Progress on Noise Reduction in Road Traffic Environment from 2000

Leyan Yu(✉)

United World College Changshu, Suzhou 215500, China
yuleyan05@163.com

Abstract. With the accelerating progress of modernization, road traffic, by means of motor vehicles, has become a common way of getting around. It provides efficient and convenient transportation to the us, at the same time, brings us massive problems. Among which, traffic noise is the most influential one for it relates to our mental and physical heath. In this literature review, the author generalized two main research topics about how to reduce noise in road traffic environment, artificial & vegetated noise barriers and road surface & tire. The literature review analyzed and evaluated the pros and cons of the research in some seminal literatures. Accordingly, it pointed out the two ways of noise reduction should be carefully chosen before use for different solutions fit different real-life situations. At the end of the literature, the author figured out the limitations in perspectives of current research and proposed a few new dimensions to think about to broaden the means of noise reduction in the future.

Keywords: Road · traffic · Noise Reduction

1 Introduction

People have lived in a world of noise for thousands of years. The recorded history of noise can be traced to 6th century BCE as the first known noise ordinance: The council of the province of Sybaris, a Greek colony in the Aegean, rules that potters, tinsmiths, and other tradesmen must live outside the city walls because of the noise they make. They ban roosters, too [1]. Nowadays, we inevitably encounter the problems of noise pollution since noise is produced in our daily life, it is around us. Among all the areas which produce daily noise, road traffic environment is the one which influence the citizens the most for people's actions and livings in cities are mainly around the roads. According to its negative impact on Physical and Psychological well-being, noise reduction has long been a public hot spot. The earliest literature which can be found in cnki.net is in 1934, "Reduction of Traffic Noise" by Herbert Maxwell. Until 30 years later, the mass research did not carry out in this area. The previous research mainly focuses on two methods: artificial & vegetated noise barriers and road surface & tires. Noise barriers made of different materials aims to prevent the spread and weaken the sound waves while road surface & tires concentrate on vibration damping which limit noise from its production. The improvements on both methods, in recent years, mostly based on the latest studies

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on new materials and structures which can absorb or obstruct sound waves effectively. This literature review will analyze and evaluate the two methods in turn, find a gap in existing research and get a conclusion.

2 Analysis and Evaluation

2.1 Artificial & Vegetated Noise Barriers

Luca Fredianelli, Alessandro Del Pizzo and Gaetano Licitra are seminal for analyzing sonic crystals as barriers for road traffic noise mitigation [2]. They gave explanations of principles of sonic crystals, researched on recent developments and evaluate the behaviors in noise reduction of barriers made of different materials such as wood, aluminum, and PVC as well as barriers with various factors, for example, how does change in parameters of scatters influence insertion loss and band gap. However, it is insufficient to fully explain the properties of barriers by solely considering the materials or factors for in some cases the combinations of a material and factor may reach an external impact on the behavior of barriers.

Unlike Luca Fredianelli, Alessandro Del Pizzo and Gaetano Licitra, most of the other researchers combined low-height barriers with vegetated barriers and evaluate the properties through multiple ways, including case studies. Real-life applications, 3D simulation and multi-dimensional analysis [3–6]. Timothy Van Renterghem et al.'s study reached that the result of reduction in dB is slightly lower than the green barriers in previous literature. The difference may be caused by the choice of wooden materials, for the previous literature uses Thuja trees as the unit of barriers. Compared to other literatures, Timothy Van Renterghem et al. consider little about the parameters as well as the arrangement of vegetation which makes the result so broad that it limits the value of the outcome.

Hui Wang et al. did a lot of evaluation on the noise reduction function of green belt along the road [7]. The literature is profound for it focus on the efficiency in different situations. It evaluates how the behavior of barrier is influenced by its width, material, arrangement density and the distance between the green belt and the road in detail by analyzing first-handed data which collected from real-world environment. Since the "green belt" in the literature refers to thick vegetation barriers (about 40 m in width), the effect is apparent that the barrier can reduce the noise for at least 30 dB.

2.2 Road Surface & Tire

For road surface & tires, Jian Yang researched and evaluated the tire in different usage conditions and how they impact the production of noise, he also explained the relationship between the design of the tire and noise [8]. Feipeng Xiao et al. focus on the rubber road surface and its function on noise reduction [9]. They first introduced the principles of noise production and reinforcement on traffic context, zoomed into the mechanism of rubberized asphalt pavement. Then listed out various factors which influence the behavior of such pavement. At last, summarized the latest progress in applications of rubberized surface for traffic noise reduction. This literature is of great importance

Fig. 1. Rubberized Asphalt Pavement [11] (Source: https://weibold.com/tsa-rubberized-asphalt-project-helps-pave-road-to-sustainability-in-australia. 2020 Licensed by weibold)

among all relevant research since it considers many aspects such as the influence of width, porosity, diameter of the rubber granules and so on.

