ICEST-2K24 [International Conference on Engineering, Science and Technology]
In Association with
International Journal of Scientific Research in Science, Engineering and Technology
Print ISSN - 2395-1990 | Online ISSN : 2394-4099 (www.ijsrset.com)

Innovative Solutions for Sustainable Pavements: Plastic Coated Aggregates in Bituminous Mixes

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ABSTRACT

Plastic pollution poses a serious threat to the environment, contributing to soil, water, and air pollution. Implementing stringent regulations governing the production and usage of plastics can mitigate the toxic effects of plastics on human health and the environment. The study focuses on the "Utilization of Plastic Coated Aggregates in Bituminous Mix for Flexible Pavement." The project aims to preserve road infrastructure through a systematic approach to ensure optimal performance and longevity, considering future maintenance scenarios. In today's context, pavements endure various loads, leading to distresses such as rutting, fatigue cracking, and temperature-induced cracking. Given the environmental challenges, a blanket ban on plastics may not be feasible. Therefore, leveraging plastic as an innovative technology strengthens road construction and extends road lifespan. Plastic recycling is paramount and demands serious attention. Plastics constitute a significant portion of solid waste and persist for centuries in landfills or the ocean. Hence, maximizing plastic recycling efforts can alleviate landfill burdens, conserve energy, and safeguard the environment.

Keywords: Waste Plastic, Flexible Pavement, Marshall Stability, Crushing value.

I. INTRODUCTION

As the global population expands, the volume and diversity of waste generated also increase. Much of the waste generated today will persist in the environment for centuries, including non-degradable materials like plastic, leading to pollution.

Innovative approaches to waste management include utilizing recycled plastic in concrete and road construction, offering a solution to the challenge of disposing of large quantities of recycled plastic. Reusing plastic in the concrete industry is regarded as one of the most viable applications for recycling plastic materials.

Research efforts worldwide are exploring new and innovative ways to utilize waste materials effectively. Numerous studies and research projects conducted by highway agencies, private organizations, and individuals focus on assessing the feasibility, environmental impact, and performance of incorporating waste plastic into highway construction.

These studies aim to align societal needs for safe and economically sound waste disposal with the goals of the environmentally conscious highway industry, which seeks better and more cost-effective construction

materials. This collaborative effort seeks to address waste management challenges while promoting the development of sustainable infrastructure.

In general, in concrete the failure occurs due the fatigue cracking the concrete which formed from modifier, it causes less cracking due its durability.Polymer modified bitumen is emerging as one of the important construction of flexible moment. The polymer modified bitumen show better properties for road construction and plastic waste can find its use in this process and this can help solving problem of pollution. The better binding property of plastic in its molten state has helped in finding out a method of safe is disposal of waste plastic.Road surface with neat bitumen can use cause bleeding in hot climate may develop crack and in cold climate possess fewer loads bearing capacity and can cause serious damage because higher axial load in present condition due to rapid infrastructure development. India has to raise transportation system it higher level both terms of length and quality. The use waste in hot bituminous mix to enhance pavement performance, protect and provide low cost roads.

II. LITERATURE REVIEW

This research paper tries to shed light on the use of PCA in asphalt mix and study the performance of PCA using different testes. Use of disposed plastics waste is the need of the hour. The studies on the thermal behaviour and binding property of the molten plastics promoted a study on the preparation of plastics waste – bitumen blend and its properties to find the suitability of the blend for road construction. A modified technique was developed and the stone aggregate was coated with molten plastics and the plastics waste coated aggregate (PCA) was used as the raw material for flexible asphalt concrete. PCA showed better binding property, it had less water absorption and also the sample showed higher Marshall Stability value.The continuous increase in road traffic in combination with insufficient maintenance due to paucity of funds has resulted in deterioration of road network in India. To improve this process there are several types measures which are proven to be effective, like securing adequate funds for proper maintenance, effective and improved roadway design, use of better quality materials and use of effective and modern construction techniques. During last three decades in many countries around the world it has been tested that modification of the bituminous binder with polymer additives enhances the properties and life of asphalt concrete pavements. The present investigation was carried out to propose the use of plastic coated aggregate (PCA) in bituminous mix of flexible pavements in order to improve their performance and also to give a way for safe disposal of plastic wastes to provide a solution to threat of environmental pollution as well. There are two processes available for mixing of waste plastic in bituminous mixes namely wet and dry process. In this study the dry process was used for bituminous concrete mixes.

