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MEASUREMENT RESISTANCE OF CRACK SEALANT ASPHALT CONCRETE UNDER REPEATED LOADING

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ABSTRACT

In this paper resistance of cracked and crack sealant asphalt samples were studied by varying temperature and time of loading to understand the crack sealant pavement behavior under Iran climatic conditions and to address the problem according to mode of distress. The common cause of pavement distress in Iran is rutting which initiates due to uncontrolled axle load and large variations in temperature. Creep tests were carried out using Universal Testing Machine (UTM-5P) on the mixes prepared in the laboratory. Polymer modified bitumen was used as sealing material and is a unique opportunity to compare the behavior of in crack sealant asphalt concrete. The results of laboratory tests on cracked and crack sealant asphalt concrete under the influence of load and environmental conditions are presented.

Keywords: polymer modified bitumen, cracked sealant, asphalt concrete, failure.

INTRODUCTION

The main cause of premature failure of pavements in Iran is rutting due to high variations in ambient temperatures, uncontrolled heavy axle loads and limitations of cracked pavement. The purpose of sealing cracks in asphalt concrete pavements is to protect the pavement structure from premature failure. The weakened pavement structure can result in load-related failures such as alligator cracking [1].

The road network system in Iran consists of approximately 168,000km of flexible pavements and about 2100km of Motorways. Recently Polymer modified bitumen has been introduced in the crack sealant of pavements to withstand the effects of high ambient temperatures. Study of resistant behavior of crack sealant asphalt concrete under varying temperatures and time of loading has not been given due consideration in the past due to non availability of relevant testing facilities. L. B. Chu *et al*. reported that the load carrying capabilities (as reported by Deflection Bowl Parameters) of a flexible pavement is significantly affected by environmental factors [2]. M Perl *et al.* carried out research on asphalt performance at low temperature. Its performance at 20°C or less was investigated and particularly below 0ºC [3]. He concluded that asphalt can fail to perform due to deformation (usually associated with temperatures above 35ºC) or by tracking (normally associated with temperature less than 10ºC). At high temperature the accelerated wheel tracking test offers a mean of measuring or specifying deformation but at low temperatures no standard method is available to characterize ductility L Goodrich considered that at low temperatures, the viscous flow of the asphalt (which permits creep and thus resists thermally induced cracking) is principally derived from the viscosity of the modified base asphalt [4].

Thus in order to design and/or maintain road pavements effectively and economically, the understanding of environmental influences on the performance of road structure is very important. This study was carried out to determine the resistance to permanent deformation of crack sealant asphalt concrete under repeated loadings at varying temperatures. In order to determine these properties, Universal Testing Machine (UTM-5P) was used for testing for the first time in Iran [5].

MATERIALS AND METHODS

Testing program

It was planned to study the property of cracked asphalt concrete i.e., Permanent Deformation (Creep). Universal Testing Machine (UTM-5P) is capable of determining permanent deformation characteristics of asphalt concrete. This machine allows asphalt to be tested for its ability to withstand repeated axial loading at varying temperatures. UTM software can replicate varying load conditions through increase in frequency and force of axial loads. Tests were carried out in accordance with ASTM D-4123 on asphalt samples at 45, 55 and 65ºC and on loading pulse period of 1500ms and pulse width of 150ms (0.15 sec), 300 ms (0.3 sec) and 450 ms (0.45 sec) [6]. The most important part of this research was to prepare samples of crack sealant asphalt concrete for laboratory testing as shown in Figure-1. A brief detail of the samples is shown in Table-1.

Table-1. Material for cracked, crack sealant and un-cracked asphalt samples.

Sieve size (mm)	**Percentage of aggregate particles passing each sieve**
37.5	100
19	84
6.7	53
2.36	34
1.18	26
0.600	20
0.300	17
0.150	12
0.075	6
Bitumen kind	60/70 Penetration at 25˚C
Bitumen percent	5.5% (Marshal Method)
Sealant Material	Polymer Modified Bitumen

Repeated load uniaxial strain test (creep test)

Repeated load uniaxial strain test was performed on the asphalt sample at 100kPa loading stress and at 45, 55 and 65ºC temperatures. The loading pulse period of 2000 ms (2 sec) and pulse width of 500 ms (0.5 sec) was selected.

Vertical deformations must be measured with a linear variable displacement transducer (LVDT). Two LVDTs, placed diametrically opposite each other, must be used to measure this deformation. The resolution on each LVDT must be better than 0.0025mm (0.000098 inch). Smooth-loading platens must be used to minimize the effects of friction on the ends of the sample. The upper-load platen must be of the same diameter as the sample being tested to provide for positive centering of the specimen under load. The upper platen must be of the floating compression type to account for minor deviations in a specimen's surface.

