COMPARATIVE STUDY ON PERFORMANCE OF BITIMINIOUS CONCRETE MIXES USING PLASTIC WASTE IN DRY PROCESS

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ABSTRACT

Usage of plastics like LDPE, HDPE has become very common now a days in the developing countries like India. So there is a need to minimize the usage of plastic, but it is difficult to ban its usage. Disposal of waste plastic is a menace and become a serious problem globally due to their non-biodegradability and anaesthetic view. Since these are not disposed scientifically & possibility to create ground and water pollution. This waste plastic partially replaced the conventional material to improve desired mechanical characteristics for particular road mix.The present paper deals with the changes in the properties of aggregates and the bituminous mix when different percentages of LDPE were added during the dry process, so that the plastic gets coated over the aggregates and then the neat bitumen is added to the plastic coated aggregates.This waste plastic modified bitumen mix show better density, stability, and more resistant to water.

Keywords–Plastic waste, Marshall stability, flow, Indirect tensile strength, tensile strength ratio

1. INTRODUCTION

1.1 GENERAL

The pavements that are generally found are flexible and rigid. In India, the major parts of the road network are flexible pavements. As our country is still emerging, there is a need to construct good roads that are economical in both initial cost and maintenance cost. The properties of bitumen depend on the type of crude and the method of refining. But there are only a few types of crude that may produce bitumen suitable for paving mixtures. The physical characteristics of the bitumen can be improved with the addition of plastic [1].

Researchers have been investigating the benefits of adding various modifiers and oils to improve the engineering properties of bitumen during the last few decades. Addition of polymer to the bitumen has resulted in better resistance to thermal cracking, lesser temperature susceptibility, increased fatigue resistance and reduced rutting. Plastic material is flexible and of low cost. The consumption of plastic materials has been growing beyond all expectations leading to several environmental problems, mainly because of the chemical constituents present in them. Consumption of plastics in India has increased over the years from 61,000 tonnes in 1996 to 17, 40,000 tonnes in 2013, with a projection of 20, 00,000 tonnes by year 2015 [2].

It has been reported that the addition of plastic waste has increased the stability value. Higher the percentage of waste plastics greater were the Marshall Stability values up to a certain optimum values. In general, it was observed, that the practice of constructing flexible pavements with plastics resulted in better performance [3].

1.2 OBJECTIVES

a. To investigate the physical properties of coarse aggregates with and without the addition of plastic at various percentages and to find physical properties of VG-10 and VG-30 bitumen.
b. To find the optimum binder content for bituminous concrete using VG-10, VG-30 bitumen.
c. To obtain the Marshall stability, flow parameters, indirect tensile strength and Tensile strength ratio for bituminous concrete mixes with the addition of various percentages of plastic for VG-10, VG-30 bituminous mixes.
d. Comparison of properties of two mixes.

2. TESTS ON THE MATERIALS

2.1 The relevant tests were carried out to find the properties of the aggregates and bitumen. The results are tabulated in tables 2.1 to 2.3

Table 2.1 Tests on Aggregates

Various tests conducted on coarse aggregates to find out the various physical properties

PROPERTIES	OBSERVATIONS	MORTH SPECIFICATIONS OF TABLE 500-17

Aggregate crushing value	26.61%	Max 30%
Aggregate impact value	20.6%	Max 24%
SG and water absorption test For Coarse aggregates	2.63 & 0.28%	
SG for fine aggregates SG for filler material	2.6 2.6	
Shape tests F I EI Combined FI and EI	 13.25% 20.24% 29.05%	Max 30%
Los Angles Abrasion test	27.79%	Max 30%

Table 2.2 Variation in properties of coarse aggregates with the addition of Waste Plastic

Stone aggregates	% of plastic	Aggregate impact value, %	Aggregate Crushing Value, %
Without plastic	0	20.5	26.6
With plastic	2	20.3	26.2
	4	19.3	25.5
	6	18	24.9
	8	16.7	24
	10	15.7	22.9