Objective

- To avoid disposal of plastics waste by incineration and land filling etc.
- To coat the aggregates with the waste plastic materials and check the properties of coated aggregate .
- To check the properties of bituminous mix specimen.
- To check the properties of bituminous mix specimen due to coating of waste plastic materials.
- To evaluate properties of Plastic coated aggregates (PCA) and comparing it to conventional aggregates.

III.METHODOLOGY

A. General

Waste plastic bags were collected from roads, garbage trucks, dumpsites and compost plants, rag pickers, waste-buyers at Rs 5-6 per kg. Household plastic was also collected for the project work, like empty milk bags, used plastic bags etc. the collected plastic waste was sorted as per the required thickness. Generally, polyethylene of 60 micron or below is used for the further process. Less micron plastic easily mixable in the bitumen at higher temperature (160'C -170'c).it is clean by de-dusting or washing if required. Collected plastic was cut into fine pieces sieve and retaining at 2.36mm sieve were sieved through 4.75 mm sieve and retaining at 2.36 mm sieve was collected. Firstly, Bitumen was heated up to the temperature about 160'C-170'C. the mixture was stirred manually for about 20-30 minutes. In that time period temperature was kept constant about 160-170'C.

B. Flow chart

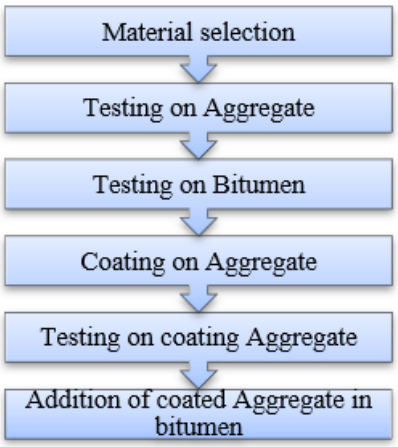

Figure1:Flow Chart

C. Material selection

- Aggregate: The coarse aggregate used is procured from a local crushing unit having 10-12mm nominal size. The coarse aggregate procured from quarry was sieved through 12.5mm and retained on 10mm sieve size.
- Bitumen: The grade of bitumen is 60-70.
- Plastic: Waste plastic glass are used of 50-60 micron.

D. Testing on Aggregate

- Water Absorption Test
- Aggregate Impact Value Test
- Aggregate Crushing Value Test
- Los Angeles Abrasion Test

E. Testing on Bitumen

- Specific gravity test
- Ductility test

- Softening point
- Flash point & fire point

F. Coating on Aggregate

The waste plastic bags, cups shredded to the required size of 2.5 mm. The Aggregate is heated to 170 C. The shredded waste plastic was sprayed over the hot aggregate. Plastic got softened and coated over aggregate.

G. Testing on coating Aggregate

Then after coating Aggregate the testing on coating Aggregate is done.

H. Addition of coated Aggregate in bitumen

The Bitumen is heated to 160 C. The coated aggregate mixed over the hot bitumen and properly mixed.

