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TO EVALUATE MOISTURE AND LOW TEMPERATURE CRACKING SUSCEPTIBILITY OF WARM MIX ASPHALT-A REVIEW

Sana ul musawir Asif[1], Yaseen Mahmood[2], Mujahid Khan[3]

[1]Sana ul musawir Asif, Department of Civil Engineering, IQRA National University Peshawar, Pakistan.E-mail: asiflohani@yahoo.com
[2]Yaseen Mahmood, Supervisor, Department of Civil Engineering, IQRA National University Peshawar, Pakistan.E-mail:yaseen@inu.edu.pk
[3]Mujahid khan, Department of Civil Engineering, IQRA National University Peshawar, Pakistan.E-mail: mujahidkhan3330@yahoo.com

ABSTRACT

Warm Mix Asphaltis a technology which is utilized to minimize energy. More ever, mixtures of asphalt are producedby minimizing compaction and mixing temperature of asphalt. In this paper to assess the effect of additives (Aspha-min and Sasobit) on behavior of mixtures of warm asphalts, laboratory study was conducted to achieve the results.The samples were fabricated and mixed in the laboratory during this study. Samples were prepared by compacting it at 100^0Cand 145^0C.The samples were subjected to two various procedures of testing. To evaluate the moisture susceptibility and thermal cracking two procedures are used i.e.1/3 model traffic simulator and thermal stress retrained test (TSRST). After experimental work it is concluded that mixtures of warm asphaltprepared with Sasobit is more liable to moisture damage as compared to mixture prepared with Aspha-min. in addition, It was also found that wet/dry rut ratio was not shown any moisture susceptibility in case of asphalt-min mixture while in case of Sasobit mixture it was more susceptible to moisture damage from MMLS3 testing. More ever, it was also concluded that performance of low temperature cracking is affected adversely by both type of additives (Sasobit and Asphalt-min) as compared to control mixture.

Keyword's
Warm Mixes, moisture susceptibility, TSRST, Thermal cracking, low temperature cracking, Warm mix asphalt

I. INTRODUCTION

Warm Mix Asphalt is a technology which is utilized to minimize energy and mixtures of asphalt are produced by minimizing compaction and mixing temperature of asphalt. Asphalt binder's viscosity was reduced mostly due to warm mixes work. This allowed to aggregate structure better coating which minimized the temperature required to obtained mixture adequate workability. As temperaturereduced which directly reduced cost of fuel at plants of asphalt. More ever, WMA having many possible benefits but negative effects on mixtures performance was also evaluated. Moisture sensitivity of WMA has been increased as shown by laboratory testing as compared to hot mix asphalt (HMA) (Wasiuddin et al. 2008).
When mixing process of WMA occurred at low temperature ,the aggregates were not dry properly during mixing process which led weaker bond between asphalt binder and aggregate. More ever , WMA production released moisture when used additives in it, to the mixtures and the asphalt binder viscosity lowered (Kandhal1992). The released moisture minimized the bond between aggregates and asphalt binders. The presence of moisture in the mixture reduced bond between surface of aggregates and binders of asphalt which directly contributed to moisture damage(Gopalakrishnan and Metcalf 2001,Bhasin et al. 2006). Low-temperature cracking was another distress thatexacerbated by warmmixtureadditives.
These distresses occurred when asphalt pavement temperature became dropped which developed tensile stresses. Mixture tensile strength increase due induction of these stresses which caused the development of micro cracks. Binders of soft grade was used in the areas where fluctuation of low temperature occurred. Thus, mixture responded with fracture to thermal stresses(Anderson et al. 2001). According to (Kim et al. 1994) failure of soft grade binders caused at high strain levels due to which fracture occurred and micro cracks developed, which have a greater ability toheal under high-temperature conditions.Under low temperature warm mixture additives changed the behavior of binders.
To describe the nature of asphalt mixtures under low temperature and to find factors which effected low-temperature susceptibility, thermal stress restrained specimen test (TSRST) was developed under the Strategic Highway Research Program(Jung and Vinson 1994). Testing in laboratory pretends thermal stresses that pavement surface layer subjected in field conditions,which allowed the parameters of fracture measurement under well-measured laboratory environments. The main aim of this study is to evaluate warm mixtures moisture and low cracking susceptibility by using two additives i.e. Aspha-min and Sasobit. The First one is zeolite asphalt modifier which consisted of manufactured synthetic sodium aluminum silicate and was hydro-thermally crystallized.
Large empty spaces was in crystal structure of Aspha-min, which contained water and released It has large empty spaces in its crystal structure; these empty spaces hold water, which is released in the heat presence (Hurley and Prowell 2005a). While former is fine crystalline, long chain aliphatic polyethylene hydrocarbon. By using process of the Fischer–Tropsch sasobit was formed from coal gasification. The chain of long molecules it gives higher melting point to the wax as compared to typical paraffin waxes. More ever Sasobit brittleness decreases at lower temperatures due to its smaller crystalline structure (Hurley and Prowell 2005b). Moisture susceptibility was evaluated by testing of samples and using of laboratory-controlled accelerated loading. Performance of Low-temperature cracking evaluated by testing samples under TSRST environments.