This test conforms to the requirements of the design draft issued by the British standards Institute as a method of measurement of resistance to permanent deformation of bitumen mixtures that are subjected to unconfined uniaxial repeated loading [7]. The test initially applies a static conditioning stress to the specimen and measures the resulting accumulating strain. The magnitude and applied time duration for conditioning stress were set to l0kPa and 600 seconds, respectively.

Following the conditioning period, a fixed 20s time delay is programmed, where the applied stress is set to zero. When the delay time expires, the specimen is then subjected to repeated pulse loading for 3600 cycles with a stress level of 100kPa. As pulse loading continues, the accumulated strain is measured and displayed as a plot with linear scale axis. The applied force is open loop controlled and rectangular in shape. Figure-2 shows a picture of the UTM-5 software interface.

Figure-1. A crack sealant sample after loading (crack width = 15mm).

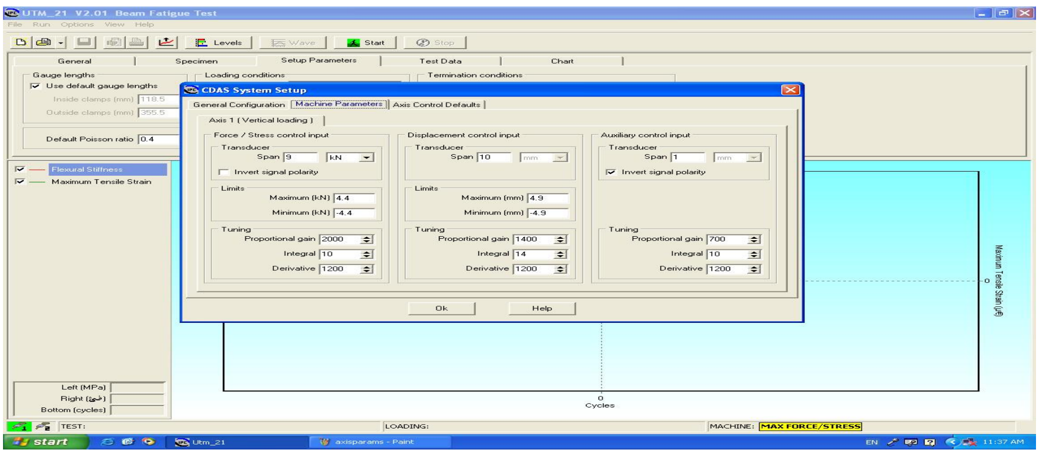

Figure-2. A picture of the UTM-5 software interface.

RESULTS AND DISCUSSION

Resistance to permanent deformation of cracked asphalt concrete

This test measures the relative performance of crack sealant asphalt samples against permanent deformation or rutting. Repeated load uni-axial strain test was performed on two samples cracked, crack sealant and un-cracked at 45, 55 and 65ºC. A rectangular loading pulse of 100kPa was applied for a duration of 0.5 sec and period of 2 sec i.e. load is applied for 0.5 sec and repeated after 1.5 sec for 3600 pulses. The detailed test results are

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shown in Table-2, whereas accumulated strain was summarized and shown in Table-2.

From Table-2 it can be observed that the relative performance of un-cracked pavement is very good with a maximum accumulated strain of 2.3% at 65ºC as compared to 2.94% of cracked pavement. Permanent deformation performance of the samples (Figure-3) shows an accumulated strain of about 0.99, 1.96 and 1.94% on the cracked samples.

Table-2. Accumulated strain values for cracked, crack sealant and un-cracked asphalt samples.

Temperature	**45˚C**	**55˚C**	**65˚C**
Sample description	**Accumulated strain** (%)	**Accumulated strain** (%)	**Accumulated strain** (%)
Un-cracked	0.99	1.72	2.3
crack sealant	1.94	2.28	2.57
cracked	1.96	2.37	2.94

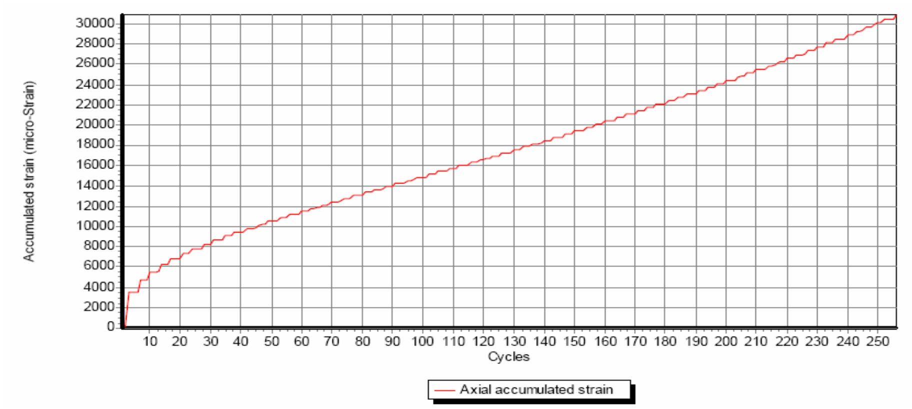

Figure-3. Accumulation of strain at 45°C for crack sealant sample.

