

Sound barrier wall to reduce traffic noises in Vietnam

Nguyen Tuan Anh

Abstract

This paper presents the applying of sound barrier wall for highways in Viet Nam studied from existing experiments in the world. Nowadays, pollution sources come from traffic noises, water sources and air environment. Especially, traffic noises such as transportations, trains and airplanes are much serious and effect population and country. On road traffic systems, noise generated by vehicles is always in high level and give discomfort to residents who live around both sides of highways. In the world, noise barrier walls are being built along the highway to minimize impact of traffic noise to the surrounding environment. However, such solution has not been properly considered in Viet Nam yet. This paper deals with sound transmission mechanism in roads as well as experiences of countries around the world in building the noise barrier system along highways, contributing to ensure the best urban comfort for the surrounding environment and create a friendly traffic landscape.

Key words: Noise source; sound transmission; sound barrier wall; noise pollution; highway; urban comfort; traffic landscape

1. Introduction

Sounds are a natural phenomenon that manifests the diversity of the living environment, a transmission of information to living entities through the absorption of the sound of the human ears. Sounds in the environment are quite various and originated from any activity that creates a sound source. Especially in the urban environment, the sources of sounds are mainly from human voices, from urban activities and particularly from the operation of transportation means. For urban traffic, due to the low motor vehicle speed, generally noise sources generated from the friction between tires and the road surface and noises from small engines do not much impact to the urban environment. However, in Viet Nam and particularly in urban areas, the greatest source of noise pollution is the horn of cars and motorbikes. In the context of this article, we briefly introduce noise level in urban areas in order to understand and evaluate greater noise level on the highways system in Viet Nam (including the ring roads system around the large cities with motor vehicle speed above 80km/h). We also analyze experiences of using noise barriers to prevent traffic noise in the world for proposing solutions to reduce traffic noise on the highways in Viet Nam.

2. Sound environment

2.1. Urban sound environments

The sound environment is a concept proposed by R.M. Schafer[1], a Canadian musician who describes the sound environment by synthesizing all of the sound sources in the environment. Most of these sources are negative for the environment, such as sound from road friction, from car horns, from motorbike noise and from trains... We can approach the sound environment as Kevin Lynch describes in his work "L'image de la cité" [2].

Talking about noise in urban areas, we should analyze its three basic elements that are closely related to each others, those are:

- Sound sources;
- Urban space; and
- Urban residents.



Figure 1: The organic relationship among noise elements in cities



Figure 2: The role of the acoustic channel between the sound source and the sound acquisition

Assoc. Prof. Nguyen Tuan Anh
Hanoi Architectural University
Email: tuananh310866@gmail.com

Date of receipt: 17/9/2022
Editing date: 03/10/2022
Post approval date: 05/10/2022

