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# Comparative Study of Recycled Polypropylene Plastic using in Construction of Flexible Pavement

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**ABSTRACT:** In India disposal of waste materials including waste plastic has become a serious problem and waste plastics are burnt which cause environmental pollution and hazard to human beings. Utilization of waste plastic in bituminous mixes has proved that properties of mix by adding waste plastic which solve disposal problem. Studied have revealed that it can be successfully utilized in bituminous mixes of flexible pavements. At present there are two methods namely Dry method (DM) and Wet method (WM) are available to utilize waste plastics in bituminous mixes. In this study a comparison has been made by utilizing shredded Polypropylene (PP) bituminous mixes by wet and dry methods. The Marshall Stability value, flow value and also check different physical properties of aggregate tests were carried out and the results were compared. Dry method was more effective and is a better option to used in pavement and produces better results as compared to conventional mix

**KEYWORDS:** Marshall Stability value, Flow value, Dry Method, Wet Method, Coated aggregate test

### I. INTRODUCTION

Disposal of waste plastic is a great problem in present era due to its non-biodegradable nature and less landfills site in India. Studied have revealed that it can be successfully utilized in bituminous mixes of flexible pavements. Most of the roads in India are of flexible pavement having surface coarse with design as a bituminous concrete as per MORTH specification. The bituminous concrete (BC) layer work may be carried out in single or multiple layers depending upon the requirement of the site and loading. A single layer shall be 25 mm to 100 mm in thickness. As per MORTH Section 500 clause 509 BC should be made with Bitumen Grade VG-30 for size of aggregate 19 mm with bitumen content 5-6% has layer thickness about 50-65 mm and for size of aggregate 13mm with bitumen content 5-7% having layer thickness about 30-45 mm. Road surface with normal bitumen can cause bleeding at high temperature especially in hot climate and may develop cracks in winter season, possess of fewer load bearing capacity and can cause serious damages because of higher axle load vehicle like truck etc in such conditions due to rapid infrastructure development. Useful life of bituminous roads has reportedly decreased to 7- 8 from average life of 5-6 years in the past and at present about 3-4%

### II. LITERATURE REVIEW

**Justo et al (2002)**, at the Centre for Transportation Engineering of Bangalore University on the possible use of the processed waste plastic bags as an additive in bituminous mix. The physical properties were compared with normal bitumen. It was observed that the properties of bitumen like penetration and ductility values of the modified bitumen decreased with the increase in proportion of the plastic addition in bitumen up to 12 % by weight. Therefore the life of the flexible pavement surfacing course using the modified bitumen by waste plasticis increase than normal bitumen.

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**Mohammad T. Awwad et al (2007)**, polyethylene is a [plastic waste which is used to investigate physical properties of bitumen. The main objectives also include determining the best type of waste polyethylene to be used and its proportion. There are mainly two types of polyethylene which were added to coat the aggregate High Density Polyethylene (HDPE) and Low Density Polyethylene (LDPE). It is observed that grinded HDPE polyethylene modifier provides improve engineering properties. The proportion of waste plastic used as modifier is 12% by the weight of bitumen content. It is observed that to increase the stability, reduce the density and increase the air voids and the voids of mineral aggregate. A common method to improve the quality of bitumen is to add waste plastic polymers at specified temperature to the hot bitumen. Modified bitumen has better resistance with water which reduced stripping value

**Dr. R. Vasudevan** states that the modified bitumen blend is a better binder compared to plain bitumen. Blend has increased physical properties like Softening point and decreased Penetration value with a suitable ductility. When it used for construction of road it can withstand higher temperature and high axial load. The coating of plastics also reduce properties of aggregate reduces the porosity, absorption of moisture and improves soundness. The plastic coated aggregate bitumen mix forms better material for using in road constructions. It shows higher Marshall Stability value. Hence the use of waste plastics for construction of flexible pavement is one of the best methods for waste plastic.