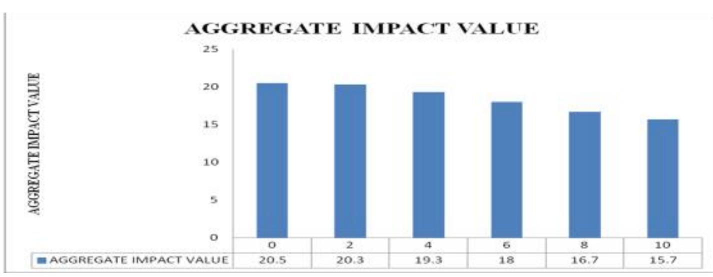


Fig 2.1 Variation in aggregate impact value with the addition of plastic waste

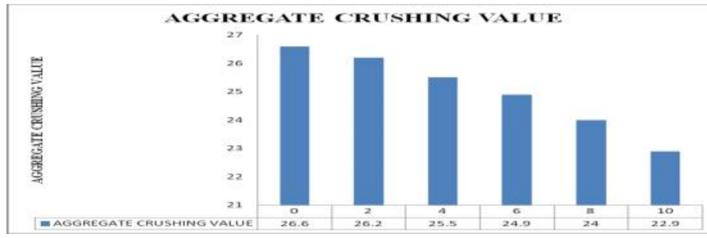


Fig 2.2 Variation of aggregate crushing value with the addition of plastic waste

Table 2.3 Test Results on Bitumen

Tests	VG 10	IS: 73-2006	VG30	IS: 73-2006
Flash point, °C	220	Min 220	260	Min 220
Fire Point, °C	250		290	
Ductility Value, cm	93	Min 75	72	Min 40
Viscosity Test, sec	5.92		7.32	
Penetration test(1/10)mm	97	80-100	69	60-70
Specific gravity (at 27° C)	0.99	Min 0.9	1.0	Min 0.9
Softening point, °C	45.8	40	47.6	47
Elastic Recovery, %	16		19	

2.2 Aggregate Gradation Adopted

The gradation adopted for the present study was Grade-1 of bituminous concrete mix. The requirement as per MORT&H was satisfied.

2.3 Marshal stability test on Bituminous concrete

To find out the OBC for the mix for both VG-10 and VG-30 grade eighteen specimens were prepared for each grade. The OBC for both the grade obtained was at 5.1%. After finding out the OBC, the waste plastic was added to the aggregates at 2%, 4%, 6%, 8% and 10% by the weight of the bitumen.

The Optimum Binder Content is found to be 5.1% for both VG-10 and VG-30 grade bitumen.

Table 2.4 Marshall Test results for VG-10 grade Bitumen

Properties	80/100 Grade of Bitumen	MORT&H specifications
OBC, %	5.1	5-6
Bulk density, (g/cc)	2.293	-
% Air voids	4.56	3-5
VMA, %	16.34	13-15
VFB, %	71.96	65-75
Stability, kN	21.56	9.0 min
Flow value, mm	3.98	2-4

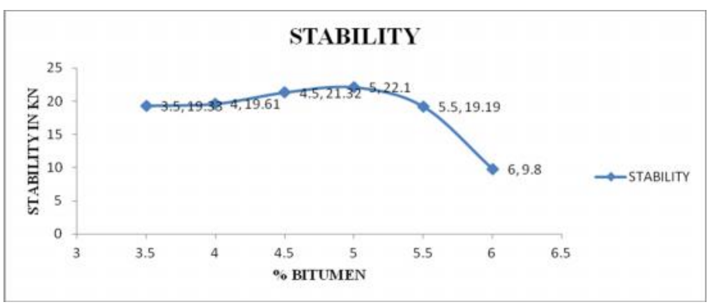


Fig 2.3 Variation of Stability for VG – 10 grade

Properties	60/70Grade of Bitumen	MORT&H specifications
OBC, %	5.1	5-6
Bulk density, (g/cc)	2.296	-
% Air voids	4.73	3-5
VMA, %	16.53	13-15
VFB, %	71.57	65-75
Stability, kN	26.42	9 min
Flow value, mm	3.42	2-4

