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SUPERPAVE VERSUS CONVENTIONAL TECHNIQUES FOR DESIGNING NORMAL AND MODIFIED ASPHALT MIXES

SAFWAN KHEDR and MARAM SAUDY

Construction Engineering Dept, American University in Cairo, Cairo, Egypt

Due to the empirical nature and drawbacks of the conventional procedures, the Strategic Highway Research Program (SHARP) has developed a Superior Performance Asphalt Pavements (SUPERPAVE) mix design procedure. The main objective of this research is to study the applicability of the Superpave in Egypt. This is done by studying aggregate characteristics using both the Superpave and the conventional techniques, investigating the normal (virgin) and SBS modified asphalt characteristics using Superpave, and designing asphalt mixtures comprised of the characterized materials using both the Superpave and the conventional Marshall design methods. Results indicate that Superpave is applicable to Egyptian aggregate with a more restrictive supervision of crushing aggregates and gradations (some gradations may need modifications). Mix design results indicated two main findings; first, most optimum asphalt contents (OAC) determined by the Superpave mix design method are consistently less than OAC determined by the Marshall Mix design method. Second, modified asphalt mixes result in less OAC than normal asphalt mixes according to both Marshall and Superpave mix design methods for both binder and surface layers.

Keywords: Aggregate properties, Aggregate gradation, OAC, SBS modified asphalt, Marshall, and Superpave.

1 INTRODUCTION

Current specifications used for road construction in Egypt do not properly account for pavement performance. Applying more mechanistic design method is essential to accommodate the rapid growth of road network and traffic volumes, and to improve network performance and safety. Superpave practices have been widely used by both developed and many developing countries. The Superpave system is now spreading over many parts of the world. The main objective of this research is to study the applicability of SUPERPAVE techniques in Egypt. In order to achieve this objective, various materials, asphalt and aggregates, obtained from Egyptian sources are used to design mixes using both Marshall and Superpave mix procedures. Environmental considerations are pertinent to Egyptian conditions and Sealoflex (SBS modifier) was the asphalt modifier considered for investigation.

Khedr and Breakah (2010) investigated the application of Superpave in Egypt. They examined aggregate graduation requirements in the Egyptian code in view of the Superpave aggregate structure. They also designed mixes using Egyptian materials with gradations that satisfy both the Egyptian code of practice and Superpave aggregate structure. They compared the results of Superpave mix design to Marshall mix design. The investigation established a relationship between resilient and residual properties of asphalt concrete made of Egyptian materials. They concluded that most of the Egyptian gradation bands do not fit the Superpave gradation limits. Then, in order to start applying Superpave in Egypt, these bands should be reviewed in view of the Superpave 0.45-power charts. Superpave shows lower optimum asphalt content as compared to Marshall Mix design for the studied mixes. The general trend found in this study indicates that the samples prepared using the Superpave gyratory compactor have higher values in stability and flow than those prepared using the Marshall method.

Asi (2007) conducted a comprehensive evaluation of the locally available aggregate in Jordan commonly used in the asphalt concrete mixtures, to ensure that these materials conform to the new mix design procedures developed by SUPERPAVE. Swami *et al.* (2004) compared the design of asphalt mixtures by the Superpave and Marshall methods of mix design in India. A detailed laboratory study was carried out using local aggregate and local bitumen. From the analysis of design of mixtures, Superpave mixes fulfilled all the criteria for easy and good construction at lesser binder content than the Marshall mixes. The study recommended that Marshall mix design be replaced by Superpave mix design for the Indian national highways.

2 MIX DESIGN USING CONVENTIONAL AND SUPERPAVE METHODS

Mix designs are performed according to conventional Marshall and SUPERPAVE methods using the Egyptian materials. The variables involved in this task were; types of asphalts, asphalt modification, types of aggregates materials, aggregates structures, traffic conditions, and climatic regions. The mix design program is limited to three sources of asphalts; Alexandria, Suez, and El Nasr Oil companies, two types of asphalts; normal and SBS modified asphalts, one type of coarse aggregate; limestone from Ataqua quarry, one type of fine aggregate; natural sand from Al-haram quarry, one type of mineral filler; limestone filler, two aggregate structures: 3D (binder course) and 4B (surface layer) as per the Egyptian specifications, and heavy traffic. This resulted in 18 mix designs.

2.1 Aggregate Characterization

The used Egyptian coarse and fine aggregates have been characterized using both the conventional and Superpave approaches. The full characterization results are illustrated in Table 1. It is clear from Table 1 that, the used coarse and fine aggregates satisfy all requirements except the fine aggregate angularity, and the coarse aggregate angularity only for surface layer requirements and marginally satisfy the clay lumps and friable materials requirements.

The shortage in the angularity percentage of fine aggregates was expected since the used fine aggregate is natural sand. The natural sand was used since it is the fine aggregates used in the majority of projects implemented in Egypt. Although these deficiencies were encountered, the aggregates were used in designing asphalt mixtures.

Table 1. Aggregate characterization using conventional and Superpave procedures.

