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Properties Comparison of Asphalt Cement and Multigrade Asphalt in Asphalt Concrete.

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ABSTRACT

The engineering properties of multigrade asphalt compared with asphalt cement grade 60/70 were investigated and the performance of asphalt concrete was mixed between both binding materials and limestones. The results showed that the engineering properties of multigrade asphalt did not pass the specifications of Department of Highways. Multigrade asphalt had more sensitivity of penetration index than asphalt cement grade 60/70, and provided flexible performance after torsion, rheological behavior and torsional recovery better than asphalt cement, but had less ductility than that of asphalt cement. Additionally, the performance of asphalt concrete mixed with multigrade asphalt gave higher stability, flow and ratio of stability and flow than those mixed with asphalt cement grade 60/70. After compaction test, the samples mixed with multigrade asphalt gave higher tensile strength and modulus of elasticity than those mixed with asphalt cement grade 60/70 but had lower poisson's ratio. Asphalt concrete mixed with multigrade asphalt also had greater strength index value and smaller rutting. Therefore, multigrade asphalt may be one of the alternative binders used for asphalt concrete design in highway construction if it had been notified of such use.

Key word : asphalt, multigrade asphalt, multigrade asphalt concrete

INTRODUCTION

Currently, the road surface made from asphalt concrete has been faced with the problem of having more traffic each year due to the increase in loaded trucks and passenger vehicles. These could deform the road and causing the road's cracking and slipping off from the surface resulting in shorten of the road capacity. The progress of technology and production, leads to the development and improvement of several binding materials such as polymer modified asphalt, stone mastic asphalt, and multigade asphalt. These binding materials have more resistant to deformation and erosion causing from temperature and more traffic. Multigade asphalt is produced by special refinery processes to provide more structure to the product and enhance the engineering performance, without the addition of polymers. This manufacturing modified the bitumen characteristics in order that the final product presents an improved stiffness modulus, visco-elastic and adhesive. It has a quality as binding material similar to asphalt cement.

Nicholls (1994) tested the road trials by using hot mix constituting of multigrade asphalt comparing with conventional binder and polymer modified asphalt. He found that hot mix having polymer-modified asphalt had deformation resistance and durability better than multigrade asphalt and conventional binder, respectively.

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Australian Road Research Board (1999) investigated multigrade and regulated the Australian road's standard for multigrade use as AS 2008 and AS2341.

The objectives of this research were to 1) study the physical properties of multigrade comparing with asphalt cement grade 60/70 and 2) investigate the properties of asphalt concrete mixed with either multigrade or asphalt cement grade 60/70 compacted by Marshall method and gyratory compactor by comparing the strength index, tensile properties, and rutting. Results from this study may indicate the possible asphalt concrete properties used in the future.

MATERIALS AND METHODS

Experiment 1 was to compare the physical properties of multigrade asphalt and asphalt cement grade 60/70. The experiment was conducted as Asphalt Institute (1984), AASHTO (1992) and ASTM (1981) involving penetration, softening point; ring and ball, penetration index, ductility, torsional recovery, flash point; cleveland open cup, solubility in trichloroethylene, loss on heating, absolute viscosity, kinematic viscosity, and density.

Experiment 2 was to study the properties of asphalt concrete mixing with either multigrade asphalt or asphalt cement grade 60/70 compacted by Marshall method. Aggregates used in the experiment were lime stone and were tested for density, volume, flow, stability, strength index, tensile properties by using indirect tensile method (Anagnos and Kennedy, 1972) and rutting.

Experiment 3 was to study the properties of asphalt concrete mixed with either multigrade asphalt or asphalt cement grade 60/70 compacted by gyratory compactor. Aggregates used in the experiment were lime stone and were tested for density, volume, flow, stability, and tensile properties by using indirect tensile method.

