The Soundscape Satisfaction Evaluation and Optimization Design of the Echo at Yingying Pagoda in Pujiu Temple

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Abstract

The Yingying Pagoda in Pujiu Temple, Shanxi, is renowned for its unique "frog echo" soundscape, which is not only a cultural icon but also a significant element of the tourist experience. However, the integration of this soundscape with the environment and its satisfaction levels among tourists have not been optimally addressed.This research aims to evaluate the current soundscape of the Yingying Pagoda and optimize it to enhance tourist satisfaction. The study seeks to analyze the physical characteristics of the soundscape, assess tourist satisfaction, and propose improvements based on environmental interactions.A comprehensive approach was employed, involving field investigations, in-depth interviews with experts, and questionnaires completed by a sample of 70 tourists. Sound field simulations were also conducted to predict the acoustic effects of various materials and design alterations. The data collected was analyzed using both qualitative and quantitative methods to assess the soundscape's integration with the landscape and to identify key factors affecting tourist satisfaction.The analysis revealed that the cultural significance of the "frog echo" soundscape was acknowledged, but its environmental integration was found to be lacking and not meeting tourist expectations. The wall material and listening position were identified as key factors influencing satisfaction.

Based on the findings, the study suggests several optimization strategies. These include using red bricks and wood to improve the wall's acoustic performance, adjusting the listening point for a more immersive experience, integrating vegetation and Buddhist cultural elements for a harmonious visual and auditory landscape, and establishing a long-term maintenance and feedback mechanism to ensure continuous improvement of the soundscape.

Keywords: Soundscape satisfaction; Soundscape optimization design; Buddhist cultural heritage; Environmental integration

Introduction

Pujiu Temple, located in Yongji City, Shanxi Province, China, is a tourist attraction with a profound Buddhist culture. Its core landscape, the Buddha Relics Pagoda, is famous for the love story of Zhang Sheng and Cui Yingying in The Romance of the Western Chamber and is called Yingying Pagoda by the locals, The existence of Pujiu Temple not only bears witness to the inclusive spirit of Buddhism but also reflects the unique status of Pujiu Temple, "No temple in the world talks about love, only Pujiu Temple in Shanxi" (Wen, 2006). According to the Fayuan Zhulin (Daoshi, 1990) and the Ji Shenzhou Sanbao Gantonglu (Daoxuan, 1983), the Yingying Pagoda was originally named Yaoqin Hedong Puban Ancient Pagoda, built by Ashoka. The "Ashoka Biography" mentions that Ashoka decided to build 84,000 pagodas in

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one day, 100 years after the Buddha's Nirvana (Guang, 2007). Through the magical power of the Venerable Yasa, these pagodas were quickly built in various parts of Jambudvīpa, of which 19 were built in the Kingdom of Zhendan (China), and the Puban Ancient Pagoda ranked fourth. This period of history reflects the complex process of the early introduction of Buddhism into China. It provides precious empirical evidence for the study of the spread of Buddhism in China. Yingying Pagoda is known as one of the four echo buildings in China, along with the Echo Wall of the Temple of Heaven in Beijing, the Pagoda of Baolun Temple in Sanmenxia, and the "Stone Qin" of the Dafo Temple in Shitong County, Sichuan (Liu, 2013). It has a unique acoustic effect - the "frog echo." The tower body and the eaves are made of stacked blue bricks, which are good reflectors. The blue bricks of Yingying Pagoda have been blown by the wind and sand of the Loess Plateau for many years, and the surface is exceptionally smooth, just like a thin layer of glaze, so almost all sound waves are reflected under the tower. Currently, the research on Buddhist temples mainly focuses on the visual and spatial environment (Zhang, Xiang, & Tao, 2017), while the research on sound focuses on the acoustic simulation of Buddhist ritual music forms and sound sources (Liang, 2022). However, existing research often ignores the narrative aesthetics and place spirit of integrating sound and landscape, resulting in tourists' satisfaction with soundscape being generally lower than the visual experience. In addition, there is currently a lack of specific soundscape design optimization cases, which is also an important direction for future research.

Therefore, tourist satisfaction is a crucial indicator for evaluating the optimization of the temple soundscape. This study takes the echo soundscape satisfaction of Yingying Pagoda in Pujiu Temple as the research object, explores the tourists' satisfaction from the echo listening position at different distances, analyzes the influence of different materials on the echo effect, and verifies the influence of sound source position and material selection on satisfaction through simulation experiments. This study aims to provide an empirical basis for optimizing soundscape design, promoting sound and landscape integration, and enriching Buddhist temples' cultural experience.

The research on the Yingying Pagoda within Pujiu Temple, Shanxi, has identified several key issues that need to be addressed to enhance the tourist experience and align the soundscape more effectively with the cultural and historical significance of the site. The main problems concluded from the research are:1.Lack of Integration: The current soundscape does not integrate well with the visual and spatial environment of the pagoda, which is a key aspect of the tourist experience.2.Cultural Disconnect: Despite the rich cultural and historical background, including the love story and the Buddhist heritage, the soundscape does not reflect or enhance these narratives effectively.3.Acoustic Design Limitations: The unique "frog echo" effect, while culturally significant, may not be optimized for all listeners due to the material and design of the pagoda structure.4.Tourist Satisfaction Gap: Tourist expectations are not fully met, as the soundscape's contribution to the overall experience is less satisfying than the visual aspects.5.Narrative Aesthetics Neglect: The research highlights that the narrative aesthetics and the spirit of place, which are essential for a comprehensive tourist experience, are often overlooked in current soundscape designs.6.Optimization Case Deficiency: There is a lack of specific案例 studies and optimization strategies for soundscape design in cultural and historical sites like the Yingying Pagoda.7.Research-Practice Gap: While there is a body of research on the visual and spatial environments of Buddhist temples, as well as on the acoustic simulation

of ritual music, there is a gap between this research and practical application in enhancing the soundscape of such sites.

