

Effect of Waste Plastic, Glass and Rubber in Combination on the Strength of Asphalt mix

Sneha S.D.¹, Manaswini B.M.², Dakshayini L.S.³, Krishna Chaitanya P⁴, Amogha Varsha K.V.⁵

¹*Sneha S.D, Asst. Professor, Dr. Ambedkar Institute of Technology*

²*Manaswini B.M, Student, Dr. Ambedkar Institute of Technology*

³*Dakshayini L.S, Student, Dr. Ambedkar Institute of Technology*

⁴*Krishna Chaitanya P, Student, Dr. Ambedkar Institute of Technology*

⁵*Amogha Varsha K.V, Student, Dr. Ambedkar Institute of Technology*

Abstract - Nowadays, there is a large amount of solid waste that is not decomposed properly. Mainly the non-degradable wastes, that is hard to manage in the landfills that reduce the lifespan of the landfill. Due to this crisis we can also observe that the roads around us are not in suitable manner to ensure safety. So, we mainly thought of using the waste materials as replacements in an asphalt mixture. We choose plastic as a replacement of bitumen, fine glass powder as a replacement of fillers and crumb rubber as a replacement of coarse aggregate.

As a result, we choose drip pipes as a plastic, beer bottles as glass and crumb rubber. In terms of total weight of bitumen 7.5% of plastic was used as replacement, similarly in terms of total weight of filler and aggregate 15% of glass and 12.5% of crumb rubber were used as a replacement respectively. With the combination of all three replacements an asphalt mixture was prepared to conduct the Marshall Stability test to analyze whether it is applicable for road construction.

Index Terms-Bitumen, Plastic, Crumb Rubber, Powdered Glass, Recycled materials in Asphalt, Marshall Stability, Modified Asphalt mix.

I. INTRODUCTION

The amount of solid waste generated everyday is too large to get it treated and is also a threat to the sustainability of the Earth. Mainly, in a country like India which is a developing country, which generates about 62 million tons every year it is an even more tricky task. About 43 million tons of solid waste is collected in which 12 million tons is treated and 31 million tons is dumped in landfills. The plastic consumption in India is about 3.4 million tons per year in which only 30% of it is treated or recycled and rest is dumped in landfills and aquatic dumps. India alone produces 3 million tons of glass waste annually of which only 35% is treated.

Every year more than 15 billion tons of tire waste is generated and India contributes to 6% of it. India also imports 3 lakh tons of waste tires for recycling every year. So, to overcome these problems caused by the solid waste we need to utilize it in innovative technologies or any other purposes of construction. In this study, we have used these three-solid wastes as a replacement in asphalt mixture to improve the strength of the roads. Addition of the plastic waste improves the fatigue behavior of the mixture.

It has been proven possible that the performance of bituminous mixture improves with the help of additives or modifiers such as polymers, rubber latex, crumb rubber [1], etc. With several types of wastes obtained from different plastic types, the use of low-density polyethylene (LDPE) and high-density polyethylene (HDPE) plastic have been found to be the most promising in asphalt mixtures compared to other types [2]. Polyethylene (PE) would be more economical and effective in asphalt paving than other polymeric materials [3]. Due to presence of PE in drip pipes, it is chosen for a plastic replacement.

Shredded tire pieces are known as crumb rubber. The incorporation of crumb rubber into asphalt binder would cause the asphalt to possess ductility and crack resistant characteristics, resistant to rutting, high softening point and better resilience, reduction of temperature susceptibility, the resistance to permanent deformation, fatigue failure and thermal cracking [3].

A. Objectives

- To compare the strength of asphalt mix at various replacement percentages of recycled waste materials such as Glass powder, Plastic and Crumb Rubber to the Referral mix.
- To estimate the percentage of replacement materials in combination which would give improved properties compared to conventional asphalt mix.

B. Scope of work

- Different Recyclable materials are used in Asphalt mix to get some of the desired properties like Water repellence, Binding property, Increased strength, longevity of the Asphalt Pavement.
- Liquid plastic added to the heated aggregates can reduce the water absorption of the aggregates thereby improving the bonding of bitumen.
- Crumb rubber is a sustainable construction material and is taken as a replacement to coarse aggregate.
- Powdered glass is used as a filler material replacement to fine aggregates as it can improve the water repellence and reduce the absorption of clogged water on the surface.

II. MATERIALS*A. Bitumen*

The bitumen used for our tests was obtained from a local road contractor, Patel Construction based in Bangalore and the grade of Bitumen was is VG- 30 Bitumen extracted by Bharat Petroleum Corporation Limited. The properties of the Bitumen were acquired from performing some basic tests on Bitumen and presented in Table I.