RESULTS AND DISCUSSIONS

Properties of multigrade asphalt and asphalt cement grade 60/70

The results showed that the properties of asphalt cement grade 60/70 passed the specifications of Department of Highways. However, the properties of multigrade asphalt did not pass the specifications for asphalt concrete grade 60/70 and polymer modified asphalt of the Department of Highways. Penetration index and rheological behavior of multigrade asphalt was 48 and +1.05, meanwhile it was 63 and –1.40 in asphalt concrete grade 60/70, respectively (Table 1). This indicated that materials made from multigrade asphalt were more rigid and sensitive to temperature change than asphalt concrete grade 60/70. After testing ductility of these two materials, multigrade asphalt yielded 61 centimeters, but asphalt cement grade 60/70 yielded 100 centimeters. This caused more fragility in multigrade asphalt compared to asphalt cement grade 60/70. Multigrade asphalt had 7% of torsional recovery, but asphalt cement grade 60/70 had 2%. However, multigrade asphalt had absolute viscosity and kinematic viscosity greater than asphalt cement grade 60/70. The test on residue from thin film oven showed that multigrade asphalt had 29% retained penetration value and 8% torsional recovery. For asphalt cement grade 60/70, it was 62% and 3%, respectively.

Asphalt concrete compaction by Marshall method

An experiment of compaction conducted by Marshall method showed that, at 4% air voids, asphalt concrete mixed either with multigrade asphalt or asphalt cement 60/70 used 5.2% binder contain. However, the materials mixed with multigrade asphalt had higher level of stability, flow, and ratio of stability and flow than mixed with asphalt cement grade 60/70 approximately 18.90%, 14.93% and 4.69%, respectively (Figures 1 and 2).

Table 1 Properties of multigrade asphalt and asphalt cement grade 60/70.

Item No.	Properties	Unit	DOH specification		AC 60/70	Multigrade
			AC 60/70	PMA*		
1	Penetration	0.1 mm	60 – 70	60 – 70	63	48
2	Softening point, ring and ball	°C	–	–	47	60.5
3	Penetration index		–	Min 3.0	– 1.40	+ 1.05
4	Ductility	cm	Min 100	–	> 100	61
5	Torsional recovery	%	–	Min 70	2	7
6	Flash point, Cleveland open cup	°C	Min 232	Min 220	319	316
7	Solubility in trichloroethylene	% Wt	Min 99.0	Min 99.0	99.83	99.80
8	Loss on heating	% Wt	Max 0.8	–	0.046	0.019
9	Absolute viscosity	Poise	–	–	1,923	> 12,800
10	Kinematic viscosity	cSt	–	–	291	1,422
11	Density	kg/m^3	–	1.00 – 1.05	1.039	1.040
Test on residue from thin film oven						
12	Retained penetration	%	Min 54	Min 70	62	29
13	Torsional recovery	%	–	Min 60	3	8

