Experimental Study on Determination and Extraction of Heat from the Surface of Flexible Pavement by Addition of Graphene

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Abstract— Flexible pavements and climate are interactive. Pavements are climate sensitive infrastructure, where climate can impact their deterioration rate, subsequent maintenance, and life cycle costs. This paper reports an extensive literature search on qualitative and quantitative pavement research related to climate change in recent years. The topic covers about the measurement of heat from the surface of the pavement and increase the temperature by the addition of Graphene. Current pavement design and life cycle management practices may need to be modified to adopt for changing climates and to reduce environmental impacts. This paper is useful for those who aim to understand the climate resilience of flexible pavements.

Keywords: Flexible Pavement, Graphene

I. INTRODUCTION

A. Flexible Pavement:

Flexible pavement can be defined as the one consisting of a mixture of asphaltic or bituminous material and aggregates placed on a bed of compacted granular material of appropriate quality in layers over the subgrade. Water bound macadam roads and stabilized soil roads with or without asphaltic toppings are examples of flexible pavements. The design of flexible pavement is based on the principle that for a load of any magnitude, the intensity of a load diminishes as the load is transmitted downwards from the surface by virtue of spreading over an increasingly larger area, by carrying it deep enough into the ground through successive layers of granular material.

B. Graphene:

It is an allotrope of carbon in the form of a single layer of atoms in a two dimensional hexagonal lattice in which one atom forms each vertex. It is the basic structural element of other allotropes, including graphite, charcoal, carbon nanotubes and fullerenes. It can also be considered as an indefinitely large aromatic molecule, the ultimate case of the family of flat polycyclic aromatic hydrocarbons

II. LITERATURE REVIEW

Shaopeng Wu et al. reported on the use of energy from heated pavements to produce electricity and at the same time lower pavement temperature during summer time with graphite as contents in middle layer, the temperature of asphalt slabs on the surface (5mm) decreases slightly while decrease significantly at depth of 50 to 75mm. The temperature change is more obvious inside the asphalt layer than that on the surface.

Bharathi B et al. reported on the Performance of bituminous graphene mixes is enhanced. Measurement of heat entrapped on the pavement surface. Extraction of heat from the surface of pavement thereby harnessing the natural Solar Energy and can be transformed to other forms

Mallick et al. The concept of extracting heat energy from asphalt pavements has been investigated in this study. Water flowing through copper tubes inserted within asphalt pavements samples were used as heat exchangers in the experiments. The rise in temperature of water as a result of flow through the asphalt pavement was used as the indicator of efficiency of heat capture. The results of small scale testing show that the use of aggregates with high conductivity can significantly enhance the efficiency of heat capture. The efficiency can also be improved by using a reflectivity reducing and absorptivity increasing top layer over the pavement.

Dawson et al. This paper considers extending the role of asphalt concrete pavements to become solar heat collectors and storage systems. The majority of the construction cost is already procured for such pavements and only marginal additional costs are likely to be incurred to add the necessary thermal features. Therefore, asphalt concrete pavements that incorporate aggregates and additives such as limestone, quartzite, lightweight aggregate, copper slag, and copper fibre are designed to make them more conductive, or more insulative, or to enable them to store more heat energy.

III. OBJECTIVE

- Determination of amount of heat on the surface of the flexible pavement.
- Performance evaluation of flexible pavement on addition of Graphene.
- Extraction of heat from Flexible pavement by using sensors.

IV. MATERIALS

A. Bituminous Macadam:

Consists of combination of mineral aggregate with bituminous binder ranging from inexpensive surface treatment ¼ in or less thick to asphaltic concrete. For good service throughout the full life bituminous pavement must retain following qualities.

- Freedom from cracking or ravelling.
- Resistance to weather including the effect of surface water heat and cold.
- Resistance to internal moisture, particularly to water vapours.
- Tight impermeable surface or porous surface (if either is needed for contained stability of underlying base or subgrade).
- Smooth riding and non-skidding surface.

