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"USE OF PLASTIC COATED AGGREGATES IN ROAD CONSTRUCTION"

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Abstract:
The increasing volume of plastic waste has become a critical environmental issue, prompting innovative approaches to waste management and recycling. This study explores the use of plastic-coated aggregates in road construction as a sustainable alternative to traditional materials. By integrating plastic waste with aggregates, we aim to enhance the mechanical properties of road surfaces while simultaneously reducing landfill burden. This research examines various types of plastic coatings, including polyethylene, polypropylene, and PVC, assessing their impact on the physical and chemical characteristics of aggregates. Laboratory tests, including compression strength, tensile strength, and water absorption, were conducted to evaluate the performance of plastic-coated aggregates in comparison to conventional materials. Results indicated that the addition of plastic coatings improved the durability and resistance to moisture, significantly enhancing the lifespan of road constructions

I. INTRODUCTION

The construction industry is facing significant challenges related to environmental sustainability, resource depletion, and waste management. As urbanization accelerates and the demand for infrastructure increases, traditional construction materials, particularly aggregates, are becoming scarcer and more costly. In this context, the exploration of alternative materials has gained momentum, leading to innovative solutions that promote sustainability and reduce environmental impact.

One promising approach is the use of plastic-coated aggregates (PCA), which involves coating conventional aggregates with recycled plastic waste. This method not only addresses the growing issue of plastic pollution but also enhances the performance characteristics of aggregates, such as durability and moisture resistance. Given the massive quantities of plastic waste generated globally, repurposing this material for construction applications presents a dual opportunity: mitigating environmental concerns while improving construction material performance. It will outline the significance of adopting sustainable practices in the industry, present the potential benefits of PCA, and highlight the key objectives of this study. Plastic-coated aggregates (PCA) emerge as an innovative solution that leverages recycled plastic to enhance the properties of aggregates.

The coating process not only improves aggregate durability and moisture resistance but also provides a structural advantage in various applications. The incorporation of PCA in road construction can lead to more resilient pavements that withstand adverse weather conditions and heavy traffic loads.

II. RESEARCH METHODOLOGY

Marshall Stability Mix Design

Weight of the Aggregate (gm)	Sieve size (mm)
172	12.5
332	10
84	4.7
204	2.6
408	Filler
Total=1200gm	

Total weight of the aggregate +Filler material = 1200(gm)

- Bitumen content = 4%,4.5%,5% Bitumen content 4% = 0.040 × 1200=48gm Bitumen content 4.5% = 0.045 × 1200=54gm Bitumen content 5% = 0.050 × 1200=60gm
- Crumb rubber content = 10%,15%,20%,

1) Plastic coated aggregates content 10% = 0.10 × 1200 = 120gm
2) Plastic coated aggregates content 15% = 0.15 × 1200 = 180gm
3) Plastic coated aggregates content 20% = 0.20 × 1200 = 240gm

Plastic coated aggregates content	Bitumen content	No of specimen
10%	4% 4.5% 5%	1 1 1
15%	4% 4.5% 5%	1 1 1
20%	4% 4.5% 5%	1 1 1

Bitumen content	No of specimen
4%	1
4.5%	1
5%	1

Fig.1.Marshall stability Test Apparatus

Fig.2. Marshall stability Test Mold

Apparatus Required:

1. Marshall Stability testing machine (50 kN capacity)
2. Breaking head (specimen Mold holder)
3. Compaction Mold with collar and base plate
4. Hammer (4.5 kg, 457 mm drop height)
5. Water bath (maintained at 60°C)
6. Dial gauge (0.01 mm accuracy)
7. Oven
8. Balance (accuracy 0.1 gm)
9. Bitumen and aggregates

Theory:

The Marshall Stability test evaluates the resistance to plastic deformation of cylindrical bituminous specimens when loaded diametrically. Two key values are obtained:

Stability: Maximum load before failure (in kN or kg)

Flow value: Deformation corresponding to the maximum load (in mm)

A. MATERIAL SELECTION & PREPARATION

1. Aggregates:

Use well-graded coarse aggregate, fine aggregate, and mineral filler as per the specified gradation (e.g., DBM, BC).

Ensure aggregates are clean, dry, and free from dust and clay particles. Sieve analysis must be done to conform to desired grading envelope.

2. Bitumen:

Use standard paving-grade bitumen, generally VG-30 or as specified.

Check bitumen properties: penetration, softening point, ductility, etc., before mixing.

