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Use Of Plastic Waste In Rigid And Flexible Pavements

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Abstract
The waste plastic and its disposal is a major threat to the environment, which results in pollution and global warming. The utilization of plastic waste in bituminous mixes enhances its properties and also its strength. In addition it will also be a solution to plastic disposal & various defects in pavement viz., pot holes, corrugation, ruts, etc. Plastic was found to be an effective binder for flexible and rigid pavements. This efficient method helps the pavements to resist higher temperature by minimizing the formation of cracks and reducing rainwater infiltration which otherwise leads to the development of potholes. These pavements have shown improved crushing and abrasion values and reduced water seepage. Plastic roads would be a boon for India's hot and extremely humid climate, where temperatures frequently cross 50°C and torrential rains create havoc, leaving most of the roads with big potholes In conventional road making process bitumen is used as binder.
In the present study an experimental investigation was conducted for rigid and flexible pavements with different percentages of plastic waste to reduce the bitumen content by the addition of Waste plastic in bituminous mix. The laboratory investigations on the bituminous mix and concrete mix have been carried out as per the Indian Standards used for the road construction. The field application is out of the scope of work. To analyze and study how the waste plastic will be effectively utilized in construction of pavement as a binder material for replacing the content of bitumen and cement. This paper deals with study on the various laboratory test performed on aggregates, bitumen and methodology of using plastic waste in bituminous mixes
Keywords: Plastic waste, Bitumen, Plastic roads, Flexible pavement, Bitumen mix.

1. Introduction

Plastic is the most widely used material in the present times. It is light in weight, moisture resistant, flexible and very inexpensive. These qualities increase our propensity towards plastic and hence making its use very common. Today plastic is used in every vital sector of the economy, ranging from agriculture to automobile, electronics, construction, etc. It has revolutionized all spheres of life. But this plastic ultimately becomes a waste. It is a common site both in urban and rural areas to see plastic wastes littering the roads. It forms the major portion of the total municipal solid wastes (MSW). Tons of plastic wastes which include polyethenes, cups, bags, etc. are discarded every year, polluting land, rivers, seas, oceans, etc. plastic is a non-biodegradable material and it has been found that it can remain on earth for about 4500 years without showing any signs of degradation. Its improper disposal can cause serious health hazards in humans. Based on the present usage scenario of plastics, its complete ban will not be justified; hence we have to find the alternatives to reuse the plastics.
Nowadays the availability of the waste plastics is huge, as the plastic materials is component of daily life. It gets mixed with Municipal Waste or thrown over land area. It is disposed either by land filling or by incineration. Both the methods are not Eco friendly. If a prohibition is put on the use of plastics on emotional grounds, the actual cost would be much higher, the chances of damage or pollution may be much greater .Hence the debate is about how best plastic waste can be used and recycled.

1.1 Need of the study

The study reports the use of waste plastic, mainly plastic bottles or polyethylene in the production of bitumen by blending waste plastic show reduction of permanent deformation like rutting and cracking of the pavement top layer. The field tests show resistance to the stress and prove that use of plastic as additive will improve the life of the roads and helps in finding the solution for environmental problems. Use of synthetic material (plastic) in design of pavements is not new. Aggregates which are used in design some will be water affectionate, but plastic bitumen is water repulsive in nature.

Hence use of water repulsive materials like plastic bitumen (polymers) by wet or dry mixing methods to bituminous mix can give better solution for reduction of rutting and cracking and improvement fatigue time and strength in pavement

1. Plastic mainly consists of small quantity of physical weight more durability than regular bitumen.
2. Improved Marshall Stability value give better strength of road.
3. Enhanced resistance towards percolation of rain water in pavement and no water storage on pavement leads reduction in stripping and potholes.
4. Increase better bonding of the mix thus reduces voids in aggregate and a reduced amount of rutting.
5. The load sustainable quality of pavement helps to fulfill today's need of increased road transport.

