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Evaluation of Noise Performance of Multi-Lane Highways in the State of Qatar

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Abstract. In recent years, a growing number of people are complaining to transportation authorities for the traffic noise as a result of increased traffic volume on the highways. Therefore, transportation authorities are actively pursuing ways to reduce the traffic noise. In recent years, quieter pavement has become one of the cost-effective ways of sustainable highway noise reduction. However, for design and construction of quieter pavements, proper and accurate noise measurement is of paramount importance for evaluating the noise level of existing pavement as well as evaluating noise level of newly constructed pavements. In this study, the variation of noise level among different lanes of existing multi-lane highways in the State of Qatar was examined. Tire-pavement noise was measured by using onboard sound intensity (OBSI) technique. OBSI test results showed that highest noise level was observed at outer lane of multi-lane highways. This is probably due to the pavement distress caused by the heavy vehicle travelling at the outer lane of multi-lane highways.

1. Introduction

Noise pollution due to moving traffic has been one of the important environmental concern for the people living close to highway vicinity. A number of psychological and health related problems of highway inhabitants has been linked to traffic noise [1]. Therefore, transport agencies are actively finding ways to minimize the noise from the road traffic. Although traffic noise is comprised of number of sources, but tire-pavement interaction noise is the major source of traffic noise at medium to higher vehicle speed [2, 3]. Therefore, reducing tire-pavement noise at source could be an important option in order to balance the benefits of well-connected highway network against the adverse impact of the residents exposed to highway traffic.

A number of ways to reduce the tire-pavement noise was adopted by various transportation authorities. Of all the noise reducing ways, three techniques are generally used which included producing quieter tire, constructing quieter pavement and providing a barrier wall between source and receiver [2]. Tire manufacturers are actively pursuing to produce tires which minimize the impact between tire and pavement. Although, noise barrier wall is most commonly used by transportation authorities, but they are not always effective due to practical problems and are very expensive (~$2.1 million per mile) [4]. On the other hand, worldwide transportation authorities have been providing great effort to identifying ways of noise reduction by altering/optimizing the road surfaces properties. However, there is always a concern that optimizing pavement surface could compromise other attributes of pavement such as safety, durability and cost of pavement. Nevertheless, researchers in Europe and USA showed that constructing quieter pavement is possible within a reasonable cost without compromising safety and long-term durability of pavement [2].

Accurate measurement of tire-pavement interaction noise is required because the data which are collected from the measurement system will be used to identify quieter pavement and to understand the noise generation mechanisms. At present, noise measurement in the field is generally performed in two ways: wayside noise measurement and noise measurement at source. However, if the goal is to identify quieter pavement, source noise measurement is more accurate compared to wayside noise measurement [2, 3]. The source noise measurement method provides a direct measure of noise in close proximity to the tire-pavement interface and allows various pavement types and textures to be directly compared [2, 3]. The main objective of this study was to examine the noise performance of various lanes of multi-lane highways in order to develop guidelines for the sustainable quieter pavement in the State of Qatar.

2. Experimental Program

2.1. Locations of Test Sections

Researchers selected pavement sections on two major highways (i.e., Dukhan and Al Shamal) in the State of Qatar to identify the variation of noise level in different lanes of multi-lane highway. Both of the highways have dense graded asphalt concrete (DGAC) surface which represents most of the pavement sections in the State of Qatar and constructed by using gabbro aggregates. Noise testing was performed at number of sections as both highways are very long. To investigate noise performance of various lanes, noise testing was performed at three lanes of both highways. At first, noise testing was conducted at outer lane of highway and followed by inner lane 1 and 2. Figure 1 depicts the locations of the lane on the map for Al Shamal highway.

Fig. 1. Lane locations for Al Shamal highway

2.2. Noise Measurement Method

In this study, tire-pavement noise was conducted on selected test sections by using onboard sound intensity (OBSI) method following AASHTO T 360-16 [5] standard. In this method, sound intensity is measured by placing sound intensity probes consisting of pair of microphones close to the tire-pavement interface. Two sound intensity probes are placed at specified positions (i.e., 101.6 mm from the center of the tire and 76.2 mm above the surface of the pavement) in accordance with AASHTO T 360-16 standard [5]. Fig. 2 shows the instrumented OBSI set up on the field test section. All the OBSI testing were conducted at AASHTO T360-16 [5] specified speed of 96.6 kM/hr (60 mph) with a tire inflation pressure 30 psi in tire cold condition. Meteorological data was also recorded during noise measurement as it impacts the generation and amplification mechanism of tire-pavement interaction noise [2, 6].