In conclusion, the research points to the need for a more holistic approach to soundscape design that takes into account the cultural context, historical significance, and the desire for an immersive experience from the perspective of tourists. There is a clear call for further research and practical strategies to optimize the soundscape of the Yingying Pagoda to better align with its visual environment and enhance tourist satisfaction.

Research Objectives

1. To examine how distance from Yingying Tower affects listener soundscape satisfaction.

2. To analyze the impact of different wall materials on soundscape satisfaction.

3. To propose soundscape optimization strategies for Yingying Tower to enhance visitor experience.

Research Methodology

This study was conducted from March 8 to March 17, 2024, using various data collection methods such as interviews, questionnaires, field observations, and simulation experiments to ensure the multi-dimensional perspective and depth of the research results.

1. Population and Sample

The population for this study consisted of tourists visiting the Yingying Pagoda in Pujiu Temple, Shanxi Province, China. The sample was selected using a random sampling method to ensure representativeness and avoid bias. A total of 70 tourists, evenly divided between men and women (35 men and 35 women), participated in the study. This gender balance was maintained to account for potential differences in auditory perception and satisfaction levels between genders. The sample size was determined to be adequate for statistical analysis and to provide reliable data for the evaluation of soundscape satisfaction.

2. Research Tools

This research employed a multi-faceted approach to collect and analyze data, ensuring a comprehensive understanding of the soundscape elements and their impact on tourist satisfaction. The primary research tools included:Field investigations: On-site observations were conducted to assess the physical environment and the acoustic characteristics of the Yingying Pagoda. These investigations captured the natural soundscape and the interaction of sound with the surrounding environment.In-depth interviews: Purposeful sampling interviews were conducted with residents, temple management, monks, and tourists to record the historical changes of the Yingying Pagoda and the evolution of its soundscape characteristics. These interviews provided insights into the social and cultural significance of the soundscape.Questionnaires: A structured questionnaire survey was designed to assess tourists' perception and evaluation of the soundscape elements, environmental integration, and personal satisfaction. The survey was administered to 70 tourists (35 men and 35 women) to Sound field simulations: Acoustic simulation software Odeon was used to construct a virtual model of the Yingying Pagoda soundscape. This model was used to simulate and analyze the propagation and perception effects of the soundscape under different conditions, such as changes in materials and listener positions. The simulations provided data to support the optimization design of the soundscape.

These research tools were selected to provide a multi-dimensional perspective on the soundscape of the Yingying Pagoda, enabling a detailed analysis of the physical, perceptual, and cultural aspects of the soundscape.

3. Data Collection

Data collection for this study was conducted using a combination of methods to ensure a comprehensive and multi-dimensional understanding of the soundscape elements and their impact on tourist satisfaction. The specific data collection methods employed are outlined below:

On-site observations: Detailed acoustic characteristics and video recordings were made of the three core soundscape elements of the Yingying Tower of Pujiu Temple: stone hitting, frog croaking, and echo. These recordings captured the physical characteristics of sound and its interaction with the environment, providing primary data for subsequent soundscape analysis. Precise measurements were also carried out to ensure the accuracy of the simulation experiment;Interviews: Interviews were conducted with residents, temple management, monks, and tourists using a purposeful sampling method. The interviews focused on the historical changes of the Yingying Pagoda and the evolution of its soundscape characteristics. These interviews provided rich qualitative data on the social and cultural significance of the soundscape;Questionnaires: The characteristic soundscape recordings and videos of Yingying Pagoda were sampled to quantitatively evaluate the soundscape satisfaction of Yingying Pagoda in Pujiu Temple. By accurately capturing the three core soundscape elements of stone hitting, frog croaking, and echo, we ensured the authenticity of the soundscape experience and the communication of cultural characteristics. 70 listeners (35 males and 35 females) evaluated the soundscape using a five-level rating scale, as shown in Table 1, thus providing a standardized satisfaction evaluation framework. In order to improve the accuracy and reliability of the evaluation, the acoustic software Odeon was used to simulate the acoustic environment of Yingying Tower and reduce external noise interference . The collected questionnaire data were analyzed using SPSS software for correlation analysis, revealing the key factors affecting visitor satisfaction and the interaction between different soundscape elements, providing a scientific basis and data support for the optimization design of the soundscape of Yingying Tower.

