iJRASET
International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 5 **Issue:** VIII **Month of publication:** August 2017

DOI: http://doi.org/10.22214/ijraset.2017.8162

www.ijraset.com

Call: 08813907089 | E-mail ID: ijraset@gmail.com

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor:6.887
Volume 5 Issue VIII, August 2017- Available at www.ijraset.com

Role of Filler in the Enhancement of Properties of Bituminous Mixes: A Review

Ankita Dhiman[1], Ajay Kumar Duggal[2]
[1]M.Tech Scholar, [2]Professor, Civil Engineering Department, National Institute of Technical Teachers Training and Research Chandigarh, India

***Abstract*—In this paper summary of the ongoing research papers concerning the effect of various fillers on bituminous mixes was reviewed. Depending upon the particle size fines can act as filler or extender of bitumen binder. Filler particles should be passed through 0.075mm sieve. Filler may be added in different range expectedly from 2% to 4% in bituminous concrete. When the quantity of filler increases in the mix, the Marshall properties of the bitumen mix may also improve directly up to certain limits. It was concluded that various fillers such as carbon black, fibres, rubbers, polymers, fly ash, silica or their combination may have different effects on properties of mix that is rutting behaviour, ageing characteristics and stripping behaviour etc. Filler makes mix stiffer, moisture resistant and durable etc.**

***Keywords*— Fillers, Voids in Mineral Aggregates (VMA), Marshall Stability value, Marshall Flow value, Asphalt.**

I. INTRODUCTION

India is the second largest country in the world which has largest development in case of economy. Government has started many projects like Pradhan Mantri Gram Sadak Yojna (PMGSY) and National Highway Development Project (NHDP) for the development of highway structures. Due to the increase in traffic, the load on pavement is increasing day by day. Due to this life of bituminous pavement and quality of riding surface get decreased. Durability of roads also decreases if there is any change in weather, rainfall intensity, terrain condition and properties of soil. Therefore, for increasing the pavement life, different types of stabilizing additives like carbon black, fibres, rubbers, polymers, fly ash, artificial silica, and brick dust or a combination of these materials and modifiers such as polymers and fibres can be used. So in present days, for enhancing the durability of roads, different types of fillers are using in bituminous mix at very fast rate. Generally, bituminous concrete is used to construct the expressway or NH or roads carrying heavy traffic. Therefore, material, grading and other requirements of bituminous concrete according to MORTH is explained in this paper. Relevant papers related to effect of fillers on bituminous mixes has been presented in this review paper. For coarse aggregates crushed rocks, gravel or other hard material retained on 2.36mm sieve may be used because its main function is to bear loads due to wheels, resist wear due to abrasion. Crushed material or naturally occurring material or combination of both passing through 2.36mm sieve and retained on 75 micron sieve shall be used as fine aggregates it should be hard, clean, and dry and free from dust or other deleterious material. The function of fine aggregates is to fill the voids which remain in coarse aggregates. Inert material may be used as filler, whole of which passes 600µm sieve, atleast 90% passing 150µm sieve & not less than 70% passing 75µm sieve. It may be brick dust, stone dust, cement, limestone dust, fly ash or pond ash. As the name indicates function of fillers is to fill up the voids. Bitumen is visco-elastic material which is used as a binder. Bitumen of suitable grade should be selected from IS: 73.

II. MATERIAL USED IN BITUMINOUS MIXES

For coarse aggregates crushed rocks, gravel or other hard material retained on 2.36mm sieve may be used because its main function is to bear loads due to wheels, resist wear due to abrasion. Crushed material or naturally occurring material or combination of both passing through 2.36mm sieve and retained on 75 micron sieve shall be used as fine aggregates it should be hard, clean, and dry and free from dust or other deleterious material. The function of fine aggregates is to fill the voids which remain in coarse aggregates. Inert material may be used as filler, whole of which passes 600µm sieve, atleast 90% passing 150µm sieve & not less than 70% passing 75µm sieve. It may be brick dust, stone dust, cement, limestone dust, fly ash or pond ash. As the name indicates function of fillers is to fill up the voids. Bitumen is visco-elastic material which is used as a binder. Bitumen of suitable grade should be selected from IS: 73.