2. Pavement design

A highway pavement is a structure consisting of superimposed layers of processed materials above the natural soil sub-grade, whose primary function is to distribute the applied vehicle loads to the sub-grade. The pavement structure should be able to provide a surface of acceptable riding quality, adequate skid resistance, favorable light reflecting characteristics, and low noise pollution. The ultimate aim is to ensure that the transmitted stresses due to wheel load are sufficiently reduced, so that they will not exceed bearing capacity of the sub-grade. Two types of pavements are generally recognized as serving this purpose, namely flexible pavements and rigid pavements. This chapter gives an overview of pavement types, layers, and their functions, and pavement failures. Improper design of pavements leads to early failure of pavements affecting the riding quality.

2.1 Types of pavements

The pavements can be classified based on the structural performance into two, flexible pavements and rigid pavements.

2.1.1 Rigid pavement

The rigid characteristic of the pavement are associated with rigidity or flexural strength or slab action so the load is distributed over a wide area of sub grade soil. Rigid pavement is laid in slabs with steel reinforcement.

2.1.2 Flexible pavement

Flexible pavements are those pavements which reflect the deformation of sub grade and the subsequent layers to the surface. Flexible, usually asphalt, is laid with no reinforcement or with a specialized fabric reinforcement that permits limited flow or repositioning of the roadbed underground changes.

2.2 Geo synthetics

Geo synthetics are synthetic products used to stabilize terrain. They are generally polymeric products used to solve civil engineering problems. This includes eight main product categories: geo textiles, geo grids, geo nets, geo membranes, geo synthetic clay liners, geo foam, geo cells and geo composites. The polymeric nature of the products makes them suitable for use in the ground where high levels of durability are required. They can also be used in exposed applications. Geo synthetics are available in a wide range of forms and materials

Various geo synthetics

3. Materials Used

3.1 Bitumen

Bitumen is a sticky, black and highly viscous liquid or semi-solid, in some natural deposits. It is also the residue or by-product of fractional distillation of crude petroleum. Bitumen composed primarily of highly condensed polycyclic aromatic hydrocarbons, containing 95% carbon and hydrogen (± 87% carbon and ± 8% hydrogen), up to 5% sulfur, 1% nitrogen, 1% oxygen and 2000 ppm metals. Also bitumen is Mixture of about 300 - 2000 chemical components, with an average of around 500 - 700. It is the heaviest fraction of crude oil, the one with highest boiling point (525°C).

Bitumen Sample

3.2 Waste Plastic

Plastic such as polypropylene (PP), low density polyethylene (LDPE), and high density polyethylene (HDPE) with paving grade asphalt. They conducted rheological tests for the unmodified and modified asphalt binders. Better performance was observed for asphalt concrete as indicated by Marshall Stability test and loss of stability test. They concluded that waste plastic can be effectively utilized as binder material with excellent results.

Making plastic sample

3.3 Coarse aggregates

Those particles that are predominantly retained on the 4.75 mm (No. 4) sieve and will pass through 3-inch screen are called coarse aggregate. Using aggregates larger than the maximum size of coarse aggregates permitted can result in interlock and form arches or obstructions within a concrete form. That allows the area below to become a void, or at best, to become filled with finer particles of sand and cement only and results in a weakened area.

3.4 Fine aggregates

Fine aggregates are essentially sands won from the land or the marine condition. Fine aggregates by and large comprise of common sand or smashed stone with most particles going through a 4.75mm sifter.

3.5 Cement

In this examination Ordinary Portland concrete of 53 review (ACC bond) has been obtained and has been utilized.

3.6 Geo textiles

Geo textile is a synthetic permeable textile material used to improve the soil characteristics. It has the ability to separate, filter, reinforce, protect and drain when used in association with soils.

Geo textile

4. Experimental process

4.1 Mixing of Bitumen and waste plastic

Collected Plastic was cut into fine pieces as far as possible. The plastic pieces were sieved through 4.75mm sieve and retaining at 2.36mm sieve was collected. Firstly, Bitumen was heated up to the temperature about 160°c-170°c which is its melting temp. Pieces were added slowly to the hot bitumen of temperature around 160-170°c.The mixture was stirred manually for about 20-30 minutes. In that time period temperature was kept constant about 160-170°c. Polymer-bitumen mixtures of different compositions were prepared and used for carrying out tests i.e. Penetration test, Ductility test.

