Self Healing Asphalt by Using Steel Fibers

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Abstract: **The cracks are produced on rode due to heavy load by using steel wool fiber cracks will be healed. Microwave technology is considered as an alternative technique to promote self-healing of asphalt mixtures with cracks will be heated filled metallic fibers. It is well known that steel wool fibers can also be used in order to modify the mechanical, electrical and thermal properties of asphalt mixtures.The use of Self-Healing Asphalt in practice is possible. It can be a solution for areas with dense traffic and with a strong need for noise reduction. Even the first experiments of a healing action have taken place.The development of such areas of self-healing technology for asphalt pavements will truly revolutionize asphalt pavement design. This will also lead to another evolutionary step in road construction and design and bring the idea of self-healing roads from science fiction to reality. Adding steel fibers to asphalt ensures that once it is worn out and cracks/potholes appear, it only needs repair. Iron molecules are heated remotely by introducing a fast-changing magnetic field. Once heated by induction, the steel fibers immediately release heat to the mortar, which melts briefly. This causes the asphalt to reset to its original structure. An induction machine is used in the repair in a process called guiding. There is little loss of energy since it travels directly between the steel fibers and mortar – where the cracks form. Additionally, the entire surface needs not be heated, only the part where cracks form. In two to three induction regimes, the lifespan of the asphalt is prolonged up to 20 years from the present 10 to 12 years.**

***Keywords*: Self-healing, Asphalt mixture, Steel fibers, Microwave.**

I. INTRODUCTION

The worldwide use of asphalt pavement and its requirement for maintenance have urged the road agencies to increase their budget. The increased budget to keep roads safe and serving efficiently without flaws could not be reached in most countries. In the India currently spends only 0.8% of its GDP on research. This need to immediately go up to at least 2%. India has come to second largest road network in the world. This issue has brought the idea of the construction of long-lasting pavements
The self-repair phenomenon, which is a natural property in bituminous materials that help heal damages by themselves without external intrusion. This phenomenon is inherent in asphalt materials that can be used as an alternative to asphalt maintenance. This can hugely decrease maintenance expenses, besides extending the service life of highways and eventually promote the environment by decreasing the emissions from slowed vehicles. Self-repair is an intrinsic property that happens due to the diffused molecules between the crack sides. In this way, it prevents the discontinuity of the cracked material. Some recent research papers studied this phenomenon mainly based on the mechanical reactions of asphalt pavements. Mechanically evaluated tests are able to quantify the macroscopic recovery of the damage. However, it is believed that not all damage recoveries are attributed to self-repair because of the viscoelastic responses. found that viscoelastic responses could recover damages in asphalt pavement mechanically similar to that of self-repair during the rest period. Therefore, it is crucial to present all these fundamental concepts and suggest relevant methods that can maximize the self-repair of asphalt material. In this research paper we have focus on bituminous road using fiber however, itmakes repair crack in any road by self-healing using steel fibers.

II. LITERATURE REVIEW

2.1 Self-Healing Asphalt Review: From Idea to Practice

Shi Xu Alvaro García JunfengSuQuantao Liu Amir Tabaković Erik Schlangen researchers have revealed the great healing potential of asphalt and proposed various novel methods to inspire and improve the self-healing capacity of asphalt aimed to prolong the service life of asphalt pavement. In this review, up to date research progresses in induction healing and embedded rejuvenator encapsulation are presented, respectively. Meanwhile, the trial section applications of induction healing and capsule healing are highlighted, which show promising results. Finally, some recommendations for the future development of self-healing asphalt are proposed.

2.2 To Study Self-Healing of Road Binding Material by Micro Capsulation and its Implementation on Durable Pavement

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In this paper, an overview of the advances in findings regarding the study of the self-healing mechanism in the bituminous binder with emphasis on its implication in the durability of the asphaltic pavements is presented. The pavement losses its strength, durability and required level of performance due to fatigue failure of the asphaltic layers under the repeated cycles of traffic loading, temperature

extremities, environmental factors such as moisture, rainfall etc.

III. EXPERIMENTAL METHOD

3.1 Materials

In the present study, the materials used were bitumen of VG 30 grade and aggregate of specific gravity 2.60. aggregate, asphalt, stone dust, steel fiber quantity is enlisted in table 1. 10 mmaggregate, 6 mm grit,stone dust, steel fiber diameter 1mm length 60 mm.

