THE FIRST ENGINEERED SELF-HEALING ASPHALT ROAD; HOW IS IT PERFORMING?

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ABSTRACT

Porous asphalt shows excellent performance in both noise reduction and water drainage. Although porous asphalt has these great qualities, its service life is much shorter (sometimes only half) compared to dense graded asphalt roads. Ravelling, which is the loss of aggregate particles from the surface layer, is the main damage mechanism of porous asphalt surface wearing courses. In this research, an induction healing approach (namely, activating the healing process of asphalt concrete through induction heating) was developed to enhance the durability of the porous asphalt roads. Steel fibres are added to a porous asphalt mixture to make it electrically conductive and suitable for induction heating. When micro cracks are expected to occur in the asphalt mastic of the pavement, the temperature of the mastic can be increased locally by induction heating of the steel fibres so that porous asphalt concrete can repair itself and close the cracks through the high temperature healing of the bitumen (diffusion and flow). The closure of micro cracks will prevent the formation of macro cracks. In such a way, ravelling can be avoided or delayed in the end.

The healing potential of porous asphalt concrete with steel wool fibre was also evaluated in this research with both cylinder and beam samples. Damaged porous asphalt concrete with steel wool fibre can greatly restore its stiffness, strength and fatigue life with induction heating, which proves that the healing capacity of porous asphalt concrete with steel wool fibre is enhanced by induction heating. The optimal induction heating temperature is 85 ºC for porous asphalt concrete to obtain the best healing rate. Reheating does not decrease the healing rate of porous asphalt concrete, which means that heating can be repeated when cracks appear again.

To apply the induction healing technology in real porous asphalt road, a trial section was constructed on Dutch motorway A58 in December 2010. This trial section survived the past three winters perfectly. Experiments were done on the cores drilled from the trial section and the results coincided with those on the laboratory made samples. The field cores showed good particle loss resistance, high strength, good fatigue resistance and high induction healing capacity. Based on the laboratory experiments and field experiences, induction healing can be a very good approach to enhance the durability of porous asphalt pavement.

1. INTRODUCTION

As the skid resistance and noise reduction functions of a porous asphalt surface wearing course can be decreased by ravelling, maintenance is required. In the Netherlands, ravelling is the main cause for maintenance or renewing of the top layer of porous asphalt pavement. To improve the durability of a porous asphalt surface wearing course, ravelling has to be avoided. The objective of this research is to prevent or delay ravelling and by that extend the service life of porous asphalt [1]. To achieve this goal, an induction healing approach (namely, activating the healing process of asphalt concrete through induction heating) is be used. The schematic diagram of induction healing can be illustrated in Figure 1. Steel fibres are added to a porous asphalt mixture. When micro cracks are expected to occur in the asphalt mastic (or between mastic and stones) of the porous asphalt pavement, the temperature of the mastic can be increased locally by induction heating of the steel fibres via an external source so that porous asphalt concrete can repair itself and close the cracks through the high temperature healing of the bitumen (diffusion and flow). The closure of micro cracks will prevent the formation of macro cracks. In such a way, ravelling can be avoided or delayed eventually. The heating process on the porous asphalt wearing course can be repeated if cracks appear again.

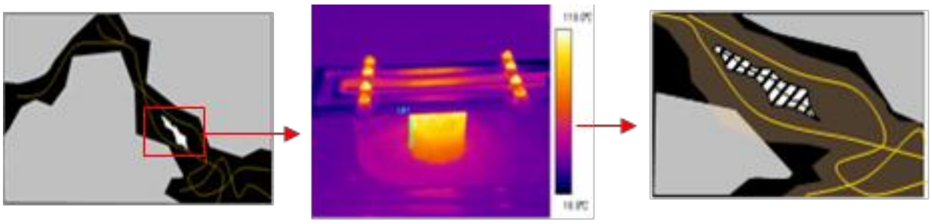

Figure 1: Schematic diagram of induction healing in porous asphalt concrete.

To apply the induction healing technology in real porous asphalt (PA) pavement, a trial section was constructed on Dutch motorway A58. This paper discusses the research performed on specimens taken from the trial section and gives an estimate for the expected service life.

2. TEST METHODS AND RESULTS

To predict the performance of the test section and to get ideas of when and how long to heat the trial section with induction energy, a series of experiments is designed in the laboratory. Cores were drilled from the trial section and beams were prepared with the same materials. Furthermore plates and large beams were cut from part of the trial section to test ravelling resistance and performance in a bridge joint. The mechanical properties of this porous asphalt concrete (Particle loss resistance, indirect tensile strength, water sensitivity, indirect tensile stiffness and fatigue, nano indentation modulus and hardness of the mortar, four point bending fatigue) were studied to predict the performance of the induction healing asphalt test section. The induction healing potential of this material was also investigated. In this paper only a summary of the results can be given. A full overview of the research is given in [1,2].
It was found that it is possible to heat the cores that were taken from the trial section with induction energy. However, the induction heating speed of the cores is not high

enough with the present heating machine to be practical. Either the induction machine or the mix needs optimization. In both there is room for improvement.

