IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

TESTING ON WASTE PLASTIC-COATED HOT MIXED BITUMINOUS CONCRETE WITH TITANIUM DIOXIDE

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ABSTRACT: With increasing pollution all over the world, the protection of the environment is a major concern or need of ours. For the protection of the environment, various innovations and experiments have been conducted around the world. Among the various innovations, treatments of titanium dioxide on the waste plastic-coated hot mixed bituminous concrete are one of them. Titanium dioxide is one of the important compounds that have different advantages. One of the advantages of titanium dioxide is that it helps to remove smog from the air when it comes to exposure to ultraviolet light. To clean the air by removing smog, nitrogen oxide should be converted into a less harmful substance, i.e., the nitrate ion. Then the nitrate ion creates nitric acid, which then reacts with grout to form a harmless neutral salt. The whole process is very slow, naturally. The presence of titanium oxide speeds up the reaction. Titanium oxide acts as a catalyst when added to the substance during the reaction. It acts as a photo catalyst, which means it will increase the speed of reaction when light is also present.

Waste plastic coated in a bituminous mix enhances the properties and strength of the bitumen. It also provides a solution to handle and dispose of plastic waste, which is a major issue nowadays. The waste plastic is added to hot bitumen with titanium oxide, which helps in pavement construction. This not only increases the strength of the pavement but also increases Waste plastic-coated hot bituminous concrete with titanium dioxide acts as a sustainable material in the construction industry

Keywords: Hot mixed bitumen concrete, photo catalyst, Titanium dioxide, Waste Plastic Materials

INTRODUCTION

In the world, around 275 million metric tons of plastic waste are generated every year. In India, 26,000 tones of waste plastic are generated every year. This large amount of plastic waste is generated from the development of different industrial sectors. It is non-biodegradable solid waste. This is one of the major problems, as it is affecting the environment in harmful ways. Plastic is nowadays being used in the construction industry for the construction of pavement, roads, parks, and runways. This is the best solution to add bitumen to increase efficiency and effectiveness. Plastic provides good binding properties between stone and bitumen. Plastic provides additional binding properties when it is used with bitumen and aggregate. It stops water penetration in bitumen pavements so that potholes do not form on the pavement surface. Due to this property of plastic, the life of roads increases. The waste plastic items that can be used in road construction work include plastic carry bags, plastic cups, and plastic packaging for potato chips, chocolates, and biscuits.

Many developing countries are considering applications of plastic waste in road construction. Plastic waste has become a highly sought-after use in many areas of construction. The use of waste plastic materials to build roads is feasible in a technical, economical, and environmental manner.

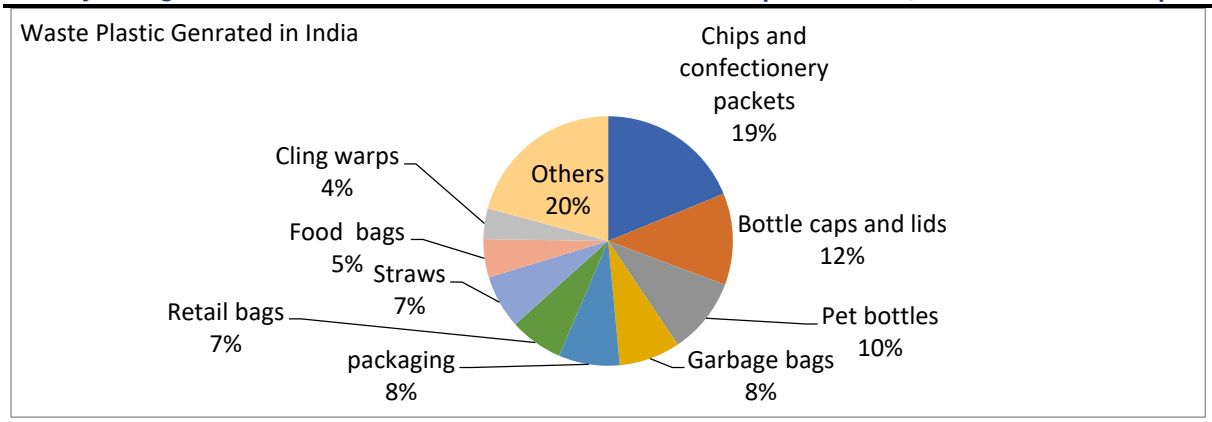


Chart: 1 Waste Plastic Generated in India.

