A short review of research on roads with low noise pavement in China

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Abstract. Roads with low noise pavement have attracted more and more attention in recent years. The scope of the current paper was to briefly review literature on different kinds of roads with low noise pavement. It will be conducive to further application of low noise pavement in the future.

1. Introduction
Traffic noise on road has become a major source of environmental noise pollution. The issue of controlling traffic noise has attracted increasing attention. Construction of low-noise road is an important way to reduce road outside-car traffic noise. Because many roads are rebuilt now, there is no pavement with low noise when initially laid. With the gradual improvement of life quality, it is imperative to reduce the pavement noise. The road pavement reconstruction should use low noise road pavement as much as possible [1].

2. Asphalt pavement of road
It is a serious problem that traffic noise affects people. Paving low-noise asphalt pavement is a main method to reduce pavement noise. The effect of reducing noise can reach expected aim to traditional low-noise asphalt pavement, but it's durability is worse [2]. Xue [3] pointed out that, though noise reduction effect of double-layer porous asphalt pavement was lower than that of single-layer porous asphalt pavement, which is about 1 dB, but it was a perspective low-noise asphalt pavement with good durability. These results of laboratory absorption coefficients and filed asphalt pavement noise tests showed that, it was feasible for using FEM software ABAQUS to analyze the noise and its conclusion was reliable.

Through studying the influencing factors of the noise-reducing effect of the porous asphalt concrete, Zhang [4] found that the 60mm thick porous asphalt mixtures of 5% (dense gradation) and 20% (open gradation) porosity have better acoustic absorption function. The two asphalt mixture samples of 15mm and 10mm maximum granule diameter also have similar frequency and coefficient in acoustic absorption under the condition of similar thickness and porosity. Though it is possible to improve the asphalt mixture’s capability of acoustic absorption by increasing its connective porosity, yet the hardness and wear ability of the pavement will also be reduced accordingly. Out of this consideration, the paper set the initial porosity as 20%. Ensuring the high porosity and anti-loose capability and reliable mechanical strength is the key technique of designing porous asphalt concrete pavement. The porous asphalt pavement with low noise can reduce the traffic noise from the source and shows better capability in noise-reducing, water drainage and protects from skidding, dazzling light and splashing...
water. This can safeguard the sustaining development of road construction and environmental protection and has a bright future for wide appliance. But there still needs extensive research for problems like endurance of road surface, block up of gaps and water damage.

After testing the tyre-to-road noise of diverse pavement structure types by the controlled pass-by method, and studying the actual noise reduction effects of 5 different pavements, Wang [5] found that it can cut 6dB, 7dB and 1.5dB on SMA-13 pavement, OGFC-13 pavement and AC pavement respectively, comparing with PCC pavement, whereas, with 5dB reduction on SMA-13 pavement, 6dB on OGFC-13 pavement, contrasting with AC pavement. On noise reduction effect, it is another effective reduction method of tyre-to-road noise with OGFC-13 pavement and SMA-13 pavement.

In the opinion of Gao [6], rubber particles’ asphalt pavement has better capability of vibration of vibration reduction and sound absorption than common asphalt pavement. The more rubber particles content, the larger the maximum aggregate size of rubber particles, the better pavement’s capability of vibration reduction and noise reduction. It can effectively depress vibration strength of vehicle tyre when rolling and much more when turn around if mixing big rubber particles into asphalt pavement, making vibration energy flow from 'low frequency’ to 'intermediate frequency' and 'high frequency'. Content of rubber particles, rubber particle size and maximal size of aggregate can affect vibrational peak acceleration of vehicle tyre in the different frequency bands. Following direction of travel, dropping height of tyre has special influence on inspiring with noise of tyre. Pavement which has fixed content of rubber particles has finite damping ability to tyre stress. Once exceeding limit of damping ability, rubber particles asphalt pavement will lose superiority of noise reduction by vibration reduction.

