EVALUATION OF SUPERPAVE INDIRECT TENSILE STRENGTH OF HMA WITH WASTE GLASS

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Abstract*—The purpose of hot mix asphalt (HMA) pavement is to serve the transportation, and provide smooth surface over which vehicles can move safely. However, at certain period of time, many problems such as rutting, fatigue failure, and low skid resistance have been arisen due to its poor performance in term of temperature sensitivity and an increase in traffic loading. Using of waste materials in road pavements is nowadays considered. Due to the widely using of glass in our daily life, and a large amount of waste glass is generated annually; waste glass has been used in the road construction as an alternative to the aggregates in the HMA. This study aims to produce HMA using waste glass by SuperPave method. Also, indirect tensile (IDT) strength test has been performed on HMA with crushed glass, and without glass. Different percentages of crushed glass materials of 7%, and 20.5% were used. Crushed glass used in asphalt concrete with maximum size of 4.75 mm. The study shows that the tensile strength increases as the increase in the size and percentage of the crushed glass.

***Index Terms*—Indirect tensile strength, glass, sulphate, SuperPave, HMA.**

I. INTRODUCTION

Hot mix asphalt can be explained as the combination of aggregate uniformly mixed and coated with the asphalt cement. The term of "hot mix" originally comes from the process of heating of the proper mixing of the aggregate and cement with the specified temperature. Asphalt cement has an important role to bind the HMA pavement together [15]. Hot mix asphalt pavement is a conventional mix that has been used to serve the transportation world. Nevertheless, at certain period of time, many problems had been arise due to its poor performance in term of temperature sensitivity and increased in traffic loading [15]. Asphalt concrete is still a popular type of pavement because it provides considerable stability and durability as well as good resistance against water damage [3].

In recent years, road pavement has been subjected to greater damages as result of increase in number and weight of vehicles passing on roads. One of the most common types of road damaging is rutting which has a noticeable impact on performance of road pavement during its service life. Rutting is defined as the accumulated permanent deformation of road pavement that occurs under applied loading [12].

There are many factors have an influence on fatigue and rutting properties of asphalt mixture, such as: aggregate type and gradation, amount of air void in asphalt mixture, type and amount of binder content, environmental temperature as well as mode and amount of loading applied on road pavement [9] [10].

Some undesirable effects can occur mainly due to high number of vehicles imposing repetitive higher axle loads on roads, environmental condition and construction errors. These usually cause permanent deformation (rutting), fatigue and low temperature cracking, service life of the road pavement is going to be decreased [9]. Permanent deformation or rutting accrues as a result of repeated loading due to heavy traffic loading which cause progressive accumulation of permanent deformation under repetitive tire pressures [13].

II. INDIRECT TENSILE STRENGTH TEST

The Indirect Tensile (IDT) strength test may be used to evaluate the relative quality of asphalt mixtures in conjunction with laboratory mix design testing and for estimating the potential for rutting or cracking. The results can also be used to determine the potential for field pavement moisture damage when results are obtained on both moisture-conditioned and unconditioned specimens. Also, the fatigue behavior of the bituminous mixtures can be characterized by the indirect tensile test [2].

This test is summarized in applying compressive loads along a diametrical plane through two opposite loading strips. This type of loading produces a relatively uniform tensile stress that acts perpendicular to the applied load plane. The peak load at failure was recorded and used to calculate the tensile strength of the specimen. The test was conducted at 25^0 C for both conventional mixture and modified ones [2] [11]. The tensile strength of the specimen is determined by the following equation:

$$S_t = 2\,P/\pi DL \qquad (1)$$

St = Indirect Tensile (IDT) Strength (psi)
P = Maximum load to cause failure (Ib)
D = Diameter of Specimen (in)
L = Length of Specimen (in)

The indirect tensile strength test (IDT) is used to determine the tensile properties of the bituminous mixture that can further be related to the cracking properties of the pavement. A higher tensile strength corresponds to a stronger cracking resistance [13].

III. USING CRUSHED GLASS

Dealing with the growing problem of disposal of waste materials is an issue that requires coordination and commitment by all parties involved. One solution to a portion of the waste disposal problem is to recycle and use these materials in the construction of highways [5].

Waste glass is considered one of the most important parts of the collected waste materials, it is nonmetallic and inorganic, it can neither be incinerated nor decomposed, so it may be difficult to reclaim. Waste glass has been used in highway construction as an aggregate substitute in hot mix asphalt paving. Many countries have recently incorporated glass into their roadway specifications, which had encouraged greater use of the material. While the use of waste glass as filler in hot mix asphalt is still not widely experimented [6]. The glass is one of the best man made products that can be recycled many times without occurring any change in their quality and structure, so in recent days the use of glass waste has been growing trend in asphalt mixtures [8]. Ordinary glass is rigid and brittle and easy to crush to form satisfactory particles for asphalt concrete applications [1].

