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Soundscape as a Tool for Place-Making in Industrial Heritage Sites

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***Abstract*—Soundscape plays a crucial role in place-making at industrial heritage sites, enhancing visitors' understanding of the site's heritage value. This study investigates public attitudes towards industrial heritage site soundscapes and analyzes the impact of sound-based place-making, using the Museum of Industrial Heritage in Bologna, Italy as a case study. Field research and questionnaires were employed to gather data. Findings reveal a positive reception among the public towards soundscape design in heritage sites, highlighting its numerous advantages. Soundscapes not only enhance visitors' perceptions and attractiveness of heritage sites but also establish a sensory connection between individuals and the heritage environment. Moreover, soundscapes enrich the visitor experience by simulating authentic sounds, creating an immersive atmosphere, and deepening the sense of presence. To facilitate effective soundscape design, a design strategy for industrial heritage sites is proposed. It emphasizes public perception, interactive elements, control of decibels and disturbances, and the creation of rich and realistic soundscapes. The empirical analysis underscores the positive influence of soundscapes on place-making in industrial heritage sites, reinforcing the connection between tangible and intangible heritage while preserving authenticity and integrity.**

Keywords—soundscape, industrial heritage, place-making, industrial heritage museums

I. INTRODUCTION

Soundscape encompasses the study of acoustic ecology or soundscape ecology, concentrating on the formation and production of sounds or combinations of sounds in immersive environments [1]. The term, which was first used in 1969 and coined by urban planner Michael Southworth, initially referred to the acoustic characteristics of urban spaces that helped people form connections with locations. However, as soundscape research gained popularity, it began to cover a wider range of topics, including music, sociology, the environment, and architecture. The introduction of soundscapes within the World Soundscape Project (WSP) by R. Murray Schafer in 1997 broadened the definition of soundscapes to include all aspects of the acoustic environment, thereby stimulating the development of soundscape studies [2]. In 2014, the International Organization for Standardization (ISO) established a standardized definition of soundscape, describing it as the acoustic environment perceived, experienced, and understood by individuals within a contextual framework, with potential influence on the soundscape through auditory sensation, interpretation, and responses to the acoustic environment [3].

The field of cultural heritage has recently become more and more of a focus of soundscape research and application [4], [5]. The acoustic environment in perceptual memory is enhanced and the public's understanding of heritage is expanded by turning soundscape design into a process of creating sound places. Industrial heritage, as a significant facet of cultural and architectural heritage, serves as a tangible testament to the history and development of local industrial culture, contributing to the preservation of heritage and the spiritual continuity of local communities. The conservation of industrial heritage holds immense importance, and the introduction of soundscapes into its preservation efforts offers a unique opportunity. When soundscapes are incorporated into the preservation of industrial heritage, they can complement and enrich the preservation process by shifting the emphasis from the exterior's purely structural aspect to a multisensory experience.

In practice, the use of soundscapes in industrial architectural heritage is widespread, exemplified by their application in museums for guided tours and the restoration of historical sounds at heritage sites. These soundscape interventions not only enhance public interest and understanding of the site but also establish a sensory connection between individuals and their environment, thereby creating a distinct sense of place for the heritage site through localized sound interventions [6]. Thus, the integration of soundscapes into the placemaking of industrial heritage sites assumes a paramount significance in the context of heritage conservation from the perspective of acoustic research.

This paper aims to examine the impact of soundscape interventions in industrial heritage sites on place-making and visitor experience, underscoring the significance of research in this domain. Through a combination of case studies and research conducted on industrial sites, this study illustrates the influence of soundscapes on public perception and the overall place experience. As a result, it illustrates the beneficial role that soundscapes can play in the development of industrial heritage sites, making contributions to the fields of place-making and heritage preservation.

II. RESEARCH REVIEW

After a brief introduction to the background and concepts of the study. In this chapter, we aim to provide a comprehensive understanding of the concepts discussed in the introduction, particularly focusing on the role of soundscapes as a tool for placemaking in industrial heritage sites. To achieve this, we will continue to delve into existing research that explores the relationship between soundscapes and industrial heritage.

