Modification of Bitumen (Using Crumb Rubber and MICA): A Case Study on Udhampur and Ramban Road Project

Parmeet Singh, Akash Pathania, Abhishek Gupta, Deepak Kumar, Kamalpreet Singh, Devinder Angurana, Abhishek Sharma, Bhrigu Sharma, Dr. Arvind Dewangan, Er. Khushwace Singh

***Abstract*— This study investigated the influence of crumb rubber and Mica on the physical performance and mechanical properties of bitumen binder. Crumb rubber was obtained from weathered tyre rubber, sieved through 700 µm sieve and mica was bought in powdered form and sieved through 700 µm sieve. Both crumb rubber and mica impact hardness, strength and rigidity to the virgin bitumen. Crumb rubber was blended into bitumen in variations of 3%, 5% and 7% by weight of sample. Mica was blended in bitumen in variation of 35%, 45% and 55% of the weight of sample.**

***Index Terms*—** Mica, Crumb rubber, Bitumen, Viscosity Grade –VG
Sub Area : Transportation Engineering
Broad Area : Civil Engg

The blended bitumen was characterised by penetration, softening point, ductility, specific weight tests. The modified bitumen has been tested for mechanical properties by Marshal Stability test.The blending of bitumen with either crumb rubber or mica has increased complex modulus,decreased phase angle and improved rutting resistance as well. There was a significant improvement in Marshall Stability, rather than marginal improvement in flow value. This study reveals that the properties of bitumen can be improved by adding either crumb rubber or mica in it with negligible raise in initial cost of construction, the life and performance by pavements can be increased for long duration

I. INTRODUCTION

For the experimental work, two types of samples were prepared using crumb rubber powder and silver mica powder. First sample consists of bitumen in which crumb rubber powder sieved through 700µ sieve (25 mesh) is added so as to note down the variation in the properties of crumb rubber modified bitumen. The crumb rubber powder enhances the properties of the bitumen and is added to the bitumen as a filler. Also, the melting point of crumb rubber is very high as compared to bitumen so it provides good properties to the bitumen. Crumb rubber powder is added in three different percentages in bitumen by weight i.e. 3%, 5%, 7% and various tests are conducted on these samples like penetration test, ductility test etc and the optimum value amongst the tests is noted for which the Marshall stability value is recorded so as to check the bitumen for its applicability on roads.Second sample consists of bitumen in which silver mica powder sieved through 700µ sieve (25 mesh) is added so as to note down the variation in the properties of silver mica modified bitumen. The silver mica powder enhances the properties of the bitumen and is added to the bitumen as a filler. Silver mica powder is added in three different percentages in bitumen by weight i.e. 35%, 45%, 55% and various tests are conducted on these samples like penetration test, ductility test etc and the optimum value amongst the tests is noted for which the Marshall stability value is recorded so as to check the bitumen for its applicability on roads.

II. CRUMB RUBBER POWDER

Crumb rubber is recycled rubber produced from automotive and truck scrap tires. During the recycling process, steel and tire cord (fluff) are removed, leaving tire rubber with a granular consistency. Continued processing with a granulator or cracker mill, possibly with the aid of cryogenics or by mechanical means, reduces the size of the particles further. The particles are sized and classified based on various criteria including color (black only or black and white). The granulate is sized by passing through a screen, the size based on a dimension (1/4inch) or mesh (holes per inch: 10, 20, etc.). Crumb rubber is often used in artificial turf as cushioning.
Day by day with the increase in number of automobiles in India during recent years the demand of tyres as original equipment and has replacement also increased. As every new tyre produced is designed to go to waste stream for disposal or recycling or reclamation, despite its passage through retreading process, the number of used tyres being discarded is going to increase significantly. Timely action regarding recycling of used tyres is necessary in view to solve the problem of disposal of used tyres keeping in view the increasing cost of raw material, resource constraints and environment problem including fire and health hazard associated with the stockpiles of the used tyres. The world generate about 1.5 billon of waste tyre annually, 40% of them in emerging markets such as china, India, south America, southeast Asia, south Africa and Europe. In India, all new vehicles have radial tyres so now there are piles of radial tyres here. Analysis indicates that 0.6 million Tons of tyres scrape is generated in the country annually. It is commonly accepted in the tyre industry that about one tyre one person per year is discarded. Since there is no industry group or industry or governmental agency that monitors tyre disposal in the country, the best estimates that can be made are based on tyre production. So supply situation of scrap tyre is only going to be improving in years to come as result of going vehicle

