EVALUATE THE EFFECT OF GROUND TIRE RUBBER ON LABORATORY RUTTING PERFORMANCE OF ASPHALT CONCRETE MIXTURES

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ABSTRACT

The nation faces ecological problems due to the accumulation of waste automobile and truck tires. There are environmental regulations that prohibit burning and burying of tires in a solid waste facility to reduce air pollution and hazardous waste. Thus, handling this accumulation, which is estimated at approximately three-quarter of a billion tires per year in the USA, is a major concern. Ground Tire Rubber (GTR) is currently used in several states for flexible pavement construction. The rutting performance of the pavement is known to improve in several states when crumb (fine) rubber is used to modify the binder. Even though its effect on performance using typical locally available New Jersey aggregates and gradation still needs to be evaluated. In this study, the effect of crumb rubber pre-blended with the asphalt cement on rutting performance of Superpave asphalt concrete mixtures as measured in the laboratory was evaluated. In addition, the effect of quantity of rubber in the mixture on the rutting performance was also evaluated. In all cases, the locally available New Jersey aggregate sources were used and the gradation were kept the same. The mixtures were evaluated using the compaction characteristics of

the Superpave Gyratory Compactor. The comparative laboratory study showed that the No. 40 mesh fine rubber was more effective in controlling rutting as compared to the No. 20 mesh. This effect was more significant from 0% to 5% as compared to 5% to 15%.

INTRODUCTION

The nation faces a major ecological problem due to accumulation of waste automobile and truck tires. Environmental regulations prohibit the open burning or burying of tires in solid waste facility. These tires are accumulating at the rate of about 3/4th billion per year [1], [2], [3]. In order to solve this problem efforts are now being made to find uses for these waste tires.

Also, there are some performance characteristics of asphalt concrete mixtures for which the properties of asphalt cement binder play an important role, such as durability. Additionally, there may be situations where the properties of the aggregate portion of a particular mix cannot be changed because of local conditions, economics, or frictional characteristics. In these cases an improvement in the characteristics of the mix will need to be obtained through change or improvement of the asphalt binder cement. One of the asphalt modifiers or additives, which indicated some promise of improved binder properties, was relatively low percentages of finely ground tire rubber (GTR) [3], [4], and [5].

Rubberized asphalts resisted rutting better than conventional (unmodified) asphalt and about as well as polymer modified binder asphalts. Wheel tracking performances were similar for dry mix and wet mix asphalts, but the fatigue life for dry mix was three times as long as wet's. The type of rubber crumb used to make binders did not affect wheel tracking very much, but had a significant effect on fatigue resistance [6].

Therefore, the rutting performance of the pavement is known to improve in several states like Florida, Pennsylvania, Colorado and Kansas when crumb (fine) rubber is used to modify the binder. But the effects of various sizes and proportions of rubber on the rutting performance of pavements with local New Jersey aggregates are still to be evaluated.

OBJECTIVE OF RESEARCH

The objective of this research is to study the effect of using different sizes and proportions of Ground Tire Rubber as an asphalt binder modifier with locally available New Jersey aggregates.

SCOPE OF THE STUDY

The scope of this study was limited to evaluating the mixtures with the following parameters:

1. One gradation from four aggregate sources (3/8" light gravel, 3/8" dark gravel, sand and dust).
2. One type of binder: AC 20.
3. Two nominal sizes of rubber: No. 20 and No. 40.
4. Two proportions of rubber for each size: 5% and 15% by weight of binder.

EXPERIMENTAL DESIGN

The following mixes were to be evaluated in order to study the effect of different sizes and proportions of rubber:

- Control section (0% rubber in asphalt binder)
- Binder with 5% No. 20 rubber + aggregates
- Binder with 15% No. 20 rubber + aggregates
- Binder with 5% No. 40 rubber + aggregatesBinder with 15% No. 40 rubber+ aggregates

The gradation used satisfies all the Superpave gradation except 2.36 mm sieve. Since the effect of smaller size aggregates on asphalt concrete mixtures is more significant to the finer rubber particles, the researchers believe that this will not affect the objective of the study.