4.2 Tests to be conducted

Plastic waste in Flexible pavements (Bitumen Mix)

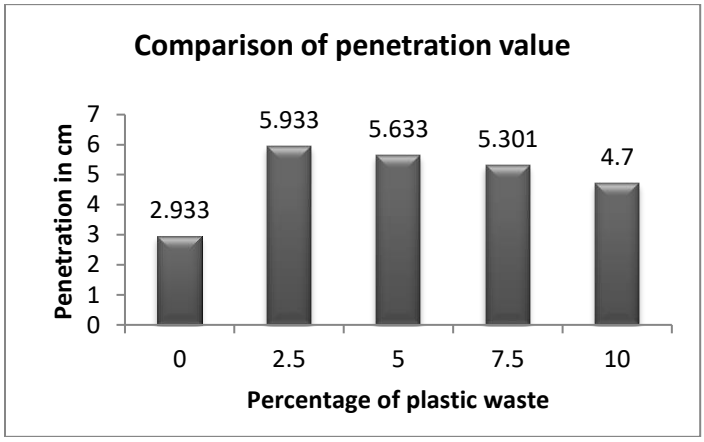
1. Softening point test
2. Penetration Index Test
3. Ductility Index Test
4. Flash and fire point test

Plastic waste in Rigid pavements (Concrete Mix)

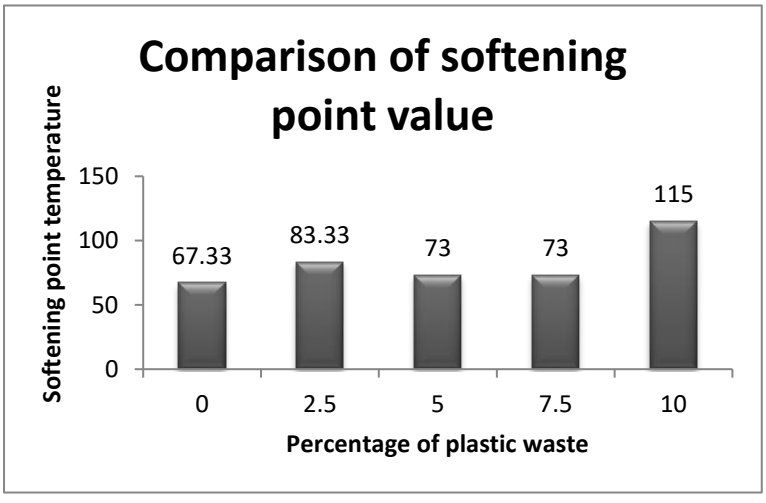
1. Aggregates impact test
2. Aggregates crushing test
3. Abrasion test
4. Compressive strength