3. Cement concrete pavement

Porous cement concrete is a novel road construction material, which uniform pore and framework structure can inhibit the monopole noise source, can reduce the noise of cement concrete pavement, can improve surrounding environment. In the research of Jing [7], considering the noise reduction effects, flexural strength, pore durable and so on, this paper recommend that the design value of the porosity is between 15% and 22%.

In the opinion of Song [8], to decrease traffic noise, with velocity of vehicle increasing, decreasing pavement noise towards exposed-aggregate cement concrete pavement becomes more and more efficient. Compared with the normal cement concrete pavement, it can decrease 2〜3dB(A) when velocity of vehicle surpass 100 km/h. It can be seen that exposed-aggregate cement concrete pavement can improve security of traffic and reduce pavement noise.

Dong [9] studied the construction technology, skid-resistance performance and noise-reducing performance of the exposed aggregate cement concrete pavement and found out that, compared with the general cement concrete pavement, the exposed aggregate concrete pavement has outstanding skid-resistance and its durability, can increase skid-resistance coefficient 5〜10(BPN) and can reduce the pavement noise Leq 4〜10(dB(A)) effectively.

In the research of Chen [10], a conception of high-performance pavement is proposed, then the advantages and feasibilities of porous cement concrete as a new skid-resistant and noise-absorptive pavement pattern and material is clarified. The tire-pavement traffic noise reasons are analyzed, and the noise absorption phenomenon of porous concrete are ascribed to sound-absorptive and energy consumptive porous structure, shock absorption and energy exhaustion of flexible damping material, diffuse reflection of stochastic uneven surface textures, optimization of surface texture parameters and so on. Based on analysis of the theoretic structural mode, damage pattern and constitution conditions of porous cement concrete, the main technical parameters of porous concrete applied in highway pavement are designed as: target porosity 18-22%, compressive strength grade no less than C35, bending strength > 4.5-5.0 MPa, skid-resistant texture depth>1.10 mm, penetration coefficient > 4.0 mm, sound absorption index>0.30 and comprehensive noise reduction > 6dB (A).

The advantages of the cement concrete pavement with high strength, good stability and good durability make it be used broadly worldwide in the highway construction. But the disadvantages of its
poor skid-resistance durability and higher noise always puzzle road engineers and researchers in all kinds of countries. Liu [11] analyzed the theoretical mechanism of anti-sliding, noise, and the features on the surface affect the road surface performance and suggested the best expose-degree range from 40 to 55, the best structure depth range from 0.8mm to 1.0mm.

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References
[1] Wentao Yu (2016). Effect of noise reduction on roads with low noise pavement. (Doctoral dissertation, Chongqing Jiaotong University).
[2] Yongsheng Yin. (2005). Research on low noise asphalt pavement. (Doctoral dissertation, Chang'an University).
[3] Guoqiang Xue. (2009). Research on low noise asphalt pavements of urban road. (Doctoral dissertation, Southeast University).
[4] Bo Zhang. (2005). Study on the application of porous and low noise asphalt concrete pavement. (Doctoral dissertation, Shandong Normal University).
[5] Caixiang Wang. (2010). Study on Reduction Technology and Prevention Method of Tyre-to-road Noise for Highway. (Doctoral dissertation, Chang'an University).
[6] Mingxing Gao. (2009). Study on Noise Reduction Characteristics of Continuous Gradation Rubber Particles Asphalt Pavement. (Doctoral dissertation, Inner Mongolia Agricultural University).
[7] Lubo Jing. (2009). Research on low noise porous cement concrete pavement. (Doctoral dissertation, Beijing Jiaotong University).
[8] Yongchao Song. (2007). Technology of low noise and high anti-skidding exposed-aggregate cement concrete pavement. (Doctoral dissertation, Chongqing Jiaotong University).
[9] Yuming Dong. (2004). Research on tunnel with skid-resistance and low noise. (Doctoral dissertation, Chang'an University).
[10] Yu Chen. (2007). Study on high performance porous cement concrete pavement of highway tunnel. (Doctoral dissertation, Central South University).
[11] Liu Liu. (2008). Study on surface performance of expose-aggregate cement concrete pavement. (Doctoral dissertation, Chongqing Jiaotong University).