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Healing Of Asphaltic Road by Adding Conductive Material

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Abstract: *This paper represents review on Healing of asphaltic road by adding conductive material.Asphalt with steel fibre for crack repair and self-healing roads using induction heating deals with the experimental and implementation of newly developed method of crack repair using induction heating and conductive materials. Cracks or potholes may develop in the road due to heavy traffic load and environmental conditions. So the new method to selfheal this crack and to treat pothole is put forward. This study will assess the properties related with steel fibre induced asphalt. The main objective of these study is to give the appropriate method to treat potholes or cracks.*
Keywords: *Induction heating, self-healing asphalt, steel fibre, bitumen, pothole and crack repair.*

I. Introduction

Asphalt concrete is one of the most common type of pavement surface material used in the highway roads in the world. It is a material that consists of a mixture of asphalt binder like bitumen, aggregate particles and air voids. This material must resist in good conditions in all traffic loads under many different climatic or weathering conditions for a long time. In order to maintain these characteristics of asphalt raods during its lifetime, asphalt concrete wearing courses should be constantly maintained and repaired. Little cracking on a highway roads and runway can mean the start of large distress. It is theoretically feasible to healing of asphalt road by induction heating mastic through the addition of different types of conductive fibres and fillers. The objective of this research is to investigate how to repair cracks in mastic asphalt heating through the addition of different volumes of electrically conductive particles. The idea is to use this electrically conductive asphalt concrete mixture for healing purposes in the future by using induction heating and microwave heating.
An ideal pothole or crack repair method should be:

- Readily available to be used in any climatic condition.
- Produce a patch of comparable quality and durability to the original road material.
- Minimize traffic disruption.
- It should have comfortable as well as low life-cost to current asphalt patching methods.

The properties generally required more importance in pothole repair materials are traffic loading,good workability, environmental durability, cohesion, and bonding. To accomplish these properties , there is a wide range of techniques, procedures, pothole repair methods and materials. These are hot mix asphalt, cold mix asphalt and other synthetic or polymeric materials or resins. In general, it is commonly accepted material hot mix asphalt, the combination of aggregates and bitumen, gives the good quality of maintainance and repairs, although it has limited applicability due to minimum mixing batches requirements and laying temperature constraints.

Furthermore, induction heating is another roads repair method. Induction energy heats the metallic fibres in asphalt concrete by means of high frequency alternating electromagnetic fields, able to induce eddy currents in materials that are electrically and magnetically susceptible. In other words it is a technique that consists in heating electrically conductive particles, for example steel wool fibres, previously mixed into asphalt.


Fig.01-Low Carbon Steel Fiber **Fig.02-**Steel Wool Fiber

II. Literature Review

Mohammad M. Karimi, Masoud K. Darabi et al. (29 Jan 2019) [1]:In this paper research on Effect of steel wool fibers on mechanical and induction heating response of conductive asphalt concrete was done.This study was characterises the mechanical, rheological, induced heating, and induced healing behaviour of asphalt concrete containing steel wool fibers (SWFs) as the conductive material.Induced heating of asphalt concrete through the electromagnetic field is a latest method to heal the damages induced in asphalt concrete. Previous studies in highway engineering used high contents of the SWF as the conductive material to improve the sensitivity of the asphalt concrete by the electromagnetic radiations. Experimental tests conducted in that study (e.g. uniaxial strength, indirect tension, semi-circular bending tests) show that the addition of 0.2% by weight SWF meets both the heating and healing requirements. The relatively low amount of content of SWF resulted in considerably less adverse effects on the mechanical and rheological properties of asphalt concrete comparing to higher percentages of SWF (e.g. 1.5% by weight of SWF). Tests conducted on different specimen sizes of asphalt concrete reveal substantial effects of specimen dimension on the heating rate that should be considered in the evaluation of asphalt concrete induction heating under electromagnetic radiation. In addition, it was shown that using 0.2% by weight SWF significantly reduces the effect of corrosion on induced heating of conductive asphalt concrete materials like steel fibre. Experimental results demonstrate that the tensile strength ratio decreases from 25% for 1.5% SWF to 7% for 0.2% SWF.