**According to V.S. Punith, (2001)**, some observed results were reported in this study that there is possibility to improve the performance of bituminous mixes of Flexible pavements. Waste plastics (polythene carry bags, etc.) on heating soften at around 130°C. Thermo gravimetric analysis has shown that there is no toxic gases were produced at temperature range of 130-180°C. Softened plastics have a good binding property with aggregate. Hence, it can be used as a binder material for construction of flexible pavement.

**Sabina et al (2001)** studied the performance of physical properties of bituminous mixes containing polypropylene (PP) (8% and 15% by wt of bitumen) normal bituminous mix(prepared with 60/70 penetration grade bitumen).by adding waste plastic it improve in physical properties and Marshall stability value

### III. METHODOLOGY

**To achieve study goals, implementation would include the following:**

1. Literature review of previous studies which include scientific papers and reports
2. The field of recycled polypropylene modifiers of Bitumen mix.
3. Study of Marshall Mix design.
4. Identifying Optimum Bitumen Content (OBC) using Marshal Mix design procedure.
5. Identifying the polypropylene of adding different percentages of polypropylene materials/ modifier in the bituminous mix properties comparing it with Normal mix by using both process
6. Discussion of testing results and drawing conclusions

#### **Methods of using polypropylene as a binder material**

##### **Dry method**

In this process aggregates are heated to 170°C and then above mentioned percentages of shredded Polypropylene are added and mixed to coat the aggregates. These coated aggregates have been used for the preparation of the bituminous mixes.

##### **Wet method**

In the wet process, shredded Polypropylene was added to bitumen at 160° C. This process did not yield a homogenous mix with separated solid deposits/pieces of mix. But wet process was adopted for this study. The proportion of Polypropylene has been selected as 8%, 10%, 12% by weight of binder contents.

##### **Marshall Mix Design**

In this method, calculation of resistance towards plastic deformation of a compacted specimen of bituminous mixture is measured it is dramatically loaded to deformation rate of 50 mm per minute.

Mainly there are two major features of design.

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- density-voids analysis
- Stability-flow tests.
- The Marshall stability is defined as the maximum load carrying by specimen of bituminous mixture at 60°C temperature. The flow value is the deformation of specimen undergoes at maximum load. Flow is measured in 0.25 mm units. In this test, number of binder contents is selected as per MORTH specification and design requirement.

### Procedure

In the Marshall Test method of mix design three compacted samples are prepared for each selected binder content. The compacted specimen needed following tests:

- Bulk density determination.
  - Stability and flow test.
  - Density and voids analysis.
1. The coarse aggregate, fine aggregate, and the filler material should be well proportioned so as to fulfil the requirements of MORTH Specification.
  2. The required quantity of the mix is taken such that it produces compacted specimens of thickness 63.5 mm approximately.
  3. 1200 gm of aggregates and filler material are required to produce the desired thickness specimen mould. The aggregates heated to a range of 160° to 170°C. The mould was kept pre-heated to a temperature of 100°C to 145°C.
  4. The bitumen is heated to a temperature of 110°C to 120°C and adds bitumen in mix properly with aggregate the mix is placed in a mould and compacted with 75 numbers of blows both side. After few minutes at room temperature mould is taken out by extractor
  5. In conducting the stability test, the bituminous specimen is immersed in a bath of water at a temperature of 60° ± 1°C for a period of 20 to 30 minutes.
  6. It is then placed in the Marshall Stability testing machine and loaded at a constant rate of deformation of 5 mm per minute until failure.
  7. The total amount of deformation is units of 0.25 mm that occurs at maximum load is recorded as Flow Value. The total time should not be more than 30 seconds from water bath to Marshall Stability apparatus.

### IV. EXPERIMENT RESULTS

Table-1 Test results of VG-30 bitumen

Properties Tested	Result	IS code	Remarks
Penetration(100 gram, 5 seconds at 25°C) (1/10th of mm)	55	IS 1203-1978	Satisfactory
Softening point, °C(Ring and Ball Apparatus)	44.3	IS 1203-1978	Satisfactory
Ductility at 27°C(5cm/ minute pull) cm	48	IS1208-1978	Satisfactory
Specific gravity at 27°C	1.02	IS 1205-1978	Satisfactory

All above result are satisfactory as per Indian standard. The penetration value is 55mm which show hardness of bitumen. Maximum ductility of bitumen is 75 cm which is greater than 48 cm, if softening point is more than quality of bitumen is good.