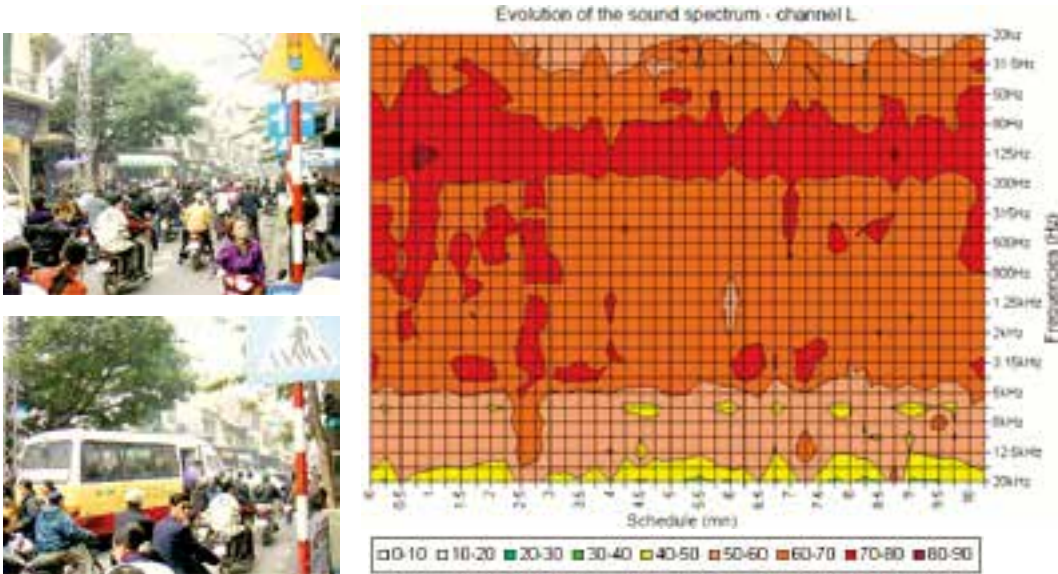
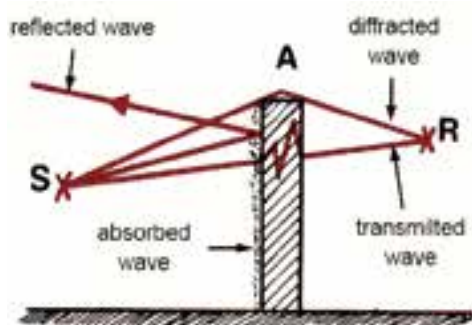


Figure 3: Spectral images in Ha Noi Down-town Area

These elements are introduced in the following diagram:

These three elements are relevant to various research fields; they explain the complexity of aggregated phenomena. To describe more accurately about the urban sound environment, we can combine each of these elements with a phenomenon that creates an organic link below:

In this diagram, we can obviously realize the important role of researching the acoustic channel in urban space. In fact, the elements illustrated in Figure 2 determine sound acquisitions that the sound environment will be received.

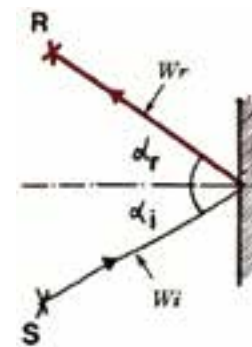


S: Sound Source; R: Virtual sound source

Figure 4: Sound transmission when facing barriers

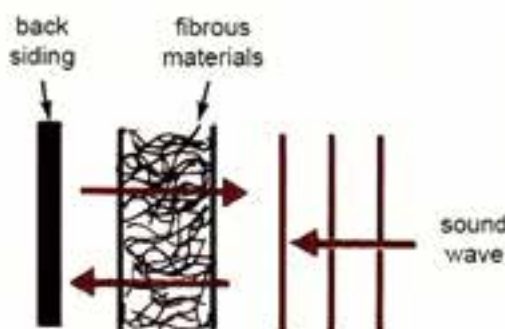
2.2. Sound level in Ha Noi Down-town Area

Sound level in Ha Noi Down-town area is a combination of sound levels emitted from various sound sources: from people, from urban activities and especially from the means of transportation. Ha Noi is the capital of Viet Nam, then the transportation system is subjected to high pressure from high traffic. The diversity of transportation means causes to frequent traffic congestion, and consequently causes negative urban noise level. In Ha Noi Down-town area, the common sound level is from 70-90dB, in which the highest



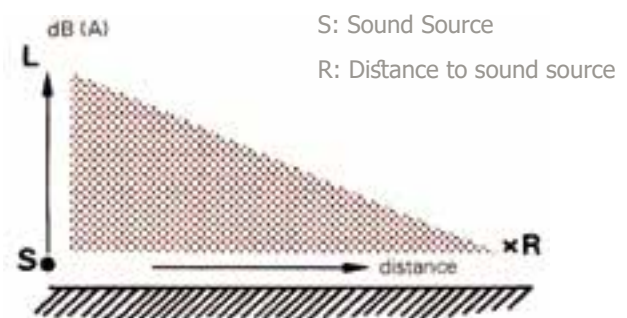
S: Sound Source

Figure 5: Reflective phenomena



Sound waves lose energy when transmitting through fiber material by absorbing sound