III. BITUMINOUS MIX DESIGN

Bituminous mix should be well designed so that it can withstand under the adverse conditions of traffic. Economy should be maintained while designing the bituminous mix. The grading of materials in bituminous mix should be done in such a way so that the resultant mix should satisfy the conditions like stability, Flow Value to meet traffic demand, sufficient bitumen content to ensure proper binding and water proofing, voids to accommodate compaction due to traffic, sufficient workability for construction and economical mix. Designing should be done by using Marshall Method. It involves determination of ratio in which aggregate should be mixed to obtain the desired grading and optimum binder content. It should meet the requirements set out in Table 500-11 of MORTH which is given in Table 1.

Table 1
MORTH Requirements for Bituminous Concrete

Property	**Minimum value**
Marshall Stability Value, KN	9.0
Flow Value	2-4
Marshall quotient (Stability/Flow)	2-5
Air Voids, %	3-5
Voids in Mineral Aggregate (VMA),% Grading-1 Grading-2	 10-12 11-13
Voids Filled with Bitumen (VFB),%	65-75

A. Gradation of Aggregates

The gradations of aggregates used should be as per Table: 500-17 of MORTH specifications given in Table 2.

Table 2 MORTH grading for Bituminous Concrete

BC Designation	**Grading-1**	**Grading-2**
Layer Thickness, mm	**50**	**30-40**
Sieve Size, mm	**Cumulative % by weight of total aggregate passing**	**Cumulative % by weight of total aggregate passing**
19.0	90-100	100
13.2	59-79	79-100
9.5	52-72	70-88
4.75	35-55	53-71
2.36	28-44	42-58
1.18	20-34	34-48
0.600	15-27	26-38
0.300	10-20	18-28
0.150	5-13	12-20
0.075	2-8	4-10
Bitumen Content, %	Min 5.2%	Min 5.4%