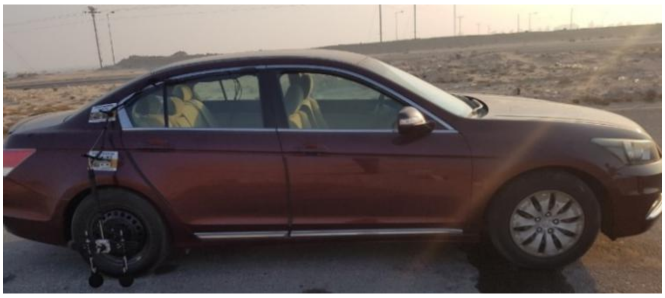

Fig. 2. Instrumented OBSI equipment on field testing section

3. Discussion of Test Results

OBSI noise testing was conducted on each section in accordance with AASHTO T 360-16 [5] standard. At least three valid runs were performed in each test section as there is slight variation of noise level among successive runs even though test was conducted by the same equipment and same operator. During post processing of data, the average noise level was calculated which represents the noise level of that particular section. Furthermore, noise level of different sections in any specific lane was varied due to slight variation of pavement during construction period and distress caused by the moving traffic due to operational period [2, 6, 7]. However, the variation of measured overall intensity level among sections in any lane is small as observed from the test data. Therefore, noise level of all the sections of any specific lane were averaged to create a representative noise profile for that highway lane. The test results for both highways at three respective lanes are shown in Fig. 3. It can be seen from figure 3 that noise intensity level is highest for outer lane and lowest for inner lane 2 for both highways (i.e., Dukhan and Al Shamal). Almost 3 dBA noise level difference was observed between outer lane and inner lane 2 for both highways. Most of the heavy vehicles are generally traveled along the outer lane of multi-lane highways which may resulted more distress and wear in pavement hence showed higher noise level. However, texture measurement at different lane is required to verify this hypothesis.

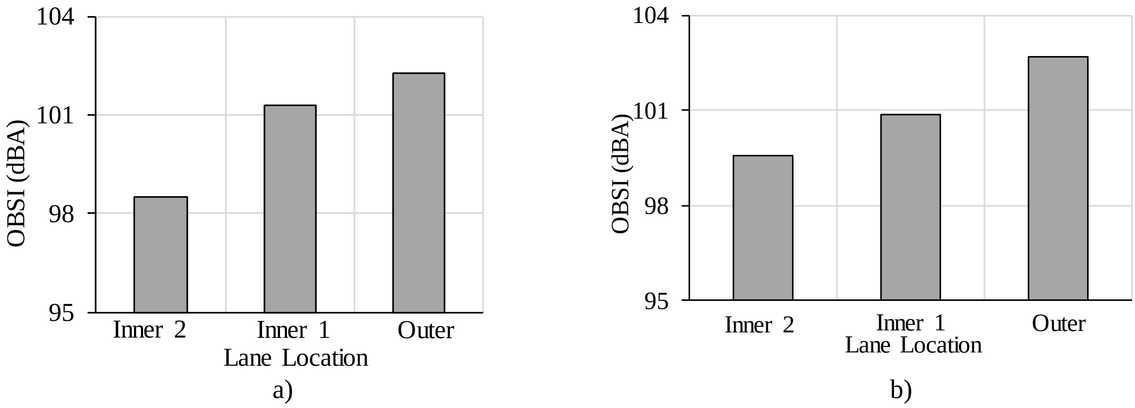

Fig. 3. OBSI data for pavement sections; a) Dukhan Highway; b) Al Shamal Road

To identify the mechanism that affects the acoustical behavior of different lane of highway, the frequency response of test sections was compared and shown in Fig. 4 and Fig. 5 for Dukhan highway and Al Shamal road, respectively. The peak sound intensity amplitude occurred at the center frequency of 1000 Hz frequency band irrespective of lane location for both highways. This demonstrated that the prominent peak around 1000Hz for small car noise spectra for DGAC surface and is also consistent with the literature [8, 9]. The noise intensity of the outer lane is lying well above compared to the other two inner lanes at all frequency range for both highways. At a lower frequency below 1000 Hz, the increase of noise intensity for outer lane of pavement was more prominent. This indicates some changes in surface texture of pavement due to wear and tear caused by heavy vehicle which generally travel on outer lane of multi-lane highway. Tire vibrations due to high macrotexture dominants tire-pavement the at the low frequencies whereas tire/pavement noise were found to be governed by air-pumping mechanisms at higher frequency that can be reduced by the presence of air voids on the pavement surface [2].

