Investigation On Bitumen Aspects in Modified Flexible Pavement and Its Characterization in Highway Construction

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Abstract*—Major The severity of rutting, cracks, ravelling, and edge drops on roads has been on the rise in recent years, attributed to heavy traffic, high tyre pressure, and large wheel loads. There have been and will be many more efforts to strengthen and prolong the life of roads by enhancing the structures of flexible pavement. To enhance the bitumen's binding capability, many additives are being added. Bitumen is being combined with various polymers to create polymer modified bitumen. Coating the heated aggregates with polymer and then mixing them with hot bitumen is the procedure. Flexible pavement is made using this combination. The procedure is environmentally benign. Only polymer waste products, such as old plastic bags, cups, foams, etc., are used. Since this procedure simply requires coating aggregate, it is easy to include a greater amount of polymer, say 15-20%. By using waste polymers as a replacement for bitumen, this approach helps to cut consumption by 15-20%. As a result of the higher bonding caused by the polymer covering, the bituminous mix's binding strength is enhanced by 50-100%. The test results from specific areas with varying climates, temperatures, rainfalls, and traffic volumes show that these plastic roads are holding up well and showing no signs of damage like ravelling, rutting, or cracking. Plastic tar road, if approved, would improve India's roads and eliminate the need to properly dispose of polymer waste; an area of 3,750 square metres necessitates at least 1 metric tonne of polymers. India could save a lot of bitumen and put all that polymer waste from polypropylene (PP), polyethylene (PE), and polystyrene (PS) to good use if its roads were built with plastic tar. The author hopes and suggests that the method be implemented throughout the whole country of India as soon as possible, paving the road for Green India.

***Index Terms*—Modified Bitumen, polymers, rutting, flexible pavement, highways.**

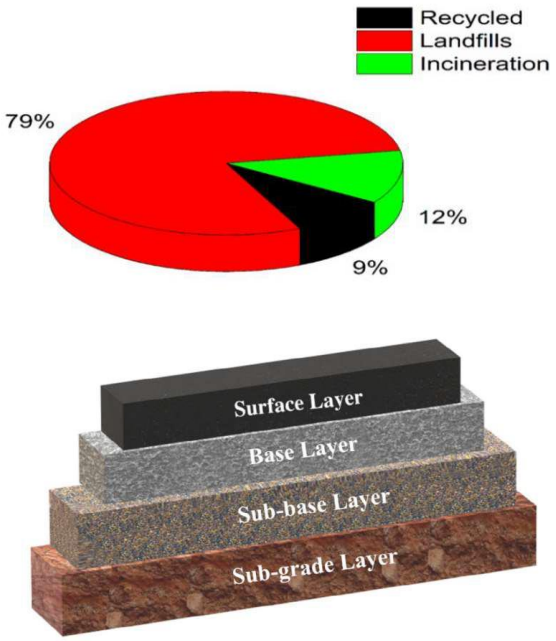
I. INTRODUCTION

1.1 General In the past, geotechnical engineers have used grouts made of cement to fix problems with foundation performance, such making underground soils more watertight, filling cracks, or strengthening weak soils or rock masses. According to Mozumder, Laskar, and Hussain (2018) and Rosquoët et al. (2003), grouting is a technique used in geotechnical engineering to increase the strength of soil by injecting a solution into the layers of soil underneath that include holes or voids. Cementations grout that is both strong and long-lasting, as well as easily permeable, is not easy to make. Fluidity, strength, impermeability, corrosion protection, sulphate resistance, and sometimes frost resistance are all important properties of a high-performance cementations grout. The in-situ conditions and the grouting objective dictate the mixing method of the several components that make up grouts[1]. More and more people are opting for polymer modified grouts (PMG) and polymer modified mortars (PMM) (Zhang et al., 2020). Solid polymer particles suspended in water form a biphasic system known as a polymer dispersions. The addition of polymer particles to cement makes the resultant paste more uniformly distributed, which increases the binder system's stiffness and durability throughout the hardening process (Larbi and Bijen, 1990). Cost-effective grout mixes with exceptional fresh-state properties and good mechanical performance are the primary focus of current research (Bonicelli et al., 2019)[2]. Acoustic termite resistance, blast resistance, performance, thermal storage capacity, and anchoring capabilities are some of the many uses for grout beyond only increasing fire and security (Jawad, 2021). Auger cast pile grout, masonry grout, and preplaced aggregate are only a few types of grouts available (Hlail, 2021). Grouts may be customised to fit specific jobsite conditions and project goals by adding chemical admixtures such plasticizers, superplasticizers, accelerators, anti-freeze agents, air-entrainers, and volume stabilisers. To make mortars