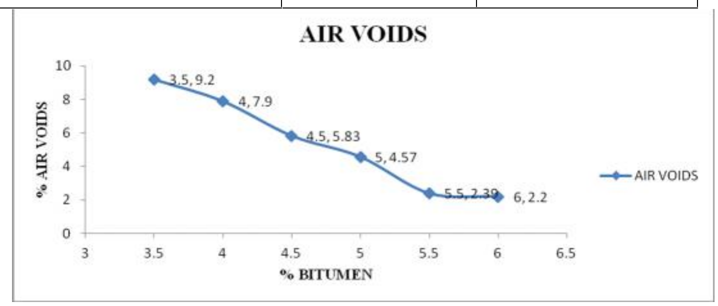


Fig 2.4 Variation of Air voids for VG-10 grade

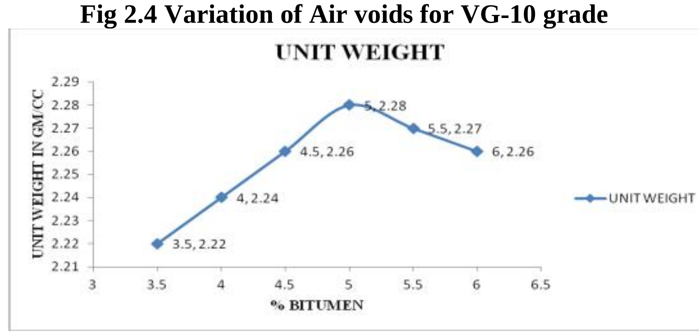


Fig 2.5 Variation of unit weight for VG-10 grade

Table 2.5 Marshall Test results for VG-30 grade Bitumen

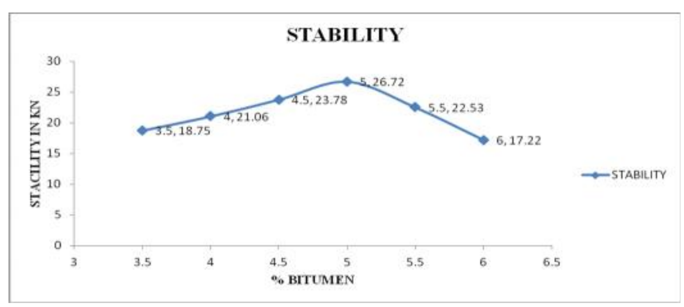


Fig 2.6 Variation of Stability for VG – 30 grade

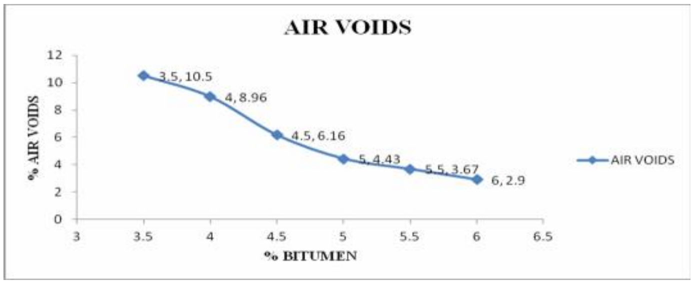


Fig 2.7 Variation of Air voids for VG-30 grade

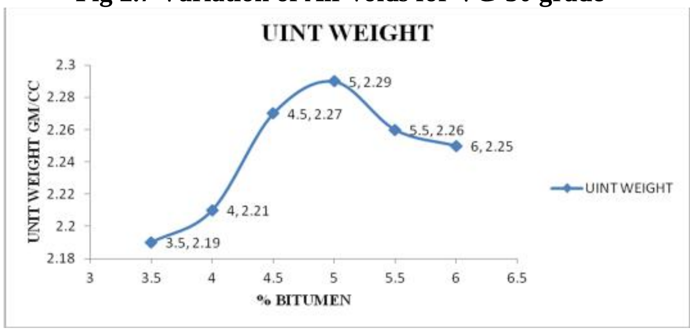


Fig 2.8 Variation of unit weight for VG-30 grade

Table 2.6 Marshall results with plastic for VG-10

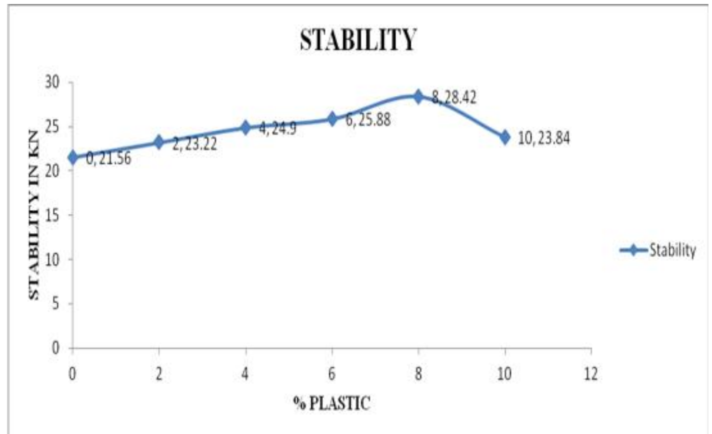


Fig 2.9 Variation of Stability with addition of plastic waste for VG-10 grade

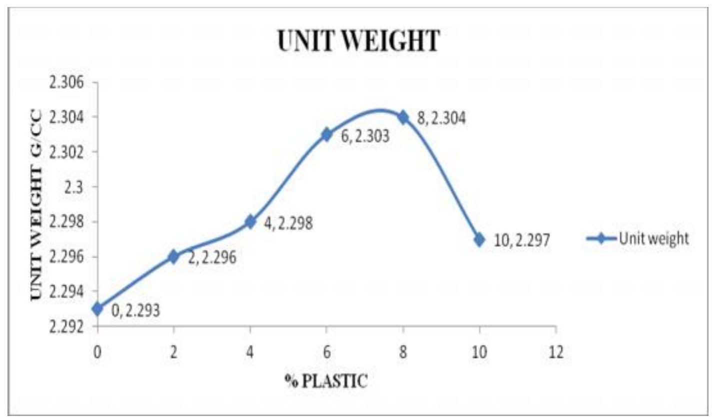


Fig 2.11 Variation of Unit weight with addition of plastic waste for VG-10 grade