PMA* = Polymer Modified Asphalt

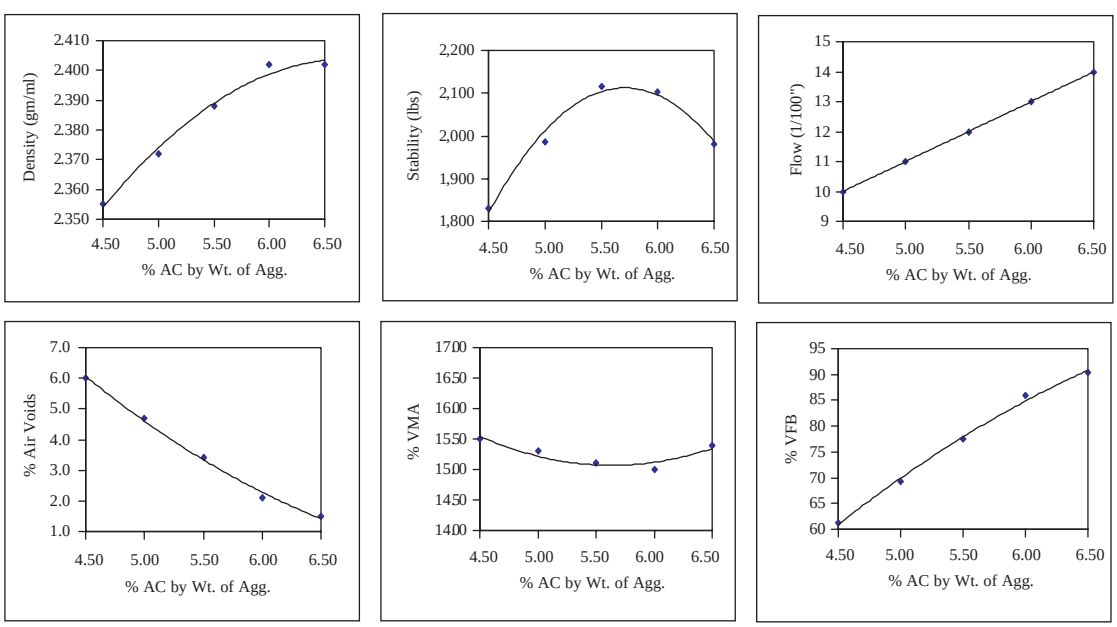

Figure 1 Relationship between asphalt concrete properties and asphalt cement grade 60/70 quantities compacted by Marshall method.

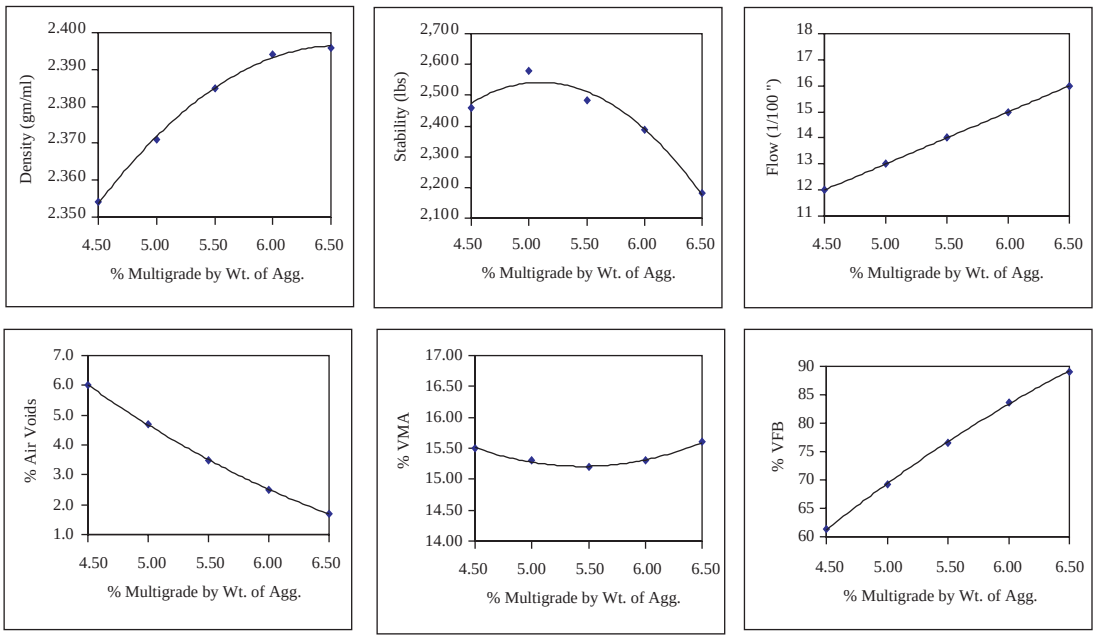

Figure 2 Relationship between asphalt concrete properties and multigrade asphalt quantities compacted by Marshall method.

Asphalt concrete compaction by gyratory compactor

Compaction conducted by gyratory compactor can be calculated using design number of gyration (N design) at 4% percent air voids, resulting in 68 gyration. The results showed that, at 4% air voids, asphalt concrete mixed with either with multigrade or asphalt cement 60/70 used 4.8% binder content. However, the materials mixed with multigrade asphalt had higher level of stability, flow, and ratio of stability and flow than mixed with asphalt cement grade 60/70 approximately 12.18%, 6.41% and 6.20%, respectively (Figures 3 and 4).