IV. RESULT AND DISCUSSION

A. Water absorption test

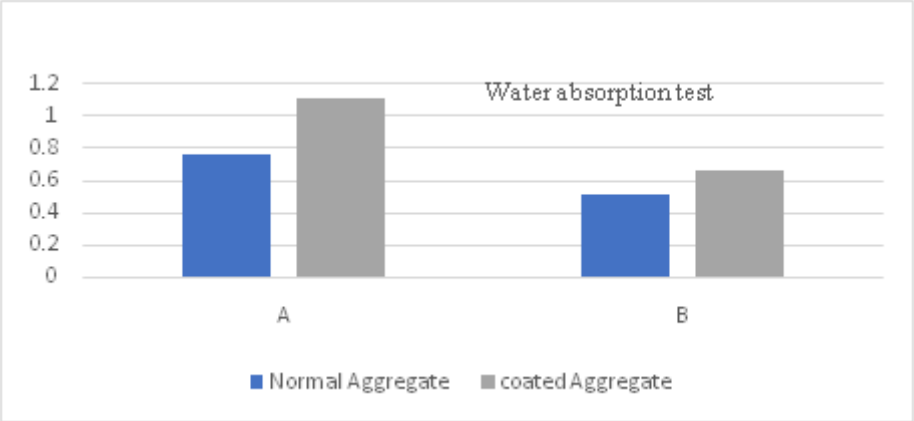

Figure2:Water absorption test

TABLE I WATER ABSORPTION PLASTIC COATED AGGREGATES

Sr.no	Type of aggregate	Wt. Ofsurface saturated dry sample w1 gm	Wt. of oven dry sample w2 gm.	% water W.A.=(w2-w1 w2/B X 100)	Average % of water
1.	A	1989	1974	0.76	0.63%
2.	B	1980	1970	0.51	

TABLE III WATER ABSORPTION PLASTIC COATED AGGREGATES

Sr.no	Type of aggregate	Wt. Ofsurface saturated dry sample w1 gm	Wt. of oven dry sample w2 gm.	% water W.A.=(w2-w1 w2/B X 100)	Average % of water
1.	A	1990	1968	1.11	0.885%
2.	B	1995	1982	0.66	

B. Impact value test

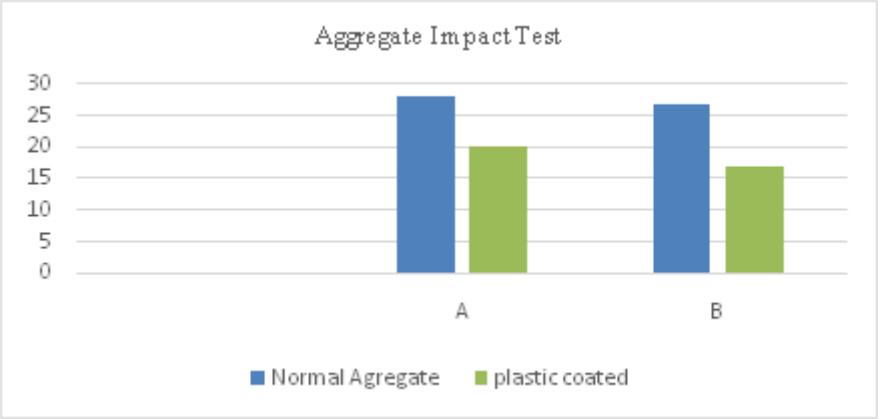

Figure3:Impact value test

TABLE IIIII IMPACT VALUE OF NORMAL AGGREGATES

Sr no.	Item	Test 1	Test2
1	Weight of oven dried sample (W1)gm	642	641
2	Weight of fraction passing 2.36mm Is sieve (W2)	58	59
3	Weight of retained 2.36mm Is sieve (W3)	584	582
4	Impact value = (W2/W1) X 100	9.03	9.20
5	Average impact value	9.15%	

TABLE IVV IMPACT VALUE OF NORMAL AGGREGATES

Sr no.	Item	Test 1	Test2
1	Weight of oven dried sample (W1)gm	636	646
2	Weight of fraction passing 2.36mm Is sieve (W2)	53	51
3	Weight of retained 2.36mm Is sieve (W3)	583	595
4	Impact value = (W2/W1) X 100	8.33	7.89
5	Average impact value	8.11%	