Properties of Bituminous mix	Waste Plastic Expressed as % by weight of Bitumen					
	0	2	4	6	8	10
Marshall stability, kN	21.56	23.22	24.9	25.88	28.42	23.84
Flow Value, mm	3.98	3.76	3.483	3.28	3.06	2.98
Theoretical Max Density (G_t), g/cc	2.42	2.42	2.42	2.41	2.41	2.41
Bulk Density(G_m), g/cc	2.309	2.309	2.312	2.31	2.317	2.310
% Air Voids	4.56	4.53	4.4	4.12	3.85	4.11
Voids in mineral Aggregates (VMA), %	16.34	16.3	16.19	15.9	15.67	15.89
Voids filled with Bitumen(VFB), %	71.96	72.21	72.82	74.18	75.44	74.34
Unit Weight, g/cc	2.293	2.296	2.298	2.303	2.304	2.297

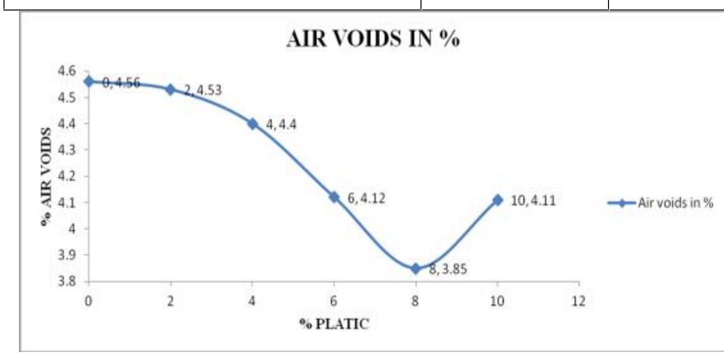


Fig 2.10 Variation of Air voids with addition of plastic waste for VG-10 grade

Fig 2.12 Variation of Stability with the addition of plastic waste for VG-30 grade