Figure 6: Example for sound absorption phenomena



Sound level decreases when distance increases from the sound source S

Figure 7: Sound level depends on distance

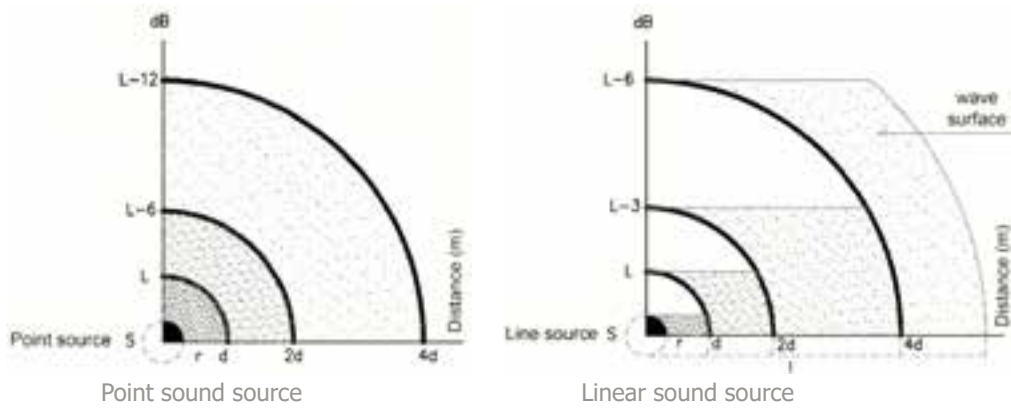


Figure 8: Sound level depends distance to the point sound source and linear sound source

sound level is derived from the horns of cars and motorbikes [3] [4].

The image of the sound spectrum in the Ha Noi Downtown area (the typical area of the sound environment in Ha Noi metropolis) shows that the noise level is quite loud and constant (effect at the frequency of 20Hz - 5kHz with a sound level of 60-80dB.) This causes to constant stressed and discomfortable state for human beings. The sound level in the center of Hanoi as in the example above is a measure of the high sound level on the highways system

3. Sound transmission in the air

Sound transmission in the air is characterized by the nature of the relationship between the sound sources and the air environment, as well as the shielding of the transmission path of the sound waves[5].

3.1. Sound transmission when facing barriers

When facing barriers during the transmission, sound energy is divided into four parts: reflexion, absorption,

transmission and diffraction. Each part represents a different physical characteristic as shown in the Figure 4 below:

*Sound reflection:

If a sound wave faces an object during its transmission, it can reflect as a way that light reflects through a mirror. In acoustics, we apply the principles as in optics.

* Sound absorption:

When a sound wave faces a barrier, sound energy may be reduced by sound absorption capability of that barrier.

* Sound transmission:

We hear sound through a barrier means that the sound has been transmitting through this barrier. Or, more precisely, the sound is partially reflected, partially absorbed by the material of the barrier and partially penetrated by the barrier and passed to the ears of the listeners.

