PERFORMANCE EVALUATION OF USING ASPHALT ADDITIVE IN AIRPORT'S FLEXIBLE PAVEMENT TO REDUCE JET FUEL FAILURE

ABSTRACT

Performance Evaluation of using Additive in Airport's Flexible Pavement to reduce jet fuel failure

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Creep phenomenon is one of the important damage factors in asphalt mixture, so this parameter causes the permanent deformation and thus it appears crack in asphalt mixture. The focus of this effort is permanent deformation caused by HMA mix problems. Regarding to the fact that flexible pavement always has problem with jet fuel spillage so the client needs to repair airfield pavement in short service life. And then after a little time the cracks reflect to the top layer then it’s necessary to maintains it soon and waste natural resource and energy for short period of time

In this study, we focus on the problem of pavement deterioration and cracking due to fuel spillage using bitumen additive in order to enhance the performance. We also will describe the development of jet fuel-resistant additive to be combined to the bitumen and asphalt mixture. In this survey, it is focused on Using FT_WAX and anti-stripping additives for improvement of asphalt properties. We developed and tested the modified asphalt and compared the mixture with HMA. For this target, we performed experimental laboratory examinations on the bitumen and hot mix asphalt mixtures. Then we focus on creep test to estimate deformation of asphalt mixtures to control failure with UTM machine.

We will show that modified bitumen with anti stripping and FT-WAX excelled conventional unmodified bitumen in basic properties and sustainability. Also Anti stripping and FT_WAX are known as very compatible materials with environment, while the Tar-based materials (the conventional Asphalt seals which used for many years) are recognized carcinogenic.

Keywords: HMA, FT-WAX, Anti stripping additives, modified bitumen, creep

1. INTRODUCTION

Numerous test methods have been used in the past and are presently being used to characterize the permanent deformation response of asphalt pavement materials. These tests can generally be categorized as: Fundamental Tests, Empirical Tests and Simulative Tests

Figure 1 shows the typical relationship between the total cumulative plastic strain (permanent) and the number of loading cycles. The cumulative plastic strain is generally divided into three zones; primary, secondary, and tertiary. In the primary zone, the permanent deformation occurs rapidly, mostly due to compaction of air voids. The permanent strain decreases to a rate, which remains constant in the secondary zone. Finally, the rate of permanent strain again increases and accumulates rapidly in the tertiary zone. The starting point, or loading cycle number, at which the tertiary flow occurs is referred to as the flow number. One of the main advantages of using the repeated load permanent deformation test is that the parameters derived from the data can be used to "material-specific" calibrate the HMA rutting model that is included in the 2002 Mechanistic Pavement Design Guide.[1]

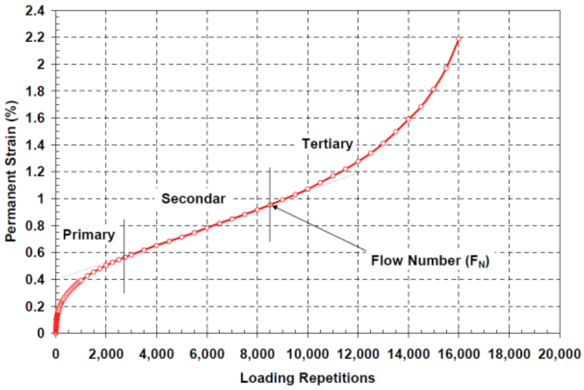


Figure1: form of permanent strain under cycle

On the other hands Protection of Hot Mix Asphalt (HMA) pavements from damage due to fuel spills or oil leaks has long been recognized as an important component of any airport pavement maintenance plan. Refining crude oil produces aircraft fuels, hydraulic fluids and most lubricating oils. Asphalt cement used in the construction of HMA pavements is also a product of the crude oil refining process. As such, jet fuel, oil, and asphalt are chemically compatible and readily mix with each other. This can cause a softening of the asphalt binder that can result in a degradation of the HMA pavement surface. [2]