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Table-2 Test results of VG-30 Modified Bitumen

Properties Tested	8%	10%	12%
Penetration(100 gram, 5 seconds at 25°C) (1/10th of mm)	47	46	37
Softening point, °C(Ring and Ball Apparatus)	49.6	50.2	55.6
Ductility at 27°C(5cm/ minute pull) cm	36	28	23
Specific gravity at 27°C	1.02	1.03	1.03

In table 2 various percentage of polypropylene were added in bitumen to modified and also change in properties the penetration value and ductility is decrease gradually by adding percentage of polypropylene, while softening point is gradually increase by adding polypropylene. There was slightly change in specific gravity

Table-3 Test results of Normal aggregate

Description of tests	0% Plastic	Specifications IRC:111-2009
Impact value	11.01 %	Max 24%
Specific gravity	2.63	2.5-3.0
Flakiness Index value	13.80 %	Max 35 %
Elongation index value	18.86 %	Max 35 %
Water absorption value	1.01%	Max 2%
Stripping value	5 %	Max 5%

In table 3 it is observed that physical properties of aggregate are satisfactory as per IRC specification. Impact value was 11.01 % which shows better resistance towards impact load of vehicle and water absorption was also less which shows reduction of pores in aggregate and good quality oaf aggregate. Stripping value was 5%

Table-4 Test results of coated aggregate (10%)

Description of tests	10% Plastic	Specifications IRC:111-2009
Impact value	6.03 %	Max 24%
Specific gravity	2.65	2.5-3.0
Flakiness Index value	13.92 %	Max 35 %
Elongation index value	18.98 %	Max 35 %
Water absorption value	0.93%	Max 2%
Stripping value	2%	Max 5%

In table 4 recycled polypropylene is added about 10% which was calculated from highest stability achieve from wet and dry method. It also called optimum plastic content (OPC).The impact value of aggregate was decreased to 6.03%

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which shows it was better resistance against impact load as per normal aggregate. Flakiness and elongation was increased because of coating of plastic over aggregate. Water absorption of aggregate was also reducing.

Table-5 Marshall Stability method (Normal mix)

Bitumin content %	Stability KN	Flow value mm	$G_r$	$G_m$	$V_v$ %	VFB %
4.5	10.54	2.39	2.44	2.35	4.07	70.81
5	11.26	3.07	2.42	2.33	3.73	74.49
5.5	12.44	3.38	2.41	2.34	2.86	80.71
6	10.17	3.73	2.39	2.33	2.48	83.91
6.5	9.42	4.03	2.36	2.34	1.79	88.64

In table 5 it shows Marshall Stability, Flow value, air voids, Voids filled by bitumen and bulk weight of Marshall Specimen of different binder content as per MORTH specification

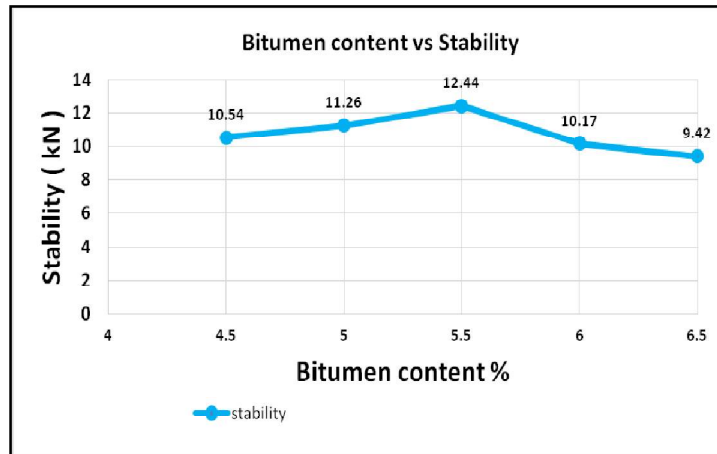


Fig 1 Bitumen content vs Stability

The graph shows increasing in stability of different bitumen content. The highest stability was at 5.5 % of bitumen content, after further increase in binder content the stability was reduced at 6 and 6.5 %.

