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Economics of Using Waste Polymer Material as An Alternative to Stone Aggregates in Bituminous Road Pavements

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Abstract- Polymer waste generated at recycled pipe manufacturing plant (locally called jali gulla) is used to obtain an alternative material for stone aggregates. These Waste Polymer Aggregates (WPA) are subjected to different tests recommended by IS codes and the test result indicates that WPA are suitable to be used in bituminous road as a substitute to traditional coarse aggregates. In the present work, efforts are taken to calculate cost of materials per kilometer length of a bituminous road for a given width of 3.7 meter. It is found that, total cost of materials in case of waste polymer aggregate road is considerably less than that for a usual stone aggregate road. Since WPA are comparatively light in weight, their use in road construction can further minimize the cost due to ease in their mixing, placing and transporting operation.
Keywords- recycled pvc pipe, waste polymer aggregates, bituminous road pavement, cost analysis.

I. INTRODUCTION

There are several polymer industries located in M.I.D.C. area Jalgaon and many of them are manufacturing recycled rigid PVC pipes. In production of these recycled pipes, main raw material is plastic scrap. In the process of hot filtration stage during manufacturing of these rigid pipes, a non-recyclable mass of plastic waste is generated which contains crude polymer constituent along with foreign bodies like stone and metal particles. After its generation, this mass of waste plastic, locally known as Jali Gulla, is allowed to cool to room temperature. Considerable amount of such gulla waste is getting generated in these pipe factories during the filtration process and stacked aside as non-recyclable solid waste material [1] & [2]. This plastic waste is decided to be used for producing aggregate material. To satisfy this requirement, the mass of waste polymers are applied to the hopper of cutting machine to cut it into small pieces of size less than 25mm. Thus Waste Polymer Aggregates (WPA) could be obtained from jali gulla (mass of waste polymer).

During the cost analysis, total cost of materials is determined. In the beginning, for the bituminous pavement where natural stone aggregates are used and after that for that kind of road where only Waste Polymer Aggregates (WPA) will be used for its construction. Since the steps involved in the construction process are assumed similar for both the cases of roads, the difference in cost occurs mainly due to the difference in the material of construction. Particularly the type of aggregates used and their quantity required to construct the given stretch of road pavement, makes the difference in cost.

II. TESTING OF WPA

An attempt has been made for laboratory assessment of this Waste Polymer Aggregates (WPA). Traditional tests have been mostly adopted as per Indian Standards and Indian Road Congress (IRC) specifications to study the basic properties of WPA. They are tested in laboratory for Percentage Water Absorption, Specific Gravity determination, Impact, Crushing and Abrasion Value Test, Stripping Test with bitumen and Marshall Stability Test. The test results indicate that, the waste polymer particles have potential to be used as an alternative material to stone aggregates in construction of bituminous road pavement. [4-6]

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Fig.1 Waste Polymer Aggregates (WPA) derived from *Gulla waste material*

TABLE I

Sr. No.	Type of property	Specifications	Test Results	Recommendation for natural stone aggregates
1	Particle size	IS 2386 (Part I) 1963	Less than 40mm size.	Recommended size.
2	Specific Gravity	IS 2386 (Part III) 1963	1.5	2.6 to 2.9
3	Water Absorption	IS 2386 (Part III) 1963	1.55%	Should not be more than 2%
4	Impact Value	IS 2386 (Part IV) 1963	1.47%	Should not be more than 30%
5	Crushing Value	IS 2386 (Part IV) 1963	1.7%	Should not be more than 30%
6	L.A. Abrasion Value	IS 2386 (Part IV) 1963	2.24%	Should not be more than 30%
7	Stripping Test	IS 6241-1971	17%	Should not be more than 25%
8	Marshall Stability Value	ASTM D 1559	848 Kg	Should not be less than 340 Kg

III. COST ANALYSIS

Considering the importance of money in every sector of life in this era of critical thinking and implementation, it becomes essential for any project, before its actual execution to check its economical feasibility. In the present study it is proposed that, Waste Polymer Aggregates (WPA) will be used as substitute to natural stone aggregates for construction of bituminous road pavement. The optimum percentage of bitumen is taken as determined in Marshall Stability test.[8] The road can either be in the form of premix carpet or surface coats (black top surfacing or painting). In the beginning, cost required for usual type of bituminous road, where stone aggregates are used is determined, and after that cost required for that bituminous road, wherein waste polymer particles (WPA) will be used as coarse aggregate, is obtained.

A. Assumptions in Cost Analysis

On experimental basis the cost analysis is conducted per kilometer length of road having 3.7m as its width.
Only waste polymer aggregates (WPA) are to be used to prepare bituminous mix. It will not contain any stone aggregates.
Cost analysis involves only cost of material required for bituminous layers.
Other conditions like foundation, construction procedure, laying material and compaction (rolling) etc. for WPA road are similar to that for the usual bituminous road.
Considering all these assumptions cost analysis is carried out separately for the two different cases of road pavements.