Polymer modified asphalt (PMA) is often applied at airports to improve the performance of asphalt with respect to resistance to permanent deformation and resistance to reflective, fatigue and thermal cracking. Best performance is usually obtained with high quality elastomer (e.g. SBS copolymer) modified asphalt [3]. Examples of airport pavements with such PMAs are runway 9R-27L of Chicago O'Hare (the busiest runway in the world) and several runways and taxiways at Amsterdam Airport Schiphol [4]. Unfortunately, spillage of jet fuel softens the commonly used PMAs, resulting in a decrease of the integrity (stability) of the asphalt. New York LaGuardia Airport has tested recovered asphalt samples from 15 year old pavements and found them to be softer than the AC-20 originally used because of jet fuel spills [5]. For better skid resistance and to protect the asphalt layers from jet fuel, a jet fuel resistant friction course is often applied.

The first time that jet fuel resistant asphalt was specified for airport pavements was in 1995 for the new Kuala Lumpur Airport in Malaysia [6, 7]. The asphalt had to meet requirements with respect to durability, resistance to deformation and resistance to cracking. A new requirement was that the asphalt had to be resistant to jet fuel, which was rated by the loss of material after 24 hours immersion in jet fuel. [2]

A comprehensive laboratory study has been carried out to assess the performance of the jet fuel resistant PMA and the asphalt in which anti-striping additives is applied. Some of the asphalt specimens were first kept in jet fuel for a certain time before the asphalt was recovered. Asphalt specimens, both treated (24 hours in jet fuel) and untreated, were tested for their resistance to permanent deformation and their fracture characteristics at low temperature. This paper presents the results of the laboratory study into the performance of jet fuel resistant polymer-modified asphalt and asphalt mixes containing fuel resistant asphalt on failure that happen due to this parameter.

In fact if we can effect on delaying of pavement cracking we save lots of natural resource and energy. It's common that every three to five years, the client in my country cut old HMA without any recycle and coating with new mixture on airport surfaces.

2. MATERIALS AND COMPOSITION

2.1 Aggregates

First of all, the 'aggregate size' affects HMA strength and stability

Moreover, the ‘aggregate gradation’ determines the mixture characteristic and the physical properties of the HMA. The aggregate’s particle size distribution (gradation) affects the stiffness, stability, durability, permeability, workability, fatigue resistance, frictional resistance and resistance to moisture damage.

Table 1 contains the gradation and properties of the aggregate used, and

The percentage of each aggregate type used. The combined gradation aggregate used is shown. The coarse and fine aggregates used were crushed limestone imported from Damavand district of Iran. The filler used was silica obtained to supplement the fine materials size in hot mix asphalt (HMA) mixture design.

Table1: aggregate properties value in project

Properties / Statement	Water Absorption (%) ASTM-C127	Specific gravity (kg/cm^3) ASTM-C128	
		Bulk	Apparent
Retained sieve 4.75 mm	1.5	2.629	2.735
Passing sieve 4.74 mm	2.1	2.622	2.772
Passing sieve 0.075 mm			2.883

Table2: Sieve test result

Sieve	Size (mm)	Passing (%)	Retained (%)
3/4	19	100	0
1/2	12.5	95	5
4	4.75	57	43
8	2.36	41	59
50	0.3	11	89
200	0.075	4.9	95.1

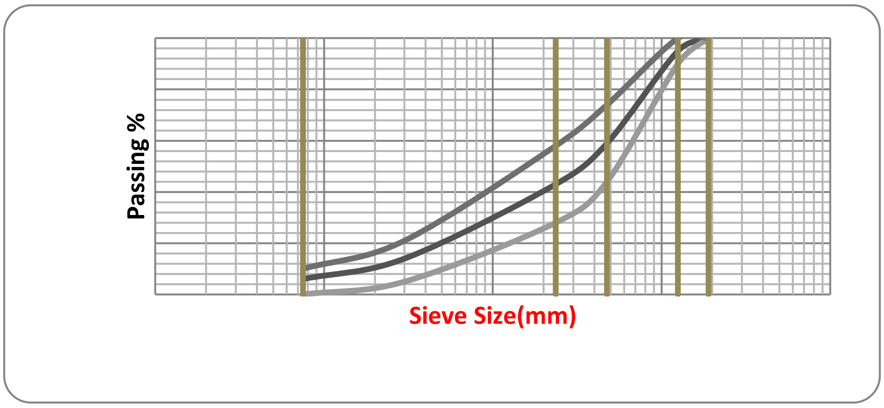


Figure 2: sieve diagram (it will be reconstructed)