Table 1 A five-level rating scale was used to evaluate the soundscape

Evaluation indicators	**Evaluating indicator**				
satisfaction level	Very satisfied	Satisfy	Generally	Not satisfied	Very dissatisfied
Score	2	1	0	-1	-2

In this study, a questionnaire survey was conducted among tourists of Yingying Pagoda of Pujiu Temple by random sampling method, aiming to evaluate tourists' satisfaction with the echo soundscape of Yingying Pagoda. 70 questionnaires were distributed to ensure gender balance (35 male and female respondents each). The basic information of the respondents is shown in Table 2. Among them, 74% of the listeners believed that the frog echo of Yingying Pagoda needed to be more highly integrated with Pujiu Temple's environment and that there should be more harmony and consistency between sound and landscape. This highlights the importance of considering the integration of sound with the visual and cultural

elements of the surrounding environment in soundscape design. At the same time, the feedback showed that the single frog echo needed to be more sufficient in terms of soundscape diversity, and it was not easy to fully reflect the profound connotation of Buddhist culture, which emphasized the necessity of incorporating diversified sound elements into soundscape design. The results showed that tourists' satisfaction with the echo of Yingying Pagoda was affected by a combination of factors, among which the distance between the listeners and the corridor wall and the material of the wall was the main influencing factors.

Table 2 The basic information of the respondents

Variable	Categories
Gender	1: Male; 2: Female
Age	1: <18; 2: 18-30; 3: 31-50; 4: >50
Frequency of visits to temples	1: First time; 2: 2-5 times; 3: 6-10 times; 4: More than 10 times
Reasons for coming to the temple	1: Sightseeing; 2: Religious pilgrimage; 3: Academic research; 4: Other
Education level	1: High school or below; 2: Associate and Bachelor's degree; 3: Master's degree or above
The integration of echo soundscape with the temple environment	1: Highly integrated; 2: Integrated; 3:Generally; 4: Not integrated; 5: Highly not integrated

Simulation experiments: The measurement data of the actual site was applied to the acoustic simulation software Odeon to construct a virtual Yingying Tower soundscape model to simulate and analyze the propagation and perception effects of the Yingying Tower echo soundscape under different conditions. This study designed and implemented a questionnaire survey to assess tourists' satisfaction with the soundscape of Yingying Tower.

4. Data Analysis

The data analysis for this study involved a combination of qualitative and quantitative methods to assess the soundscape satisfaction of the Yingying Pagoda in Pujiu Temple. The analysis aimed to identify key factors influencing tourist satisfaction and develop optimization strategies based on the simulation results. The specific data analysis methods employed are outlined below:

Qualitative Analysis: (1) Interview Data: Interviews with residents, temple management, monks, and tourists were transcribed and analyzed using content analysis techniques. The data was coded and categorized to identify themes and patterns related to the historical and cultural significance of the Yingying Pagoda's soundscape. (2) Observational Data: Behavior and experience of tourists in the soundscape environment were carefully observed and recorded. The data was analyzed to understand the interaction between tourists and the soundscape, including their reactions to frog sounds and echoes.

Quantitative Analysis: (1) Questionnaire Data: The questionnaire data was analyzed using SPSS software for correlation analysis. The data was used to reveal the key factors affecting visitor satisfaction and the interaction between different soundscape elements. The satisfaction evaluation framework used a five-level rating scale. (2) Simulation Data: Acoustic simulation software Odeon was used to model and analyze the propagation and perception

effects of the Yingying Tower echo soundscape under different conditions. The simulation results were compared to identify the most effective optimization strategies.

Integrated Analysis:Soundscape Optimization Design: Based on the results of the acoustic field simulation, optimization design suggestions were proposed. These suggestions included the use of red bricks and wooden materials for wall materials, optimization of tourists' tour routes to guide them to the best listening positions, integration of vegetation configuration and Buddhist cultural elements, and regular evaluation of soundscape characteristics and visitor satisfaction.

In summary, the data analysis for this study involved a comprehensive examination of the collected data, using both qualitative and quantitative methods. This included the assessment of the current soundscape design's integration with the landscape, the identification of key factors influencing tourist satisfaction, and the development of optimization strategies based on the simulation results.

5. Conceptual framework

This study constructs a multidimzensional conceptual framework aimed at deeply exploring the impact of the soundscape of Yingying Pagoda at Pujiu Temple in Shanxi on tourist satisfaction and proposing corresponding optimization strategies to promote the protection and promotion of cultural heritage. The framework considers the physical properties of the soundscape, the perceptual experience of tourists, and the deep connections of the cultural context, revealing the key role of soundscape design in enhancing tourist experience and cultural heritage through a systematic analysis of the interactions between these elements. The study employs a combination of quantitative and qualitative methods to comprehensively assess the physical characteristics of the soundscape, tourist perceptual feedback, and the integration of the cultural environment, thereby proposing empirical data-based optimization design suggestions. These suggestions aim to achieve a harmonious unity of aesthetics and functionality in soundscape design, while providing strategic support for the continuous protection and effective dissemination of cultural heritage. (Figure 1)

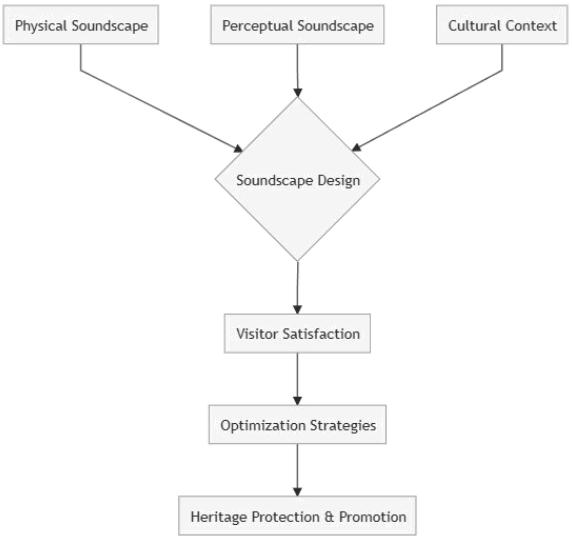


Figure 1 Conceptual framework
(Source: Constructed by the researcher)