B. PREPARATION OF BITUMINOUS MIXTURE

3. Heating Materials:

Heat coarse and fine aggregates separately to 170–180°C in an oven. Heat bitumen to 150–160°C for fluidity. Preheat compaction Molds and base plates to 150°C.

4. Mixing:

Mix the required quantity of heated aggregates and filler in a large metal pan or mechanical mixer. Add the calculated amount of hot bitumen at the selected bitumen content (e.g., 4.0%, 4.5%, 5.0%, 5.5%, 6.0% by weight of total mix).

Mix thoroughly to ensure uniform coating of aggregates, maintaining mixture temperature at ~155°C ± 5°C.

C. SPECIMEN PREPARATION (COMPACTION)

5. Weighing and Melding:

Weigh approximately 1200–1300 gm of the hot mix (exact weight depends on desired height and specific gravity).

Place a filter paper at the bottom of the Mold.

Transfer the hot mix into the Mold with a collar on, and level it evenly without segregation.

6. Compaction:

Compact the specimen using a standard Marshall hammer (4.5 kg) with 75 blows on each face for dense bituminous mixtures (as per MoRTH standards).

The compaction should be done on a solid base (compaction pedestal).

After 75 blows, remove the collar, reverse the Mold, and apply 75 blows on the other face.

D. SPECIMEN CURING AND CONDITIONING

7. Demoulding:

Allow the compacted specimen to cool at room temperature (air-cooled for 1–2 hours). Remove the specimen from the Mold using a hydraulic extractor.

8. Specimen Curing:

Allow the specimen to rest for 12–24 hours before testing to ensure proper stiffness.

9. Dimensional Checks:

Measure the height and diameter of the specimen using a Vernier calliper. Weigh the air-dry specimen (W_1).

E. WATER BATH CONDITIONING

10. Immersion in Water Bath:

Place the specimen in a water bath maintained at 60°C ± 1°C. Ensure complete immersion for 30–40 minutes (IS:1206 Part I).

F. TESTING FOR STABILITY AND FLOW

11. Test Setup:

Remove the specimen from the bath, wipe off surface water with a damp cloth. Place it between the upper and lower segments of the breaking head.

12. Fixing in Loading Frame:

Mount the breaking head in the Marshall Stability testing machine. Ensure proper cantering so the load is applied diametrically.

13. Application of Load:

Start the machine; apply vertical compressive load at a constant rate of 50.8 mm/min. Monitor the proving ring/digital load cell to record the load.

14. Flow Measurement:

Attach a flow dial gauge (0.01 mm least count) with zero set before loading. Record the flow value in mm corresponding to the maximum load.

15. Recording Stability:

Note the maximum load (kN or kg) the specimen can resist before failure (cracking or bulging).

G. REPEAT FOR ALL BITUMEN CONTENTS

Conduct the test on minimum 3 specimens per bitumen content.

III. RESULTS AND DISCUSSION

➢ **Marshall Stability Test Results (With Out Plastic Coated Aggregates)**

Bitumen % = 4% (0% Plastic coated aggregates)

Cr %	Specimen	Stability (Kg)	Flow (Mm)	Bulk Density	Air Voids (%)	Vma (%)	Vfb (%)
0	1	850	3.7	2.28	5.3	15.6	65.7
	2	845	3.6	2.29	5.2	15.5	66.1
	3	855	3.8	2.27	5.4	15.7	65.3
	Avg	850	3.7	2.28	5.3	15.6	65.7

Bitumen % = 4.5% (0% Plastic coated aggregates)

Cr %	Specimen	Stability (Kg)	Flow (Mm)	Bulk Density	Air Voids (%)	Vma (%)	Vfb (%)
0	1	900	3.8	2.31	4.8	15.2	68.4
	2	895	3.9	2.32	4.7	15.1	68.8
	3	905	3.7	2.3	4.9	15.3	68.0
	Avg	900	3.8	2.31	4.8	15.2	68.4

Bitumen % = 5% (0% Plastic coated aggregates)

Cr %	Specimen	Stability (Kg)	Flow (Mm)	Bulk Density	Air Voids (%)	Vma (%)	Vfb (%)
0	1	875	4.0	2.33	4.4	14.9	70.5
	2	870	4.1	2.32	4.5	15.0	70.0

	3	880	3.9	2.34	4.3	14.8	71.0
	Avg	875	4.0	2.33	4.4	14.9	70.5

Marshall Stability Test Results (With Plastic coated aggregates)