Table I-Properties of Bitumen evaluated from Basic Tests

Specific Gravity	1.11
Penetration Test	52mm
Softening Point	58°C
Ductility Test	80cm

B. Aggregates

Aggregates used for the tests and preparation of asphalt mixtures were acquired from the laboratory of our university.

- Specific gravity of aggregates : 2.79
- Water absorption of aggregates : 0.70%
- Impact value of aggregates : 26.46%
- Crushing Test value : 25%
- Elongation Value : 58.57%
- Flakiness Value : 20.38%
- Abrasion Test of aggregates : 19.8%

C. Plastic

Plastic Waste used for this project was in the form of used Drip pipes from agricultural field. These pipes were cut shredded into small pieces of 2 – 3 mm in size and mixed along with the bitumen while making asphalt mix.

D. Glass

Waste Alcohol bottles that were thrown away were collected around the campus area and these bottles were finely powdered and sieved through the 75 micron IS Sieve and the powder passing through is used as the filler powder material for the asphalt mix in small replacement quantities.

E. Crumb rubber

Recycled Tire rubber is used as a replacement material for aggregates in a small quantity and was acquired from Nature and Greens (Natural material Suppliers) and the Recycled rubber was acquired from waste truck tires that were recycled.

III. EXPERIMENTAL METHODS*A. Marshall Stability Test*

The Samples prepared for the Marshall Test were prepared according to the specifications and requirements of the Marshall Stability Test.

A dry process of sample preparation was used in which the recycled materials are added to the graded aggregates before it was mixed with bitumen.

The aggregates were mixed with Powdered glass as a filler replacement and Crumb rubber was added as a replacement material instead of aggregates in a small percentage by weight of the aggregates considered for the asphalt mix. Then the plastic was mixed and heating along with the aggregates and then the Bitumen binder was added to the aggregates.

After the moulds are casted, the samples are then tested in the Marshall Stability testing equipment and the results are tabulated and compared.

The properties that are evaluated from the Marshall Stability test are Stability values and Flow values.

Stability indicated the extent up to which the sample can carry a load without fracture. The optimum temperature at which samples show maximum load bearing capacity is 60°. Hence the Marshall Stability Test must be conducted when the sample is at a temperature of 60° to get optimal results.

Flow value is nothing but the deformation that the sample undergoes until it reaches maximum load capacity. The main comparing factors for this project are the Marshall Stability and Flow values of the samples tested.

B. Sample Preparation

Based on the different replacement percentages, the samples are prepared for testing.

Firstly to calculate the Optimum Bitumen content to be considered for the tests, three samples were prepared with 4%, 4.5% and 5% Bitumen by weight of aggregates. After calculating the optimum Bitumen content, three samples were tested with Optimum Bitumen Content.

Next, the samples are prepared by using replacement percentages. In case of using Plastic as the replacement material, we prepared 9 samples, 3 samples for each of the replacement percentages which are 5%, 7.5% and 10%. Similarly, with Crumb Rubber replacement the different replacement percentages are 10%, 12.5% and 15% by weight of aggregates. For replacement of Filler material with Powdered Glass we have used the different replacement percentages as 10%, 12.5% and 15% by weight of aggregates.

After testing the samples as mentioned above, the optimum amount of replacements for different materials, to be used in combination, obtained are 7.5% Waste Plastic, 15% Powdered Glass, and 12.5% Crumb Rubber.

IV. RESULTS AND TABULATIONS

Results of the Marshall Stability tests performed on the samples with all three replacement materials in combination are in the presented below.

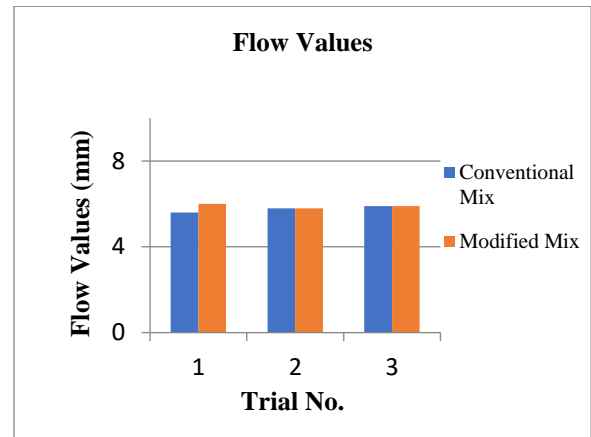
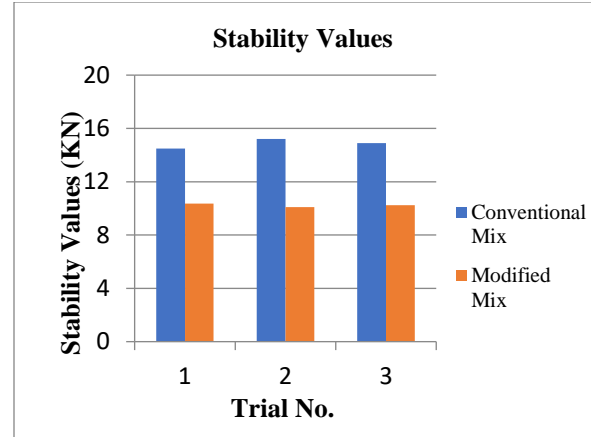
Table II. Comparison of Conventional Asphalt mix with Modified Asphalt mix in terms of Marshall Stability measured in KN.

