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Review the Effect of Using Waste Glass on Resistive Characteristics of Glass Asphalt Mixtures

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Abstract: In recent years, the increasing cost of the repair and resurfacing of roads and airports caused by the traffic load that resulted in the increase in intensity and frequency of comprehensive research on the use of additives in the manufacturing the asphalt mixtures ability against dynamic loads. Sustainable variable shapes in pavement layers that increased with increasing temperature have prompted researchers to seek solutions to deal with this problem in structural asphalt pavements. Meanwhile, the use of waste materials that have the potential to improve dynamic characteristics of asphalt pavements can be an effective method for reducing the harmful effects of this dynamic phenomenon. The study aims to review the effect of recycled glass on the resistance of asphalt profile to use it to the sample density changes and the optimal pitch and the amount of water uptake in the use of glass resulted by glasses is determined instead of aggregate and to provide appropriate solutions to increase functionality of asphalt pavements against dynamic loads. A sample of asphalt has been tested based asphalt different tests, the resistance evaluated and were compared with conventional asphalt mixture. The results show that the glass due to the characteristics such as high hardness, comprehensive sharp angles and fracture fully is able to improve behavioral characteristics of asphalt mixtures.

Key words: Evaluation, impact, recycled glass, resistance, asphalt mix

INTRODUCTION

Per day, numerous waste material of factory activity, service sector, industrial and domestic waste water plant is produced in the world. Asphalt production industry in recent years has changed a lot due to the many changes resulting from the use of waste materials in the mixture. This despite the fact that every year about 10 million tons of waste glass can be manufactured in large cities in the world and it is about 3-5% weight of household waste (Arabani and Abdolazimi, 2009). The enhanced interlock between grains of the aggregate asphalt is one of the factors that increase the load-bearing capability of the asphalt pavement. In the meantime, because of the broken glass in all aspects of its particles can make a significant contribution to increased internal friction angle asphalt. For non-metallic materials and inorganic glass component is not burned and not be decomposed. The glass can be called one of the best man-made products that can be recycled many times without occurring any slightest change in the quality and structure. In recent years, the use of glass waste has been a growing trend in asphalt mixtures. Glassy materials that are brittle and full of silicone and called hydrophilic materials are the so-called convergence that show less adhesion with the pitch. Glassy asphalt is the same as common asphalt mixture essentially with the difference that replaced by 5-40% fine or coarse aggregate glass (Malisch *et al*., 1970). One of the most important parameters are for predicting profile stiffness modulus of asphalt mixtures resistance against dynamic loads.

MATERIALS AND METHODS

Research hypotheses:

- The use of glass waste and increasing the percentage of a certain part of the aggregates resulted in reducing the asphalt marshall resistance
- The use of waste glass in the asphalt mix for overall fracture particles, increases 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

Definition of terms and technical expressions: Pavement is a surface consisting of a layer that is in direct contact with the wheels of passing vehicles traffic is called

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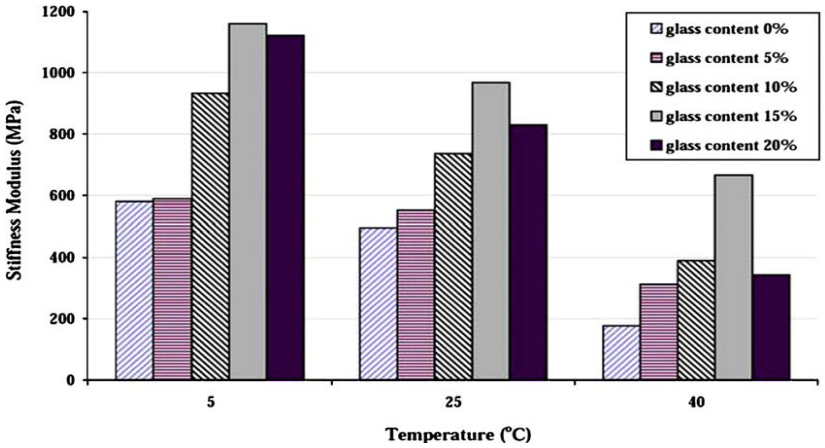

Fig. 1: HMA stiffness modulus changes with temperature and the amount of samples in different glass topeka

pavement or path surfacing. Deformation of asphalt or fluency is the creep in other words, the asphalt deforms under load or the amount of compression in the perpendicular direction to the sample before breaking. Marshall pressure resistance Marshall test is the maximum load is created that sample study tolerates without breaking.

