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A Study on the Use of Waste Materials in Flexible Pavement

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ABSTRACT

Bituminous mixes are used in different spots in flexible roads development. Asphalt mix consists of asphalt/bitumen which are mixed together, laid down in layers and then compacted. When designed and executed under normal conditions asphaltic pavements perform quite satisfactorily but the performance of bituminous mixes is worse under different situations. Today's asphaltic concrete pavements are expected to perform better as of what they are experiencing nowadays due to more amount of traffic, huge amount of loads and large variations in seasonal temperatures on daily basis that has been experienced in the past. Not only this, but asphaltic roads are seen to perform very poor when prone to moisture induced situations. Focussing on this problem, a lot of research work has been carried out on using admixtures in bituminous mixtures and in modifying the bitumen. Research have shown that by adding polymer to asphalt binders can enhance the interfacial cohesive bond between the aggregate and binder which in turn can enhance different characteristics/properties of the asphalt pavements to meet this increased demand. Also the admixture which has to be used in modifying the mix should satisfy both the strength requirements as well as economic aspects.

Keywords : Bituminous Mix, Asphalt, Concrete Pavements, Aggregate, Design Strength

I. INTRODUCTION

The evolution and advancement in transportation facilities have been closely linked with the development of human being throughout the history. Transportation contributes to economic, industrial, social & cultural progress of a country. Transportation is vital for the economic development of any part since every commodity produced, even if it is agricultural or industrial product needs to be transported at different stages starting production to distribution. At the production stage, transportation is required for carrying raw materials like seeds, manure, coal, steel, machines, component parts, etc. Inadequate transportation facilities retard the process of socio-economic and cultural development of the country. Development of adequate transportation system in a country indicates its economic growth and progress in social development.

In the present day concept, the main objective of good transportation system is to provide safe, efficient, economical transportation facilities for the travel of passengers & transportation of goods.

In the current era of economic development with such a enormous population, it is necessary having a dense circuit of road for the smooth transportation of goods & passengers. India, despite having one of the largest railway network moves mostly on roads.

Everybody from passenger or goods all move on roads. Nearly 65% of freight and 85% of passenger traffic use roads for moving. Today India is having 3.34 million km of road network out of which 65579 km is the network of national highways.

TABLE 1
LENGTH OF ROADS IN INDIA

Category of road	Length in Km
Total road network	3.34 million
National Highways	65,569
State Highways	1,30,000
Major Dist. Road, Rural road & Urban road	3.14 million

The transport infrastructure sector in India is likely to grow at 6.1% in 2017 and increase in growth in Compounded Annual Growth Rate (CAGR) of 5.9% through the year 2021, thereby it is to become the fastest-expanding component of the country's infrastructure portion.

The construction of highways reached 8,142 km during FY 2016-17, with an all-time high average pace of 22.3 km per day. For first two months of FY 2017-18, 1,627 km of highway was constructed at an average of 26.3 km per day.
Under the Pradhan Mantri Gram Sadak Yojana (PMGSY), 133-km roads per day in 2016-17 were constructed as against a 2011-14 average of 73-km per day.

The Union Minister of State for Road, Transport and Shipping has stated that the Government aims to boost corporate investment in roads and shipping sector, along with introducing business-friendly strategies that will balance profitability with effective project execution.

Some of the key investments and developments in the Indian roads sector are as follows:

- The National Highways and Infrastructure Development Corporation (NHIDCL) has been awarded a contract to build five all-weather access tunnels worth Rs 23,000 crore (US$ 3.57 billion) in Jammu and Kashmir by 2024.
- Abertis Infraestructuras SA, a Spanish infrastructure firm, has agreed to buy two toll road assets in operation in South India from Macquarie Group for Rs 1,000 crore(US$ 150 million) to scale up its presence in India.
- In the Union Budget 2017-18, the Government of India has allotted Rs 64,000 crore (US$ 9.55 billion) to NHAI for roads and highways and Rs 27,000 crore (US$ 4.03 billion) for PMGSY.