and concretes more fluid, scientists have recently included latexes, which are polymeric particles dispersed in water, and a number of water-soluble polymers (Anagnostopoulos and Dimitriadi, 2021). "C6" (an acrylic-modified cementations coating compound) performed exceptionally well when applied to a deteriorating highway wayside barrier in Xinjiang as part of a project to protect it[3].

II. LITERATURE AND REVIEW

1.2 Plastic In today's world, energy conservation is highly valued for its role in reducing the utilisation of non-renewable fuels, costs, and several other advantages (Fadzil et al., 2021). Polymer matrix composites are an example of a lightweight material that is in high demand due to its potential to reduce energy consumption (Wu et al., 2020; Wang et al., 2017; Fan and Njuguna, 2016; Costa et al., 2021).



Bshara, et.al (2014), studied the improvements of strength characteristics of poor soil byadding the stone dust and observed better results in the strength aspects[14].

Bindhu Lal, et.al (2014), This study shows that stone dust can be satisfactorily used as a cheap stabilizing agent for sub-grade layers and sub-base layers of a Flexible Pavement. Observed that the Optimum Moisture Content, Maximum Dry Density and California Bearing Ratio properties are optimally improved by adding stone dust[14].

III. OBJECTIVE OF THE PRESENT WORK AND METHODOLOGY

A detailed study on the construction of the roads and subsequently on performance of these roads is the need of the hour. The coating of polymers over aggregate improved not only the quality of the road but also the quality of aggregate. A detailed scientific analysis based on physical and chemical properties is being attempted in this work. To ascertain physical properties of polymer coated aggregate, the following tests were carried out[22].

a. Los Angeles Abrasion Value
b. Aggregate Impact Value
c. Crushing Test
d. Soundness
e. Combined Index Value
f. Water Absorption
g. Specific Gravity

IV. PROCESS METHODOLOGY

4.1 Process: I (using Mini Hot Mix Plant) At first, the aggregate mix was prepared as per IRC specification and then heated in the cylindrical drum to 170 ^{o}C. It was then transferred to the puddling compartment where polymer waste (size between 1.6mm and 4.75mm) was added. As the temperature of the aggregate was around 170 ^{o}C and the softening temperature of polymer waste is around 135 ^{o}C, the polymer waste got softened and got coated over the aggregate within 30 to 60 seconds. Immediately the hot bitumen 60/70 grade (160^{o}C) was added and mixed in the puddling chamber. The bitumen got coated over the aggregate. As the polymer and the bitumen were in liquid state they got mixed well. The mixture was transferred to the road and it was spread and compacted using 8 Ton rollers. 4.2 Process: II (using Central Mixing Plant)

In this process, the polymer waste was mixed quantitatively with the aggregate using a mechanical device before the addition of bitumen. Central Mixing Plant helps to have better control of temperature and better mixing of material and thereby enabling to have a uniform coating.