Research Results

1. The influence of the distance between listeners and Yingying Tower on the soundscape satisfaction

Through questionnaires and on-site measurements, this study collected data on the impact of changes in listeners' distance from Yingying Tower on soundscape satisfaction. The study used a structured questionnaire to assess soundscape satisfaction among listeners at different distance points. The questionnaire design includes specific evaluation indicators for soundscape clarity, echo intensity, and environmental integration. As shown in Figure 2, the red point is the sound source, the blue point is the receiving point, and the blue point represents the distance from the wall to the receiving points, with 2 meters as a unit. The blue dots represent receiving points 1 to 5 from right to left, and the distances are 2 meters, 4 meters, 6 meters, 8 meters, and 12 meters, respectively. The survey results show that, as shown in Table 3, at receiving point 5, the listener's soundscape satisfaction dropped significantly, with an average score of -0.5, indicating dissatisfaction.

Table 3 Soundscape satisfaction among listeners at different distance points.

Evaluation Indicators		Point 1 (2m)	Point 2 (4m)	Point 3 (6m)	Point 4 (8m)	Point 5 (12m)
Very Dissatisfied	-2	2	1	0	8	20
Dissatisfied	-1	5	5	1	11	30
Generally	0	15	17	5	26	10
Satisfied	1	27	22	30	11	5
Very Satisfied	2	21	25	34	14	5
Satisfaction Evaluation		0.86	0.93	1.46	0.29	-0.5

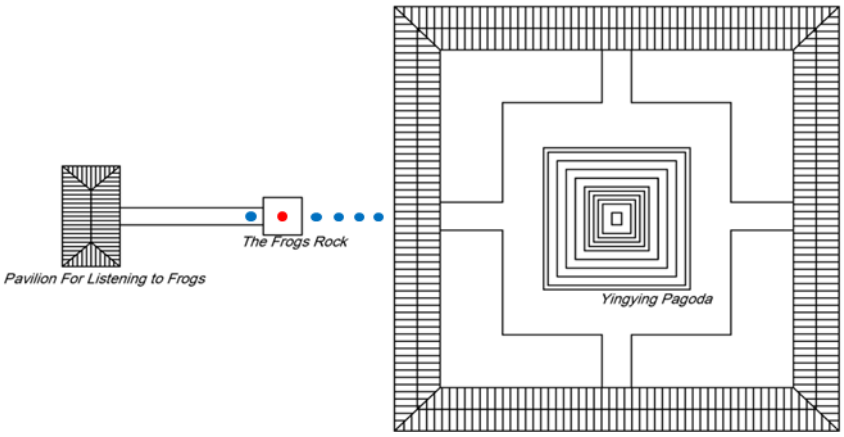


Figure 2 Plan Layout Diagram
(Source: Constructed by the researcher)

In contrast, at point 3, the audience's satisfaction reached the highest, with an average score of 1.46, showing extremely high satisfaction; satisfaction at point 2 followed closely, with an average score of 0.93. Within the range of 2 to 6 meters from the Yingying Tower, the

listeners' soundscape satisfaction increases as the distance increases. Due to this phenomenon, the direct propagation path of sound is shorter, and the attenuation of sound waves is negligible, thus maintaining a higher sound pressure level and clarity. As shown in Figure 3, visible particles are used to demonstrate the propagation of sound waves generated by the knocking of the stone platform and the echo effect reflected by the eaves of the Yingying Tower. The simulation results provide intuitive sound propagation and reflection effects for the questionnaire survey, helping respondents to evaluate the soundscape experience more accurately. tourists said that when the distance exceeds 6 meters, the clarity and intensity of the echo are reduced, especially at 12 meters, and the average satisfaction score decreases. This may be due to the impact of air absorption and environmental interference during the propagation of sound waves. In addition, this study also found that young listeners and first-time visitors have higher expectations for the soundscape and are more sensitive to distance changes. At the same time, residents who visit frequently show higher adaptability to soundscape changes.

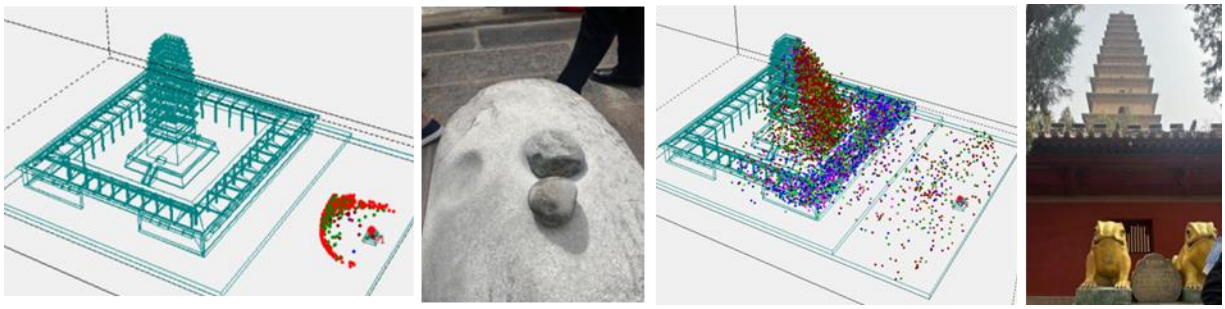


Figure 3 Simulated Acoustic Wave Visual Particles with On-site Photos
(Source: Constructed by the researcher)