C. Crushing value test

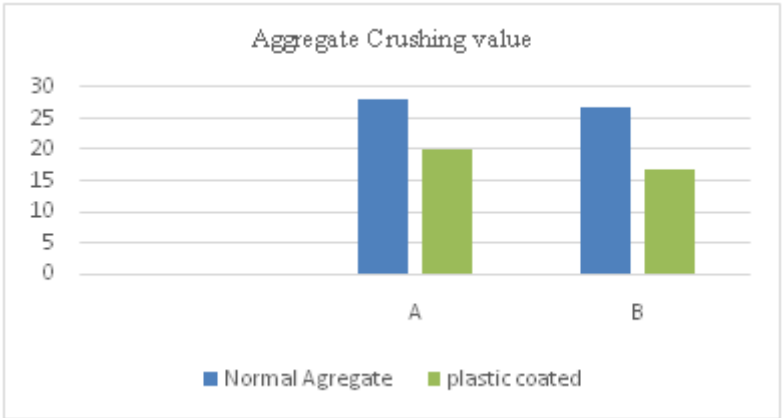

Figure4:Crushing value test

TABLE V CRUSHING VALUE OF NORMAL AGGREGATES

Sr no.	Item	Test 1	Test2
1 .	Total wt. of dry sample taken =W1 gm	3000	3000
2 .	Weight of portion passing 2.36mm sieve = W2 gm	540	600
3 .	Aggregate crushing value = (W2/W1) x 100	18%	20%
4 .	Mean aggregate crushing value =	19%	

TABLE VI CRUSHING VALUE OFPLASTICCOATED AGGREGATES

Sr.no	Items	Test 1	Test 2
1 .	Total wt. of dry sample taken =W1 gm	3000	3000
2 .	Weight of portion passing 2.36mm sieve = W2 gm	404	420
3 .	Aggregate crushing value = (W2/W1) x 100	13%	14%
4 .	Mean aggregate crushing value =	13.5%	

D. Los Angeles abrasion test

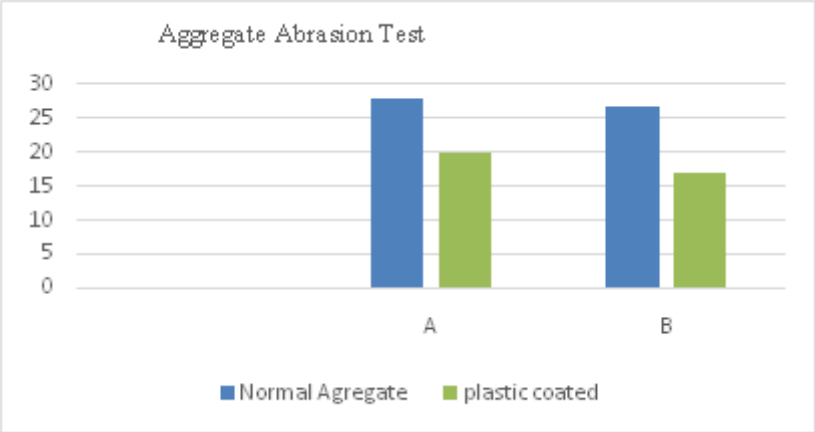

Figure5:Los Angeles abrasion test

TABLE VII ABRASION VALUE OF NORMAL AGGREGATES

Sr.no	Items	Test 1	Test 2
1 .	Total wt. of dry sample taken =W1 g m	1.250	1.250
2 .	Weight of portion passing 2.36mm sieve = W2 gm	350	335
3 .	Aggregate abrasion value =(W2/W1) x 100	28%	26.8%
4 .	Mean aggregate abrasion value =	27.4%	

TABLE VIII ABRASION VALUE OF PLASTICCOATED AGGREGATES

Sr.no	Items	Test 1	Test 2
1 .	Total wt. of dry sample taken =W1 g m	1250	1250
2 .	Weight of portion passing 2.36mm sieve = W2 gm	250	210
3 .	Aggregate abrasion value =(W2/W1) x 100	20%	16.8%
4 .	Mean aggregate abrasion value =	18.4%	

