Investigation on Self-Healing of Recycled Asphalt Mixes - A Method to Incorporate Mixture Properties into the Pavement Design

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In India, there are many new highways being constructed and many major road corridors are being widened. The use of good quality road aggregates and binders in a) construction of new pavements and b) rehabilitation of existing pavements is leading to the depletion of raw material.

Research has shown that this material consist of both valuable aggregates and binder that can be reused for construction of new bituminous layers. This material is referred to as reclaimed asphalt pavement (RAP). With the increasing costs of the virgin materials and also the constraint of limited availability of road quality materials, the use of high percentages of RAP in the construction of bituminous layers is being considered as a feasible solution.

Use of RAP material has many potential benefits including improvement in rut resistance. There are mixed views on the effect of RAP on the fatigue cracking performance of the mixes. Cracking is one of the major modes of failure in bituminous pavements. Due to the time constraint during the laboratory experimentation, continuous load pulses are applied unlike the pattern of loading the pavement. The actual period of the rest period between load pulses will vary in the field and usually depends on the traffic volume/speed. Longer rest periods are known to yield longer fatigue lives. The process of recovery from damage is generally termed as "healing".

Healing is an age-old and interesting concept where the materials are considered to have the structurally incorporated ability to repair damage caused by mechanical usage over time. Many polymeric materials and composites have healing capacity and are being used in different structural applications like aircraft, cars, ships, construction industries and the defence sector.

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* Ms. Ramya Sri Mullapudi, Ph.D. Scholar from Indian Institute of Technology, Kharagpur, is pursuing her research on "Healing Characteristics of Asphalt Mixtures Containing Recycled Asphalt Pavement Material." Her popular science story entitled "Investigation on Self-Healing of Recycled Asphalt Mixes – A Method to incorporate Mixture Properties into the Pavement Design" has been selected for AWSAR Award.

Many researchers report that the asphalt concrete used as road construction material has the ability to heal when there is a sufficient rest period. Healing of the asphalt concrete is one of the important factors which are responsible for the significant difference between laboratory and field fatigue lives.

The mechanism of healing in the asphalt mixes is when two surfaces of binder film are placed in contact and the interface gains strength when the suitable time and temperature is available. In this process, the molecules present at the surface diffuse to the other surface and increase in the strength happens due to the randomization of the molecules. The healing capability of the asphalt mixture depends on the type and quantity of binder, traffic and environmental conditions and mix properties such as aging. Healing characteristics of recycled asphalt pavement (RAP) mixes will be different from those of normal mixes since the RAP material consists of aged binder. This will have significantly different healing properties from that of virgin binder and the diffusion between RAP and virgin binders is also known to be complex and non-uniform.

The study explores the healing characteristics of mixes containing RAP. The healing characteristics of the asphalt mixes containing RAP material will be dependent upon the quality of the combined binder. Commonly used surface course mixture for national highways with a nominal maximum aggregate size of 19 mm with varied RAP percentages (0, 15, 25, 35 and 45 %) was used for the current study.

After characterizing the RAP material, mix design was carried out using the Marshall mix design method to determine the optimum binder contents. Mixes were prepared at respective optimum binder contents for evaluating their healing potential. The healing potential of the mixtures has been evaluated for short as well as storage rest periods. Fatigue testing with different rest periods (0.4, 0.65, 0.9 and 1.4 s) after a loading pulse has been conducted to evaluate the effect of short rest periods on the fatigue life.

The effect of temperature (40 and 60 °C) on the healing capability of the mixes has been evaluated by providing storage rest period after inducing damage. Increase in the temperature of storage rest period facilitates the binder flow into the micro-cracks formed due to the mechanical usage. The effect of the initial damage level was evaluated; this would give an idea about the healing ability of the mixture at different stages of its life period. The healing ability of the mixtures remained more or less similar till half of the life is consumed, beyond which the ability is reduced. Once the bituminous pavement deteriorates to a level where cracks are visible on the surface, healing those cracks will be less efficient than the micro-cracked mixtures. Indirect tensile strength test was conducted on the specimens and the failed specimens are placed in split moulds for application of constant pressure and then conditioned for healing. The samples were re-tested after the healing conditioning and it is observed that the effect of RAP is nominal on the healing characteristics of the macro-cracked mixtures.

The healing potential obtained for varied rest periods and high temperature healing at 40 °C followed a similar trend as the branching of the aliphatic side chains present in the binders (obtained through Fourier transform infrared spectroscopy). The healing potential of the mixes where the healing conditioning is done at 60 °C reduced with an increase in the RAP content in the mixture. This is similar to the order of the stiffness of the binder present in the mixture.

It is seen that the healing characteristics of the mixtures change depending on the damage level and environmental conditions. Hence, there is a requirement of a comprehensive methodology (unified model) that would compute the healing potential of the asphalt mixtures by taking different conditions into consideration. To calculate the healing potential as a single number by considering all the factors, tests have to be conducted for different conditions that would prevail during the usage of the particular asphalt mixtures (like temperatures, number of years for which the pavement is being designed, traffic details). Then by using the weighting factors for each of the tests/conditions prevailing for considered pavement location and the healing capabilities obtained, a single index that represents the healing potential of the mixture can be calculated.

Once these numbers are obtained, normalization of the healing potential has to be done by dividing the healing potential of a particular mix one is going to use with the healing potential of the mixtures for which design methods have been proposed. This relative healing shift factor can directly go into the design equation of fatigue cracking as a multiplication factor. The usage of this kind of methodology would reduce the errors in the estimation of the fatigue life of any pavement that is being designed with new types of material/recycled material.