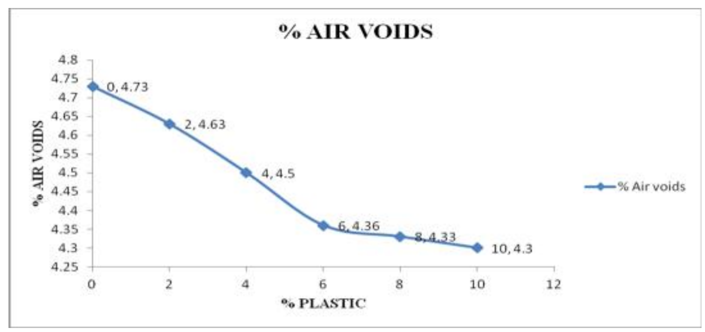
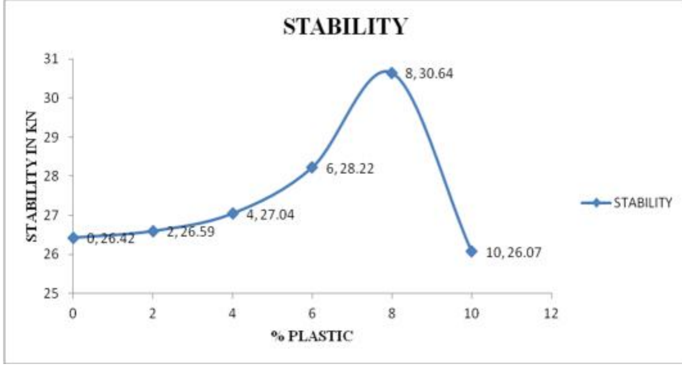


Fig 2.13 Variation of Air voids with the addition of plastic

Table 2.7 Marshall results with plastic for VG-30

Properties of Bituminous mix	Waste Plastic Expressed as % by weight of Bitumen					
	0	2	4	6	8	10
Marshall stability in KN	26.42	26.59	27.04	28.22	30.64	26.07
Flow Value	3.42	3.41	3.32	3.1	2.98	2.74
Theoretical Max Density(G_t) g/cc	2.42	2.42	2.42	2.41	2.41	2.41
Bulk Density(G_m), g/cc	2.31	2.306	2.303	2.304	2.305	2.303
% Air Voids	4.73	4.63	4.5	4.36	4.33	4.3
Voids in mineral Aggregates (VMA),%	16.53	16.39	16.24	16.11	16.07	16.04
Voids filled with Bitumen(VFB), %	71.57	71.73	72.29	72.9	73.40	73.09
Unit Weight, g/cc	2.296	2.296	2.297	2.298	2.292	2.288



waste for VG-30 grade

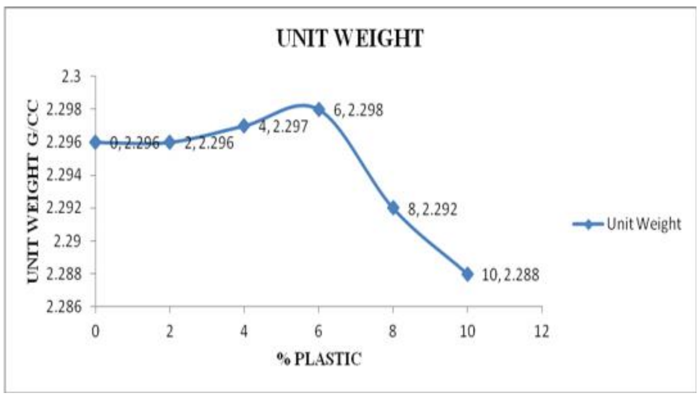


Fig 2.14 Variation of Unit weight with the addition of plastic waste for VG-30 grade