Recycled glass processed from empty soft drink, beer, food, wine, and liquor containers collected at residential curbside, drop boxes, trash barrels, deposit stations, or recycling stations, and is either source-separated or co-mingled with plastics, aluminum cans, ceramics, or colored glass containers [7]. The recycled crushed glass can be considered valuable alternative sources of aggregate for asphalt mixture production [1].

Asphalt that containing glass as an aggregate is called "glassphalt," and has been widely tried as a mean to dispose of surplus waste glass since the 1960's. The glass must be properly cleaned and crushed, and combined with the natural aggregate, preserving agents, and bitumen in their specified proportions [1]. Glassphalt is basically the same as conventional hot-mix asphalt, except that (5% to 50%) of the aggregate is replaced by crushed glass [4].

The use of glass waste and increasing the percentage of a certain part of the aggregate resulted in reducing the asphalt Marshall resistance. The use of waste glass in the asphalt mix for overall fracture particles, increase the angle of internal friction between particles and improve their resistance to cracking. To provide a certain amount of asphalt in glass, less pitch is needed compared with conventional asphalt [8]. Most glasphalt has been placed on city streets, driveways and parking lots, and not on high-volume, high-speed highways. Potential problems with glasphalt include: loss of adhesion between asphalt and glass. Glasphalt should be used only as a basecourse as glass in the surfacing mixture could reduce skid resistance and create surface ravelling problems. The maximum size of glass used in glasphalt is 9.5 mm and hydrated lime should be added to prevent stripping [5]. The dynamic properties of glass–asphalt concrete, the fatigue life, stiffness modulus and creep compliance are improved in comparison with those of ordinary asphalt concrete [17].

IV. SUPERPAVE METHOD

In 1987, the Strategic Highway Research Programme (SHRP), USA began developing a new system for specifying asphalt material. The final output of the SHRP asphalt research programme was a new system called Superior Performing Asphalt Pavement (SUPERPAVE). Superpave represents an improved system for specifying asphalt binder and mineral aggregates, developing asphalt mixture design and analyzing and establishing pavement performance prediction [14]. The Superpave methodology is believed to be the best available at this time . However, it is an evolving methodology, and as such there are various asphalt characterization routines that are under consideration as future additions to the Superpave [16].

A Superpave mix design involves selecting asphalt and aggregate materials that meet the Superpave specifications and then conducting volumetric analysis. Hot mix asphalt specimens were compacted with the Superpave gyratory compactor. The Superpave gyratory compactor (SGC) can provide information about the compactability of the particular mixture by capturing data during compaction [14].

The main objective of this research is to produce HMA using waste glass by SuperPave method, and evaluate and comparing the tensile strength with and without glass.

V. MATERIALS USED

The materials used in the research are:

Aggregate

One type of limestone aggregate was used. Gradation requirements of aggregate materials based on the ASTM Designation 3515. Table 1 shows the gradation of aggregate, and figure 1 shows the gradation curve.

Table 1 Gradation of Aggregate

Sieve Size (mm)	Sieve Size (in)	Specification	% Passing	Cumulative % Retained	Weight Retained (g)
19	3/4.	100	100	0	0
12.5	1/2.	90-100	95	5	325
9.5	3/8.	---	87	13	520
4.75	No. 4	44-74	46	54	2665
2.36	No. 8	28-58	32	68	910
1.18	No. 16	---	24	76	520
0.6	No. 30	---	20	80	260
0.3	No. 50	5-21	17	83	195
0.15	No. 100	---	9	91	520
0.075	No. 200	2-10	5	95	260
PAN	PAN	---	0	100	325
	`				6500

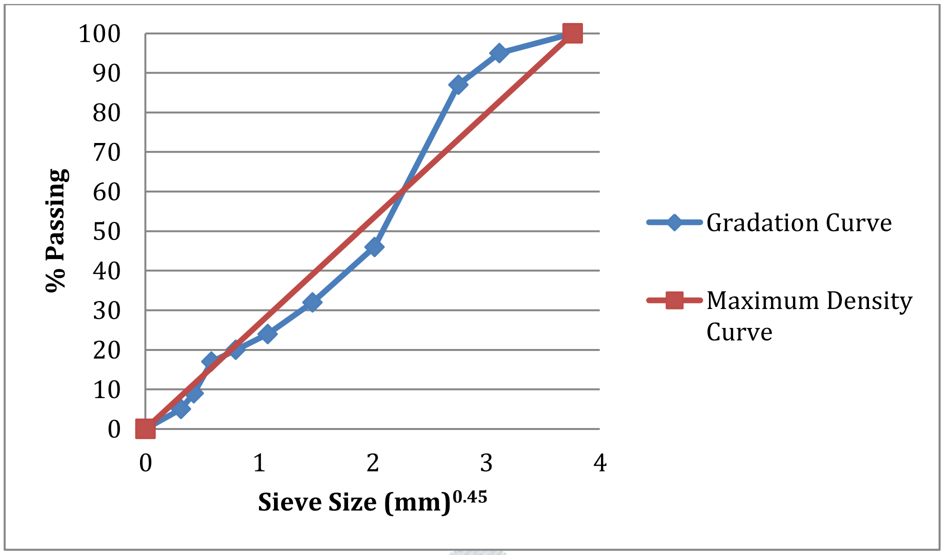

Figure 1 Gradation Curve

Asphalt

The binder selected for this research is based on the range of temperature through which the pavement will be exposed and the traffic to be carried during its lifetime. The binder classified as PG64-22. The optimum asphalt content is 6.2% of the asphalt mixture.