Chart 1 shows that in different fields in India, how much waste plastic is generated every year. Different innovations and research have been done on the use of non-biodegradable materials, i.e., waste plastic. Plastic can be used as a mixer with hot bituminous concrete for the construction of pavement and roads. It will help reduce plastic waste across the world. With the different studies and literature, it was found that there are various advantages to mixing plastic with bituminous concrete. Some of them are:-

1. It also makes the material cheaper and more affordable.
2. It helps to increase the durability of the pavement or any construction infrastructure.
3. It improves the abrasion and slip resistance of the pavement.

In India, different state roads and national highways are constructed by using waste plastic

Sr.no.1	waste plastic + bitumen road build in India	KM	Year
1	MP Indoor	35	2014
2	Seurat Gujarat	32.56	2016
3	Karnataka	440	2022
4	Maharatra Pune	1.5	2016
5	Haryana Gurugram	10	2019
6	National highway	703	2024

Table 1: India Build waste plastic roads with bitumen concrete.

Table 1 shows that there are different Indian state roads and national highways that build bitumen by using plastic waste in India.

Problems face the plastic waste-coated bitumen road.

The use of titanium dioxide (TiO2) in the form of fine particles as a coating for concrete pavement has produced pollutants such as nitrogen oxides (NO) and carbon dioxide (CO2). These particles can trap organic and inorganic air pollutants by photo catalytic processes.

In nature, a large amount of nitrogen oxide is present in the air, which is harmful to the environment and can react with oxygen to create ozone in the layer, which is dangerous. Nitrogen oxide should be converted into a less harmful substance, i.e., the nitrate ion. Then the nitrate ion creates nitric acid, which then reacts with grout to form a harmless process, harmful nitrogen oxide is converted to harmless neutral salt ions. neutral salt. It is a multi-step process. In this process, harmful nitrogen oxide is converted to oxide, neutral salt ions. This can happen with presence of the presence titanium oxide but it will take a lot of time. Due to thincrease.um oxide presence, the efficiency and effectiveness of the reaction increase

Apart from this, when waste plastic-coated hot bituminous concrete is mixed with titanium oxide, it increases the advantages of the material. Adding titanium oxide to the bituminous concrete increases its strength and resistance. It also helps to absorb smoke caused by the vehicle as it acts as a photocatalyst during the process of converting nitric acid into harmless neutral salt. Some of the literature reviews have been added to prove the thesis.

The main objectives of this research paper are:

Study the test on waste plastic-coated hot-mix bituminous concrete with titanium oxide.

2. LITERATURE REVIEW

Sufficient research on PMA mixtures as well as the use of virgin polymers has been conducted to improve asphalt properties over a wide temperature range in the past two decades. However, when recycled polymers are added to asphalt, pavement performance is significantly improved as compared to virgin polymers. Use of polymers in bitumen to improve pavement properties like durability, stability, and compressive strength and decrease penetration and potholes.

According to S. G. Dhundalwar, using waste plastic as a modifier in bitumen construction would effectively protect the environment from additional contaminants and help the ecosystem. Increases in population, urbanisation, construction activities, and changes in lifestyles result in widespread littering on the landscape. As a result, the disposal of waste plastic has become an unauthentic and serious problem today. Due to its incompatibility with nature and lack of biodegradability, Since waste plastic cannot be disposed of scientifically and causes pollution in the groundwater, waste plastic has slightly replaced conventional binders for a specific road mix material. (S.G.et.al 2022).

According to P. Singh (2018), the minimization of waste material is an important factor for growth and development in modern times. The plastic used in domestic and industrial applications is very common. In the present review, we summarise the research on the use of waste plastic. As plastic does not biodegrade, it poses a major disposal problem. It can also be used for road construction and other construction-related activities (Singh et al., 2018).

