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EVALUATION OF NORMAL AND MODIFIED ASPHALT ACCORDING TO CONVENTIONAL AND MODERN GRADING SYSTEMS

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Asphalt plays a significant role in pavement quality. The need for high-performance pavements with long service life and low maintenance requirements is the motive behind thorough research and studies of asphalt characteristics. This research focuses on studying all sources of Egyptian asphalt over a span of time using both conventional and Superpave grading techniques in order to characterize asphalt performance and also to answer the question whether the Egyptian asphalts need modification. The results of this research indicate that all Egyptian normal (virgin) 60/70 asphalt samples from different sources failed to meet penetration grading requirements, viscosity grading standardsAC-20 (high quality); with minor exceptions, viscosity grading system AC-20 (low quality), and both AR-8000 and AR-1000 Aged Residue grading systems. When Superpave grading system was employed, results indicate that all normal asphalt samples failed to meet the basic requirements (without traffic adjustment) according to the Egyptian climatic requirements for high reliability projects (PG70-10 and PG76-10). The testing results accommodate Superpave requirements for lower levels of reliability and/or lower level of conservativeness. This emphasizes the flexibility and reliability of Superpave grading system as compared to conventional grading systems. On the other hand all modified asphalt samples, using an SBS modifier, passed according to the base high reliability projects and/or high level of conservativeness requirements of the Superpave grading system. Finally it is concluded that Egyptian asphalt should be modified in order to provide satisfactory performance especially for high reliability projects in hot regions with high and/or slow traffic.

Keywords: Superpave, Penetration, Viscosity, AR viscosity, SBS modification, Performance grade.

1 INTRODUCTION

The pavement construction industry has been having problems with the asphalt and asphalt mixtures used over the years in Egypt. Similar problems with asphalts are not uncommon in various part of the world. The need to modify and improve the asphalts has been recognized by roadway agencies around the world.

Traditional methods of evaluation of bituminous materials were developed to assess the quality of normal asphalts. They are not suitable for assessing modified asphalts. This was one of the major motivations to develop the recent SUPERPAVE technology. Research efforts have been conducted to evaluate locally produced bituminous materials; e.g., Al-abdulWahhab *et al.* (1997) who studied the chemical and physical

characterization of Arab bitumen and evaluated the suitability of the used regional normal bitumen on the basis of the SHRP performance-based specifications. The study concluded that locally produced bitumen needed modification to suit the different Gulf temperature zones. Aflaki and Nader (2009) investigated the properties of locally produced asphalt in Iran with suitable performance grade through modification techniques. Eleven normal bitumen samples, including 40–50, 60– 70, and 85–100 penetration grades, were obtained from seven asphalt production plants. The study indicated that grades of four out of five PGs were met through modifications. Al-Abdul Wahhab *et al.* (1998) determined Arab Gulf asphalt performance based characteristics and assessed their needs for modification. He concluded that the Gulf asphalts satisfy the low temperature performance requirement but need to be modified to be able to perform adequately in the Gulf countries' hot environmental conditions.

The main objective of this study is to assess the Egyptian locally produced asphalt quality using different grading systems. In order to achieve this objective, various asphalt samples obtained from the three Egyptian sources; 60/70 produced by Alexandria, El Nasr, and Suez Oil Companies, were the subject of investigation. Environmental considerations were pertinent to the Egyptian conditions, and Sealoflex (SBS modifier) was the asphalt modifier considered for investigation. These binders, as original (normal without modification) collected over one year span of time, were subjected to full characterization using two different approaches; conventional (including penetration, viscosity, and AR viscosity) and modern (superpave) grading systems. The SBS modifier used in this research is called Sealoflex. Its contents and morphology are granted by the producer (Ooms Co). A sample of the binder from each source was modified by the SBS modifier, Alex asphalt had two modified samples. The conventional grading systems were inadequate to characterize the modified asphalt. Only the superpave grading system was used to characterize the modified asphalt. Twenty different asphalt samples were obtained to accomplish the asphalt characterization task, sixteen samples for the normal asphalt and four modified samples.

2 EVALUATION OF EGYPTIAN ASPHALT USING CONVENTIONAL GRADING SYSTEMS

Sixteen samples of normal asphalt (5 samples produced by Alex Oil Company, 7 samples produced by El Nasr Oil Company, and 4 samples produced by Suez Oil Company) were tested against the requirements of 60/70 penetration, AC-20 viscosity (with both high and low qualities), and AR-1000 and AR-8000 aged residue viscosity grading systems. A conclusion of the final status (either failed or passed) to all tested asphalt samples according to the conventional grading systems is illustrated in Table 1. It was found that although some asphalt samples passed for individual test (requirement), when the whole grading system is considered asphalt samples could not meet the whole requirements and then considered to be "failed". Detailed asphalt test results (each test result for each sample for all grading systems considered) are available in Khedr *et al.* 2010).