Effect of broken glass on the concrete asphalt mixture behavior: The results reported by the Alaska Department of Transportation and Public Facilities is as follows:

- Using glass measuring <3.8 inches by 15% in the asphalt mixtures, satisfies the regulations in Alaska but based on the results, the optimized 7.5% has been reported as the improved limit
- Based on the results, the greatest impact of glass on the asphalt mixture is stable and empty space in the mixture. Optimized limit for maximum stability is in the rate of 7.5%. The percentage of empty space to a minimum of 1.2%, under the glass is at a rate of 5-7.5 %
- Stripping or decrease the stability of asphalt flower mixtures was observed in the presence of moisture
- Mix of asphalt flowers tend to retain the heat than conventional asphalt, the behavior has some advantages such as the time of rolling road, reducing fuel and the implementation of the thicker layer of asphalt in cold weather that the behavior of the economic feasibility is more efficient than conventional asphalt. In this context, rough estimate shows that the use of asphalt flower per 6 ton is associated with savings in dollars

In a study entitled "the impact of glass on improving the dynamic behavior of asphaltic concrete, the behavior of hot asphalt (HMA) was determined in different conditions depending on the mix and aggregate values. One of the most important parameters of pavement stiffness modulus is the resistance against dynamic loads. Past research suggests that glass-due to its unique requirements and specifications, caused the lower cost of asphalt pavements and better dynamic behavior. In order to predict fineness modulus of glass asphalt, temperature parameters, the percentage of additives and aggregation model, the results indicate improved dynamic behavior of asphalt glass compared to HMA. In this study, the optimum pitch conventional asphalt and asphalt mixtures was determined with respect to changes in the percentage of the materials. To determine this amount, asphalt concrete samples were prepared at different temperatures and stiffness modulus tests. Finally, a model for the behavior of asphalt mixture stiffness modulus glass was based on test results.

Figure 1-12 and 2-13 show HMA stiffness modulus change and asphalt flower (with 4% in different glass composition) and Binder to Topeka at 3 different temperatures. As shown in figures, the sample-containing glass tends to increase the hardness and modulus. Special features lime, resulting in strong adhesion between the stone and the pitch-coated glass. In addition, the interlock between the compounds increase because of the sharp angle in the amount of glass mixed. So, HMA stiffness modulus increases. Higher internal friction due to increased due to the angle of the glass, plays an important role in increasing the stiffness modulus of asphalt samples of glass. However, when this amount is higher than a glass boundary (optimum), the hardness module will be reduced.

As shown in Figure 2-12 and 2-13 in the event that increasing the glass of a specific optimized percent pass rate, stiffness modulus decreases, as higher density glass

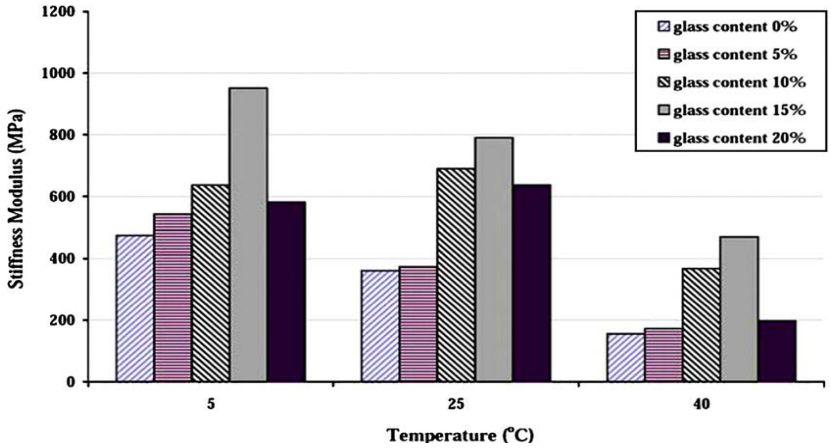

Fig. 2: HMA stiffness modulus changes with temperature and the amount of samples in different glass binder

Fig. 3: Marshall tester

Fig. 4: Removing the mold test samples of actual specific gravity in a water bath