Sandra Wiegel and Gupta's 2020 different samples of bitumen are tested with photocatalyst titanium oxide, and there is no negative effect of titanium oxide on the bitumen. It has been found that there are changes in the physical and chemical properties that depend upon the types of bitumen and amount of titanium oxide (Gupta et al. 2020).

Bhatt and R. Vasudevan (2017) Plastic is long-lasting and non-biodegradable. Plastic gets mixed with water, does not disintegrate, and takes the form of small pallets that kill fish and other aquatic animals. Since plastic has become a part of our everyday lives, the problem of disposing of plastic waste is increasing. They are either mixed with municipal solid waste or thrown into an empty land area when they are not sent to be recycled. In that case, its disposal may be done by either land filling or burning. Environmental impacts are significant for both processes. Under these circumstances, an alternate use for plastic waste is needed because if it is incinerated or dumped, it will pollute the air and soil (Bhatt and Gupta 2017).

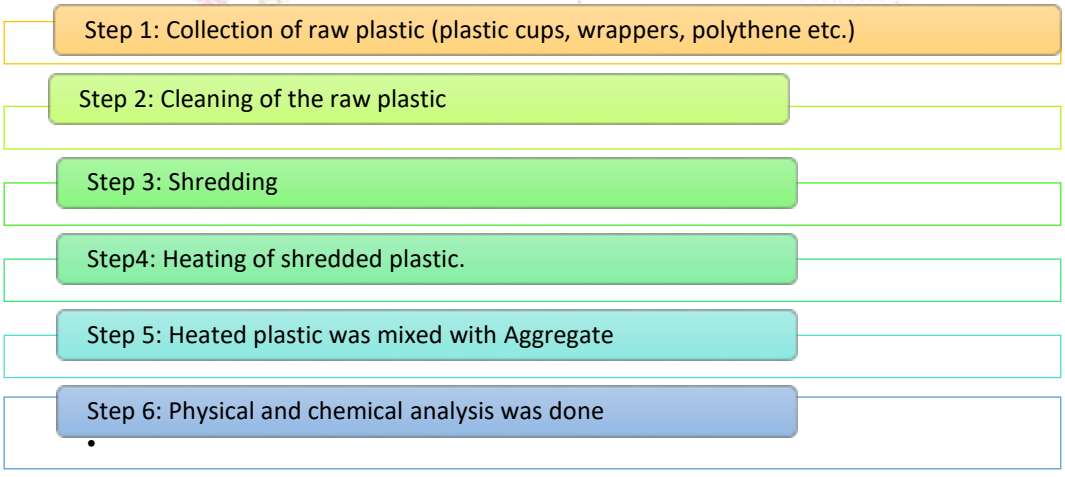
M. Chavan, 2019 It can be concluded that plastic waste can be conveniently used as a modifier for bituminous concrete because it reduces porosity and moisture absorption and improves the mixture's binding properties by coating over the aggregates (Chavan et al. 2019).

A.N. Ali (2018) Bituminous concrete is a material that is used for the construction of pavement. Bituminous concrete works as a composite material that is used to construct several things like roads, parking lots, airport runways, etc. With the increasing traffic and temperature, some of the alternatives need to look out for constructions that will have higher strength, durability, and economy (Ali et al. 2018).

R. Jayaram, 2017 The disposal of plastic is a major concern nowadays as it is a non-biodegradable material. Right now, bitumen is used as pavement material because of its binding properties, but in our research, we use plastic as a binding material, and it is also found from experiments that plastic is a better binding material as it results in high strength and resistance. Jayaram et al. (2017).

The literature studies show that the use of various kinds of waste plastic materials in road construction enhances the mechanical properties of bitumen pavement.

3. RESEARCH AND METHODOLOGY



3.1 Collection of raw plastic. First of all, we need a collection of raw plastic-like cups, wrappers, and polythene. Raw data was collected from different fields such as municipal waste stores, shops, railway stations, bus stands, etc.

Fig.1Waste Plastic.