In summary, the research suggests that the listener's location and movement path should be considered in the soundscape optimization design, and the he listener l should be guided to the best listening position to enhance their soundscape satisfaction. At the same time, it is recommended that appropriate landscape optimization and wall material adjustment be carried out around the Yingying Tower to enhance tourists' overall experience.

2. Influence of wall materials on soundscape satisfaction

This study collects and analyzes tourists' subjective evaluations of soundscapes under This study collects and analyzes tourists' subjective evaluations of soundscapes under different wall material conditions. The questionnaire design covers evaluation indicators such as scattering coefficient, sound absorption coefficient, soundscape clarity perception evaluation, environmental integration, and soundscape satisfaction. The scattering coefficient indicates how effectively a material scatters sound wave energy in multiple directions . As shown in Table 4, the bracket has the highest scattering coefficient of 0.40 among the existing building materials, meaning it can significantly scatter sound waves. In contrast, the scattering coefficients of the cloister masonry walls and stone steps are relatively low, 0.10 and 0.13 , respectively. The sound absorption coefficient reflects the material's ability to absorb sound. Within the frequency range of 500 Hz to 4 kHz, wooden doors and windows have consistent sound absorption performance, and the sound absorption coefficient is s List at 0.10, which indicates that the sound absorption effect of wooden materials is relatively uniform . The sound

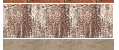
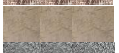
absorption coefficient of the cloister masonry walls, stone steps, and masonry floors in the high-frequency area is low, 0.05 for both. In contrast, the sound absorption coefficient in the low-frequency area is even lower, which also indicates that they have high reflectivity. These sound characteristics Relate to the material structure and surface characteristics, which are more conducive to sound reflection.

Table 4 Tourists' subjective evaluations of soundscapes under different wall material conditions

Material Name	Scattering Coefficient	Sound Absorption Coefficient at Different Frequencies			
		500	1k	2k	4k
Corridor Brick and Stone Wall	0.10	0.07	0.06	0.05	0.05
Stone Steps	0.13	0.02	0.02	0.02	0.05
Brick and Stone Floor	0.15	0.02	0.02	0.02	0.05
Wooden Doors and Windows	0.20	0.10	0.10	0.10	0.10
Dou Gong (a traditional Chinese architectural element)	0.40	0.42	0.40	0.42	0.40
Corridor Roof Tiles	0.50	0.01	0.01	0.02	0.02

Based on the simulation experiment test, as shown in Table 5, the red brick fence with a low sound absorption coefficient of 0.02 has the lowest soundscape clarity score of 0.24. However, the landscape integration and soundscape satisfaction have reached a high level, indicating that the red brick fence Tourists have recognized it in terms of landscape integration; the sound absorption coefficient of wooden materials is the highest at 0.40, and the soundscape clarity is the highest at 1.34. The satisfaction is similar to that of red bricks, but the degree of landscape integration is slightly lower than that of red bricks; the rammed earth walls The sound absorption coefficient is between the two, and the soundscape satisfaction and landscape integration scores are low. The data shows there may be better choices than cement fences in landscape design; the experimental test indicators of gray brick fences perform well but are still lower than those of red brick fences: brick and wooden materials. Among them, soundscape clarity, landscape integration, and soundscape satisfaction adopt a five-level evaluation standard from -2 to 2.

Table 5 Simulation experiment test

Wall Material	Material Image	Sound Absorption Coefficient (1kHz)	Soundscape Clarity	Landscape Integration	Soundscape Satisfaction
Red Brick		0.02	0.24	1.33	1.36
Wooden		0.40	1.34	0.94	1.33
Rammed Earth		0.29	1.26	-0.29	0.79
Cement		0.04	0.27	-0.13	0.03
Grey Brick		0.09	0.93	0.89	1.11

To sum up, red brick and wooden materials show a high overall evaluation of soundscape design, especially regarding soundscape clarity and satisfaction. Rammed earth and cement materials perform poorly on multiple evaluation indicators, and it is recommended that alternative materials or improvement measures be considered in the design. The gray brick material performed moderately, but there is room for improvement. Factors such as material aesthetics, durability, cost, and environmental adaptability should be considered simultaneously during the design process. To improve tourists' satisfaction with the soundscape while maintaining the natural echo characteristics of Yingying Tower, appropriate landscape optimization design and wall material adjustments should be made to its surrounding environment to enhance the tourists' overall experience.