Fig. 5: Raw materials

Fig. 6: The combination of materials, heating and preparation of asphalt

Fig. 7: Electronic devices and Marshall devices

Fig. 8: Our sample

Fig. 9: Samples came out of asphalt bathroom

Fig. 10: The device resistance thermometers

in HMA mix resulted in more fragile structure. Moreover, further filter glass, asphalt will prevent them from absorbing sufficient. As another effect of this

Fig. 11: Softness meter device

phenomenon, the adhesion between the stone and glass is reduced with pitch. Finally as a result, it can be said that the optimal value of glass samples increases stiffness modulus. In this study, maximum stiffness modulus glass diminishes in the amount of 15% occurred in the values of these modules. The negative effects much more efficient than glass, binder samples are deeper to be able to justify in coarse aggregate texture. So, the impact on the behavior of glass samples will be more important with larger grain. Using the results of experiments and numerical analysis results with the application Minitab15, two models to predict the dynamic behavior of HMA and asphalt flowers samples was proposed in different conditions of temperature, grain size and the amount of glass.

HMA stiffness modulus changes with temperature and the amount of samples in different glass-topeka. HMA stiffness modulus changes with temperature and the amount of samples in different glass-binder. In this study, the dynamic behavior of asphalt mix temperatures and aggregation were assessed. For the first time, the temperature and the percentage of additives were introduced to predict asphalt flower stiffness modules in two different modes. The results showed that the improvement is observed in the dynamic behavior of asphalt flower mix compared with HMA. Other important results are as follows.

The results of tests for Marshall and ITSM (Indirect Tensile Stiffness Modulus) samples grading for topeka and binder showed that 15% of glass is the optimal value. Sample containing hydrated lime glass had a tendency to increase the stiffness modulus. Anti-volatility limestone aggregate and glass coated with pitch was very effective to better adhesion.

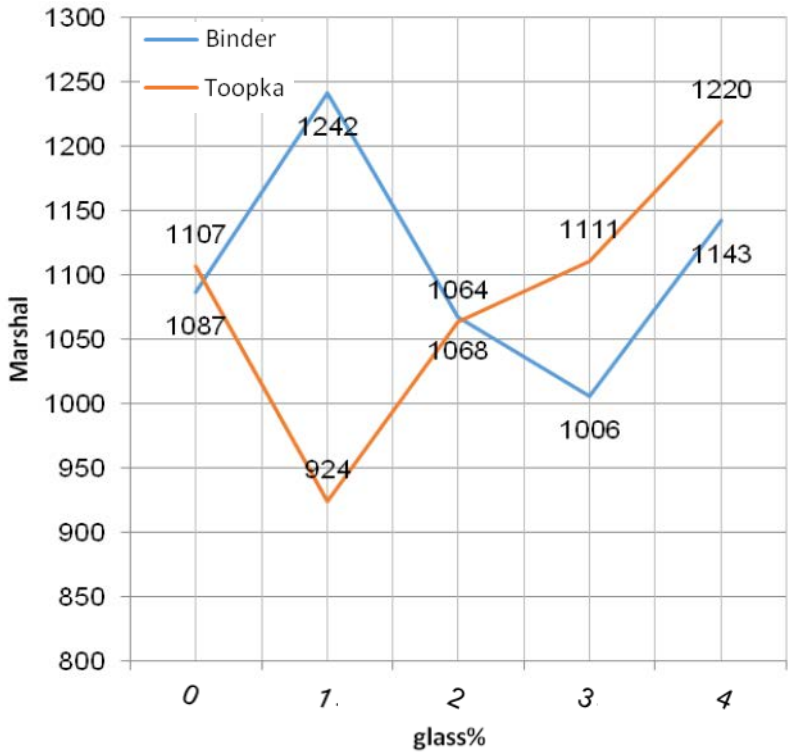

Fig. 12: Resistance glass quantity Marshall (topeka and binder)

Higher internal friction which is caused by the angle of the glass plays an important role in increasing the stiffness modulus glass containing the sample. On the other hand, more smoothness in the glass did not allow to absorb the pitch, so results in more reduction in stiffness modulus glass samples.

Because of the sensitivity of bitumen in different temperatures, hardness modulus of HMA and asphalt flower reduced at higher temperatures. This phenomenon can be explained such that the viscous modulus and hardness of the pitch dropped at higher temperatures and reduce the stiffness modulus of the mix.

Asphalt mix with different amounts of glass does not have similar response to changes in temperature. However, the dynamic behavior of asphalt flower mix compared to conventional asphalt is less sensitive to temperature changes.

