Acoustical Evaluation of Soundscape in Urban Spaces Along Traffic Corridor

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Abstract. In recent years, Taiwan's public transport infrastructures at all levels have improved and enhanced public convenience which is including the airport, high-speed railway, metropolitan rapid train (MRT), and so on. The aircraft channel location and highway plane elevated, the formation of the connected trail system and open recreation spaces can provide people holiday gathering and recreation of the important field. The NIMBY effect of the noise in the public open space along the traffic facilities is not reduced, it is the best choice for another area of residents' gathering and recreation on the contrary. For the urban traffic corridor along the adjacent channel system and open space, to the urban soundscape theory as the basis, through the time, energy and space and other factors for the exploring the sound energy distribution of the sound field. In this study, objective physical measurements were taken as an evaluation method, and the equivalent sound level L_{Aeq} (dB) was used to monitor the field, and the sound energy distribution map was drawn from the point, line and region. This paper discusses the relationship between subjective physical measurement and objective evaluations and tries to construct an important exposition of urban soundscape as the research theme of the next stage. The results of this study provide an alternative assessment of the development and sightseeing of urban corridors in terms of urban comfort, which are based on the sound field comfort.

Keywords: Urban soundscape · Sound field comfort · Objective measurements

1 Introduction

Urban development is a collection of industrial development and economic development, with the progress of human civilization and the city development, close to the crowded roads have become the habitat of urban living environments, and thus cause a sense of hearing a certain degree of impact. Acoustic ecology or Eco-acoustics is the study of soundscape research which explores the sound in the biological of live beings and environmental society of interaction relationship. When the face of surrounding sound,

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hearing and living in the natural environment produce a linkage, which interactive relationship is the focus of attention on soundscape. In the early 1970s, Schafer, a Canadian scholar, participated in the creation of the World Soundscape Project (WSP). Its first major project was a field study of the acoustical environment of natural landscape in Vancouver [1–3], it was also the most comprehensive text in the description of soundscape and sound recordings and a series of sound features. Similarly, the British scientist Truax [4] in the West Coast of British Columbia recorded natural soundscapes which were associated relative size of the different sound source volume. Dunn and Van Peer (1999) [5] found that soundscape can transmit the good impression in the environment. In 1969, soundscape researcher M. Southworth also began to explore the sound overall impression of the urban and built environment [6]. Schafer [7] began to attempt to classify the sound data between the country and the city and evaluated them from a historical perspective, and found that specific or repetitive patterns of sound were able to determine the design factors of the soundscape. The function of the sound is important to be able to convey the emotions, when listening to the sound or the virtual signal, the listener has reset the time and space in the memory of the brain [8]. The sound that exists in a particular context is not a natural phenomenon, and every sound is filled with its own vocabulary. "Soundscape" is defined by the International Organization for Standardization (ISO) as "one or more people in the perception, experience, and understanding of the acoustic environment morphology" [9], "soundscape" is also different from the "sound environment", because the former refers to Is the perception of morphology, latter refers to physical phenomena, and both are affected by the environment. "Soundscape", the combination of auditory and landscape terms, in the environment as a whole, the two coexist consistency, the lack of one of them will make the environment seem unnatural [10]. Cai (1998) [11, 12] and Wang (1996) [13] once again define the sound plus the scenery of the composite word, translated into Chinese can be called "Sound landscape" or "Soundscape". Owing to the denseness of the population and the concentration of the metropolitan areas, the annoying voices generated in different urban development stages are considered "noise". After entering the 21st century, most of the international environmental policies focus on noise control in the related studies of economic activity or social science in recent years. However, reducing the noise level does not necessarily improve the quality of life in cities [14–17]. This is why the study of urban sound environment tends to complex, in addition to monitoring the physical basis of information, may have to pay attention to people's actual experience and listening experience. The diversity of the customs and cultures of different countries has become a kind of available "resource" of urban environmental sound, not a kind of "pollution". Brown [18] summarizes the differences between perceived "pleasant soundscapes " and "disturbing noise" and their corresponding differences in characteristics. The impact of sound generated by various infrastructure constructions in people's living environment, such as roads, rapid transit and airports, and the public transport system; whether to re-examine the urban context and development plan from a sound perspective. In particular, Jian Kang, a professor of architecture at the University of Sheffield in the UK, has initiated research in Europe and has devoted considerable attention to soundscape research in North America, East Asia and South Asia, including Australia, Canada, the United States, Japan, China, Hong Kong and Korea [19]. The degree for sound preferences was proposed by Professor Toshimitsu Musha in 1980 [20]. His research mainly focused on the