Haopeng Wang, Yuan Zhang, et al.(4 Jan 2019) [2]: In this paper Laboratory and Numerical Investigation of Microwave Heating Properties of Asphalt Mixture was demonstrated. Microwave heating was an incentive heating technology for the maintenance, recycling, and deicing of asphalt pavement. To investigate the microwave heating properties and characteristics of asphalt mixture, laboratory tests and numerical simulations were done and compared. There were Two types of mixture samples of Stone Mastic Asphalt (with basalt aggregates and steel slag aggregates) were heated using a microwave oven for different times. In asphalt mixture Numerical simulation models of microwave heating of the mixture were developed with finite element software COMSOL Multiphysics. The thermal and electromagnetic properties of asphalt mixture, served as the model input parameters, were measured through many laboratory tests. Both numerical simulated and laboratory-measured surface temperatures were recorded and analysed.By replacement of basalt aggregates with steel slag aggregates resulted that significant increase in the microwave heating efficiency of asphalt mixture. There was good correlation of Numerical simulation results with laboratory test results. It was feasible to use the developed model coupling electromagnetic waves with heat transfer to simulate the microwave heating process of asphalt mixture.

Carlos J. Slebi-Acevedo, Pedro Lastra-González (23 Dec 2018) [3]: The use of fibers in hot mix asphalt (HMA) had became a much more attractive alternative for the construction of road pavements. Numerous studies had shown that the incorporation of fibers in the asphalt mixture improves fatigue resistance, permanent deformation and stiffness. The aim of this paper was that a review of the mechanical impact of fibers in hot mix asphalt by analyzing their reinforcement effect in a qualitative and quantitative manner. Fiber properties and characterization tests on fiber-modified bitumen was discussed. Quantities, blending procedures and performance of bituminous mixtures with different types of fibers were presented. Results of mechanical improvement were displayed. on the basis of latest research results obtained, depending on the properties and the type of mixture in which they were used, each type of fiber was seems to improve certain parameters more than others. Coconut fibers and waste fibers were described as environmentally friendly alternatives.

Jiusu Li, Jianfang Liu et. al.: (21 Dec 2018) [4]: Asphalt pavements maintenance was a critical infrastructure issue. This paper reported on a high thermal conductivity asphalt pavement mastic and mixture. Thermal asphalt mortar (ThAM) produced with asphalt, silicon-carbide (SiC) powder in the presence, and absence, of styrene-butadiene styrene (SBS), was evaluated. Optimal SBS and SiC proportions were determined by optimization and the balance of viscosity, ductility, and temperature stability. The results indicated that styrene-butadiene styrene and silicon-carbide optimum contents were 5% and 10%, respectively. The corresponding penetration (25 C), ductility (5 C), and softening point were 44 dmm, 380 mm and 78 C, respectively. Heat absorption rates for both traditional asphalt (TrA) and thermal asphalt (ThA) were tested and compared. It was shows that temperature differences up to 30 C. Two types of thermal asphalt concrete (ThAC), blending with or without iron powder, were prepared. The performance of ThAC was systematically evaluated. The dynamic stability of sample achieved 5872 times/mm, whereas the low temperature bending stiffness modulus of sample was 5505 MPa, indicated that both the rutting resistance and cracking resistance was favorable. The most unfavorable load position was analysed by using a node tracking method, Bond strength was five times greater than the maximum shear stress. Then ThAC and TrA mix thermal conductivities were compared. ThAC thermal conductivity was 19.642 W/mK, which was four times of thermal conductivity TrA mix.

Esther Lizasoain-Arteaga,IruneIndacoechea-Vega (21 Oct 2018) [5] : This paper was demonstrates the sustainability of induction-healed asphalt mixtures (Healroad) by comparing the impacts, this technology causes with those generated by asphalt mixtures maintained by conventional practices such as mill and overlay. The functional unit selected was a 1 km lane with an analysis period of 30 years, and the stages considered were production, construction, maintenance, congestion, leaching and end-of-life. Two case studies had analysed to evaluate the influence of different traffic strategies on the environmental impact of each maintenance alternative. Results was show the benefits of using the induction technology at hot points where traffic jams occur.