A. Soundscapes and Industrial Heritage

The preservation and conservation of industrial heritage have traditionally focused on physical objects and landscapes, neglecting the crucial aspect of sound. However, it is imperative to recognize the significance of sound

conservation within the industrial heritage and explore new approaches in this regard [6]. Industrial heritage sites are characterized by open workshops or factories with mechanical equipment, and their materials, such as concrete, glass, and steel, are prone to reverberation effects, making sound an integral part of the site's ambiance [7].

The combination of soundscape and architecture gives rise to the concept of spatialized sound, which influences listeners' perception of space through auditory experiences [8]. By incorporating soundscape design into heritage sites, it is possible to optimize historical and cultural spaces and enhance the quality of life within the surrounding region [9]. In the context of industrial heritage, soundscape serves as a tool that evokes the auditory character of the industrial past and establishes a connection between sound and heritage sites [2]. This tool plays a vital role in conveying historical narratives, enriching visitors' understanding of the site's heritage values, and strengthening the link between tangible and intangible aspects associated with industrial heritage. Utilizing spatialized sound as a medium, it becomes possible to evoke the public's memories of industrial history and post-industrial heritage, employing both environmentally sound approaches and personal narrative approaches to endow industrial sites with spatial meaning [10], [11]. This integration enhances the public's emotional connection and cultural understanding of the sites.

The feasibility of integrating soundscapes into industrial heritage is demonstrated through practical examples. One such example is the collaborative project "Voices of Change" undertaken by six European museums, which aims to document and preserve endangered or disappearing sounds in industrial societies. To date, the project has collected 1,604 sounds, established a specialized sound database of industrial heritage, and provided a strong foundation for cultural heritage conservation and site-specific soundscape design. Furthermore, ongoing practical projects, such as the European Cultural Education Programmer's call for projects on "Architectural Sites in Motion - Soundscapes for Industrial Heritage," actively seek sound-related artists and architects worldwide to enrich the tangible and intangible heritage associated with industrial archaeology. These endeavors, combining theory and practice, contribute to deepening research and understanding of the relationship between soundscapes and industrial heritage, while showcasing their immense potential when combined. These practical initiatives serve as effective drivers for research related to soundscapes as a tool for heritage conservation and placemaking.

B. Placemaking and Industrial Heritage

The concept of placemaking, introduced in 1960 by journalist Jane Jacobs and urban planner William H. Whyte, encompasses the planning and design of public spaces, aiming to create high-quality places where people desire to live, work, play, and learn. It closely relates to the concept of a "sense of place" and revolves around the active improvement of spaces beyond merely attracting attention or people [12]. Placemaking strives to create quality public spaces that promote happiness, health, and well-being, placing the community at its core. It inspires collective reimagining and reshaping of space while emphasizing the human connection to place [13]. Furthermore, placemaking emphasizes the significance of public space and public assets, which, akin to heritage, belong to the commonwealth of humanity. Placemaking within the context of heritage offers opportunities for the public to reassess and reevaluate sites [14].

Early placemaking efforts in heritage sites aimed to restore identity, preserve heritage, and enhance the aesthetic quality of urban spaces [15]. Presently, placemaking in heritage revolves around the creation of appealing heritage places through the incorporation of local identity, sense of place, image, and experiential aspects [16]. Within industrial heritage, placemaking assumes a more profound experiential process, strengthening social cohesion, and cultural identity, deepening understanding of the site's industrial heritage, and enhancing people's sense of place within the heritage site [17] [18]. Additionally, placemaking in industrial heritage contributes to the economic well-being of the site by attracting visitors and generating economic benefits, among other advantages.

Numerous placemaking projects utilize industrial heritage sites as practical sites for implementation. An illustrative example is the Alcova section of Milan Design Week 2023, where a disused abattoir has been created as an exhibition space through interventions in industrial heritage spaces. This creative endeavor enhanced the experience of the place while also generating economic benefits for the site. Many similar practical studies translate the concept of placemaking into tangible projects involving local activities. By examining past experiences and establishing a theoretical foundation, valuable insights can be gained regarding the intersection of industrial heritage and placemaking, expanding our understanding of these fields.

