EXPERIMENTAL INVESTIGATION OF BITUMEN WITH PARTIAL REPLACEMENT OF POLYMER

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Abstract: Bitumen is a Petroleum by-product and also non-hazardous at room temperature Known for its viscoelastic, rheological and, Non-magnetic material which highly consists Of hydro-carbon with low dielectric constant and also a component of asphalt binders that Combines gravel, sand and mineral powder thus the usage of any alternative binder can lead to Cause reduction in carbon-di-oxide emission and one such thing is by using polymer as a partial Replacement on bitumen for effective usage on roads because of the incapable recycling of the Polymer which can be effectively used as a replacement material. The most commonly used tests in this experiment are ductility test, penetration test, softening point test, viscosity test, crushing test, abrasion test, impact test, specific gravity test, Marshall's stability test, water absorption test and los angles test

***Keywords*: Hydrocarbon, Polymer, partial replacement, Alternative binder .**

1. Introduction

Polymer waste is used to improve the properties And environmental stability by using a alternative material instead of bitumen By usage of the polymer, a partial substituent For bitumen will improve the stability condition Of the road and also helps us to reduce and Protect the natural environment from the Hazardous polymers. Where these polymers are Hard to get recycled but most of them are Non- recyclable and cause a heavy reaction on Poly-Ethylene, HDPE & LDPE Polymers for the effective replacement of bitumen in a small quantity. We are making these plasticwaste (solid) into a wet form of material thus the reaction pf them with bitumen is the comparatively higher than the dry mixing type and the non-convertible plastics are converted into finer materials by grinding them. Thus, the addition of these waste plastic to bitumen leads to a comparative increase in bitumen. The built-up quality was asphalt flexible pavements. The chemical solvents that have been used such As Xylene & Acetone which shows aggressive Reaction on the waste plastic material. These Chemical solvents are used because while heating these plastic polymers release a toxic Gases like dioxins and Hydrochloric acids and Many other greenhouse gases. Thus, the addition of the polymer is calculated percentage shows an increase in the properties of pavement The, tests were conducted on both bitumen and aggregate (Marshall Stability, a penetration test, Ductility test, Viscosity test, impact test, Specific gravity test, Crushing & abrasion test) environment and can be used as low carbon-di-oxide emitting material by thus partial replacement. Where polymer places a vital role i amount of availability makes it n the durability of the construction and also with its huge amount of availability makes it wider usage of such polymers as a substituent for the bitumen as a partial replacing factors. Polymer used are PVC, Poly-propylene etc.., Cementitious material where its stiffness depends on the temperature. Bureau of Indian Standard (BIS) in 1950 introduced paving grade bitumen of specification and classified it on the penetration and revised in 1962 & in 1992 and also the specifications were classified based on the viscosity in 2006 July to improve the quality of the Bitumen being used. As per this regulation, there were Mainly four types of bitumen available they are VG-10, VG-20, VG-30 and VG-40. For now, almost 90 percent of the roads in the world are being, constructed with bitumen.

Mixture of bitumen in each layer of flexible pavement varies like For, B.M (Bituminous Macadam) the quantity should be 3.5 percent and for D.B.M (Dense Bituminous Macadam) the quantity should be 5 Percent & for B.C (Bituminous Concrete) quantity should be 5 percent. Where these Quantities are arrived from I.R.C & M.O.R.T.H.

2. Material Used

Bitumen:

Bitumen is thermo-plastic, amorphous, formed from a mass of fragments or the Particles are loosely compacted together. These are the solid form of materials Which are being widely used in the laying of the flexible pavements. Where they give the compressive strength to the pavement. These Aggregates are also been Classified into different types, based on Their size like 13.2mm aggregate, 11.2mm Aggregate, 6.7mm aggregate, and also chip Consist of Quarry Dust to fill the minute Pores on the top surface of the pavement.

ISSN (Print): 2204-0595
ISSN (Online): 2203-1731

Plastic Waste

Polymers are the main ingredient of plastics Thus they are synthetic or semi-synthetic Materials where the plasticity behaviour of The, polymer makes it possible in making of Plastics to mold or extrude them to form Solid materials or objects into different shapes by using polymerization or poly-condensation process.

