is the left over of processed plastic waste and cannot be recycled.

**Quarry dust:** Quarry dust was collected from nearest quarry stone site at Kothamangalam, Ernakulam District. The sample used for the study .

### TESTS CONDUCTED

1. Grain size analysis for soil sample, plastic and quarry dust
2. Liquid limit for different soil-waste mixes
3. Shrinkage limit for optimum mixes
4. Standard proctor test
5. CBR

Table1: PROPERTIES OF MATERIALS USED

| Properties                  | Soil  | Plastic | Tyre  | Quarrydust |
|-----------------------------|-------|---------|-------|------------|
| 1) Specific gravity         | 2.55  | 0.471   | 0.55  | 3.03       |
| 2) Grain Size Analysis      |       |         |       |            |
| a) D <sub>10</sub>          | 150   | 100     | 150   | 66         |
| b) D <sub>30</sub>          | 560   | 240     | 250   | 310        |
| c) D <sub>60</sub>          | 1700  | 330     | 400   | 720        |
| d) C <sub>u</sub>           | 10    | 3.3     | 2.67  | 10.9       |
| e) C <sub>c</sub>           | 1.39  | 1.75    | 1.04  | 2.02       |
| f) >4.75mm(Gravel)(%)       | 11.64 | 0       | 0.78  | 0          |
| g) 4.7-0.75mm(sand)(%)      | 78.06 | 84.28   | 98.55 | 77.5       |
| h) <0.75mm(Silt+Clay)(%)    | 10.3  | 15.72   | 0.67  | 22.5       |
| 3) Consistency Limit        |       |         |       |            |
| a) W <sub>L</sub> (%)       | 37.8  | -       | -     | -          |
| b) W <sub>s</sub> (%)       | 11.2  | -       | -     | -          |
| c) W <sub>p</sub> (%)       | 28.2  | -       | -     | -          |
| 4) Standard Proctor Test    |       |         |       |            |
| a) $\gamma_{d \max}$ (g/cc) | 1.75  | -       | -     | -          |
| b) OMC(%)                   | 16    | -       | -     | -          |

### SAMPLE PREPARATION AND DESIGNATION OF SOIL WASTE MIX

The different soil waste samples were prepared by thoroughly mixing weighed amount of soil and waste in the required proportion.

Table 2: DESIGNATIONS OF SOIL AND WASTE MIX

| Soil | Plastic Waste | Quarry dust | Tyre waste | Percentage by mass |
|------|---------------|-------------|------------|--------------------|
| S0   | P0            | Q0          | T0         | 0                  |
| S4   | P4            | Q4          | T4         | 4                  |
| S10  | P10           | Q10         | T10        | 10                 |
| S20  | P20           | Q20         | T20        | 20                 |
| S36  | P36           | Q36         | T36        | 36                 |
| S54  | P54           | Q54         | T54        | 54                 |
| S80  | P80           | Q80         | T80        | 80                 |
| S100 | P100          | Q100        | T100       | 100                |

### III RESULTS AND DISCUSSIONS

First phase of studies were on the soil-plastic mixes. From the standard compaction test it was observed that as the proportion of plastic increased, the maximum dry density was decreasing. Hence another waste with maximum density was mixed with soil-plastic waste and again the standard proctor test was carried out. In addition to the above two

waste, another locally available tyre was also mixed and the same test was done. From these various tests different optimum soil-waste samples were obtained and CBR tests were carried out. The test results of the different soil waste mixes are tabulated in table 3 and 4

The required percentage of waste plastics/waste tyre rubber chips/quarry dust by dry weight of soil was mixed uniformly with the soil, water content corresponding to OMC was added to the soil. CBR tests were conducted in the laboratory on soil sample mixed with different percentages of waste materials.