C. Soundscape Creation in Industrial Heritage Sites

Previous research on placemaking in soundscapes has primarily focused on religious buildings, theaters, and museums, while neglecting other types of buildings, including industrial heritage sites. Integrating soundscapes into the creation of industrial heritage can enrich the practice of designers and heritage practitioners [19]. One of the primary objectives of placemaking in industrial heritage sites is to enable and activate public participation. Soundscape interventions facilitate participants in connecting their personal experiences with the heritage site, fostering a deeper connection, and encouraging imaginative reflections on the space. This contributes to the spatial activation of the site[20].

The integration of soundscape design into the conservation and reuse of industrial heritage offers a novel approach to placemaking. By designing soundscape elements that recreate the ambiance of the site's industrial past, the storytelling and authenticity of industrial heritage can be enriched, providing an immersive experience for the public. Soundscapes in industrial heritage creation can be categorized into indoor and outdoor soundscapes. Outdoor soundscapes encompass natural sounds like weather and sounds from plants or animals, as well as sounds from outdoor transportation. Indoor soundscapes, on the other hand, include sounds from ventilation systems, operating machinery, ambient noise, communication, or audio guide presentations. Enriching the soundscape through the design of different sound elements contributes significantly to the placemaking of industrial heritage sites.

In practice, soundscapes are commonly employed, albeit on a relatively small scale, particularly in industrial heritage museums. For example, at the Humber Stone Nitrate Mine site in Chile, designers simulated the sounds of a past grocery shop

by utilizing acoustic recordings and model scene recreations. This approach created a soundscape that evoked the sounds and conversations of the historical grocery shop, progressively establishing a shared memory for viewers and fostering an emotional connection between the scene and the public. The integration of soundscape design and industrial heritage placemaking not only enhances the spatial environment of the heritage site but also enriches the overall experience of the visiting public.

III. Methodology

Following the comprehensive exploration of theoretical concepts and relevant research on soundscapes, Chapter 3 shifts its focus toward the practical aspects of this study. The chapter employs a combination of case study methodology and questionnaire design is used in this chapter to set the scene for an in-depth exploration of the complex relationship between soundscapes and industrial heritage.

A. Case Study

The case study of this research to the Industrial Heritage Museum, (Museo del Patrimonio Industriale di Bologna) located in Bologna, Italy. Positioned alongside a navigable river within the northern suburbs of Bologna, the museum underwent a transformative conversion process from a brick factory. Originally erected in 1887, it held the distinction of being Bologna's largest brick factory, accommodating 250 workers and facilitating the year-round operation of 16 Hoffmann kilns. Subsequently, in 1966, the brickworks ceased production and was subsequently acquired by the Bologna government. Between 1984 and 1990, extensive renovations were undertaken to reconfigure the brickworks into a museum, ultimately integrating it into the museum department of the Bologna municipality.

At present, the museum encompasses a vast expanse of 3,500 square meters, spanning three floors and six aisles. Its primary objective revolves around the study, documentation, and dissemination of the productive history associated with the city of Bologna and its surrounding territory. Within this context, the museum elucidates the remarkable productive prowess that Bologna has exhibited throughout the past five centuries. The showcased historical trajectory encompasses diverse realms, ranging from the ancient production of silk through the utilization of a sophisticated electrical distribution network to the advent of mechanical and mechatronic production during the twentieth century. The museum's exhibition space accommodates a wide array of artifacts, including machines, models, working models, exhibits, laboratory equipment, and scientific instruments. To augment the narrative journey, the museum employs scenic installations, interactive structures, slide projections, multi-screen displays, and documentary films. An intriguing facet of the museum lies in its integration of soundscape design, whereby the auditory dimension complements the exhibitions. For instance, （ Fig. 1 ） showcases several authentic production machines housed within the museum, predominantly emphasizing the developmental and production processes associated with product ingredients, packaging, and wrapping in Bologna spanning the 1940s to the 1960s. Upon proximity to these machines and subsequent activation through a designated button, visitors are granted a visual and auditory encounter with the operational machinery, accompanied by realistic mechanical sounds. This immersive experience enables the public to observe the intricacies of the production process and heightens their sensory perception on an aural level. Furthermore,（ Fig. 2） captures a watermill weaving machine situated on the museum's second floor, replicating a device once utilized within a Bologna silk factory during the period spanning the 14th to 18th centuries, harnessing the power of a water wheel. By activating the demonstration button, visitors are allowed to perceive the scenes and sounds of water flowing through the mechanism, thereby fostering an ambiance that accentuates the physical and perceptual environment of the historical context. Consequently, the museum's design of the soundscape cultivates a multi-sensory user experience that captivates and engages its audience. The Industrial Heritage Museum, serving as an emblematic exemplar of practical soundscape design implementation, assumes a representative and characteristic role within this research, thus meriting its selection as a compelling case study for detailed analysis.

