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Effects of Polymers in Bituminous Road Pavements

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Abstract – *The fundamental goal of this project is to diminish the dumping of waste in the environment by using waste plastic as a filler in bituminous mixes. This in-hand resource is being used as an asphalt modifier to promote the poor performance of walkways on streets due to brutal climate and high traffic loads, to increase the stability of the asphalt mix, and to diminish the amount of bitumen utilized. A large amount of plastic is being dumbed day by day and only 9.1% is recycled and 75% is being dumped in the environment. Polymers can be added to the bituminous mix to some percentage, which can alter the properties of the conventional mix. Various experiments have been completed on whether waste plastic can reuse productively. The polymers which we are using in this current experimental study are LDPE plastic. The filler also plays a major role in the bituminous mix design. The filler used here in this study is M sand.*

Key Words: Design, LDPE

1. INTRODUCTION

1.1 General

For accomplishing this project, it is necessary to acquire knowledge about the different tests conducted for aggregates and bitumen for checking whether the aggregate and bitumen are good standards. The Marshall stability test is the main test required to conduct and the various test to be conducted for asphalt mix is Marshall stability, Marshall flow value, and Bulk density.

Objectives

- To use waste plastic in the bituminous pavement.
- To evaluate the optimum replacement of % of filler with plastic at 10%,20%,30%, and 40% in the bituminous pavement.
- To compare Marshall stability parameters of bituminous pavement.
- To conduct different tests and compare them.

1.2 Scope

- To limit global warming, greenhouse gases, and pollution.
- The life expectancy of the streets can be expanded.
- To eradicate potholes.
- Eco-friendly in nature.
- To yield better-enhanced waste management and better city hygiene and environment.

2. METHODOLOGY

The methodology adopted for the study includes the following stages.

a) **Literature reviews**: References and journals are collected related to the subject. It helps to understand the various aspects of the project and thereby leads to the progress of the project.

b) **Collection of materials**: Aggregates, bitumen, and polymer are collected for the study to conduct various tests.

c) **Test on aggregates and bitumen**: Different tests on aggregate and bitumen were carried out to check the standards of materials.

d) **Preparation of ordinary bituminous concrete specimen**: Normal conventional mix was prepared to check the efficiency of the normal mix.

e) **Preparation of modified bituminous concrete specimen**: Modified bituminous mix was prepared to check the efficiency of LDPE modified mix.

f) **Analysis**: Normal conventional mix and LDPE modified bituminous mix are tested and compared.

3. MATERIAL PROPERTIES

3.1 Tests on Bitumen

- **Penetration Test on Bitumen:** Penetration is a measurement of the consistency or hardness of bituminous material.
- **Softening point of bitumen:** The softening point of bitumen is the temperature at which the substance accomplishes a special degree of softening.
- **Ductility Test:** The ductility test gives the bitumen adhesive quality and ability to stretch.
- **Specific gravity of bitumen:** The specific gravity is characterized as the proportion of the mass of a given volume of a substance to the mass of an equivalent volume of water, the temperature being specified at 270C ± 0.10C.

3.2 Tests on aggregate

- **Aggregate Crushing Value Test:** The "aggregate crushing value" gives the relative magnitude of the total resistance to crushing under the compressive load applied gradually.
- **Aggregate impact value:** The characteristic of a material to resist sudden impact is known as toughness.
- **Specific gravity of aggregate:** Specific gravity is the ratio between the total weight and the weight of an equivalent amount of water.
- **Los Angeles Abrasion Value**: The surface of highway sidewalks is subject to wear due to the overall traffic movement used.
- **Shape test for aggregates:** Flakiness index and Elongation index.

3.3 Filler

The filler is used to fill small voids in the SMA mix and to make it denser. By performing laboratory tests, the properties of the filler can be determined.

4. MARSHALL MIX DESIGN

4.1 Marshall stability analysis

This test procedure is used to design and evaluate bituminous paving mixes and is widely used in routine test programs for paving jobs. Here, we are focusing to analyse; Marshall stability, Marshall flow value, and Bulk density.

4.2 Mix design

Mix design aims to have an economical mix of the right gradient of aggregates and a sufficient ratio of bitumen to meet the necessary properties of the mix. Bituminous concrete or asphalt is one of the most expensive and flexible pavement layers used on concrete surfaces. The desirable properties of a good bituminous mixture are stability, durability, flexibility, skid resistance, and performance.