Table 3: PROPERTY VARIATION FOR DIFFERENT MIXES

| Mix       | Liquid limit(%) | OMC(%) | ( $\Gamma_d$ ) <sub>max</sub> max g/cc |
|-----------|-----------------|--------|--|
| S100      | 37.8            | 16     | 1.75                                   |
| S80Q20    | 33              | 18     | 1.79                                   |
| S60Q40    | 28              | 14.2   | 1.93                                   |
| S40Q60    | 22              | 13.6   | 1.95                                   |
| S96P4     | 39              | 17     | 1.63                                   |
| S88P12    | 31              | 18     | 1.52                                   |
| S80P20    | 35              | 22     | 1.35                                   |
| S20P80    | 59              | 46     | 0.72                                   |
| S80T20    | -               | 18.2   | 1.49                                   |
| S40Q40P20 | 28.5            | 18.9   | 1.385                                  |
| S54Q36P10 | 27              | 15.5   | 1.66                                   |
| S36Q54P10 | 24.5            | 14.6   | 1.67                                   |
| S36Q54P10 | 24.5            | 14.6   | 1.67                                   |
| S54Q36T10 | 23.5            | 13.2   | 1.72                                   |
| S36Q54T10 | 22.5            | 12.5   | 1.76                                   |

Table 4: PROPERTIES OF OPTIMUM MIXES

| MIX         | LIQUID LIMIT(%) | SHRINKAGE LIMIT(%) | OMC (%) | $\gamma_d$ max (g/cc) | CBR   |
|-------------|-----------------|--------------------|---------|-----------------------|-------|
| S100        | 37.8            | 11.2               | 16      | 1.75                  | 12.16 |
| S60,Q40     | 28              | -                  | 12.5    | 1.93                  | 13.62 |
| S40,Q60     | 22              | -                  | 13.6    | 1.95                  | 15.82 |
| S54,Q36,P10 | 27              | 13.85              | 15.5    | 1.66                  | 7.77  |
| S36,Q54,P10 | 24.5            | 22.93              | 14.6    | 1.67                  | 10.9  |
| S54,Q36,T10 | 23.5            | 28.65              | 13.2    | 1.72                  | 4.82  |
| S36,Q54,T10 | 22.5            | 12.7               | 12.5    | 1.76                  | 4.85  |

Based on the Standard proctor test results it was observed that, for soil sample mixed with waste plastics, the maximum dry density decreases and the optimum water content increases as the percentage of plastic waste in mix increases. Hence higher percentage of plastic waste is not advisable as the plastic waste percentage increases liquid limit increases. At 12% plastic, contrary to this trend the liquid limit decreases and later mixes continues the old trend. Thus for further work optimum percentage of plastic was fixed as 10%. Based on the Standard proctor test results it was observed that, for soil sample mixed

with quarry dust, by the addition of quarry dust the maximum dry density of the soil increases, and for every 10% increase in quarry dust liquid limit decreases at the rate of about 2.6%. But the rate increases as the percentage increases. Since the soil plastic waste mixes gave lower CBR value, quarry dust was introduced to this mix. Based on the Standard proctor test results it was observed that, for soil sample mixed with plastic waste and quarry dust, maximum dry density decreases as the percentage of plastic waste increases in the mix. And maximum dry density is higher for 10% plastic waste with higher quarry dust percentage and as the percentage of plastic increases liquid limit decreases and shrinkage limit decreases with increases in soil percentage in the mix. Based on the Standard proctor test results it was observed that, for soil sample mixed with tyre waste, the maximum dry density decreases as the waste tyre percentage in mixes increases. Hence increase in percentage of tyre in mix is not advisable. By the addition of 80% tyre waste the maximum dry density of the soil sample decreased from 1.75 g/cc to 0.85 g/cc. The same trend is observed for 80% plastic waste addition. From these we can conclude higher percentage of tyre or plastic addition to soil is not advisable. Based on the Standard proctor test results it was observed that, for soil sample mixed with tyre waste and quarry dust, at a constant tyre percentage as the quarry dust increase the maximum dry density increases and optimum moisture content decreases and as the percentage of quarry dust increases the liquid limit decreases and the shrinkage limit decreases with increase in quarry dust percentage in the mix.