Fig. 1. Production scene of packaging machines in the museum.

Fig. 2. Water mill textile machine production scene in the museum.

To comprehensively investigate the sound environment within the case museum, this study conducted field research to collect and record the decibel values in each spatial area of the museum. The sounds within the museum were captured using recording devices to gain a deeper understanding of the industrial heritage site. Through analysis, the relationship between soundscape and industrial heritage was further explored.

The planned heritage site became more comprehensive, resulting in a more complex landscape system. The soundscapes within the industrial heritage museum can be broadly categorized into two types. The first type comprises deliberately designed soundscapes, such as interactive

simulations of machine production, the sound of silk weaving machines, documentary soundtracks played in the screening hall, audio guides, and background music in certain areas. The second type consists of natural or non-designed soundscapes, including the noise from exhaust fans, the sound produced by air conditioning systems, conversations among visitors, footsteps on the steel stairs, bird chirping outdoors, and the sound of wind. To facilitate measurement and recording, functional areas were combined with specific locations, dividing the measurement areas and points. The "Decibel Meter" app was primarily used during the measurement process. This app is capable of measuring soundscapes within the range of 0 to 110 dB, which aligns with the decibel range of the industrial heritage museum. It accurately measures the average decibel value within a 10-second timeframe. Overall, in the three-story exhibition space of the museum, the first floor comprises the entrance ticket area, model displays, and interactive simulations of machine production. The overall decibel values are relatively high, reaching a maximum of 84 dB when visitors activate the simulated production devices. The lowest value, 48 dB, is recorded when all simulated production devices are inactive. The second floor primarily showcases motorcycles and features an open conference room as the main functional area. In proximity to the audio guide area, the highest decibel value is 50 dB, while the lowest decibel area reaches 47 dB. The top-floor exhibition focuses on water-related industrial production, including displays of water-powered textile machinery and other production equipment, as well as two screening halls. The highest decibel value is recorded in the interactive water-powered textile machinery area, reaching 79 dB, while the lowest is 48 dB within the space. In addition, there are two staircases connecting the 0-2 floors. The stairs, made of metal, produce footsteps of 53 dB when visitors traverse them to access other floors. When the elevator operates, the sound reaches 63 dB. Additionally, the sounds of birds chirping and wind can be heard outside the glass windows. The collected sounds were classified into four categories based on their decibel values. Sounds above 70 dB mainly originated from simulated production machines. In the 60-70 dB range, it includes audio guide devices and sounds surrounding the simulated machines. The 50-60 dB range consists mainly of video narrations and documentary soundtracks. Sounds between 40-50 dB primarily come from areas distant from machine noises and conversations among visitors, as shown in （Fig. 3）. The industrial heritage museum's soundscape design demonstrates its unique characteristics and representativeness, making it an exemplary case for analysis.

