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Analysis of traffic noise distribution and influence factors in Chinese urban residential blocks

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Abstract

To improve the acoustic environment of residential blocks, noise mapping is employed in this study to analyze traffic noise distribution and the influence factors of four types of residential blocks in China. The study shows that high-rise small blocks have the highest average noise level (L_{avg}) for ground and building facades, followed by small low-rise blocks while modern residential blocks yield the lowest value. An analysis of the standard deviation (STD) of spatial statistical noise level (L_n) shows that the STD of the ground and building façade of two types of small blocks is higher than that of other blocks. The analysis of influence factors indicates that the lot area of residential block has significant negative correlation with ground and building facade average noise level (L_{avg}), and street coverage ratio (SCR) has significant positive correlation with ground and building facade average noise level (L_{avg}). In low-rise and high-rise small blocks, ground space index (GSI) has significant negative correlation with ground and building facade average noise level (L_{avg}); street interface density (SID) has significant positive correlation with the STDs of ground and building facade noise. Floor space index (FSI) shows significant positive correlation with the STDs of ground and building facade noise in low-rise small blocks.

Keywords

Noise mapping, residential block, traffic noise, China

Introduction

With the rapid progress of urbanization, environmental noise has become an important factor that affects the health of residents (Skanberg and Ohrstrom, 2002). Numerous studies have shown that traffic noise has become a major environmental concern and a source of increased levels of discomfort, particularly in urban areas with significant levels of traffic congestion (Ali and Tamura, 2003; De Coensel et al., 2005; El-Fadel et al., 2002; Steele, 2001; Torija, 2010; Yang and Kang, 2005).

According to a relevant study, urban traffic noise is closely related to factors such as urban morphology, transport organization and building layout (Lee et al., 2007; Tang and Tong, 2004; Tang and Wang, 2007; Yu and Kang, 2009). Therefore, the improvement of urban morphology parameters, which is a method for suppressing traffic noise, has attracted an increased level of attention from researchers. Salomons and Pont (2012) analyzed the influence of urban density, urban structure and traffic elasticity on traffic noise. Guedes et al. (2011) analyzed the influence of construction density, the existence of open spaces and the location of street construction on environmental noise distribution. Kang (2000, 2001, 2002, 2005) analyzed the acoustic field distribution of typical urban streets, crossroads and squares. Wang and Kang (2011) analyzed the influence of urban morphology on traffic noise distribution. Zhou et al. (2011) evaluated the influence of street construction's height and gap variation on block acoustic environments. The results of those studies have proved the effects of urban morphology on the reduction of urban environmental noise.

A city is an organism, and its origin and development is restricted by social, technological, economic and cultural factors (Whitehand, 2009). Numerous current urban morphologies comprise the best responses to these constraints. Thus, they are the morphologies with the greatest potential for sustainable development (Chen, 2008). As an important part of a city, a residential block is the primary space where people live, and it is also an area sensitive to these constraints. To adapt to the new economic and social situations in an era, residential block space and structure are continually evolving to form a new structural configuration (Gu, 2001). Therefore, scientific analyses of the environmental potential of these morphologies and their influence factors are of significant scientific importance.

European cities regularly produce noise maps and distributions of noise levels for the facades of dwellings in cities in order to assess and control the effect of environmental noise. China has initiated a plan to introduce EU noise mapping techniques into its metropolises (Wang and Kang, 2011).

This paper aims to apply the noise mapping method to the analysis of traffic noise level statuses and distribution characteristics in typical urban residential blocks in China. Statistical analysis is used to analyze the influence of urban morphology and building layout on traffic noise distribution. The study is expected to provide support for reducing the noise level in residential blocks.

Research methods

Selection of blocks for study

Tianjin is one of the central cities in northern China. The city's history spans more than 600 years. The urban development of Tianjin has an important position in the history of modern China's urban construction, and the development of its residential area represents that of China's residential area in miniature. As shown in Table 1, prior to the foundation of the P.R. China (1949), Tianjin's early residential blocks were influenced by transport modes at that time: road spacing was limited, streets were narrow, corresponding block areas were small, buildings primarily consisted of low-rise styles (1-story to 3-stories), street construction primarily consisted of shops, and typical low-rise small blocks were formed (Xia et al., 2012). During the 1950s and the 1960s under the guidance of planned economy, some unit community blocks were constructed. The spacing and width of roads increased from previous levels, and the block size also correspondingly increased. Buildings primarily consisted of

Table 1. Characteristics of different residential blocks development in Tianjin.

Block type	Construction period	Block morphology characteristics (area, street, building and function)	Perspective views
Low-rise small block (LSB)	Prior to the 1950s	Block areas were less than 6 hm^2; main road spacing ranged from 70 to 200 m; road width ranged between 7 and 15 m; building styles primarily low-rise; layouts were diversified; shops on the two sides of streets were abundant	
Unit community block (UCB)	1950s–1960s	Block areas ranged between 5 to 10 hm^2; main road spacing ranged between 150 and 300 m; road widths ranged between 6 and 20 m; building layouts primarily consisted of multi-story rows; function focused on residences	
Modern residential block (MRB)	1980s–1990s	Block areas exceeded 10 hm^2; main road spacing exceeded 400 m; road width ranges from 12–40 m; transport organization methods were diversified; building layouts were diversified; function focused on residences	
High-rise small block (HSB)	21st century	Block areas were less than 5 hm^2; main road spacing ranged between 70 and 200 m; road width ranged between 12 and 30 m, building styles primarily consisted of medium-rise and high-rise structures; building layouts primarily consisted of enclosures along the street; numerous shops could be found on street sides	

multi-story rows, and block function was primarily focused on residence (Du et al., 2012). During the 1980s and the 1990s, China's economy achieved considerable progress, the number of automotive vehicles increased, and modern residential blocks were influenced by the idea of neighboring unit guiding urban construction. The spacing and width of roads continued to be increased. Transport organization was refined on each level. Buildings' stories and layouts were diversified (Jiang et al., 2011). During the 21st century, with urban expansion and the increase of automotive vehicles, energy and environment encountered enormous challenges, and people began to rethink previous methods of development. To reduce the use of cars and to facilitate travel by public transport, road spacing has exhibited a declining trend, block areas have begun to decrease, the style of buildings has primarily consisted of high-rise styles, and high-rise small blocks have been formed (Brazier et al., 2009).

To analyze traffic noise's distribution and influence factors of a typical residential block, as shown in Table 2, ten low-rise small blocks, seven unit community blocks, eight modern residential blocks and seven high-rise small blocks were selected as study subjects.

Selection and calculation of urban morphological parameters

To quantitatively compare diverse urban textures, urban morphological parameters have been explored and employed in the studies of urban design, landscape and wind environment (Hao et al., 2015; Ng et al., 2011). Spatial form is an important factor which influences acoustic propagation for analyzing the relationship between the spatial characteristics of typical residential areas and traffic noise distribution. This study selects lot area (LA), street coverage ratio (SCR), ground space index (GSI), street interface density (SID) and floor space index (FSI) as study parameters (Dong, 2012; Zhou et al., 2012). Table 3 shows the formulas for calculating those urban morphological parameters.

Table 4 lists the descriptive statistical characteristics of the urban morphological parameters for the sample blocks of four types of residential blocks. As shown in the table, the value range of the parameters of the selected blocks has a relatively wide span, which can effectively represent the characteristics of different types of blocks.

Traffic noise map

This study employs CadnaA software to calculate noise maps. The software includes a noise source model and an ISO9613 acoustic propagation model (DataKustik GmbH, 2006). For the purpose of calculating noise maps, detailed 2D vector maps in DXF format of sampled areas were obtained from the Tianjin Bureau of Urban Planning in China. 3D information for modeling was subsequently obtained from the digital maps. Figure 1 shows the 3D building models of typical sample areas.

The traffic status of each sampling block during the peak-hour period (5:00-6:00 pm) and other periods, including the nadir-hour period (9:00-10:00 am), was measured in working days. In the nadir-hour period, the trunk roads had no much difference in the traffic volume with that in the peak-hour period, the neighborhood-level roads had reduced traffic volume by about 1/2, and some roads

Table 2. The image of sampled areas from Google Earth (study area with broken line).

Low-rise small blocks				
				
L-1	L-2	L-3	L-4	L-5
				
L-6	L-7	L-8	L-9	L-10
Unit community blocks				
				
U-1	U-2	U-3	U-4	
				
U-5	U-6	U-7		
Modern residential blocks				
				
M-1	M-2	M-3	M-4	

(continued)

inside enclosed blocks had no vehicles passing by. The traffic distribution in the peak-hour period was thus used, in order to better examine the relations among the urban roads, building layout and traffic noise distribution. Table 5 summarises the traffic data during peak-hour periods in working days, where as shown in the table, the number of vehicles per hour, vehicle type composition and proportion, and average vehicle speed are calculated and entered into the model. Because low-rise small blocks and high-rise small blocks are of open structure, the average traffic volume, average heavy vehicle rate and average velocity of each street of the two types of land plots are higher than that of other blocks. In addition, all road surfaces

Table 2. Continued.

			
M-5	M-6	M-7	M-8
High-rise small blocks			
			
H-1	H-2	H-3	H-4
			
H-5	H-6	H-7	

in the sampling blocks are made of dense asphalt.

For the calculation, the maximal order of reflection was set as 2 (Kang and Huang, 2005). The calculation grid size was set as 4m. To obtain a noise map for different heights of the sampled blocks, the receiving grid's height was set as 3(X-1)+1.5m, where X represents the floors of the building. X rounds of calculation were employed for each block. Table 6 shows the noise maps at the height of 1.5m at 32 sites, for example.

During traffic data collection, as shown in Figure 2, four typical test points were selected at the site to measure the noise level for the calibrating acoustic model. During the measurement, the microphone for the sound level meters was positioned approximately 1.5m above the floor and kept separate from any reflective surfaces to avoid interference caused by reflections (Meng et al., 2013). The results were compared with the data of the noise map calculation at the same location to ensure that the error is within 2dB(A) (See Table 7).

Data analysis

As shown in Figure 3, 1dB(A) is the unit in the analysis of the noise level for the noise map in the study area. The space of street and building is not included in the statistical analysis results. Noise indexes include ground noise indexes and building facade noise indexes. The ground noise indexes are the grid data at the height of 1.5m above the ground in the study area. The building facade noise indexes are the grid data on the outline of all the floors of the buildings in the study area. These

Table 3. Calculation of urban morphological parameters.

Parameter	Definition	Formula	Notes
Lot area (LA)	Total plan area of the region of interest	A_T	A_T is the area surrounded by the central line of each type of residential block's external street
Street coverage ratio (SCR)	Street coverage ratio is the ratio of the vehicle transport street area in the block to the lot area	$SCR = A_S/A_T$	A_S is the area of street
Ground Space Index (GSI)	Building coverage ratio is the ratio of building base area to the lot area	$GSI = A_B/A_T$	A_B is building base area
Street Interface Density (SID)	Street interface density is the ratio of the sum of the street-side projection widths of all street constructions to the length of the street	$SID = L_B/L_S$	L_B is the sum of street-side projection widths of all street constructions, and L_S is the street length
Floor Space Index (FSI)	Floor space index is the ratio of the total floor area in the block to the total lot area.	$FSI = A_F/A_T$	A_F is the total floor area.

Table 4. Descriptive statistical characteristics of the urban morphological parameters for the sampled residential blocks.

Block types	Lot area (hm^2)	Street coverage ratio	Ground space index	Street interface density	Floor space index
Low-rise small blocks					
Mean	3.9	0.12	0.37	0.70	0.94
STD	0.8	0.02	0.03	0.05	0.13
Min	2.9	0.09	0.33	0.59	0.74
Max	5.2	0.14	0.41	0.78	1.15
Unit community blocks					
Mean	7.2	0.13	0.29	0.62	1.12
STD	1.2	0.01	0.02	0.05	0.18
Min	6.0	0.11	0.27	0.56	0.88
Max	9.0	0.14	0.33	0.69	1.35
Modern residential blocks					
Mean	15.7	0.15	0.21	0.56	1.06
STD	3.2	0.03	0.02	0.07	0.08
Min	10.7	0.11	0.19	0.46	0.95
Max	20.0	0.19	0.24	0.66	1.18
High-rise small blocks					
Mean	2.1	0.21	0.26	0.65	2.77
STD	0.5	0.06	0.07	0.08	0.32
Min	1.7	0.13	0.17	0.55	2.50
Max	3.1	0.33	0.36	0.76	3.38

parameters include average noise level (L_{avg}), standard deviation (STD) and space statistical noise level (L_n). The average noise level (L_{avg}) was calculated by linear averaging of all the grid noise level in the sample area, L_n represents the value that is

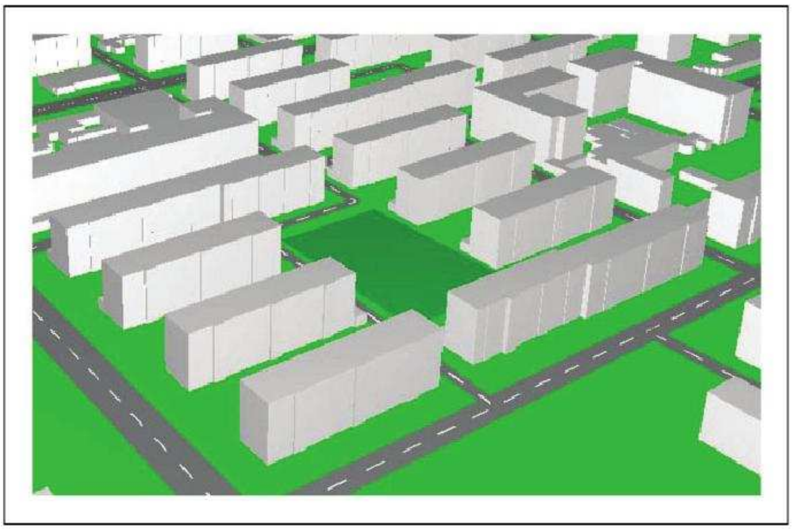


Figure 1. 3D building model of the typical sample area.

Table 5. Summary of the traffic data input into the model.

	Traffic volume				% (v_{heavy})				Speed			
Block types	Mean	STD	max	min	Mean	STD	max	min	Mean	STD	max	min
LSB	821	715	2376	156	11	2	24	0	28	4	40	20
UCB	269	293	864	24	4	6	24	0	24	5	40	20
MRB	597	672	2556	36	3	4	24	0	25	5	40	20
HSB	960	1167	4680	36	7	3	24	0	31	6	40	20

LSB: low-rise small blocks; UCB: unit community blocks; MRB: modern residential blocks; HSB: high-rise small blocks.

surpassed by the noise level for n% of the area. For example, L_{50} represents the value that is surpassed by the noise level for 50% of the area, and L_{90} represents the value that is surpassed by the noise level for 90% of the area (Wang and Kang, 2011). SPSS16 is used for statistical analysis (SPSS Inc, 2007).

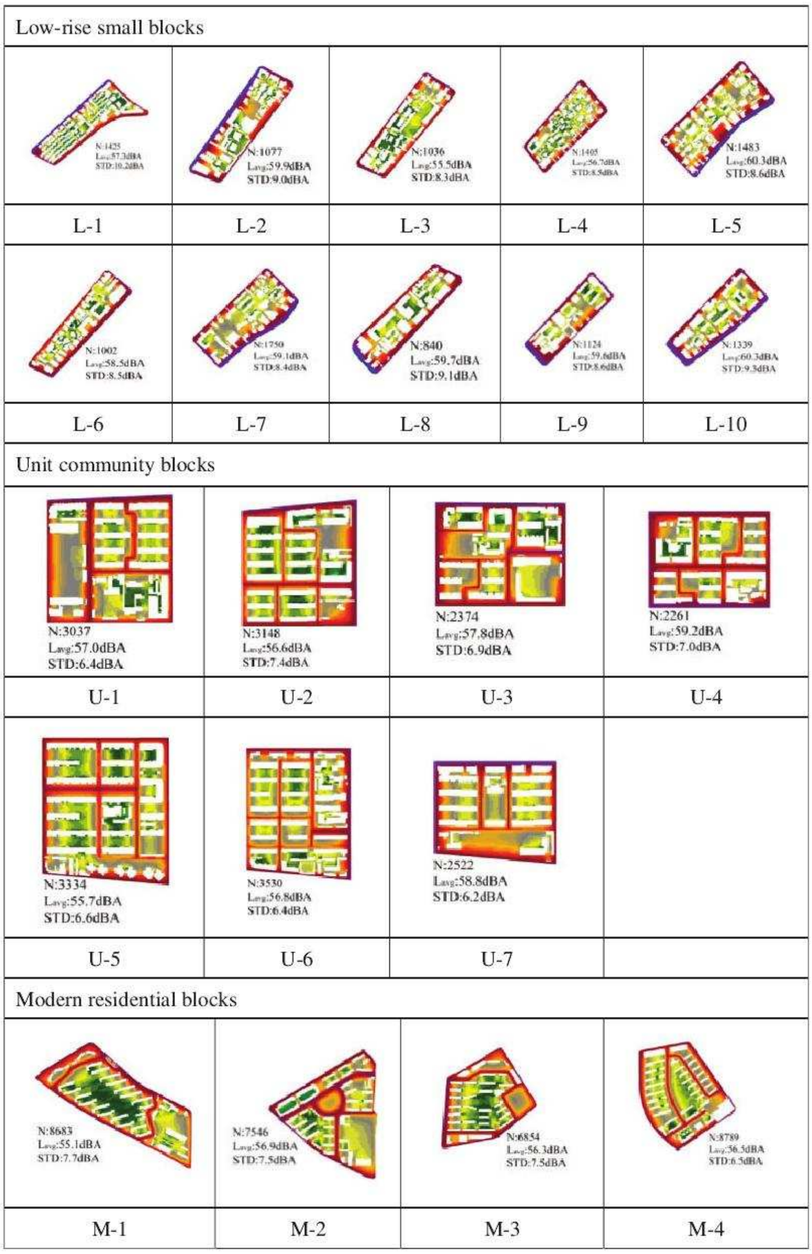
Results and discussion

This section addresses two issues: (1) what are the characteristics of traffic noise distribution in residential blocks; (2) how do urban morphological parameters influence noise distribution.

Traffic noise distribution in the residential blocks

Figure 4 shows the noise levels of the four types of sampled blocks in terms of spatial noise level indexes of L_{10}, L_{50}, L_{90} and L_{avg}, where it can be seen that the ground noise L_{avg} of the four types of blocks ranges from 56 to 61 dB(A) and the building facade noise L_{avg} ranges from 55 to 59 dB(A) during traffic peak hours. The high-rise small block has the highest ground and facade noise L_{avg}, ground noise is 1-4dB(A) higher than that of other blocks and its facade noise is 2-4dB(A) higher than that of other

Table 6. Noise maps at height of 1.5 m in 32 sites.



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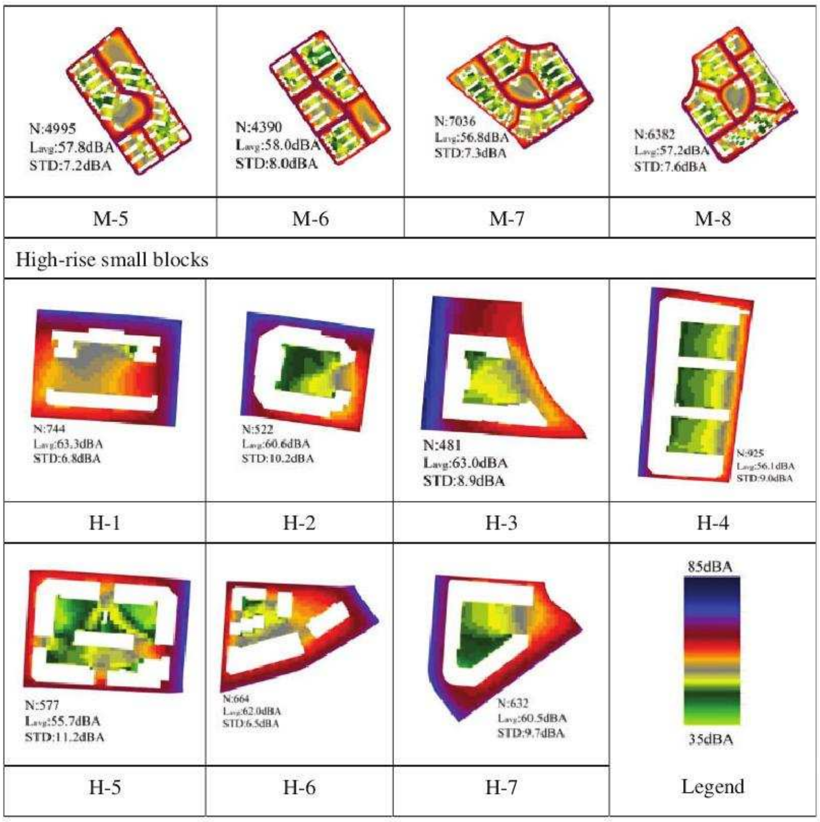
blocks. Based on the advantages relating to the relief of traffic congestion and the improvement of block vitality, small block style residential areas are highly praised by many scholars and planners (such as Calthorpe, 1993; Jacobs, 1961;). However, through this research it has been observed, since small block streets take the shape of a square grid and are open to the city, that traffic volumes of the streets are more than that of other blocks (see Table 5), and urban street intervals decrease and the areas influenced directly by traffic noise increase, which finally leads to relatively a high ground and building façade noise. Taking high-rise small block as an example, during peak traffic hours, both ground and building façade L_{50} were observed to have

Table 6. Continued.



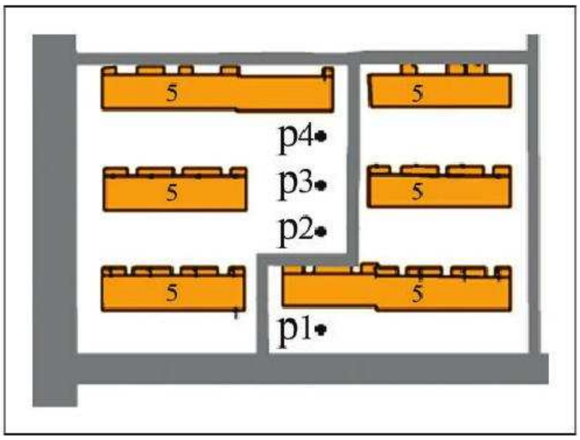


Figure 2. Layout of the measurement points.

been above 60dB(A), indicating 50% areas are above the limit value of acoustic environment criterion for residential areas in China. Therefore, the issue of traffic

Table 7. Comparison of measured noise levels and simulated noise levels with CadnaA.

Points	P1	P2	P3	P4
Measured (dB A)	61.7	56.2	54.7	54.9
Simulated (dB A)	63.5	57	55	54
Difference (dB A)	1.8	0.8	0.3	0.9

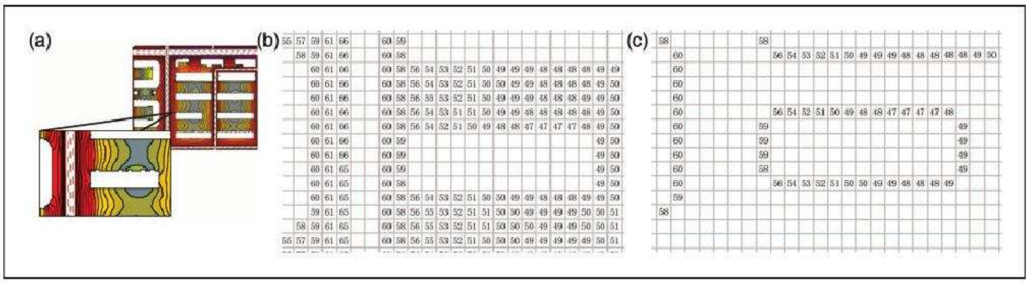


Figure 3. Data processing of noise map: (a)noise map of the unit community blocks; (b) initial arrays obtained by data processing program, numbers representing noise levels; (c) arrays of building facade noise level of every floor.

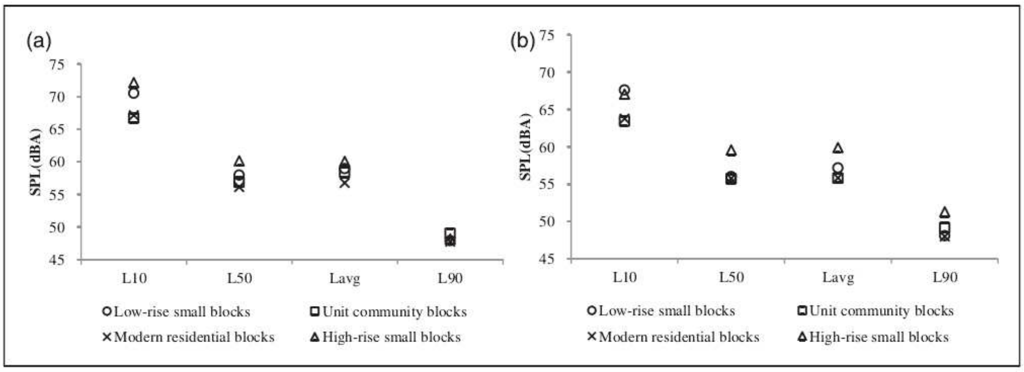


Figure 4. Comparison of sampling blocks' noise level: (a) ground; (b) building façade.

noise in small block style residential areas deserves attention. However, it is interesting to note that ground and building façade L_{90} of small block style residential areas are equal to or even lower than that of other blocks (ground noise difference value is below 1dBA), although their L_{50} are obviously higher than that of other blocks (their difference value is above 3dBA). This might be relevant to the building layout for the blocks, indicating the acoustic environment of residential areas can be improved effectively through reasonable building layouts.

Different urban morphologies indeed induce different distributions of spatial traffic noise, as indicated by the STDs of L_n among the sampled blocks in Figure 5. Similar to the change in noise mean value, the STD of spatial noise level in small block style residential area is relatively high, especially for high-rise small blocks with maximum ground L_{50} of 5.2dB(A) and a maximum building façade L_{80} of 5.4dB(A). This indicates that high-rise small blocks are sensitive to urban morphology in quiet

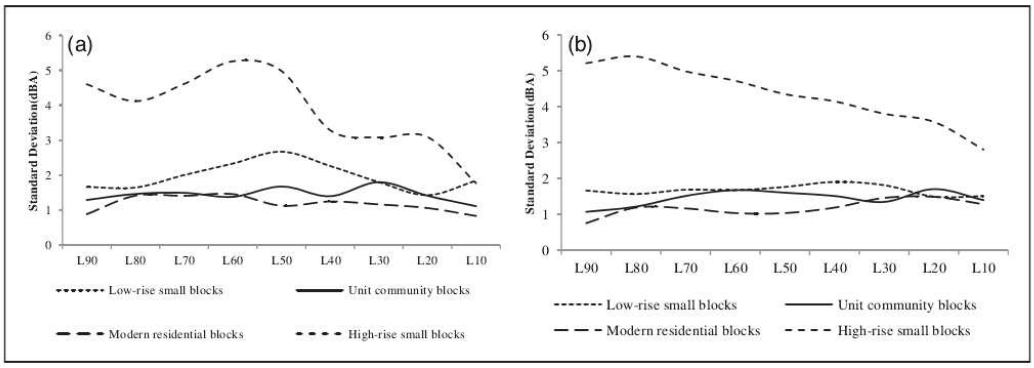


Figure 5. Standard deviations of spatial noise Ln of the sampling blocks: (a) ground; (b) building façade.

areas. In order to increase the area of quiet areas effectively, more attention should be paid to the reasonable layout of interior architecture in city design for those blocks.

If all road traffic volume is reduced to 1/2, ground noise L_{avg} of the four types of residence areas will reduce by 2dB(A) to 4dB(A) and building facade noise L_{avg} by 2dB(A) to 5dB(A) when traffic noise propagates at the same sites. The STDs of spatial noise levels are the same as that of all the traffic volume, which means the impact of urban morphology on traffic noise distribution remains constant, and the rules still work when traffic volume is reduced.

Influence of lot area and street coverage on traffic noise

To investigate whether and how the spatial noise level distribution of traffic noise is related to road layout, a linear correlation analysis is conducted among block's lot area (LA), street coverage ratio (SCR) and noise indexes. As shown in Table 8, ground and building facade noise L_{avg} are negatively correlated with LA. The reason is because urban street intervals increase accordingly along with an increase in LA, leading to an increase in quiet areas in blocks and a decrease in the L_{avg} of the blocks. It is not surprising that there is a positive correlation between ground and building facade noise L_{avg} and SCR, since traffic volume increases correspondingly with an increase in SCR. Figure 6 further shows an example of the relationship between ground and building facade noise L_{avg} and LA, SCR in unit community blocks. As shown in the figure, the land plot area increases from 6.1hm^2 to 9.0hm^2 , the mean value of ground and building façade noise level decreases by 3.5 dB(A), road density increases from 0.11 to 0.14 and ground and building façade noise level increases by 3.5 dB(A).

It is interesting that, by analyzing the relationship between LA, SCR and spatial noise level indexes L_n, it has been observed that, in many types of blocks, LA and SCR are more correlated with $L_{10,}$ but are irrelevant with $L_{90,}$ which indicates carriage ways relatively influence the noise environment of nearby areas significantly, while their influence on the acoustic environment of quiet areas relatively far from the road is insignificant. Therefore, for modern block style residential areas M-1 and M-2 blocks, ground noise L_{90} are respectively 1.8dB(A) and 0.8dB(A) lower than the mean value of L_{90} for all samples of such blocks and the façade noise L_{90} is 1.0dB(A) lower, since

Table 8. Correlation between street layout parameters and spatial noise indexes for the sampled residential blocks (1-tailed), where the bold entries are those at a significant level, with $*p < 0.05$ and $**p < 0.01$.

Pearson correlation	Ground noise				Facade noise			
	LSB	CUB	MRB	HSB	LSB	CUB	MRB	HSB
LA								
L_{avg}	−0.098	**−0.837****	**−0.801****	−0.588	−0.301	**−0.899****	**−0.843****	−0.244
STD	0.367	−0.017	−0.515	−0.137	0.118	−0.581	**−0.650***	−0.3
L_{10}	0.318	**−0.756***	**−0.894****	−0.331	0.101	**−0.920****	**−0.872****	**−0.729***
L_{50}	−0.374	**−0.774***	**−0.798****	−0.756*	−0.392	**−0.941****	**−0.845****	−0.189
L_{90}	0.027	−0.648	−0.515	−0.016	−0.127	−0.498	−0.162	−0.156
SCR								
L_{avg}	**0.590***	**0.879****	**0.643***	0.623	**0.611***	**0.770***	0.538	**0.713***
STD	0.36	0.083	**0.651***	−0.021	0.36	0.459	**0.717***	−0.078
L_{10}	0.500	**0.937****	**0.832****	**0.750***	0.538	**0.714***	**0.722***	**0.923****
L_{50}	**0.710***	**0.895****	**0.662***	0.530	**0.626***	**0.790***	0.596	**0.675***
L_{90}	0.155	0.615	0.232	0.267	0.243	0.244	−0.136	0.590

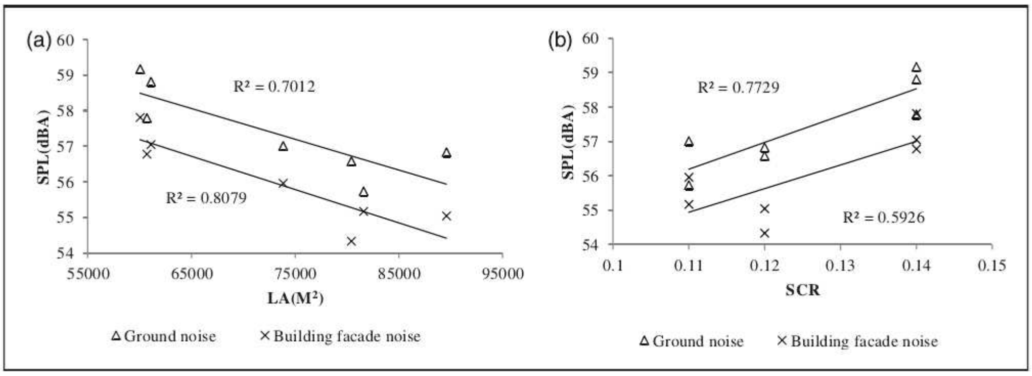


Figure 6. Relationships between spatial noise Lavg and street layout parameters in the high-rise small blocks: (a) lot area; (b) street coverage ratio.

separate roads for pedestrian and vehicles are used and motor vehicles are forbidden to pass through the interiors of the blocks.

Influence of building layout on traffic noise

A linear correlation analysis of building layout parameters and spatial noise indexes of the sample blocks was performed in this study in order to assess the influence of residential block building layout on traffic noise. The building layout parameters include ground space index (GSI), street interface density (SID) and floor space index (FSI).

GSI mainly reflects the distribution proportion of buildings and public space within the block. There is a relatively significant difference between the GSIs of different types of blocks and between their influence on noise distribution. As shown in Table 9, in low-rise and high-rise small blocks, a significant negative correlation exists between GSI and $L_{avg.}$ The reason is that, the land plot areas of the two types of blocks are relatively small and increase with GSI, and the acoustic shadow area

Table 9. Correlation between building layout parameters and spatial noise indexes for the sampled residential blocks (1-tailed), with $*p < 0.05$ and $**p < 0.01$.

	Ground noise				Facade noise			
	LSB	CUB	MRB	HSB	LSB	CUB	MRB	HSB
GSI								
L_{avg}	**−0.606***	0.27	0.48	**−0.891****	**−0.727****	0.11	0.283	**−0.764***
STD	0.399	0.498	−0.438	0.456	0.46	−0.07	−0.5	0.361
L_{10}	−0.344	0.199	0.012	−0.41	**−0.652***	−0.117	−0.324	**−0.804***
L_{50}	−0.249	0.407	0.57	**−0.759***	**−0.579***	0.016	0.363	−0.669
L_{90}	**−0.897****	−0.176	0.513	−0.664	**−0.799****	−0.213	**0.732***	**−0.714***
SID								
L_{avg}	−0.146	0.291	**0.822****	**−0.863****	−0.16	0.447	**0.671***	**−0.800***
STD	**0.610***	0.521	−0.041	**0.790***	**0.797****	0.496	−0.016	**0.760***
L_{10}	0.135	0.187	**0.717***	0.042	0.107	0.482	0.277	−0.439
L_{50}	0.059	0.438	**0.646***	**−0.760***	−0.152	0.524	**0.760***	**−0.797***
L_{90}	**−0.570***	−0.069	**0.790****	**−0.841****	−0.525	0.006	**0.656***	**−0.867****
FSI								
L_{avg}	0.025	−0.426	**0.788***	0.533	−0.135	−0.511	**0.742***	**0.806***
STD	**0.816****	**0.718***	−0.108	−0.238	**0.768****	−0.059	−0.081	−0.261
L_{10}	0.306	−0.218	0.436	0.616	0.146	−0.558	0.221	**0.770***
L_{50}	0.299	−0.169	**0.811****	0.335	−0.072	−0.36	**0.771***	**0.797***
L_{90}	−0.547	**−0.699***	**0.740***	0.437	−0.466	**−0.714***	**0.751***	**0.680***

formed in the blocks increases. Therefore, the noise of ground and building façade has a tendency to decrease.

SID is an important index for measuring the building layout along the two sides of streets. As shown in Table 9, in low-rise and high-rise small blocks, with an increase in SID, the STD of block noise has obvious tendency of increase. It indicates the noise attenuation rate of the block decreases with an increase in SID. It is worth noting that a correlation which is positive and which may either be significant or insignificant exists between the SID and noise parameters for the other two kinds of blocks. It is possible that the two types of blocks have relatively large areas and their interior is influenced by the internal streets in blocks. Therefore, the traffic noise of carriage ways in large-scale blocks should also be considered seriously.

FSI can reflect the 3D distribution status of buildings. The increase in FSI will result in an increase of building density or the heights of buildings. As shown in Figure 7, in low-rise small blocks, with an increase in FSI, both building density and SID have the tendency to increase. In high-rise small blocks, building density and SID have the tendency to decrease with an increase in FSI. Different ways of FSI increase will cause different distribution characteristics in the noise of blocks. As shown in Table 9, in low-rise small blocks, similar with SID, a positive correlation exists between the FSI and the STD for ground and building façade noise. However, in high-rise small blocks, along with an increase in FSI, the STD has the tendency to decrease. The reason might be that most of high-rise small block buildings are constructed along streets, and when the height of the buildings increases, the buildings' height in the east-west direction decrease to meet the requirements of building lighting. Therefore, the acoustic shadow area decreases, which causes a decrease in the noise attenuation rate.

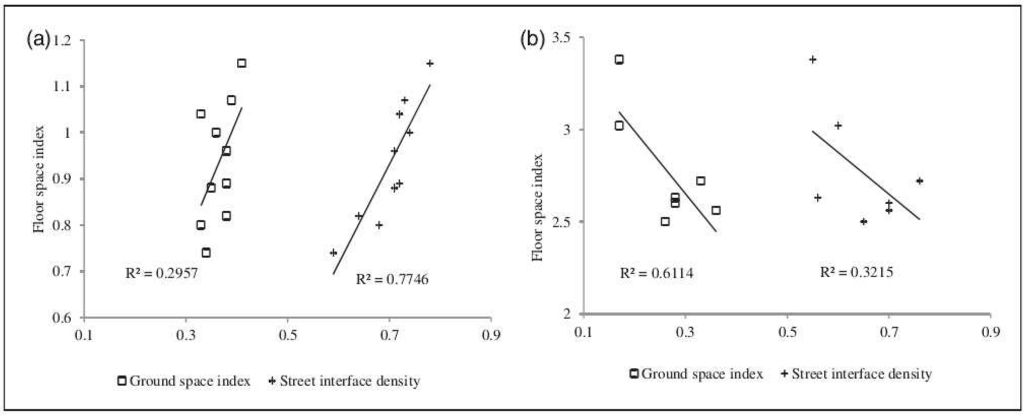


Figure 7. Correlations between floor space index and ground space index, street interface density: (a) low-rise small blocks; (b) high-rise small blocks.

Conclusions

Noise mapping was used to analyze the acoustic environments of four types of typical residential blocks in Tianjin, China. The results showed that different types of residential blocks exhibit different traffic noise distributions. The ground noise L_{avg} ranged between 56 to 61 dB(A). The high-rise small block yielded the highest value, followed by the low-rise small block, and the modern residential block yielded the lowest value. The building facade noise L_{avg} ranged between 55 to 60 dB(A) and its distribution rule was similar to that of ground noise L_{avg}.

The analysis of the relationship between urban morphological parameters and noise indexes revealed that ground and building facade noise L_{avg} tend to decrease with an increase in block area. Ground and building facade noise levels increase with an increase in street coverage.

The analysis of the relationship between building layout parameters and noise indexes showed that ground and building facade noise L_{avg} exhibit a decreasing trend with an increase in GSI in low-rise and high-rise small blocks. Ground and building facade noise STDs increase with an increase in SID in low-rise and high-rise small blocks. Ground and building facade noise STDs exhibit an increasing trend with an increase in FSI in low-rise small blocks.

Recently Chinese government is actively promoting the construction mode of “narrow roads and dense road network”, which may lead to the reduction of block areas and increase of the density of road network in cities in the future, thereby increasing noise pollution inside the neighborhoods. According to this study, the distribution of traffic flow, form of the architectural layouts and others are important factors that influence the distribution of traffic noise in the small blocks. Thus, when planning new blocks, effective measures are important, such as advocating the mixed use of neighborhood areas, encouraging low carbon travel of the residents, in order to reduce the flow of motor vehicles in the block areas, properly increasing GSI and SID, so as to reduce the transmission of traffic noise towards blocks.

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