Accumulated strain of the same mixes has been plotted at different temperatures (Figure-4) which shows similar behavior, i.e., increase in strain at higher temperature. Less accumulated strain has also been observed on the un-cracked samples.

Stiffness modulus or creep stiffness is calculated with the help of following formula:

$$E_c = \frac{\sigma}{\varepsilon_c} \quad (1)$$

Where

E_c = Stiffness modulus

σ = stress applied on the specimen

ε_c = accumulated axial strain (creep)

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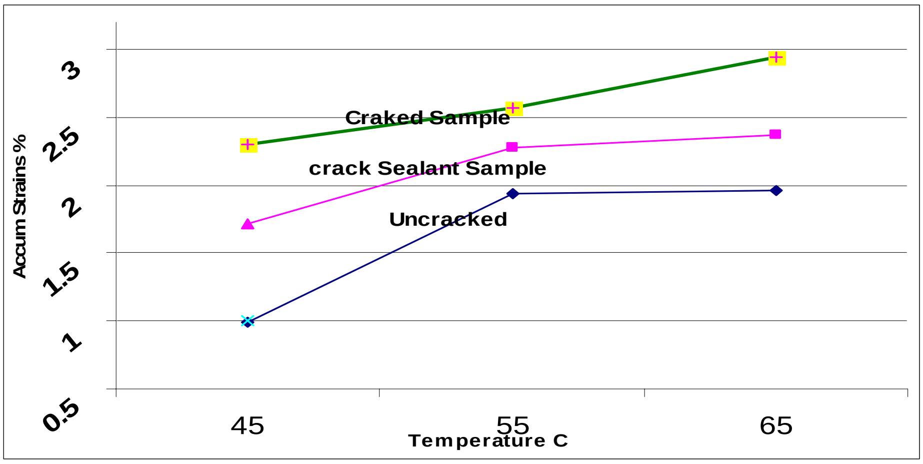

Figure-4. Accumulated strain vs. temperature for cracked, crack sealant and un-cracked asphalt samples.

Figure-5 shows the variation of creep stiffness with temperature. Creep stiffness is related with the accumulated strain at an applied stress value of 100kPa. This shows that the creep stiffness of un-cracked samples is higher as compared to cracked samples. Hence, this also shows that accumulation of strain is less in un-cracked samples.

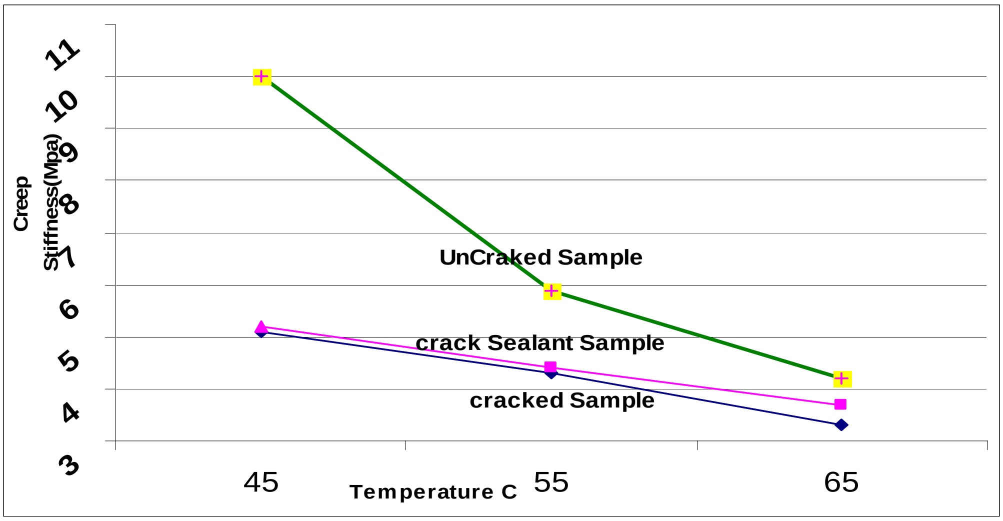

Figure-5. Creep stiffness vs. temperature for cracked, crack sealant and un-cracked asphalt samples.

CONCLUSIONS

- Un-cracked samples show encouraging results i.e. less accumulated strain and high creep stiffness values at higher temperatures as compared to the conventional mix.
- Cracked sealant sample constructed with polymer modified bitumen is expected to perform well in terms of rutting resistance.
- Preventive maintenance with cracked sealant costs 30% more than normal maintenance but it may save by its long term performance and lesser maintenance cost.
- As the load carrying capacity of flexible pavements reduces drastically in summer, axle load limit and control is essential to save the premature failures of pavements.

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