E. Marshall Stability Test

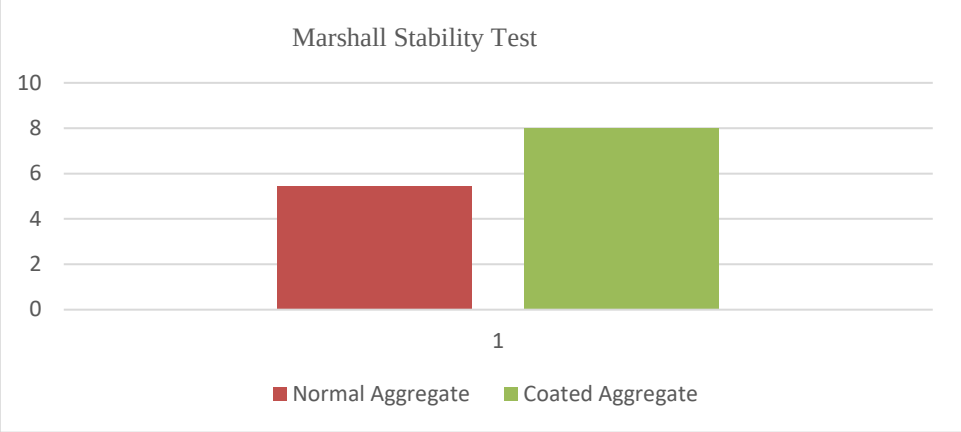

Figure6:Marshall Stability Test

TABLE IX MARSHALL STABILITY TEST OF BITUMEN

Sr No	Wt of Aggregate (Kg)			% Bitumen	Wt. of Bitumen (Kg)	Specific Gravity			
	Coarse Aggregate	Fine Aggregate	Filler			Coarse Aggregate	Fine Aggregate	Filler	Bitumen
1	2895	450	225	3	108	2.61	2.46	2.41	0.99
2	2895	450	225	4	144	2.61	2.46	2.41	0.99

Sr No	% Bitumen by Weight of Total Aggregate Mix	Weight of specimen (g)		Gt	Gm	Vv	Vb	VMA	VFB	Stability		Flow
		In air	In water							Obs	Carr	
1	3	1197	654.4	2.40	2.17	9.18	6.28	16.16	35.1	799		9
2	4	1163	647.5	2.42	2.21	6.67	8.58	16.75	43.3	717		9.6

TABLE X MARSHALL STABILITY TEST PLASTIC COATED AGGREGATES

Sr No	Wt of Aggregate (Kg)			% Bitumen	Wt of Bitumen (gm)	Specific Gravity			
	Coarse Aggregate	Fine Aggregate	Filler			Coarse Aggregate	Fine Aggregate	Filler	Bitumen
1	1200	0	225	4	57	2.61	2.46	2.41	0.99
2	1200	0	225	5	72	2.61	2.46	2.41	0.99

Sr No	% Bitumen by Weight of Total Aggregate Mix	Weight of specimen (g)		Gt	Gm	Vv	Vb	VMA	VFB	Stability		Flow
		In air	In water							Obs	Corr	
1	4	1197	654.4	2.40	2.17	9.18	6.28	16.16	35.1	799		9
2	5	1163	647.5	2.42	2.21	6.67	8.58	16.75	43.3	717		9.6

TABLE XI TESTING RESULT

Aggregate type	Water absorption	Impact value	Crushing value	Abrasion value
Normal Aggregate	0.63%	9.20%	19%	27.40%
Coated Aggregate	0.885%	8.11%	13.5%	18.40%

Discussion

- The crushing value reduces from 19 to 13.5 % for normal and plasticcoated aggregate. The value was reduced by 40%. Lower the aggregate crushing value higher is the strength.
- The aggregate impact value of plasticcoated aggregate was reduced by 9.20 to 8.11 % than the normal aggregate. It is the higher toughness of plasticcoated aggregate.
- Loss Angeles abrasion value indicates the hardness of the aggregate.
- The abrasion value of plasticcoated aggregate were 27.40% less than the normal aggregate.
- The stability of modified bitumen (10% bitumen replaced by plastic) is higher than the normal bitumen.

V. CONCLUSION

The plastic mixed with bitumen and aggregate is used for better performance for the roads. The polymer coated on the aggregate reduces the voids and moisture absorption. This results in the reduction of ruts and there is no pothole formation. The plastic pavement can be withstand heavy traffic and are durable than flexible pavement.

- It shows that with the increase of waste plastic in the bitumen increase the properties of aggregate and bitumen.
- Use of waste plastic in flexible pavements shows good result when compared with conventional flexible pavements.
- This has added more value in minimizing the disposal of plastic waste as an eco-friendly technique.
- Coating of polymer on the surface of the aggregate has resulted in many advantages, which ultimately helps to improve the quality of flexible pavement

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