REFLECTION OF AN URBAN FORM TO A SOUND ENVIRONMENT

Lei Yu, Dong Chao Xu

Harbin Institute of Technology (Shenzhen), Shenzhen University Town, Shenzhen, P.R.C
email: leilayu@hit.edu.cn

Yun Hai Sun, Dui Dui Liang

Shenzhen Urban Planning & Land Resource Research Centre, Shenzhen, P.R. C.

Jian Kang

University of Sheffield, School of Architecture, Sheffield, UK,

Nowadays, ambitious urban sound is threatening physical comfort and social health. This is mainly because of fast urbanization that caused enormous changes of a sound environment. Due to this, the study is hypothesized that a different urban developmental way would present a differential sound environment, in which urban form plays an important role. Shenzhen is a typical Chinese metropolis transforming from a small village-town. Its sound environment has changed lots after a tremendous land use change. With a fast urbanization, Shenzhen has a variety of urban forms presenting a broad different sound environment. Through investigating relationships between urban forms and its corresponding sound environments, how developmental way to determine an urban sound environment is discovered. It is found that urban planning indices significantly influence an urban sound environment. The results are useful to urban planners to pay more attentions on sound environment and.
Keywords: urban form, sound environment, reflection

1. Introduction

It is known that each urban form has its corresponding sound environment, which is much related with land uses and landscape variation. As a big metropolis such as Shenzhen, ambitious sounds are threatening citizen's social health, which has to be taken seriously in urban planning. Urban forms constituted by nature and social environments in an urban context are essential for sound production and propagation that is matter sound environment and its influence [1]. It is clear that a built environment has its definite sounds that connect with many urban developmental components, land uses, landscapes, humans activities and so on [2-4]. It is important to understand their relationships and make correct developing ways in aspect of noise issue. Although Shenzhen is a modern metropolis, it has various urban forms and built environments since developed from original ecological seashore in just 30 years. It is not only traffic noise but also many other sounds exist in the city. Therefore, noise levels and sound sources should be considered equally when attenuating ambitious noise in a certain built environment. Many authored studies have been done in this area [5-7]. However, less effort has been made on exploring urban physical space variation to its sound environment. It is not clear which parameters of urban development in terms of planning

and design might decide its sound environment, and what relations of planning indices and acoustic parameters to some built environment.

As having complicated urban functions with mountain and sea topography, Shenzhen has different urban forms that create rich urban sound environments. It is useful to study various urban forms of Shenzhen and their relationships with sound environments, and provide useful guidelines for urban designers and planners. The study focuses on the noise problems that a metropolis has, and aims on giving solutions to attenuate ambitious noise according to various urban sound environments. For addressing the study, an intensive field studies were carried out in three different morphology of Shenzhen. Sound environments in three typical sites were monitored and measured in each morphological area. Based on the field studies, relationships of various urban forms and their corresponding sound environments were explored, and approaches for noise attenuation in urban design or planning stage were promoted based on previous studies [8, 9].

2. Field studies

In order to investigate urban sound environments caused by various built environments, intensive route and fixed field studies have been taken in Shenzhen from 2014 to 2017. Shenzhen has a speeding urbanization, which is evolved from a small village-town to be a famous Chinese metropolis. Nowadays, it still remains ecological nature patches. According to its various urban forms, some typical fields have been chosen to study sound environments.

2.1 Study Sites

In the study, three areas, namely Da Peng, Lian Hua, and Yang Tai, representing undeveloped, semi-developed, and well-developed, respectively, were selected to do sound environment measurement. In the Da Peng, 44 sites representing a different urban morphology were chosen to make a route sound measurement. After analysing data of the route measurements, 3 sites standing for typical urban forms of the area were chosen to make a fixed measurement. In the Lian Hua, 16 sites were chosen to make a route measurement and 3 of them were used for a fixed measurement. In the Yang Tai, 14 sites' sound environments were measured and also 3 of them were made a fixed measurement. Although the urban morphology is different for three chosen areas, there is not a very clear different between each other study site. The route study site was broadly selected for possible differentials of urban forms, while the fixed study site was specific selected for representing very different urban forms in the study area. Totally, 74 sites were chosen to do a route measurement and 9 of them were chosen to do a fixed measurement. The route measurement was made in 3-5 time periods of a day for each site, covering morning, afternoon, and evening. It lasts 1-5 minutes in each period and was carried out in a weekday and a weekend. The measurement equipment is the SQuadriga II. The fixed measurement was made in one week of each season. Each day's measurement was done in a way as continuing 7.5 hours' measuring stopping in 0.5 hour and re-doing. All of the study sites in the three study areas are shown.