3 EVALUATION OF EGYPTIAN ASPHALT USING SUPERPAVE GRADING

In order to use the modern SUPERPAVE grading system, the prevailing Egyptian climatic conditions have to be determined in order to specify the required performance grade (PG) for asphalt to be used in Egypt. Then, the performance grade (PG) of the locally produced asphalt has to be determined. Determining the required asphalt PG pertinent to the Egyptian climatic conditions was the subject of a research by Khedr *et al.* (2014). The results of this research indicated that for high scale projects (with reliability more than 98%) the required base (without traffic adjustments) PG for Egyptian conditions ranged from 70-10 to 76-10; whereas for low scale projects (with reliability more than 50%) base PGs requirements ranged from 52-10 to 64-10. In this research, base PG for high scale projects are considered as the specification requirement to characterize asphalt for use in Egypt employing the superpave technique. This consideration may also account for higher traffic volumes, Khedr *et al.* (2014).

Table 1. Characterization of all Egyptian asphalt sources and types using conventional grading systems.

Asphalt Source	Asphalt Type	Sample ID	Grading system		
			Penetration (60/70)	Viscosity AC-20 (low and high qualities)	AR-1000 AR8000
Alex	Normal	AN1	Failed	Passed, low quality	Failed
		AN2	Failed	Failed	Failed
		AN3	Failed	Failed	Failed
		AN4	Failed	Failed	Failed
		AN5	Failed	Failed	Failed
	Modified	AM1	N.A	N.A	N.A
		AM2	N.A	N.A	N.A
El Nasr	Normal	NN1	Failed	Passed, low quality	Failed
		NN2	Failed	Failed	Failed
		NN3	Failed	Failed	Failed
		NN4	Failed	Failed	Failed
		NN5	Failed	Failed	Failed
		NN6	Failed	Failed	Failed
		NN7	Failed	Failed	Failed
	Modified	NM1	N.A	N.A	N.A
Suez	Normal	SN1	Failed	Passed, low quality	Failed
		SN2	Failed	Failed	Failed
		SN3	Failed	Passed	Failed
		SN4	Failed	Failed	Failed
	Modified	SM1	N.A	N.A	N.A

3.1 Egyptian Asphalt Characterization According to Superpave Requirements

The results of the tested samples show the status of the asphalt sample either passed or failed as per the criteria explained above to meet the Egyptian climatic requirements is summarized in Table 2. Detailed results for each individual test are available in Khedr *et al.* (2010).

3.2 Determining Performance Grade (PG) for Egyptian Asphalt

In order to fully apply the superpave grading system in characterizing the locally produced asphalt and after finding that it fails according to the Egyptian climatic conditions (for high reliabilities). It is suitable to determine the Egyptian asphalt performance grade (PG) to find out whether it could be fitted for use in lower reliability requirements. The high-end and low-end performance grades were determined for all asphalt samples using the dynamic shear test as recommended in the literature, Freddy *et al.* (1991). The final performance grades (PGs) for all samples are summarized in Figure 1. It is observed from Figure 1 that the performance grades of the normal Alex and the normal Suez asphalt samples ranged from PG58-40 to PG64-40; whereas the normal El Nasr asphalt samples gave higher PGs ranging from PG64-40 to PG70-40. When the modified asphalts for the three sources were considered, it was found that the performance grade of both modified Alex and modified Suez asphalt were PG82-40, which was noticeably higher than the performance grades provided by the normal asphalt of these two sources. As for the modified El Nasr asphalt, it resulted in the highest performance grade of all Egyptian asphalt samples at PG94-40. It can be stated that Nasr asphalt as normal or modified gave the higher performance grades compared to the other two asphalt sources.