B. Graphene

Graphene is an allotrope (form) of carbon consisting of a single layer of carbon atoms arranged in a hexagonal lattice. It is the basic structural element of many other allotropes of carbon, such as graphite, charcoal, carbon nanotubes and fullerenes.

Properties of Graphene:

- It is one atom thick
- Conducts electricity better than silver
- Conducts heat better than diamond
- Two times harder than diamond

C. LM35 Temperature Sensor Applications

- Measuring temperature of a particular environment
- Providing thermal shut down for a circuit/component
- Monitoring Battery Temperature
- Measuring Temperatures for HVAC applications.

Pin Configuration:

Pin Number	Pin Name	Description
1	Vcc	Input voltage is +5V for typical applications
2	Analog Out	There will be increase in 10Mv for raise of every 1°C. Range from -1V to 6V
3	Ground	Connected to ground of circuit

V. METHODOLOGY

Impact Test	32.4 %
Crushing Test	18.36 %
Abrasion Test	23.6 %
ShapeTest: 1. Flakiness	12.4 %
2. Elongation	11.6 %

Table 1: Test Results on Aggregate

SL NO.	TEST NAME	TRIAL 1	TRIAL 2	TRIAL 3	AVERAGE
1	PENETRATION	62 mm	55 mm	42 mm	54 mm
2	DUCTILITY TEST	75cm	78 cm	77 cm	77 cm
3	SOFTENING POINT TEST	57 ^{0}C	58 ^{0}C	57.5 ^{0}C	57.5 ^{0}C
4	VISCOSITY TEST	-	-	-	(70-80 sec)

Table 2: Test Results on Bitumen

SL NO.	SIZE OF AGGREGATE (mm)	PERCENTAGE (%) USED
1	19	10
2	13.2	32
3	4.75	25
4	2.36	17
5	0.3	8
6	0.075	8
Bitumen Percentage (%)		3.4

Table 3: Aggregate Grading

% of Bitumen	voids in Bitumen (VFB)
3.5	62.69
3.8	62.85
4	63.7

Table 4: Percentage of Air voids in Bitumen

VI. MARSHALL MIX DESIGN:

The mix design determines the optimum bitumen content. This is preceded by the dry mix design.

The Marshall Stability and flow test provides the performance prediction measure for the Marshall Mix design method.