Using waste glass powder instead of polymer: Increasing the number of traffic on the roads and the resulting damage caused by it and on the other hand, the high cost of repair and pavement improvement, maintenance is faced with serious problems. Extending the service life, improve pavement strength against loads of traffic and reduce the negative effects of temperature changes on the asphalt of categories that continuous attention had been involved in the construction of roads.

The use of polymer pitch increased the asphalt stiffness, will increase pavement performance and reduce maintenance costs. However, the addition of polymer increases the cost of production and the environmental effects. The most common polymers used in modified pitch are Styrene-Butadiene-Styrene (SBS). SBS to increase the elastic properties of asphalt, increases its resistance to permanent deformation. SBS high molecular weight polymers with high shear mixers should be combined with asphalt. Because the polymers are very expensive, so even if the percentage used increases the asphalt production cost.

Polacco *et al*. (2005) conducted a research on the effects of adding polyethylene polymer based on pitch properties. The research proved that the hard plastic polymer has increased several times the asphalt base. Khodaei *et al*. (2009) studied the impact on the reduction of permanent deformation of asphalt SBS polymers. In this study, the percentages of SBS polymers 4, 5 and 6 were added to the pitch and showed that the sample with 5% SBS, the constant strain of asphalt under ten thousand cycles were reduced to one-third.

Although, the use of polymer pitch increased asphalt stiffness, will increase pavement performance and reduce maintenance costs while the addition of polymers are expensive even at low levels due to the chemical structure of the materials and increase the cost of production and the negative effects environmental on their nature.

SBS polymer plasticizers was used as the most common modified asphalt. SBS can add between 3-7% of the combined weight of pitch. In this study (Khodaei, 2009), 5% of SBS has been combined with pitch. Made of ordinary glass waste powder prepared by grinding the powder, then was passed in sieve 200. Polymer modified pitch was used replacing the glass powder with 10, 30, 50, 70 and 90% by weight of the polymer. SBS and glass powder were mixed completely for 60 min using the mixer with pitch. No problem was found mixing pitch with SBS and glass powder.

Glassphalt: Glass asphalt is essentially the same as conventional asphalt mixture. The difference is that 5-40% fine or coarse aggregate replaced by glass. Glassphalt was exposed to many experiments in the early 70s and it was found that is acceptable for some pavements. Then, the glass pavement due to the high cost of building glass was less used gradually. Recycled glass can save energy and reduce environmental waste. Focus on glassphalt, used to expand the scope of glass waste technology and accelerate the development of glass technology. Performance materials used in the construction is of one of the most important concepts that engineers face with. Once waste materials are used, they must be equivalent or better performance of the usual materials.

Glass is one of non-metallic inorganic materials, so not burned or decomposes. Glass materials that are brittle and full of silicone and hydrophilic materials are called term convergence with the pitch that show fewer adhesions. The adhesion disappeared in the presence of water and gradually during the operation was influenced by the bare glass and asphalt pavement surfaces are separated. So, the sensitivity of the mixture against water and humidity with the trials should be examined and, if necessary, anti-stripping of the material should be used. Anti-stripping agent (usually 2% hydrated lime) is added to protect the resist stripping mixture. Because pitch is a viscoelastic substance, so the viscoelastic properties of asphalt are found. One reason for the occurrence of rating the surface is one of the viscoelastic properties of pavement structures. One way to explain is the creep analysis of viscoelastic properties of the asphalt. Creep includes time-dependent deformation under constant pressure and temperature. Asphalt mixture is placed under the influence of constant loading and reaction is measured to vertical deformation. Creep asphalt feature was used to estimate the depth of the groove track wheel traffic loads used in flexible pavement structures.

Stiffness modulus of tension is under uniaxial loading conditions as well as Young's modulus of elasticity. Because asphalt is sensitive to temperature and load and stiffness modulus as a function of the parameters, so it is not fixed for different materials. The most important characteristic of asphalt that is effective in cracking is stiffness modulus of asphalt. Research and studies have shown that the size ratio of asphalt mixture stiffness is higher, the risk of thermal cracking will be higher at low temperatures.

