USE OF RECYCLED AGGREGATES WASTE PLASTIC FIBER AND FLY ASH IN PRODUCTION OF BITUMINOUS MIX FOR THE FLEXIBLE PAVEMENTS

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ABSTRACT

This study discussed the suitability of plastic waste materials for pavement construction... The waste is mixed in different proportions to the soil sample and their influences on geotechnical properties were studied. The results of the tests indicated that plastic alone is not suitable for pavement sub grade. When quarry dust was added along with soil plastic mix, it maintains the CBR value within the required range.

Plastic use in road construction is not new. It is already in use as PVC or HDPE pipe mat crossings built by cabling together PVC (polyvinyl chloride) or HDPE (high-density poly-ethylene) pipes to form plastic mats. The plastic roads include transition mats to ease the passage of tyres up to and down from the crossing. Both options help protect wetland haul roads from rutting by distributing the load across the surface. But the use of plastic-waste has been a concern for scientists and engineers for a quite long time. Recent studies in this direction have shown some hope in terms of using plastic-waste in road construction i.e., Plastic roads.

Plastic roads mainly use plastic carry-bags, disposable cups and PET bottles that are collected from garbage dumps as an important ingredient of the construction material. When mixed with hot bitumen, plastics melt to form an oily coat over the aggregate and the mixture is laid on the road surface like a normal tar road.

1. INTRODUCTION

Flexible pavements (bituminous roads) traditionally rely on natural aggregates, bitumen, and mineral fillers. However, increasing demand for road construction and depletion of natural resources have encouraged the use of sustainable and waste-based materials in bituminous mixes. Among these, recycled aggregates, waste plastic fibers, and fly ash have gained significant importance.

Recycled aggregates are obtained from construction and demolition waste. Their use reduces the need for fresh quarry materials and helps in waste management while maintaining acceptable strength and durability in pavement layers.

Waste plastic fibres, derived from discarded plastic materials (like bags, bottles, and packaging), are incorporated into bitumen or aggregates. They improve properties such as stability, resistance to rutting, moisture damage, and cracking, while also addressing the environmental problem of plastic waste disposal.

Fly ash, a by-product from thermal power plants, is used as a filler material in bituminous mixes. It enhances binding properties, workability, and void filling, and contributes to improved strength and durability of the pavement.

The combined use of these materials leads to eco-friendly, cost-effective, and durable pavements, reducing environmental pollution and conserving natural resources. This approach aligns with sustainable construction practices and modern infrastructure development needs.

Recycled Aggregates

Recycled aggregates are obtained from construction and demolition (C&D) waste, such as broken concrete, bricks, and old pavements. After proper crushing, screening, and processing, they can be used as a substitute for natural aggregates in bituminous mixes.

They help in reducing the demand for natural aggregates, thus conserving natural resources. They are cost-effective and reduce disposal problems.

Properly processed recycled aggregates provide adequate strength, stability, and durability. However, they may have higher water absorption, so proper mix design is necessary.

Waste Plastic Fibers

Waste plastic fibers are produced from discarded plastic materials such as carry bags, bottles, and packaging waste. These plastics are cleaned, shredded, and added to the bituminous mix.

There are two common methods:

Dry process: Plastic is mixed with hot aggregates before adding bitumen.

Wet process: Plastic is blended with bitumen before mixing with aggregates.

Plastic improves binding properties of bitumen.

It increases Marshall Stability and load-bearing capacity.

Fly Ash

Fly ash is a fine powder obtained as a by-product from coal-based thermal power plants. It is widely used as a filler material in bituminous mixes.

- It fills the voids between aggregates, improving density and compactness.
- It enhances workability and binding characteristics of the mix.
- It improves strength and durability of the pavement.
- It reduces the need for conventional mineral fillers like cement or lime

WHAT IS PLASTICS?

A material that contains one or more organic polymers of large molecular weight, solid in its finished state and at some state while manufacturing or processing into finished articles, can be shaped by its flow.

TYPES OF PLASTICS:

- Elastomers.
- Thermosets
- THERMOPLA
- STIC

BASIC PROCESS PLASTIC FOR ROAD CONSTRUCTION

1. **Segregation/collection of raw plastic: -** Plastic waste collected from various sources must be separated from other waste. Maximum thickness is 60 microns.

2. Cleaning Process: - Plastic wastes get cleaned and dried.

3. Shredding process: - Will be shredded or cut into small piece. The different types of plastic wastes are mixed together.