Crushed waste glass

Two samples of crushed waste glass were used. Some percentage of the natural aggregate is replaced with crushed glass. The glass must be clean and crushed, and combined with natural aggregate and bitumen in their specified proportions. First; 50% of the aggregate retained on Sieve No 4 replaced with crushed glass that weighs 1332g. The glass in the first specimen makes up about 20.5% of the aggregate. Second; 50% of the aggregate retained on Sieve No 8 replaced with crushed glass that weighs 455g. The glass in the second specimen makes up about 7% of the aggregate. The glassphate is then placed and compacted using SuperPave method.

Results and Discussion

The specimens were compacted with 100 gyrations in the gyratory compactor. The mixing and compaction temperature were 135^0 C (275^0 F). Indirect tensile strength test was performed on the HMA without glass. The maximum load to cause failure was 5450.8 Ib, and the tensile strength was 157.11 psi.

Indirect tensile strength test was performed on the HMA with 20.5% of crushed glass, and 7% of crushed glass. Table 2 shows the results of the tensile strength. Figure 2 shows the comparison of the results.

Table (2): Indirect Tensile Strength Results

Specimen	% of Glass	Max Load (Ib)	Tensile Strength (psi)
Control	---	5450.8	157.11
1	20.5	5196.7	149.78
2	7	2731.2	78.72

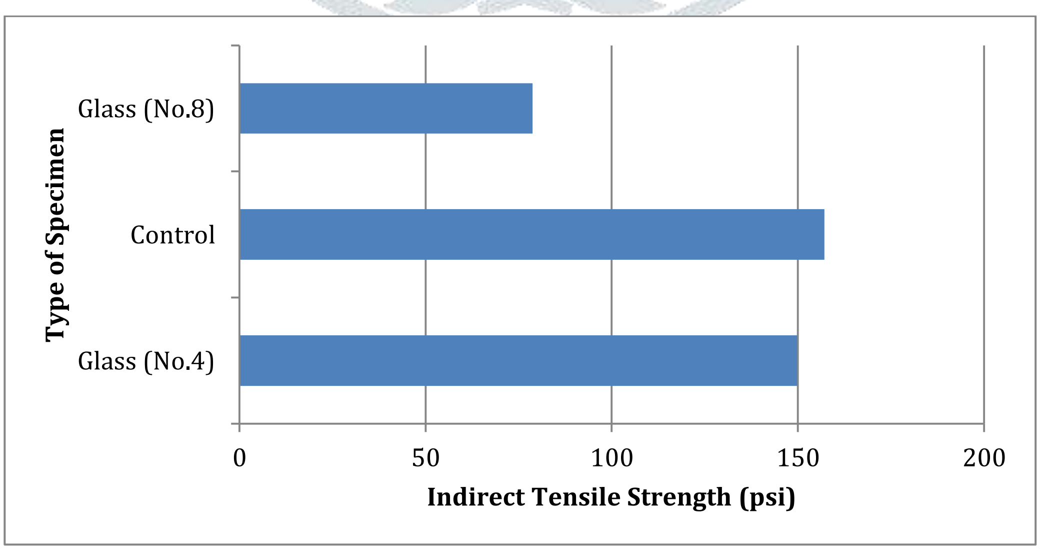

Figure 2 Comparison of Indirect Tensile Strength Results

By using crushed glass of 20.5% retained on Sieve No 4, the tensile strength was 149.78 psi, while using 7% of crushed glass retained on Sieve No 8, the tensile strength decreased to 78.72 psi.

VI. CONCLUSION

Based on the results obtained in this study, the following conclusions can be drawn;

1. Crushed glass can be used in asphalt concrete with maximum size of 4.75 mm.
2. The indirect tensile strength increases with increasing of crushed glass size.
3. Increasing the percentage of crushed glass in HMA could increase the tensile strength.
4. High angularity of the glass aggregate helps to build VMA into the mix.
5. Using waste glass in HMA will decrease pollution and environmental problems.
6. Due to its glass content, glassphalt holds heat longer than conventional asphalt, and glassphalt surfaces dries faster than traditional paving surfaces after rain
7. The glassphate should be placed on city streets and parking lots, and not on high volume, high speed highways.

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