Jiuming Wan, Yue Xiao,et al. (9 Aug 2018) [6]: Ultra-thin wearing course (UTWC) had developed in pavement preventive maintenance for many years. However, how to prolong the service life of UTWC still requires further investigation and research. That study introduced AC-5 and SMA-5 asphalt mixtures, which could induction heated. Steel slag and steel fiber were used in the mixtures as additives. Induction heating and Marshall Stability property of mixtures were characterized. In addition,self-healing property of UTWC materials had emphatically conducted. Addition of steel fiber in mixtures led to higher Marshall Stability and lower flow value, while steel slag normally showed a negative effect. Induction heating property of UTWC materials showed a positive relationship with the additives. Induction heating time was positively correlated to the healing ratio of the asphalt mixtures. Induction heating on the mixtures could recover the strength of aspalt mixtures to a certain degree. The Mixtures with more steel fiber showed a higher healing ratio.Healing ratio of Basalt-steel slag based mixtures was greater than the basalt based mixtures. As the healing cycle increased the healing ratios of mixtures decreased.

Doo-YeolYoo, SoonhoKima et al. (2 July 2018) [7]:This study was interrogated in asphalt concrete the effect of carbon-based materials, i.e., carbon fibers (CFs), carbon nanotubes (CNTs), and graphite nanofibers (GNFs), on the selfhealing and mechanical properties of asphalt concrete. For that, 0.5% CF, CNT, and GNF, and 1.0% CF were incorporated, and also plain asphalt concrete was considered for comparison. The selfhealing capability of asphalt concrete was evaluated based on induction heating and was quantitatively examined by comparing the flexural strengths of virgin and healed specimens. The test results indicated that adding the carbon nanomaterials, i.e., CNTs and GNFs, was more impressive in improving the Marshall stability, indirect tensile strength, dynamic stability, and reducing the porosity, compared to adding macro CFs. However, the flexural performance of asphalt concrete was more efficiently improved by adding the CFs relative to CNTs and GNFs. Asphalt concrete specimens those completely failed under flexure were partially self-healed using induction heating due to the incorporated carbon materials. The best healing capability, i.e., 40% recovery of the actual flexural strength, was obtained for the specimens with 0.5% GNFs and CFs.

QuantaoLiu,Cheng Chen et al (29 May 2018) [8]:This paper was interrogated the heating characteristics and properties and induced healing efficiencies of asphalt mixture containing steel fiber under induction heating . The heating properties of an asphalt mixture with different heating methods were studied with an infrared camera. The healing performance of the asphalt mixture specimens in conditions of different healing were investigated by observing and testing the fracture resistance recovery and crack closure after healing. The results shows that the heating speed at the surface of asphalt mixture with microwave machine heating was much lower than that with induction heating, under a similar output power and the same method of radiation, microwave heating resulted in a more uniform temperature distribution. The effective heating depth of microwave heating was much higher than that of. Gradient healing takes place within the sample heated with induction healing, while a uniform healing effect could achieved with microwave heating.

YashwanthPamulapati, Mostafa A et al.(Aug 2017) [9]:While healing of asphalt pavements through induction heating is a promising technology, the effectiveness of this approach is yet to be demonstrated. In addition, limited studies have been conducted to study the recovery of cracking damage and fracture resistance properties after healing. The objective of that study was to found out or test the hypothesis, a new types of asphaltic materials could be artificially healed in service condition by embedding metallic fibers in the asphalt concrete mix and by applying an electromagnetic field at the surface. To achieve that objective, an open-graded friction course was designed and prepared to incorporate up to 5% aluminium and steel fibers by weight of the mix.Based on the study results, it was found that the control mix and the mix prepared with aluminum fibers exhibited greater ultimate load at failure prior to healing than the specimens with steel fibers. The induction heating experiment was conducted successfully and shows that the the feasibility of inducing Eddy current in the metallic fibers in the mix without contact to the specimens. After healing, the control mix had the highest ultimate load although it was not successfully heated through Eddy current. This indicates that other healing mechanism was present during to the recovery period,which allowed the control specimens to heal during the rest period. Healing efficiency was the much more for the control specimen as it approached 85%. Healing efficiency of the specimen with aluminum and steel fibers was 72% and 62% respectively. Microscopic image analysis confirmed that induced cracks healed efficiently during the recovery period.