**CBR**

From the above data, the optimum mixes were determined based on the maximum dry density of the different waste soil mixes. The optimum mixes were concluded as S60Q40, S40Q60, S54Q36P10, S36Q54P10, S54Q36T10, S36Q54T10. The results are tabulated in table 5

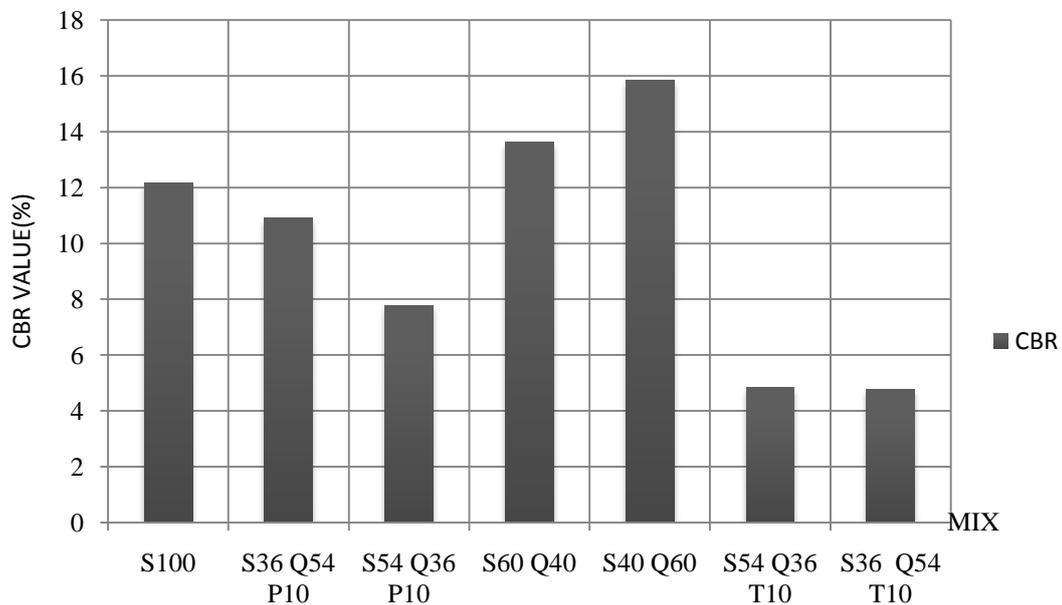


FIG 1 CBR VALUES OF OPTIMUM MIXES

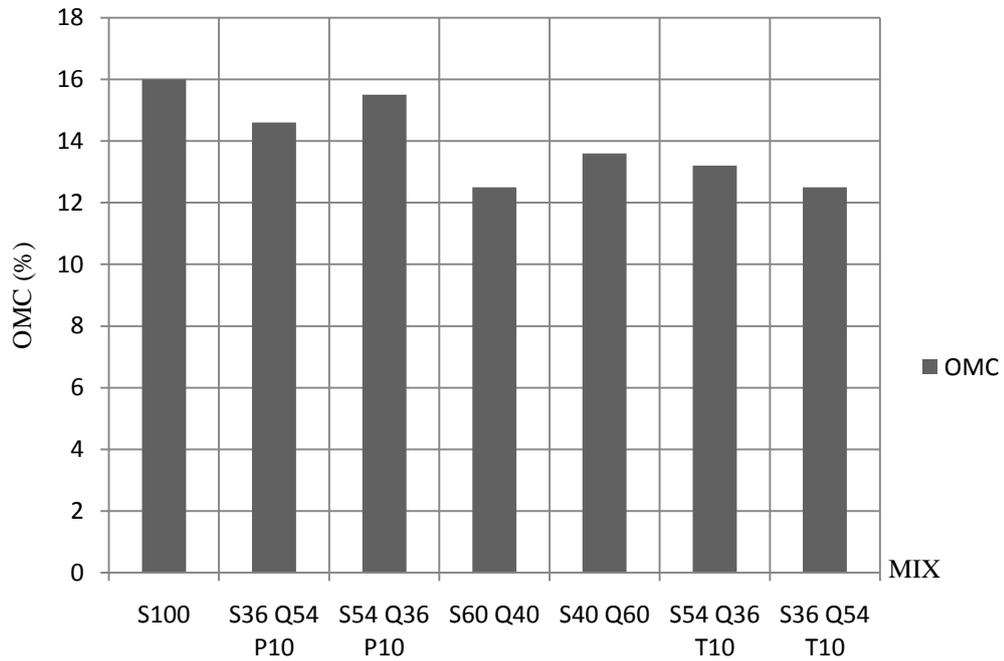


FIG 2. OMC OF OPTIMUM MIXES

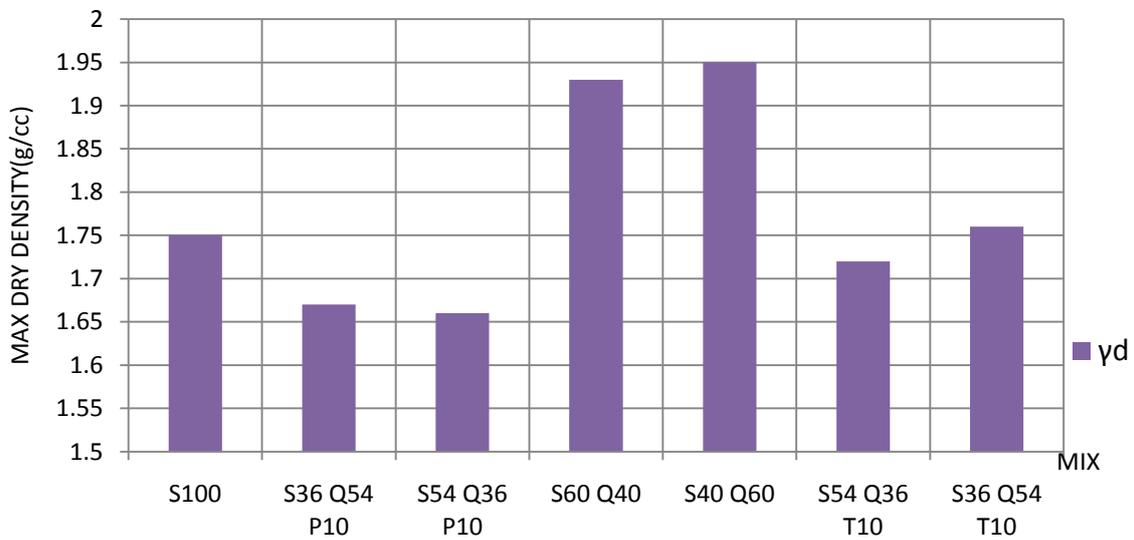


FIG 3 MAXIMUM DRY DENSITY OF OPTIMUM MIXES

Based on the CBR results it was observed that

1. CBR value of quarry dust mix is higher than the blank soil
2. CBR value of plastic and tyre waste is less than the blank soil but can be used for the pavement subgrade
3. CBR value of soil quarry dust plastic mix is higher than the soil quarry dust tyre mix
4. For all the mixes the liquid limit was decreasing. But the shrinkage limit increases for all the combination. While observing the shrinkage limit for higher percentage of quarry dust in soil mixes, it's observed that 10%

plastic is having more effect than tyre. The reverse trend is observed for lower percentage of quarry dust in soil quarry dust mix.