4.3 Design of bituminous mixes

1. **Selection of aggregates:** Aggregates with sufficient strength, toughness, toughness, and toughness are selected based on availability and financial considerations. Crushed aggregates and sharp sand give higher stability to the mixture compared to gravel and round sand.
2. **Gradation of aggregates**: The properties of bituminous mixtures, including density and stability, depend largely on the overall size and distribution of their grain size.

Sieve size(mm)	Weight(g)
12.5-10	120
10-4.75	360
4.75-2.36	240
2.36-0.600	216
0.600-0.300	48
0.300-0.150	96
0.150-0.075	48

3. **Modified bituminous mix:** The filler is 10%, 20%, 30%, and 40% polymer modified. The experimental procedure is performed using a filler of this size. The resulting value is then compared to normal and modified mixtures.

4.4 Various tests conducted

- Marshall stability

  Corrected load = Dial gauge reading*correction factor*coefficient factor of proving ring

- Marshall flow value
- Bulk density

4.5 Graphs plotted

- Strength vs % polymer content
- Marshall flow vs % polymer content
- Bulk specific gravity vs % polymer content

5. RESULTS AND DISCUSSION

5.1 Test on Aggregates

Sl No	Property	Test Result	Remarks
1	Aggregate impact value	24.70%	satisfactory
2	Specific gravity of Coarse aggregate	2.62	satisfactory
3	Specifc gravity of fine aggregate	2.61	satisfactory
4	Aggregate Crushing Value	23.5%	satisfactory
5	Los Angeles Abrasion Value	37.52%	satisfactory
6	Elongation index	9.54%	satisfactory
7	Flakiness Index	14.47%	satisfactory

Discussions of the test results follow:

- **Aggregate Impact Value:** The total impact value obtained from this test is 24.70%, which is in the range of 20-30%. It is subdivided into good for rough surface of pavement, which can be used for bituminous concrete surface dressing and carpet, bituminous concrete surface and cement concrete surface rough.
- **Specific Gravity of Coarse Aggregate:** The specific gravity of the rough aggregate was found to be 2.62 between 2.6-2.8. So folk aggregate is of good quality and can be used for road construction.
- **Specific Gravity of Fine Aggregate:** The specific gravity of the fine aggregate was found to be 2.61, which is 2.6-2.8. Therefore, good aggregate is of good quality and can be used for road construction.
- **Aggregate Crushing Value Test:** The total crushing value acquired from this test is 23.5%. So, the given amount can be used for construction.
- **Los Angeles Abrasion Value Test**: The Los Angeles abortion value acquired is 37.52%, which is less than 40% and more than 35%. Therefore, it can be used for wet mix macadam, water-bound macadam, bituminous macadam, bituminous carpet, and surface dressing as a whole.
- **Shape Test:** According to SK Eye CEG Justo 'Highway Engineering', the total flaccinus index & elongation index used in road construction should not be less than 15% & not more than 25%. Since the total sample size given is 14.47% & 9.54%, it can be used for pavement construction.

5.2 Test on Bitumen

SI NO	PROPERTY	TEST RESULT	REMARKS
1	Penetration Test	61.34	Satisfactory
2	Softening Point	48.9	Satisfactory
3	Ductility	75	Satisfactory
4	Specific Gravity of Bitumen	1.013	Satisfactory

Discussions of the test results follows:

- **Penetration test:** The penetration value of a given bitumen is 56. The bitumen provided under IS 73: 2006 is 50/70. So, it can be used for pavement construction.
- **Softening Point:** The bitumen softening point is obtained as 48.9^0c. According to IS 334.1982, the given bitumen can be used for pavement construction
- **Ductility:** The ductility value obtained from the test was 75 cm. The minimum ductility value specified for bitumen in pavement construction is 50 to 75 cm. Therefore, the given bitumen is suitable for pavement construction
- **Specific gravity of Bitumen:** The specific gravity of bitumen was found to be 1.013, ranging from 0.97 to 1.02. Given that bitumen is free from impurities it can be used for pavement construction.

5.3 Optimum bitumen content

The optimal bitumen content is calculated as 5% as a standard result for conducting martial stability tests.