natural factor of wind, chaostic fluctuation (1/fluctuation) has the pleasant characteristics of this fluctuation frequency to which it gives the feeling tends to be positive. The conclusion is that if people like the natural sound which are affected by spectral characteristics of 1/f, but with a sound 1/f spectral characteristics with preference are not accepted necessarily by people in the world, which was related with one's emotions. Consistent with the theory of chaostic fluctuation stimulation can achieve a certain degree of sense of stability. 1/f is defined by as the following formula (1):

$$\text{Log Pw} = \text{Log } 1/\text{f a} = -\text{a Log f} \tag{1}$$

Pw: Sound magnitude (W), F: Frequency (Hz), a: Constance

One of the concepts of the soundscape, as the sound of the existence of the environment, should be accepted by the majority of people, so the first environmental noise to the initial objective to identify the characteristics of environmental sound. How the sound of the city is recognized as the soundscape is generally pleasant to listen to, not necessarily the city noise, including traffic generated by the sound is disturbing voice, Professor Jian Kang notes the current activities and listeners expectation that the visual perception of the sound source plays an important role in hearing the expected perception of the sound. Therefore, the sound energy level is measured by A-decibel dB(A), which is very similar to the frequency response of the human ear. It is the basic unit of sound energy level measurement, and L_{Aeq} and L_{Amax} are the main measurement physical quantities of this study. Most of the measurements of the environmental acoustic energy use sound pressure level (SPL), using the unit for the decibel (dB) that represents loudness, and human hearing and the environment for the decibel standard phase corresponding to the subjective feelings of knowledge has also been discussed. For example, there are many good examples to improve the perception of sound environment characteristics of sound in European cities, with water features and noise barriers embedded in the city's open recreation space, the use of noise barriers block the noise source and the water sound cover the nuisance of background noise. Different water features provide spectral types and different frequency ranges, which can effectively shield traffic noise. Such facilities create culturally significant connotations, such in Sheffield city, fountain water and metal noise barrier facilities, where fountains represent rivers and metals on behalf of the steel industry, symbolizing two important aspects of Sheffield's industrial development and urban planning historical context, in addition to improving the residents and tourists to enjoy the rest of these areas, and rich cultural and educational significance [21]. Through preliminary research on soundscape related three field measurements have been initially completed which are including 1. Sound field is underneath the aircraft channel, 2. Sound field is in the perimeter of high speed rail station and 3. Green belts and recreation areas are along MRT facility. The characteristics of sound field environment are established. The purpose of this study is shown in the following three points:

(1) Distributions of actual sound energy may discuss and sound characteristics of the urban traffic environment are also proposed.
(2) Processes may explore the impact of sound on environmental behavior and provide the proposed model of soundscape analysis.

(3) Research results may present urban planning direction, possibilities with a view to the development of tourism and open space as a national decision-making.

2 Research Methods

Based on the theory of soundscape, this paper defines the sound source types of urban soundscapes and discusses the sound environment of urban public transport corridors around the open space of the airport channel, the space between the high-speed railway stations green belt and the recreational area along rapid transit. The urban soundscape is mainly concerned with the activities of open space, including the fashionable and characteristic business circle in the metropolis. The traffic along the line is close to the high-density residential area and a large number of crowds. The characteristics of the linear greenbelt bring together different groups such as commuting and leisure. Such as the urban corridor along the MRT facility, from the point, line and area distribution, drawing with the characteristics of the sound energy distribution map, with a view to re-interpret the potential of the business district and the traffic node of the green belt of urban identity. The contents and methods of the study are mainly based on the related literature and research. After the establishment of the research process, the objective physical quantities of the auditory aspects are collected and analyzed to sum up their frequency analysis of sound environment. The sound field focused on monitoring traffic noise through the instantaneous acoustic energy to a single event, the acoustic energy over time, can be as an equivalent level Leq described volatility sound energy. Record results following two evaluation indicators, including the volume of noise can process the event (equivalent) L_{Aeq} (dB) and the maximum volume (Maximum) L_{AFmax} (dB). L_{Aeq} is defined by as the following formula (2):

