THIN PAVEMENT OVERLAY MIXES FOR HIGHWAY NOISE MITIGATION

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The Austin District of the Texas Department of Transportation in the United States has implemented the use of Thin Overlay Mixes as pavement surfaces for the purpose of reducing traffic noise. Such overlays are non-structural hot-mix asphalt mixes that are typically placed in thin lifts of about 2.5-cm thick. Commonly, these applications are part of a pavement preservation program to address surface distresses such as raveling, aging, bleeding, minor cracking, minor disintegration, texture loss, skid resistance loss, etc. However, the Austin District has recently experimented with the placement of several of these overlays solely for the purpose of mitigating noise generated at the tire-pavement interface with excellent results, both on low-volume roads and major highways. The benefits include lower noise levels perceived at adjacent neighborhoods that had been affected by highway noise, as well as lower noise levels perceived by the driving public, by reducing the annoyance inflicted to the drivers inside the vehicle. This investigation has conducted on-board sound intensity tests on these pavements in and around the vicinity of Austin, Texas, USA for approximately four years, finding significant noise level reductions when compared to conventional pavements, whereas other pavements in the area deemed also as quieter pavements, i.e., permeable friction courses (open-graded asphalt concrete) have not delivered such magnitude of noise level reductions.

Keywords: Quieter Pavements, On-Board Sound Intensity, Highway Noise, Thin Overlay Mixes

1. Introduction

Noise associated to transportation has progressively become a nuisance to communities along highways. As transportation of people and goods continues to grow, roads expand, and noise levels rise. Nowadays, transportation agencies have to be environmentally sensitive and have to respond to pollution problems including noise. An alternative to noise barriers as the most common highway noise mitigation solution is the use of “quieter pavements.” In recent years, there has been a growing interest in designing and constructing quieter pavements as a way to abate traffic noise by reducing noise at the source. The most typical among the quieter pavements has been the open-graded asphalt concrete, also known in Texas as permeable friction course (PFC). These surfaces have been successfully applied for a number of years as a way to reduce the noise at the tire-pavement interface. In recent years, the Austin District of the Texas Department of Transportation (TxDOT) has implemented the use of Thin Overlay Mixes (TOM) as pavement surfaces for the purpose of reducing traffic noise. These overlays are non-structural hot-mix asphalt mixes that are typically placed in thin lifts of about 2.5 cm thick, although some are as thin as 1.25 cm.
Several of these overlays in the vicinity of Austin, Texas, have been tested by means of the on-board sound intensity method [1], which measures noise at the tire-pavement interface. For the time being, it is only the Austin District that has implemented these pavement mixes for noise abatement purposes among the TxDOT districts. The noise test results suggest that these surfaces can be implemented at a larger scale elsewhere by other districts and agencies for which noise abatement in urban areas is a concern.

2. Thin Overlay Mixes

Conventional asphalt overlays, which are typically about 5-cm thick, are a common rehabilitation technique for all pavement types, capable of improving surface characteristics and extending the pavement’s service life up to 10 years. However, for economic reasons there has been a need to search for even more cost-effective alternatives. Surface treatments such as seal coats could be an option, but the drawbacks of loose aggregates and high tire-pavement noise generation have diminished their application, especially in urban areas where those two disadvantages could be cause of concern. As a result of complaints about noise and flying aggregates, TxDOT started the development of asphalt mixtures that can be placed in thinner lifts, and that can provide reduced life-cycle costs [2]. Thin overlays are non-structural preventive maintenance hot-mix asphalt (HMA) mixes used for the routine maintenance and rehabilitation of existing pavements. These overlays are commonly placed in thin lifts of about 2.5 cm thick, and are mainly used to preserve pavements exhibiting surface distresses such as raveling, aging, bleeding, minor cracking, minor disintegration, texture loss, skid resistance loss, etc. [3]. Among the benefits that TOMs provide, the most important are related to enhancing the pavement performance and extending its service life including functional characteristics such as improved user serviceability (i.e., smoothness and comfort), skid resistance, splash and spray reduction, and noise reduction. Some other advantages of using thin lift asphalt mixtures include reduced life cycle costs, no loose stones, and no curing time required [4]. Even a thinner version of the overlay has been developed, as thin as 1.25 cm, called ultra-thin overlays. In order to enable such thin lifts, the overlays use a small nominal maximum aggregate size (No. 4).

Thin overlays are applicable to both asphalt and concrete pavements, and they can also be utilized to resurface bridge decks. Because these overlays are made with high quality aggregate and polymer modified asphalt, they are expected to last longer and to require less maintenance [5]. With all these advantages, the quieter ride that the surfaces provide may seem only a bonus. However, the Austin District of TxDOT has started to capitalize on this benefit by placing them solely for noise reduction purposes.

3. Noise Testing Procedure

The noise mitigation properties of some of these pavement mixes have been studied in the field by The University of Texas Center for Transportation Research (UT-CTR).

The testing procedure utilized is the on-board sound intensity (OBSI) method for close-proximity tire-pavement noise measurement (Figure 1). This method allows for measurement of the noise produced at the tire-pavement interface, isolating it from other sources of noise such as the engine, exhaust, or noise from other vehicles, due to the proximity of the microphones to the source: the tire and the pavement. The test fixture includes two pairs of microphones each pair placed at the edge of the tire contact patch with the pavement. The procedure has been standardized as an AASHTO test, which allows for comparison of results performed by different agencies. The standard also specifies the type and characteristics of the test tire.