2.2 Urban forms

The three study area, Da Peng, Lian Hua, and Yang Tai, has a different urban morphology. Da Peng is a protection ecological site, so it remains its original natural sea and mountain topography. There is barely urban development; the built environments are mainly villages, small towns and some modern roads. The area has a low local population but large tourists especially in weekends and holidays. However, Lian Hua is a well-developed urban centre. It is a high density area with many urban functions. In its development, a hill named Lian Hua Hill was kept as a city park to provide natural environment for leisure and social events. Unlike Lian Hua and Da Peng, Yang Tai was an outskirt of Shenzhen back to 15 years ago. The Yang Tai Hill stands in the middle of the

area. It is now becoming an important economic growing pole in Shenzhen, which connects with the Qian Hai Free Trade District. Nowadays, it is in an extraordinary change from a city suburb to a modern town. According to 74 study sites, 11 urban forms have been extracted as shows in Figure 1. These include urban forms 9 fixed measurement study sites.

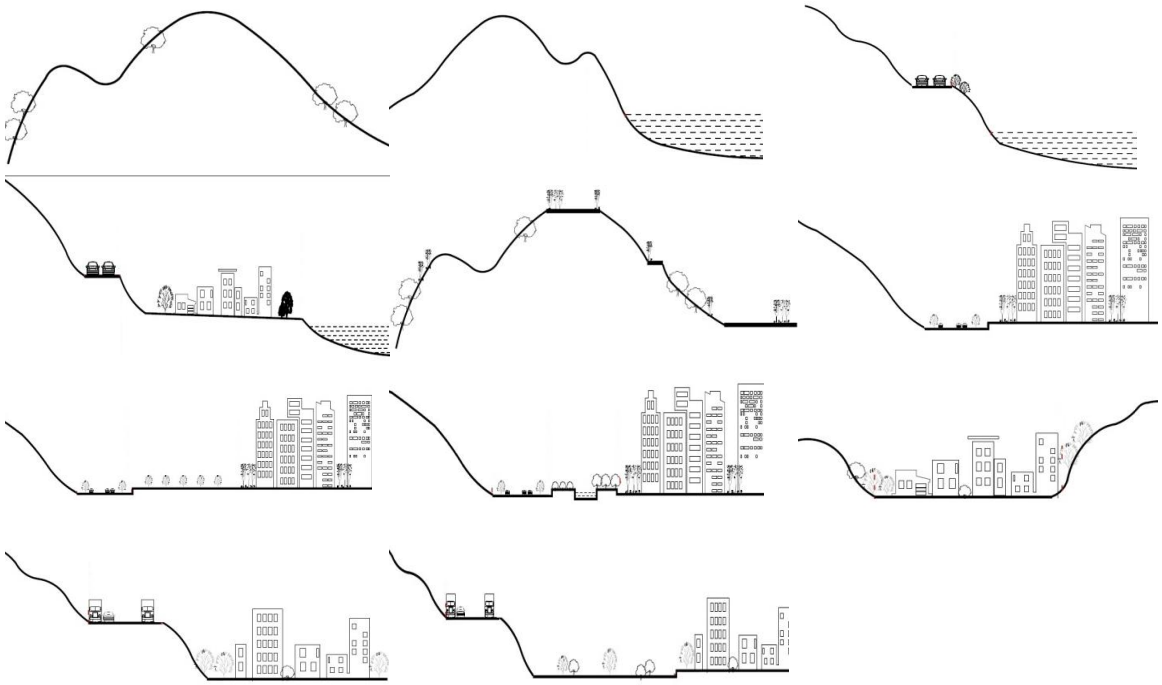


Figure 1: 11 Urban forms

3. Results

To explore relationships between various urban forms and corresponding sound environments, measurement data of the route and fixed field studies were used to get acoustic parameters of sound environment, while the indices of urban development were calculated via analysing the Shenzhen Statutory Plan documents. Five indices have been got, which are Land Use, Floor Area Ratio (FAR), Building Coverage, Road Density, and Greenery Ratio.

3.1 Relationships between Urban Forms and Sound Environments

In the route measurement study, 365 recordings were got standing for 74 sound environmental characteristics. Table 1 shows correlation analyses of urban planning indices and L_{eq} and sound source to the all route measurement field sites.