There are different types of polymers or Plastics like Poly-Ethylene Terephthalate (PET), Poly-Propylene (PP), High-Density Poly- Ethylene (HDPE), Low-Density Poly-Ethylene (LDPE), Poly Styrene (PS), Poly Vinyl Chloride (PVC), etc.,

Aggregate:

The aggregate is the naturally occurring material that can be defined as a material or structure Grade 1 to Grade 5 concerning for their Polymer Density. Thus, the Poly-Ethylene Terephthalate (PET) has grade 1 High-Density Poly-Ethylene (HDPE) has grade 2 and so on.

The type of plastic we have used are plastic waste materials that are reacted with the chemical solvents and the leftout plastic which does not react with solvents are being ground into a small like particles thus for the effective mixing of these plastics with the bitumen and Give effective results. Some of the real time examples of these plastic wastes are plastic bags, polyvinyl chloride material & wire cables.

3. BLENDING

The plastics materials which are collected consist of Poly-Ethylene Terephthalate (PET), Poly-Propylene (PP), High Density Poly-Ethylene (HDPE), Poly-Styrene (PS) and other similar types of polymers.

These polymers are being blended with the help of chemical solvents like Xylene & Acetone and some other plastic materials are made in the form, of small-sized chips by hand or machine.

4. Literature Review

Marshall stability test:

1.D. Movilla-quesada et al(2019)

This experiment deals with use of plastic scrap in asphalt mixture added by dry method as partial replacement. In the recent decade, the usage of plastic is been more when compared with the olden days. Where plastic scrap has a lower viscosity when compared to the binder, which results in aggregate particles to be separated from each other also helps to increase the air voids content in the mixture. Marshall test, samples were then conditioned at 60degree Celsius for45 min according to the standard. Afterwards, the test samples were tested in the Marshall press, at a displacement rate of 50.8 mm/min, until reaching the maximum load.

Thus, the dry addition of polymer to the binding material (bitumen) replaces the partial amount.10% reduction of binder & 10-20% increase in addition of coarse & fine polymers. Where they consist of reduced moisture damage, greater indirect tensile strength, higher air void content, with a 2% decrease in tensile strength ratio.

Shows high resistance to building to rutting by 1 or 2 tons of plastic scrap with 5cm thick pavement for a two-lane road.

3.Moatasim Attaelmanan et al(2011)

This experiment deals with evaluation of HMA with high density polyethylene as modifier. This, paper investigates the use of high-density polyethylene as a modifier in asphalt pavement. The result shows HDPE content of 5% by weight of asphalt is recommended for the improvement of performance. Penetration is good at medium and high temperatures. Specimens were placed in water bath at 60 _C for 30 min and then loaded at a ratio of 50.8 mm/min and the stability and flow values were recorded. While the addition of 5% HDPE results in increase of Marshall Stability of control mix by 13%, whereas decreases in flow value was observed.

Softening point increases with the addition of HDPE content to increase resistance for deformation. % loss of air & heat decreases by using asphalt. Marshall's result gives 5% HDPE rise MQ mix control by 55% & has better resistance on deformation due to high stability.

5.U. Arun Kumar et al(2015)

This experiment deals with case study of polyethylene and SBS polymer modified bitumen's effect. Increasing road traffic coupled with an inadequate degree of maintenance. Research on Polymer Modified Bitumen as the addition of Polyethylene, PVC, etc.., Penetration & softening point value of SBS Polymer Modified Bitumen increasing. For 4% of B.C has 6% of P.E with 14.01 KN and 2.20 flow in mm and has 25.25 KN/m3.

The ductility value & Marshall Stability Value of SBS modified bitumen is higher than that of Poly Ethylene bitumen. Marshall flow value & improvement in a unit weight of SBS modified bitumen is higher than that of Poly Ethylene Modified Bitumen increase cohesion property.