3.2. Free sound transmission with no barrier

Free sound transmission with no barrier is a common

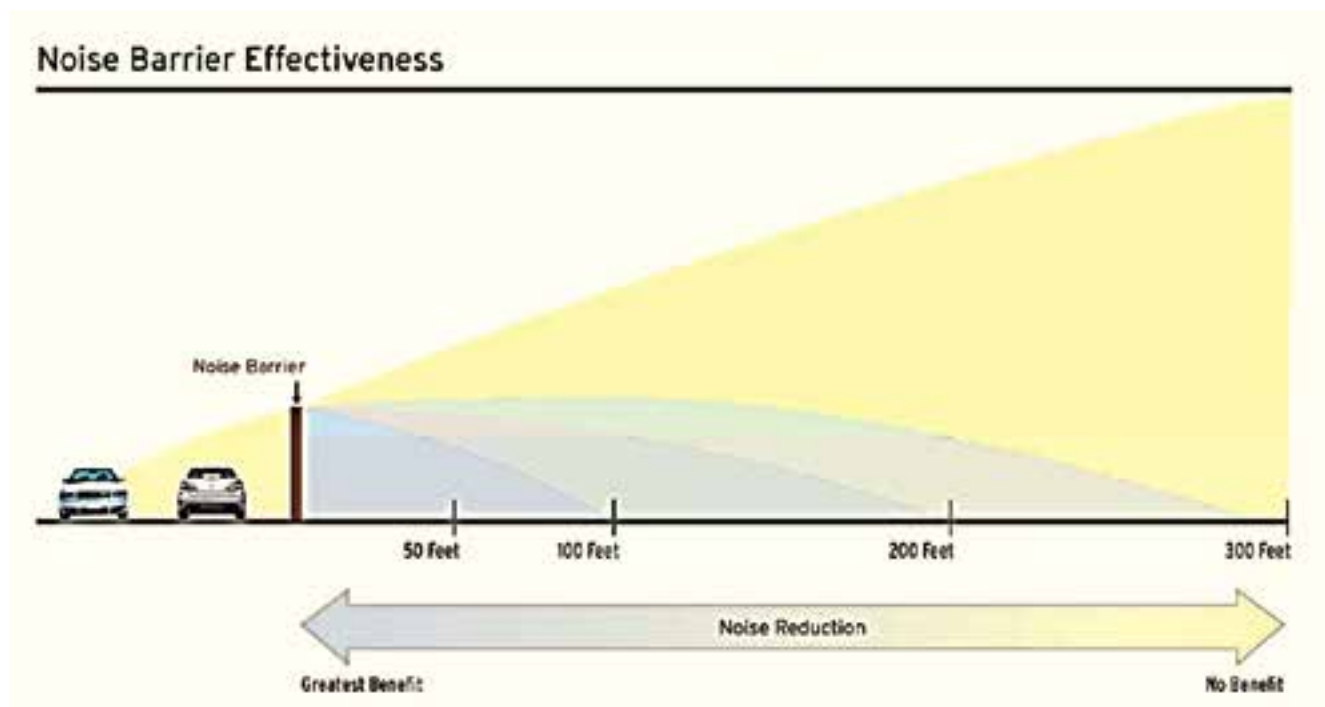


Figure 9: The spread of traffic noise level after sound barrier wall

transmission in the environment. Sound level decreases when the sound source is further away. In free of barrier environment, sound is being transmitted from the sound source, spreads to surrounding space, and shuts off until the energy is negative. In this paper, we would like to analyze the phenomenon of sound transmission in air freely without clarifying the physical nature of the sound transmission.

3.3. Free sound transmission faces barrier on the transmission line

As mentioned above, when the sound source emits sound to the surrounding environment, the sound level decreases when the sound source is distant. Point sound source attached to fixed sound source. The sound source emitted by the road traffic (also known as the linear sound source) creates a sound line along the road [6].

Thus, the phenomenon of sound transmission on the road will form a stream of sound transmitted to both sides. Therefore, when facing a sound barrier wall, the sound level will be significantly reduced for the two sides of the road.

4. Highways and Sound barrier wall solutions in the world

Countries in the world have been using various solutions to reduce noise from traffic such as creating sound barrier walls made from concrete, wood, glass, aluminum or building mud dikes. These solutions minimize traffic noise to ensure the best comfort for the areas along the roads. Sound barrier walls have been building both on highways, ring highways and highways from the outerto city centers. This is an effective solution to reduce traffic noise, as well as a decorative solution to creating landscape architecture on the roads. Each country has different solutions to build sound barrier walls, but all aim to reduce traffic noise to ensure sustainable environmental development.