5.4 Marshall Test results

Sl. No.	% of polymer	Strength (KN)	Flow Value(mm)	Bulk Density
1	0	15.122	3.7	2.38
2	10	15.816	4.1	2.42
3	20	17.545	4.4	2.48
4	30	18.534	4.7	2.46
5	40	16.453	4.87	2.43

➢ Strength vs % polymer content

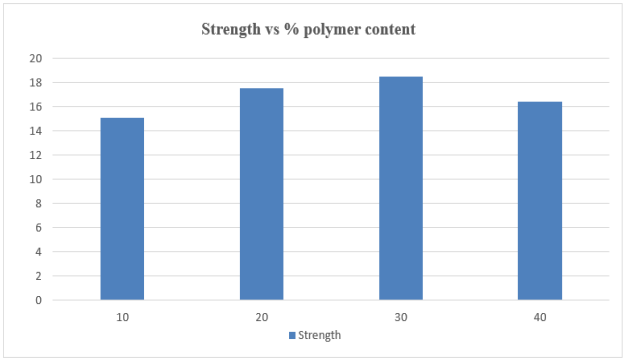

Fig -1: Strength vs %of polymer

Samples were prepared using different polymer contents of 10%, 20%, 30%, and 40%. This was done to find the effect of replacing the filler content at the consistency value. This plot helps us to find the optimal polymer content for this mix. The plot above indicates that the stability value initially increases and then gradually decreases as the filler (M sand) content is replaced. This is due to the fact that with the initial increase in the polymer content, the overall bitumen bond gradually strengthens, but with a further increase in the polymer content, the stability decreases.

➢ Flow value v/s %polymer content

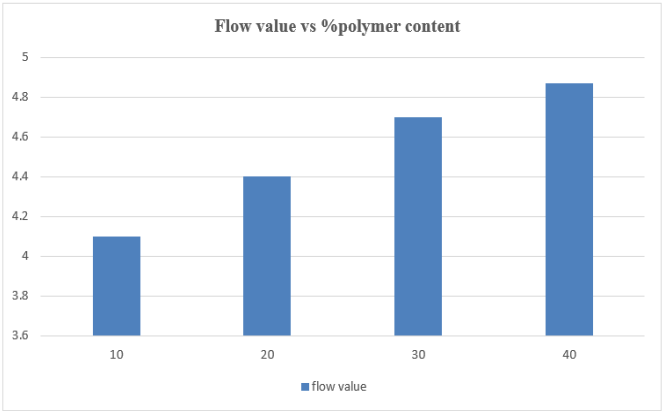

Fig -2: Flow value vs %of the polymer

Flow is a variation in which the specimen performs at maximum load at the point of failure. The value of the flow increases as the M sand content is replaced. Initially, the increase was small, but then the rate increased as the polymer content increased.

➢ Bulk specific gravity v/s % polymer content

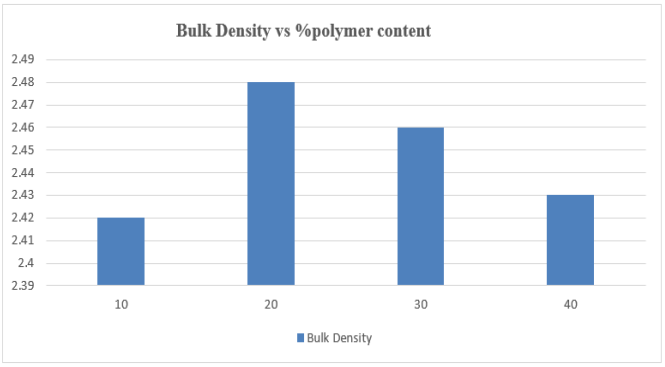

Fig -2: Bulk density vs %of the polymer

It is seen that the Bulk density increments at first with an expansion in polymer rate and afterward it steadily diminishes. This is because the density of bitumen is low compared to the total density and influences the overall mixed bulk density.

6. CONCLUSION

This project deals with the reuse of LDPE waste is beneficial in improving the vital properties of the mixture. With the initial increase in the polymer content, the overall bitumen bond gradually strengthens, but as the polymer content increases further the stability decreases. As the polymer content increases, the flow value of the LDPE modified asphalt mixture increases. In general, waste LDPE modified asphalt mix improves the mechanical quality of road pavements to the utmost extent. The waste can be used effectively in LDPE pavement construction. This increases the effective disposal of municipal waste. Now the availability of waste plastic is not a problem as the amount of waste dumped is increasing day by day.

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