2.4 Indirect Tensile Strength

Table 2.8 Indirect tensile strength for VG-10

% Plastic	Diameter in cm	Height in cm	P in KN	ITS in N/mm^2
0	6.30	10.1	11.9	1.19
2	6.4	10.0	12.2	1.2
4	6.35	10.1	12.54	1.24
6	6.4	10.1	12.88	1.27
8	6.3	10.1	13.18	1.31
10	6.3	10.0	12.84	1.28

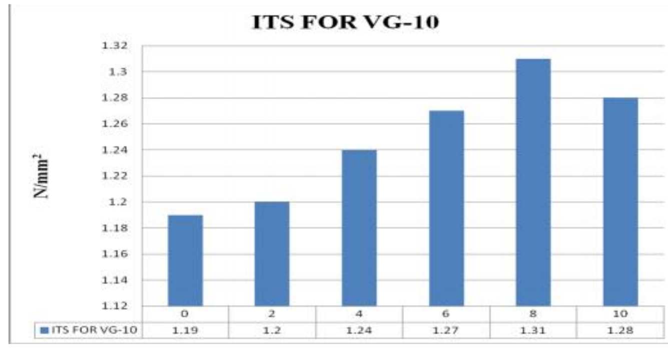


Fig 2.15 Variation of ITS with the addition of plastic waste for VG-10 grade

Table 2.9 Indirect tensile strength for VG-30

% Plastic	Diameter in cm	Height in cm	P in KN	ITS in N/mm^2
0	6.5	10.1	13.77	1.33
2	6.3	10.1	14.18	1.42
4	6.2	10.1	14.65	1.48
6	6.3	10.1	14.87	1.49
8	6.3	10.1	15.1	1.51
10	6.3	10.1	14.64	1.48