Experimental Results

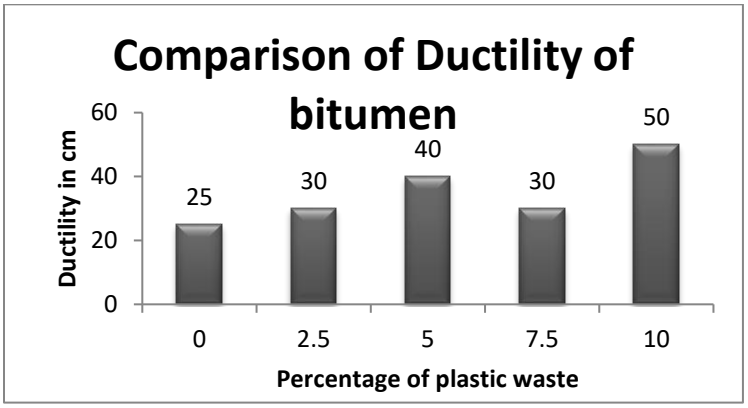
Comparison of penetration value test



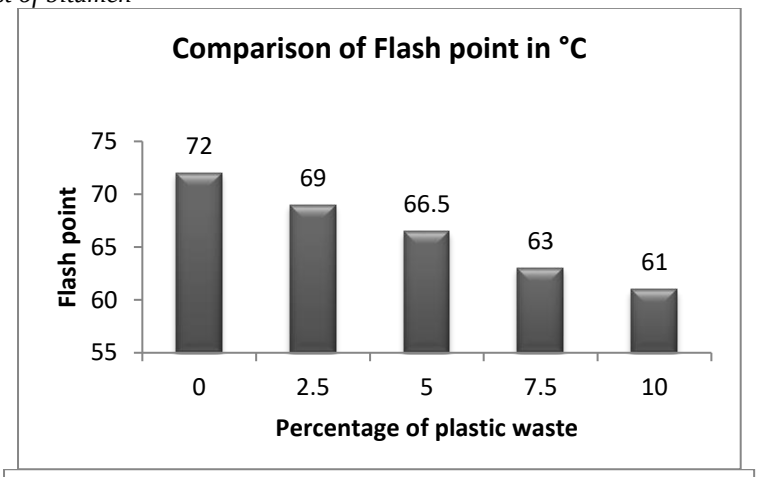
Softening point test

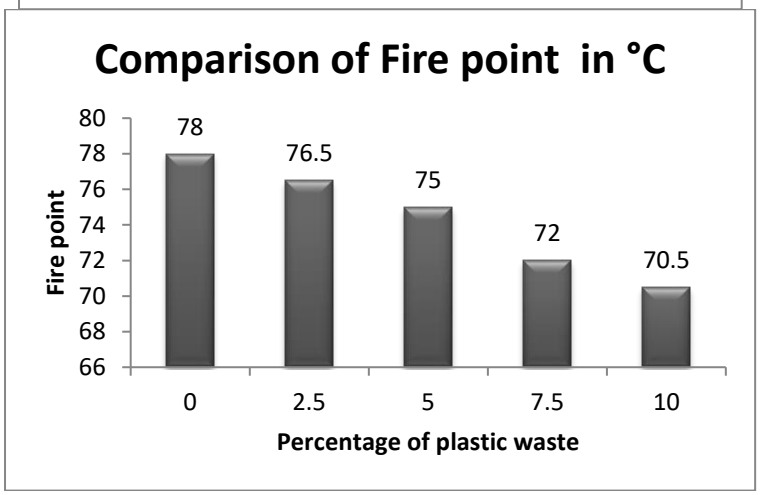


Ductility test results