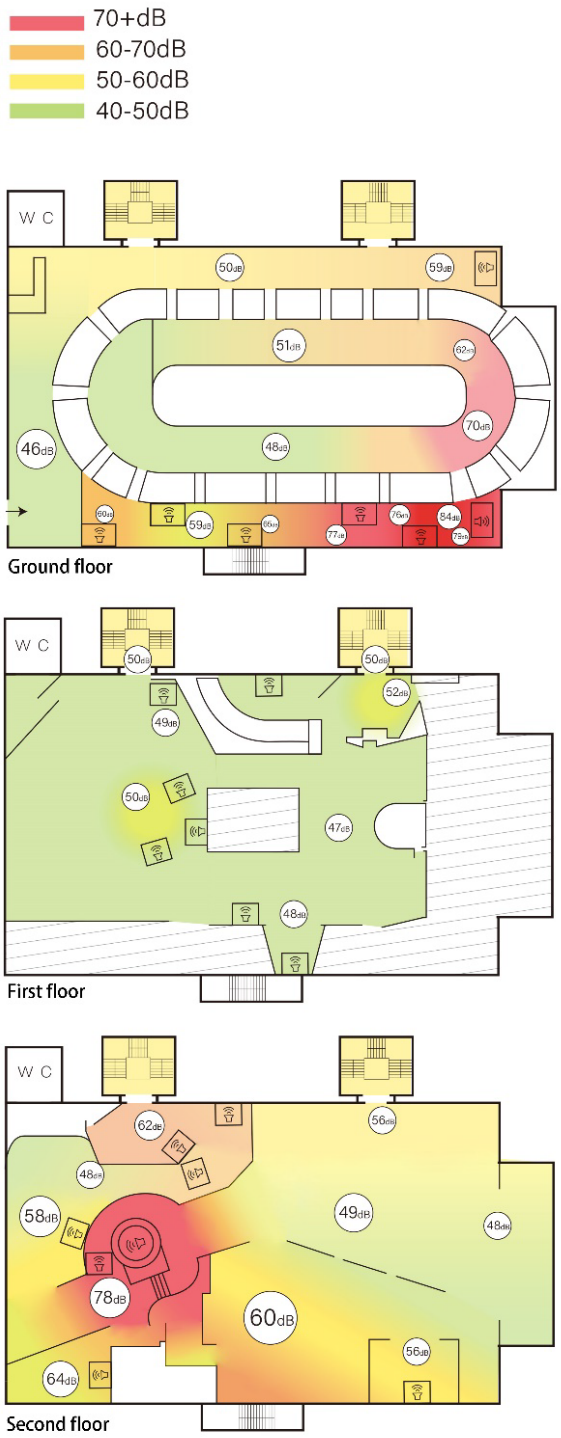

Fig. 3. Decibel values by area in the Industrial Heritage Museum

B. *Survey Methodology*

In this research, the methodology employed a questionnaire survey to investigate the public perception of soundscape design within an industrial site. The survey was administered on 14 May 2023, between the hours of 10 am and 4 pm, at the Museum of Industrial Heritage situated in Bologna, Italy. Visitors to the museum were invited to partake in the survey, wherein they were requested to rate the provided questions utilizing a five-point Likert scale. This Likert scale encompassed five levels, with levels 1 and 2 indicating negative feedback, with level 1 denoting a stronger negative sentiment than level 2. Level 3 represented a neutral attitude,

while levels 4 and 5 corresponded to positive feedback, with level 5 reflecting a stronger positive response than level 4. The collected data underwent analysis, and the mean value for each question was computed to evaluate visitors' perspectives concerning the implementation of soundscapes within the Industrial Heritage Museum.

IV. Results

The study received a total of 45 responses, with 22 completed by visitors from countries such as Greece and the Netherlands using the English version of the questionnaire, and 23 completed by Italian visitors from cities such as Rome and Sicily using the Italian version. Among these responses, 20 were provided by male participants, accounting for 44% of the total, while 25 responses were provided by female participants, constituting 56% of the total.

Regarding Question 1, which addressed the participants' awareness of sounds within the museum, including sounds produced by weaving machines, operating machinery for packaging products, and audio guides, the mean value obtained was 4.61, indicating that participants found such sounds to be highly noticeable. Question 2 examined the participants' emotional response to the sound of machinery running. With a mean score of 4.38, participants expressed a considerable level of interest when exposed to the sound of machinery, ranging from "not at all" to "strongly interested. “When considering the association between the sound of machinery running and the perception of the past, as explored in Question 3, the mean score obtained was 3.88. This suggests a moderate level of association between the auditory experience and the participants' recognition of the historical context. The effectiveness of soundscapes in enhancing the visitor experience was evaluated in Question 4. The average score obtained was 4.5, indicating that participants perceived soundscapes to be highly effective in augmenting their overall experience within the museum. Inquiring about the impact of the soundscape on understanding the industrial heritage in the exhibition, Question 5 received an average score of 4.31. This suggests that participants generally agreed that the soundscape contributed positively to their comprehension of the industrial heritage showcased in the museum. Finally, Question 6 assessed the extent to which the soundscape contributed to the sense of place and atmosphere within the industrial heritage museum. The average score obtained was 4.57, indicating that participants strongly agreed that the soundscape played a significant role in shaping the ambiance and fostering a sense of place within the museum.

