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STUDY ON EFFECT OF PLASTIC WASTE AND STEEL SLAG IN BITUMINOUS CONCRETE MIX

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ABSTRACT

The plastic wastes like polyethylene, polypropylene, poly vinyl chloride can be effectively used in road construction. Steel Slag has been used in the road laying work as a viable recyclable material due to its mechanical excellence in terms of its strength, skid and abrasion resistance compared to natural aggregate. The frequent problems faced in India regarding roads are potholes, rutting and decreased durability of pavements. In this project the use of plastic waste with bitumen and also the steel slag with aggregates for replacing them to a limited extent. Specimens for Marshall test was prepared with various proportions of waste plastic and steel slag and the optimum content of plastic waste and steel slag for replacement are determined.

Keywords: *Plastic, Steel slag, Polyethylene, Polypropylene, Poly vinyl chloride.*

1. INTRODUCTION

As per the report from International Solid Waste Association (ISWA), India generates 150 million tons of waste which is equivalent to 3 million truck loads which is the result of rapid industrialization and vast infrastructure. On daily basis people widely depend on plastics specifically those of use and throw culture like cups, carry bags. Some of the factors like ease of availability of plastics, economically beneficial, corrosion resistant, light weight and more importantly a versatile element for packaging have given it immense popularity and a remarkable place in domestic and in industrial sectors. But these plastics pose a serious threat to environment and human health. The Objective of this project is to study the effect of plastic waste as an additive material to the weight of bitumen in bituminous pavements and to study the effect of bituminous mix replacement by steel slag material.

1.1 Bitumen

Bitumen is used as binders in pavements constructions. It is primarily derived from the residue from the refinery from naturally occurring asphalt. American society of testing materials defines bitumen as “Mixtures of hydrocarbon of natural or progenies origin or combination of both frequently accompanied by their non-metallic derivatives which may be gaseous liquid semi-solid and which are completely soluble in carbon disulphide”.

1.2 Plastic

The usage of plastic as a material is enormous; to deal it chemically they are long chains of polymers. Some important groups in these classifications are the acrylics, polyesters, silicones, polyurethanes, and halogenated

plastics. Plastics can also be classified by the chemical process used in their synthesis, such as condensation, poly addition, and cross-linking.

1.3 Classification of plastic waste

1. Polyethylene LDPE (low density poly-ethylene)

Low density poly-ethylene this plastics waste available in the form of carry bags generally in stores these plastics bags are very thin and also easily available.

2. Polypropylene

This plastic may be available in the form of carry bags or solid plastic it`s depend upon the use and need of the industries. It is available in the form of plastic bottles and mat sheets etc.

1.4 Plastic in bituminous mixes

India experiences a tropical climate which leads to variations in temperature. Under these conditions, flexible pavements tend to become soft in summer and brittle in winter. Investigations in India and abroad have revealed that properties of pavements with the bituminous mixes can be improved to meet requirements of pavement with the incorporation of certain additives or blend of additives. Theses additives are called bitumen modifiers and the bituminous mixes premixed with theses modifiers are known as modified bituminous mixes. In addition to above point, modified bituminous mixes are expected to give higher life surfacing depending upon the degree of modifications and type of additives and modification process adopted.

The achieve this improvement, it is necessary to add natural or synthetic polymers to bituminous mixes in order to obtain modified bituminous mixes, using several synthetic polymers like polyethylene, polythene, ethylene vinyl acetate, waste plastic is added to enhance the property of the bituminous mixes and improves the quality of the road.

1.5 Steel slag

Steel slag aggregates have properties to retain heat considerably longer than conventional natural aggregates. The heat retention characteristics of steel slag aggregates can be advantageous during variable weathering conditions. It has over 20% interconnecting voids. These voids absorb noise from the traffic and allow water to drain. In addition, less water on the road means better road grip and less spray effects improve the driver's visibility. Roads built with porous asphalt using steel slag are quiet, safe and long – lasting. This study aims to investigate the feasibility of utilizing steel slag aggregate in bituminous concrete mixtures. The use of steel slag as the fine portion of aggregates can enhance Marshall Stability, Tensile Strength, resistance to moisture damage and resistance to the permanent deformation of bituminous concrete mixtures.