Bitumen % = 4%

PCA%	Specimen	Stability (kg)	Flow (mm)	Bulk Density	Air Voids (%)	VMA (%)	VFB (%)
10	1	880	3.8	2.3	5.0	15.3	67.3
	2	860	3.9	2.31	4.9	15.1	68.2
	3	875	3.7	2.29	5.1	15.4	66.8
	Avg	872	3.8	2.3	5.0	15.3	67.4
15	1	910	4.0	2.28	5.2	15.5	66.4
	2	900	4.1	2.29	5.1	15.3	67.0
	3	905	3.9	2.3	5.0	15.2	67.2
	Avg	905	4.0	2.29	5.1	15.3	66.9
20	1	875	4.2	2.27	5.3	15.6	65.9
	2	860	4.1	2.26	5.4	15.7	65.6
	3	870	4.3	2.28	5.2	15.5	66.0
	Avg	868	4.2	2.27	5.3	15.6	65.8

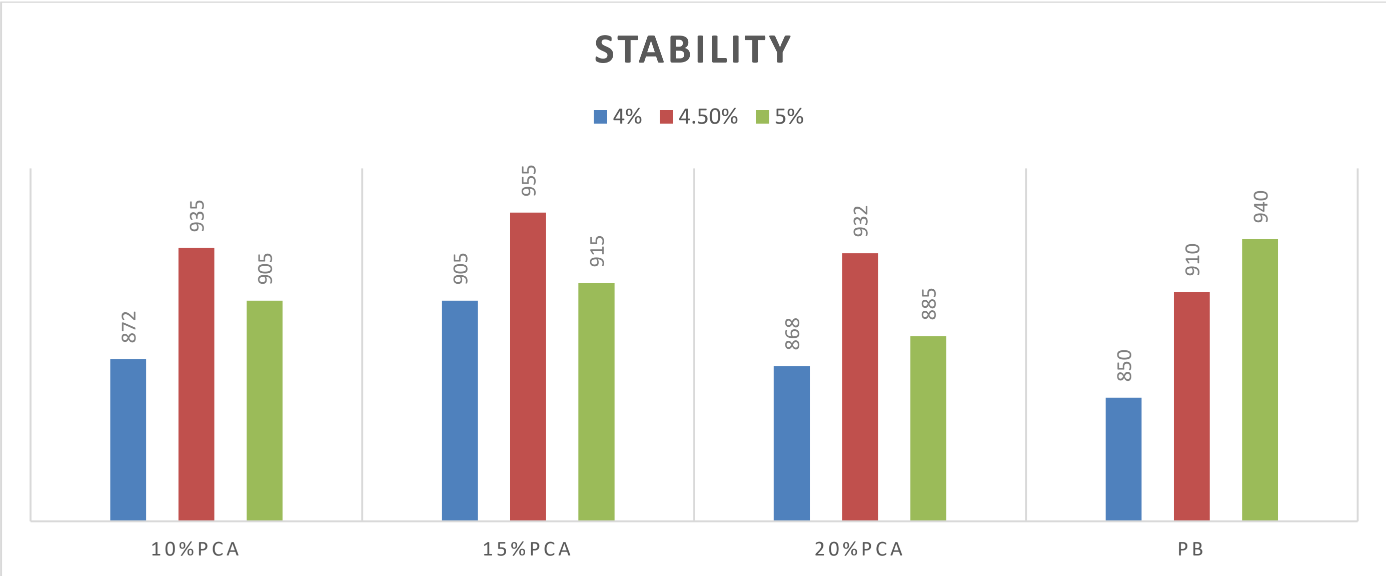
Bitumen % = 4.5%

PCA%	Specimen	Stability (kg)	Flow (mm)	Bulk Density	Air Voids (%)	VMA (%)	VFB (%)
10	1	940	3.9	2.33	4.6	15.0	69.3
	2	930	4.0	2.34	4.5	14.9	69.8
	3	935	3.8	2.32	4.7	15.1	68.9
	Avg	935	3.9	2.33	4.6	15.0	69.3
15	1	960	4.1	2.34	4.4	14.8	70.3
	2	950	4.0	2.33	4.5	14.9	69.8
	3	955	4.2	2.32	4.6	15.0	69.3
	Avg	955	4.1	2.33	4.5	14.9	69.8
20	1	940	4.3	2.31	4.7	15.1	68.9
	2	925	4.4	2.3	4.8	15.2	68.4
	3	930	4.2	2.32	4.6	15.0	69.3
	Avg	932	4.3	2.31	4.7	15.1	68.9