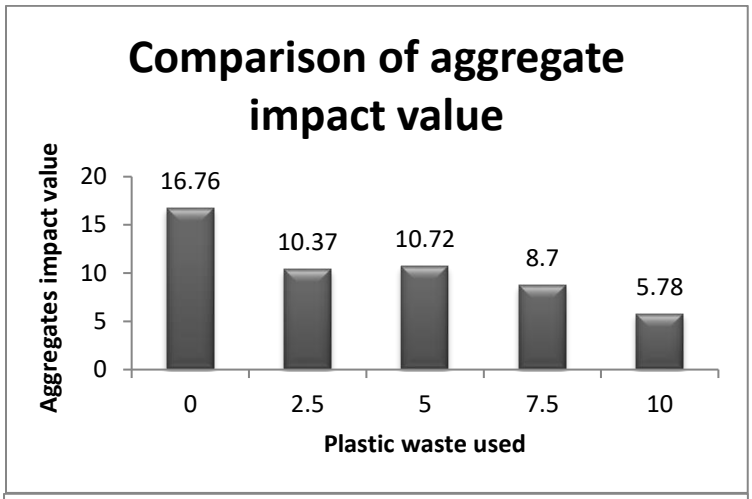
Flash and fire point test of bitumen

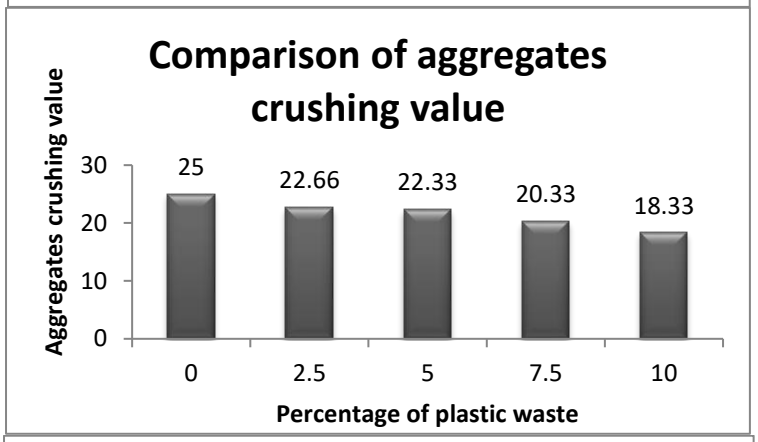


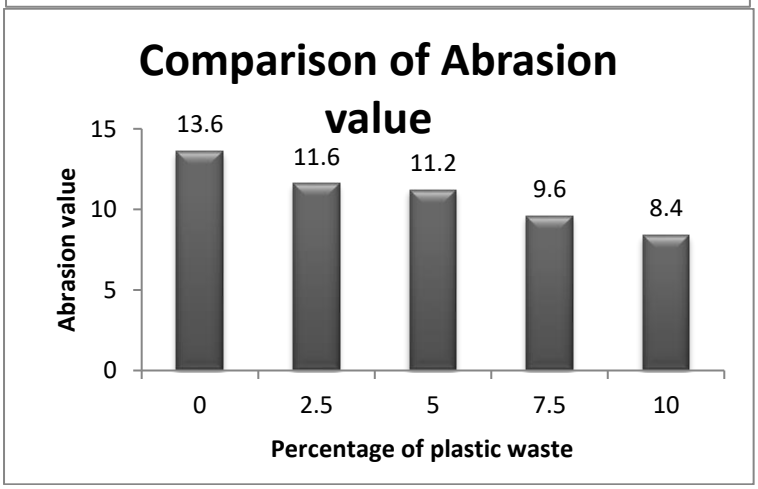


Plastic waste in Rigid pavements (Concrete Mix)