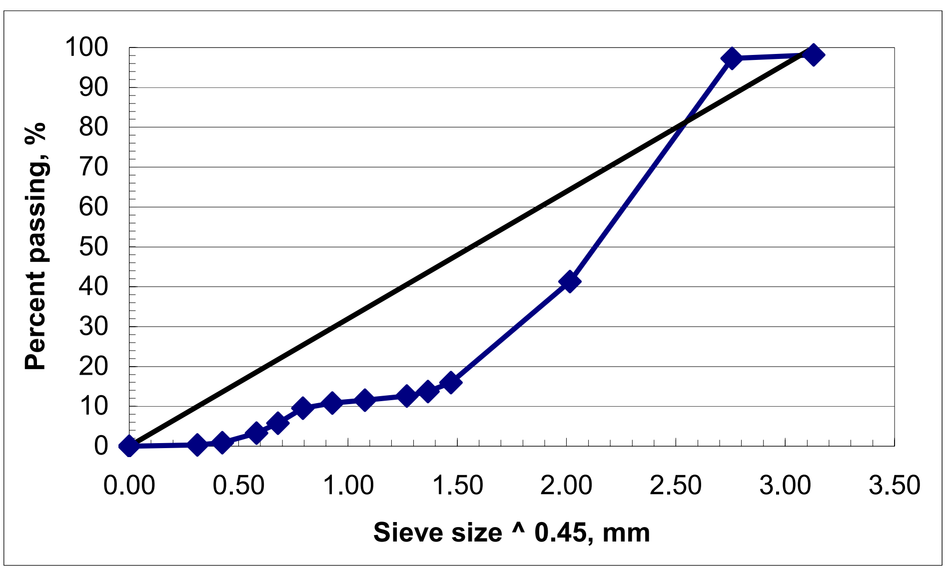

Figure 1: Gradation of the mixtures.

LABORATORY STUDY

The specimens were made out of the mixes with different sizes and proportions of rubber particles. They were compacted in the Superpave Gyratory Compactor up to 100 gyrations and the bulk specific gravity, the maximum specific gravity of the compacted samples were measured using ASTM standards [7]. The air voids of the compacted specimen was calculated using the following equation:

$$\%AirVoids = 100x(1 - \frac{G_{mb}}{G_{mm}}) \tag{1}$$

where:

G_{mb}	=	Bulk specific gravity
G_{mm}	=	Maximum specific gravity
% Air Voids	=	Air voids of compacted specimen, %

Initially, for each mixture, trial binder content is selected and the air void of the compacted specimen is measured. Then the mixture is re-compacted at a modified binder content to attain a target air void of 4%. This binder content is called the design binder content. The mixture is considered stable and has a good aggregate structure at that air void and design binder content. The rutting performance of the mixtures at the design binder content is then evaluated.

RESULTS

As the asphalt concrete mixture compacts, the data acquisition system records the reduction in height with number of revolutions. A typical compaction curve is shown in Figure 2. The same curve is a straight line on a semi-log scale as shown in Figure 3.

Based on the compaction curve (Figure 3) two Superpave Gyratory Compactor parameters can be obtained, the slope of the curve (k) and the area under the curve. The product of the slope and the air voids of the compacted specimen and the area under the curve are related to the rutting performance [8].

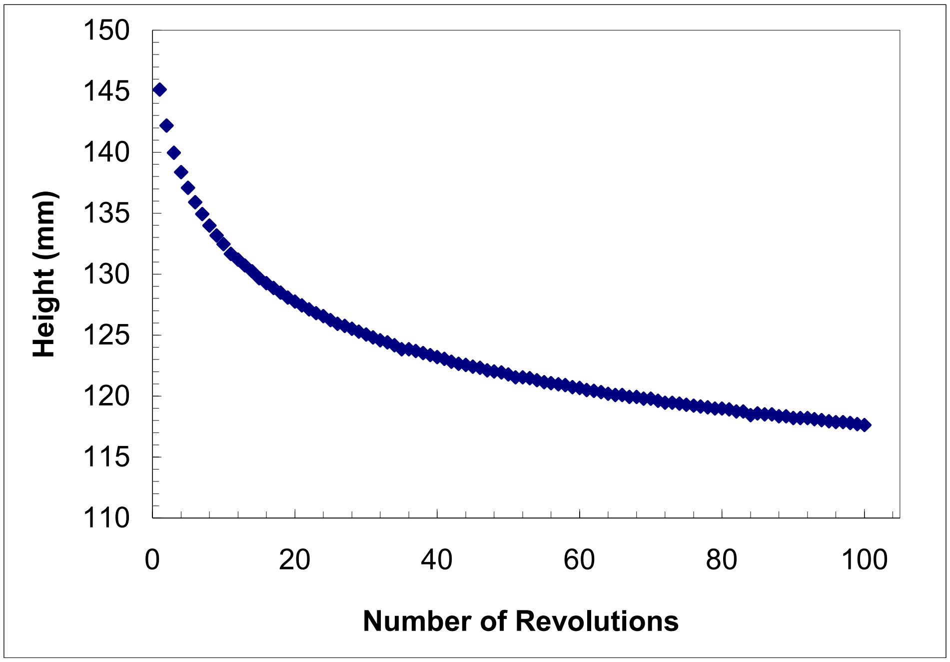

Figure 2: Compaction Curve: Height (mm) Vs. Number of Revolutions (With 5% No. 40 rubber and 7% design binder content).