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TABLE II
COST OF MATERIAL FOR USUAL BITUMINOUS ROAD

Particulars	Material required	Proportion	Total quantity	Rate	Amount in Rs.
First coat	Stone grit (20 mm gauge)	1.35 cu. m per 100 sq. meter	50 cu. M	900 / cu.m.	45000
	Binder (Road Tar No. 3)	220 kg per 100 sq.m	8.14 tonne	2900/tone	23606
Second coat	Stone grit (12 mm gauge)	0.75 cu. m per 100 sq. meter	28 cu. M	900/cu.m.	25200
	Binder (Asphalt)	120 kg per 100 sq.m	4.44 tonne	2900/tone	12876
Total amount for materials only					106682

TABLE III
COST OF MATERIAL FOR WASTE POLYMER AGGREGATE (WPA) BITUMINOUS ROAD

Particulars	Material required	Proportion	Total quantity	Rate	Amount in Rs.
First coat	WPA (20 mm gauge)	1100 kg.per 100 sq. m. (according to 1.35cu.m of grit)	40.70 tonne	1000/tone	40700
	Binder (Road Tar No. 3)	11 % by weight of WPA	4.477 tonne say 4.5 tonne	2900/tone	13050
Second coat	WPA (12 mm gauge)	620 kg.per 100 sq.m. (according to 0.75cum)	17.36 tonne	1000/tone	17360
	Binder (Asphalt)	11 % by wt. of WPA	1.91 tonne say 2 tonne	2900/tone	5800
Total amount for materials only					76910

IV. CONCLUSION

The above cost analysis clearly indicates that cost of materials per kilometer length in case of WPA bituminous road is **less by Rs.** 29772/- than the cost of materials required for traditional bituminous road. In percentage it is **27.9% less**. Since WPA are comparatively light in weight (specific gravity is 1.5) their mixing, placing and transportation will be comparatively easy, fast and convenient and transporting given volume of WPA will require lesser powered vehicles. Moreover there is no need to heat WPA before mixing. Due to all these reasons there is further scope to reduce the cost of construction of bituminous road pavement.

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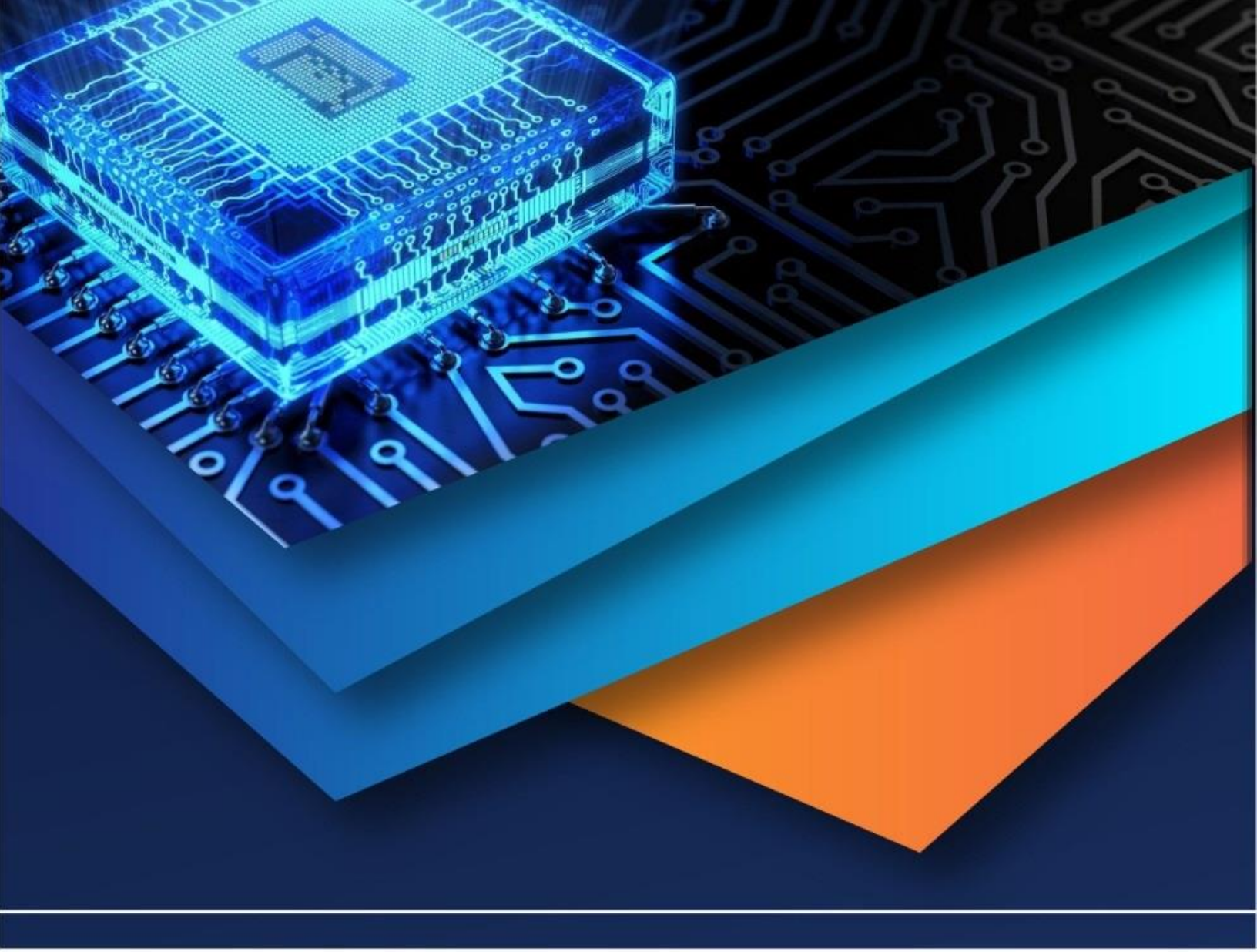

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