3. Soundscape optimization design of Yingying Tower in Pujiu Temple

3.1 Sound field simulation and analysis of Yingying Tower

In this study, SketchUp software was used to conduct three-dimensional modeling of the actual site of Yingying Tower and restore its proper structure. The modeling files are then imported into ODEON acoustic software to simulate the propagation of sound waves in complex acoustic environments. Due to the complexity of ancient Chinese architecture, especially the eaves, tower head, tower body, brackets, and other detailed components of the Yingying Tower, necessary simplifications were made when establishing the model, as shown in Figure 4. Sound sources include rock banging, frog croaking, and echoes, and their location, intensity, and frequency characteristics are precisely set based on field measurements and recording data. The simulation results show that the different wall materials around the Yingying Tower significantly affect the satisfaction evaluation. Wooden and red brick materials provide a better soundscape experience due to their high degree of landscape integration, while rammed earth and cement materials provide lower soundscape satisfaction due to their lower sound absorption coefficient and landscape integration. Based on the simulation results, this study puts forward the following optimization design suggestions: use red bricks and wooden materials with high landscape integration as wall materials; optimize tourists’ tour routes to guide them to the best est listening positions; integrate vegetation configuration and Buddhist cultural elements, Enhance the integration of soundscape and visual landscape; regularly evaluate changes in soundscape characteristics and visitor satisfaction, provide continuously updated data support for soundscape design, and make adjustments based on visitor feedback.

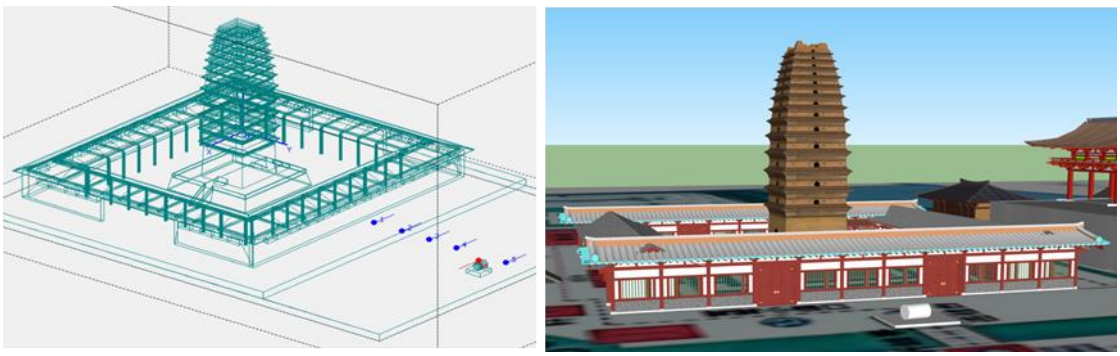


Figure 4 ODEON Acoustic Simulation Diagram and SketchUp Modeling Diagram
(Source: Constructed by the researcher)

3.2 Soundscape Optimization Design of Yingying Tower

Based on the results of the acoustic field simulation, this study proposed the following acoustic field optimization design suggestions:

Fence material: The fence materials selection meets the audience's acoustic needs. As shown in Figure 5, red brick and wood materials were selected as the first choice for fence optimization design due to their high landscape integration and acoustic reflection characteristics. These materials can not only create appropriate acoustic effects but also use red brick materials to express the simplicity and heaviness of Pujiu Temple and use the natural state of wood materials to express the cultural memory of Yingying Pagoda. Wood's renewability and warm texture symbolize Buddhism's sustainable development and inclusiveness.

Figure 5 Wall Material Optimization Design
(Source: Constructed by the researcher)

Optimization of the listening point position: According to the results of the sound field simulation, the ening point was adjusted to 6 meters outside the wall of the Yingying Tower corridor to ensure that tourists could feel the echo effect of the Yingying Tower at the best ening point. In addition, to provide a richer soundscape experience and soft route guidance, landscape trees were introduced to guide tourists to the best ening point. The Yingying Tower is located at a high altitude and has strong winds. The natural wind sound produced by the trees planted on the roadside can bring a relaxing feeling to tourists.

Integration of landscape elements: Through the configuration of vegetation and the introduction of natural sounds, as well as the enhancement of Buddhist cultural connotations, the integration of the Yingying Tower echo soundscape and the visual landscape is enhanced, and the integration of the spiritual atmosphere of the Buddhist temple and the landscape is enhanced, thereby enhancing the immersive experience of tourists. Vegetation configuration can enhance visual beauty and absorb and scatter sound. Therefore, trees with good scattering characteristics are selected to enhance the naturalness and clarity of the soundscape; wind chimes written by tourists are hung on the trees to guide tourists to the Yingying Tower ening point with the wind, enhancing the layering of the soundscape. The floor paving comprises seven lotus-patterned bricks, symbolizing "lotus blooms in seven steps." This design is inspired by the legend of the birth of Sakyamuni Buddha , symbolizing the Buddha's purity and transcendence and inner purity amid worldly turmoil, as shown in Figure 6.