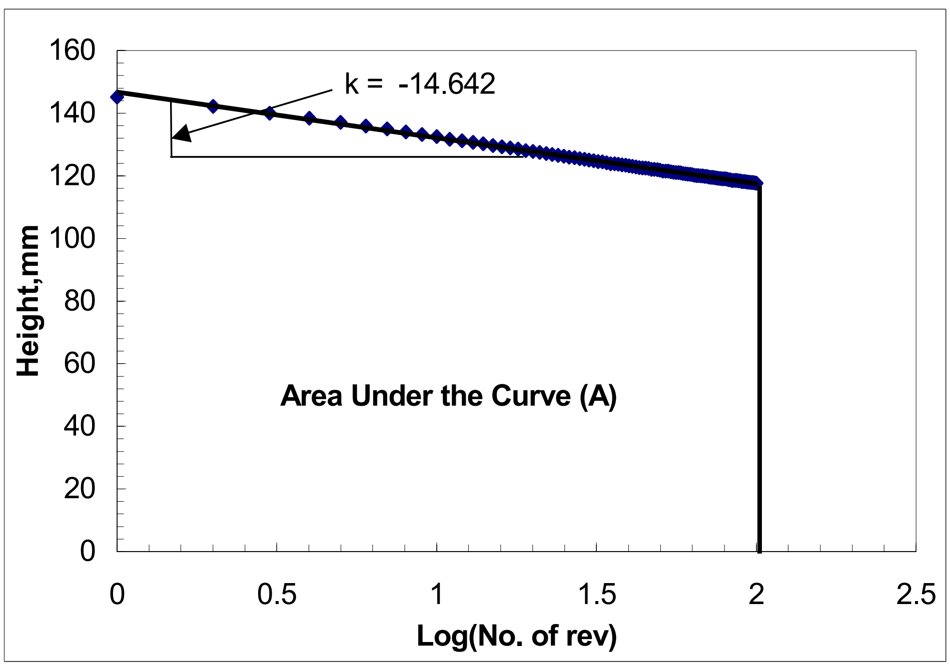

Figure 3: Height versus Log of Number of Revolutions (sample with 5% No. 40 rubber in optimum binder content).

SIGINIFICANCE OF SGC PARAMETERS

Area under the curve

Area under the curve reflects the amount of energy absorbed by the specimen during compaction at a given gyration level. A smaller value indicates lesser susceptibility to external loads, thus less rutting and a better mix

K*air voids

The product represents the condition of the material at the end of a given gyration level. The lower value indicates poor aggregate structure and over compaction, which may lead to more rutting and thus a worse mix. The values of these parameters at design binder content are shown in TABLE 1.

ANALYSIS

The data obtained above was plotted to obtain a comparison between the different mixtures. Figure 4 shows that the parameter k*Air voids increases significantly as the amount of rubber increases in the binder, which indicates improved rutting performance. This increase is more significant while going from 0 to 5% than it is while going from 5% to 15%. This may indicate that the improvement rate levels off. Also, the improvement is more significant for the No. 40 rubber particles than it is for the No. 20 particles. This may indicate that the finer particles are more effective.

Figure 5 indicates that the area under the curve parameter does not change as drastically as the k* Air voids parameter. This shows that area under the curve may not be that sensitive to the rubber content in the binder. This may be because the area under the curve mainly depends on the gradation of the aggregate mixture rather than the properties of the binder.