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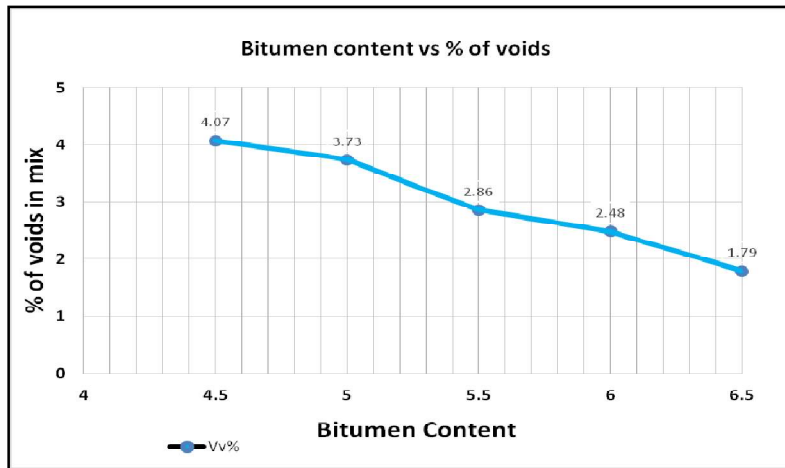


Fig 2 Bitumen content vs % of Voids

The graph shows decreasing gradually of different bitumen content. For finding Optimum binder content the value of air voids was taken at 4% of voids in mix. In this graph value at 4% of voids was 4.6%

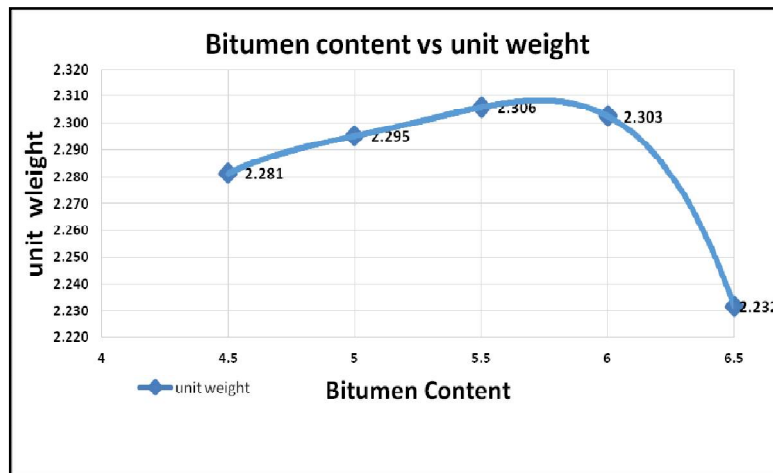


Fig 3 Bitumen content vs unit weight

The graph shows maximum unit weight was found between 5.5 to 6% . For finding Optimum binder content the value of maximum unit weight was 5.565% binder content

**Optimum bitumen content (OBC) =  $(5.5+4.6+5.565) / 3 = 5.23 \%$**

**Polypropylene into bituminous mix:**

The shredded polypropylene was added by wet and dry process in different percentages 3%, 5%, 10%, 12%, 15% and 17% by weight of OBC of conventional mix. The Marshall stability, flow value and other parameters were obtained by conducting laboratory testing .The results are shown in Table 6 is dry process and table 7 is wet process.