Properties of asphalt concrete

After performing the asphalt concrete compaction by Marshall method, the strength index of asphalt concrete mixed with multigrade had similar value as that mixed with asphalt cement grade 60/70 which was 81.1% and 83.9%, respectively. Tensile strength, poisson's ratio, and modulus of elasticity of both binding materials tended to but less, while ultimate tensile strain tended to be higher (Figures 5 and 6). Compaction by gyratory compactor also provide the same results (Figures 7 and 8).

At 4% air voids, the tensile strength and modulus of elasticity of multigrade asphalt concrete were 32.84% and 32.24% higher that of asphalt cement concrete, by Marshall method, and were 28.67% and 25.25 higher by gyratory compactor.

In the experiment of rutting by wheel tracking test at 140,000 passes, asphalt concrete mixed with multigrade asphalt showed rutting 31.64% less than mixed with asphalt cement grade 60/70 (Figure 9).

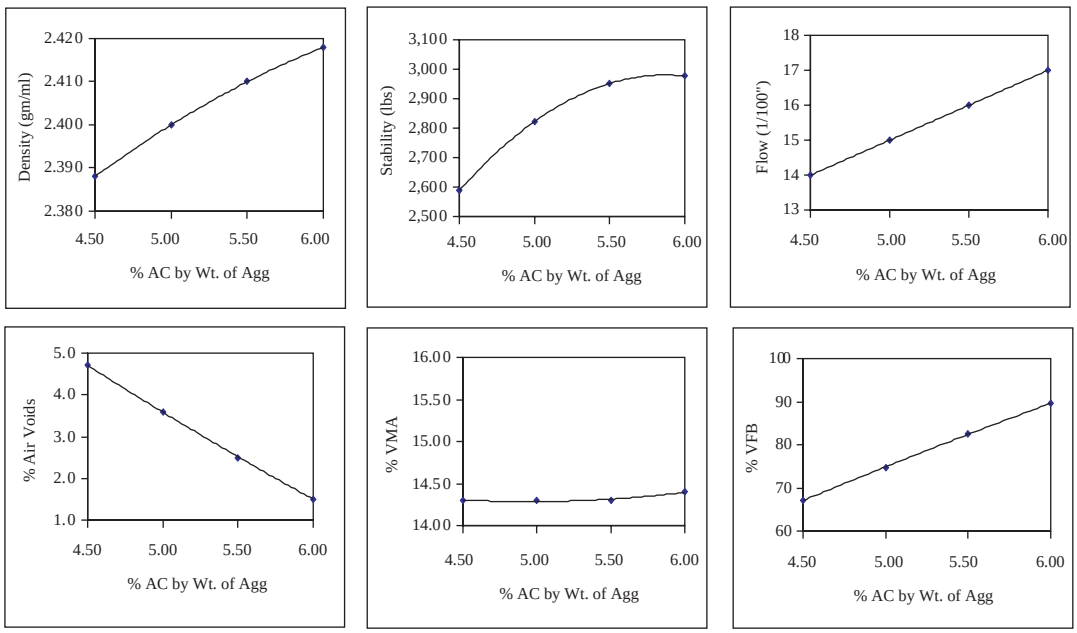

Figure 3 Relationship between asphalt concrete properties and asphalt cement grade 60/70 quantities compacted by gyratory compactor.