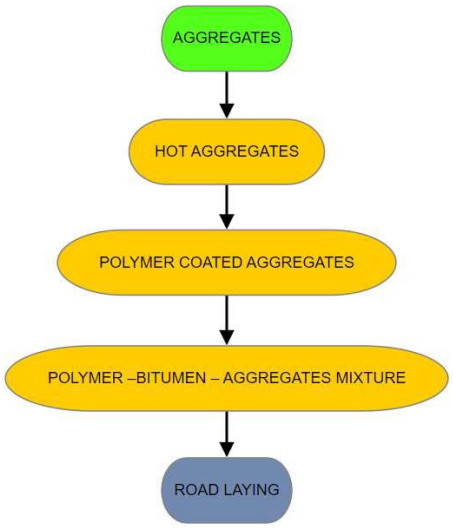


Fig. 4.2: Cleaning Process

Fig. 4.4: Heating of Aggregate to 170º C in Mini Hot Mix Plant

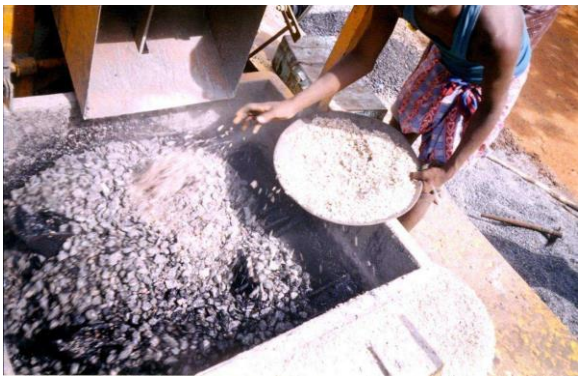


Fig. 4.6: Adding Waste Polymers to Hot Aggregates

V. PROPERTY EVALUATION OF MATERIALS

5.1 Evaluation of Properties of Aggregate Aggregates were collected at four different corners of Nellore Samples for testing were collected as per specifications. Sample I and II were collected from the quarries, which are source of aggregate for road work. Sample III and IV were chosen from the waste obtained in granite quarry where the granite is used for making granite tiles. Large quantities of this waste are available which can be made useful for pavement construction. Basic analyses of these four samples were carried out and the results are tabulated[3].

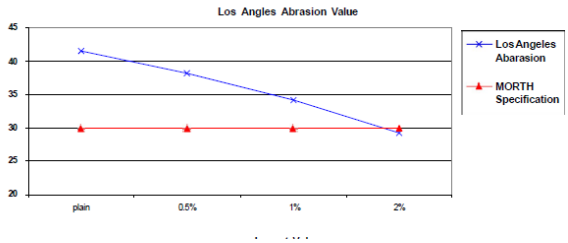
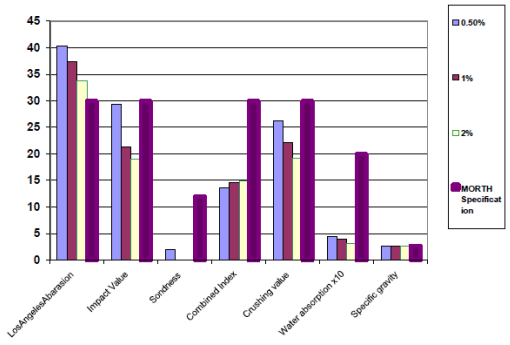


Table 5.9: Laboratory test results of polymer coated aggregate of Southern Rocks and Minerals Pvt.Ltd Quarry

S.no	Details / Particulars	Units	Percentage of polymer coated over aggregate		
			0.5%	1%	2%
1	Los Angeles Abarasion Value (B Grade)	%	38.2	34.1	29.2
2	Impact Value	%	29.30	21.30	19.00
3	Soundness Value	%	2.0	0.0	0.0
4	Combined Index Value	%	13.6	14.73	14.95
5	Crushing Value	%	26.20	22.10	19.20
6	Water Absorption Value	%	0.45	0.40	0.32
7	Specific Gravity	--	2.64	2.623	2.554



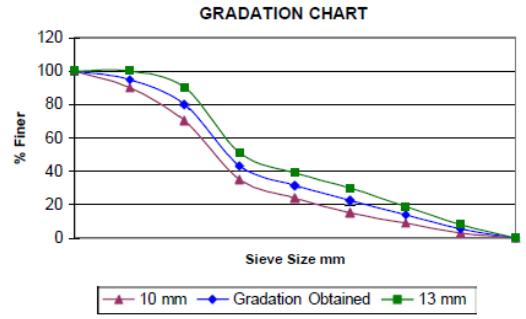


Fig. 5.12: Gradation Graph

Table 5.17: Comparative Study on Marshall Stability Value for PCA and PMB

Percentage of Bitumen	Percentage of Polymer w.r.t wt of bitumen	Type of Polymer	PCA/PMB	Marshall Value (kN)	Flow Value (x 0.25mm)	Void Percentage	Marshall Quotient kN/mm
4.5	10	PP	PCA	20.00	5	55	4.00
4.5	10	PE foam	PCA	20.00	4	58	5.00
4.5	10	LDPE	PCA	17.50	4	55	4.38
4.5	10	PP	PMB	17.00	3.3	62	5.15
4.5	10	PE foam	PMB	18.00	3.4	66	5.29
4.5	10	LDPE	PMB	17.00	3.5	62	4.86

Fig. 5.15 shows the comparison of Marshall Stability Value and Flow Value of PCA and PMB.