7.B. Surya et al(2018)

This experiment explains on partial replacement of bitumen by using waste bio-medical and plastic bags. Where he has used Marshall method of analysis to find stability-flow test and strength by maximum load carried by specimen at 60 degree Celsius. where the specimen breaks at 50.8mm/min

Thus, the temperature 60 degree Celsius represents as a weakest condition for the bituminous pavement. Whereas the most optimum and preferable use of plastic can be 15%, 20%, 25% and 30% of bitumen based on the Marshall stability test. 2.Rabindar K Padhan et al(2017)

This experiment deals with evaluation of waste PET derived polyurethane polymer modified bitumen. Polymer Modified Bitumen (PMB) pavement has evolved for the past decade & in the 20th century. But usage of BHETA-PU product which is

ISSN (Print): 2204-0595
ISSN (Online): 2203-1731

produced in the laboratory by modification. The Marshall stability of the bituminous pavement specimen is defined as the maximum load bearing capacity of the compacted cylindrical specimen at a standard test temperature and load. Average of 5% dosage 12.45/2.49. Average of 5.5% dosage 13.67/2.48

Average of 6% dosage 14.07/3 obtained values from Marshall test

Gives greater results than the nominal bitumen, PMB and SBC based PMB. The Reaction of MDI with BHETA leads to a homogeneous mixture of polyurethane polymer.

This opens up a new chapter on recycling of waste PET in bitumen & for disposal of waste PET polymer.

4.Sinan Hinislioglu et al(2003)

This experiment gives details on use of waste high density polyethylene as bitumen modifier in asphalt concrete mix. Thus, the high-density polyethylene is been used as a polymer additive. HDPE shows an increase in Marshall Stability, Flow & Quotient. when hot minimum asphalt is mixed on HDPE with 4-6% & 8% by weight. Marshall Quotient (MQ) is an indicator of the

resistance against the deformation of the asphalt concrete, MQ values are calculated to evaluate the resistance of the deformation of the HDPE-modified specimens. Void ratio (%) 3.32 (control mixture), 3.07 (4% HDPE), 3 – 5 (limits).

MQ which is being increased to 50% compared to the control mix and providing a waste

HDPE modified bituminous binder providing better resistance. To deformation high stability & high Marshall's quotient to plastic waste & protect the environment. A Higher MQ value indicates a high stiffness mix with a greater ability to spread the load.

6.A.Rangaraj et al(2019)

This experiment deals with investigation on partial replacement of bitumen with rubber tyre. Where the bitumen is the most widely used component for laying of flexible pavements, by replacing it with rubber tyre gives a Marshall result of 672 for standard bitumen whereas the value increases to 686 for 5% bitumen with rubber and it goes till 741 when 20% of bitumen with rubber.

The static creep test reveals that deformation occurs and value decreases by addition of 15% partially replaced with rubber. And the moisture stability value also increases on addition of rubber material on bitumen and reduces the drain down effect though the values are not that significant.

8.Shubham Bansal et al(2017)

This experiment deals with evaluation of modified bituminous concrete mix which is being developed by rubber and plastic waste. To investigate this experiment, he has used Marshall stability and flow test which is been done on both modified and non-modified mixes to find their stability and BM9, BM6, and BM3 were used which proves that BM modified mix has better result that non-modified mix on comparison.

Marshall's flow value for non-modified mix is 3.8mm whereas the flow value for the modified BM9 is about 3.9 similarly for other modified mixes also lies within (2-4mm) limit.

Penetration, Softening Point, Ductility test:

1.Marta Vila Cortavitarte et al(2019)

In this experiment the recycled plastic is used as a partial substituent for concrete. Thus, the penetration, softening point and ductility test have been conducted from which the penetrating value at 25 degree Celsius of 100 g for 5 second is 57 (50/70 bitumen) and 45-80 (modified bitumen 45/80) and the softening point value is 51.6 (50/70 bitumen) and 65 (modified bitumen 45/80). More than 34 million kilometres around the globe is constructed by normal asphalt bitumen road. Among which 92% of European road network is asphalt with minerals aggregate and bitumen.

But the use of bitumen is 5% whereas the cost of bitumen is 60% of material cost.

Hence it is refined of crude oil containing hydrocarbon. The PET tends to give high efficiency.

Thus, the polymer was added to bitumen as they are cheap but give high durability.