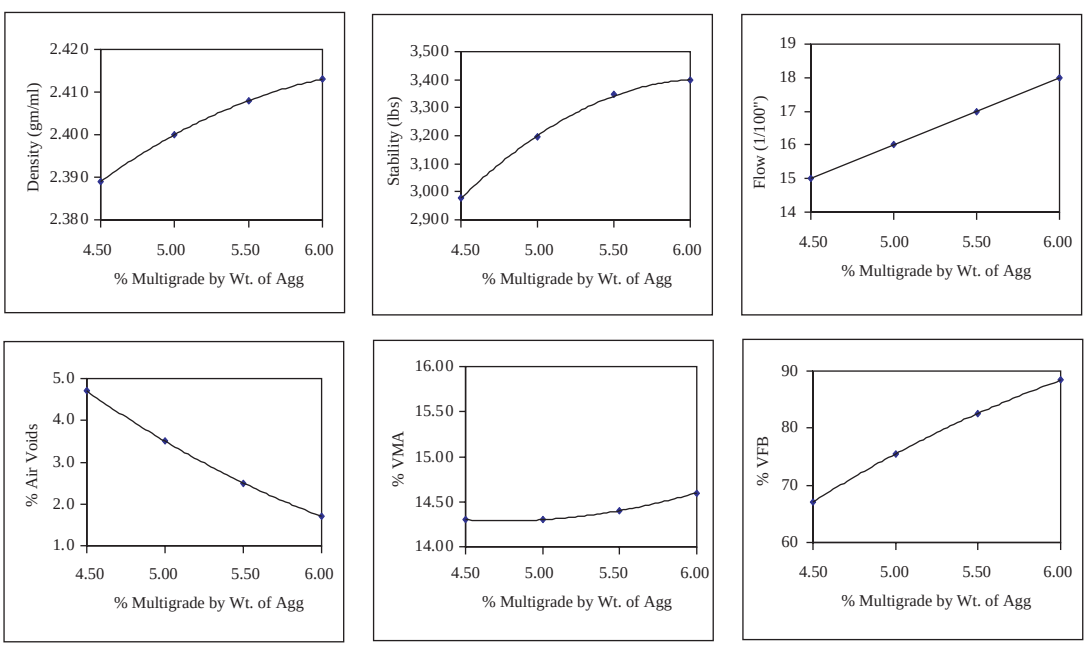

Figure 4 Relationship between asphalt concrete properties and multigrade asphalt quantities compacted by gyratory compactor.

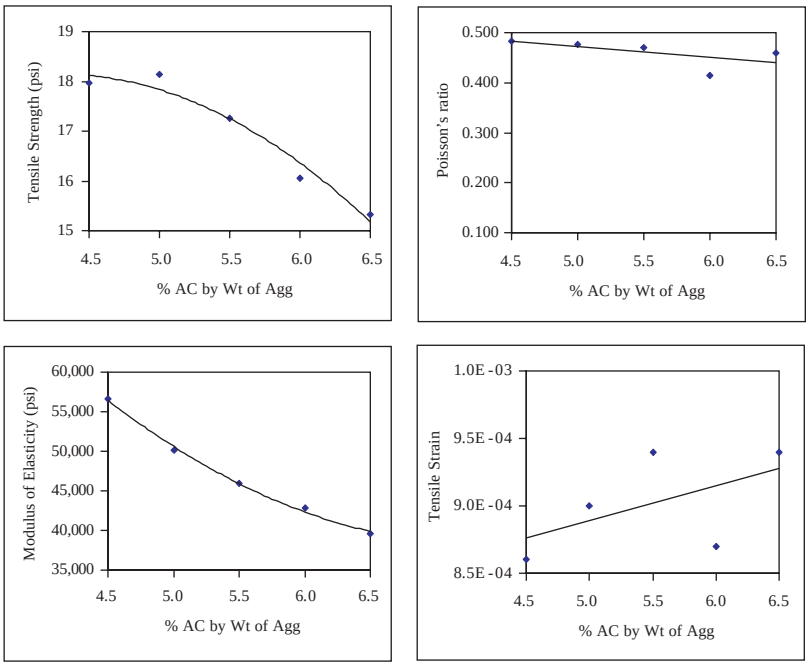

Figure 5 Tensile properties of asphalt concrete compacted by Marshall method mixed with asphalt cement grade 60/70.