MehrdadMasoumi, Sayyed Mahdi Hejazi, et al. (Jan 2017) [10]:Using fibers to reinforce bitumen is relatively a innovative method to enhance mechanical properties of asphalt concrete (AC). Economical competitive merits, ease of use and enhancement of physical and mechanical properties was the benefits of reinforcing AC with fibers in comparison with other modifiers, e.g. polymers, synthetic fibres. This paper investigates the adhesion in between aggregates and fiber-reinforced bitumen. This concept had been described in two parts including theoretical and experimental sections. In the former section, pull-out force of aggregate through fiber-reinforced bitumen had been modelled by using "force-equilibrium method" and "slippage theory of short fiber composites". Therefore, the adhesion force between aggregate and fiber-reinforced bitumen was achieved based on fiber parameters. In the later , polypropylene (PP) and polyester (PET) fibers of 12 mm length, at fiber content of 0.1%, 0.2% and 0.3% were used for reinforcing bitumen. Both of lime and quartz aggregates were considered in the experimental design. Consequently, the Instron tensile tester was modified to perform pull-out tests. Pull-out test measured the force required to pull-out the aggregate through the bitumen and/or fiber-reinforced bitumen. The experimental results of the tests showed that the proposed model could predict the pull-out force of fiber-reinforced bitumen samples.

P. Apostolidis, X. Liu,et al. (Sept 2016) [11]:The development of asphalt mixes with improved electrical and thermal properties was critical in terms of generating induction healed mixes. This paper was studied the induction healing capacity of asphalt mixes without aggregates was part of asphalt concrete where inductive particles were dispersed especially contributing to the final response of asphaltic pavements. Special attention was given to the characterization of inductive asphalt mixes using numerical methods and experimental techniques. The research reported in this paper was divided into two parts. In first part, the impact of iron powder as filler-sized inductive particle on the rheological performance of asphalt-filler systems was studied. The mechanical response, the healing capacity and induction heating of asphalt mortar by adding iron powder and steel fibres was evaluated. In the second part, the utilization of advanced finite element analyses for the assessment of the induction heating potential of inductive asphalt mortar with steel fibres were presented. The influential factors of induction mechanism in asphalt mixes was also described. The numerical and experimental findings of this research provided an optimization method for the design of induction healed asphalt concrete mixes.

José Norambuena-Contreras , José L.Concha (August 2016) [12]:This paper was provides a novel set of laboratory results of a research about the development of a fibre-reinforced asphalt mixture with self-healing characteristics by microwave heating technique. Microwave technology was considered as an alternative technique to stimulate self-healing of asphalt mixtures with metallic fibres. It was well known that steel wool fibres could also used in order to modify the mechanical, thermal and electrical properties of asphalt mixtures. However, it was not clear that what was the optimum fibre amount required in order to an improvement on the mechanical behaviour and healing by microwave heating of mixtures. For those reasons, different mechanical and thermo physical properties of fibre-reinforced dense asphalt mixture had studied in this research. Main results showed that fibres dispersed very well in the dense mixture, although mixtures with high fibre contents may cause formation of clusters. It was found that fibres did not significantly enhance the mechanical behaviour of dense asphalt mixture. However, the fibres in asphalt mixture increased the electrical conductivity but reduced the thermal conductivity of asphalt mixtures.Finally, it was proved that the crack healing in asphalt mixtures by means of microwave heating is possible.

Aniruddh and ParveenBerwal (July 2016) [13]:One of the innovative technique of improvement in bitumen concrete surface taken into practices all over the world is addition of steel fibres in it. The role of asphalt concrete mixes with steel fibre used in different proportions (2%,2.5%,3%,4%,& 5% with 11 mm and 18 mm length was studied by conducting Marshall Stability Test of Bituminous Mixes.The results had notice that the considerable improvement in stability of bitumen concrete was at an optimum percentage of added steel fibre for bitumen concrete in amount of 11 mm long steel fibre 3.5 % in amount. . Therefore these fibre content had recommended for making improvements in parameter of Bituminous Mixes.