3. ASPHALT ADDETIVES

3.1 FT_WAX

It is a long chain aliphatic hydrocarbon (chain lengths of 40 to 115 carbon atoms) obtained from coal gasification using the Fischer–Tropschprocess.

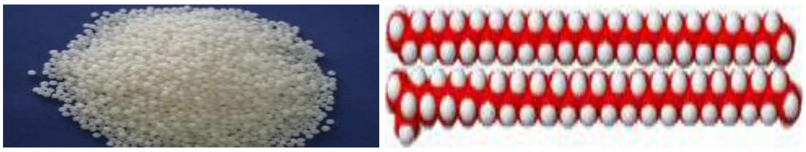


Figure3: FT_WAX chain

FT_WAX melts in the bitumen at temperatures of 85 to 115 °C (185 to 240 °F), causing a marked reduction in the viscosity of the binder. The manufacturer reports a reduction in mixing and handling temperatures of 30 to 50 °C.

3.2 anti-stripping

Anti stripping agents are surfactants capable of modifying interfacial tension aggregate-bitumen reduce the contact angle aggregate-bitumen to values smaller than 90º and allow the aggregate to be wetted by the bitumen (active adhesion). Anti stripping agents also improve the binder resistance to not being displaced by water after its fixation on the aggregate's surface (passive adhesion). Table 3 shows anti stripping properties were used in this study case.

Table 3: anti stripping properties

Form	**Liquid**
Color	Dark brown
PH	11.9
Boiling point/range	255 °C (492.44 °F)
Melting point/range	-24.00 °C (-11.20 °F)
Flash point	146 °C (294.98 °F)
Vapour pressure	0.01 mmHgat< 20 °C (< 68.00 °F)
Relative vapour density	4.6
Water solubility	Completely soluble
Relative density	1.09at20.00 °C (68.00 °F)
Viscosity, dynamic	11.000 - 12.000 mPa.s

4. Bitumen

In this research, we used developed three kind of bitumen for each sample: 1- conventional 60/70 bitumen. 2- Modified bitumen with FT_WAX and 3- modified bitumen with anti stripping additive. The performance of the binders was tested according to the basics tests: penetration, softening point, viscosity at three temperatures, fire point specific gravity and Viscosity in 120C. In FT_WAX Modified bitumen, we added FT_WAX 2% of bitumen weight in each specimen. Also, in case of anti stripping Modified bitumen, we added anti-stripping0.5% of bitumen weight for each specimen.

The Binder content (optimum amount) for conventional 60/70 bitumen obtained 5.5% of Asphalt mixture. Also, in case of anti stripping Modified bitumen, we took into consideration the same binder content amount (5.5%), because the amount of this additive in each specimen is very low (0.5% of Binder weight) and it doesn't affect the binder content amount. We knew that adding FT_WAX reduce the binder content 0.1% to 0.2%, but according to this fact that this study case was a comparative study, we decided to waive this reduction. So we considered the same binder content (5.5% of asphalt mixture weight) for FT_WAX modified bitumen, too.

Table 4 compares the results obtained with two modified bitumen and conventional bitumen.