3.M.Naskar et al(2010)

This experiment deals with waste plastic as a modifier on thermal stability of the bitumen and the penetration test was carried out at 25 degree Celsius and bitumen was placed in water bath and loaded with 100g resulting in tenth of mm. similarly the ductility test was also carried out to find the cohesive strength of bitumen at 27 degree Celsius. Where the sample is elongated upto 5cm/minute. Modified Bitumen binders are used in Pavement construction for improving durability.

Where they have 5% plastic was found to have the highest thermal stability.

The rheological parameter of a modified binder prepared with plastic suggests 5% plastic weight is expected to yield optimal performance.

Bitumen decomposes early than modified bitumen because of the volatile content in the bitumen.

At low weight %, WP content interaction between bitumen & WP is significantly high because of better swelling of the polymer.

5.Chunfa Quyang et al(2005)

This experiment deals with, Low-Density Poly-Ethylene modified asphalt with high-temperature storage stability. Where the softening point and viscosity test are done.

With 1% of silica content the softening point is about 47.5, similarly for 2% of silica content the softening point value is 48 and viscosity value at 135 degree Celsius when 1% of silica content is added gives 0.30(pas) similarly when 2% of silica content is added the viscosity rate is about 0.31(pas).

LDPE ratio in the compound has a greater effect on high-temperature storage stability.

ISSN (Print): 2204-0595
ISSN (Online): 2203-1731

Modified asphalt is stable when the ratio of LDPE is around 100/60

Silica content in modified asphalt is less than 3.2% has a slight influence on the mechanical property of modified asphalt.

High-temperature storage property was obtained by decreasing the density in asphalt.

7.B. Singh et al(2012)

This experiment deals with the polymer-modified bitumen of recycled LDPE and bitumen. Thus, the softening point test is been taken for base bitumen LDPE which has the value 49. And has 60 for maleated bitumen-LDPE bitumen blend. Similarly, penetration value is also taken which results in 72 for base bitumen LDPE blend and 58 for maleated bitumen-LDPE blend. Bitumen is prepared by penetration grade bitumen (80/100) with maleic anhydride at 150 degrees Celsius for 2 hours.

LDPE blends in terms of softening point & elastic recovery of blend increased after maleation of base bitumen.

The difference in the softening point of recoverable bitumen blend was 5 degrees Celsius when compared to 60 degrees Celsius.

The Phase angle was also reduced to 7.4 at 70 degrees Celsius compared with the base bitumen blend.

The roofing bitumen is also made by melted bitumen containing about 9 weight % recycled LDPE content.

2.Anjana Ramesh et al(2019)

This experiment deals with partial replacement of bitumen with lignin material. Where lignin is a bio-based material and a naturally available source and so the tests are being conducted with 25 degree Celsius of 100g for 5 seconds and the result shows that the penetration value is 58 for normal bitumen and 59 when 5% of lignin is added, and 60 when 10% of lignin is added, till it goes upto 15 when 25% of lignin is added to bitumen and the softening point value are noted 50 for ordinary bitumen, 44 when 5% of lignin added and goes till 70 when 25% of lignin is added. Then ductility test is done where 58 for standard bitumen and reaches 15 on addition of 25% of lignin. Bitumen is produced from fossil sources & asphalt market with high in term of Carbon dioxide emission.

Bitumen is partly alternated with lignin which is the most abundant naturally occurring polymer.

As a replacement of bitumen with lignin increases, penetration value first increases up to 60mm. then suddenly decreases.

Replacement of bitumen with lignin first increases softening point then gradually decreases & reach minimum 15-degree Celsius,

% of replacement of bitumen with lignin increases the ductility value decreases.

4.Giovanni Polacco et al(2005)

In this experiment the polymer modification is done by different polyethylene-based polymer. Where the penetration value is about 69.4 and by analysing the viscosity rate for PMA6 shows the relationship between shear rate and density where they tend to increase. Some poly-ethylene & poly Ethylene-based co-polymers were used to modify 70/100 penetration grade asphalt.

Among them, the linear low-density polymer allowed the preparation of mix which was strongly enhanced.

Mix with different % was analysed and studied for rheological point of view for both small & large deformation.

It contains different % of this modifier in the range of small & large deformation.