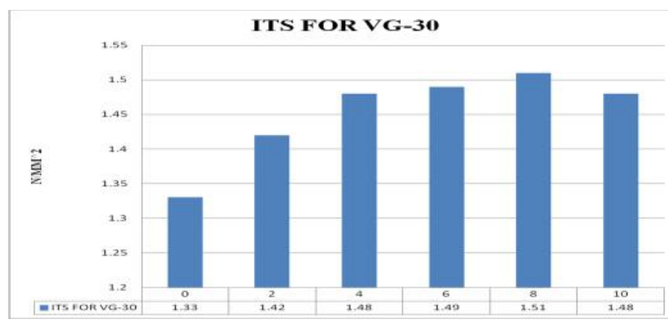


Fig 2.16 Variation of ITS with the addition of plastic waste for VG-30 grade

2.5 Tensile strength ratio for VG-10 and VG-30

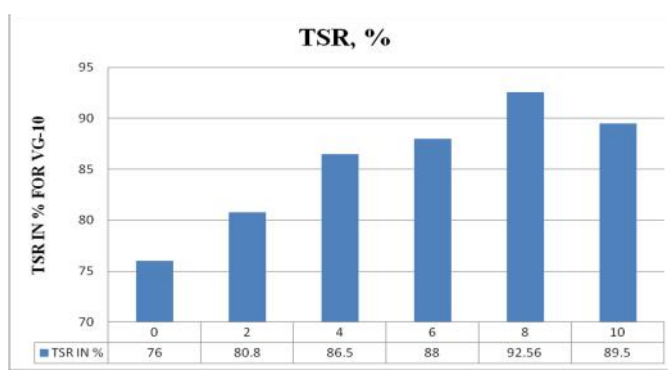


Fig 2.17 TSR results for VG-10

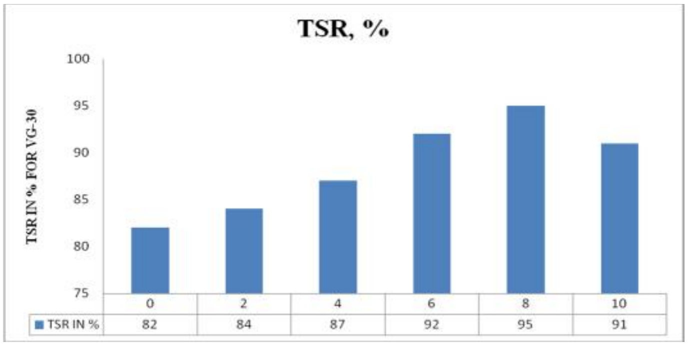


Fig 2.18 TSR results for VG-30

2.6. Comparison of properties of two mixes

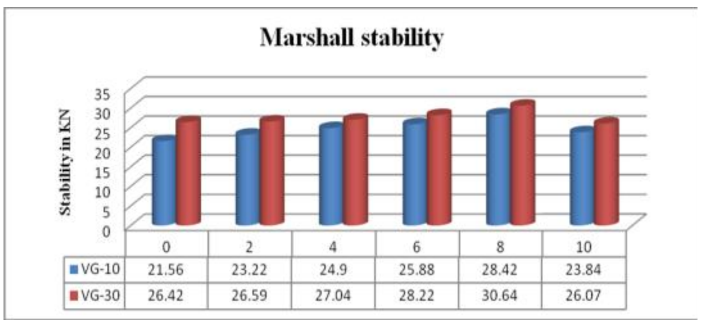


Fig 2.19 Variation of stability for VG-10 and VG-30 Mixes

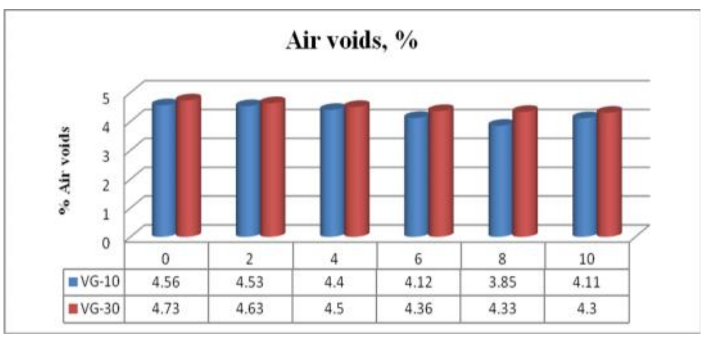


Fig 2.20 Variation of Air voids for VG-10 and VG-30 Mixes

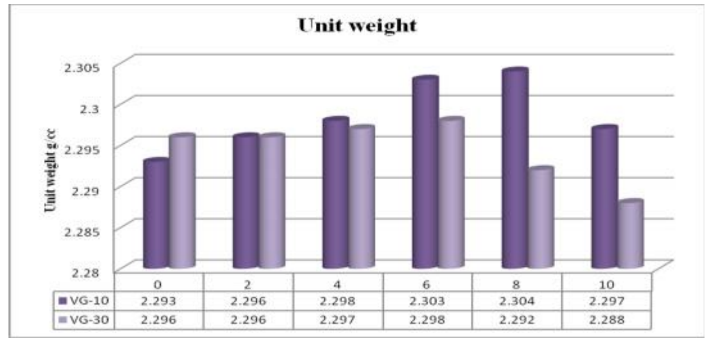


Fig 2.21 Variation of Unit weight for VG-10 and VG-30 Mixes

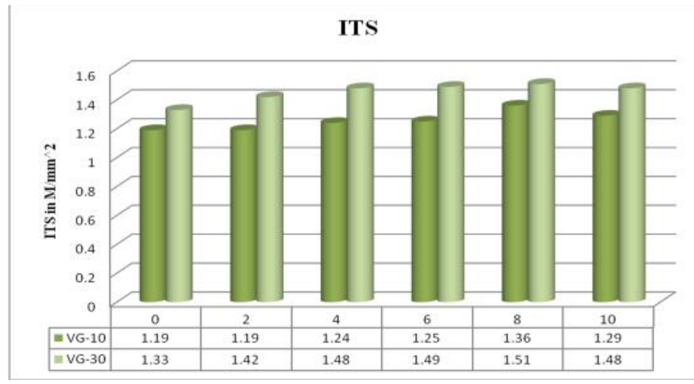


Fig 2.22 Variation of ITS for VG-10 and VG-30 Mixes

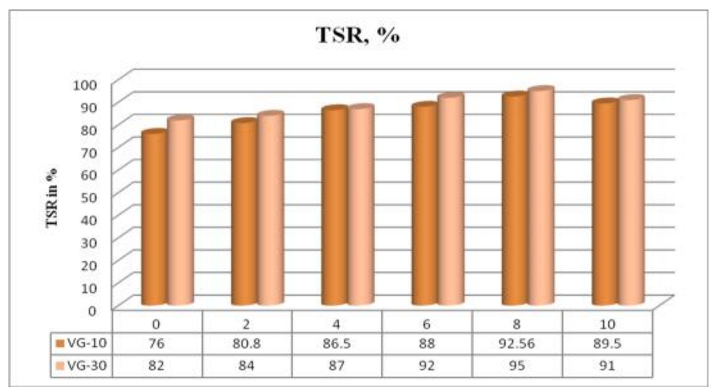


Fig 2.23 Variation of TSR for VG-10 and VG-30 Mixes

3. DISCUSSION AND CONCLUSIONS

3.1 Effect of waste plastic on properties of aggregates

As seen in Table 2.3, the aggregate crushing value steadily decreased with increase in percentage of waste plastic. The maximum reduction of 23.41% was observed at 10% of plastic waste. A similar trend was observed in the case of aggregate crushing value, the reduction being 13.9% for 10% of waste plastic. The increase in the toughness and strength of the aggregates could be due to the thin film of plastic that is formed around the aggregates and the resultant decrease in the breaking down of the aggregates.

3.2 Improvement in properties of VG-10 mix with addition of waste plastic

a. As seen in Table 2.6 there was a steady increase in the stability values with increase in percentage of waste plastic. The stability value at 0% of waste plastic was 21.56 kN as compared to 28.42 kN at 8% of waste plastic with an increase of 31.8%.
b. As seen in Table 2.6 there was a steady decrease in the flow values with increase in percentage of waste plastic.
c. As seen in Table 2.6 there was a steady decrease in the air voids with increase in percentage of waste plastic up to 8%. Subsequently the air voids increased with increase in percent of waste plastic.
d. As seen in Table 2.6 there was a steady increase in the VFB with increase in percentage of waste plastic up to 8%.