G. Licitra et al. are essential for the current application on the rubberized road surface [10]. Unlike Feipeng Xiao et al., they focus on some practical problems of the road surface such as its durability and variability. They analyzed the behaviors of the rubberized surfaces which have put in use over 1 year, comparing them with normal surfaces and the way they behaved before to reach a conclusion. They collected real world data from four different case of rubberized pavement applications, got different results in all four rubberized surface they chose and explained that the difference may be due to the various quality of installation. Figure 1 shows the process of installing rubberized asphalt pavement.

2.3 Evaluation and New Approaches

The existing researches and progresses on noise reduction in road traffic environment are relevantly broad, for they explore on various ways such as barriers of different materials, tires and road surfaces, which cover the production and spread of noise sound waves. The research is active in these areas currently. However, previous research lens did not take much regard of some dimensions such as the frequency traits of traffic noise. According to research, the center frequency of traffic noise is divided into 3 parts, 150–250 Hz on flat and straight roads on the ground, 250–350 Hz on skyway and 350–450 Hz in tunnel, belong to low and middle frequency sector [12]. Since sound waves with longer wavelength can easily circumvent the barriers, the barriers may need specially design before they are put into use. At the same time, the center frequency gives us a clue to reduce the noise more efficiently. For example, some types of materials, such as aluminum fiber sound absorbing materials and broad-leafed trees, perform well in low-frequency noise absorbing. Some special shapes of barriers are unique for noise reduction when the noise is in a specific frequency sector. It is widely acknowledged that barriers with a circular arc (Fig. 2) or T-shape body (Fig. 3) behave the best in noise absorbing when the noise is under 500 Hz [13]. Also, digging ditches or artificial rivers

Fig. 2. Circular Arc Barrier [14] (Source: http://www.hanlinsiwang.com/yongtu/3.html. 2021Licensed by HB-HANLIN)

Fig. 3. T shape Barrier [15] (Source: http://m.geyinwang.net/news/175.html. 2022 Licensed by HUAJIU)

near the subgrade can also contribute to cut the spread of low-frequency vibration in the ground. There is great need of research in noise frequency dimension for the low and mid frequency noise are supposed to be more harmful to the environment wellbeing. As a result, we should pay more attention to the function of absorbing low frequency noise when we design a barrier aiming to reduce traffic noise.

Additionally, when we try to reach a better result of noise reduction, it is also a good idea to think about how does sound wave travels: they need transmission medium. Sound cannot propagate in vacuum atmosphere which means an artificial vacuum area would keep us from noise disturbing, thus we have double vacuum glass. (Fig. 4) This type of glass combined two pieces of glass together and use vacuum technique to exhaust the air between them, creating an approximately vacuum atmosphere. It is approximate since we need to set some microscopic props to separate two sides of glass, if not, they will fit each other tightly. Accordingly, the sound can still propagate through the double vacuum glass by the props, but the degree of noise reduction would be considerable.

Besides the technical solutions, there are still more ways to take such as working with local government to promulgate a new policy about limit the noise level of traffic or raising citizens' awareness of noise pollution and its damage.

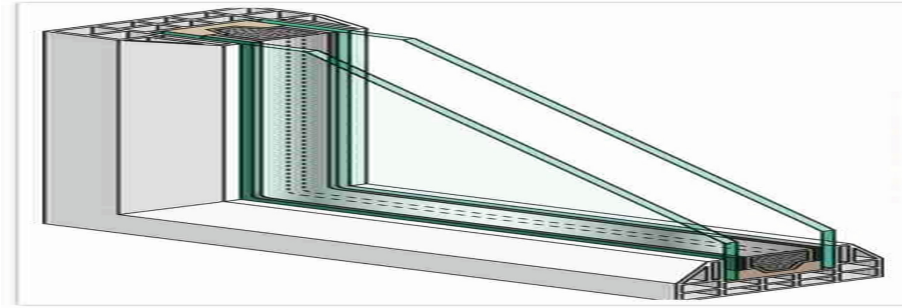

Fig. 4. Double Glass [16] (Source: https://szdragonglass.com/low-e-window-glass-supplier-china/. 2022 Licensed by Shenzhen Dragon Grass)

3 Conclusion

In the article, the author, focusing on two main ways of traffic noise reduction: artificial & vegetated noise barriers and road surface & tires, analyzed and evaluated several researched and experiments conducted by predecessors. He reached the conclusion that both methods are well developed and considered from their depth and breadth for most of the dimensions in these two methods, such as characteristics of materials and structures, longevity and different modes of traffic are included. The article did well in comparing different experiments and the solutions and come out with a general idea about which combination of factors in a specific method fits which type of noise situation or reduction goal the most.

For more solutions, the author discovered the gap in previous research and point out some new area to think about for future developments, including central frequency of noise, vacuum glass and political solutions.

The literature has considerable practical significance for traffic noise is a main source for noise pollution, which, along with the development of technology, has long been a problem of human life disturbance. Finding more efficient ways to reduce noise impact is good for the wellbeing of human society.

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