The rheological analysis suggested a possible formation to a small extent of cross-linking due to thermomechanical stress.

6.Sergii Kishchynsky et al(2016)

This experiment deals with improving durability and quality of bitumen and asphalt concrete by modification using recycled poly-ethylene based polymer. Thus, the penetration test is been taken as depth of needle penetrated at 25 degree Celsius is 99 for 90/130 type of bitumen. Similarly, the softening point test is also conducted and the result is 46 by ring and ball method and the ductility value is about 100 at 25 degree Celsius. Bitumen is a component of asphalt binder that combines gravel, sand & mineral powder.

Has property becoming liquid when heated & solid on cooling.

To reduce the defect caused due to temperature instead of high-cost modifiers these cheap plastics can be utilized.

Best result obtained when polymer modifier: latex & SBS type thermoplastic.

Has high strength, water& heat resistance value compared to conventional asphalt.

8.Imran M. Khan et al(2016)

This experiment deals with asphalt design using recycled plastic for sustainable pavement construction. So, for proving this experiment they have used penetration and softening point test. Thus, the penetration value at 25 degree Celsius is said to be 59.10 for base bitumen. Similarly, for Softening point test the base bitumen value tends to 49.45 whereas, for LDPE the softening point value is 95 and it goes till 127 for High Density Polyethylene. Similarly, the ductility value is found to be 126.5mm for base bitumen, and the viscosity value at 135 degree Celsius is been measured about 460.35 for the base bitumen value.

9.Abolfazl Hassani et al(2005)

This experiment briefly explains about the use of plastic waste (Polyethylene Terephthalate) in asphalt concrete mixture as a aggregate replacement material. Hence the standard penetration, Softening Point and Ductility test are being taken. Where the penetration value for bitumen under 25 degree Celsius for 60/70 pen bitumen is 67 and the specific gravity value for the same 60/70 pen bitumen is about 1.04 and the softening point test result shows that about 56 is being obtained for 60/70 pen bitumen. Also the melting point of the bitumen is calculated to be 255 for the PET granules.

ISSN (Print): 2204-0595
ISSN (Online): 2203-1731

5. BBR and FTIR Test:

1Johnson Kwabena Appiah et al(2016)

This experiment has a case study on use of plastic material for road construction. Similarly, the Fourier Transform Infra-Red (FTIR) test has been conducted, on base bitumen and bitumen plastic composite (PMB) which shows that HDPE composed mainly of hydrocarbons. It can be observed that HDPE at 3% polymer loading tends to have least intense peak thus polymer ratio could be increased beyond 3% for modified bitumen. He examines the effects of blending Waste thermoplastic polymer.

Mainly High-Density Poly-Ethylene and Poly-Propylene.

The blended plastic is kept at a temperature range of 160-170 degrees Celsius.

Thus by adding plastic enhances the Increase in life span.

Decrease on polymer bitumen ratio Increases while softening temperature increases.

3.Peng lin et al(2019)

This experiment deals with the rheological, chemical and aging property of high content polymer in modified asphalt. Thus, the FTIR test is done to find out the chemical and aging property of polymer which shows that carbonyl index began to decrease with the increase of SBS content and remains stable when the SBS content is more than 7%. When SBS concentration increases the residual undamaged SBS content will also increase. To overcome high temperature & anti-revealing properties required in open-grade.

Thus use of high content Polymer Modified Asphalt (HCPMA) can be used for a better reaction.

HCPMA with higher SBS content will have better rheological properties but also the economy.

Where 9% is considered to be an optimum dosage to have good durability.

ESSO asphalt and SK asphalt are two kinds of asphalt used for the preparation of HCPMA.

6.Metin Guru et al(2014)

This experiment deals with usage of Polyethylene Terephthalate (PET) waste as roadway pavement material. The FTIR test is done the modified samples were observed to contain different bond structure of PET additives. The C=C double bond was found in FTIR base asphalt at 1600cm. The use of plastic bottles has become an environmental issue in the recent decade.

TLPP & VPP tend to improve low-temperature performance & fatigue resistance. They tend to decrease Viscosity & softening point & increase penetration of base bitumen.

The low temperature cracking resistance of base asphalt was improved by the BBR test.