II. RESEARCH METHODOLOGY

Materials and Methods:

In this paper the materials used of single aggregate gradation (12.5mm). To reduce variable numbers in mixture single aggregate gradation was mixed with asphalt binder (PG 64-28). Table 1 clearly shown final gradation of aggregates.

Table 1. Gradation of Sample

S.No	Sieve Size		% Passing
	mm	US Customary	
1	25	1"	100
2	19	3/4"	100
3	12.5	1/2"	99
4	9.5	No. 4	89.8
5	4.75	No.8	57.1
6	2.36	No.16	42.6
7	1.18	No.30	34
8	0.6	No.50	23.2
9	0.3	No.100	13.1
10	0.15	No.100	6.1
11	0.08	No. 200	4
12	Pan		0

Binder content of 5.8% was used for fabrication of all samples and target was 7.0 ±0.5% air voids. From targeted range of air voids six samples found outside the range. Tests were conducted onthese specimens andanalyzed the resultswith these aggregatedsamples and separated. In statisticalconclusions no variation was found , so all data included in the averages presented.To remove the remaining moisture possibility in aggregates used in mixture during this paper was dried for minimum of 8hours in oven. Warm mixture additives effect on test samples was examined on moisture susceptibility after aggregates having 100% dried. The two samples which prepared for assessing moisture were mixed and compacted at two various temperature also termed as low temperature i.e. 115^0C and 100^0Cand high i.e.155^0C and 145^0C. To determine the effect of warm mixtures production the two sets of temperatures were selected at normal production temperatures.To extend time of compaction and allowing paving to occurin cold temperatures this is done. This is an application of warm-mixture technology that is of interest in cold climates to effectively extend the paving season. In this study two additives (Sasobit and Aspha-min)were used and added to the mixture. Sasobit was mixed to the liquid binder in the form of wax bead at 1.5% by weight of asphalt binder. While Aspha-min was mixed to the hot aggregate at 0.3% by weight of total mixture in the form of powder. Using same aggregates and binder control samples were produced. Thus, in this research 86 number of samples were prepared and test were conducted to achieve objectives.

Experimental Work: Third-scale model mobile load simulator (MMLS3)

It is accelerated loading device composed of 4 pneumatic tyres having diameter of 300mm and connected by a chain bogey system. The variable speed motor was used to drive the MMLS3. During testing in laboratory, the samples was fixed in test bed and unidirectional load applied to samples by the MMLS3.Using Suspension system axle load held constant which allowed for loads between 2.1 and 2.7 kN (MLS Test Systems 2002). Individual samples were tested in the MMLS3 are fastened in the test bedas shown in Figure 1.

