TIRE NOISE ASSESSMENT OF ASPHALT RUBBER CRUMB PAVEMENT

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1. INTRODUCTION

With the ever increasing traffic volumes and prevalent desire to minimize residential noise levels, various noise mitigating methods are commonly employed. The use of Asphalt Rubber Crumb (ARC) pavement is widespread in the southern United States, and has a proven track record of performance [1]. Use of ARC in Canada, however, has been limited mainly to pilot projects covering relatively short sections of road. The purpose of this paper is to discuss measured noise level results obtained during a pilot ARC paving project conducted in and around Edmonton, Alberta in 2003.

2. PAVEMENT DESCRIPTION

Typical conventional asphalt pavement is comprised of aggregate (small rock) and a binder of 5% to 6% conventional asphalt cement by total weight [2]. The ARC mix used for the study contained approximately 7.5% to 8.5% asphalt rubber binder by total weight. The asphalt rubber binder itself contained approximately 19% rubber crumb by weight, thus about 1.4% to 1.6% of the total ARC pavement contained the rubber crumb. The rubber crumb typically comes from recycled vehicle tires. For this study the primary source was large truck tires.

In production, the asphalt mix is heated and the rubber crumb is added resulting in a gel-like material that surrounds and bonds with the asphalt cement. Application is exactly the same as conventional asphalt.

3. MEASUREMENT DESCRIPTION

Various road sections in and around the Edmonton area were paved with ARC as part of the 2003 pilot project. At one highway location (single lane in each direction and a posted speed limit of 100 km/hr), a 7 km stretch of old conventional pavement was re-surfaced with ARC pavement, and an adjacent 14 km stretch was re-surfaced with new conventional pavement. As such, a direct comparison could be made with *before* and *after* conditions for both ARC and conventional pavement.

3.1. LONG TERM NOISE MONITORING

A 26-hour environmental noise monitoring was conducted at both the ARC and conventional pavement locations both *before* and *after* the application of the new surface. The noise monitoring was conducted using a 30-second L_{eq} time period in both broadband (linear and A-weighted) and 1/3 octave band spectral analysis. In each case, the noise monitor was located approximately 20m from the centerline of the road. The key was to maintain the same location for both the *before* and *after* measurements to minimize the effects of distance attenuation, ground absorption, air absorption, and surface reflections. The 26-hour time was used so that a 2-hour observation period could be used at the same time on two consecutive days to document traffic conditions, determine consistency of traffic, and record subjective observations.

3.2. SHORT TERM MAXIMUM SOUND LEVELS

While on site for the 2-hour observation periods, the short term maximum sound levels obtained with specific vehicle pass-by's were noted. These maximum sound levels were collected and analyzed statistically to further determine the consistency in traffic conditions for each observation period, as well as give another measure of the amount of noise reduction.

3.3. CONTROLLED VEHICLE TESTING

The final measurement involved the use of a specific vehicle for controlled drive-by testing. A 2002 Dodge Grand Caravan (a very common vehicle type) was driven by the sound level meter at a specific distance (10 m) and speed (100 km/hr) in each road direction with engine on and off. The sound level meter was set to measure with 1-second L_{eq} sound levels in both broadband (linear and A-weighted) and 1/3 octave band spectra.

4.1. RESULTS: LONG TERM NOISE MONITORING

The results of the long term noise monitoring are presented in Table 1. There was a reduction in sound levels with the application of both the ARC and conventional asphalts. The amount of reduction with the ARC, however, was greater. Note the two key external factors that affected the measured sound levels (listed below the table). It is estimated that the day-time sound levels at the conventional location *before* would have been approximately 2-3 dBA lower than those measured resulting in less of a reduction from *before* to *after*. As well, the daytime sound levels at the ARC section *after* would have been approximately 1-2 dBA lower, resulting in a larger reduction in the sound levels from *before* to *after*. Both of these factors would have resulted in L_{eq}Day and L_{eq}24 sound reductions of approximately 6 dBA for the ARC section and 2 dBA for the conventional section.

In addition, there was a very small amount of traffic during the night-time. As a result, even small changes in vehicle counts for the night-time period will result in large changes to the L_{eq}Night. Due to this, the L_{eq}Night is not particularly useful for comparison at this location.