% of Bitumen	voids in Bitumen (VFB)
3.5	62.69
3.8	62.85
4	63.7

Table 5: Percentage of air voids in bitumen

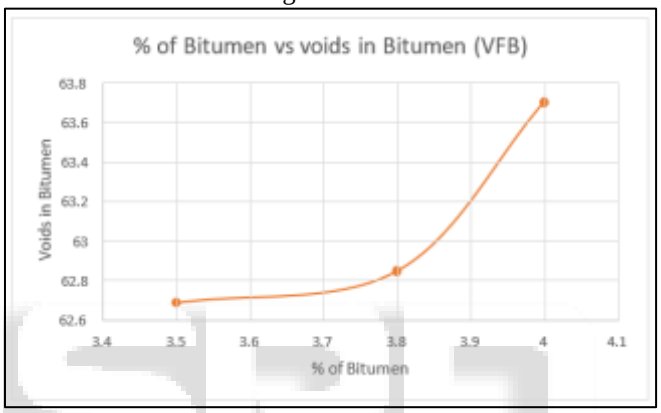

Fig. 1: Percentage of bitumen vs voids in bitumen

% of Bitumen	Air voids
3.5	5.57
3.8	5.51
4	5.31

Table 6: Percentage of air voids

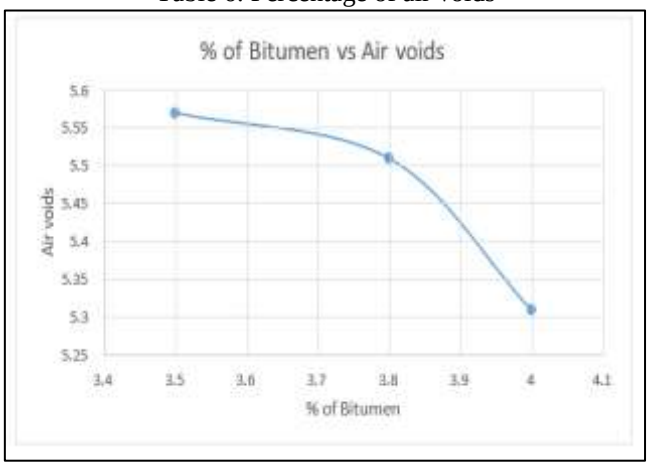

Fig. 2: Percentage of Bitumen Vs Air voids

% of bitumen	voids in aggregate (VMA)
3.5	14.93
3.8	14.83
4	14.63

Table 7: Percentage of voids in aggregates

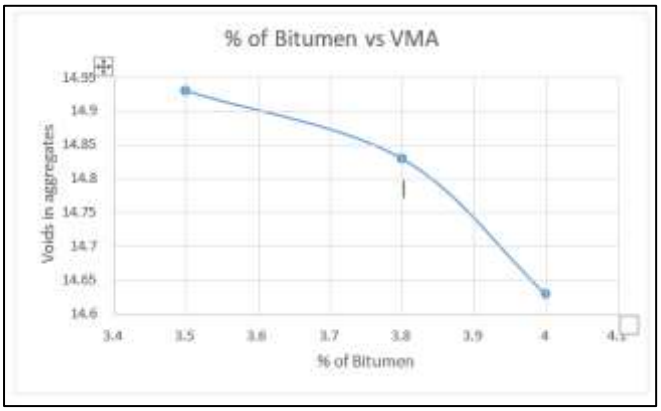

Fig. 3: Percentage of Bitumen vs Voids in aggregates

VII. CONCLUSION

- Crushing strength less than 45% non-wearing course.
- Abrasion value for the selected aggregates is 23.3% which can be used for surface course of flexible pavement.
- The Impact value of selected aggregate of 32.4% which can be used for construction of flexible pavement.
- Flakiness and Elongation index of the selected sample of aggregate is 12.4% and 11.6% respectively hence can be used for construction of flexible pavement.
- Penetration value of the selected Bitumen of grade VG-30 is 54mm and hence it can be used for surface course.
- Ductility value of the selected Bitumen of grade VG-30 is 77mm and hence it can be used for surface course.
- Softening point of the selected Bitumen of grade VG-30 is 57˚c and therefore it can be used for surface course.
- Viscosity of the selected bitumen is 75sec and hence can be used for surface course.
- If graphene is added to bitumen by 0.015%, the temperature is observed to increase by 20-25%
- If graphene is added to bitumen by 0.025%, the temperature is observed to increase by 25-30%
- If graphene is added to bitumen by 0.035%, the temperature is observed to increase by 30-35%

REFERENCES

[1] Shaopeng Wu et al. "Laboratory Study on Solar Collector of Thermal Conductive Asphalt Concrete" ISSN 1997-1400 Int. J. Pavement Res. Technol. 2(4):130-136 Copyright @ Chinese Society of Pavement
[2] Bharathi B et al. "Performance Evaluation & Measurement of Heat from the Bituminous Surface by the Addition of Graphene" IJSRD - International Journal for Scientific Research & Development| Vol. 6, Issue 04, 2018 | ISSN (online): 2321-0613
[3] Rajib B Mallick et al. "Capturing Solar Energy from Asphalt Pavements" ISAP 2008 Article · January 2008
[4] Dawson et al. Sources; Patent data: Graphene Patent Landscape dataset Cambridge IP (January 2013); Journal article data, Global Research Report, Material Science and Technology, Thompson Reuters (2011)