4. **Collection process: -** The plastic waste retaining in 2.36 mm is collected

STUDY OF MATERIAL USED OVERVIEW:

In this chapter we give a detailed description of the property and characteristics of material used in our project and also give detail about their performance and handling. The material used in this study is:-

- Bitumen.
- Shredded Plastic.
- Coarse aggregate.
- Medium aggregate & Sub grade filling material

BITUMEN:

In this study we use VG 30 Bitumen. This is the hardest of all the grades and can withstand very heavy traffic loads. The characteristics of this grade confirm to that of S 35 grade of IS731992. Bitumen 30/40 is used in specialized applications like airport runways and also in very heavy traffic volume roads in coastal cities in the country.

Bitumen (fig. 5)

The specification guide for VG30 Bitumen as per IS 73:2006:

Sno.	Characteristic	Unit	VG 30
1.	Absolute viscosity at 60O C, min	Poises	2400
2.	Kinematic viscosity at 135O C, min	cst	400
3.	Flash Point, Cleveland open cup, min.	C*	220
4.	Matter soluble in trichloroethylene, min	% wt	99
5.	Softening Point, min	C*	50
6.	Penetration at 25 O C, 100 gm, 5 sec.	1/10 mm	40 to 60

Shredded Plastic

In this study the shredded plastic contains plastic bottle, plastic disposals and polybags. And shredded at size of 2.36 to 4.35mm. This type of plastic is soft and easily melts with the Bitumen at required temperature and this type of plastic having a good binding property as compare to hard plastic.

Coarse aggregate:

In this study coarse aggregate which passes through 12.5mm sieve and retain at 10mm sieve. And the shape and structure of aggregate is sharp which interlocks the aggregate to each other during laying and compaction.

Medium aggregate & sub grade filling material:

In this study used the medium aggregate of size 4.5 to 6mm which is generally used for surface coating in flexible pavement and the sub grade filling material used like muram, bricks bats, red.

2. LITERATURE REVIEW

International Conference on Quality Up-gradation in Engineering, Science and Technology (2015): In this paper the study of some of plastic waste materials which we can reuse by certain processing and use in road construction...the materials as a result we are equipped with useful and valuable information about these materials. The discussed materials have many advantages over conventional/traditional materials and methods... This project will conduct a study on recycling plastic waste and blending it with bitumen to lay roads in India and compare with the environmental and economic conditions some of these materials are relatively cheaper and provide more strength as compared to traditional road materials. This project will come up with useful information and creating awareness amongst the learner in the industry regarding waste material. So that one can have a step towards further detailed information about these materials and thus be able to implement on field which will definitely improve the level of construction.

The director of the Central Road Research Institute (CRRI) said that bitumen mixed with plastic or rubber improves the quality and life of roads. The deputy director of the CRRI said that polymers mixed with bitumen increased the construction cost up to six per cent, but increased the longevity of roads manifold. The performance studies carried out on the roads constructed in Tamil Nadu indicated satisfactory performance with good skid resistance, good texture value, stronger and less amount of progressive unevenness over a period of time. The experimentation carried out by CRRI also indicated better stability value, indicating higher strength, less flow and more air voids. Al-Hadidy A.I., Yi-qiu Tan (2009), “Effect of polyethylene on life of flexible pavements”.

Yash Menaria (Poornima Institute of Engineering and Technology) Rupal Sankhla (India Centre for Environmental Planning & Technology, Ahmedabad,)

Open Journal of Civil Engineering, 2015, Use of Waste Plastic in Flexible Pavements-Green Roads: Wrappers of betel nuts, chocolates, chips, hand bags, cold drink bottles and all other forms of plastic create significant environmental and economic problem. They consume massive energy and other natural resources, depleting the environment in various ways. In manufacturing firms, con-struction industries and products delivery services, use of plastic is a priority to handle and pack things comfortably due to its light weight, cost effectiveness and strength. Plastics cannot be banned as it will result in usage of natural resources like paper, wood at a great extent. It is made up of various chemical elements and is regarded as a highly pestilent material which does not easily degrade in the natural environment after its usage. Waste plastics are made up of Polyethylene, Polystyrene and Polypropylene. Temperature varying between 120℃-160℃ gives the softening point of these plastics. They do not produce any toxic gases during heating but the softened plastics have tendency to form a lamination or coating over the aggregate, when it is sprayed over the hot aggregate at 160℃.

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Bituminous mix with recycled plastics mainly LDPE replacing 30% of 2.36 - 5mm aggregates showed 250% increase in Marshall stability and the mix density reduced to 16% and in addition to it the Indirect Tensile Strength (ITS) was also improved.
On heating at 100-160’C polythene, polypropylene and polystyrene soften and exhibit good binding properties, blending it with bitumen results in a mix which is suitable for road laying. In Maharashtra 1,500 km of road have been laid by the above mix and other states including Tamil Nadu, Andhra Pradesh, Karnataka, Pondicherry, Kerala have also laid test roads which

have successfully withstood loads due to heavy traffic, rain and temperature variation.India generates 5.6 million metric tons of plastic waste annually, with Delhi generating the most of at municipality at 689.5 metric tons every day, according to a report from the Central Pollution Control Board (CPCB). CPCB submitted the report to the Indian Supreme Court, which said, "We are sitting on a plastic time bomb."