Manuscript received May 31, 2018

population in India. Mandatory scraping of end of life vehicle, in metros by 2010-11 and across India by 2012-13 is also likely to insure large scale availability of scrap tyre at select locations there by encouraging organized players. The management of scrap tyre has growing problem in recent years, scrap tyres represent one of several special wastes that are difficult to municipalities to handle. Whole tyres are difficult to landfill because they tend to float to the surface. These stockpiles are also direct loss of energy and resources in addition to fire & health hazards and also environmental issues. The main constituent of tyre is rubber and the largest single application of rubber is vehicle tyres. Also the requirement of tyre is directly related to growth of automobile. Waste tyre stockpiles constitute environmental and health hazards by producing air pollution from tyre stockpile fires and breeding for potential disease carrying mosquitoes and vermin Under recent environmental legislation that encourages the reuse or recycling of waste products in the India, the use of discarded tyres has been increasing. The IEPA estimated in 1990 that 11% of the waste tyres generated in the India annually were converted into energy and 7% were recycled into new products. In order to avoid even larger stockpiles across this country, alternate ways of using waste tyres must be implemented.

III. Composition

- 71% recoverable rubber
- 14% steel
- 3% fiber
- 12% extraneous material

IV. Mica Powder

The mica group is a large group with nearly 30 members recognized, but only a few are common. Those few however make up a large percentage of the most common rock types found in the Earth's crust. The general formula for mica is AB2-3 (Al, Si)Si-3 O-10 (F, OH)2. In most micas the usually potassium, K, but can be calcium, Ca, or sodium, Na, or barium, Ba, or some other elements in the rarer micas. The B in most micas can be aluminum, Al, and/or lithium, Li, and/or iron, Fe, and/or magnesium, Mg.

V. Availability of Mica in Our Country

Andhra Pradesh is the largest producer of mica in India. For over hundred years, India had enjoyed monopoly in production and export of sheet mica in the world. Of late, there has been a steep decline in mica production in India, largely due to technological improvements that facilitate use of reconstructed mica and emergence of mica substitutes consequently resulting into fall in the demand of natural mica in the world market. Still India stays there at 8th position in the list of largest producers of mica in the world. Andhra Pradesh is the largest producer of Mica. Nellore district of Andhra Pradesh is famous for its mica (crude) production. On the other hand, mica (waste and scrap) is largely produced by the states of Andhra Pradesh, Rajasthan, Bihar and Jharkhand. With a production of 7626 tons of Mica in the year 2013-14, Andhra Pradesh comes at the top of the list of mica producing states.

- Rajasthan has occupied second place with an estimate production of 6635 tons of mica in the year 2013-14. The mines of mica are located in Bhilwara, Ajmer and Rajsamand districts if the state.
- Bihar comes at third position with an estimated production of 3381 tons of Mica in the year 2013-14. Mica production in the state is centered in Nawada district.
- Jharkhand comes next in the list with an estimated production of 2110 tons of mica in the year 2013-14.
- Mines of mica are found in Giridih and Kodarma districts of the state. There was a time when Kodarma was considered as the Mica capital of India due to city's worldwide fame for mica production.

VI. The following are some of the more common mica minerals

- Biotite
- Fuchsite
- Lepidolite
- Muscovite
- Phlogopite
- Zinnwaldite

Micas are characterized by a sheet or plate like structure which because of its excellent basal cleavage enables particles of high aspect ratio to be produced. These lamellar particles are flexible, tough, relatively soft, have a low co-efficient of thermal expansion, exceptional electrical properties and excellent chemical resistance Mica is a reinforcing agent that will impart excellent dimensional stability of molded parts. Some of it's advantages include low warp, excellent electrical properties, reduced flammability, reduced creep, planar reinforcement and excellent resistance to weathering and corrosive attack by acids of alkalis.