$$L_{Aeq} = 10\log\left(\sum_{n=20Hz}^{20kHz} 10^{1/10Leq}\right) \tag{2}$$

3 Approaches of Sound Field

The Soundscape triangle, developed by M. Schafer (1978) [1], includes sound marks, foreground sounds and Keynote. The term “Sound mark” derived from the landmark, used to be connected or even think of the unique sound of its source, such as church bells, the signal is noticeable and has been consciously heard the foreground sound, because different from the background sound, it is often organized into a sound code and passes the message. Keynote highlights the tone or tone of a string of sounds, although the main tone is not necessarily consciously aware, it summarizes or condensed a string of sound characteristics. From this, the classification of soundscape are classified by acoustical measurements, and all the collected sounds are decomposed into many elements to be analyzed, which is the basis of the research. In this study, the nodes of traffic facilities may choose which have features as measurement objects. The results of the previous studies

are mainly the follow-up work of this study, whether the measured sound energy features are masked in term of the noises or the definition of frequency characteristics.

3.1 Sound Filed is Underneath the Aircraft Channel

Sound field is investigated underneath the aircraft channel which is located at MRT station (Yuanshan Station). Yuanshan Station is located in Taipei Basin in the mountains north of administrative Jiantan slopes with flat terrain area at an altitude of about 153 m, the north side of the river through Keelung. Yuanshan station is currently planning a hub node of "Taipei Flora Expo Park". Building and other facilities in the park of the series as "City museum settlement" recently completed restoration of the music garden, open for the publics, and this is the south side of the base as the opening food court. Since this sound filed is located in the aircraft-landing path, the sound source was generated by aircraft landing frequently which may have an impact on performance and activities in the park. Measuring point a total of three points, take off the next two points (Point A, Point B), another point is set in the Minzu West Road and Yumen Street, the base of the corner (Point C). The sound energy instantly through the sound generated by the aircraft, and synchronized three sets of sound energy instantaneously. The relative positions of three measuring points are shown in Fig. 1.

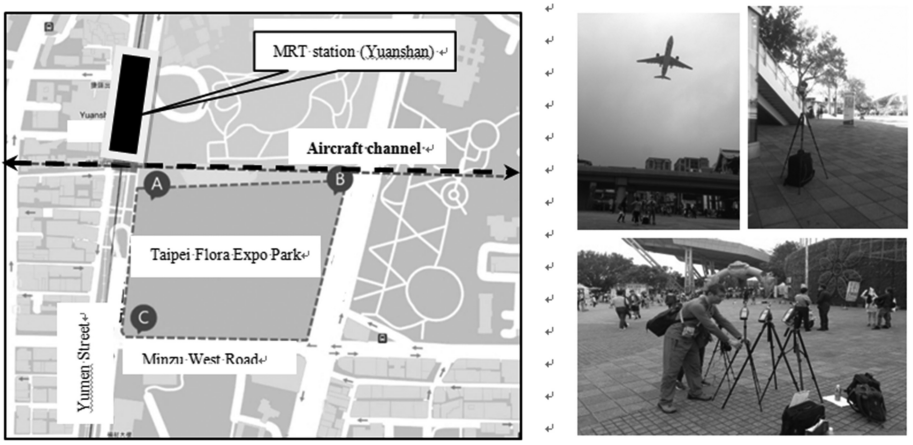

Fig. 1. Three measurement points are illustrated for the real time sound measurement when aircraft instantaneous pass through (left), and figures (right) show the measurements at Taipei Flora Expo Park.

3.2 Sound Field is in the Perimeter of High Speed Rail Station

The second study field is in the vicinity of Hsinchu High Speed Rail Station, which is located in North Taiwan. For the purpose of prohibiting the construction land from the land within 25 m from the centre line of the outer track of the high-speed railway,