Table 4: Bitumen properties

Properties	**60/70**	**FT_WAX**	**Anti stripping**	**Standard**
Penetration at 25 C, 1/10 mm	70	55	50	ASTM-D5
Specific gravity, g/cm^3	1.012	1.065	1.023	ASTM- D70
Softening point, C	48	78	63	ASTM-D36
Fire point, C	300	375	314	ASTM-D92
Viscosity, in 120C (Pa.s)	683	730	700	ASTM-D4402

5. EXPERIMENTAL TESTS

In this survey, it is focused on using FT_WAX and anti-stripping additives for improvement of asphalt properties and increase mixture resistance against create cracking and reflect of its. In order to challenge the conventional Hot Mix Asphalt (HMA), we developed and tested the modified asphalt and compared the mixture with HMA. We compared the performance of bitumen (AC 60/70) asphalt with the asphalt submersed in jet fuel. In these examinations, the samples were fully immersed in Jet GP4 fuel. After immersion test, all samples were done creep test with UTM machine.

5.1. Test Conditions for the Static Creep and Repeated Load Tests

Static creep and repeated load tests, confined and unconfined, were conducted using at least two replicate test specimens for each mixture. All tests were carried out on cylindrical specimens, as marshal for the static creep tests, a static constant load was applied until tertiary flow occurred. For the repeated load tests, a haversine pulse load of 0.1 sec and 0.9 sec dwell (rest time) was applied for a target of 300,000 cycles. This number was less if the test specimen failed under tertiary flow before reaching this target level. An IPC Universal Testing Machine (UTM 25-14P) electro-pneumatic system was used to load the specimens. The machine is equipped to apply up to 90 psi (620 kPa) confining pressure and 5,500 lb (24.9 KN) maximum vertical load. The load was measured through the load cell, whereas, the deformations were measured through six spring-loaded LVDTs.

5.2 Preparation of Marshall Specimens:

Three types of Marshall Specimens were prepared in the laboratory condition According to ASTM D1559-76: **1-**Standard Hot Mixed Asphalt, **2-**Sasobit Modified Asphalt, and **3-**anti-strippingModified Asphalt. Eight (8) specimens were prepared from each type.

5.2 Fuel Resistance Immersion test:

Marshall Specimens were fully immersed in Jet GP4 fuel, at room temperature (air conditioned room at 25, C) for the specified controlled period. Four specimens should be prepared from each type of specimens for testing condition. Afterwards, the specimen were carefully lifted out of the fuel and placed in a fume cupboard and air-dried until they had reached constant weight (normally after 24hrs).

The specimen weight before and after immersion was recorded. Table 5 shows results of immersion test according to Brush test. Also, figure 4 below shows Marshall Specimens after the immersion test.

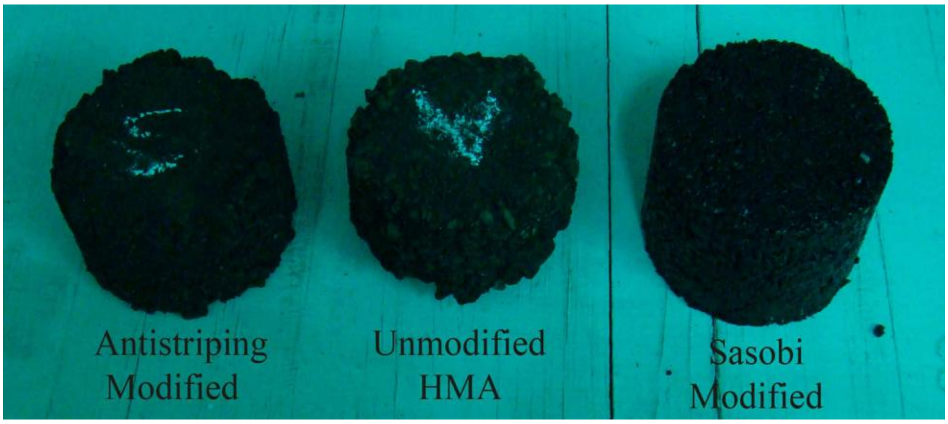


Figure4: Marshall Specimens after immersion in jet fuel

Table 5: Resistance to Jet Fuel after Immersion [7]

Test	Unmodified 60/70	FT_WAX Modified	Anti striping modified
Average mass loss after 24h immersion, in Jet GP4 fuel, %	15%	0.63%	4.3%