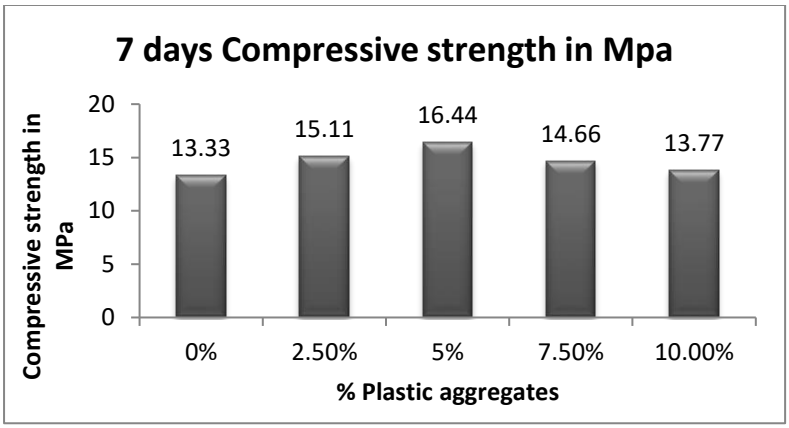
Aggregates impact test



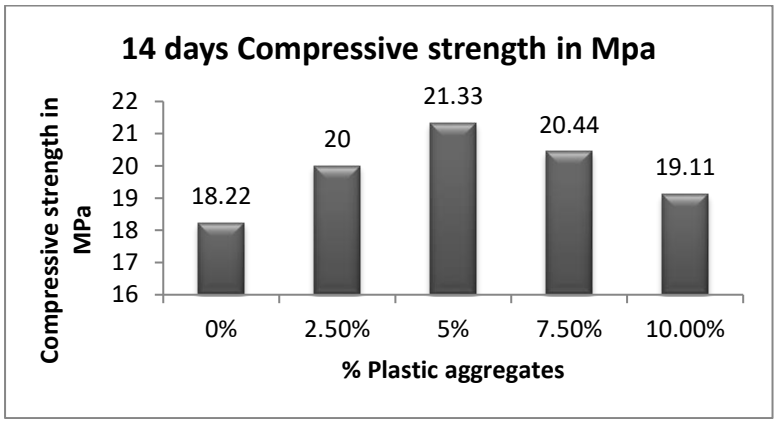




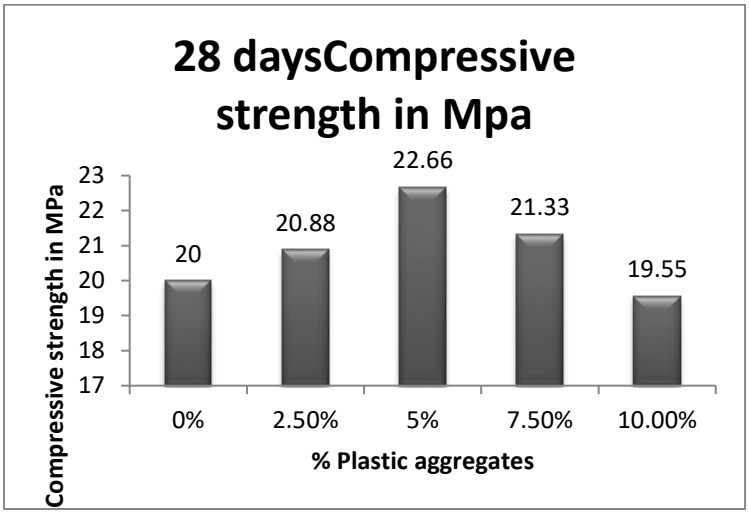
Compressive strength
7 days strength



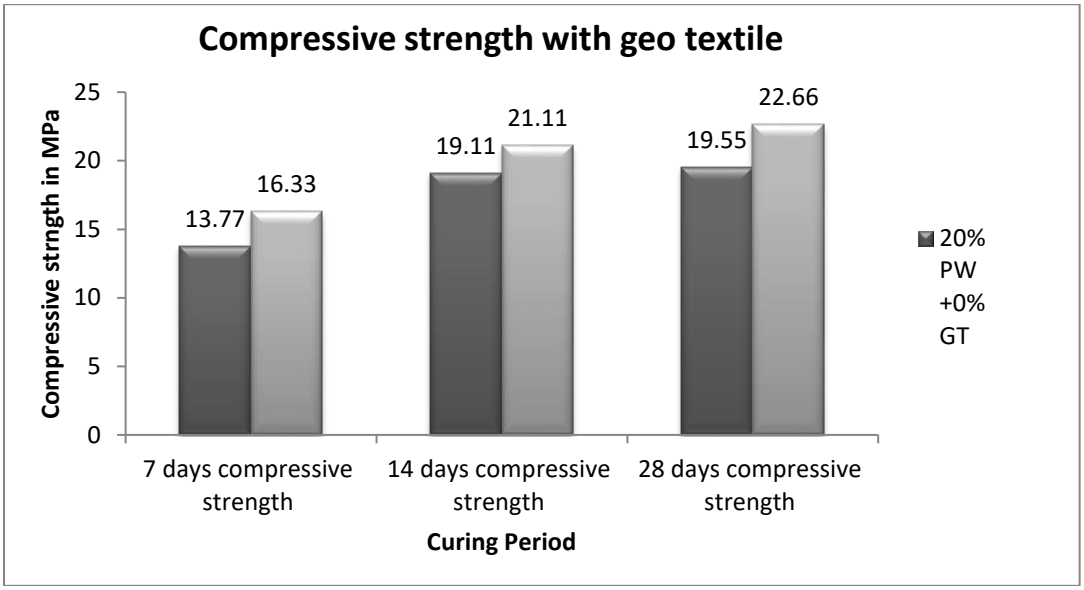
14 days strength



28 days strength



Compressive strength of concrete by using geo 5% synthetics



4. Conclusions

From this study the following conclusions were made

1. Construction of highway involves huge outlay of investment. A precise engineering design may save considerable investment as well a reliable performance of the in-service highway can be achieved.
2. A good design of bituminous mix is expected to result in a mix which is adequately strong, durable, resistive to fatigue, permanent deformation, and environment friendly, economical and so on.
3. The maximum value of penetration was observed at 2.5% plastic waste and minimum value of penetration was observed at 0% plastic waste. So the 2.5% plastic waste has more strength than remaining cases.
4. The maximum value of softening point was observed at 10% and 0% plastic waste and minimum value of softening point was observed at 0% plastic waste. So from this point it was concluded that by using plastic waste temperature effect on the bitumen reduces for the Flexible pavements.
5. At 0% plastic waste and minimum value of ductility was observed at 10% plastic waste maximum value of ductility was obtained.
6. The value of aggregates impact test in percentage decreases with increasing the percentage of waste plastic from 0% to 10%
7. The value of aggregates crushing test in percentage decreases with increasing the percentage of waste plastic from 0% to 10%
8. The value of abrasion test in percentage decreases with increasing the percentage of waste plastic from 0% to 10%.
9. The compressive strength for the flexible pavements maximum for 7 days, 14 days and 28 days curing is obtained at 5% plastic waste materials. By sing geo textile we can achieve maximum strength for the M20 grade concrete mix.