IV. FINDINGS FROM THE LITERATURE REVIEW

Byong Chol Bai, Dae-Wook Park, Hai Viet Vo, Samer Dessouky, and Ji Sun Im [1] studied the thermal properties of asphalt mixtures modified with conductive fillers. Two different mixing processes were adopted to mould asphalt mixtures, dry- and wet-mixing, and two conductive fillers were used in this study, graphite and carbon black. Evaluation of combination of conductive filler with carbon fibre in asphalt mixture was done. The rheological properties of modified asphalt binders with conductive fillers were measured using dynamic shear rheometer and bending beam rheometer at grade specific temperatures. On the basis of rheological testing, the improvement in rutting resistance and decrease thermal cracking resistance on the addition of conductive fillers was studied. Thermal testing indicated that graphite and carbon black improve the thermal properties of asphalt mixes and the combined conductive fillers are more effective than the single filler. Therefore, graphite and carbon black have a potential to increase rutting resistance but decrease thermal cracking resistance. The wet-mixing process provides a better distribution of conductive filler in asphalt mixtures; however, the dry process can be performed more simply. Debashish Kar, Mahabir Panda and Jyoti Prakash Giri [2] studied the influence of fly-ash as filler in bituminous mixes. Control mixes with cement and stone dust were made so for comparison. For the purpose of mix design and evaluation of paving mix Marshall Test has been considered. Other performance tests such as indirect tensile strength and retained stability has been carried out. It has been observed that the mixes in which fly ash was added as filler show inferior properties compared to control mixes but satisfy desired criteria specified by a much higher margin. Hence, recommendation was made to use fly ash wherever available, as it reduces the cost of execution and solve the fly ash disposal problems. However it has been observed that at optimum bitumen content the mixes satisfy all the Marshall criteria but the optimum bitumen content required in case of cement and stone dust were same while for fly ash, it was slightly higher. **Farag** Khodary, M.S. Abd El-sadek, H.S. El-Sheshtawy **[3]** explained the mechanical properties of modified asphalt concrete mixtures using $Ca(OH)_2$ as nanoparticles. Ca $(OH)_2$ nanoparticles were synthesized by sol.gel method and analyzed by XRD and TEM. The results showed significant improvement on both physical and mechanical properties of modified asphalt concrete mixtures. When 5% $Ca(OH)_2$ nanoparticles were added, there was decrease in the penetration grade of the blend nearly by 30%. Softening point was increased by 15°C (45%) and the viscosity was decreased by 7%. The specimens without modification had the lowest value of indirect tensile strength, while $Ca(OH)_2$ nanoparticles modified asphalt concrete mixtures has the highest value of indirect tensile strength specially at modification level 4%. Finally the use of modified asphalt concrete mixtures with $Ca(OH)_2$ was preferred in hot climate as well as in heavy traffic load area as it may improve road mechanical properties, including rutting resistance and enhance bitumen performance to resist high traffic loads. Hossein Zalnezhad, Saeed Sadeghpour Galooyak, Hossein Farahani, Ahmad Goli [4] investigated the effect of nano-silica on the specification of the sasobit warm mix asphalt. In this investigation, Nano-silica has been added in three percentages of 2%, 4% and 6% to improve the physical, rheological and mechanical properties of warm mix asphalt (WMA) containing 2% Sasobit. The results of investigations indicated that by increasing the percentage of Nano-silica, the quality and functionality of the warm mix asphalt has been improved. Resilient modulus of WMA was slightly increased by increasing the Nano-silica content. So, the pavement responded towards the traffic loading at 25°C well. Crack depth at a specified load cycles was decreased dramatically by adding the Nano-silica to the Sasobit WMA. At the same time, the stiffness of modified samples was much lower than control WMA. The results showed that the combination of Sasobit and Nano-silica improves the rutting resistance. Wheel track test implied that asphalt concrete with modified binders are less temperature susceptible and have less rut depth and permanent deformation. K.B. Raghuram& Venkaiah Chowdary[5] studied the performance evaluation of stone matrix asphalt using low cost fibres. Cellulose fibre has been used to reduce the drain down of asphalt from SMA mixes. Stability & the resistance to rutting were evaluated. It was done by standard Marshall Procedure. By using wheel track test setup depth of rutting was checked where rut depth achieved after 20,000 repetitions, was used to evaluate the performance of SMA mixes. SMA mixes stabilized with FERP showed lower draindown than the SMA mixes with other fibres. FERP & jute fibres resulted in higher stability values, resisting the permanent deformation when compared to other fibres which might replace the high cost cellulose fibres in SMA Mix.Lt. Gen. A.K. Nanda & Lt. Col. Manoj Gupta [6] studied the performance characteristics of modified bitumen with respect to its physical and rheological properties. In order to enhance the performance of bitumen, polymers were added. The rheological study and characterization of bitumen was done by dynamic shear rheometer. The change in physical & rheological properties by addition of ethylene vinyl acetate (EVA), a plastomer, linear styrene butadiene styrene (SBS), an elastomer & crumb rubber (CR) were discussed in the paper to some extent. There was improvement in the response of binder to the loading at service temperatures after polymer addition. Complex modulus of modified bitumen is higher as compared to neat bitumen. For low cost roads CRMB can be used because it is cheapest binder. At high temperatures/low frequencies PMB has better performance. The addition of polymer and CR in binder may increase its initial cost of construction but it will provide better and long lasting roads which reduces its life cycle