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Table-6 Marshall Stability method (Dry mix)

PP %	Stability KN	Flow value mm	$G_t$	$G_m$	$V_v$ %	VFB %
3	12.35	3.3	2.46	2.41	5.16	68.79
5	13.96	4.23	2.57	2.47	4.04	73.98
8	15.95	4.8	2.68	2.58	3.71	75.68
10	18.62	4.49	2.52	2.43	3.5	76.60
12	17.62	3.21	2.61	2.53	3.12	78.82
15	12.63	3.15	2.56	2.49	3.03	79.31
17	10.91	2.3	2.57	2.49	2.94	79.82

In table 6 it shows Marshall Stability, Flow value, air voids, Voids filled by bitumen and bulk weight of Marshall Specimen of different binder content and different proportion of polypropylene. In this method the plastic is added to aggregate

Table-7 Marshall Stability method (wet mix)

PP %	Stability KN	Flow value mm	$G_t$	$G_m$	$V_v$ %	VFB %
3	9.65	4.33	2.43	2.30	5.43	67.40
5	11.23	4.23	2.43	2.31	4.99	69.35
8	13.7	5.02	2.42	2.31	4.62	71.01
10	15.23	3.63	2.41	2.32	3.71	75.50
12	14.23	4.25	2.41	2.37	2.13	84.54
15	12.21	2.65	2.39	2.35	1.91	85.95
17	8.65	3.08	2.39	2.37	1.15	91.11

In table 7 it shows Marshall Stability, Flow value, air voids, Voids filled by bitumen and bulk weight of Marshall Specimen of different binder content and different proportion of polypropylene. In this method waste plastic is added into bitumen

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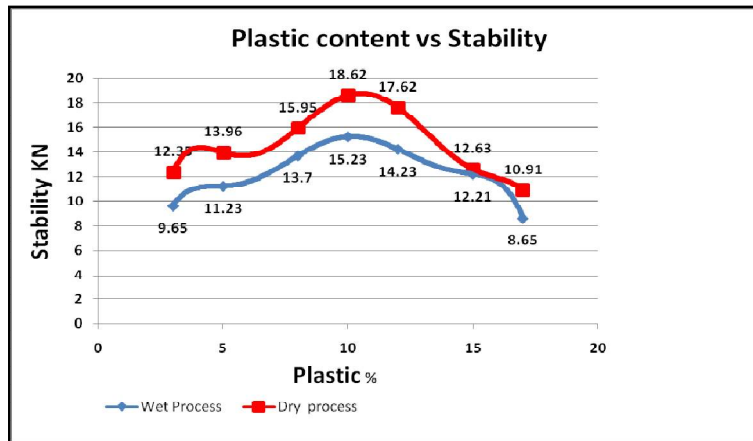


Fig 4 % of plastic vs Marshall Stability Value of wet process and dry process

From this graph we observed that the Marshall stability at 10% plastic content is more in dry and wet process than normal Marshall Stability. The value is increased up to 10% plastic content further it was decreased. So from this graph optimum plastic content was 10%

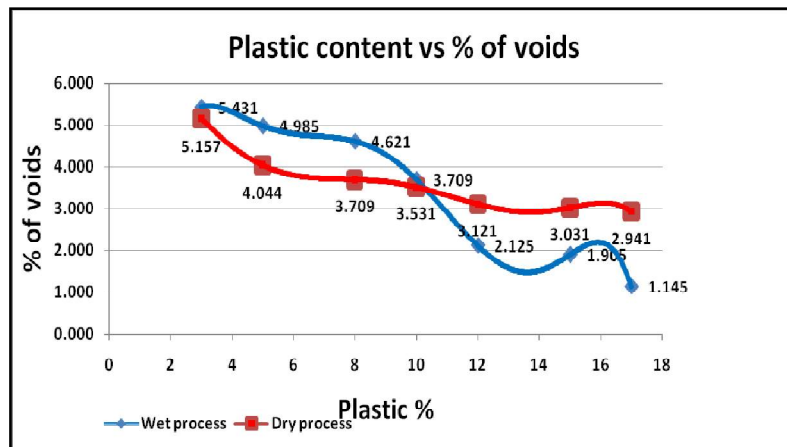


Fig 5 % of plastic vs % of air voids of wet process and dry process

From this graph we observed that at 10% plastic content the voids ratio is slightly higher in wet process than normal mix but in dry process air voids was less than normal mix.