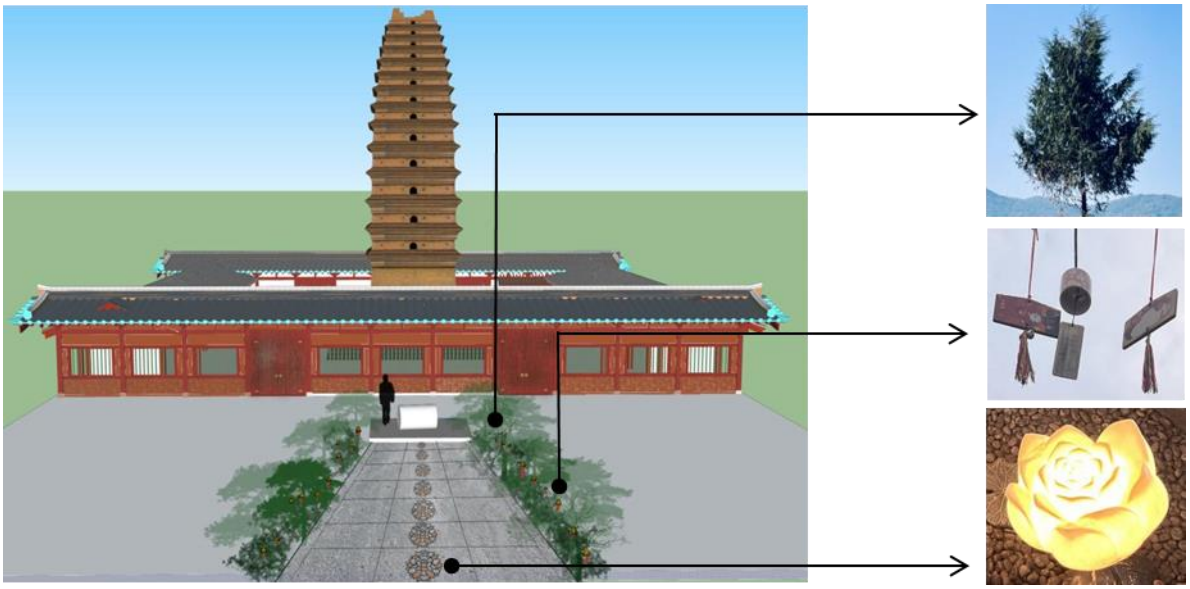


Figure 6 Landscape Element Integration Design
(Source: Constructed by the researcher)

Regular maintenance of soundscape: Regularly evaluate the characteristics and changes of the soundscape of Yingying Tower to provide dynamic data for soundscape optimization. Establish a tourist feedback mechanism to collect tourists' feelings and suggestions on the soundscape and form a feedback mechanism. This feedback information will be used to continuously optimize the soundscape design to ensure that the soundscape experience meets the expectations and needs of tourists.

Discussion

This study aims to evaluate the soundscape satisfaction and optimization strategies of the Yingying Pagoda at Pujiu Temple in Shanxi Province, revealing the relationship between the soundscape and tourist satisfaction, and proposing feasible optimization plans. By specific design strategies, this research guides how soundscape design can promote the harmonious coexistence of tourist satisfaction and Buddhist cultural heritage. The innovations of this study include: (1) Multidimensional integration of methodology: Combining field investigations, interviews, questionnaires, and simulations, a panoramic framework for soundscape analysis is constructed. (2) Integration of soundscape and culture: This study considers the combination of soundscape and Buddhist cultural connotations, exploring its role in cultural heritage. (3) Specific soundscape optimization plans and measures: Based on sound field simulations, optimization suggestions such as wall material selection, listening position adjustment, landscape element integration, and regular maintenance are proposed. This paper provides a research basis for the optimization design of Buddhist temple soundscapes.

Comparison with Previous Research: (1) Relationship between Soundscape and Tourist Satisfaction: Compared to the studies by Wang et al. (1994) and Mo et al. (2004), this study not only focuses on the physical characteristics of the soundscape but also delves into the psychological and socio-cultural connections between soundscape and tourist satisfaction. Our findings emphasize the importance of soundscape design in enhancing the visitor

experience, echoing the cultural value of Buddhist temple soundscapes proposed by Liu (2013). (2) Integration of Soundscape and Cultural Heritage: In contrast to Zhang et al. (2017) who studied the soundscape of Tibetan Buddhist temples, this research emphasizes the harmonious coexistence of soundscape with Buddhist cultural heritage. The optimization strategies proposed aim to protect and promote Buddhist cultural heritage while improving tourist satisfaction, aligning with Liang (2022) who discussed the social efficacy of Buddhist ritual music. (3) Effectiveness of Soundscape Optimization Measures: Through sound field simulations, the optimization measures proposed in this study show potential effectiveness in enhancing soundscape satisfaction. This is consistent with Peng et al. (2002) who studied the application of acoustic design software ODEON in engineering, confirming the practical value of simulation technology in soundscape design.(4) Cultural Sensitivity in Soundscape Design: This study highlights the importance of considering cultural sensitivity in soundscape design, resonating with Yan et al. (2024) who studied the role of wood materials in indoor acoustic regulation. Our research further expands this concept, exploring how cultural elements influence the perception and evaluation of soundscapes.

Future Research Directions : (1) Universal Exploration of Soundscape Design: Apply the findings of this study to other Buddhist temples or cultural sites to explore its applicability in a multicultural geographical environment.(2) In-depth Integration of Technology, Art, and Culture: Combine soundscape technology with art and local culture to create immersive soundscape research with social and cultural significance.(3) Continuous Tracking Mechanism: Monitor the long-term effectiveness of optimization measures and evaluate their impact on tourist satisfaction and Buddhist cultural heritage.