VII. Chemical Properties

Muscovite- Muscovite Mica is a hydrated silicate of potassium and aluminum. Phlogopite- Phlogopite Mica is a hydrated silicate of potassium and magnesium.

VIII. Physical Properties

Various flake and powder granulations usually to customer specifications

IX. Typical Applications

Used as a heat insulator & electrical insulator for industrial purposes, for mineral specimens and ornamental stones.

Background

Previously, most of the road pavements were generally constructed by using vg30 satisfying the conditions of the site. Due to increase in production of waste crumb rubber, it became essential to use it in an effective manner. This lead to the use of crumb rubber in the road pavements. It not only improves the properties of the bitumen, but also makes the projecteconomical. On testing the modified bitumen using crumb rubber, tests such as penetration test, softening point test etc gives good results. Another filler which is used in the project is mica which is a substance formed of group of minerals which is used in powdered form. This is generally, not easily available thatswhy it is not an effective substitute for modifying the bitumen. However, it also improves the

strength of bitumen to great extent, but on considering the economy it not used as much. On the comparising the two (Crumb rubber modified bitumen and mica modified bitumen) it is observed that crumb rubber modified bitumen predominates our mica modified bitumen in terms both economy as well as in improvement of properties.

OBJECTIVES

- To modify and enhance the strength of conventional bitumen of viscosity grade 40.
- To prepare various bitumen samples containing different proportions of crumb rubberpowder and mica powder to determine the basic characteristics such as penetration value, soft ending point, Marshall Stability etc. of crumb rubber and mica powder modified bitumen.
- To check the applicability of modified bitumen for the optimum value of crumb rubber and mica powder added to the bitumen.
- Case study of Udhampur and Ramban road project.

SCOPE

To make use of crumb rubber obtained from tyre scrap into bitumen so as to reduce the environmental problem of dumping and safe disposal of waste rubber and to make use of mica powder for enhancement of properties of bitumen. The aim is the usage of bitumen with optimum results and less cost.

THERE ARE TWO METHODS OF GRADING

- Standard Viscosity Grade Bitumen (AC-Grades), in which the Viscosity of the standard bitumen (asphalt) is measured at 60 ºC (140 ºF).
- RTFOT Viscosity Grade Bitumen (AR-Grades), in which the Viscosity of bitumen (asphalt) is measured at 60 °C (140 °F) after the roll on thin film oven test.

Viscosity grade bitumen has a thermoplastic feature which causes the material to soften at high temperatures and to harden at lower temperatures. This temperature viscosity relevance is significant when specifying the performance parameters such as the adhesion, rheology, durability and application temperatures of bitumen. In the Viscosity Grade Bitumen specifications, the most important emphasizes is based on the Bitumen ductility.

ADVANTAGES OF VISCOSITY GRADE BITUMEN

- Viscosity grade bitumen is based on fundamental engineering properties and not on empirical properties. It is a performance based grading system.
- Viscosity grading system takes into account both low and high temperature susceptibility of bitumen.
- Viscosity grade bitumen is very easy to handle as viscosity value at two different temperatures is available, which would enable user to measure accurate mixing and compaction temperatures.
- In order to check the quality of viscosity grade bitumen, we only have to conduct 7 no. of tests. This reduces time and cost of testing.
- The pavements made from VG bitumen will have better performance, because viscosity value at 135°C gives sufficient idea about mixing and compaction temperature ad as a result pavement life is improved.
- Pavements constructed using VG bitumen can take higher traffic load with extreme weather condition.