Aggregate Type	Test	Result	Specification	Status
Coarse Aggregate	Nominal Max. Size (NMS)	1inch (25mm)	…..	……
	Los Angeles Abrasion at 100 cycles, %	5.1	< 10%	Passed
	Los Angeles Abrasion at 500 cycles, %	25.5	< 40%	Passed
	Bulk Specific Gravity	2.475	….	…….
	Apparent Specific Gravity	2.643	….	…….
	Absorption, %	2.49	<2.5%	Passed
	Clay Lumps and Friable Materials, %, Supe.	1.06	<1%	**Marginal**
	Flakiness Index	20.25	<25%	Passed
	Elongation Index	8.85	<25%	Passed
	% of Flat and/or elongated, Superpave	2	<10%	Passed
	Angularity, %, (Binder course), Superpave	85.5% have one fractured face and 93.74% have two	Min 80% have one fractured face and Min 75% have two*	Passed
	Angularity, %, (Surface layer), Superpave	85.5% have one fractured face and 93.74% have two	Min 95% have one fractured face and Min 90% have two**	**Failed**
	Chemical Soundness (%materials lost)	0.25	<12%	passed
Fine Aggregate	Bulk Specific Gravity	2.659	….	……
	Apparent specific Gravity	2.68	….	……
	Absorption, %	0.3	<2.5%	Passed
	Clay Lumps and Friable Materials, %, sup.	1%	<1%	**Marginal**
	Chemical Soundness (%materials lost)	0.5%	<10%	Passed
	Angularity, %, Superpave	30.3	Min 40%***	**Failed**
	Sand Equivalent, Superpave	76%	Min 45%****	Passed
Filler	Apparent Specific Gravity	2.7	….	…….

2.2 Aggregate Gradation

Two different layers gradations, binder course and surface layer, were designed using both Marshall and Superpave procedures with the normal and the modified asphalts. The first step was to select the aggregate gradation. Binder gradation 3D according to the Egyptian pacifications was selected as shown in Figures 1. It is clear from figure 1 that 3D gradation fits easily into the Superpave control points. Many difficulties were encountered in selecting a surface gradation which can best fit with the Superpave requirements. A modified 4B surface gradation was selected for the surface layer as shown in Figure 2. It was modified to satisfy the requirements of the Superpave gradation and voids ratios.

2.3 Binder Characterization

Table 2 illustrates the final results of both the normal and the modified Egyptian asphalt obtained from the three available sources according to the Superpave grading system.

3 MIX DESIGN

Once materials used (aggregates and binder) have been fully characterized, the next step is designing the mixture using the normal and the modified asphalts for two different layers (gradations), binder course and surface layer. The Marshall and Superpave methods were used to design the mix.

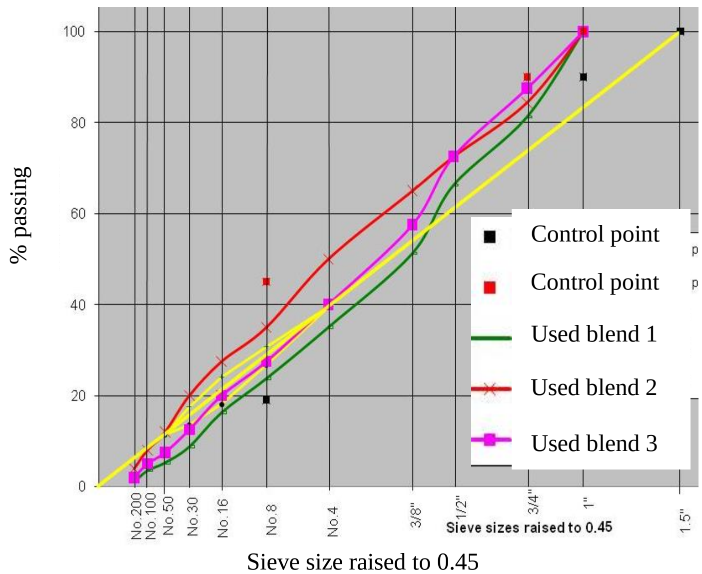

Figure 1. 3D binder gradation used for Superpave mix design method.

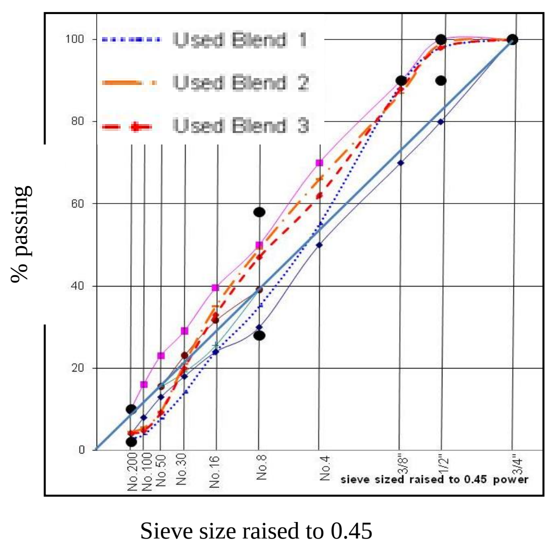

Figure 2. Modified 4B surface gradation used for Superpave mix design method.