COLLECTION OF RAW MATERIAL

The material used in this study is:

Bitumen: VG30 from Gupta construction pvt ltd.

Plastic waste: soft plastic of size 2.36mm from Bairagarh junk yard.

Coarse aggregate: size of Agarwal group of construction.

Fine aggregate: size of 5mm from local contractor yadav construction.

Base & sub grade material: from local contractor kanta sharavan residential constructions

RESULT & DISCUSION

5.1. Test on Aggregate: - Result of Crushing Test

The test is conducted on 6 samples. In which 3 samples are of plain coarse aggregate and 3 samples are of plastic coated aggregate.

Test results of plain coarse aggregate:-

Sno.	(W1)Weight of sample(grm)	(W2)Weight of crushed sample(grm)	Aggregate crushing value **(W2/W1)*100**	Results (%)
Sample 1	670	40	(40/670)*100	5.97%
Sample 2	650	38	(38/650)*100	5.84%
Sample 3	720	44	44/720)*100	6.11%

Test results of plastic coated aggregate:-

Sno.	(W1)Weight of sample(grm)	(W2)Weight of crushed sample(grm)	Aggregate crushing value **(W2/W1)*100**	Results (%)
Sample 1'	620	32	(32/620)*100	5.16%
Sample 2'	610	31	(31/610)*100	5.08%
Sample 3'	695	37	(37/695)*100	4.46%

Result of Abrasion Test: The test is conducted on 8 samples. In which 4 samples are of plain coarse aggregate and 4 samples are of plastic coated aggregate.

Test results of plain coarse aggregate:-

Sno.	(W1)Weight of sample(grm)	(W2)Weight of crushed sample(grm)	Abrasion value = **(W2/W1)*100**	Res ults (%)
Sample 1	5200	1794	(1794/5200)*100	34.51%
Sample 2	6080	2304	(2304/6080)*100	37.9%
Sample 3	6533	1999	(1999/6533)*100	30.6%
Sample 4	9790	3093	(3093/9790)*100	31.6%

Test results of plastic coated aggregate:-

Sno.	(W1)Weight of sample(grm)	(W2)Weight of crushed sample(grm)	Abrasion value = **(W2/W1)*100**	Res ults (%)
Sample 1'	5275	1655	(1655/5275)*100	31.37%
Sample 2'	5500	1639	(2304/5500)*100	29.8%
Sample 3'	7100	2336	(2336/7100)*100	32.6%

Result of water Absorption Test: - The test is conducted on 6 samples. In which 3 samples are of plain coarse aggregate and 3 samples are of plastic coated aggregate

Test results of plain coarse aggregate:-

Sno.	(W1)Weight of saturated sample(grm)	(W2)Weight of oven dried sample(grm)	(Wo) Weight of water absorption(grm)	Water absorption value = **(Wo/W2)*100**	Results (%)
Sample 1	2409	2405	5	(5/2404)*100	.208%
Sample 2	2380	2375	5	(5/2375)*100	.210%
Sample 3	2491	2485	6	(6/2485)*100	.210%
Average Value = .206%					

Testresultsofplasticcoatedaggregate:-Inthistheratioofplasticmixis20% by aggregate weight during heating of coarse aggregate

Sno.	(W1)Weight of saturated sample(grm)	(W2)Weight of oven dried sample(grm)	(Wo) Weight of water absorption(grm)	Water absorption value = **(Wo/W2)*100**	Results (%)
Sample 1'	2400	2396	4	(4/2396)*100	.166%
Sample 2'	2425	2422	3	(3/2422)*100	.123%
Sample 3'	2380	2375	5	(5/2375)*100	.210%
Average Value = .166%					

Test results of VG30 bitumen:

Sno.	Penetration value (mm)
Sample 1	69.5
Sample 2	67
Sample 3	70
Mean value = 68.83(mm)	

CONCLUSION

Plastic will increase the melting point of the bitumen. This innovative technology not only strengthened the road construction but also increased the road life. Plastic roads would be boon for India's hot & extremely humid climate, where temperature frequently crosses 50°C

COMPARISON

1. The durability of the roads laid out with shredded plastic waste is much more compared with roads with asphalt with the ordinary mix.

2. While a normal 'highway quality' road lasts four to five years it is claimed that plasticbitumen roads can last up to 10 years.

3. Rainwater will not seep through because of the plastic in the tar.

4. The cost of plastic road construction may be slightly higher compared to the conventional method.

5. The maintenance cost is low as compared to conventional method.

6. It initial cost is slightly more as compared to conventional method.

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