Overall, the findings of this study highlight the positive reception and perceived value of soundscapes in the Industrial Heritage Museum, as indicated by the participant's responses to the questionnaire.

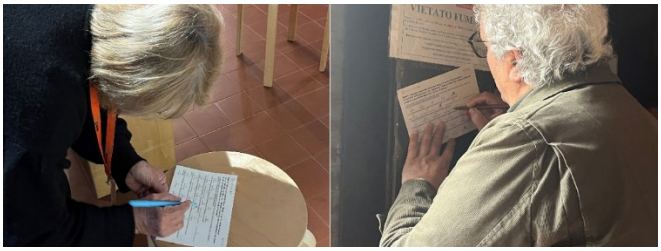

Fig. 4. Visitors' perception ratings of the soundscape

A. Soundscape Enhancement of Visitor Perception

The impact of soundscape interventions on visitor perception was assessed through questions 1, 2, and 3 in the questionnaire. The results indicate that the soundscape in the Bologna Industrial Heritage Museum has a strong appeal to visitors, as evidenced by the average score of 4.61 for question 1. Visitors notice the soundscape within the heritage site, including sounds produced by weaving machines, packaging machines, and other designed soundscapes. This finding emphasizes the significant role of soundscapes in capturing the attention and interest of the public, providing essential prerequisites for the implementation of soundscapes at heritage sites. Question 2 examined the public's emotional response when exposed to the designed soundscape at the heritage site. With an average score of 4.38, participants displayed a positive reaction and expressed a certain level of interest in the soundscape. This finding demonstrates the capacity of soundscapes to stimulate the senses of the public, heightening their interest in industrial heritage sites as part of the heritage creation process. It also highlights the potential of soundscape placemaking in transforming the environment into an emotionally evocative space, influencing the mood of the visitors [21]. Regarding question 3, the average score obtained was 3.88, indicating that when the public engages with a soundscape at an industrial heritage museum, they can associate it to some extent with scenes from past heritage sites. Although the strength of association may vary among individuals due to visual factors, the emotional state of the public, and other factors, resulting in lower scores, it nevertheless demonstrates that the soundscape of a heritage site is linked to the public's past experiences, memories, and imaginative interpretations of the site. This further deepens the public's perception and emotional connection to the heritage site, thereby achieving a place-making effect.

Overall, the findings indicate a positive and highly perceived perception of the soundscape by the public. Soundscape interventions at industrial heritage sites effectively enhance the public's perception of these sites. By creating space and intervening with visitors, soundscapes establish a sensory connection between individuals and the environment, creating a sense of place within the industrial heritage site. These findings underscore the positive role of soundscapes as place-making tools for industrial heritage sites and their impact on enhancing public perception.

B. Soundscapes Enrich the Experience of Place

Questions 4, 5, and 6 in the questionnaire examined the impact of soundscape interventions on the public's experience of place. The results revealed that the incorporation of soundscapes positively influences the visitor experience, as indicated by the average score of 4.5 for question 4. The intervention of soundscapes contributes to a more engaging and enriching experience for visitors at heritage sites, further enhancing the overall visitor experience. Through the creation of soundscapes, visitors can quickly immerse themselves in the atmosphere of the industrial heritage site, establishing a connection with the heritage environment through their auditory senses and establishing a bond with the spatial surroundings. This enhances the overall quality of the visitor experience. Question 5 received an average score of 4.31, providing additional evidence of the significant role played by soundscapes in creating immersive scenes at heritage sites. While traditional forms of viewing heritage models may struggle to fully convey the process of industrial production,