Table 1

Materials	
Bitumen Concrete	1200 gm
Fine Aggregate	70% (840 gm)
Stone Dust	25% (300 gm)
Bitumen	5% (60 gm)
Steel fiber (volume of bitumen)	2% (1.2 gm)

3.2 specimen preparation

To manufacture Marshall specimens, the materials were manually mixed into a metallic bowl at a constant rate of 100 rpm. Previous to mixing process, aggregates were heated at a temperature of 150°C during 24h, while bitumen and steel fibers were heated at the same temperature but during 2h. Therefore, the materials were added into the bowl in the following order: first, bitumen and fibers; second, coarse aggregate; third, fine aggregate and finally, filler. All materials were mixed during approximately 3.5min at a constant temperature of 150°C into the bowl. After the mixing process all materials were put into a Marshall mould with a diameter of 10cm and height of 6 cm and then compacted applying 75 blows on each side of the specimen with a Marshall Hammer. After compaction and cooling of the specimens to ambient temperature, Marshall specimens were mechanically extracted from the mould. Finally, Marshall Specimens of asphalt mixture type were manufacture.

Figure 1: Marshall stability

Figure 2: Marshall stability mould

IV. TEST METHODS

4.1 Microwave heating:

With the purpose of proving that asphalt mixtures with and without fibrescan be heated usingmicrowave radiation, 2 Marshall specimens were cut into halves through their flat sides andthen heated into a microwave oven during 6 different heating times (20s, 40s, 60s, 80s, 100s,and 120s), starting the test at an initial temperature of approximately 20°C. Surfacetemperature variation on the samples was measured using an infrared camera of 640x480pixels, contrasting these measurements with an infrared thermometer. Finally, in order to heatthe mixture, the used microwave oven used in this study had an output of 1150W and a 230V,50Hz power supply. The oven can produce microwaves of up to 700W, with a work frequency of 2.45GHz, which corresponds to an approximate wavelength of 120mm.

Figure 3: Mould without steel fiber

figure 4: Mould with steel fibers

4.2 Healing process

For healing process, we create specimen of 10cm diameter and 7cm height of mould and then we develop micro crack using Marshall's stability test machine. After developing micro crack healing process is done on this specimen. Microwave oven used in this study had an output of 1150W and a 230V, 50Hz power supply. In this microwave specimen is heated for 20 second and then for 5 minutes rest on normal

room tempermature this is complete one healing cycle and in this healing process five healing cycle is done on specimen after this process we can see that crack is healed. After healing process specimen's Marshall's stability test is done after 24 hours in normal room temperature for the find out the stability is regain and it's normal strength is also regain.

V. RESULTS AND DISCUSSION

Specific gravity and water observation

The specific gravity of aggregate normally used in road construction ranges from about 2.5 to 2.9. Water observation values ranges from 0.1 to 2.0 present for aggregate normally used in surfacing

Table 1. Test on Aggregate

Properties	Observation Result	MORTH Specification
Flakiness Index (IS 2386 part)	12.06%	Max. 30%
Elongation Index (IS 2386 part 1)	14%	Max. 30%
Combined Index	28.05%	Max. 30%
Aggregate Impact Value (IS 2386 part IV)	23.60%	Max. 30%
Abrasion value (IS 2386 Part IV)	21.30%	Max. 30%
Specific Gravity	2.7	

Table 2. Test on Bitumen

Properties	Observation Result
Penetration (IS 1203-1978)	65.00
Specific gravity (IS 1203-1978)	Min. 0.99
Ductility (IS 12032-1978)	40cm
Softening point (IS 1203-1978)	47 Degree Celsius

5.1 Marshall stability test

Loading Machine: It is provided with a gear system to lift the upward direction. Pre-calibrated proving ring of 5 tones. capacity is fixed on the upper end of the machine, specimen contained in the test head is placed in between the base and the proving ringthe load jack produces a uniform vertical moment of 5 cm per minute. Machine is capable of reversing its moment downward also. This facilitates adequate space for placing test head system after one specimen has been tested. Flow meter consist of guide, sieve and gauge. The activating pin of the gauge slides inside the guide sleeve with a slight amount of frictional resistance. Least count of 0.025 mm is adequate. The flow value refers to the total vertical upward movement from the initial position at zero load to value at maximum load. The dial gauge of the flow meter should be able to measure accurately the total vertical moment upward.

Material quantity:

Total Wight of cube – 1200GM

Fine Aggregate – 840GM (70%)

Stone Dust - 300GM (25%)

Bitumen – 60GM (%)

Steel Fiber (volume of Bitumen) – 1.2GM (2%)

Table 3. Stability of Asphalt mould before Healing:

Sample	Stability with out Steel (kg)	With steel fiber (kg)
1.	3161.1 kg	3302.18 kg
2.	3418.4 kg	3584.84 kg
3.	2840.08 kg	2984.64 kg
4.	3518 kg	3796.95 kg
5.	3168 kg	3289.1 kg