Table 1: Relationships between urban planning indices and L_{eq} and PctN

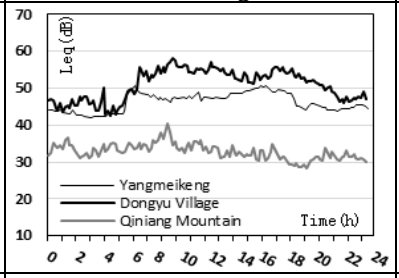
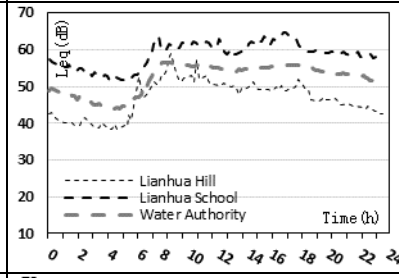
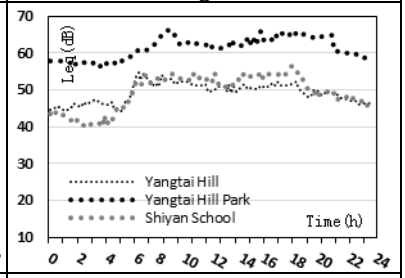
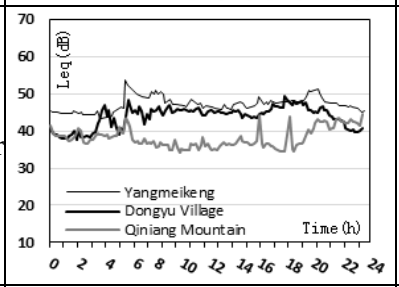
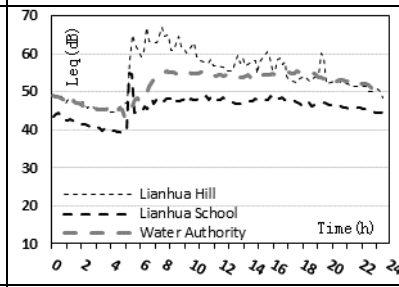
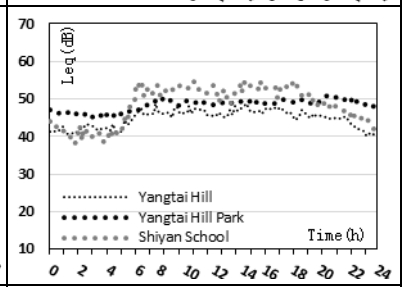
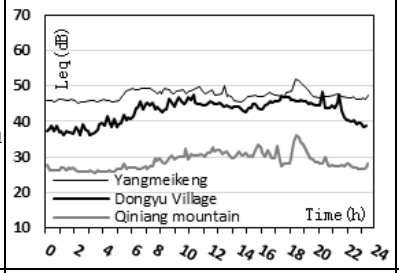
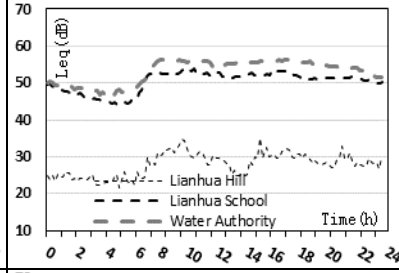
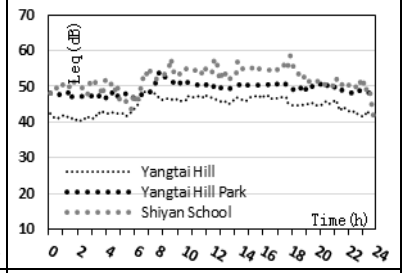
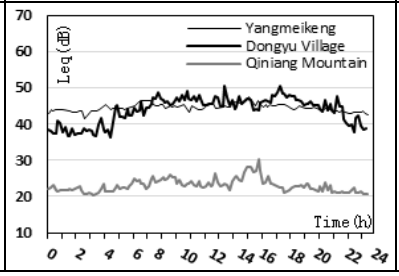
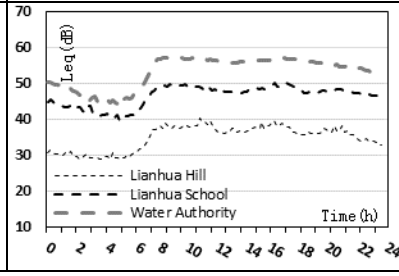
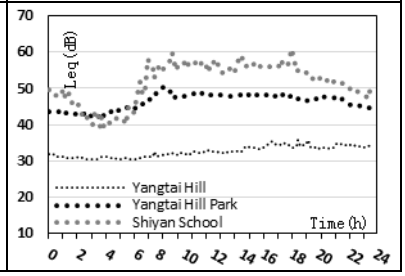
	Land Use	FAR	Building Coverage	Road Density	Greenery Ratio
L_{eq} for the route	0.447**	0.412**	0.405**	0.548**	-0.484**
PctN for the route	-0.634**	-0.554**	-0.58**	-0.522**	0.685**
L_{eq} for the fixed	0.473**	0.297**	0.348**	-0.495**	-0.536**

It can be seen that a significant correlation exists for all urban planning indices and L_{eq} either according to the route study sites or the fixed study sites. This means an urban sound environment in terms of sound level is determined much by the built environment. In addition, analyses of sound source and planning indices were also made. An index of percentage of natural sound occupation (PctN) was used to express sound source variations. It was obtained via dividing each recording into 6 second-sections and listened one by one to distinguish natural sounds and then added all up to calculate the percentage of such kinds of sound occupation. It is also found that PctN is

significantly related with all planning indices too, which means various built environment corresponding of different urban form determines its sound sources too. From Table 1, it is interesting to note that a relationship between the planning indices and sound level and between the planning indices and PctN is generally reverse. It indicates when sound level of a study site is higher it is usually less occupied by natural sounds.