Testing asphalt density, compressive strength and relative deformation: There are several ways to design asphalt that one of these methods is the Marshall method. Asphalt plan should be identified the criteria on which asphalt is made. These criteria include:

- The actual specific gravity of compacted asphalt
- The volume of compacted asphalt space
- Compressive strength of compacted asphalt
- Change the relative compacted asphalt
- The aggregate volume percentage of empty space in dense asphalt
- Percentage of the aggregate volume of empty space in the compacted asphalt

It is necessary to do the tests to determine the criteria on samples made by Marshall. In the actual specific gravity of asphalt pavement used by Marshall opening, defined as the ratio of the actual volume of asphalt tests in the air. Detailed tests to determine the actual specific gravity of the asphalt on the following standards include: ASTM Methods: D 1188. AASHTO Methods: T 166.

Marshal compressive strength or pressure swing is the maximum time that the sample bears the pressure in the test without fracture in it. The resistance is not considered alone as the stability criteria, but rather to determine the criteria, two Marshall parameters and fluidity strength should be examined together. Relative deformation is defined as the asphalt or fluidity of creep or otherwise asphalt deformation is made under the load shed. Greater relative deformation, the asphalt creep under load will be higher. Another definition of the fluidity could be to break the sample compression in the direction perpendicular to it.

Table 1: Results of stone materials quality

	Test results		
Index	Materials filler	Sand 6-0 mm	Mixed coarse
Sand value (AASHTO-T176)	-	69	-
The percentage of weight loss against the Los Angeles abrasion method (AASHTO-T96)			
Type of aggregation	-	-	C
The number of rounds	-	-	500
Wear percent	-	-	22
Atterberg limits			
Grain dough (PI)	N.P	-	-
(AASHTO-T89,T90)			
Plastic Limit (PL)	-	-	-
Liquidity Limit (LL)	Indeterminable	-	-
Fracture of rock materials on a sieve No. 4 (ASTM-D5821)			
In one side	-	-	100
In two sides	-	-	99
Percent coating of bitumen to aggregate (AASHTO-T182)	-	->95	
Percent prolongation and ductility (BS-812)			
Ductility	-	-	25
Tautologi	-	-	6
Percent by weight of the sodium sulfate (AASHTO-T104)			
Coarse	-	-	-
Fine-grained	-	-	-

Filler of fine sand is actually in throughput

The test aims to determine the actual specific gravity of asphalt, Marshall compressive strength, relative deformation of asphalt as well as graphs of these three parameters percent of the bitumen and the determination of the optimum bitumen for asphalt mix plan.

Process development of laboratory research: In this study, overview making glassphalt samples tested will be discussed. The mixing takes place after combination of specific raw materials. For primary materials include gravel, sand, filler and glass with a mixing ratio calculated aggregation, their mixing process is done. After the mixing process and the preparation of materials mixed with shards of glass, the material placed within the cast and electric oven at 160°C for 24 h.

After the warm materials were brought out from the oven, indirect heating of the pitch 100/85 will continue by sand heated to a temperature of about 140°C. Then, heated materials and the pitch spilled in a copper pot and mixed by mixers or manually.

Glasssphalt mixed inside the container and copper will be thrown in the Marshall Hammer device mold this operation is completed and applying 75 hits of 10£to both sides of the mold. Then, the mold is removed from the device for 24 h and is placed in the environment air and finally, samples are removed from the mold.

Then, the samples are placed in water bath asphalt. The water temperature is 60°C and the duration of stay is 30 min. The samples are then removed from the water, it is required that the samples to be transferred to the device resistance thermometers Marshall force in <30 sec and pressure parameters obtained strength and softness. Results will be reviewed in Table 1.

RESULTS AND DISCUSSION

Following the results of Marshall stability and flexibility and space to mix and density of the mix design study charts the percentage of glass 0-4% is provided for topeka and binder layer.

Figure 12 shows the amount of glass is sent against glass Marshall stability of asphalt mix design drawing to the binder layer of glass 1 has reached its maximum value and maximum resistance, resistance to the layers of glass is 4 obtained topeka. Figure 1-15, binder layer of glass smooth asphalt mix design with a maximum of 2% of glass in the glass layer would be appropriate to achieve maximum value binder topeka 1%.

According to Figure 1-15, the percentage of vacant space is 1% glassphalt in binder layers and in layers of topeka is least 3% glass. It is shown in the chart that in binder layer the weight contains 1% broken glass and in topeka layer reaches to its maximum with 3% broken glass.