cost, which makes it economical. Mohd Ezree Abdullah, Kemas Ahmad Zamhari, Rosnawati Buhari, Norhidayah Abdul Hassan [7] gave review on the exploration of nanomaterials application in pavement engineering. This paper described the theory of nanotechnology and its historical development including the method used by the researchers. The effect of different types of nanoparticles, their suitable dosages, modifying procedures, problems and benefits on binder and mixture were explained. In flexible pavement application, researchers focused on the modification of binder using nanoclay, nano-hydrated lime and carbon nanoparticles. The physical property like penetration and ductility has been decreased by nanomaterials and increase softening point value. The rheological properties such as performance grade, rutting resistance, low-temperature cracking resistance and aging resistance also showed better improvements. There was improvement in engineering properties like stiffness, rutting resistance, indirect tensile strength and resilient modulus. When nano-TiO_2 as modifier is applied in rigid pavement it also gave positive effects. Nano-TiO_2 showed higher compressive strength when added into concrete which indicates higher abrasion resistance, higher fatigue life as compared to controlled concrete. The use of TiO_2 coating as a photocatalytic compound would also provide acceptable durability and wear resistance. M.S. Ranadive and Honne Gowda S. **[8]** studied the enhancing stability of flexible pavements using plastic waste and fly ash. To evaluate the strength and deformation Marshall Stability value and flow value was determined. Mix with fly ash and plastic waste gave better result than mix with fly ash. AT 5% fly ash maximum stability value recorded on Marshall test apparatus was 1560 kg and the values of flow, Percentage air voids, VMA & VFB was 2.3, 4.2%, 13.4% and 68.2% respectively. Also bituminous mix with addition of 5% fly ash & 2% plastic gave higher value of stability 1700 kg & the values of flow, percentage air voids, VMA & VFB is 2.4, 3.9%, 13.1% & 70.0% respectively, which were within the limits of specifications given by MORTH.M Satyakumar, R. Satheeshchandran& K.C. Wilson [9] determined the texture depth for sand mix asphalt modified with sulphur, slurry & fly-ash. This paper deals with the texture depth contribution to tire pavement contact. Three tests stretches of length 275m was made for study by adding mineral fillers such as fly-ash, slurry & sulphur with beach sand & bitumen at different combination. The analysis was made to check the effect of properties such as percentage of air voids, flow value & unit weight on the texture depth of the experimental surface mixtures along with the skid resistance. The result of investigation showed that it gave superior surface characteristics compared to conventional dense mix. M. Veerendra Kumar, R. Muralidhara & Divya J. Nair [10] did the comparative study of wet and dry blending of plastic modified bituminous mix used in road pavements. In this study engineering properties of wet mix & dry mix is evaluated. The optimum binder content observed by Marshall Test was 4.98%. There was increase in the performance at 8% partial replacement by waste plastic in both WM & DM. DM gave better performance in terms of fatigue, strength, stiffness by utilization of waste plastics than WM. From this waste disposal problem of plastic waste is solved and economy in pavement construction may be achieved. P.Vilvakumar, N.Senthil, S.Lakshmi, C.Kamaraj, S.Gangopadhyay **[11]** studied the performance of sugarcane fibre in stone matrix asphalt. In this study the dosage of fibres were 3g, 5g, 7g and 10g by weight of mix i.e. 0.26%, 0.43%, 0.6% and 0.86% by weight of mix respectively. The SMA mix of 50mm thickness made as per MORTH specification showed good stone contact. The VMA and air voids observed were17% & 4% respectively. The drain down values was in the range of 0.04% to 0.17% by weight of mix. 0.6% was the optimum dosage of sugarcane bagasse by weight of mix. The range of permanent deformation was 1-2 mm & samples compacted at 160^{o} C showed that the samples are resistant to rutting. Ravindra Tomar, R K Jain and M K Kostha **[12]** studied the effect of filler on paving mix. This project stressed on the mix design considerations. It has been observed that bituminous mixes with the non-conventional fillers such as brick, dust and silica fume gave satisfactory result in terms of Marshall Properties & the problem of waste disposal can be solved in making bituminous concrete. But the bitumen content needed was high. Saeed Sadeghpour Galooyak, Massoud Palassi, Hosein Zanjirani Farahani, Ahmad Goli **[13]**studied the effect of carbon nanotube on the rheological properties of bitumen. In this, carbon nanotubes of different contents were used for the modification of the conventional bitumen. It was observed that the agglomerated Nano-materials were peeled off and uniformly dispersed in bitumen in ultrasonic mixture. The rheological tests were done by using Dynamic Shear Rheometer & x-ray analysis was done on the modified bitumen. Master curves were plotted, and the results showed that addition of 1.2 % by weight of carbon nanotubes to the bitumen increased the stiffness and reduced the phase angle of base bitumen. So, the carbon nanotubes improved the classical properties (softening point, penetration, etc.) and performance of modified bitumen compared to base binder. S.B Patil, A.K. Vyas, A.B. Gupta, A.N. Arora, Pawan Kalla**[14]**studied the influence of imperial smelting furnace slag aggregate on properties of bituminous mixes. In DBM and BC the replacement of natural aggregates was done by ISF slag from 5% to 25%, at different binder contents. The properties of these mixes such as bulk density, stability, void content, void in mineral aggregate and voids filled with bitumen were determined. On bituminous mixes containing ISF slag, Leachate analysis was done. 20% fine aggregates replacement by ISF slag in BC and DBM satisfied all the criteria of MORTH Specifications. For crushing broken fine stone aggregates economy was achieved for saving fuel, electricity, mechanical energy etc. The problem of disposal of waste can be reduced in an environmentally acceptable manner. Y.C. Tewari& R.S. Bharadwaj[15]studied the role of nanotechnology in highway