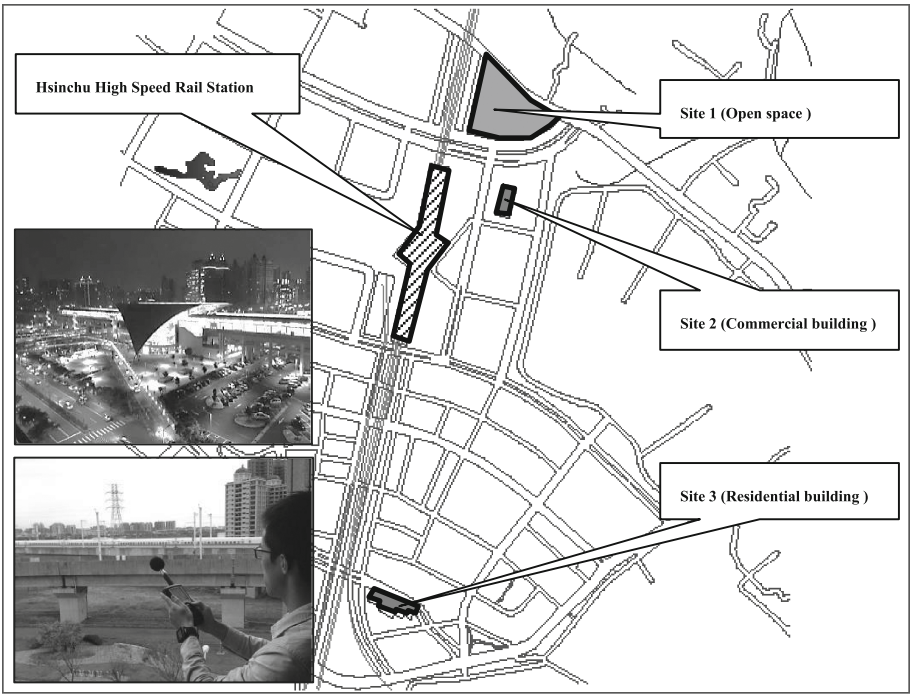

Fig. 2. Three measurement points in the perimeter of Hsinchu high speed rail station and field pictures are abstracted (left side)

the external noise of the building shall be assessed and the distance from the building wall line shall be 1.5 m. Indoor measurements shall be made at least 1.5 m from the interior walls or other major reflecting surfaces. All measuring positions are 1.2 m from the ground or floor. In order to effectively understand the height of the building in the temporary high-speed railway station building level and elevation location, and the other two near the peripheral area of similar base location to assess. The measurement and measurement are three locations, one is the open space (Site 1), the other two are the commercial (Site 2) building and the high rise residential building (Site 3), respectively (Fig. 2).

3.3 Sound Field is Along MRT Facility

Based on previous stage of aircraft measurement, monitoring measurement of greenbelt station and the surrounding sound field space were under progress continually, measurement method are followed by L_{Aeq} equation which are divided into morning, afternoon and evening hours phase, traffic flows information as a reference for the measurement are plotted in Fig. 1(Left). Gray shadows demonstrate the level of transportation level. 12 Measurement locations which are from Yuanshan station to Shuanglian station as also shown in Fig. 3(Right). Preliminary observation is divided into two

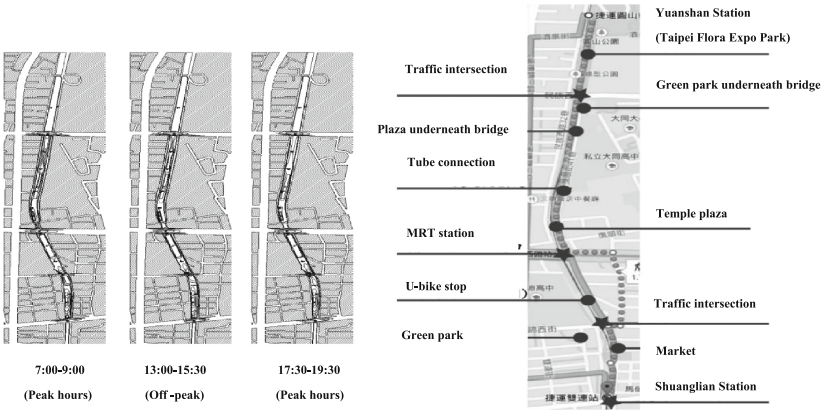

Fig. 3. Traffic flows information with 3 period hours phase as a reference for the measurement are plotted in the left side figure, 12 measurement locations which are illustrated from Yuanshan station to Shuanglian station in the right side figure.

sections, the first part is on the "Human activity", realize the visiting purpose, standing time, frequency of uses and activity behaviors. Second part is on the "Environment", visually observed moving peripheral line configuration of mobile mainly in the green belt, distribution of planting, infrastructure of MRT device, as a reference for future subsequent discussion. As shown in Fig. 1, the 12 locations of measurement are illustrated, the measurement period are divided into peak and off-peak hours, peak distinction from the intersection of the main measuring points, the criteria L_{Aeq} (dB) and the maximum volume L_{AFmax} (dB) are as the evaluation index. After having measurement data in the road and off-peak sections of different time, sound energy distribution are pointed out.