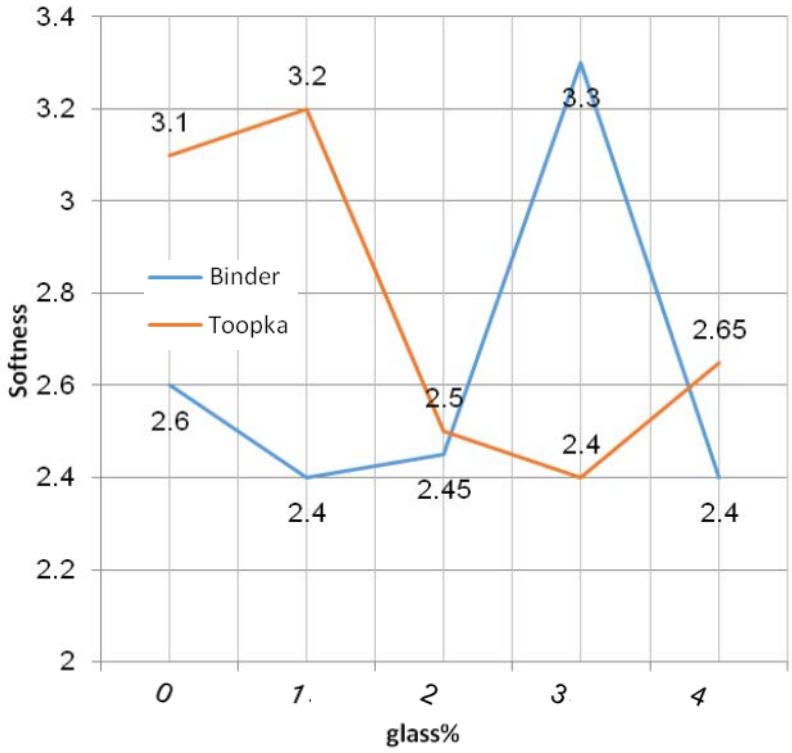

Fig. 13: The glass-smooth graph (topeka and binder)

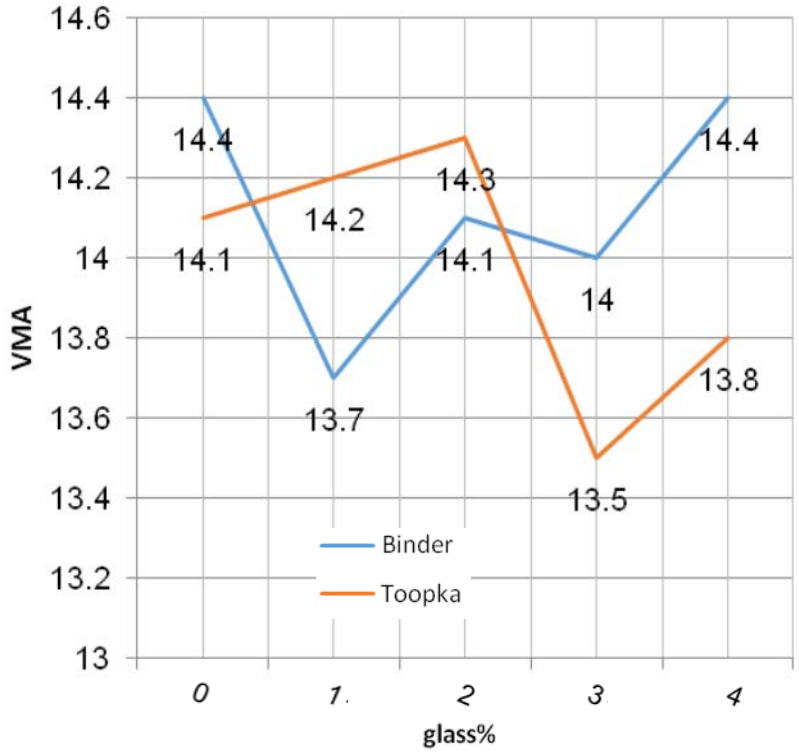

Fig. 14: Glass diagram in the amount of VMA (topeka and binder)