VISCOSITY GRADE BITUMEN USES

- VG-10 BITUMEN
  VG-10 is mostly used in spraying applications such as surface dressing and Paving in very cold climate instead of 80/100 penetration bitumen grade. It is also used to produce Bitumen Emulsion and Modified Bitumen products.
- VG-20 BITUMEN
  VG-20 is used for paving in cold climate & high altitude regions.
- VG-30 BITUMEN
  VG-30 is especially used to construct extra heavy duty Bitumen pavements that need to tolerate significant traffic loads. It can be used instead of 60/70 penetration bitumen grade.
- VG-40 BITUMEN
  VG-40 is used in highly stressed areas such as intersections, near toll booths and truck parking lots instead of 30/40 penetration grade. Because of higher viscosity, stiffer Bitumen mixes can be produced to amend resistance to shoving and other problems related to higher temperature and heavy traffic loads.

X. LITERATURE REVIEW

A brief outline of different literatures approaches along with few important references is presented in the subsequent paragraphs as follows:

Crumb rubber modified Bitumen

Nabin Rana Magar, (2014) investigates the performance of crumb rubber modified bitumen by varying the sizes of crumb rubber. The test results of common laboratory test on plain bitumen and crumb rubber modified bitumen shows that the penetration values and softening points of plain bitumen can be improved significantly by modifying it with the addition of crumb rubber which is a major environmental pollutant. The best size to be used for crumb rubber modification is suggested as (0.3-0.15mm) size for commercial production of CRMB.

Siddharth Rokade, (2012) The Crumb Rubber was added to 60/70 grade bitumen in varying percentage. The mix was prepared with 5 % bitumen and the varying percentages of Crumb Rubber. The bitumen, when mixed with Crumb Rubber, is termed as Crumb Rubber Modified Bitumen (CRMB). The results observed that the Marshal Stability Value is increased from 4% to 12% Crumb Rubber and then it is decreased 15% of Crumb Rubber of the weight of bitumen is the optimum dose for getting enhanced strength characteristics of the mix.

Nuha S.Mashaan, (2012) In their study presented the application of crumb rubber modifier in the asphalt modification of flexible pavement. From the results of the previous study, it aspires to consider crumb rubber modifier in hot mix asphalt to improve resistance to rutting and

produce pavement with better durability by minimizing the distresses caused in hot mix asphalt pavement. Hence, road user would be ensured of safer and smoother roads.

Mashaan et al, (2011) The penetration is a measure of hardness or softness of bitumen binder which shows an effect by adding crumb rubber to bitumen binder; it decreases as rubber content is increased. The penetration shows lower values as rubber content increases at different mix conditions of rubberized bitumen binder, indicating that the binder becomes stiff and more vicious The softening point refers to the temperature at which the bitumen attains a particular degree of softening. The use of crumb rubber in bitumen modification leads to an increase in the softening point and viscosity as rubber crumb content increases.

Becker et al, (2001) claimed that blend properties will be influenced by the amount of crumb rubber added to the bitumen. Higher amounts indicated significant changes in the blend properties. As rubber content generally increases, it leads to increased viscosity, increased resilience, increased softening point and decreases penetration at 25°C.

Abedlrahman and Carpenter et al, (1999) From the study he determines that the various properties of CRMB vary with blending temperature and blending time. The optimum blending temperature and blending time found out 175ºC and 45 minutes respectively for preparing high-quality CRMB.

MATERIALS, METHODOLOGY AND EQUIPMENT U

The present study envisages the performance of crumb rubber modified bitumen modified bitumen in comparison to virgin bitumen. The chapter gives detail avarious materials used in present study along with its physical, chemical and other properties. To accomplish the objectives of study experimental program was carried various samples.

In accordance to environmental aspect, the use of waste crumb rubber in bitumen way to solve the problem of disposal of bitumen either in land or by burning. Also, rubber is easily available due to large amount of increase of automotives over There is also availability of mica in various states of India like Andhra Pradesh, etc. which make the use of mica to modify bitumen viable.