3.1 **Cleaning of the Raw Plastic:** After the collection of row waste plastic, we have to clean the row plastic to get better results. Collected plastic has so many impurities. Waste plastic impurities are removed by air pressure.

3.2. Analysis of shredded plastic

The process of adding plastic to bitumen or asphalt is to break or cut the plastic into several small pieces. Then heat is provided for conversion and then added to bitumen for a better result.

3.3. **Heating of shredded plastic and heated plastic was mixed with aggregate.**

This process is very simple. Waste plastic is cut into small pieces, and heat is provided to the coarse aggregate in a hot mix plant at 170 °C. Shredded plastic is put into heated aggregate.

The shredded plastic and coarse aggregate are mixed in a hot mix plant for 2 minutes at a temperature of 170 °C.

Fig.2 Hot Mixed Bitumen Plant

After mixing shredded plastic and aggregate, bitumen is mixed in the hot, mixed plant. In this process, bitumen uses less than 10 percent as compared to the to the traditional method because shredded plastic coats the aggregate. Most of the voids on the aggregate surface are filled with shredded plastic. The heated, plastic-coated bitumen aggregate is completely mixed with titanium dioxide.

Plastic waste uses 10 percent bitumen content and 1 percent titanium dioxide total weight of bitumen. Titanium dioxide is thoroughly mixed. It is ready to lay on the road after mixing the aggregate, titanium dioxide, shredded plastic, and bitumen.

3.4. Physical and chemical analysis

Sr. no	Property	value
1	Density	0.92gm/cc
2	Surface hardness	SD48
3	Tensile Strength	10MPa
4	Flexural modulus	0.25GPa
5	Max. operating temperature	50^0c
6	Water Absorption	0.01%
7	Melting Temperature	220^0c-260^0c

Table: 2 Physical properties of Waste plastic.

Table 2 shows the physical properties of waste plastic. Before mixing with aggregate, we check the physical properties of plastic.

3.5 Analysis of Bitumen: Bitumen is an important product that is generated by mineral crude oil. It is used for the production of asphalt concrete. Its main application is waterproofing roofing material and pavement design, as it is the best binding material. Typical bitumen structures are referred to as bee structures.

3.6 Chemical analysis of titanium oxide

To understand why titanium oxide has such a strong effect on nitric acid, we need to understand the chemical properties of the material. There are two types of mineral structures of titanium oxide present in nature, i.e., retile and anatine. They are highly significant because they have a high refractive index. It means light travels slowly through this material. The refractive index of anatine is 2.5 to 3, whereas that of retile is 3.8, which is higher. This makes it a photo catalyst, which means it can make chemical reactions at high speed in the presence of light. It oxidises and reduces the material in the reaction to speed up the process.

In nature, a large amount of nitrogen oxide is present in the air, which is harmful to the environment and can react with oxygen to create ozone in the layer, which is dangerous. Nitrogen oxide should be converted into a less harmful substance, i.e., the nitrate ion. Then the nitrate ion creates nitric acid, which then reacts with grout to form a harmless neutral salt. It is a multi-step process. In this process, harmful nitrogen oxide is converted to harmless neutral salt ions. This can happen without the presence of titanium oxide, but it will take a lot of time. Due to the presence of titanium oxide, the efficiency and effectiveness of the reaction increase (Hassan et al. 2010).

4. Results and Discussion

4.1. Crushing strength test:-The aggregate crushing test can measure the aggregate crushing strength of coarse aggregate. A total fracture value represents how resistant a structure is to fracture when applied to progressively increasing compression stresses. An aggregate with high resistance to crushing or an aggregate with a low crushing index is preferable to a high-quality paving aggregate. Test results comparing waste plastic-coated aggregate and normal bitumen aggregate are shown below.

Sr.no	Aggregate Types	Load apply	Test result crushing value in %	According to IS: 2386-IV Crushing value for the surface course in %	According to IS: 2386-IV Crushing value for the base course in % Should not be greater than
1	Normal bitumen aggregate	4KN/min	20	30	45
2	The plastic Coated bitumen aggregate	4KN/min	16	30	45

Table: 3 Aggregate Crushing Values Test Results.