Some recent developments are as follows

- The Cabinet Committee of India of Economic Affairs, Government, has approved the development of 19 kms long four laning from Pandoh Bypass end to Takoli section of National Highway (NH) -21 in Himachal Pradesh, which is estimated to cost Rs 2,775.93 crore (US$ 430.27 million).
- The Road Transport & Highways Ministry has invested around Rs 3.17 trillion (US$ 47.55 billion), while the Shipping Ministry has invested around Rs 80,000 crore (US$ 12.0 billion) in the past two and a half years for building world class highways and shipping infrastructure in the country.

The government, through a series of initiatives, is working on policies to attract significant investor interest. The Indian government plans to develop a total of 66,117 km of roads under different

programmes such as National Highways Development Project (NHDP), Special Accelerated Road Development Programme in North East (SARDP-NE) and Left Wing Extremism (LWE). The government has identified development of 2,000 km of coastal roads to improve the connectivity between ports and remote villages.

The National Highways Authority of India (NHAI) plans to build 50,000 km of roads worth US$ 250 billion by 2022 as part of a long-term goal of doubling the length of the national highway network to 200,000 km.

A. Suitability of Industrial Wastes as Highway Material

Limited information is available on suitability of individual industrial wastes for its utilization in highway construction. The following table summarizes the advantages and disadvantages of using specific industrial wastes in highway construction

TABLE 2
SUITABILITY OF USING INDUSTRIAL WASTE PRODUCTS IN HIGHWAY CONSTRUCTION

Material	Advantages	Disadvantages
Fly Ash	Light weight, Use as binder in stabilized base/ sub-base because of pozzolonic properties	Lack of homogeneity, Presence of sulphates, slow strength development
Metallic Slag (a) Steel Slag	Higher skid resistance	Unsuitable for concrete works
(b) Nonferrous Slag	Light weight (phosphorus slag	May show Inconsistent properties
Construction And Demolition Waste	Being strong can be used as aggregates granular base	May show Inconsistent properties
Blast Furnace Slag	Used in production of cement, granular fill	Ground water pollution due to Leachate in used as unbound aggregates
Colliery Spoil	-	Combustion of unburnt coal, Sulphate attack in case of concrete roads
Spent Oil Shale	-	Burning of combustible materials
Foundry Sands	Substitute for fine aggregate in asphalt mixes	Presence of heavy metals in nonferrous foundry origin, less affinity to bitumen
Mill Tailings	Some are pozzolonic in nature	Presence of poisonous materials (e.g., cyanide from gold extraction)
Cement Kiln Dust	Can be used in soil stabilization because of its hardening property when exposed to moisture	Corrosion of metals (used in concrete roads) in contact because of significant alkali percentage
Used Engine Oil	Being very good	Requires well

	air entertainer could be used in concrete works	organized oil collection system
Waste Tyres	Enhances fatigue life	Requires special techniques for fine grinding and mixing with bitumen, sometimes segregation occurs

B. What is Plastic Road?

A material that contains one or more natural polymers of substantial atomic weight, strong in its completed state and at some state while assembling or preparing into completed articles, can formed by its stream is called 'Plastic'. Plastics are strong and debase gradually, the concoction bonds that make plastic so sturdy make it similarly impervious to characteristic procedures of corruption. Plastics can be partitioned into two noteworthy classes, bottles and thermoplastics. A canteen sets or "sets" irreversibly when warmed. They are watchful for their solidness and quality, and are in this way utilized principally as a part of vehicles and development application. These plastics are polyethylene, polypropylene, polyamide, polyoxymethylene, polytetrafluoroethylene, and polythyeneterephthalate. A thermoplastic relaxes when presented to warmth and comes back to unique condition at room temperature. Thermoplastics can without much of a stretch be formed and shaped into items, for example, milk containers, floor covers, charge cards, and cover strands. These plastic sorts are known as phenolic, melamine, unsaturated polyester, epoxy gum, silicon, and polyurethane.