Materials

In view of the proposed experimental study, the materials used are:

- VG 40 Bitumen
- 25 mesh crumb rubber
- 25 mesh silver mica powder
- Distilled water
- Glycerine
- Diesel

Methodology

The bitumen was prepared to stand out against the minimum specifications as per IS1201 to IS1220:1978 by Bureau of Indian Standards. As the crumb rubber or mica content is increased in the bitumen it became dense. There is variation in the properties of such bitumen. So in order to obtain optimum results, the quantity of crumb rubber or mica is varied accordingly. VG40 grade of bitumen is hence, further modified by preparing numerous samples according to the requirement of the tests which were carried out. The prescribed procedure of various tests according to Indian standards was followed to obtain desired results.

Preparation of sample

In the preparation of modified bitumen sample is prepared in a container , the bitumen is firstly heated to 70°C to 100°C which is the melting point of bitumen and crumb rubber powder (in 3%, 5%,and 7% by weight) or mica (in 35%, 45%, 55% by weight) are added to the melted bitumen. The sample is stirred thoroughly so that no air bubbles are formed.

OBSERVATION

- **For Crumb Rubber**

Sample 1: 3% crumb rubber powder by weight of bitumen

- Weight of empty specific gravity bottle, W1 = 27g
- Weight of bottle + Bitumen, W2 = 40g
- Weight of bottle + Water, W3 = 74g
- Weight of bottle + Water + Bitumen, W4 = 75g

$$Specific.Gravity = \frac{(W_2 - W_1)}{(W_3 - W_1) - (W_4 - W_2)}$$

- Specific Gravity = 1.083

CONCLUSION

Since it is hilly region, design speed of the vehicles cannot exceed 70-80 kmph. Hence, strains on the pavement is more. So, Vg40 which is a better grade bitumen is used. Since there is lot of variation in environment (Temperature, Humidity, ground water table &atmospheric pressure) at the two ends of the road proposed to be constructed thus we need Vg40 to accomplish the above requirements.

ACKNOWLEDGEMENT

We express our deep sense of gratitude to our beloved Er. Khushwace Singh (M.Tech.) Assistant Professor, for his constant guidance, innovation suggestion and warm encouragement throughout the program and preparation of this project. We are grateful to **Dr. Arvind Dewangan, Director- Yogananda College of Engineering & Technology, Jammu** for their support throughout our stay in the college and inspired for publication of our work in an International journal of Engineering Research & Management-IJERM. We would also like to thank our HOD Er. Rajnish Magotra for his valuable suggestions. We are greatly indebted to faculty members of department of Civil Engineering for their encouragement and facilities extended to complete this project. We would like to humble sense of gratitude to **Hon. Chairman Sir- Er. V.S.S Jamwal & Hon. Managing Director-Er. R. Bangroo Madam**, (JGEI) for

providing Lab facilities to accomplished to this minor project work.

REFERENCES

[1] Nuha S. Mashaan*, Asim Hassan Ali, Mohamed RehanKarim and MahrezAbdelaziz "An overview of crumb rubber modified asphalt".International journal of the physical sciences vol. 7(2), pp. 166 - 170, 9 January, 2012.
[2] Nuha S. Mashaan, Asim Hassan Ali, Mohamed RehanKarim and MahrezAbdelaziz."Effect of blending time and crumb rubber content on compacting-properties of crumb rubber modified asphalt binder" international journal of the physical sciences doi: vol. 6(9), pp. 2189-2193, 4 may, 2011.
[3] Shankar (2009) "Use of Waste Rubber Tyre in Flexible Pavement", International Journal of Application or Innovation in Engineering and Management. Vasudevan, R et.al," Utilization of crumb rubber for flexible pavement and easy disposal of crumb rubber"
[4] http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.633.1739&rep=rep1&type=pdf
[5] https://www.mapsofindia.com/answers/india/state-largest-mica-producer/
[6] https://www.ijirset.com/upload/2015/december/167_Influence.pdf
[7] http://shodhganga.inflibnet.ac.in/bitstream/10603/6226/9/09_chapter%204.pdf
[8] http://www.iran-bitumen.com/bitumen-vg40/
[9] Highway material and testing Khanna and Justo
[10] Google
[11] Wikipedia
[12] www.answer.com
[13] 15.http://www.thehindu.com/business/Turning-waste-tyre-into-'greensteel'/article14518524.ece