5.3 Permanent deformation

The permanent deformation under dynamic loading effect conducted according to BS:DD226 . Figure 4 shows the process of deformation in 4 condition of test. It tested with special assumption table6

basic assumption for testing**Table 6:**

Test method	Units	Australian: AS 2891.12.1

Cross-Sectional area	mm^2	7906.429
Volume	mm^3	513917.9
Pulse width (ms)	(ms)	500
Rest period (ms)	(ms)	1500
Contact Stress (kPa)	(kPa)	2
Contact Load (kN)	(kN)	0.016
Deviator Stress (kPa)	(kPa)	400
Deviator Load (kN)	(kN)	3.163
Load Cell STC-2000/E23646	kN	10
FBC Displacement S/N 43B 707-20	mm	30
Axial LVDT 1 D5-200AG (ILC)/12729	mm	5
Axial LVDT 2 D5-200AG (ILC)/12731	mm	5
Core temperature PT100/TP256	Deg.C	100
Skin temperature PT100/TP257	Deg.C	100

permanent deformationantistripping immerssed sample**diagram1:**

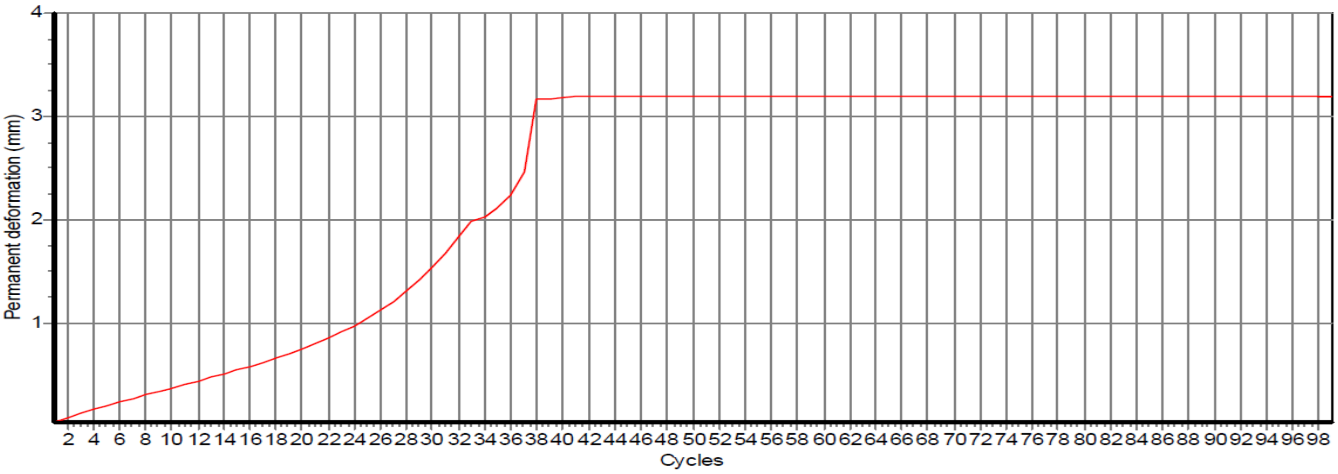


diagram2:permanent deformation of sasobit immerssed sample

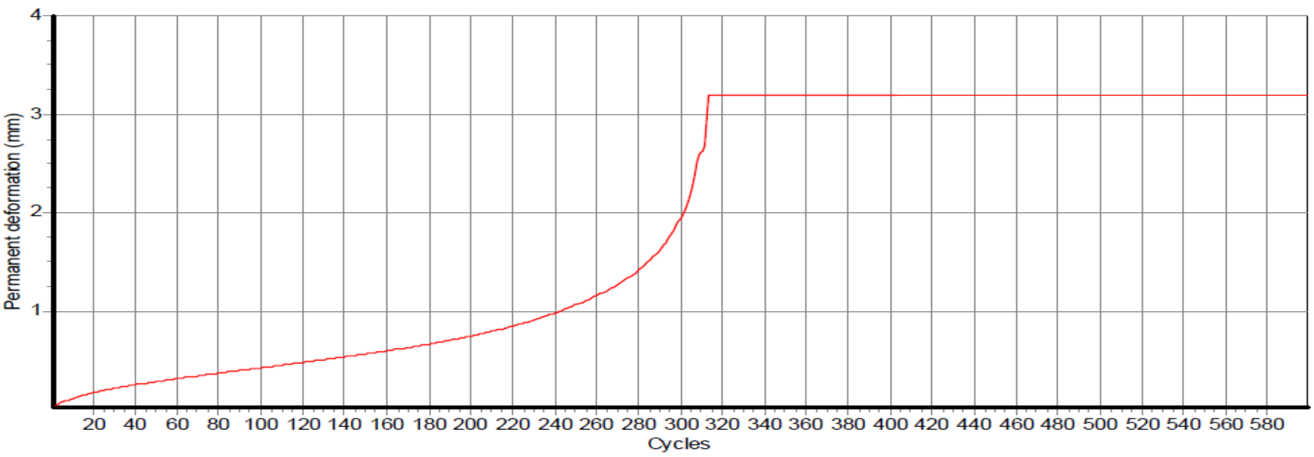
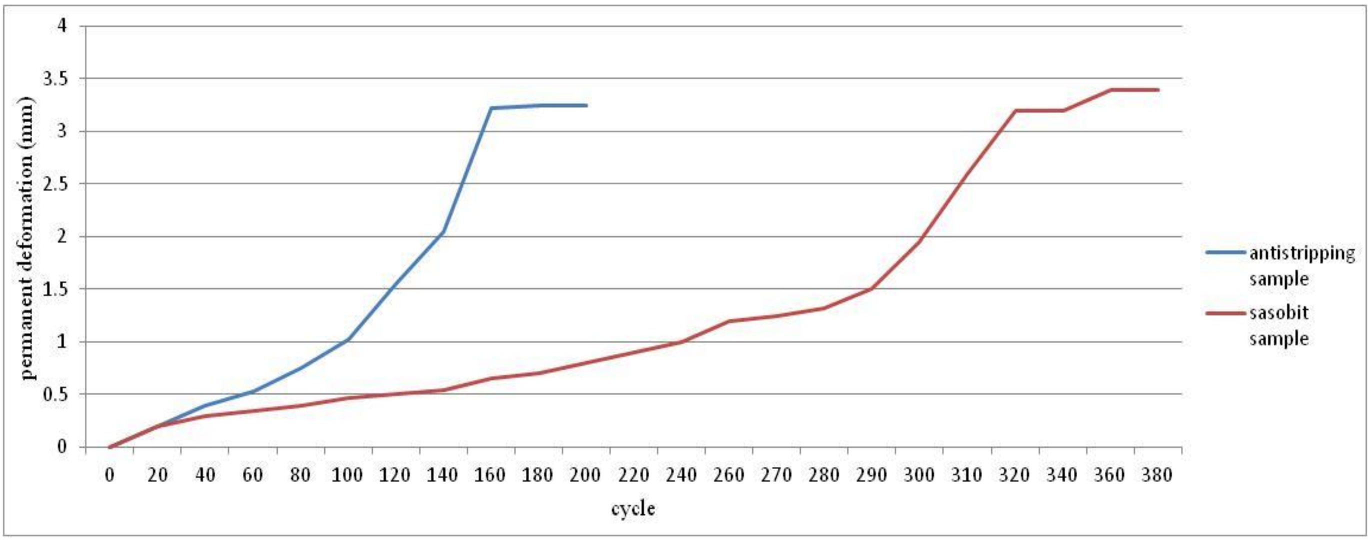


Diagram3: Comparetive diagram of two modeifed sample



In comparative diagram it seems that all the modified samples were resisted on loading until it was failed, but there behave were different. The value of deformation shows that modified FT_WAX sample could resist under loading better than anti stripping sample. On the other hand number of load cycle on FT_WAX modified sample are 170 percent of anti stripping sample up to reach approximately 3.5 mm deformation. Failing simple sample after immersion was exciting and it's out of shape and couldn't tested in UTM machine

6. CONCLUSION

The results presented in this paper can be summarized to the following conclusions:

Using Anti stripping materials and modifying bitumen Hydrocarbon bonds by bitumen additives can improve adhesion between bitumen and aggregates. Also increases the resistance of asphalt mixture against the fuel. Due to improved asphalt quality against moisture damages and striping, it can be impact on asphalt behavior in the project period. So, it is recommended to use this additive, if the materials used in the project area was silica and the moisture of region was high.