To 9 fixed study sites, 27987 recordings were obtained covering sound variations of one week in each season. Table2 shows L_{eq} variations of each study site in three study areas in four seasons. Generally speaking, there is not much difference of L_{eq} to these study sites if considering four seasons. However, the Qi Liang site has an obvious low L_{eq} than all others, while the Lian Hua and Yang Tai Hill site have very different L_{eq} of the autumn and winter than that of the spring and summer. In one study site, its L_{eq} for four seasons is rather different. Some season has a low L_{eq} but some has a rather high, which addresses different sound events happened in the site.

Table 2: L_{eq} of 9 study sites in four seasons

Season	Da Peng	Lian Hua	Yang Tai
Spring			
Summer			
Autumn			
Winter			

3.2 Sound Environment Variation in terms of Urban Development

From Table 2, it is found that L_{eq} of Da Peng study sites are lower than that of Lian Hua and Yang Tai. This indicates that with a low urban development, the sound level of the area is generally lower than the more developed area. However, there is not much difference of Lian Hua and Yang Tai. Sound environment of these two areas has not much difference, which is varied more with a specific urban form. According to average L_{eq} of the area's all study sites for all seasons, it is found that Da Peng has the lowest of 40.2 dB, while Lian Hua and Yang Tai has a similar value of 48.1 dB

and 48.7 dB respectively. To analyse PctN obtained in the route measurement, it is found that Da Peng has most natural sounds, while Lian Hua and Yang Tai has similar amount of occupied natural sounds.

4. Conclusion

This study explored relationships of urban form and sound environment based on intensive field studies including the route measurements and fixed measurements. After analysing 74 route field study sites, 11 urban forms representing a variety of built environment were extracted. A significant relationship is found between planning indices and sound level and sound source, which indicate that urban forms have much influence on urban sound environment. One kind of urban form could reflect its corresponding environment. Giving a result of the fixed measurement for Da Peng, Lian Hua, and Yang Tai, it shows that a more developed area has a higher sound level than less developed area, which might be caused by road construction more than buildings. For these having a rather higher sound level area mostly from traffic, some design and planning approaches have been proven useful, which are setting proper design or planning layout of buildings to the road, putting not noise sensitive rooms towards the road in the building's floor design, or using landscape facilities or façade structures to reduce noise.

Acknowledgement

This research is supported by the Shenzhen Habitat Environment Committee Foundation and the Funding from Shenzhen Urban Planning and Land Resource Research Centre. The authors are indebted to all research members for useful discussion.

REFERENCES

1 Kang, J., *Urban Sound Environment*, Taylor & Francis Incorporating Spon, London (2007).

2 Carles, J. L, Barrio, I. L. and De Lucio, J. V. Sound influence on landscape values, *Landscape and Urban Planning*, **43**(4), 191 – 200, (1999).

3 Alvarson, J. J, Wiens, S. and Nilsson, M. E. Stress recovery during exposure to nature sound and environmental noise, *Public Health*, **7**, 1036-1046, (2010).

4 Yu, L., Yang, Y., Kang, J., Zhang, M. D. and Xu, Y. A relationship of urban built environment and soundscape identification, Proceedings of INTER-NOISE 2016, Harburg, Germany, 21-24 August, (2016).

5 Schulte-Fortkamp, B., Brooks, B. M. and Bray, W. R. Soundscape: an approach to rely on human perception and expertise in the post-modern community noise era, *Acoust. Today*, **3**, 7-15, (2007).

6 Berglund, B., Lindvall, T., Schwela, D. H. and Goh, K. T. Ed., *WHO. Document Guidelines for Community Noise*, World Health Organization, Geneva (2000).

7 Penn, C. N., *Noise Control*, Shaw & Sons, London (1987).

8 Lee, P. J., Kim, Y. H., Jeon, J. Y. and Song, K. D. Effects of apartment building façade and balcony design on the reduction of exterior noise, *Building and Environment*, **15** (2), 3417-3528, (2007).

9 Yu, L. and Wang, C. Design approaches to noise abatement for the high-rise residential along the Shenzhen main roads, *Proceedings of the 21th International Congress on Sound and Vibration*, Beijing, China, 13-17 July, (2014).