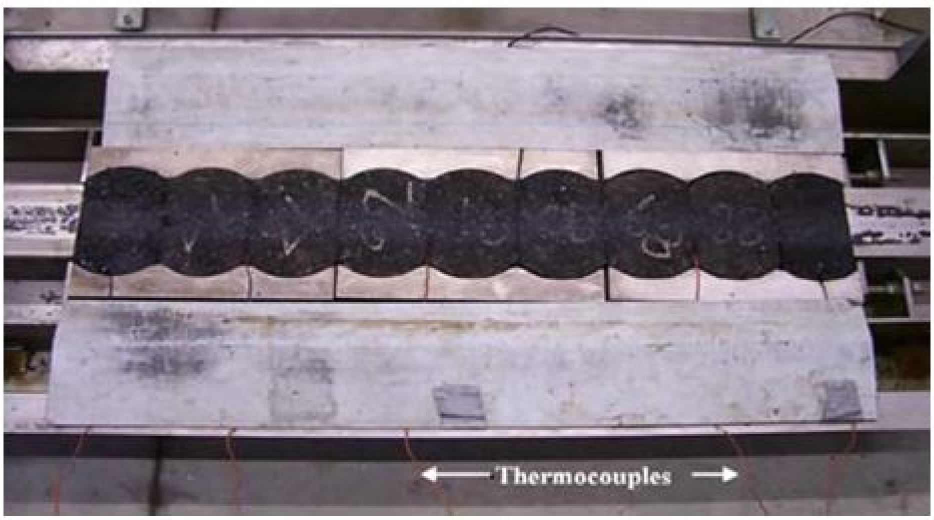

Fig.1 Test Bed of MMLS3

The samples used for testing having diameter of 150mm with removal of two parallel edges. The wheel load transfer through samples after removing aligned samples edgesas compared to transfer through test bed clamps. To measure the subsequent deformation from each sample an initial surface profile was taken before wheel loadingas a reference point.More ever in order to measure deformation of samples various profile measurements taken over the course of MMLS3 test to a maximum of 100,000 load cycles.

Thermal Stress Restrained Specimen test:

For evaluation and to find warm mix asphalt mixtures low cracking susceptibility the test used in this paper known as thermal stress restrained specimen test (TSRST). During this test specification of AASHTO TP10-93 was followed. Apart from this cylindrical sample having dimensions of 150mm x 75mm was utilized instead of standard dimensions.After this analysis was conducted and at regular interval of 0.5^oC the data of temperature was noted regularly. Due to lack of availability of materials 12 samples was used on which TSRST's was conducted. All mixtures were not tested while 3/4 mixtures had only two replicates tested. During each test four parameters were achieved. Graphical representation of parameters was shown in figure 2. Before the sample failure the fracture and temperature strength which were ultimate temperature and strength noted by the system. The temperature in which properties of materials varies form visco-elastic to elastic termed as transition temperature. After this temperature stress temperature curve slope was determined. To describe the transition temperature the point in which the second derivative of the curve varies from zero was used.

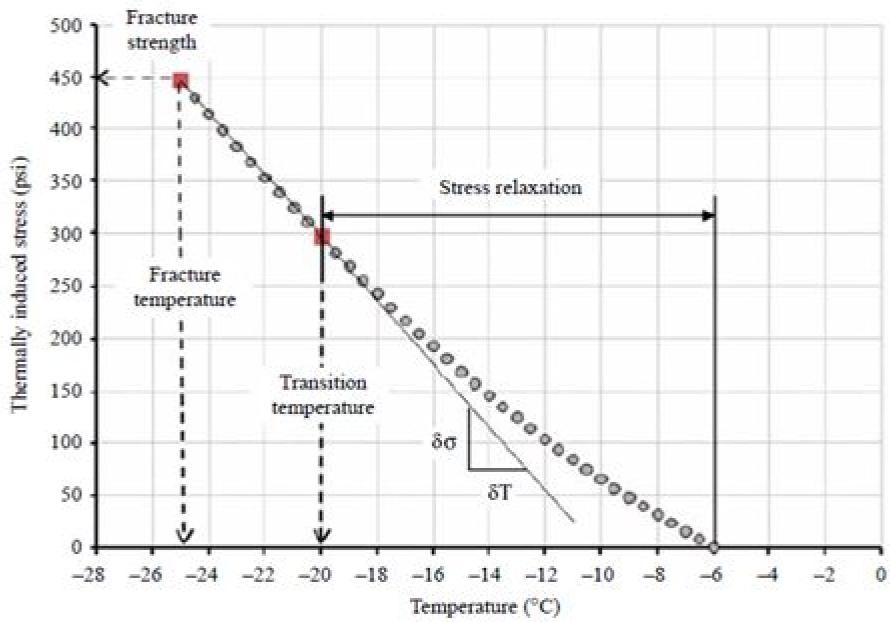

Fig.2 Typical stress vs. Temperature curve

III. Results

This section summarizes results which obtained during experimental work in this research. Individual samples and various statistical analysis results and details were found elsewhere (Daniel et al. 2010).

Evaluation of Moisture Susceptibility:

Control Specimens

After 100,000 loading cycles the average rutting experienced by control high temperature mixture in the wet condition was found 2.2mm greater than that in drycondition. For both conditions (dry and wet) statistical T-test analysis was conducted, and date was obtained which clearly revealed statically significant difference.In addition, it was also indicated thatthe control high-temperature mixture experienced moisture-induced damage. After 100,000loading cycles the average rutting experienced by control low-temperaturemixture was less than 0.5mm difference between testing in wet and dry condition. It was observed that for low mixture temperature the variance between wet and dry testing was not different statistically.During testing at dried condition control low-temperature mixturepresented reduction in rutting at 100,000 loading cycles as compared to control high-temperature mixture; but this variation is not important statistically. It is essential to describe the temperature reduction was performed for the control mixture in order to provide a better assessment with other two warm mixture. More ever, it was noticed after results that moisture susceptibility was also not increased. During filed compaction reduction in mixture workability was observed and thus not practical for applications in field.