FT_WAX with high quality and suitable performance in asphalt mixtures had an important role in controlling damages due to fuel spills. According to low temperature of mixture design, FT_WAX is an ideal option for pavements, which are under heavy frequency loading.

Asphalt samples behavior under creep tests indicate that modified samples have better performance in terms of maintaining quality and resistance indices in immersed conditions; also it will increase the service life of pavement.

The result of modified sample under dynamic loading shows that the numbers of cycle for failing sample are different. The FT_WAX modified can resist better than all immerses sample. According diagram we achieve that it increase 170 percent of load cycle up to special deformation, so it demonstrate that this modified sample can exceed delaying under load repletion under different type of fuel spillage.

Permanent deformation results from the accumulation of small amounts of unrecoverable strain as a result of repeated loads applied to the pavement. The result shows that the averages of permanent deformation for FT_WAX sample in 380-load cycle are 3.19 mm. and this deformation happens for anti stripping immersion sample in 40 load cycles. According to creep test and deformation of modified sample shows that it can reduce wasting natural resources and energy to produce during new HMA because of delaying on cracking and repairing.

An exciting phenomenon was happened that asphalt mixture was changed to fail form, so we couldn't test it in UTM machine. It shows that HMA isn't appreciated for special place near jet fuel such as airports and petrol station.

According to our test results, it's seems that using additives reduce the maintenance and rehabilitation costs. It's highly probable to increase the service life. Although we don't have any references and data or practical experience in our country to analyze and evaluate.

Jet A1 fuel has been used in most of previous studies and researches for immersion tests, while for this study we used jet GP4 fuel which has a higher solubility degree, with the aim of worse condition for testing the samples.

7. REFERENCES

[1] Bennett, Maher.A "Evaluation of Crumb Rubber in Hot Mix Asphalt*",* Rutgers University Department of Civil and Environmental Engineering.
[2] khadem.M, moosavi.h, "CASE STUDY OF ASPHALT ADDITIVE EFFECT ON JET FUEL RESISTANCE IN AIRPORT'S FLEXIBLE PAVEMENTS*".* 5th International Conference Bituminous Mixture and Pavements, Thessaloniki, Greece, 1-3 June 2011
[3] Emery, S.J. and J. O'Connell, "*Development of High Performance SBS Modified Binder for Production Transported", CSIR*, PO Box 395, Pretoria, SouthAfrica, pp: 463-684.
[4] Stet, Voorwinde.M, and Van dervegte.R, "*Safe Ground Runway Pavement at Schiphol With Respect to the Arrival of NGA by Means of PC*
". Worldwide Airport technology transfers conference, Atlantic City, New jersey, USA. April 2007
[5] Masson, J-F. and M. A. Lacasse (1998), "*Considerations for a Performance-Based Specification for Bituminous Crack Sealants", flexible pavement rehabilitation andmaintenance*, ASTM-STP-1348,
[6] Nataraj, Ir. A.R., "*Use of Polymer Modified Asphalt Mixes in Airport Pavements – Design Approach and Case Histories*," International Sealoflex Conference, Rome, 2001.
[7] ASTM, *Annual Book of ASTM Standards, Part 15: Road, Paving, Bituminous Materials, Travelled Surface Characteristics*, 1982.
[8] Tabatabaee A.M, *Road pavement*, p210, Vol.6, Markazedaneshgahi Publisher, Iran, Tehran, 2006
[9] Buijs, J., and Van Buël, T., *Chemical resistance of asphalt*, Hogeschool `s-
Hertogenbosch, 2001.