Another aspect that was investigated is how to age the materials from the road. It is known that due to ageing the bitumen will oxidize and become stiffer. To predict the long term behaviour it is necessary to check how damage progresses in time and whether healing works at older age. It turned out that the porous asphalt cores that contain steel-wool can be placed in an oven at 85 ºC to age them. Ten days in the oven is equivalent to 5 years field aging.

To check the particle loss of the porous asphalt two different type of tests were performed, i.e. the Cantabro tests and the RSAT-test. The Cantabro test were performed on cores from the road with and without steel-wool and with and without ageing. The cores with steel wool showed a much better resistance to particle loss then the plain asphalt cores, also after ageing. This indicates that the fibres also help to improve the mechanical behaviour. In the RSAT (Rotating Surface Abrasion Test) which were conducted at research partner Breijn-Heijmans an asphalt plate is subjected to loading with a wheel with rubber tile, while the plate is rotating (figure 2). In this way abrasion forces are acting on the surface. The test is done on plates with steel-wool with and without ageing. The standard loading-level used in this test for porous asphalt did not result in any damage in the RSAT. With doubling the load level and running for a longer period some damage was obtained in the plates with steel-wool. After some damage was obtained (this means a few stones were released form the surface), the plates were treated with an induction heating until the surface reached 85 ºC. The RSAT-tests were then continued and it was found that no more damage was obtained after that, at least for the up to 24 hours that the tests was run after treatment.

Figure 2: RSAT and joint-tester at Breijn-Hejmans.

Part of the trial section was a bridge. Usually there is a standard bridge joint between the road and bridge-deck which is filled with a flexible bituminous materials. In the trial section it was decided to have continuous asphalt surfacing also over the joint. This joint was tested in the joint-tester at Breijn-Heijmans, see figure 2. It turned out that not one single crack occurred in the material, which happens in a standard (porous) asphalt, but due to the steel fibres a multiple crack pattern occurred. Since these cracks were relatively small it turned out to be easy to heal them with induction energy.

The healing potential of the asphalt beams with steel-wool was evaluated in four point bending fatigue tests (figure 4). The healing ratio (fatigue life extension ratio) of porous asphalt concrete is strain and temperature dependent. Healing is much higher when induction heating is applied on the samples.

Figure 3: Specimen after cracking in joint-tester at Breijn-Hejmans.

The optimal heating temperature is 85 ºC. Damage extents affect healing ratio. Heating should not be too early or too late. The stiffness of fatigue damaged beam can recover much more with induction heating. With multiple times induction heating, the fatigue life of porous asphalt beam can be greatly increased as shown in figure 4. Furthermore it was found that ageing doesn’t influence the healing of porous asphalt beam very much.

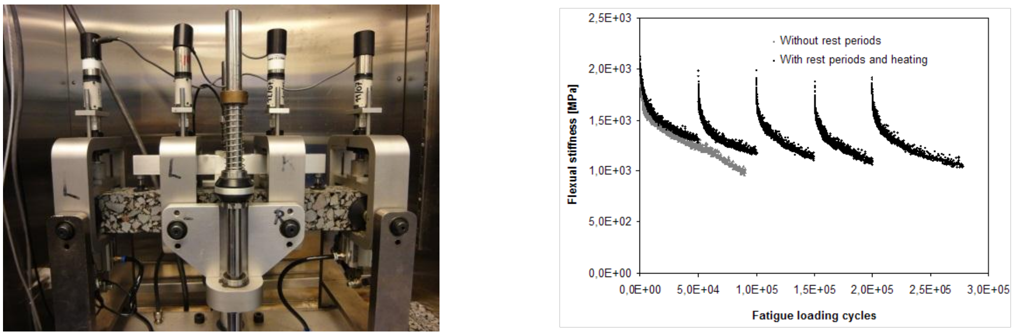

Figure 4: Set-up and results for four point bending fatigue test.

3. CONCLUSIONS

Based on the strength recovery, stiffness recovery, RSAT-tests and fatigue life extension of porous asphalt cores and beams, it is concluded that the healing capacity of porous asphalt concrete is increased by induction heating. Furthermore it has been shown that this self-healing asphalt can also be a great solution for bridge joints in roads. Finally, it can be concluded that the durability of porous asphalt concrete roads will be improved enormously with the induction heating, because of the reinforcement of steel wool and the improvements in the healing capacity. In practice the trial section performs perfect, but it is too early to have a final judgement.

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