4 Preliminary Results

In addition to the substantial impact of the environment, in the history of culture, human psychology, environmental behavior and ecology of the discussion are also pondering. In the study of sound field survey, due to the highly developed city, adjacent to the transport facilities and the convenience of the road, are important choices for living elements of modern urban residents.

4.1 Measurement Result Underneath the Aircraft Channel

The results of the preliminary assessment of a single aircraft through the event to record the aircraft energy, mainly to the equivalent level of sound level L_{Aeq} sound energy over a period of time to describe the volatility of noise (such as traffic noise) or impulsive noise. The results of the record are the following two evaluation indicators, including the average volume L_{Aeq} (dB) and the maximum volume L_{AFmax} (dB) of the noise event during the process. Mainly to daily flights landing in the Taipei Airport are conducted

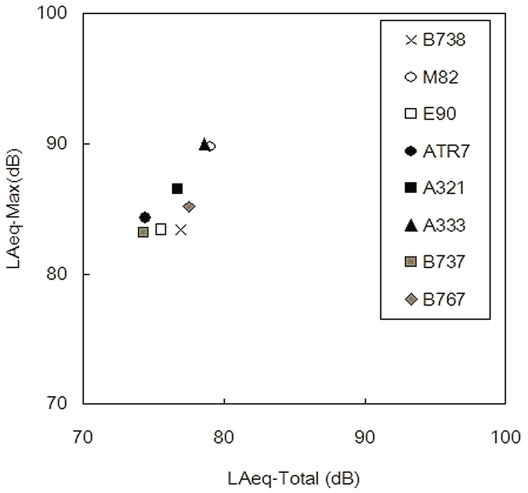

Fig. 4. Point B is illustrated L_{Aeq} (dB) derived from mainly aircraft landed at the Taipei international airport as a function of frequency band comparing the L_{AFmax} (dB).

which are including A321, A333, B738, B767 and other large aircraft. The main aircraft takeoff and landing of the Taipei Airport is based on the No. 10 runway (West→East) as the priority runway, but if there is a more obvious westerly wind will be on the 28th runway (East→West) landing. The maximum noise volume measured for the day is A and B, and the maximum volume is 92.9 dB(A) of M82 and A333, with an average maximum volume of 86.9 dB(A), and all aircraft events are volume is 80.0 dB(A) with an average of 75.4 dB(A). The measurement position (point B) underneath takeoff and descending channel for the instance, the L_{Aeq} (dB) as a function of frequency band comparing the L_{AFmax} (dB) of the aircraft landing sound, as shown in Fig. 4.

4.2 Measurement Result in the Perimeter of High Speed Rail Station

When the high-speed train through, the noise was generated by the value of the content of this stage of assessment. Although the noise value may be reduced by the distance of sound source which is from station body, traffic noise L_{Aeq} (dB) is between 54.1 to 64.8 dB(A). However, up to speed of 250 km/hr through the car close to the high-speed rail station body and pass through the station caused by the impact of the

Table 1. LAeq (dB) at 1/3 octave frequency band for high speed trains pass through

Freq. (Hz)	250	315	400	500	630	800	1 k	1.25 k	1.6 k	2 k	2.5 k	3.15 k	4 k
dB(A)	57.8	54	52.4	58.6	53.5	59.7	60.7	66.7	68	69.7	70	75.8	70

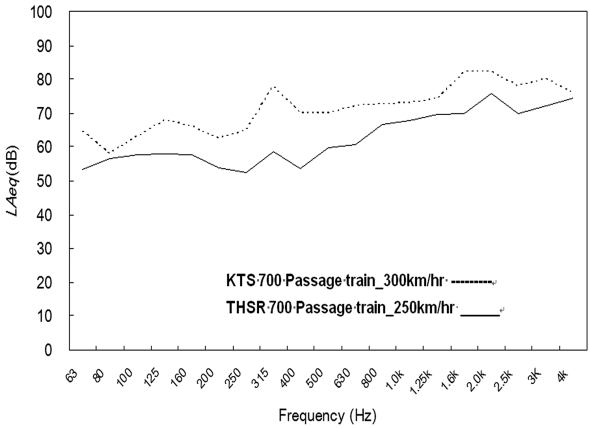

Fig. 5. Measurement results of L_{Aeq} (dB) of THSR (—) in the perimeter of Hsinchu Station at 1/3 octave frequency band compared with the measurements of Korea high-speed railway (KTS) (—) between the station Chunan to Chungwon.