2. LITERATURE REVIEW

Dr S.L. Hake et al., (2020) have discussed the utilization of plastic waste inbitumen mixes for flexible pavement. In this research, plastic waste coated aggregate is mixed with hot bitumen at the temperature range 130°C to 140°C. The measurements of plastic of 5%, 7.5%, 10%, 12.5% and 15% utilised as substitution of bitumen. The advance plastic content is 10% with 5.25% of bitumen content. This paper concentrated on

Marshall test and extreme executionof hot blend black-top. In this examination work, it is explored that the general cost of plastic blends bitumen spared 5.18% cost as contrast with customary bitumen. Subsequently it is efficient and earth advantageous for development of plastic blend bituminous street.

Mengzhen Zhao et al., (2018) have focussed on the feasibility and effectiveness of the application of waste cooking oil in desulfurizing and degrading rubber particles through co-pyrolysis of them at mild temperature. Chemical and microscopic analyses were performed to investigate the structuralchanges of vulcanized rubber. Results showed that solubility of rubber powder reached above 60 wt% after pyrolysis in waste cooking oil. The surface of pyrolysis product was even and smooth without obvious rubber particles.

Ruikin Dong et al., (2018) have reported the feasibility of application of waste rubber oil produced by light pyrolysis of crumb tire rubber in waste cookingoil as a bitumen modifier. The chemical properties, thermal behaviours and reaction process of waste rubber oil were characterised by gel permeation chromatography, Fourier Transform infrared spectroscopy. The results showed that the storage stability, Plasticity at low temperature and Workability of Wasterubber modified bitumen are greatly improved, compared to normal bitumen.

Sara R.M Fernandes et al., (2018) have focussed on developing enhancedmodified bitumen with waste engine oil products combined with polymers. Materials used in this study were waste engine oil, 35/50 penetration grade binderas base bitumen, polymers. Physical, chemical and rheological properties of binder were investigated using different laboratory tests and evaluated. The results showed that bitumen modified with waste engine oil products and polymers have similar penetration values and softening point temperatures higherthan those of commercially modified binders. A rheological analysis of the mostencouraging solutions showed low thermal susceptibility, high values of high temperature PG and low non recoverable creep compliance values, which could indicate a promising performance using high amounts of waste materials.

Sudheer Ponnada et al., (2020) have described the possibility of using waste plastic bottles in flexible pavements. In this study, shredded waste plasticwater bottles were added to the bitumen to improve its rheological properties. Plastic is heated up to its melting point, and then bitumen is added to the liquid plasticand mixed thoroughly with the help of mechanical stirrer. On the prepared composite material (i.e. Plastic Modified Bitumen), laboratory tests were conducted like softening point, ductility value, elastic recovery, penetration, specific gravity, flash and fire point. Marshall stability test was conducted on thesame plastic modified bitumen samples to finalise the optimum percentage of plastic to be added. Finally, comparison made between plastic modified bitumensample with original bitumen sample. The results indicated that, replacing the bitumen with 5% and 7.5% of plastic improves the rheological properties of the bitumen. From the Marshall test, it was declared that 7.5% replacement of bitumen with plastic gives more stability and it is the optimum percentage whichcan add to the bitumen to use in flexible pavements for improving the maintenance period also for improving the rheological parameters of bitumen.

3. MATERIALS

3.1 Bitumen:

The bitumen used in this study is of VG 30 grade and is shown in Fig.1.

Fig 1 Bitumen

3.2 Steel Slag:

The steel slag used in this study is collected from a private steel manufacturing plant located in Ingur, Perundurai and is shown in the Fig.2.

Fig 2 Steel Slag

4. TESTS ON MATERIAL

4.1 Tests on Aggregate

The tests conducted on aggregate and their results are shown in Table 1.

Table 1 Test on Aggregate

S. No	Tests	Result
1	Specific gravity	2.38
2	Water absorption	1.7%

3	Impact test	26%
4	Los angles abrasion	30%
5	Crushing test	29%

4.2 Tests on Steel Slag

The tests conducted on steel slag and their results are shown in Table 2.

Table 2 Test on Steel Slag

S. No	Tests	Result
1	Specific gravity	2.35
2	Water absorption	2%
3	Impact test	24%
4	Los angles abrasion	27%
5	Crushing test	27.5%

4.3 Test on bitumen

The tests conducted on bitumen and their results are shown in Table 3.

Table 3 Test on Bitumen

S. No	Tests	Result
1	Penetration	65 mm
2	Softening point	49^{o}C
3	Ductility	100 cm

5. MIX DESIGN FOR BITUMINOUS CONCRETE MIX

The mix proportion for bituminous concrete mix is done as per Ministry of Road Transport and Highways (MoRTH) specifications. The total aggregate content is taken as per IRC guidelines. The specifications for the mix are given below

Total weight for each mould = 1300 g (Approx.)