e. As seen in Table 2.6 there was a steady increase in the unit weight with increase in percentage of waste plastic up to 8%.
f. As seen in Table 2.8 there was a steady increase in the indirect tensile strength with increase in percentage of waste plastic up to 8
g. As seen in Fig 2.17 there was a steady increase in the tensile strength ratio with increase in percentage of waste plastic up to 8%.
h. From the foregoing discussions it can be concluded that the addition of waste plastic generally improves the properties of the bituminous mix. Also the indirect tensile strength and tensile strength ratio have increased with the addition of waste plastic. For the materials chosen in this study the optimum percentage of plastic waste was obtained as 8% by weight of bitumen.

3.3 Improvement in properties of VG-30 mix with addition of waste plastic

a. As seen in Table 2.7 there was a steady increase in the stability values with increase in percentage of waste plastic. The stability value without the addition of waste plastic was 26.42 kN as compared to 30.64 kN at 8% of waste plastic with an increase of 13.77%.
b. As seen in Table 2.7 there was a steady decrease in the flow values with increase in percentage of waste plastic
c. As seen in Table 2.7 there was a steady decrease in the air voids with increase in percentage of waste plastic.
d. As seen in Table 2.7 there was a steady increase in the VFB with increase in percentage of waste plastic up to 8%.
e. As seen in Table 2.7 there was a steady increase in the unit weight with increase in percentage of waste plastic up to 6%.
f. As seen in Table 2.9 there was a steady increase in the indirect tensile strength with increase in percentage of waste plastic up to 8%.
g. As seen in Fig 2.18 there was a steady increase in the tensile strength ratio with increase in percentage of waste plastic up to 8%.
h. From the above discussions it can be concluded that the addition of waste plastic generally improves the properties of the bituminous mix. Also the indirect tensile strength and tensile strength ratio have increased with the addition of waste plastic. For the materials chosen in this study the optimum percentage of plastic waste was obtained as 8% by weight of bitumen.

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