Reduction in rutting resistance but both of them were found to offer improved fatigue cracking resistance based on the DSR test.

6. Conclusion:

Therefore, the use of bitumen is higher than compared before where these bitumen are non-renewable sources as they are being obtained from the petroleum products and are definitely going to get extinct in the future, So, the world is in search of its new Alternative for almost all of its natural resources and it has been also found For some cases like M.Sand in place of the normal river sand.

Similarly, the use of these PVC, Poly-Propylene, High-Density Poly- 2.Muhammad Rafiq Kakar et al(2020)

This experiment briefly explains about the analysis of waste Polyethylene and its by-product in asphalt binder. Where the FTIR test was conducted to monitor PE-P and PE-S on their chemical structure. Where the result shows that presence of waste PE in binder 70-100 which does not affect the functional group being present in the asphalt binder. Transfer of waste plastic is a difficult issue of all-inclusive due to non-biodegrade.

Waste plastic is partly supported as regular material.

Present research work created procedure to utilize plastic waste.

Measure of plastic of 5%,7.5%,10%,12.5%&15% are utilized as substitution of bitumen.

Examination of work explodes the higher cost of plastic blends bitumen which spared 5% cost as a contrast with the customary bitumen.

4.Sevil Kofteci et al(2014)

This experiment shows the performance evaluation of bitumen modified by various types of plastic waste. Thus, the BBR test is being conducted the behaviour of hot-mix asphalt pavement (HMA) under low-service temperature thermal cracking is identified. By adding 5% leads to decrease the PG from Y-22 to Y-16. Similarly while adding cable-waste by 3% increases PG from Y- 22 to Y-28. Bitumen is being modified by three groups of plastic waste (Window, Blinds & Cable Waste).

They are considered to be Poly Vinyl Chloride (PVC) based material.

Among them, PVC windows & blinds waste is 1.3% improved performance of bitumen.

The only waste cable of amount 5% improved the performance of bitumen at low temperature.

5.Marzieh Habibi Karahrodi et al(2016)

This experiment deals with modification of rheological characteristics of bitumen by waste PET blend. Where the FTIR test is done and noticed that all FTIR spectra resemble each other. Where higher content of waste PET blend in the bitumen matrix weaker the transmittance peak in range of 1750-1250cm. This confirms that bitumen has partly entered waste PET due to swelling and partial dissolving of modifier in bitumen. Usage of waste PET & Ground rubber in the various components used as a low-cost modifier.

ISSN (Print): 2204-0595
ISSN (Online): 2203-1731

Depending on weight ratio the acquired dispersion of single domain waste polymer in the bitumen has been promoted and interaction between them.

When higher content of GTR in wPET blend causes disturbance in distribution of modifier phase.

This affects physical interaction between used components & consequently compatible between bitumen & modifier phase by FTIR result.

TGA & DSR result indicates the application of wet wPET blend into bitumen & improves stiffness & resistance against rutting at high temperature.

Ethylene, Low-Density Poly- Ethylene, PET etc.., can be a great alternative products when added With the bitumen partially.

Thus, from the above review it is clear that when addition of PVC, Poly-propylene is done the results shows an extensive increase in the compressive, tensile strength. And also has increased result in ductility, Penetration values.

References

[1] Marta Vila-Cortavitarte , Pedro Lastra-Gonz “The use of recycled plastic as partial replacement of bitumen in asphalt concrete”

[2] Anjana Ramesh, Anitha P A, Joel Francis K J “Experimental Study on Partial Replacement of Bitumen with Lig” ISSN: 2278-0181

[3] D. Movilla-Quesada a , A.C. Raposeiras a , L.T. Silva-Klein a , P. Lastra-González b , D. Castro-Fresno “Use of plastic scrap in asphalt mixtures added by dry method as a partial substitute for bitumen”.2019.03.018

[4] . Moatasim Attaelmanan , Cheng Pei Feng , Al-Hadidy AI “Laboratory evaluation of HMA with high density polyethylene as a modifier”2010.12.037

[5] Sinan Hınıslıog˘lua, Emine Agarb “Use of waste high density polyethylene as bitumen modifier in asphalt concrete mix” doi:10.1016/S0167-577X(03)00458-0