Percentage of bitumen by weight of mix = 5%

Percentage of aggregate by weight of mix = 95%

Table 4 Mix Proportioning for Bituminous Concrete

AGGREGATE SIZE(mm)	% BY WEIGHT OF AGGREGATE
12.5	30
10	20
6	15
Stone Dust	35

5.1 Preparation of Specimen

The aggregates after proportioning are taken in a pan in required quantity and heated to a temperature of 170°C. The bitumen is heated to a temperature of 160°C and added to the aggregates and mixed well. The mixing temperature should be maintained between 135°C – 140°C. The aggregate bitumen mix is then put in marshal stability mould and compacted on both sides by giving 75 blows using rammer of standard weight. After 24 hours, the specimen is extracted from the mould.

5.2 Addition of Plastic Waste

The plastic wastes are shredded in to small pieces and 10% of plastic by weight of bitumen is added for modified bituminous mixes.

5.3 Addition of Steel Slag

The steel slag is replaced with coarse aggregates in following proportion and separate samples are prepared for each proportion.

Sample 1: 5% of steel slag

Sample 2: 10% of steel slag

Sample 3: 15% of steel slag

Sample 4: 20% of steel slag

6. TEST ON BITUMINOUS MIXES

6.1 Marshal Stability Test

The marshal stability test is used in designing and evaluating bituminous paving mixes and is widely applied in routine test programs for the paving jobs. The major features of the Marshall method of designing mixes are to determine the two important properties strength and flexibility.

Strength is measured in terms of the Marshalls Stability of the mix which is defined as the maximum load carried by a compacted specimen at a standard test temperature of 60°C. This temperature represents the weakest condition for a bituminous pavement in use. The flexibility is measured in terms of the 'flow value' which is measured by the change in diameter of the sample in the direction of load application between the start of loading and the time of

maximum load. In this test an attempt is made to obtain optimum binder content for the aggregate mix type and traffic intensity and sample are shown in Fig 3.

Fig 3 Marshall Specimen

6.2 Test results for Marshall Stability test

The prepared specimens are placed in the testing head of Marshal Stability apparatus and load is applied gradually. The maximum stability was achieved in 15% of steel slag and the stability value is 16.03 KN. The tests conducted on different samples of bituminous mix and their results are shown in Table 5. Fig.4 shows the graph for stability versus percentage of steel slag in bituminous mixes.

Table 5 Tests on Bituminous mix

% of steel slag	Average stability (KN)	Flow (mm)
0	12.32	4.40
5	14.75	3.50
10	15.52	3.20
15	16.03	2.90
20	15.34	3.30

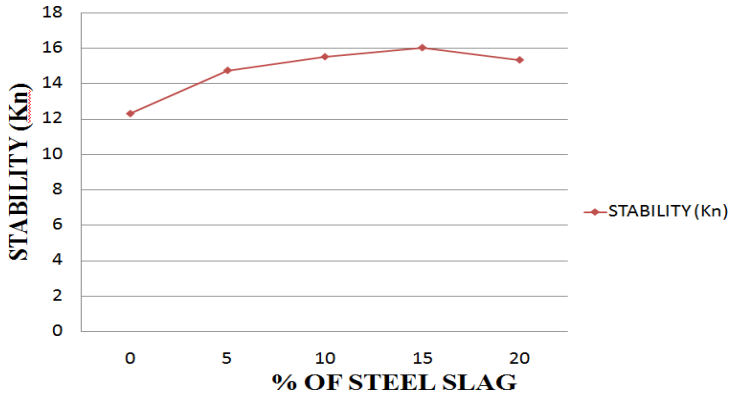

Fig 4 Optimum Steel Slag Replacement

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CONCLUSION

In India, road construction is one of the most important sectors in infrastructure development. The use of waste materials in the construction of new bituminous pavements may benefit the environment and also increases the scope by conserving the natural resources. The use of steel slag as a replacement for aggregate and the plastic as additive for bitumen in pavement not only reduces the waste disposal but also increases the stability of the pavements. By using the Marshall Stability test, it is proved that the increase in steel slag could increase the stability of pavements. The results also showed that excess use of steel slag will increase in the bitumen content. It is seen that up to 15% use of steel slag can improve the stability of pavements. The above project gives a new idea to utilize the waste material in effective manner.

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