C. Plastic Waste – As a Road Construction Material

Owing to its properties, Plastic can be a good road construction material. The properties of the plastic which makes it a good road construction material are:

- **Castability:** Plastics generally have a low melting point & can be casted in any desired shape. This makes it a good recyclable material. In India alone approximately 8000 tones per day plastic wastes are recycled. The waste plastic can be melted & used for the making layers of pavement.

- **Water Repellent:** Plastic is a good water repellent. Plastic is a waterproof material. Therefore, the road made by plastic cannot be degraded due to water.

- **Excellent Binding Capacity:** Plastic is an excellent binder. It can be used to bind the aggregates together with excellent efficiency (better than the bitumen).

II. PROBLEM STATEMENT

The debate on using and abuse of plastics vis-à-vis environmental protection can go on, without yielding results until practical steps are initiated at the grassroots level by everybody who has a position to do something for it. The plastic wastes can efficiently be used in road construction and the field tests withstood the stress and proved that plastic wastes used after proper processing as an additive would enhance the life of the roads and also solve environmental problems. The present statement highlights the developments in using plastics waste to construct plastic roads. Fast rate of urbanization and development has led to increasing plastic waste generation. As plastic is non-biodegradable in nature, it remains in environment for several years and disposing plastic wastes at landfill are unsafe since toxic chemicals leach out into the soil, and under-ground water and pollute the water bodies. Due to littering habits, inadequate waste management system / infrastructure, plastic waste disposal continue to be a

major problem for the civic authorities, especially in the urban areas. As stated above, plastic disposal is one of the major problems for developing countries like India, at a same time India needs a large network of roads for its smooth economic and social development. Scarcity of bitumen needs a deep thinking to ensure fast road construction.

A. Objectives

Basic intention is to efficiently utilize the waste plastic in constructive way so that it can be beneficial to society however main objectives of current project work are:

- The purpose of this project is to utilize this waste plastic as useful binding material, save the bitumen concrete road.
- To coat the aggregates with the waste plastic materials.
- To check the properties of bituminous mix specimen with coating of waste plastic materials and compare the properties of bituminous mix specimen with the properties of coated aggregates.
- To find a suitable alternative over conventional materials with cost reduction and improvement in strength and other parameters in flexible pavements.

III. LITERATURE REVIEW

Waste plastics both by domestic and industrial sectors can be used in the production of asphalt mix. Waste plastics, mainly used for packing purpose are made up of Polyethylene Polypropylene polystyrene. Their softening fluctuates between 110 °C – 140 °C and they do not produce any toxic gases during heating but the softened plastics have tendency to form a film like structure over the aggregate, when it is sprayed over the hot aggregate at 160 °C. The Plastics Coated Aggregates (PCA) is a better raw material for the construction of flexible pavement. PCA was then mixed with hot bitumen of different types and the mixes were used for road construction. PCA - Bitumen mix showed improved binding property and less wetting property. The sample showed higher Marshall Stability value in the range of 18-20KN and the load bearing capacity of the road is increased by 100%. The roads laid since 2002 using PCA-Bitumen mixes are performing well. A detailed study on the performances of these roads shows that the constructed with PCA –Bitumen mix are performing well. This process is eco-friendly and economical too.

Use of plastic along with the bitumen in construction of roads not only increases its life and smoothness but also makes it economically sound and environment friendly. Plastic waste is used as modifier of bitumen to improve some of bitumen properties Roads that are constructed using plastic waste are known as Plastic Roads and are found to perform better compared to those constructed with conventional bitumen. Further it has been found that such roads were not subjected to stripping when come in contact with water. The use of higher percentage of plastic waste reduces the need of bitumen by 10%. It also increases the strength and performance of the road. Plastic increases the melting point of bitumen and hence mixing can be done in more better and easier way. Plastic waste replaces 10% to 15% of bitumen, and thereby saves approximately Rs. 35000 to Rs. 45000 per kilometre of a road stretch. Inclusion of plastic waste in road construction eliminates the plastic shrinkage cracking of road surface and reduces the drying shrinkage to some extent.