Table 1. Long Term Noise Monitoring Results

	Leq24 (dBA)	LeqDay* (dBA)	LeqNight (dBA)
Before (ARC)	57.8	59.2	52.9
After (ARC)	53.1**	54.9**	44.8
Difference (ARC)	**-4.7**	**-4.4**	**-8.1**
Before (Conventional)	58.7***	60.0***	54.8
After (Conventional)	54.5	56.3	46.0
Difference (Conventional)	**-4.2**	**-3.7**	**-8.8**

* Day-time hours are 07:00 – 22:00; night-time hours are 22:00 – 07:00

** Farm machinery operating in nearby field during day-time (results estimated to be 1-2 dBA higher than normal)

*** Abnormally high volume of dump-trucks during day-time (results estimated to be 2-3 dBA higher than normal)

The typical 1/3 octave band spectral results are shown in Fig. 1. It can be seen that both surfaces resulted in lower levels near 800Hz, but the ARC was consistently lower at frequencies beyond this, while the conventional resulted in no difference.

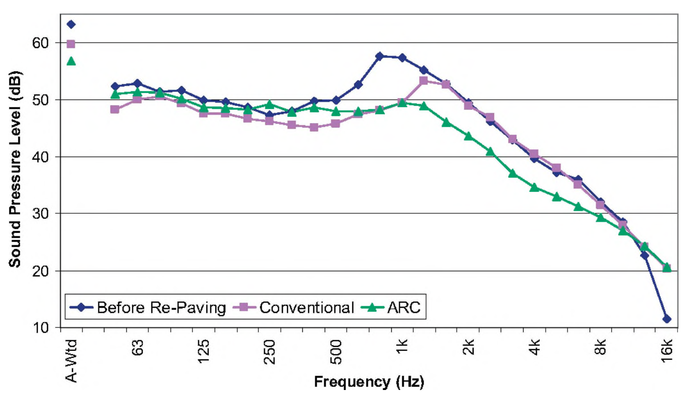

Figure 1. Typical 1/3 Octave Band Results

4.2. RESULTS: SHORT TERM MAX SOUND LEVELS

For light autos, the sound level reductions were much greater with the ARC section than the conventional pavement section. There was an increased amount of reduction with larger vehicles as well, but the difference between the ARC and conventional was not as great. This gives evidence that less of the total noise emanating from the larger vehicles is associated with tire noise than compared to the light autos (as expected).

4.3. RESULTS: CONTROLLED VEHICLE TESTING

The spectral results matched very will with those of the long term monitoring. This test also illustrated the increase in the slope for the rise and fall of the sound levels resulting from the passing vehicle. Thus, in conjunction with reduced maximum sound levels, the ARC pavement also reduced the length of time during which the higher vehicle pass-by sound levels occurred. The net effect is that residents in proximity to the roadway would experience both lowered maximum sound levels and shorter exposure times (both of which affect the L_{eq} sound levels).

4.4. RESULTS: SUBJECTIVE OBSERVATIONS

In general, it was noted that the use of ARC resulted in lower overall noise levels, as well as a substantially notable reduction in the mid to high frequencies. Essentially, it sounded as if the tire noise was somewhat "muffled" compared to both the old and new conventional pavement. The new conventional pavement was noted to have a slightly noticeable reduction in noise levels, but the frequency content of the noise did not change. In addition, newer light vehicles could be heard as far as 1 – 2 km away with the new conventional asphalt but only 300 – 400 m away with the ARC.

5.5. FUTURE WORK

There are still many important unknowns which should be addressed. Of prime importance for most regions within Canada is the effect of one or several freeze/thaw cycles. Road surface conditions such as partial snow or dirt/mud coverage and varying stages of road repair could have an impact on the noise levels. Also, variable mixtures of ARC could be investigated to find an optimal mixture for noise reduction. Finally, other vehicle related aspects such as different vehicle speeds could be investigated to determine the relative reduction levels for highway conditions compared to urban roads with slower speeds.

6.0. CONCLUSION

The use of asphalt rubber crumb pavement as a road surface material has been quantitatively and subjectively noted to reduce tire noise levels compared to conventional asphalt pavement. The various measurement techniques used to quantify the level of reduction all achieved similar results and the measured data corroborated well with subjective observations. Further work is also required to determine the longevity of the noise reduction benefits.

REFERENCES

1. Rubber Pavements Association, 1801 South Jentlilly Lane, Suite A-2, Tempe, AZ 85281 USA, Web: www.rubberpavements.org
2. Alberta Rubber Asphalt Project Report, Prepared for the Consulting Engineers of Alberta by EBA Engineering Consultants Ltd. of Edmonton.