[6] Marzieh Habibi Karahrodi , Omid Moini Jazani , Seyed Mohammad Reza Paran , Krzysztof Formela , Mohammad Reza Saeb “Modifification of thermal and rheological characteristics of bitumen by waste PET/GTR blends”.2016.12.134

[7] Sergii Kishchynskyi1, Vasyl Nagaychuk1 , Artem Bezuglyi1 “Improving Quality and Durability of Bitumen and Asphalt Concrete by Modification Using Recycled Polyethylene Based Polymer Composition” doi: 10.1016/j.proeng.2016.06.016

[8] 11. B. Singh,1 Lokesh Kumar,1 M. Gupta,1 G. S. Chauhan2 “Polymer-Modified Bitumen of Recycled LDPE and Maleated Bitumen”DOI: 10.1002/app.36810

[9] Md Maniruzzaman A. Aziz , Md Tareq Rahman , Mohd. Rosli Hainin , Wan Azelee Wan Abu Bakar “An overview on alternative binders for flflexible pavement”84 (2015) 315–319

[10] A. Rangaraj , P. Mukesh “An experimental investigation on partial replacement of bitumen using rubber tyre” 2019.05.465

[11] Shubham Bansal, Anil Kumar Misra, Purnima Bajpai “Evaluation of modified bituminous concrete mix developed using rubber and plastic waste materials” 2017.07.009

[12] . Rabindra K Padhan , Anurag A Gupta “Preparation and evaluation of waste PET derived polyurethane polymer modifified bitumen through in situ polymerization reaction” .2017.09.147

[13] . M. Naskar , T.K. Chaki , K.S. Reddy “Effect of waste plastic as modififier on thermal stability and degradation kinetics of bitumen/waste plastics blend” doi:10.1016/j.tca.2010.06.013

[14] . Peng Lin , Chuanqi Yan , Weidong Huang , Yi Li , Lu Zhou “Rheological, chemical and aging characteristics of high content polymer modifified asphalt” .2019.02.086

[15] Giovanni Polacco , Stefano Berlincioni , Dario Biondi , Jiri Stastna , Ludovit Zanzotto “Asphalt modifification with difffferent polyethylene-based polymers” 41 (2005) 2831–2844

[16] . Chunfa Ouyang, Shifeng Wang, Yong Zhang, Yinxi Zhang “Low-Density Polyethylene/Silica Compound Modifified Asphalts with High-Temperature Storage Stability” , Vol. 101, 472–479 (2006)

[17] U Arun Kumar “Comparison of the Polyethylene and SBS Polymer Modifified Bitumen's EffectA Case Study” ISSN: 2231-5381

[18] Imran M. Khan, Shahid Kabir, Majed A. Alhussain, Feras F. Almansoor “Asphalt Design using Recycled Plastic and Crumb-rubber Waste for SustainablePavementConstruction”doi: 10.1016/j.proeng.2016.04.196

[19] Abolfazl Hassani Hossein Ganjidoust Amir Abedin Maghanaki“Use of plastic waste (poly-ethylene terephthalate) in asphalt concrete mixture as aggregate replacement”Box: 14115-143,

[20] . Sevil Köfteci , Perviz Ahmedzade , Baurzhan Kultayev “Performance evaluation of bitumen modifified by various types of waste plastics” 2014.09.067

[21] . Metin Gürü, M. Kürs¸ ubuk , Deniz Arslan, S. Ali Farzanian, Ibrahim Bilici “An approach to the usage

ISSN (Print): 2204-0595
ISSN (Online): 2203-1731

of polyethylene terephthalate (PET) waste as roadway pavement material".2014.07.018

[22] B.Surya , R.Praksh , S.Ranjithkumar , S.M.Saravanan , Dr.M.Sivaraja "A EXPERIMENTAL INVESTIGATION ON FLEXIBLE PAVEMENT WITH PARTIAL REPLACEMENT OF BITUMEN BY USING WASTE PLASTIC (BIOMEDICAL WASTES AND BAGS" March-2018

ISSN (Print): 2204-0595
ISSN (Online): 2203-1731