impact of the surrounding area, will make sound noise enlarged. The distance from the centre line of the outer track 50 m, 1.5 m above the ground height of the noise measured by one of third octave band frequency of L_{Aeq} (dB) values is shown in Table 1. The measurement resulted (THSR) similar to the research of distribution at 1/3 octave band of L_{Aeq} (dB) of Korea high-speed railway (KTS) between the station Chunan to Chungwon [22], as measured in the case of the relative position and elevation measurements, measuring 107 classes of trains to speed of 150 to 300 km/hr. Comparison the measurement results of L_{Aeq} (dB) between THSR700 and KTS700 are illustrated in Fig. 5.

4.3 Measurement Result Along MRT Facility

Acoustic energy distribution were illustrated with selected four different measurement locations along the sound field of MRT Yuanshan station to Shuanglian station which are included mainly Yuanshan MRT station, Tatung University Square next to the green belt, temples and Shuanglian station. Energy distribution was interval centre spacing of 5 m outwards, based on the number of 9 measured points and were plotted as a soundscape map, the measurement period is divided into two peak hours (7:00–9:00 and 17:30–19:30) and off-peak hour (13:00–15:30), peak distinction was from the traffic intersection of the main measuring points. Around the MRT Shuanglian station, L_{Aeq} (dB) sound distribution with three periods of hours were illustrated in Fig. 6.

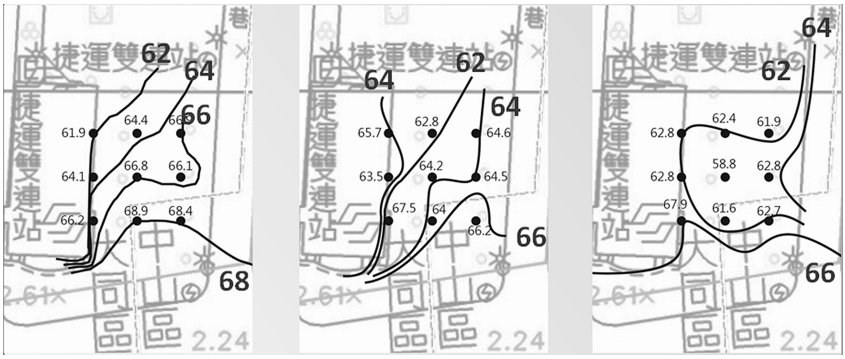

Fig. 6. L_{Aeq} (dB) sound distribution with three period of hours 7:00–9:00 (left side), 13:00–15:30 (middle) and 17:30–19:30 (right side) were illustrated in the around of MRT Shuanglian station.

5 Discussion

It is the primary task of monitoring sound energy along the traffic facilities, and discover whether this frequent impacts of noise may interrupt events in sound field, and then interference problems convert this important hearing characteristics to relative atmosphere of visiting experience. The results of the study have collected all the current sound parameters with sound characteristics, and then confirm the frequency, it should be noted that in the case of urban public space, the overall sound level is higher than the maximum, such as 65–70 dBA, no matter what type of sound source, people will feel annoyed. In this study, reducing noise will become the primary task in the future. However, this study selected the characteristics of the sound field of the characteristics of traffic facilities nodes, a variety of sounds and factors for the re-interpretation of the sound become more important. Some preliminary results are abstracted as followed:

(1) For the urban transport facilities along the open space sound environment, specifically present the status of the characteristics of sound scenes.
(2) Through the survey of interview and field survey, summarize the environment and sound field index and image on the urban transportation node.
(3) Assess the difference between the actual sound energy status and the subjective preference degree in the traffic facilities, and then integrate the interface basis of the future field characteristics and environmental impact.
(4) The data accumulated in this study will help to evaluate the correlation between the physical quantity of the sound field and the subjective preference degree in the public open space along the urban transport facilities.
(5) In addition to the physical characteristics of the field through the physical characteristics of the technology, reproduce the voice of the sound characteristics of environment, complete the subjective preferences adjectives with consultation philosopher experts.

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