Sample of Sasobit:

Sasobit high-temperature mixture showed 1.9mm less rutting in case of dry condition when compared to wet samples tested. This showed significant variances statistically. After testing in wet condition, the average rut depth of Sasobit low-temperature mixture was increased 1.6mm. In both type of condition i.e. wet and dry, no significant changes were found in rutting depth of low mixture temperature. When control high-temperature mixture was compared with the Sasobit high-temperature mixture less rutting at100,000 loading cycles was noticed under both test conditions i.e. wet= 0.7 and dry= 1.0 mm. While Sasobit low-temperature mixture tested in the dry and wet condition showed rutted depth 0.3mm and 2.2 respectively, which was more than the control low-temperature mixture.

Sample of Asphalt-min:

It was observed that under dry condition tested sample showed more rutting as compared under wet condition for both type of high and low mixture temperatures. At loading cycles of 100,000, for high and low mixture temperature variation in average rutting depth were 1.3 and 0.2 mm, respectively. While Asphalt-min low-temperature mixture tested in the dry condition showed significant differences and rutted depth more than 2.4mm as compared to control high-temperature mixture.

Comparison of mixture Type:

All mixtures of high temperature results were shown in figure 3. It was noticed that mixture of Sasobit showed less rutting in both wet and dry condition when compared to control mixture. In addition, Sasobit and control mixtures showed less rutting as compared to mixture of Asphalt-min. The results of low temperature mixture were shown in figure 3. In wet and dry condition best performance was shown by controlled mixture. The Sasobit mixture showed better performance in dry condition as compared to Asphalt-min mixture while in case of wet condition it was vice versa.

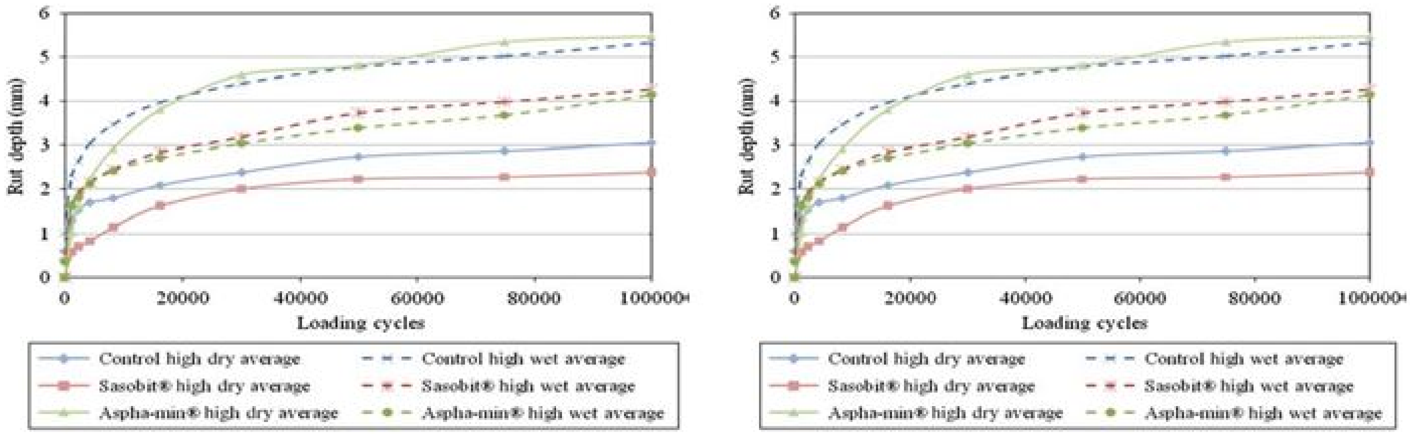

Figure 3. Cumulative rutting summary for all laboratoryspecimens fabricated at high and Low temperature

All tests conducted under wet and dry condition was summarized in figure 4. At low temperature, control mixture performed well while under high temperature the performance was found opposite. At high and low mixture temperature of Asphalt-min the sample showed most rutting.