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Table - 8 Comparison of properties of Wet Mix and Dry Mix

Properties	OBC of 5.23%	Dry Mix	Wet Mix
%Waste Plastic by weight of Optimum Bitumen Content	0	10%	10%
Marshall Stability Value ( KN)	12.44	18.62	15.23
Flow Value (mm)	3.21	4.49	3.63
% Air Voids (Vv)	3.73	3.5	3.71
% Void filled with bitumen (VFB)	78.23	76.60	75.50

In this table there is comparison of wet mix and dry mix method of using polypropylene in road construction from this table we show that at optimum binder content the stability was 12.44 KN, but in wet process and dry process it was increased to 15.23 KN and 18.62 KN respectively

### V. CONCLUSION

It observed that by adding polypropylene it can be conveniently used as a modifier for bituminous mix as it gets coated over the aggregates of the mixture and reduces porosity, absorption of moisture, impact value, and improves binding property of the mix. The Optimum Bitumen Content (OBC) was found to be 5.23% by weight of aggregates and the Optimum Plastic Content (OPC) to be added as a modifier of bituminous mix was found to be 10% weight of Optimum Bitumen Content (OBC) of bituminous mix. The maximum value of Marshall Stability was observed at plastic content of 10 % for both dry and wet mixes there was an increase in Marshall Stability value of 18.32 % for wet mix and 33.19 % for dry mix as compared to Normal of bituminous concrete. It resist again higher load and deformation There was a slightly increase in flow value at 10%about for wet mix and for dry mix as compared to conventional mix. There was a slight decrease in air voids of dry mix as compared to wet mix but the changes are within the permissible range. Bituminous mix modified with polypropylene coated aggregates showed higher Marshall Stability as compared to normal bituminous mix. Marshall Stability value increases with plastic content up to 10% and thereafter decreases. Thus the use of higher percentage of polypropylene is not preferable. But it shows that plastic waste blended bituminous mix is better option and more suitable for flexible pavement construction.

### REFERENCES

- [1] Abdul Hamid Ahmad, "Waste Plastic for Road Construction" Feb 17, 2012 .
- [2] C.E.G. Justo, Dr. A. Veeraragavan Utilisation of Waste Plastic Bags in Bituminous Mix for Improved Performance of Roads (2002)
- [3] Zoorab S.E. and Superma I.B.(2000) "Laboratory design and Performance of Improved Bituminous Composites Utilizing Recycled Plastic Packaging Waste". Presented at Technology Watch and Innovation in the Construction Industry, Palais Descongres, Brussels, Belgium 5-6 pp 203-209.
- [4] Vasudevan R, Nigam S.K. Velkeneddy R, Ramalinga Chandra Seker A and Sunderakannan B., "Utilization of Waste Polymers for Flexible Pavement and Easy Disposal of Waste Polymers". Proceedings of the International Conference on Sustainable Solid Waste Management, 5-7 September 2007, Chennai, India, pp, 105-111.
- [5] Utilization of Waste plastic Bags in Bituminous Mixes (November 2002), CRRI Report submitted to M/s KK Plastic Waste Management Ltd.(Bangalore).
- [6] Sridhar, R Bose, S Kumar, G and Sharma G, (2004) "Performance Characteristics of Bituminous Mixes Modified by Waste Plastic Bags" Highway Research Bulletin, No 71, IRC pp 1-10.
- [7] IRC:111-2009, Specifications for Dense Graded Bituminous Mixes.
- [8] Vasudevan R., Nigam S. K., Velkeneddy R., A. Ramalinga Chandra Sekar and B.Sundarakannan, Utilization of waste polymers for flexible pavement and easy disposal of waste polymers, In : Proc. Intern. Conf. Sustainable Solid Waste Manage. Chennai, India, 105-111, (2007)
- [9] IS Indian standard paving bitumen specification, 2nd Rev., New Delhi, India, Bureau of Indian Standards, 73, (1992)