Trial No.	Stability of Conventional mix	Stability of Modified Asphalt mix
1	14.5	10.36
2	15.2	10.1
3	14.9	10.24

Table III. Comparison of Flow values (measured in mm) of Conventional Asphalt mix and Modified Asphalt mix

Trial No.	Flow Value of Conventional Asphalt mix	Flow Value of Modified Asphalt mix
1	5.6	6
2	5.8	5.8
3	5.9	5.9

Comparison Graphs between Conventional Asphalt mix and the Modified Asphalt mix with all three replacement materials are as shown below.



V. CONCLUSION

This study has shown that waste materials like plastic, recycled glass and crumb rubber can be used in combination along with the conventional asphalt mix, at various optimum replacement percentages as an alternative recycling method while improving the sustainability of the environment.

The obtained optimum replacement quantities of trial tests performed on each of these waste materials individually with the asphalt mix are discussed below:

- Optimum Bitumen content: 5% by weight of aggregates
- Optimum Plastic replacement: 7.5% by weight of Bitumen
- Optimum Glass powder filler replacement : 15% by weight of aggregates
- Optimum Crumb Rubber replacement : 12.5% by weight of aggregates

The combination of these materials at their optimum replacement percentages perform well under the tests and have given slightly lesser strength when compared to the Conventional Asphalt mix. However, the results are still within the permissible limits hence these materials can be used in Asphalt mix practically.

VI. REFERENCES

- [1] Appiah, J. K., Berko-Boateng, V. N., & Tagbor, T. A. (2017). Use of waste plastic materials for road construction in Ghana. *Case studies in construction materials*, 6, 1-7.
- [2] Awoyera, P. O., & Adesina, A. (2020). Plastic wastes to construction products: Status, limitations and future perspective. *Case Studies in Construction Materials*, 12, e00330.
- [3] Prasad, A. R., & Sowmya, N. J. (2015). Bituminous modification with waste plastic and crumb rubber. *IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)*, 12(3), 108-115.
- [4] Ewa, D. E., Ukpata, J. O., Akeke, G. A., Etika, A. A., & Adah, E. I. (2022). Use of waste glass fines to improve rigidity ratio of asphalt. *Cogent Engineering*, 9(1), 2107197.
- [5] Raja, C. J. S., Sampath, N. S., Suresh, C., & Bhaskar, A. P. (2020). A review on use of plastic in construction of roads. *Journal of Advancement in Engineering and Technology*, 7(4).
- [6] Hake, S. L., Damgir, R. M., & Awsarmal, P. R. (2020). Utilization of plastic waste in bitumen mixes for flexible pavement. *Transportation Research Procedia*, 48, 3779-3785.
- [7] Zakaria, N. M., Hassan, M. K., Ibrahim, A. N. H., Rosyidi, S. A. P., Yusoff, N. I. M., Mohamed, A. A., & Hassan, N. (2018). The use of mixed waste recycled plastic and glass as an aggregate replacement in asphalt mixtures. *Jurnal Teknologi*, 80(1).
- [8] Manju, R., Sathya, S., & Sheema, K. (2017). Use of plastic waste in bituminous pavement. *Int J ChemTech Res*, 10(08), 804-811.
- [9] Pitake, S., Tapkir, O., Takalkar, J., Thorat, V., Patil, V. (2021). Use of Glass as aggregate in Bitumen Asphalt Pavement. *IJCRT, ISSN : 2320-2882*.
- [10] Nitish Kumar, K., & Rajakumara, H. N. (2016). Study of using waste rubber tyres in construction of bituminous road. *Int. J. Sci. Eng. Res.*
- [11] Finkle, I., & Ksaibati, K. (2007). *Recycled glass utilization in highway construction* (No. MPC Report No. 07-192).
- [12] Bariaya, N. D. (2013). Use of waste rubber tyres in constructions of bituminous roads-An Overview. *International Journal of Application or Innovation in Engineering & Management (IJAIEM)*, 2(7).