* In Japan: Japan is very interested in the sound environment on the transportation system. The sound barrier walls built by glass have significantly reduced noise and created urban landscape aesthetic.

* In Hungary: Hungary builds wooden sound barrier walls to increase sound absorption and fit with the surrounding terrains.

* In Russia: Mud dikes with grass in



Sound barrier



Arts creativity

Figure10: Sound barrier walls in Korea



Figure 11: Sound barrier walls in Japan



Figure12: Sound barrier walls in Hungary



Figure13: Sound barrier walls in Moscow - Russia



Figure14: Sound barrier walls in Paris - France



Figure 15: Sound barrier walls in Czech



Figure 16: Sound barrier walls in the U.S



Figure 17: Sound barrier walls in Vancouver, Canada



The Highway System in Viet Nam consists of 31 highways with a total length of 6410 km

1. North-South Highways:
 - 02 highways with are 3083 km long
2. Highway system in the North:
 - 14 highways with 1368 km long
3. Highways system in the Central and Highlands:
 - 03 highways with 264 km long
4. Highways system in the South:
 - 7 highways with 983 km long
5. Highways ring road system in Ha Noi and Ho Chi Minh city:
 - HaNoi: Ring highways No.3, 4 and 5 with 425 km long
 - Ho Chi Minh: Ring highways No. 3 and 4 with 287 km long

Figure 18: Master-plan of the highway system in Viet Nam to 2030



Figure 19: Highway Ha Noi-Hai Phong-Ha Long



Figure 20: Highways Ha Noi - Ninh Binh (Cao Bo - Mai Son)



Figure 21: Highway Ha Noi - Thai Nguyen

Moscow are built to prevent and absorb sounds. This solution can prevent noise levels quite well. However, this solution requires large area for the walls construction and does not harmonize with the urban landscape.

* In France: Sound barrier walls in Paris are built from concrete with art-shapes to reduce the heavy and monotonous scenes. The solutions are being used depend on the terrains and surrounding spaces.

* In Czech: sound barrier walls have both functions; those are preventing negative noise and creating art-scenes to the urban landscape.

* In the United States: the U.S. is one of the countries has the largest highway system. The pace of economic development is fast and the demand for road traffic is high, so that many highways in the U.S. run through many residential areas. Therefore, minimizing noise levels from road traffic is a strict requirement in the U.S.

* In Canada: the Canada is one only of the countries has the largest highway system. The city of Vancouver has a special geographical position, so the north-south highway runs through many residential areas. Therefore, a sound barrier solution has been designed along the route.

5. Sound barrier walls on highways in Viet Nam

The Master-plan for highways system in Viet Nam toward 2020 and 2030 shows that Viet Nam will have 31 highways spread across the country [7]. This highway-system creates as

important backbone for road traffic in Viet Nam. This system also forms continuous connections with other transportation systems. Each region in Viet Nam will construct its highway-system based on the Master-plan and available financial resources.

5.1. Highways in Viet Nam

The highway system in Viet Nam is built by either renovating, expanding the old ones or constructing new highways. For that reason, many highways are still running through various residential areas. Particularly, the ring-highway-systems in the two largest cities, Ha Noi and Ho Chi Minh, are all run through residential areas and seriously impact to the surrounding environment.

Many highways in Viet Nam have been or are being constructed under the master-plan of the national highway system in order to promote economic development, though the construction also creates challenges for the environment around the roads.

The East Highway Hanoi - Ho Chi Minh City (1st highway) is being implemented with many sections already in use (Ha Noi-Cau Gie-Cao Bo-Mai Son).

The new highway construction of the road and surrounding infrastructure has been putting into operation to satisfy traffic demand. However, there is almost no evaluation on the impact of traffic noise to the surrounding environment and solutions to reduce noise from traffic are undertaken.