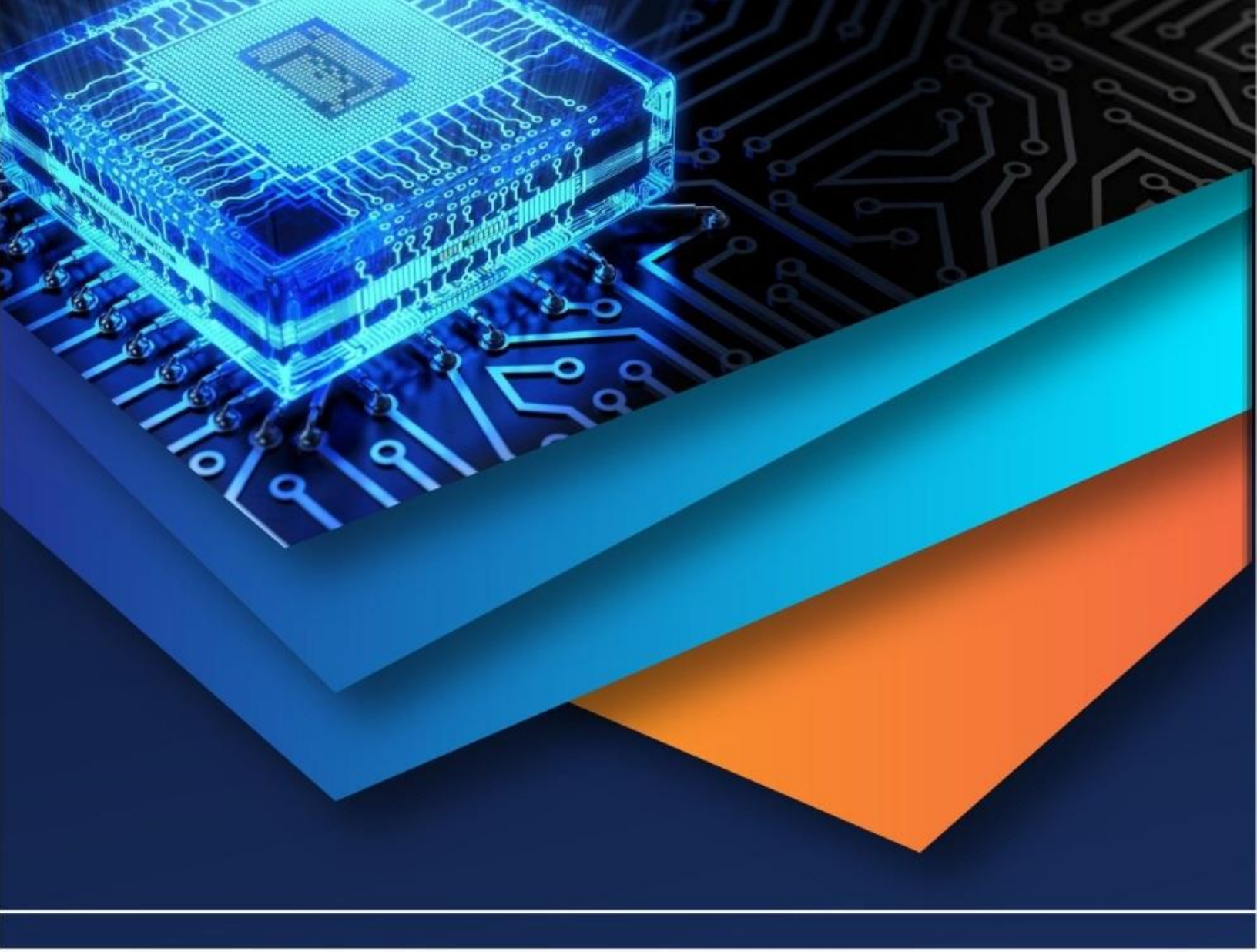
engineering. It deals with understanding, controlling & manipulating matter at the level of individual atoms & molecules in the range of 0.1-100nm & creating materials, devices & system with new properties and functions. In this study nanotechnology and its effects on highway engineering was explained. When nano material like carbon nano tube is added to cement it may improve its performance. In asphalt nano material addition may enhance its mechanical performance, durability, reflectivity & skid resistance, better binding, quicker curing, better maintenance & sustainability. Although the cost of nanotechnology is high, this may hinder their application for highway engineering. But the benefits drawn from nanotechnology are more which can justify the additional cost. But inappropriate vision and lack of knowledge may also affect its use in highway engineering.