Table: 3 Test result shows that's crushing value reduces from 20 to 16 normal aggregate and plastic-coated aggregate respectively. The value is reduced by 25percentage because the shredded plastic coating is applied on aggregate so that hardness is increased.

4.2. **Abrasion Test**

Abrasion test results show the hardness of aggregate. Pavement stones should be sufficiently hard Due to traffic movements on roads. The top layer of the road surface is exposed to abrasion stress. Therefore, the paving stones must be enough hard. According to IS: 2386-IV Abrasion value for the surface course and base coarse is given in the table below: -

Sr.no	Aggregate Types	The charge applies (Steel ball)	Lab test Abrasion value in %	According to IS: 2386-IV Abrasion value for surface course in%	According to IS: 2386-IV The abrasion value for the base course is %

1	Normal bitumen aggregate	11 450gm weight	balls22	30		50
2	The plastic-coated aggregate		14.22	30		50

Table: 4 Los Angeles Abrasion Test Value Results.

Table 4. Los Angeles abrasion test value reduces from 22 to 14.22, which means that when we coat to aggregate with the waste plastic, Abrasion value decreases and strength increases. Abrasion tests are performed to determine the hardness of the concrete or aggregates for the construction of the pavement. The abrasion value of plastic-coated aggregate or concrete is found to be less than that of normal concrete. It was found that the abrasion value of plastic-coated concrete is 37 percent less than that of normal concrete, which means that plastic concrete, is harder than normal concrete.

4.3 Marshal stability test (MST)

Preparing the sample requires 1200 g of coarse aggregate, filler, and bitumen. 1 percent fly ash is used as the filler material. Heating of the aggregate from 175 °C to 190 °C is required. Bitumen is heated at a temperature of 121°C to 125°C. Bitumen content is taken as a percentage by weight of aggregate with the first trial percentage and then increased up to the stability value.

The heated, plastic-coated bitumen aggregate is completely mixed with titanium dioxide. Plastic waste uses 10 percent bitumen content and 1 percent titanium dioxide in the total weight of bitumen. Then titanium dioxide is mixed properly. The mixture is placed, moulded, and compacted with the 4.5 kg hammer with 75 blows specified. The sample is then extracted from the mould after 24 hours. Then the specimen is immersed in 60-degree-C water for 30 minutes. Then it is placed in a marshal stability machine, and a load is applied.

Sr.no	Bitumen Content (%)	Weight of mix(gm)	Stability of Normal bitumen concrete (KN)	Stability Plastic Coated bitumen (KN)	% Air Voids	Height In (cm)
1	5	1255.5	5	9.0	3.6	6.35
2	5.5	1253.4	7.0	11.1	3.5	6.38
3	6	1257.3	7.4	12.	3.4	6.32
4	6.5	1268.2	6.2	10.	3.2	6.40

Table: 5 The Marshall Stability test result.

Table 5 Shows that The Marshall Stability test result get maximum at 6 % of bitumen content. When we add 6.5% marshal stability value decreases.