III. METHODS AND MATERIALS

There are two processes for the laying of Plastic Tar Road & they are:

Wet Process: Wet process is basically the polymer enriched/modified bitumen (PMB) process. In this process 3-4% molten plastic is mixed with the molten bitumen with the aim of increasing the binding

capacity of the bitumen. 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.

Dry Process: This process is basically poly coated aggregate (PCA) process. In this process aggregate is heated to a temperature of 170 degree centigrade & the dry shredded plastic is then added to it which melts & gets coated over the aggregate thus transforming the aggregate into poly coated aggregate. Then this PCA is mixed with bitumen & this road mix is used for road laying at 110^0 degree centigrade.

A. Pavement Materials

Aggregates:- Aggregate is a collective term for the mineral materials such as sand, gravel, and crushed stone that are used with a binding medium (such as water, bitumen, Portland cement, lime, etc.) to form compound materials (such as bituminous concrete and Portland cement concrete). By volume, aggregate generally accounts for 92 to 96 percent of Bituminous concrete and about 70 to 80 percent of Portland cement concrete. Aggregate is also used for base and sub-base courses for both flexible and rigid pavements. Aggregates can either be natural or manufactured. Natural aggregates are generally extracted from larger rock formations through an open excavation (quarry). Extracted rock is typically reduced to usable sizes by mechanical crushing. Manufactured aggregate is often a bye product of other manufacturing industries.

Bitumen: Bituminous materials or asphalts are extensively used for roadway construction, primarily because of their excellent binding characteristics and water proofing properties and relatively low cost. Bituminous materials consists of bitumen which is a black or dark colored solid or viscous substances consists high molecular weight hydrocarbons derived from distillation of petroleum or natural asphalt, has adhesive properties, and is soluble in carbon disulphide. Tars are residues from the destructive distillation of organic substances such as coal, wood, or petroleum and are temperature sensitive than bitumen. Bitumen will be dissolved in petroleum oils where unlike tar.

- **Cutback Bitumen:** A suitable solvent is mixed to reduce viscosity.
- **Bitumen Emulsion:** Bitumen is suspended in finely divided condition in aqueous medium 60% bitumen and 40% water.
- **Bituminous Primers:** Mixing of penetration bitumen with petroleum distillate.
- **Modified Bitumen:** Blend of bitumen with waste plastics & or crumb rubber.

Various Grades of Bitumen Used For Pavement Purpose

- Grade: 30/40
- Grade: 60/70

% of plastics	Specific Gravity	Impact Value (%)	Crushing Value (%)	Abrasion Value (%)	Stripping Value (%)
0	2.42	8	18.35	12.4	9
10	2.9	6.35	12.32	11.23	Nil
12	2.75	5.25	10.26	10.65	Nil

- Grade: 80/100

TABLE 3
TEST RESULTS OF AGGREGATES

Properties	Observations	MORTH Specifications
Specific Gravity	2.42	2.5-3.0
Flakiness Index	16.21%	MAX 30%

		(Combined)
Elongation Index	13.6%	MAX 30% (Combined)
Combined Index	29.81%	MAX 30% (Combined)
Impact Value	8%	MAX 24%
Crushing Value	18.35%	
Abrasion Value	12.4%	MAX 27%

TABLE 4
TEST RESULTS OF BITUMEN

Properties	Values (Bitumen VG10 Grade)
Penetration test at 25 °C, 1/10th of mm, min	71 mm
Softening Point, °C min	43
Ductility at 25 °C, cm min	78
Flash Point °C, min	270
Fire Point °C, min	290