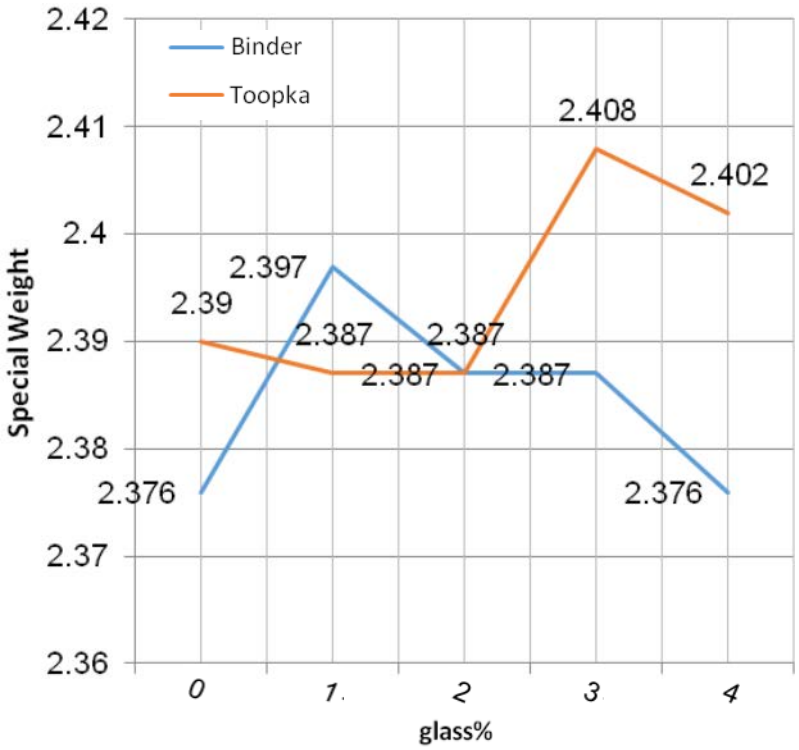

Fig. 15: The glass-density (topeka and binder)

CONCLUSION

The aim of this study was to evaluate the laboratory behavior of glassphalt in Tehran area. Asphalt samples were examined with two different particle size (normal and containing glass) at the optimum bitumen content of asphalt. The behavior of asphalt samples with two different particle sizes is provided in the percentage of waste glass. The results show that:

- Marshall specifications of asphalt will be improved with a certain amount of glass profile. According to the test results to improve resistance Marshall would be appropriate to mix design asphalt binder layers of glass and a layer of 1% in topeka 4%
- The density of asphalt, binder layer with 1% glass and in layer of topeka with 3% glass account for the largest amount
- According to the results, the highest Marshall resistance is obtained in asphalt binder using 2 percent glass and topeka using 4% glass, respectively
- Accordingly, minimal space is achieved by mixing 1% glass in asphalt binder. To get the lowest empty space in asphalt topeka, the mixing amount of glass should be 4%
- The specific gravity of asphalt samples with 2% in glassphalt binder reached its highest level in topeka asphalt, the maximum density can be achieved by mixing 4% glass
- Use of waste additives substantially reduces the amount of optimum pitch in modified asphalt samples
- Adding glass lesions due to comprehensive sharp angles, causes high hardness and hundred percent more fracture resistance
- Factors such as interlock and better medium grained result in more roughness because of sharp angles of glass particles lead to gradually reduce the amount of these deformations. But with increasing the glass by more than the optimal percentage, sliding glass particles gradually leads to permanent deformation on asphalt samples containing glass
- Using waste glass on the pavement of roads, will prevent increasing efficiency and reducing the thickness of the asphalt pavement, the further accumulation of non-degradable material in nature. In addition to saving aggregate and bitumen, the waste of national resources will be avoided more than ever before
- In this study, the warm asphalt mixes containing waste glass were evaluated in laboratory studies and computational analyzes and it was determined that the glass can be used as an alternative to the usual hot asphalt mixtures

- To sum up the overall positive effect determines the dynamic behavior of asphalt pavements in glass waste in a way that increases the ability to mix and reduce pavement thickness, not only will avoid the overuse of aggregate and pitch, but the use of the waste of analysis not be prevented from accumulating more than it would in the nature

SUGGESTIONS

With regard to the aggregation of various types of porous asphalt and pitch modification in general, extensive tests should be done to determine the best combination of these two parameters, there are many alternatives for each performed.

Using the percentages of a combination of glass and additives, can provide interesting results on asphalt tests. Performing other tests on glassphalt, can shed light on other features of this type of aggregation.

The economic assessment of additives in asphalt and pitch and compared to their effects on parameters of asphalt can lead users to use the best additives.

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