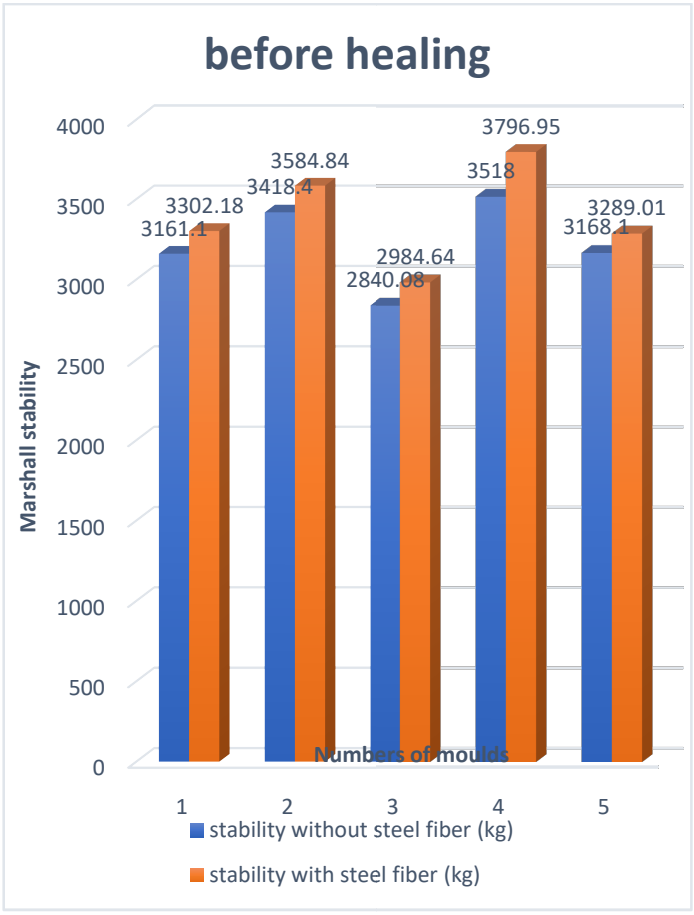

Figure 5: Marshall stability graph

Table 4. Stability of Asphalt mouldAfter Healing

sample	Stability of Asphalt Without steel Fiber (kg)	Stability With steel Fiber (kg)
1.	2725.8 kg	3436.94 kg
2.	2858.2 kg	3639.08 kg
3.	2625.7 kg	3035.02 kg
4.	3123.13 kg	3856.25 kg
5.	3061.25 kg	3489.38 kg

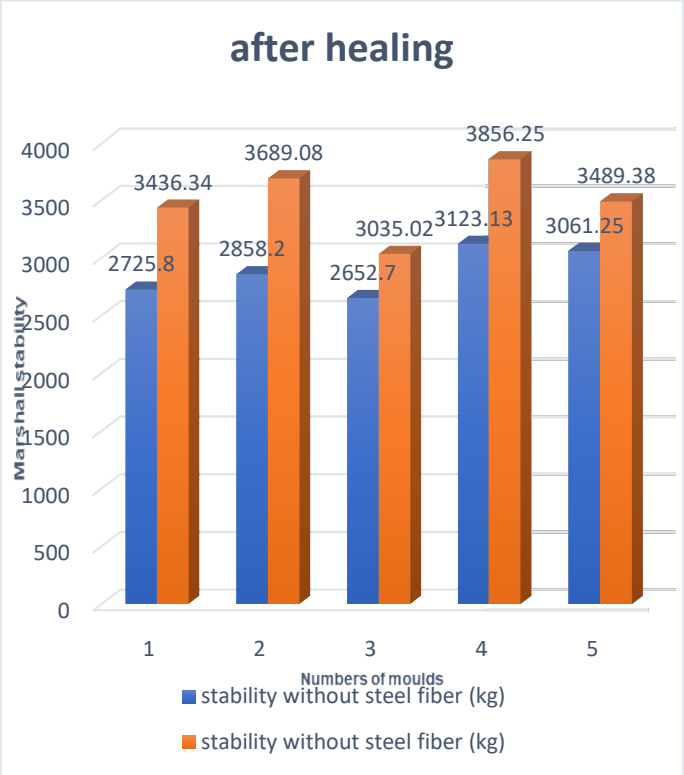

Figure 6: Marshall stability graph

As shown in graph specimen without adding steel fibers stability is decreases and with adding steel fibers stability is increases after developing crack on the specimen. And also if we add steel fibers specimen's stability is increases.

VI. CONCLUSION

The aim of developing an asphalt pavement with self-healing properties via microwave heating, it is recommended to add 2% of fibers byvolume of bitumen, to obtain a mixture with a healing level over 80% for the first five healing cycles and with mechanical resistance slightly higher thanthat of a reference asphalt pavement without fibers.

The induction that cures asphalt. The microwave oven used in the laboratory heats up the steel wool, which melts the bitumen and binds everything together again.

So the question now is whether what is applied in a laboratory environment can be transferred to the real world.

For the real world we can develop special vehicle which carries induction coils over the road, performing the heating function. This machine would have to be used every three to four years to repair small damages and prevent the appearance of potholes, thus extending road life.

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