REFERENCES

[1]. Miss Apurva J Chavan1" Use Of Plastic Waste In Flexible Pavements" IJAIEM Volume 2, Issue 4, April 2013 ISSN 2319 - 4847 Lecturer At Pravatibai Genba Moze College of Engineering, Pune. J.

[2]. Yash Menaria1, Rupal Sankhla2 "Use of Waste Plastic in Flexible Pavements-Green Roads" Open Journal of Civil Engineering, 2015, 5, 299-311 Published Online September 2015 in SciRes 1Poornima Institute of Engineering and Technology, Jaipur, India 2Centre for Environmental Planning & Technology, Ahmedabad, India

[3]. Shirish N. Nemade and Prashant V. Thorat, "Utilization of Polymer Waste for Modification of Bitumen in Road Construction", Scientific Reviews And Chemical Communications, Volume 2, Issue 3, 2013, 198-213

[4]. Vikas R Agrawal1, Saurav Anand Agrawal2, Nikhil Kale3 "Performance Evaluation of Plastic Modified Bitumen In Flexible Pavement"department of Civil Engineering, Priyadarshini College Of Engineering/Rtmnu, India.

[5]. Johnson Kwabena Appiah, Victor Nana Berko-Boateng, Trinity Ama Tagbor, et al.,(2016) "USE OF WASTE PLASTIC MATERIALS FOR ROAD CONSTRUCTION IN GHANA", Case Studies in Construction Materials 6 (2017) PP1-7.
[6]. Amit Gawande, G. Zamare, V.C. Rengea, Saurabh Tayde, G. Bharsakale, "AN OVERVIEW ON WASTE PLASTIC UTILIZATION IN ASPHALTING OF ROADS" Journal of Engineering Research and StudiesEISSN0976-7916Vol. III/ Issue II/AprilJune,2012/01-05:
[7]. Imran M. Khan, Shahid Kabir, Majed A. Alhussain, Feras F. Almansoor "ASPHALT DESIGN USING RECYCLED PLASTIC AND CRUMBRUBBER WASTE FOR SUSTAINABLE PAVEMENT CONSTRUCTION", Procedia Engineering 145(2016):
[8]. Utibe J. Nkanga, Johnson A. Joseph,Feyisayo V. Adams, Obioma U. Uche "CHARACTERIZATION OF BITUMEN/PLASTIC BLENDS FOR FLEXIBLE PAVEMENT APPLICATION",Procedia Manufacturing 7(2017)PP 490-496
[9]. Shivraj Sarojero Patil, "EXPERIMENTAL STUDY ON BITUMEN WITH SYNTHETIC FIBER", Journal of Information, Knowledge and Research in Civil Engineering, ISSN: 0975 – 6744| Nov 14 to Oct 15 | Volume 3, Issue 2 pp213216.