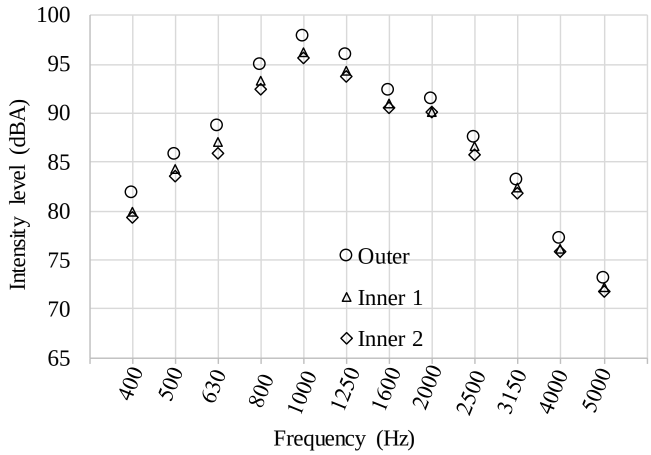

Fig. 4. Frequency response of various lanes at Dukhan Highway

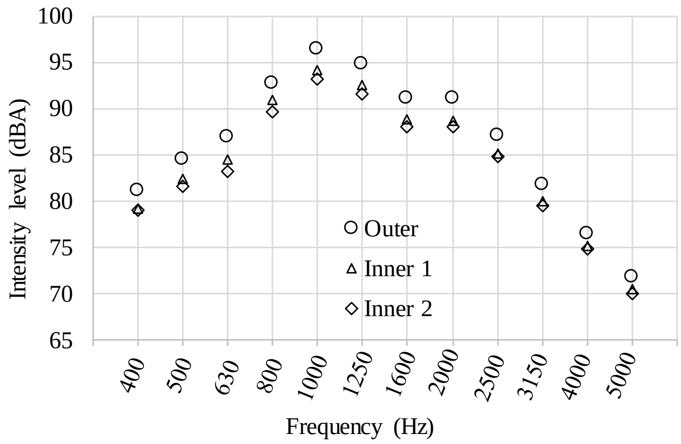

Fig. 5. Frequency response of various lanes at Al Shamal Road

4. Conclusions

Tire-pavement noise generated due to interaction between rolling tire and pavement surface can be reduced by proper design of pavement surfaces. In this study, noise performance of various lanes of two major highways in the State of Qatar was investigated by using OBSI technique. OBSI test results showed that noise level of outer lane was generally the loudest for both highways, resulting in overall OBSI levels of about 3 dBA differences between outer and inner lane of highway. This study provides insights the acoustical performance of asphalt mixture subjected to real traffic and harsh climate conditions which will be important when preparing quieter pavement guidelines in the State of Qatar.

5. Acknowledgments

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6. References

[1] WHO. Night noise guidelines for Europe. Regional Office for Europe, Copenhagen, Denmark:2009.http://www.euro.who.int/__data/assets/pdf_file/0017/43316/E92845.pdf, accessed April (2018).

IOP Conf. Series: Materials Science and Engineering **517** (2019) 012010 doi:10.1088/1757-899X/517/1/012010

[2] Ohiduzzaman, M., Sirin, O., Kassem, E. and Rochat, J. "State-of-the-Art Review on Sustainable Design and Construction of Quieter Pavements—Part 1: Traffic Noise Measurement and Abatement Techniques" Sustainability (MDPI), Vol 8 Issue 8 (2016), 742.
[3] Sandberg U, Ejsmont J. Tire/road noise reference book. Informex, Kisa, Sweden: (2002).
[4] Hanson, D.I., James, R.S., NeSmith, C. "Tire/Pavement Noise Study." National Center for Asphalt Technology, Report 04-02 (2004).
[5] AASHTO TP 360-12-Standard method of test for measurement of tire-pavement noise using the on-board sound intensity (OBSI) method. American Association of State Highway and Transportation Officials (AASHTO), Washington, D.C (2016).
[6] Rasmussen, R., Bernhard, J., Sandberg, U. & Mun, P., The little book of quieter pavements. The Transtec Group, Inc., Austin, Texas (2007).
[7] Sirin, O. State-of-the-Art Review on Sustainable Design and Construction of Quieter Pavements—part 2: factors affecting tire-pavement noise and prediction models. Sustainability (MDPI), Vol 8 Issue 7 (2016), 692.
[8] Ohiduzzaman, M., Sirin, O., Kassem, E. Assessment of tire-pavement noise by using on-board sound intensity (OBSI) method in the State of Qatar. 10th International conference on the bearing capacity of roads, railways and airfields (BCRRA 2017), JUNE 28~30, Athens, Greece, (2017).
[9] Sandberg, U. The multi-coincidence peak around 1000 Hz in tire-road noise spectra. Euro noise, Paper ID: 498, Naples, (2003).