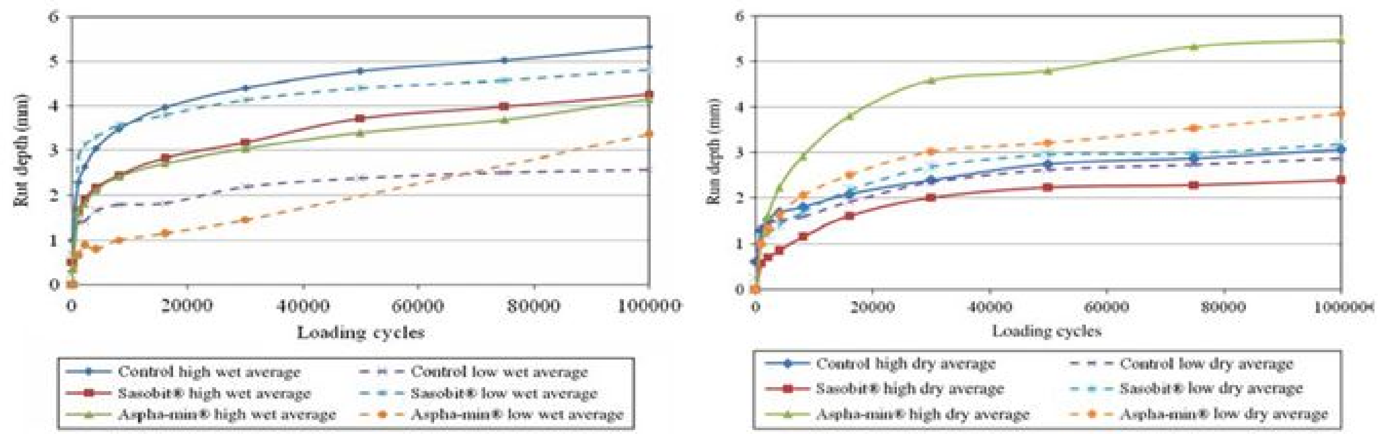

Figure 4. Cumulative rutting summary for all laboratoryspecimens tested in wet and dry conditions

Thermal Stress Retrained Specimens test:

Figure 5 shown fracture and transition stresses and temperatures for each type of mixtures.

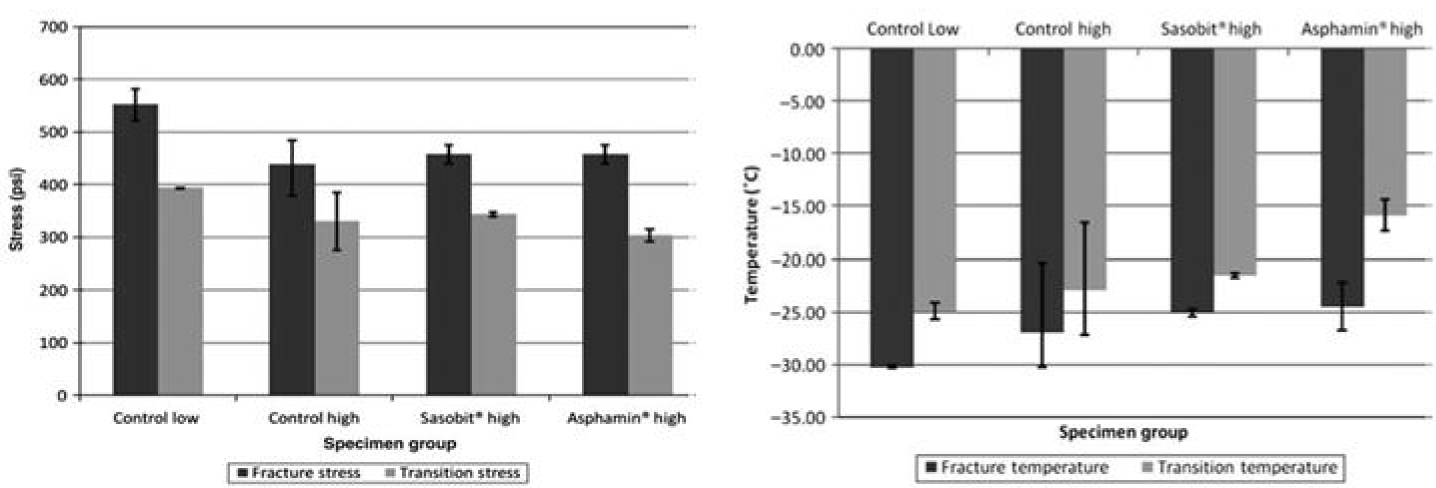

Fig 5 TSRST Fracture and Transitions Stresses and Temperatures

In this figure, average values were presented by bars while maximum and minimum values represented by lines for each type of mixture. Themixtures have relatively close fracture and transition stresses, excluding for the control low-temperaturemixture because of failure at a higher stress andlower temperature. Mixture with additives have intermediate strength but failed at low temperatures while compared with the control mixture. The specimens of Sasobit and Aspha-min having very close fracture stress to fracture temperature ratio, which showed reduced performance at low temperatures.