The test duration is 5 s, and the vehicle speed is 97 km/h. Several subsections are identified within each project section, and tests are repeated in each subsection to ensure consistency among the results. The results are reported as an average of at least three tests for each subsection.
Figure 1: OBSI equipment: vehicle, fixture and test tire

4. Pavement Sections Studied

Five TOMs have been the main subject of this research; besides those pavements a few different pavement surfaces, also within the Austin District have been studied for comparison. These include PFCs, as well as dense-graded asphalt concrete (DGAC).

Four TOMs have been measured in this study starting in 2014: Interstate Highway 35 main lanes (IH-35), Ranch to Market Road 12 (RM 12), Ranch to Market Road 3238 (RM 3238), and the frontage road of US 183A. One more TOM was added in 2018: Farm to Market Road 1626 (FM 1626).

4.1 IH-35

This TOM was placed on a 21.5-km stretch on one of the busiest Interstate highways – from the Bell/Williamson County line to Lakeway Dr., near Georgetown.

4.2 RM 12

RM 12 is a more rural road, just west of Austin. In this case, the overlay is 1.25 cm thick. The overlay mix – one of the first ultra-thin pavements in the Austin District, extends for 10 km– from just south of US 290 to Wimberley city limits. This section was originally resurfaced with a seal coat, but it was so noisy, that shortly thereafter, the district decided to replace it with the ultra-thin pavement.

4.3 RM 3238

The TOM on RM 3238, west of Austin, covers a 12.9-km stretch, from just north of US 290, between Bee Cave and Dripping Springs.

4.4 US 183A Frontage Road

US 183A is a new toll road near Leander, north of Austin, which roughly follows its non-tolled counterpart, US 183, and serves as a bypass to it. A TOM was recently placed on the frontage road, which is not tolled.

4.5 FM 1626

FM 1626 is a modern four-lane divided highway. This new TOM is located in Hays County, south of Austin, near Kyle. It was tested for the first time in August 2018.

Figure 2 shows the five TOM sections studied.
4.6 Other Pavements in this Study

Other pavements that are part of this research, within the Austin District include the PFC on IH-35, adjacent to the IH-35 TOM; the PFC on FM 1431, near Lago Vista; the DGAC on Ronald Reagan Blvd., near Leander; and the PFC on SH 195, in Florence. All these pavements were tested in conjunction with the TOMs as part of the Austin District highway noise study for comparison purposes.

5. Results

The acoustic performance of the TOM surfaces is excellent as shown by the results of the OBSI tests. The average noise levels of the TOMs are between 96.7 and 99.8 dBA, which can be considered very quiet, especially when compared to other pavement types. The tests are performed twice a year and the results for each section correspond to their averages over the duration of the study. The noise levels are presented in Figure 3, which shows the other pavements that are part of this study as well. The TOMs were quieter than other pavement types, even delivering better performance than PFCs, which are commonly regarded as one of the quieter pavement types.

Figure 2: TOMs: IH-35, RM 12, RM 3238, US 183A, and FM 1626

Figure 3: TOM, PFC, and DGAC average noise levels
The frequency spectra for the TOM pavement sections are presented in Figure 4. The frequency spectra for the PFCs and the DGAC section are shown in Figure 5. In these plots, each line corresponds to an OBSI subsection. The shapes of the spectra are similar for each pavement type. The TOMs have a peak for the 1kHz frequency band but the peak value is lower than that of the PFCs, which have a peak at the 800 Hz band, and a dip for the 1600-2500 Hz bands. The DGAC shape is similar to the TOMs, but with higher sound intensity values.

![Figure 4: TOM frequency spectra](image-url)
Figure 5: PFC and DGAC frequency spectra

The frequency spectra indicate that each pavement type has a “signature” sound that determines how the noise is perceived by the receivers in adjacent residences and establishments as well as by the drivers inside their vehicles.

5.1 Comparison with Other Pavements

The noise level results of the pavement sections in this research were analysed alongside those of other sections corresponding to various pavement types from other studies [6, 7, 8], all of which are located within the Austin District. This historic analysis includes OBSI tests that have been performed ever since OBSI has been used in Texas, as far as 2006. The comparison emphasizes the excellent performance delivered by the TOMs, and confirms that they are quieter than any other pavement type. The OBSI test results, including the pavements in this study, as well as transversely tined continuously reinforced concrete pavement (CRCP) and seal coats, are shown in Figure 6. The plot also helps to understand why on certain roads some seal coats have been replaced with TOMs, and tined CRCPs have been overlaid with TOMs in an effort to reduce noise.
6. Discussion of Results and Conclusions

The average noise level for the TOMs tested in this study was 98.2 dBA, whereas that for the PFCs was 101.6 dBA. Even though the sample size is small, the TOMs tested have been consistently quiet over time. Furthermore, although the TOM surfaces that have been tested are all fairly new pavements, their performance has been excellent throughout the length of this study; this suggests that, unlike the PFCs, the acoustic benefit of the TOMs may last for the duration of their service life. The acoustic benefits of the PFCs are greatly diminished when the voids in the open graded surface, which absorb the acoustic energy, are reduced by clogging from road debris and compaction under heavy traffic loading [6, 7].

The TOMs have shown that, besides being a viable pavement preservation solution, they can be placed for the purpose of noise reduction with excellent results. The comparisons with other pavements indicate that these mixes have become the quietest pavement type among the existing pavements in the Austin area, which indicates that they can also be applied elsewhere with favourable results. By reducing the noise at the source with quieter pavements, the noise mitigation benefits apply to the neighbourhoods adjacent to the highway, as well as to the driving public.

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REFERENCES