Fig. 5.13: Comparison of Marshall Stability and Flow Value of PCA and PMB

VI. RESULTS AND DISCUSIION

6.1 General PMB 70-10 its company, Nanda Chemical Pvt. Ltd, Sarvepalli, Nellore sources its grade-II bitumen from corp. India Ltd. After being modified with EVA and CR at varying percentages, this bitumen is utilised as a base bitumen. Below are the results of the bitumen's tests for ductility, penetration, softening point, and viscosity. The Marshall Quotient falls within the acceptable range as well, proving that the bitumen mix that incorporates plastic waste (polyethylene) is superior and more suited for the building of flexible pavements[11]. The outcomes are detailed below:

Summary of Bituminous concrete Grading-II with PMB 76-10		
Apparent Specific Gravity of Mixed Aggregate (Gsa)=2.888		Specific Gravity of 20-14 mm= 2.956(Bulk) & 3.007 (Apparent)
Bulk Specific Gravity of Mixed Aggregate (Gsb)=2.824		Specific Gravity of 20-14 mm= 2.956 (Bulk)& 3.007 (Apparent)
		Specific Gravity of 20-14 mm= 2.956 (Bulk)& 3.007 (Apparent)
		specific Gravity of Lime= 2.27 (Bulk & Apparent)
S. No.	**Determination**	**Limits/Results**
1	Grade of Bitumen	PMB 76-10
2	Spg. of Bitumen (Pb)	1.035
3	Effective Spg. of Total Agg.(Gse)	2.884
4	Ingredients by batch mix for 1Mt	
	Bitumen(kg)	51.7
	20-14 mm (kg)	142
	14-6 mm (kg)	332
	6 mm down (kg)	455
	Lime (kg)	19
5	Bulk Density Gmb(gm/cc)	2.535
6	Max Spg. Of Mix (Gmm)	2.64
7	Air voids (Va) %	3.98
8	VMA (%)	14.87
9	VFB (%)	73.23
10	Marshall stability (kgf)	1806
11	Flow	3.83
12	Marshall Quotient	4.62
13	Retained stability (%)	94.30%

CONCLUSION

- Better binding property as observed in extraction of binder test
- Higher softening point (upto53 ºC) and thereby withstanding high temperature
- Lower penetration value (65mm) and hence higher load carrying capacity
- The Marshall stability value of the Semi Dense Bituminous Concrete (SDBC)has increased by about 30 percentage on using PCA
- Water absorption was found to be less in PCA by 30.80 percentages as compared to plain

aggregate which indicates a higher degree of water susceptibility.

- Comparatively better riding quality and low distress for the road sections laid using PCA mix when compared to the control section with plain aggregate mix
- The PCA mix showed better skid resistance as compared to plain aggregate mix and hence more suitable for heavy traffic
- The road using PCA was found to have a smoother surface texture as compared to those using plain aggregate.
- The unevenness of the road modified with PCA was found to be less than that of plain aggregate.
- Aggregates which are found to be not suitable for road work becomes Suitable for road works when polymer coated.
- The study shows that the physical properties of the plain bitumen are increased by modification of EVA polymer and crumb rubber.
- Pavements made with modified bitumen are more resistant to fatigue, thermal cracking, rutting and temperature susceptibility than neat bitumen.
- As the EVA polymer and crumb rubber increases the penetration of the modified bitumen decreases.
- As the penetration value decreases, the bitumen becomes harder, due to this the quality of bitumen improves.
- The viscosity of the modified bitumen increases with the increase in EVA polymer and crumb ru bber.
- Page 63 7.1 Scope for Further Research 1. Recycling old bituminous pavement by mixing in used polymer. 2. Boosting the strength of flexible pavement by mixing in fly ash with polymer-
- coated aggregate bituminous mix. 3. Use high-quality fly ash to get the desired strength. 4. Performance-based finite element modelling of flexible pavement is required.

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