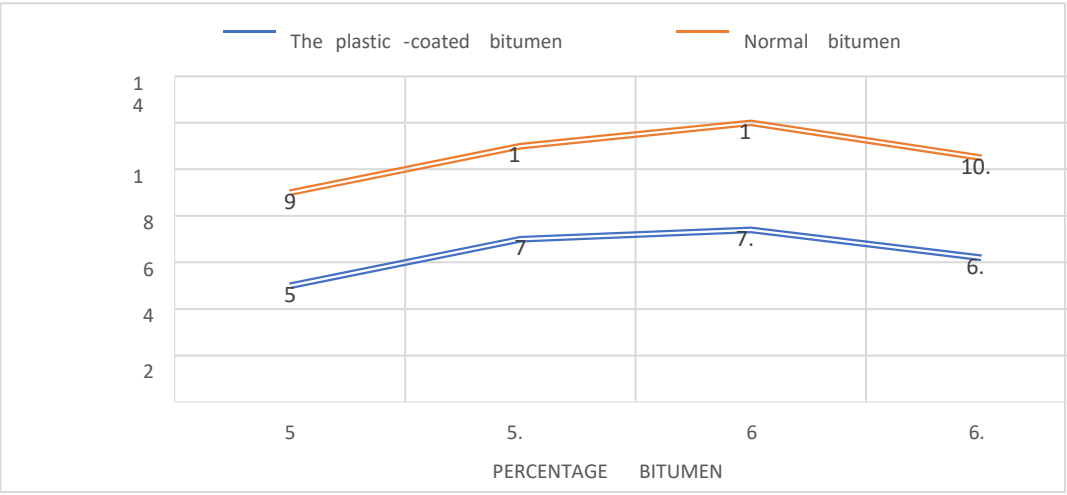


Fig.3The Marshall Stability test result.

Fig. 3 shows that up to 6 percent of bitumen content, the marshal stability value increases but when we add more than 6 percent bitumen, the marshal stability value decreases because after 6 percent bitumen behaves like a lubricant.

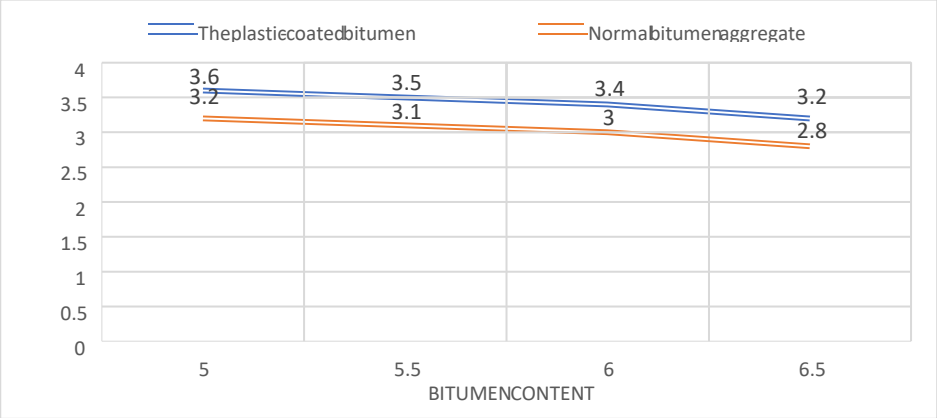


Fig.4 Percentage air void v/s percentage bitumen content.

Fig.4 shows that the percentage of air void value decreases continuously because when the percentage of bitumen content increases the aggregate and voids are filled with shredded plastic and bitumen. Aggregate is also coated with plastic so that it requires less bitumen to get mixed properly.

3.4 Penetration test of plastic mixed bitumen

A penetration test is used to determine the hardness of the bitumen. In the penetration test of the bitumen, a standard needle is penetrated in the bitumen under a load of 100 gm for 5 sec at 25 degree Celsius. It defines the softness of the bitumen.

	Penetration value(mm) Plain Bitumen	Penetration value(mm)Modified Bitumen(10% Plastic Replaced)
1	79	67
2	63	49

Table 6 Penetration Test

Table 6 Shows that the penetration value of plain bitumen decreases after mixing plastic in plain bitumen. Penetration value of bitumen decreases 79 to 67 and 63 to 49.

5. CONCLUSION

From the whole study of the titanium dioxide with the waste plastic hot bitumen concrete, it was found that there is no negative impact of the titanium dioxide over the bitumen concrete. Rather, it provides more strength, durability, and resistance in the material, which can be used for better construction of pavement, roads, runways, etc. Waste plastic hot-bitumen concrete with titanium dioxide is a better solution for the construction industry. It not only reduces and helps in the disposal of plastic waste but also will help to reduce or absorb the smoke caused by the vehicle on the road due to its titanium dioxide properties. It is one of the best alternatives to normal bitumen. It is also cost-efficient. This is the future of many countries. In India, the first waste plastic hot bitumen concrete material road is already made up in Ahmadabad, Gujarat. The use of waste plastic in bituminous concrete with titanium dioxide is safe and sustainable. It will help to reduce plastic waste as well as absorb vehicle smoke with the help of titanium oxide.

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