V. CONCLUSIONS

After going through the studies carried out by different authors it may be concluded that use of fillers in the bituminous mixes result in enhancement of performance of bituminous mix in one or other way. It also helps to utilize the waste material, as disposal of such material may adversely affect the atmosphere. If graphite and carbon black are used together as filler in bituminous mix, it will increase the rutting resistance but decrease thermal cracking resistance. Use of fly ash as filler is economical but the mix having fly ash had inferior properties as compared to controlled mix. If cheap and non-conventional fillers are added in the mix then high bitumen content is needed. But non-conventional fillers give economical mix and satisfy all the specified criteria. Use of nano particles may improve the properties of mix but it may make mix uneconomical as cost of nanotechnology is presently very high. However, since the high performing and long lasting pavements are the need of the hour, it becomes imperative to work out overall economy on the basis of higher life and performance. Evidently use of nano particles or similar fillers may reduce the maintenance cost of roads and increase its durability.

REFERENCES

[1] Byong Chol Bai, Dae-Wook Park, Hai Viet Vo, Samer Dessouky, and Ji Sun Im, *The thermal properties of asphalt mixtures modified with conductive fillers* (Journal of Nano Material, May, 2015).
[2] Debashish Kar, Mahabir Panda and Jyoti Prakash Giri, *The influence of fly-ash as filler in bituminous mixes* (ARPN Journal of Engineering & Applied Sciences, June, 2014).
[3] Farag Khodary, M.S. Abd El-sadek, H.S. El-Sheshtawy, *Effect of $Ca(OH)_2$ as nanoparticle on mechanical properties of modified asphalt concrete mixtures* (International Journal of Civil Engineering & Technology (IJCIET, May, 2014).
[4] Hossein Zalnezhad, Saeed Sadeghpour Galooyak, Hossein Farahani, Ahmad Goli, *The effect of nano-silica on the specification of the sasobit warm mix asphalt* (Petroleum & Coal, ISSN 1337-7027, Nov, 2015).
[5] K.B. Raghuram& Venkaiah Chowdary, *The performance evaluation of stone matrix asphalt using low cost fibres* (Journal of the Indian Road Congress, July-September, 2013).
[6] Lt. Gen.A.K. Nanda & Lt. Col. Manoj Gupta, *The performance characteristics of modified bitumen with respect to its physical and rheological properties* (Indian Highways, May, 2010).
[7] Mohd Ezree Abdullah, Kemas Ahmad Zamhari, Rosnawati Buhari, Norhidayah Abdul Hassan, *Review on the exploration of nanomaterials application in pavement engineering* (Journal Technology, January, 2015).
[8] M.S. Ranadive and Honne Gowda S., *Enhancing stability of flexible pavements using plastic waste and fly ash* (Indian Highways, Oct, 2011).
[9] M. Satyakumar, R. Satheeshchandran& K.C. Wilson, *Texture depth determination for sand mix asphalt modified with sulphur, slurry & flyash* (Indian Highways, Sept, 2013).
[10] M. Veerendra Kumar, R. Muralidhara & Divya J. Nair, *Comparative study of wet and dry blending of plastic modified bituminous mix used in road pavements* (Indian Highways, Dec, 2013).
[11] P.Vilvakumar, N.Senthil, S.Lakshmi, C.Kamaraj, S.Gangopadhyay, *A study on the performance of sugarcane fibre in stone matrix asphalt* (Indian Highways, June, 2013).
[12] Ravindra Tomar, R K Jain and M K Kostha, *The effect of filler on paving mix* (International Journal of Engineering Research & Science & Technology (IJERST), Nov, 2013).
[13] Saeed Sadeghpour Galooyak, Massoud Palassi, Hosein Zanjirani Farahani, Ahmad Goli, *The effect of carbon nanotube on the rheological properties of bitumen* (Petroleum & Coal, ISSN 1337-7027, Nov, 2015).
[14] S.B Patil, A.K. Vyas, A.B. Gupta, A.N. Arora, Pawan Kalla, *The influence of imperial smelting furnace slag aggregate on properties of bituminous mixes* (Indian Highways, Feb, 2009).
[15] Y.C. Tewari& R.S. Bharadwaj, *Nanotechnology in highway engineering* (Indian Highways, March, 2013).
[16] Ministry of Road Transport and Highways, Specifications for Road and Bridge Works, Fifth Revision, Published by IRC New Delhi, 2013.



10.22214/IJRASET

45.98

IMPACT FACTOR: 7.129

IMPACT FACTOR: 7.429

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY