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Study on the acoustic environment of Tibetan Buddhist Temples in Han Region

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ABSTRACT

Buddhism, especially Tibetan Buddhism, has an important influence on Chinese social folk culture. Their monasteries are mainly divided into plain monasteries and mountain monasteries according to different geographical features, but the type of acoustic landscape is still unknown. In order to explore the acoustic landscape of Tibetan Buddhism in the city, mining variety of sound sources, and further exploring the influence of Tibetan Buddhist soundscapes on the physical and mental health of believers, this paper takes two Tibetan Buddhist monasteries, Wutai mountain in Shanxi Buddha temple and lama temple in Beijing as the research objects, making investigation and analysis on the acoustic landscape elements of representatives positions, analyzing the field testing data, and the relationships between their typical spatial characteristics and the present situation of acoustic environment are discussed, besides, design suggestions are proposed. At last, the key nodes are modeled, calculated and simulated, then some conclusions are provided.

Keywords: Tibetan Buddhist temples in Han Region, acoustic landscape, simulation calculation

1. INTRODUCTION

Tibetan Buddhism belongs to Mahayana Buddhism. Tibetan Buddhism requires practitioners to seriously emphasize discipline and cultivation in practice, emphasizing both teaching and practice, influencing and changing China's social and cultural traditions (1). The research work of acoustic landscape has been carried out in Buddhist temples and some achievements have been made (2~5). Currently, scholar Xie H is exploring the mechanism of acoustic landscape in the treatment of patients with depression(6), whereas, the domestic research on the acoustic landscape of mountainous Tibetan Buddhist temples as well as the internal and external acoustic landscape on the physical and mental health of believers are still blank. The particularity and multidimensionality of the space of mountain Buddhist temple make it different from the acoustic environment of plain Buddhist temple and shows its own uniqueness. In order to open up new perspectives for theory research and design applications, this paper puts forward contrast of SPL values of the both field measurements and research thought of Cadnaa simulation, aiming to dig the rich soundscape existing in Tibetan Buddhist temples of Han nationality, further explore the multi-types of sound sources in the city, simultaneously explore the influence mechanism in Tibetan Buddhist monasteries soundscapes towards mental health of visitors.

2. RESEARCH METHODS

2.1 Object Selection and Acoustic Landscape Survey

Two Tibetan Buddhist temples, 16 spatial measuring points in the Bodhisattva Roof temple group of mount Wutai in Shanxi province and 12 nodes in the Yonghegong in Beijing were selected as measuring points. The plane distribution of each measuring point are shown in Figure 1. Through sound pressure level measurement, the test data of temple groups with similar architectural form and function, but different gradient heights, different spatial scales were analyzed. The types of sound sources in specific environments were also analyzed. Both of them belong to the nature of Tibetan

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Buddhism, however, the difference in spatial form, topographic height and activity type of pilgrims between the two temples of Bodhisattva Roof and Yonghegong make them have very distinctive characteristics of sound landscapes. The symbolic spatial nodes of Imperial Carriage Pathway, Mountain Gate and Memorial Archway were selected to establish the models, and the noise simulation software Cadnaa was used to simulate the sound pressure levels of them. Then, the conclusions were given through analysis.

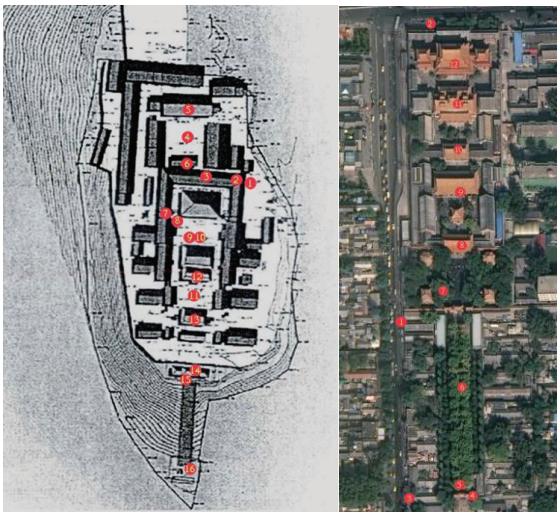

Figure 1 -- Plane distribution of each measuring point of the Bodhisattva Roof Temple on Mount Wutai（left） and in Yonghegong Hall（right）

P01: East gate of Bodhisattva Roof backyard;P02: East gate in front of the wall;P03: Steps outside the courtyard of the large pot;P04: In the large pot yard;P05: Inside the big pot courtyard;P06: Inside the courtyard of the large pot;P07: Inside the two doors of the great Manjusri Hall;P08: Entrance of the great Manjusri Hall;P09: Inside the great Manjusri Hall;P10: Archway of great Manjusri temple;P11: Inside the grand Buddhist temple;P12: Inside the Hall of the giant Buddha;P13: Inside the temple of heavenly king;P14: Under the archway outside the mountain gate;P15:108 Steps top;P16: At the foot of 108 steps.

P01: Yonghegong Street;P02: East Andingmen Street;P03: West gate archway facing the street;P04: East gate tourist ticket office;P05: South gate;P06: Albion road;P07: Drum Tower;P08: Yonghegong gateP09: Lama Temple;P10: Yongyou Hall;P11: Falun Hall;P12: Suicheng Hall (Hall with white canopy).

2.1.1 Bodhisattva Roof

Wutai Mountain have diverse topographical gradients, vertical topography changes, and rich elevation difference. The temples there own unique characteristics of the mountain complex. The Bodhisattva sits on the dragon head in the middle of mount Wutai." Any building can fully show its value and expressiveness only when it integrates with the environment and becomes an organic whole together with the surrounding.(7)’’ The group arrangement of the temple on the mountain conforms to the nature and promotes the nature, and respects the original appearance of the site in a higher significance. According to geomantic thought of "8 doors set 9 stars", its architectural pattern means to set a door respectively in 8 directions, from south to north 9 courtyards are laid out. Eight front yards are on central, west, east three axises, followed by the Copper Pot backyard. Underlying landscape characteristics explain spatial variation of urban soundscape patterns (8,9). The layout of Bodhisattva Roof is shown in Figure 2.

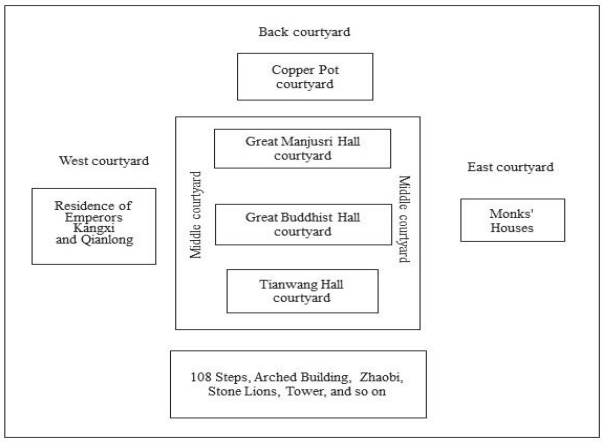

Figure 2--Architectural layout of the Bodhisattva Roof Temple (This map originally from document)

Pilgrims take a bus along the mountain road to the northeast gate, then enter the Bodhisattva Roof, firstly visit the backyard, then enter the main building of the front yard, and finally walk to the south gate. In the incense route, the sounds of conversation, the guide's loudspeaker horn, and the excited shouts can be heard continuously. Because of the inversion of the tour route, the pilgrims have an inverted experience of the spatial sequence of the temple. They first perceive the "climax" of the architectural courtyard, and then gradually march towards the Mountain gate and the Alley Steps.

2.1.2 Lama Temple

Located in the northeast corner of Beijing city, known as latent elysian fields, the temple is a place with gentle terrain. Its layout appears in three rectangular buildings in the north facing south, and the layout of the central axis courtyard shows seven steps in one road(10), gradually shrinks from the south to the north, while the temple buildings gradually rise, forming a structure of main tall halls and deep multiple courtyards(11).

Pilgrims walk along the middle road towards the north, through doors, halls into next courtyard and hall. There are mainly the sound of conversation, footsteps, the occasional pram wheel, incense kneel, stand up when the clothes friction sound and other sound sources.

3. ANALYSIS OF ACOUSTIC LANDSCAPE SURVEY RESULTS

3.1 Analysis of the Relationship between the Architecture Spatial Characteristics of Yonghegong and the Acoustic Landscape.

The shape of L_{eq} trendency line belonging to the Drum Tower is similar with that of the West Second Gate Archway of Yonghegong, which partly result from that both of them adjoin Yonghegong street on the west side. In addition, there are standing buildings at two locations, which is related to the “up” in the rhythm of "up, continuing, converting, together" in the overall layout of the facade. In the rear of several main palaces, cumulative SPL values at Yongyou Hall and Falun Hall are similar, and quiet degrees are on the same level; In general, the decibel number of Yonghegong is slightly higher than that of Falun Hall by 3-5dBA. Except at the low frequency of 31.5Hz, the decibel number of Falun Hall is about 7.5dBA higher than that of Yonghegong Hall. However, the sound pressure level in Suicheng Hall (White Umbrella Hall) in the northernmost part is the highest, which is directly related to that this place is the end point of the complex and is the concentration of visitors resting and staying.

According to the analysis in Figure **3**, the Yonghegong is dominated by low and medium frequency sounds. At the frequency of 63Hz, locations of P01, P03, P07 and P09, especially at the entrance and exit of P03 Archway, the low-frequency sound interference of people and traffic flow is strong (Leq≈83dBA).However, most visitors in P10 Yongyou Hall keep quiet, and there is a significant fall (Leq≈58dBA) at this frequency. In addition, at the place of Albireo road and Yonghe gate Hall, because of the coming of a small climax of the museum complex, the mood of expectation of the visitors is rising, the conversation are endless, and the trend line of the SPL value of 500Hz shows an obvious upward convex trend. Especially in Albireo, the sound pressure level values of 500Hz and 1kHz frequencies are larger in the entire spectrum (up to 55dB), but at the same time, compared with other

locations, the overall L_{eq} value is still lower, and the environment is still relatively quiet.

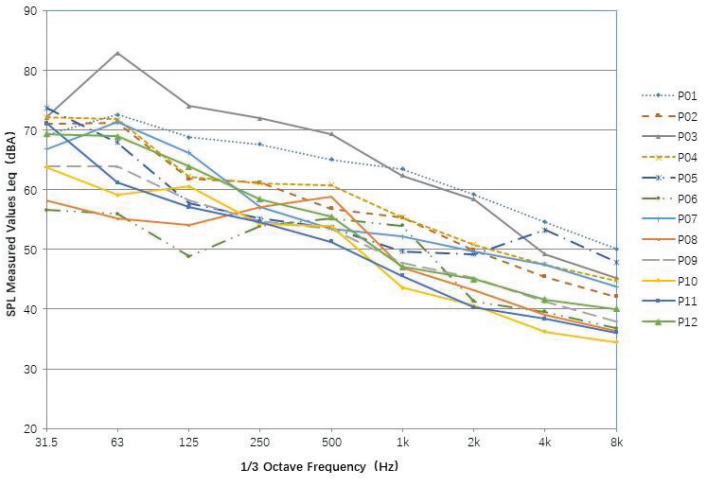

Figure 3-- SPL value distribution diagram of 1/3 octave measured in Yonghegong

The frequency distribution of SPL value spectrum at each frequency is larger than that at other measurement points, such as frequent visitors and vehicles, footsteps, tire grinding, talking, and occasional metal collision of personal belongings at P03.The low-frequency sound is higher, and the high-frequency sound is lower , at 31.5Hz(Leq≈73.5dBA),4kHz(Leq≈48.5dBA),8kHz (Leq≈45dBA). Generally speaking, low-frequency and medium-frequency sound is the main sound, and high-frequency sound is the auxiliary sound. Human voice is the main sound source, simultaneously mechanical sound and sound energy is very weak.

3.2 Comparison of Spatial Characteristics, Order and Related Acoustic Landscape Between the Two Places

According to the visiting order of the site, the author measured L_{max}, L_{min}, equivalent sound pressure level (L_{eq}), statistical sound pressure level (L10, L50, L90) and standard deviation (SD) at various measuring sites.

As shown in Figure **4**, except for SD value, P03 in the Bodhisattva Top Temple Group has a small space and a high visitor density. Besides, it is noisy and noisy to talk, and the sound of the guide's loudspeaker trumpet is high. L_{eq} is the largest, and P10 is the second. Location P13 has the smallest sound index and is the quietest place in the temple, especially L90 (43dBA) and L_{min}(40dBA), which are the smallest in all measurement points.P14 has individual tourists occasionally voice, the overall quiet, sound indicators in the lower middle level. At the location P06, the background noise is low, L90 and L_{min} values are low, while visitors' voices are rising one after another, and other indicators are on the high level in the middle. The trend lines of L90 and L_{min} are in good agreement, and the background noise rule of temple measurement sequence line is basically high and low interval. Location P05 and P10 are Lamas ' living areas, which are intermixed with the Hall, so the background noise is the highest, and the L90 reaches about 57.5dBA.

Inside the Big Pot courtyard and the Grand Manjusri Hall, the inner courtyard space itself is relatively narrow. Double Tables, Memorial Archway, Incense Burner, The Clock and other contents are set up, and then the flow of people is concentrated, which are the two main core scenic spots of the temple, reaching two small climax. The Buddha statue enshrined in the temple of Heavenly King is dignified, and the visitors' mood are dignified and their voice are weak. This is the quietest place in the temple.

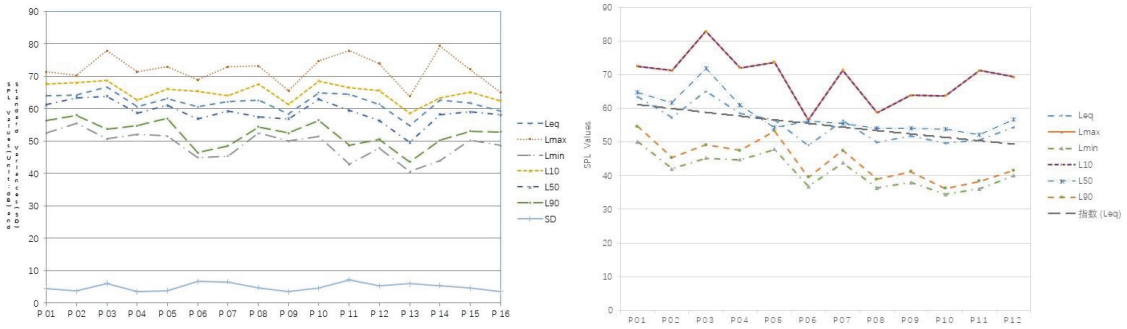

Figure 4--SPL value distribution line of each measurement site inside the bodhisattva roof（left）and in Yonghe temple（right）

3.3 Discussion on the Application of Design Improvement

Inside the top of the Bodhisattva, Lamas and monks in the temple are all living in halls courtyards due to the demolition of living areas in the temple. Functions such as accommodation, dining and lecturing should be divided separately, with deputy abbot's courtyard, abbot's courtyard and monk's house. Each courtyard includes Sutra Hall, lecture Hall and residence, and the sound will not interfere with each other. Xinglong courtyard and Bridal chamber courtyard are the courtyard where the abbot can preach or live, and the 18th floor courtyard is the courtyard where the monks chant scriptures. The single-function longevity courtyard is designed for worshippers, while the fenced courtyard is designed for catering, so as to avoid disturbing the monks.

Noise reduction pavement should be installed on the ground adjacent to the Yonghegong Archway to reduce the low frequency sound.

4. ESTABLISHMENT OF KEY NODES MODELS (12) FOR CADNAA ACOUSTIC SIMULATION ANALYSIS

4.1 Key Points of Modeling

1 The Lama temple trees shelter over the stack processing method is, because sound travels up is more difficult, and vocals point set at 1.6 m height from the ground, about 7 ~ 8 m from the crown of a tree, so the canopy omitted, only keep the trunk, and visitors have marched into and out of the two sequences, so the human voice to face north or south two direction is given priority to, the rest is complementary, so the sound source directivity unified simplified as open or no directivity, as far as possible to the actual situation. The reflection coefficient was set 0.3.

2 Due to the severe corrosion of the aged wood structure and the frequent contact with the outside air near the step foundation, the memorial archway on the top of the Bodhisattva top step can no longer support its own structure independently. In addition, there are 15 inclined columns supporting it to make it stable. The model is simplified as 15 vertical columns.

3 The sound source of the visitors was simulated with each individual point sound source, and the operating time was similar to the time when the sound of the visitors (voice, conversation, individual footsteps, etc.) was emitted, finally achieving the smooth progress of the simulation process and obtaining various preset results. On the 108 steps of the Bodhisattva top, visitors and ticket sales staff are set as the point audio source, with 30 point audio sources and one point for each of the three positions. Visitors and ticket sales staff in Imperial Carriage Pathway of Yonghegong are set as point audio sources, 39 point audio sources and 3 points of reception are set, and the parameters of building evaluation are set. Attached tables are omitted here.

4 The human voice characteristics of high frequency sound (6000Hz ~ 8000Hz) in a single frequency band are usually one sentence or a limited number of sentences, which are set within the instantaneous interval of 1min and about 10s ~ 15s.For middle frequency sounds (2000Hz), the sounding time is set to 30s ~ 40s.The 50s ~ 65s, which are characterized by spectral sounds, usually occur in the form of phone calls, conversations.

Figure **5** and Figure **6** show the perspective models of the Bodhisattva's 108 steps and the Yonghegong Imperial Carriage Pathway in Beijing and the final evolution model.

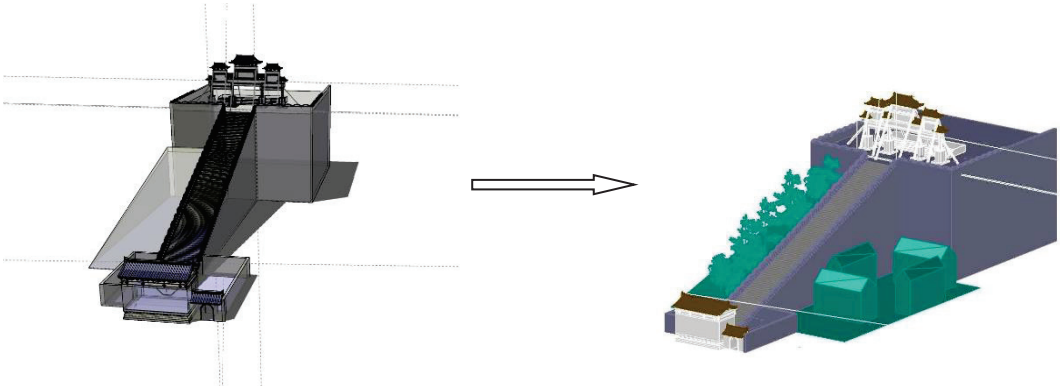

Figure 5--The final models of the 108 steps of the Bodhisattva Roof's Imperial Carriage Pathway node established by Sketchup and CAD

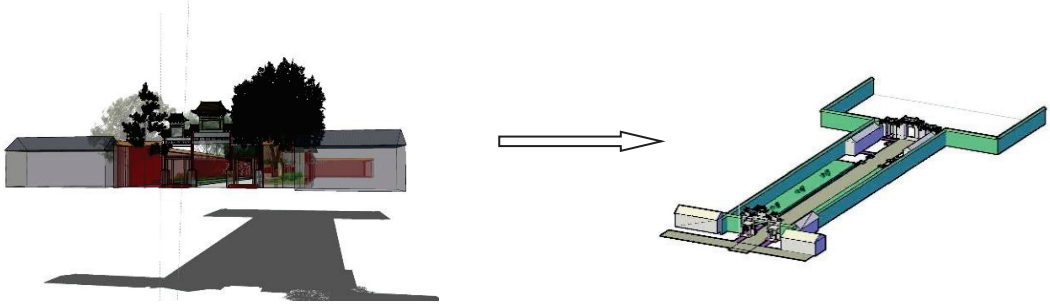

Figure 6-- The final models of Yonghegong Imperial Carriage Pathway node established by Sketchup and CAD

4.2 Analysis of Simulation Results

The plane shapes of both are very similar. The narrow and long corridor has archways or gate at the beginning and end as the symbolic node of the tour line, and the steps and the passage are both courtyards and green plants. Yonghe Hall Imperial Carriage Pathway is located in the flat terrain, and the sound source from the point is 1/10 of the total number of worshippers and visitors. The sound from the point source is very isolated, and there is no continuous sound field of equal sound pressure level, which can also be seen in Figure 7 (right).On the contrary, on the top step of mount Wutai Bodhisattva, the sound field is able to present a continuous pattern of vocal cords, as shown in Figure **8**(right).On the average sound pressure series, the latter is also about 15dB higher than the former. In topography with elevation difference, the sound line will be refracted repeatedly, which will shorten the rate of sound energy attenuation and greatly improve the sound energy. This is also consistent with the conclusion that sound travels more easily in a vertical direction (13). The sound sources with the same frequency and sound power show significant difference in the sound field performance in the environment with similar plane layout and shape of buildings in mountain and flat land.

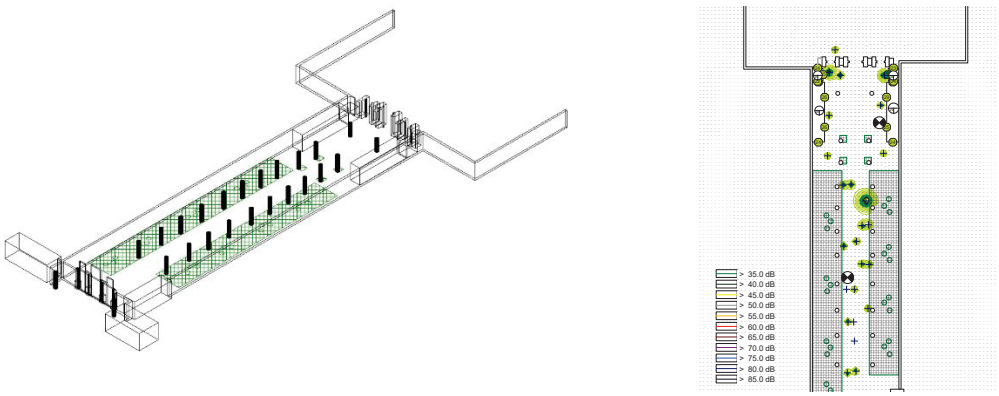

Figure 7--The model established by Cadnaa (left) and SPL distribution of Yonghegong Imperial Carriage Pathway(right) simulated and calculated by Cadnaa

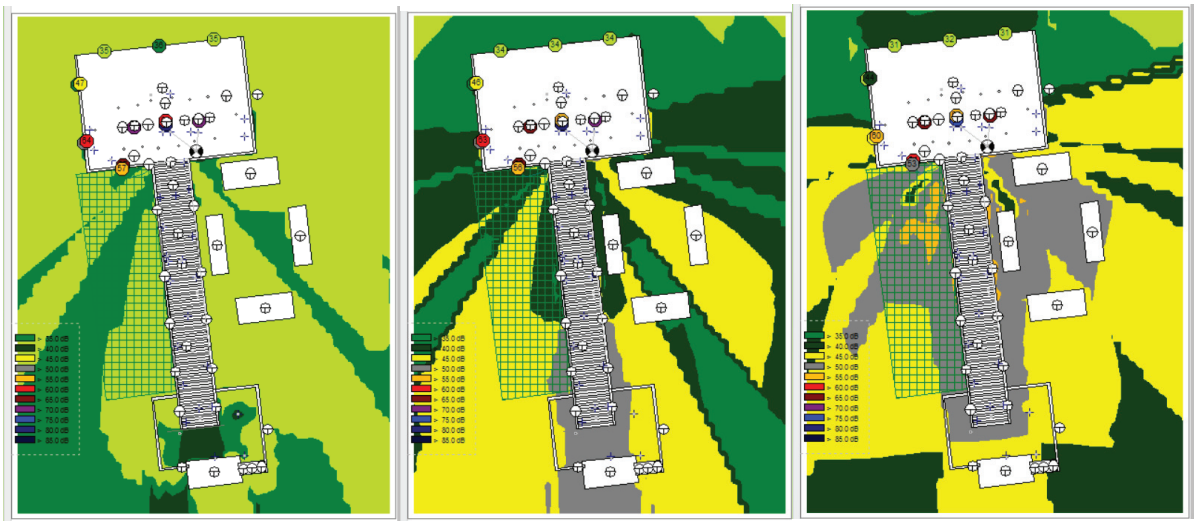

Figure 8-- SPL distribution diagram of the absolute height of sound receiving points 1.6m(at the bottom of the step)(left) ,8.5m(in the middle of steps)(middle)and 15.17m(in the top of steps)(right)respectively obtained by Cadnaa simulation

In addition, courtyard alley scale analysis. Yonghegong aisle width reach 23 meters, the height of the wall is 4.5 meters (Figure **8** left), channel 5 meters wide, 108 steps, wall is composed of semicircular low enclosure (Figure **8** middle), the bushes on both sides of the Lama temple of green belt and covered corridor tree-lined belt (Figure **8** right) also absorbed most of the sound energy, so the original weak acoustic field sound energy is more lower.

Figure 9--Perspective (left) and photograph (middle) of Imperial Carriage Pathway model of Yonghegong, photo (right) of the protective wall on both sides of 108 steps of Bodhisattva Roof

5. CONCLUSIONS

1. The transitional space is often the temple in the low-frequency sound prominent position, but the overall sound field sound energy is not large, and is quite quiet.

2. On the 108 steps of the Bodhisattva's top, the long rising time is usually in the middle part of the low wall on both sides of the steps, which is generated by the dialogue of visitors or the explanation of the guide, etc., while at the beginning and end of the steps, most of the short or high frequency sounds are caused by the exclamations of worshippers or visitors or by the individual voices. In the Yonghegong Hall, there are two times more visitors compared with the 108 steps of the top of the Bodhisattva, and the categories of sound sources and their characteristics are roughly the same. However, due to the different geographical areas, the tourists' performance and the characteristics of the sound field are quite different (14). This phenomenon may also be related to the administrative level of the scenic spot.

3. To the person as a point source sound energy diffusion degree is very small, only about plane radius affected the scope of 1 m, other than 1 meter distance can't form a continuous sound pressure level of noise source, even if the occasional individual high frequency (6000 Hz) voice, short duration (usually around 0.3s), not to sound field have a significant influence on change. Therefore, visitors generally think that the alley is very quiet. From the measured SPL value, the simulated situation is

also consistent with it.

4. The future papers will further explore the acoustic influential mechanism towards deep “mental space” (15) and scenery of Tibetan Buddhist temples on visitors' mental health (16).

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