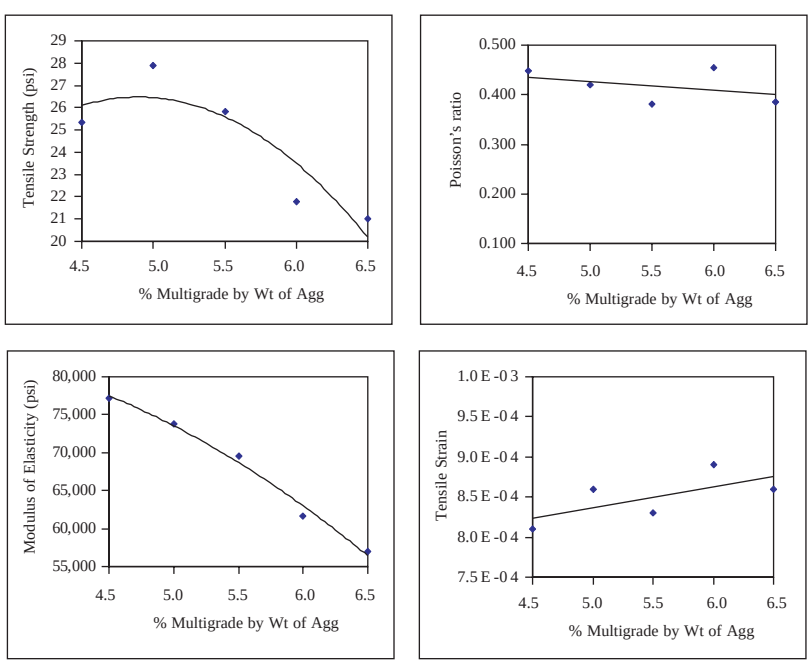

Figure 6 Tensile properties of asphalt concrete compacted by Marshall method mixed with multigrade asphalt.

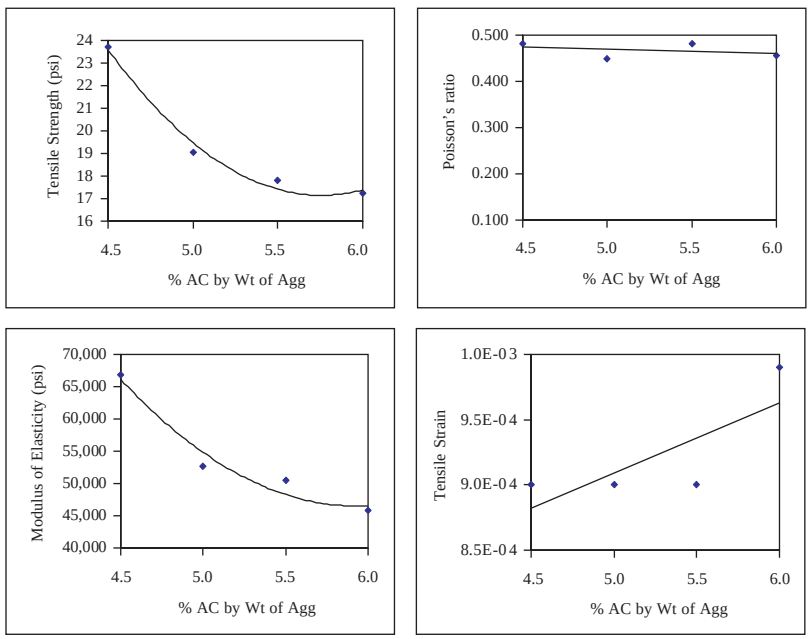

Figure 7 Tensile properties of asphalt concrete compacted by gyratory compactor mixed with asphalt cement grade 60/70.