TABLE 1. The Superpave Gyratory Parameters

Rubber	Design Binder Content, %	K * AV	Area Under the Curve
0% (Control)	7.0	51.0	245.5
5% No. 40	7.0	58.5	243.0
15% No. 40	7.8	63.9	248.7
5% No. 20	7.0	52.3	214.3
15% No. 20	7.8	56.6	221.1

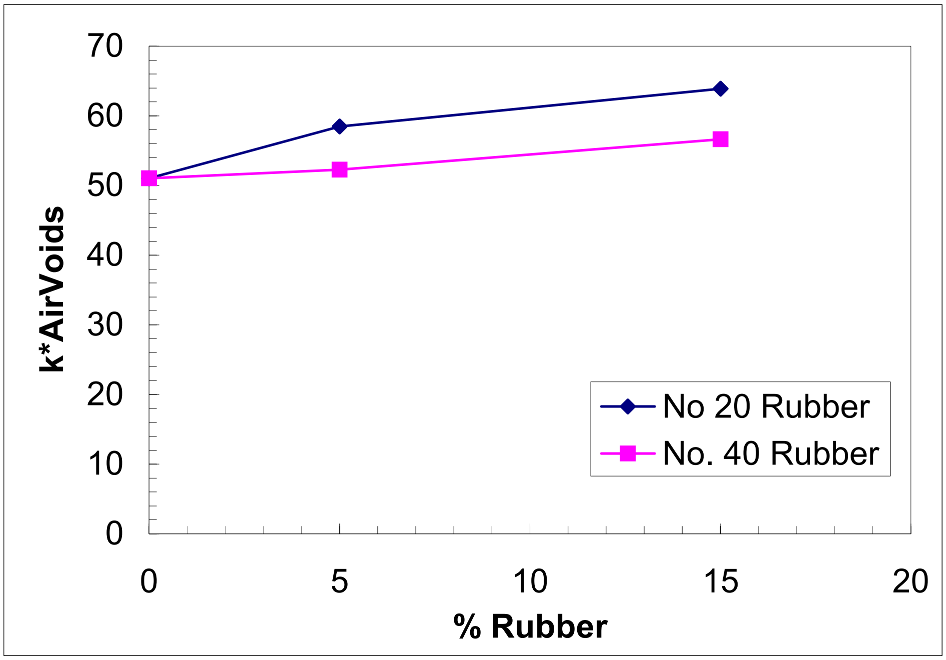

Figure 4. k*Air Voids versus Percentage of Rubber

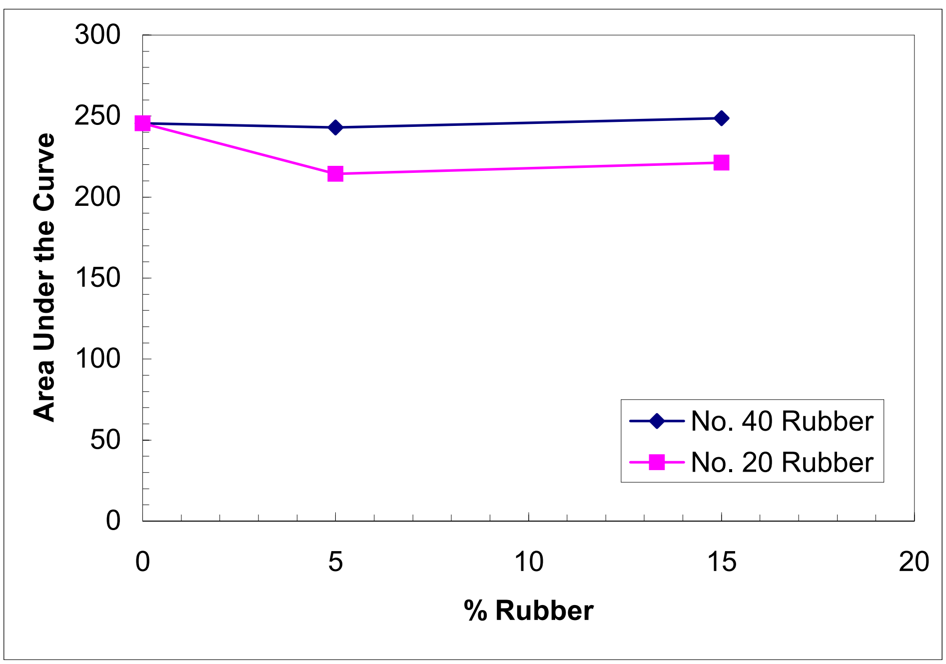

Figure 5: Area Under The Curve Versus Percentage of Rubber.

CONCLUSIONS

The conclusions based on this study are:

1. Based on the k*AV parameter, the performance of the mixture improves appreciably with rubber.
2. The most significant improvement is from 0% to 5%.
3. The No. 40 (finer) rubber is more effective than No. 20 (coarser) rubber in controlling rutting.
4. The area under the curve is not that sensitive to rubber as a modifier. This is because it mainly depends on the gradation of the mix, which is constant in all mixtures tested.

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