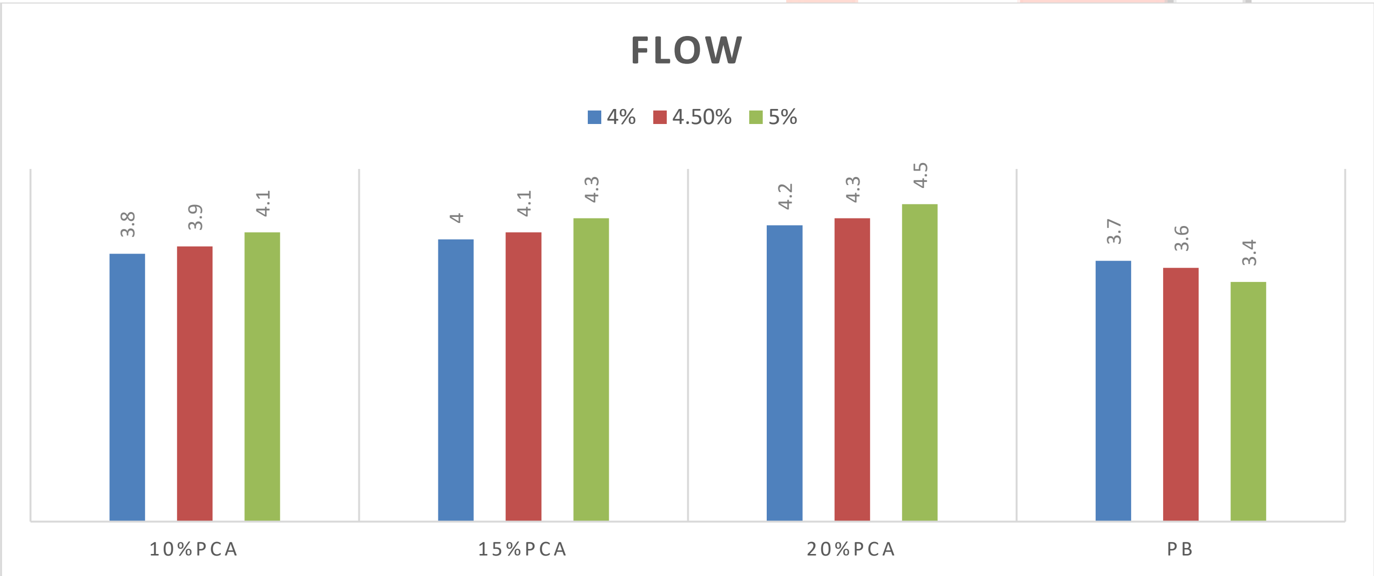
Bitumen % = 5.0%

PCA %	Specimen	Stability (kg)	Flow (mm)	Bulk Density	Air Voids (%)	VMA (%)	VFB (%)
10	1	910	4.1	2.35	4.2	14.7	71.4
	2	900	4.2	2.36	4.1	14.6	71.9
	3	905	4.0	2.34	4.3	14.8	70.9
	Avg	905	4.1	2.35	4.2	14.7	71.4
15	1	920	4.3	2.34	4.3	14.8	70.9
	2	910	4.2	2.35	4.2	14.7	71.4
	3	915	4.4	2.33	4.4	14.9	70.4
	Avg	915	4.3	2.34	4.3	14.8	70.9
20	1	890	4.5	2.32	4.5	15.0	69.9
	2	880	4.6	2.3	4.6	15.1	69.5

	3	885	4.4	2.31	4.5	15.0	69.7
	Avg	885	4.5	2.31	4.5	15.0	69.7



Comparison Table: Plain Bitumen Mix vs Plastic Coated Aggregates Bitumen Mix For Stability (kg)



Comparison Table: Plain Bitumen Mix vs Plastic Coated Aggregates Mix For Flow (mm)

IV. CONCLUSION

1. The aim of the study was to utilize the waste materials i.e. Plastic coated aggregates waste for mass scale utilization such as in highway construction in an environmentally safe manner.

2. Beyond 15% PCA, stability decreases and flow increases, showing diminishing structural performance.

3. Optimal Mix: 4.5% Bitumen + 15% Crumb Rubber = Maximum Stability (955 kg) and balanced flow (4.1 mm).

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