Table 2. Binder characterization for different Egyptian asphalt sources and types using Superpave grading system.

Asphalt Source	Asphalt Type	PG
Alex Oil Company	Normal	PG64-22
	Modified	PG82-40
El Nasr Oil Company	Normal	PG70-40
	Modified	PG94-40
Suez Oil Company	Normal	PG58-40
	Modified	PG82-40

3.1 Mixture Design using Marshall Method

The Marshall mix design method was applied only to the binder course to compare Mix OAC to the Superpave mix OAC, see Figure 3. It can be noted from Figure 3 that modified asphalt results in less OACcompared to the normal asphalt for both Alex and Suez binders which may indicate that using the Sealoflex modifier provides better lubrication and coating to the aggregates results in reducing the amount of the optimum asphalt required for the mix when using the Marshall method. This was not observed in the case for asphalt El Nasr and this may be explained by the unexpected high viscosity (RV = 3.8 Pa.s), according to Khedr *et al.* (2010), encountered by El Nasr asphalt which may require a higher percentage of the optimum asphalt content to sufficiently coat the aggregates.

3.2 Mixture Design using Superpave Method

3.2.1 *Binder course with normal and modified asphalts*

The normal asphalt was first used to design the mixtures with the Superpave to select the optimum blends (aggregate structures) and to select the optimum asphalt content. The results indicate that the optimum blend was blend # 1 within the 3D gradation (see Figure 1). Then, the modified asphalt was used to design the mixture of the binder course using the Superpave method. The selected blend was blend # 2 within the 3D gradation (see Figure 1). Figure 4 illustrates the OAC for both normal and modified asphalt selected for the three Egyptian asphalt sources used.

3.2.2 *Surface layer with normal and modified asphalts*

The typical Superpave procedure was followed again to design the surface layer with gradation 4B surface gradations according to the Egyptian specifications. Difficulties were encountered to fit the standard 4B gradation with the Superpave requirements then 4B surface gradation was used but with some modification in sieves numbers 30, 50, 100 and 200 as illustrated in Figure 2. Mixture was designed with both normal and modified asphalt using the Superpave procedure. The selected blend was blend # 1and Blend # 3 for normal and modified asphalt, respectively as illustrated in Figure 2. Also Figure 4 shows the final selected OAC for surface layer for the three sources used.

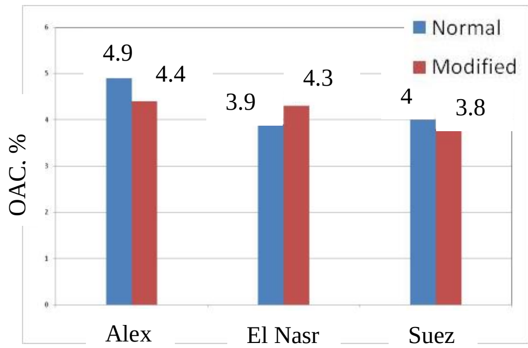

Figure 3. Marshall optimum asphalt contents for different asphalt mixtures.

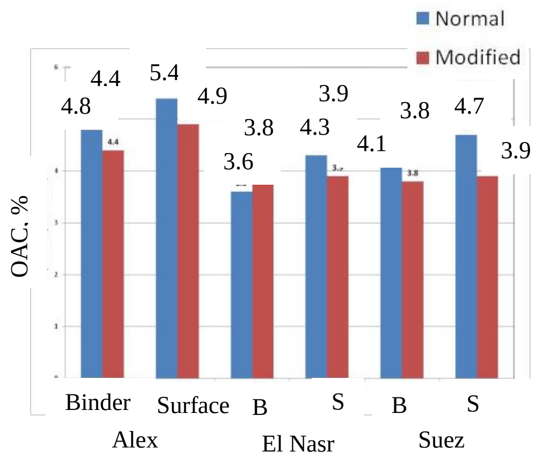

Figure 4. Superpave optimum asphalt content for different asphalt mixtures.

4 CONCLUSIONS AND RECOMMENDATIONS

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

- The used Egyptian fine and coarse aggregates marginally satisfy the requirements for clay lumps and friable materials. The used Egyptian fine aggregates fail in satisfying the requirement of the fine aggregates angularity. Also, the used coarse aggregates fail in satisfying the Superpave angularity requirements only for the surface layer.
- For binder course, gradation within standard 3D binder according to the Egyptian specifications satisfies Superpave requirements for mix design. Also, for Surface course, standard 4B surface gradation according to the Egyptian specifications need some modifications to satisfy Superpave requirements for surface layer mix design.
- Most OAC determined with the Superpave mix design method are consistently less than OAC determined by the Marshall Mix design method for both binder and surface Courses. Superpave mix design method is applicable with Egyptian materials, gradations and environment.

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