IV. Conclusions

In this paper, moisture and low cracking susceptibility of warm mix asphalt evaluated using additives of Asphalt-min and Sasobit. For this purpose, samples were fabricated and mixed in the laboratory. Third-scale model mobile load simulator (MMLS3) accelerating loading was used for samples testing to evaluate moisture susceptibility under wet and dry conditions. To assess low temperature cracking as thermal stress restrained specimen test (TSRST) was used. The conclusions of study were summarized in this study was given below.

- During MMLS3 sample testing results, no significant variations in rutting performance between HAM and WMA was found.
- Mixtures of WMA showed increased susceptibility to thermal cracking on average in TSRST results. In addition, to determine the the variations between HMA and WMA more samples to be tested to know its importance.
- From MMLS3 testing results of wet/dry ratio rut depth clearly showed that mixture of Sasobit was more moisture susceptible to damage when compared to controlled mixture.
- Wet/dry ratios was not indicated any moisture susceptibility in case of Asphalt-min.
- Based on above results the obtained data clearly showed that Sasobit mixture having potential susceptibility to moisture damage. More ever, mixtures of Aspha-min and Sasobit having potential for thermal cracking when compared with the control mixture.
- In warm mixtures behavior, actual mixture and process of compaction used for filed mixtures production played important role in relation to their moisture and low-temperature cracking susceptibility.

References

[1] Wasiuddin, N.M.,Zaman,M. and O'Rear,E., 2008.Effect of sasobit and aspha-min on wettability and adhesion between asphalt binders and aggregates. Transportation Research Record: Journal of the Transportation Research Board, 2051, 80–89.

[2] Gopalakrishnan, K. and Metcalf, J.B., 2001. A study on moisture susceptibility of asphalt concrete mixturetures modified with ethylene-propylene residual. International Journal of Pavement Engineering, 2, 157–167.

[3] Bhasin, A., et al., 2006. Limits on adhesive bond energy for improved resistance of hot mixture asphalt to moisture damage. Transportation Research Board 85th Annual Meeting, Washington, DC.

[4] Anderson, D.A., et al., 2001. Low-temperature thermal cracking of asphalt binders as ranked by strength and fracture properties. Transportation Research Record: Journal of the Transportation Research Board, 1766, 1–6.

[5] Kim, Y.R., Whitmoyer, S.L. and Little, D.N., 1994. Healing in asphalt concrete pavements is it real. Transportation Research Record: Journal of the Transportation Research Board, 1454, 89–96.

[6] Jung, D.H. and Vinson, T.S., 1994. Low-temperature cracking: test selection. Strategic Highway Research Program (SHRP), Report number SHRP-A-400, Washington, DC.

[7] Hurley, G.C. and Prowell, B.D., 2005a. Evaluation of aspha-min zeolite for use in warm mixture asphalt. NCAT Report No. 05-04, National Center for Asphalt Technology, Auburn, AL.

[8] Hurley, G.C. and Prowell, B.D., 2005b. Evaluation of sasobit for use in warm mixture asphalt. NCAT Report No. 05-06, National Center for Asphalt Technology, Auburn, AL.

[9] MLS Test Systems, 2002. MMLS3 traffic simulator operator's manual. MLS Test Systems, Cape town, South Africa.

[10] AASHTO TP10-93, 1993. Method for thermal stress restrained specimen tensile strength. Washington, DC: American Association of State Highway and Transportation Officials.

[11] Daniel, J.S., et al., 2010. An evaluation of the moisture susceptibility of warm mixture asphalt mixture. Final Report to New Hampshire Department of Transportation, Concord, NH.

[12] Kandhal, P.S., 1992. Moisture susceptibility of HMA mixturees: identification of problem and recommended solutions. NCAT.Report No. 92-1, National Center for Asphalt Technology, Aunurn, AL.