Mostafa Elseifi, Ph.D, Yashwanth Pamulapati et al. (June 2016) [14]: The aim of this study was to recognised the hypothesis that a modern types of asphaltic materials could be artificially healed while in-service by embedding metallic fibers in the mix and by application of an electromagnetic field at the surface of asphalt mixture. To achieve that objective of this study, an open-graded friction course (OGFC) was successfully designed and prepared to incorporate up to 5% steel and aluminum fibers of the mix. The repeatability of the fracture resistance measurements was acceptable with a coefficient of variation ranging from 4.8 to 13.2% with an average amount of 8.0%. Based on the results of the experimental program, the observation that was found that the control mix and the mix prepared with aluminum fibers show greater ultimate load at failure prior to healing than the specimens with steel fibers.The Eddy current flowed through the metallic fibers in the mixture which was the agent for causing heat due to the resistance opposing the current. Given their higher electrical resistivity,After the rest period, the control mix had the highest ultimate load after healing although it was not successfully heated through Eddy current; yet, differences were not statistically significant.Healing efficiency was the highest for the control specimen as it reached 85%. Healing efficiency for the specimen with steel and aluminum fibers was 62% and 72%,respectively.

Kaushik Neogi, Pradip Kr. Sadhu,Atanu Banerjee.(Apr 2016) [15]:Induction heating method is a well-established process to produce heat in a localized area on a susceptible metallic object. High frequency power, an ancillary and a work coil instrument part is the basis of induction heating. It was used in industrial and domestic areas where uniform and rapid heating was absolutely essential. As it was highly needed, in that research work, the effectiveness of induction heating will be verified by different curing methods. In first stage start the asphalt concrete curing by high frequency induction heating so that the concrete become more durable, electrically conductive and appropriately adjusted for induction heating, steel wire mesh is employed which was a good conductor of electricity. Then when micro cracks were likely to occur in asphalt product, the temperature of the asphalt material could make high by induction heating of the steel wire mesh due to which the micro cracks were repaired itself and cracks were repaired by the increased temperature curing of bitumen by the physical process of diffusion and flow of the material.

Abdul Ahad, Zishan Raza Khan, (Nov 2015) [16]:The use of steel fiber had introduced as the sole method of reinforcement for fully elevated and suspended slabs had long span such as 5 m to 8 m each way, with a span to depth ratio of up to 33.Within the project framework a demonstration of a steel-fiber reinforced roller-compacted concrete pavement was constructed in a rural and urban areas. The main output of that paper was that SFR-RCC was more economically sustainable than others and also helps in reducing the thickness of the pavement up to 20 to 25 percent, due to the excessive and more strength of steel fiber. The roads of the system required high cost investment. And the life period is nearly 20 years theoretically but the actual life of the road is depending on the maintenance and the applied load.Also the cost of the construction was increased continuously; as a result, the construction of roads was more and more complicated and time consuming task. For the better and economical construction of the roads,they use steel fibers in the composite pavement.There they use the composite pavement in which the steel fiber is mixed in the concrete layer, after which the bitumen layer was laid for the smooth and suitable riding of the vehicles.

Quantao Liu, Erik Schlangen, AlvaroGarcía(May 2014) [17]**:**The lifetime of porous asphalt pavement was only about 11 years. In that research, a porous asphalt concrete with long lifetime, based on a healing mechanism triggered by means of induction heating, was explained. Conductive fillers (steel fibers and steel wool) were added to porous asphalt concrete for enhancing its electrical conductivity and induction heating was used to increase the temperature, just sufficient to increase the healing rate of asphalt concrete to heal the micro-cracks and to repair the bond between aggregates and binder or fillers. The main purposes of that research were to examine the electrical conductivity, particle loss resistance and induction heating speed of electrically conductive porous asphalt concrete and prove that damage in the material could healed via induction heating. It was found that long fibers with small diameter were give more benefits as compared to short fibers with bigger diameter to make porous asphalt concrete electrically conductive, induction heatable and had high particle loss resistance . Finally, it was also proved that damage in porous asphalt concrete could healed via induction heating.

III. Conclusion

After study of all the literature review we have seen that all the authors demonstrate the use of different techniques used in asphalt concrete to maintain and repair of the pavement after occurance of some failures like cracks produced in asphalt concrete pavement in which use of some steel fibre with different proportions etc.and it was prove that damages in the material could healed via induction heating. also we have concluded that the by using conductive materials in asphalt concrete there is production of ease in the repairing and maintainace of the asphalt concrete road or pavement,the process is that when the heat is applied at the surface of asphalt road due electromagnetic field generated due to which there is eddy currents are produced which flowed through the metalicfibers in the mixture which was the agent for causing heat due to the resistance opposing the current,and finally the cracke were repaired.some times these cracks are repaired by self healing.and some times by means of microwave healing and induction heating.

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