#### IV CONCLUSIONS

CBR and standard proctor tests were carried out for finding the optimum percentages of waste plastics, and quarry dust in soil sample. Based on the laboratory studies carried out in this work, the conclusions that can be drawn here

1. As the percentage of plastic waste increases the maximum dry density decreases, thereby decreasing the CBR value. Hence quarry dust was mixed along with the soil plastic mix, to increase its maximum dry density.
2. Increase in percentage of quarry dust resulted in increase of maximum dry density and CBR value. Hence quarry dust was found to be suitable for pavement subgrade.
3. In case of tyre, as the percentage of tyre increases maximum dry density decreases. Hence tyre alone is not suitable for subgrade. .
4. Soil plastic mix with quarry dust maintains the CBR value within the required range. Soil tyre-soil mix with quarry dust gives lesser CBR value than soil plastic quarry dust mix but it can be used for pavement subgrade

#### REFERENCES

1. IS: 2720 (Part 1). 1979. Method of test for Soils: Part 1, Preparation of Dry Soil Samples for Various Tests.
2. IS: 2720 (Part 2). 1979. Method of test for Soils: Part 2, Determination of Water Content.
3. IS: 2720 (Part 3). 1979. Method of test for Soils: Part 3, Determination of Specific Gravity.
4. IS: 2720 (Part 4). 1979. Method of test for Soils: Part 4, Grain Size Analysis.
5. IS: 2720 (Part 5). 1979. Method of test for Soils: Part 5, Determination of Liquid Limit and Plastic Limit.
6. IS: 2720 (Part 7). 1979. Method of test for Soils: Part 7, Determination of Water Content-Dry Density Relation Using Light Compaction.
7. IS: 2720 (Part 16). 1979. Method of test for Soils: Part 16, Laboratory Determination of CBR Indian Standards.
8. Foose, G.J, Benson, C.H., and Bosscher, P.J. (1996) 'Sand reinforced with shredded waste tyres', Journal of Geotechnical Engineering, Vol. 122, No. 9, 760-767.
9. Prasad, Prasada Raju, Ramana Murthy 'Use of Waste Plastic and Tyre in Pavement Systems', IE(I) Journal-CV, Vol.89, pp 31-35, 2008
10. <http://www.wikipedia.com>
11. Benson, C.H. and Khire, M.U. "Reinforcing Sand with Strips of Reclaimed High-Density Polyethylene", Journal of Geotechnical Engineering, Vol.121, pp 838-855,1994
12. Venkatappa Rao, G. and Dutta, R.K , "Ground Improvement with Waste Plastic", Proceedings of 5<sup>th</sup> International Conference on Ground Improvement Techniques, 22-23 March, Kuala Lumpur, Malaysia, pp 321-328,2004.
13. Venkatappa Rao, G. and Dutta, R.K, "Sand Plastic Mixtures in Ground Improvement", Proceedings of International Conference on Geosynthetics and Geoenvironmental Engineering, Mumbai 8-10 Dec, pp 189-194,2004.
14. Yetimoglu, T., Inanir, M. and Inanir, O.E. "A Study on Bearing Capacity of Randomly Distributed Fiber-Reinforced Sand Fills Overlying Soft Clay", Geotextiles and Geomembranes, Vol 23, pp 174-184,2005
15. Yetimoglu, T. and Salbas, O. "A Study on Shear Strength of Sands Reinforced with Randomly Distributed Discrete Fibers", Geotextiles and Geomembranes, Vol 21, pp 103-110.,2003.
16. Kaniraj, S.R. and Havanagi, V.G. "Behavior of Cement-Stabilized Fiber-Reinforced Fly Ash-Soil Mixtures", Journal of Geotechnical and Geoenvironmental Engineering, Vol 127, pp 574-584,2001.
17. Kumar, R., Kanaujia V.K. and Chandra D. "Engineering Behavior of Fiber-Reinforced Pond Ash and Clay", Geotextiles and Geomembranes, Vol 23, pp 174-184,2005.
18. Dutta, R. K., Sarda, V. K. "CBR Behaviour of Waste Plastic Strip-Reinforced Stone Dust/Fly Ash Overlying Saturated Clay ", Journal of Geotechnical Engineering, Vol. 31,pp 171-182,2007.
19. Prasad, S. V., Prasada Raju, G. V. R., "Performance of Waste Tyre Rubber on Model Flexible Pavement", ARPN Journal of Engineering and Applied Sciences, Vol. 4, No. 6.,2009.