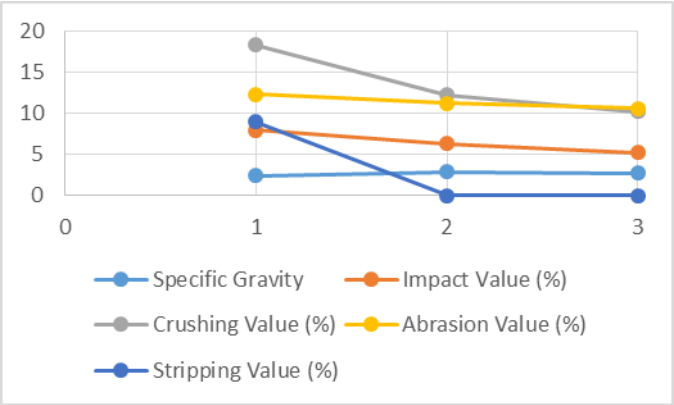

TABLE 5
TEST RESULTS OF AGGREGATES WITH/WITHOUT PLASTIC COATING

Fig. 1 Graph Showing Comparison Of Conventional And Coated Aggregates

IV. CONCLUSION

We can conclude that, using plastic waste in mix will help reduction in need of bitumen by around 10%, increase the strength and performance of road, avoid use of anti-stripping agent, avoid disposal of plastic waste by incineration and land filling and ultimately develop a technology, which is eco-friendly.

Increased traffic conditions will and are reducing the life span of roads. Plastic roads are means of prevention and ultimately will be the cure. It will save millions of dollars in future and reduce the amount of resources used for construction.

REFERENCES

[1]. Huda Shafiq, Anzar Hamid, "Plastic Roads: A Recent Advancement in Waste Management", ISSN: 2278 -0181, IJERTV5IS090574 Vol. 5 Issue 09, September-2016

[2]. Yash Menaria, Rupal Sankhla, "Use of Waste Plastic in Flexible Pavements-Green Roads", Open Journal of Civil Engineering, 2015

[3]. Aditya Rauti, Prof. Sagar W. Dhengare, Prof. Ajay L. Dandge, Prof. Harshal R. Nikhade, "Utilization of Waste Plastic Materials in Road Construction:, Journal of The International Association of Advanced Technology and Science Vol 2 Issue 3, March 2016

[4]. Axay Shah, Amit Macwan, Farhan Vahora, Nirmal Patel, Nisarg Gajjar, "Utilization Of Waste Materials In Pavement Construction", IRJET Volume: 02 Issue: 03 e-ISSN: 2395 -0056 p-ISSN: 2395-0072, June-2015

[5]. Punyaslok Rath, Stuti Mondal, "Optimization of Waste Materials for the Sub Base Layer of Flexible Pavement", IJETAE ISSN 2250-2459, ISO 9001:2008 Certified Journal, Volume 4, Issue 12, December 2014

[6]. Sravanth B Sambaturu, Surendra Y.L, "Usage Of Waste Materials In Pavement Construction With Replacement Of Conventional Materials Construction", IJCIET Volume 8, Issue 4, pp.

1305–1312, ISSN Print: 0976-6308, ISSN Online: 0976-6316, April 2017

[7]. Savita Devi, Rupesh Kumar, Shad Ahmad, Jitendra Kumar Dhawan, Premchand Yadav, "Partial Replacement of Bitumen by using Plastic Waste in Bitumen Concrete", SSRG-IJCE Volume 3 Issue 7, July 2016

[8]. Prakash Somani, Vikash Maharaniya, Banwarilal Kumawat, Rahul Dev Rangera, "Strengthen of Flexible Pavement by using Waste Plastic and Rubber", SSRG-IJCE Volume 3 Issue 5, May 2016

[9]. Miss Apurva J Chavan, "Use Of Plastic Waste In Flexible Pavements", IJAIEM Volume 2, Issue 4, ISSN 2319 – 4847, April 2013