5.2. Sound barrier walls in highways in Viet Nam



Figure 22: Highway Đa Nang-Quang Ngai



Figure 23: Highway Ha Noi-Hai Phong-Ha Long

Sound barrier walls are constructed in some roads only in Viet Nam due to difficulties in mobilizing financial resources. The number and length of sound barrier walls is too small in comparison to the length of the highways and the status of residential areas surrounding the roads.

Currently, some highways have speeds up to 120 km/h such as Ha Noi - Hai Phong - Ha Long, Ha Noi - Lao Cai and Phap Van - Cau Gie, cause to high noise level to surrounding areas. On the other hand, since there are many residential areas along the routes so in the near future, when the traffic increases, negative noise will be more serious. It requires carrying out necessary surveys and constructing sound barrier wall systems to reduce noise level affects to the population along the roads.

5.3. The ring highways in Ha Noi city

Ring-highway-system in Ha Noi runs through many residential areas in the city. The distance from the residential area to the road is too short, causes to serious pollution level. The lack of soundproofing solutions from the traffic to the residential area causes negative feelings to the residents; and high traffic and congestions on the roads destroys harmonization of the urban landscape.

The 2nd route ring is also under construction and is the closest road in centre of Hanoi.

Some roads which connect between the city center and the suburbs have been improved in terms of environmental landscapes but no solutions to reduce traffic noise are being employed. In the near future, when the construction along the road Vo Nguyen Giap is finished as planned, noise pollution will become more serious.

6. Conclusion

The diversity of sound environment brings flavor to our life but also brings several negative affect. In particular, traffic noise is a source of pollution and cause discomfortability to environment and human beings. Applying different solutions to minimizing noise pollution, such as constructing sound barrier walls in roadsides is a popular and effective solution in the world. Viet Nam is constructing and renovating the highway system, but does not yet carefully to create sound barrier walls along the road to reduce noise pollution. It therefore is a requirement to urban-planners, architects and constructors in Viet Nam to understand the modes of sound transmission; analyze noise level causes from urban transportation and learn experiences from countries in the world in building sound barrier walls with the aim at bringing a more comfortable living environment to Viet Nam./.



Figure 24: Highways Ha Noi-Lao Cai và Phap Van - Cau Gie



Figure 25: 3rd highway ring to Thanh Tribrige and to Thang Long bridge in Ha Noi



Figure 26: 2nd route ring to Nga Tu Vong and Nga Tu So in Ha Noi



Figure 27: Highway Vo Nguyen Giap connects between Hanoi Center and Noi Bai Airport

References

1. SCHAFER. R. M, *Le paysage sonore*, Ed. J-C.Lattès, Paris, 1979.
2. LYNCH. K., *L'image de la Cité*, Dunod, Paris, 1999.
3. NGUYEN. T. A., C. SEMIDOR, *Relationship between urban activities and soundscape: commercial areas in Bordeaux and Hanoi*, 23th PLEA, Geneva, Switzerland, 6-8 September 2006.
4. NGUYEN. T. A, *Comparison of soundscape on the ground floor of tube house in Hanoi and open urban space in Bordeaux*, 23th PLEA, Geneva, Switzerland, 6-8 September 2006.
5. BAR. P et al, *Bruit et Formes Urbaines: propagation du bruit routier dans les tissus urbains*, Centre d'Etude des Transports Urbains, Paris, 1981.
6. NGUYEN. T. A, *Caractérisations des particularités dominantes de la morphologie urbaine à travers l'environnement sonore: Etude dans le vieux quartier de Ha Noi et dans le quartier Saint-Michel à Bordeaux*, PhD, University of Bordeaux I, France, 2007.
7. [7] The Prime Minister, *Approving the planning on development of Vietnam's highway network up to 2020 and orienting to 2030*, Decision No 326/QĐ-TTg, 2016.