Through these discussions, this study not only provides an empirical basis for the optimization design of soundscapes but also points the way for future soundscape research, especially in the context of Buddhist cultural heritage(Figure 7).

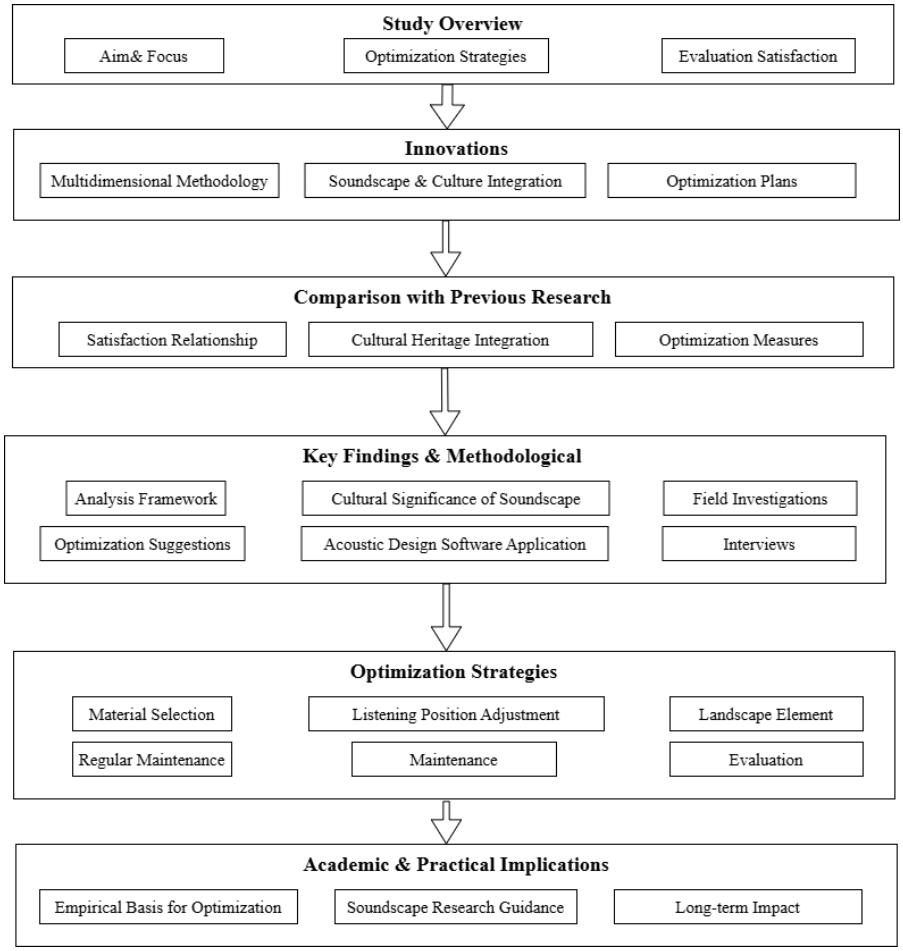


Figure 7 Research process mind map
(Source: Constructed by the researcher)

Recommendations

1. Theoretical Recommendations

(1) Interdisciplinary Research Framework for Soundscapes: It is recommended that future research adopts an interdisciplinary approach to further understand the complexity of soundscapes, integrating theories and methods from acoustics, psychology, sociology, and cultural studies. (2) Quantitative and Qualitative Analysis of Soundscape Perception: Researchers are encouraged to use mixed-method studies that combine quantitative data with qualitative descriptions to comprehensively assess the impact of soundscapes on tourist experiences. (3) Impact of Cultural and Religious Backgrounds on Soundscape Perception: In-depth studies are suggested to explore how people perceive and evaluate soundscapes under different cultural and religious contexts, and how these perceptions influence their satisfaction and behavior.

2. Policy Recommendations

(1) Cultural Heritage Protection and Soundscape Management: Policymakers should consider integrating soundscapes into cultural heritage protection, developing appropriate conservation and management strategies. (2) Standards and Guidelines for Soundscape Design: It is recommended to establish standards and guidelines for soundscape design to provide guidance for urban planners and designers, aiming to create more harmonious and satisfying public spaces. (3) Public Participation and Education: Policymakers and managers are encouraged to enhance public awareness of the value of soundscapes through public participation and educational activities, promoting community involvement in soundscape planning and management.

3. Practical Recommendations

(1) Best Practices in Soundscape Design: Based on the findings of this study, it is recommended that best practices be adopted in design practices, such as selecting appropriate materials, optimizing listening positions, and integrating landscape elements to enhance the overall quality of soundscapes. (2) Continuous Monitoring and Evaluation of Soundscapes: A regular monitoring and evaluation program for soundscapes is recommended to track changes and make adjustments based on tourist feedback and satisfaction data. (3) Application of Technology and Innovation: The use of new technologies and innovative methods in soundscape design is encouraged, such as acoustic simulation software, interactive sound installations, and environmental sound art, to enhance the visitor experience. (4) Inter-departmental Collaboration: It is suggested that tourism departments, cultural heritage institutions, and urban planning departments establish collaborative relationships to jointly advance the optimization of soundscapes and the protection of cultural heritage.

Through these theoretical, policy, and practical recommendations, the development of soundscape research can be further advanced, and more effective management and design can be implemented in practical applications to enhance visitor satisfaction and protect cultural heritage.

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