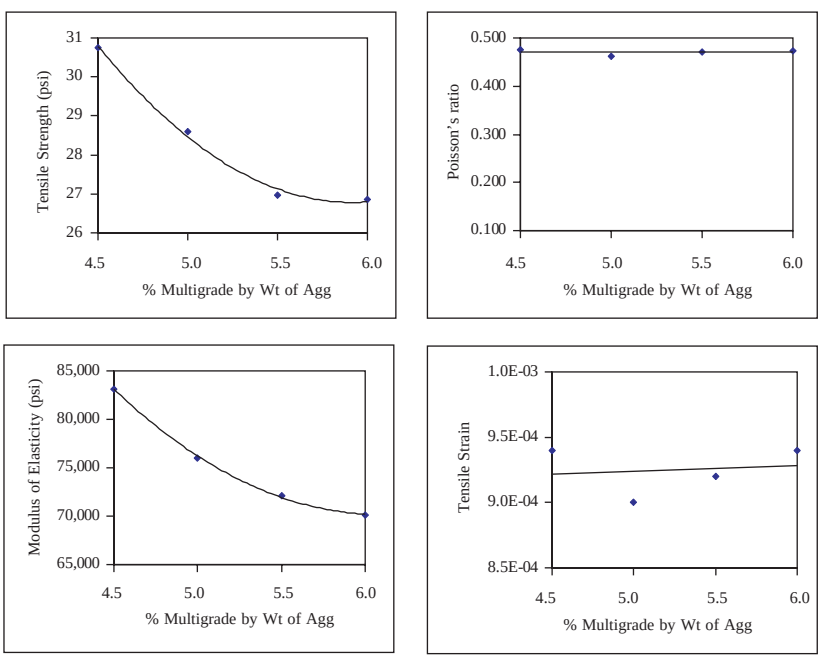

Figure 8 Tensile properties of asphalt concrete compacted by gyratory compactor mixed with multigrade asphalt.

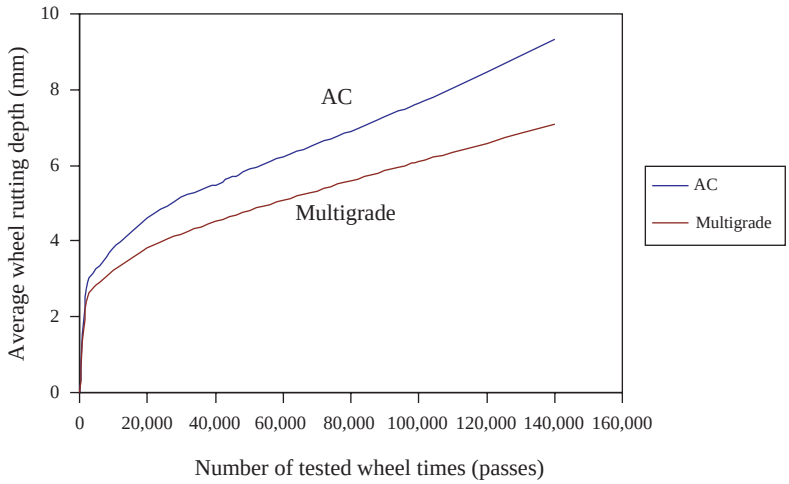

Figure 9 The relationship between means of tested wheel times and wheel rutting depth of asphalt concrete mixed with asphalt cement grade 60/70 compared to mixed with multigrade asphalt at 140,000 times.

CONCLUSION

From the studies described above, it was concluded that : 1) the penetration of multigrade asphalt was more rigid than asphalt cement grade 60/70, had more sensitivity to temperature change (higher value of penetration index, rheological, and torsional recovery) than asphalt cement grade 60/70, but multigrade asphalt was more fragile than asphalt cement grade 60/70; 2) asphalt concrete compacted by Marshall method and mixed with multigrade asphalt had better stability, flow, and ratio of stability and flow than mixed with asphalt cement grade 60/70 approximately 19%, 15%, and 5%, respectively; 3) asphalt concrete compacted by gyratory compactor and mixed with multigrade asphalt had better stability, flow, and ratio of stability and flow than mixed with asphalt cement grade 60/70 approximately 12%, 6%, and 6%, respectively; 4) asphalt concrete mixed with multigrade asphalt had strength index value of 3% less than mixed with asphalt cement grade 60/70; 5) asphalt concrete mixed with multigrade asphalt had higher tensile strength and modulus of elasticity value, but had lower poisson's ratio than asphalt cement grade 60/70; and 6) asphalt concrete mixed with multigrade asphalt had rutting of 32% less than mixed with asphalt cement grade 60/70.

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