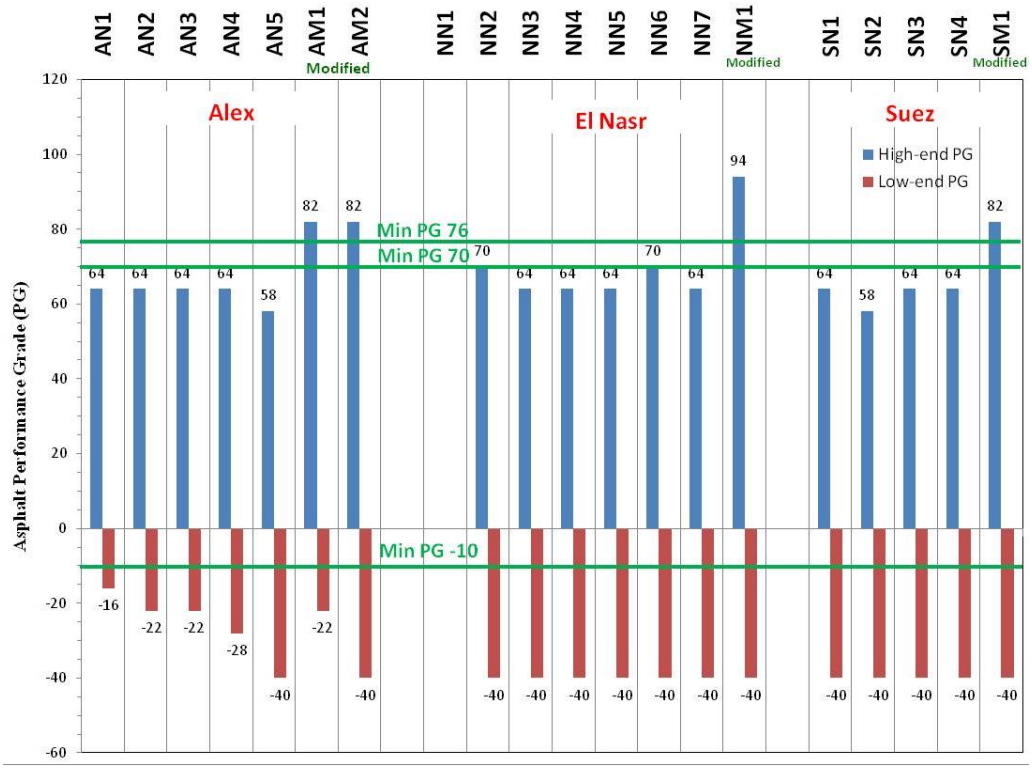
Table 2. Final characterization of all Egyptian asphalt sources and types using superpave grading system.

Asphalt Source	Asphalt Type	Sample ID	Superpave @ (PG70-10 and PG 76-10)
Alex	Normal	AN1	Failed
		AN2	Failed
		AN3	Failed
		AN4	Failed
		AN5	Failed
	Modified	AM1	Passed
		AM2	Passed
El Nasr	Normal	NN1	Failed
		NN2	Failed
		NN3	Failed
		NN4	Failed
		NN5	Failed
		NN6	Failed
		NN7	Failed
	Modified	NM1	Passed
Suez	Normal	SN1	Failed
		SN2	Failed
		SN3	Failed
		SN4	Failed
	Modified	SM1	Passed

4 EGYPTIAN ASPHALT PG "SUPPLY" VERSUS EGYPTIAN ASPHALT CLIMATIC REQUIREMENTS "DEMAND"

The Egyptian asphalt PG "supply" was determined in the previous section, and the required asphalt performance grades according to the Egyptian climatic requirements "Demand" were determined by Khedr *et al.* (2014). The question to be raised is "Does the supply satisfy this demand?". In other words, "Do the performance grades of the normal asphalts locally produced in Egypt can satisfy the wide range of Egyptian asphalt performance grade requirements?", and if not "Do modified ones can meet these required PGs?" The following paragraphs should answer these questions.

Figure 1. Determining performance grades (PGs) of all used Egyptian asphalt samples.



For high scale projects (with reliability more than 98%), when high conservative level of analysis is applied, Egypt is divided into two zones, Khedr *et al.* (2014), zone I with requirements of PG70-10 which cannot be met by any normal asphalt, except some samples of El Nasr, and zone II with PG76-10 which cannot be met by any normal asphalt and the move to the modified asphalt is a must.

For lower reliability projects (50% reliability), when moderate level of conservation in analysis is considered, Egypt is divided into 3 zones, Khedr *et al.* (2010). According to this zoning, zone I requires PG 52-10, zone II requires PG58-10, and zone III requires PG64-10. Accordingly, in this case, there is no need for the modified asphalt since many different normal asphalt samples can work efficiently all over Egypt.

It can be stated that normal asphalt can be used in moderate climatic conditions at lower reliability projects with low to moderate traffic levels. In hot regions with higher traffic levels especially at higher reliability projects modified asphalt becomes an obligatory need.

5 CONCLUSIONS

Based on the work carried out in this research, the following can be concluded:

(1) All normal Egyptian asphalt samples fail according to conventional grading systems with minor exceptions.

(2) All normal Egyptian asphalts fail according to high conservative level of analysis and high reliability projects of Superpave grading system requirements.

(3) The modified asphalt does satisfy all Egyptian PG requirements

(4) The actual PG of the normal Egyptian asphalt could not satisfy the Egyptian asphalt requirements for high reliability projects; whereas it may fit for lower reliability projects and/or less conservative analysis.

(5) Superpave grading system is a more fundamental more reliable system and is more flexible in its requirements. It even accommodates Superpave requirements for lower levels of reliability and/or conservativeness; while conventional grading requirements reject most normal asphalt samples.

(6) When using modified asphalt, conventional grading systems are not applicable and superpave grading system must be used.

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