the incorporation of soundscapes brings the heritage site to life through auditory stimuli, significantly enhancing the public's understanding of the scenes and historical narratives presented at the site. By providing an enjoyable and interactive experience, the public can engage in a deeper and more comprehensive exploration of the industrial heritage site, gaining a clearer interpretation of its industrial history. Furthermore, the intervention of the soundscape stimulates interest and curiosity, prompting the audience to actively contemplate the mechanisms of industrial heritage and deepen their understanding of these sites. Question 6 yielded an average score of 4.57, indicating that the public possesses a positive attitude towards the sense of place and atmosphere created by soundscapes in industrial heritage sites. During the questionnaire collection process, the public was provided with an understanding of soundscapes as "acoustic environments that are perceived or experienced and or understood by people in context" [22]. The creation of soundscapes within spaces complements the heritage of the past, aids the public in interpreting the visual aspects of the heritage, and facilitates a better integration of the public into the environment created. Through the perception and engagement with the soundscape, the public gains a deeper sense of the historical context and cultural significance carried by the heritage site. The design of the soundscape also enhances the visitor experience, providing a more immersive encounter and promoting public interaction while contributing to the placemaking of the industrial heritage site.

Overall, the soundscape enriches the visitor experience at the industrial heritage site. The introduction of soundscapes creates a more multifaceted and nuanced sensory experience for visitors, deepening their perception and emotional connection to the heritage site. Through the creation of soundscapes, the public can perceive and experience the unique qualities of industrial heritage sites more diversely, resulting in a richer, more captivating, and more meaningful visit. These findings provide evidence of the important role played by soundscapes in enhancing the visitor experience and conveying heritage values when utilized as place-making tools for industrial heritage sites.

V. Design Strategies

By analyzing and researching the soundscapes in industrial heritage sites, valuable insights and areas for improvement can be extracted. Therefore, these issues can be discussed as design strategies with the aim of further enhancing the effectiveness and experience of soundscape design within industrial heritage sites, while also providing references for soundscape design in other industrial heritage contexts.

Firstly, the primary objective of soundscape design in industrial heritage sites is to ensure that the public can hear and fully perceive the designed soundscapes. To achieve this goal, designers can employ sound positioning strategies to immerse visitors in the process of scene creation. By creating more realistic and immersive soundscapes, the perception and experience of visitors can be heightened. During the soundscape design process, designers should consider the visitor's route and place sound systems or sound-emitting devices in appropriate locations along the routes. Additionally, incorporating sound landmarks or audio guide systems can guide visitors to specific points of interest or exhibition areas, effectively integrating them into the scene. Furthermore, the introduction of expressive sound elements can greatly enhance the atmospheric effects of the soundscape. Unique sound effects, sound fragments, ambient music, and other means can be employed in the design process to create distinctive and appealing scene atmospheres and experiences. By introducing innovative and creative sound elements, visitors' sensitivity to sound can be heightened, providing them with a richer sensory experience.

Secondly, enhancing public engagement and enriching the experience of the place are important considerations in soundscape design. Designers can introduce more interactive elements to enhance user experiences and the effectiveness of the soundscape. For example, in the Bologna Industrial Heritage Museum, simulated production devices are triggered by user-operated buttons to initiate production simulations and generate sound effects. This approach allows visitors to actively participate in the creation of soundscape while enhancing their sense of engagement. Additionally, the application of new technologies offers new possibilities for enriching visitors' interactive experiences. Designers can incorporate interactive devices or equipment in the heritage site, allowing visitors to actively participate in the creation of the industrial heritage soundscape through user interactions and triggers. This interactive experience not only stimulates visitors' interest in the heritage site but also further enriches their overall experience, enabling them to gain deeper insights into the history, culture, and unique values associated with industrial heritage.

Next, attention should be given to controlling the decibel levels of the soundscape. When designing the soundscape, the placement of each sound-emitting device needs to be carefully considered to avoid interference with the sound effects of other devices. Taking the soundscape design in the Bologna Industrial Heritage Museum as an example, although analog production equipment requires visitors to trigger them with a button to activate the sound, optimal listening can only be achieved with a single device in operation. However, research has shown that the arrangement of soundscape devices in the museum site is dense, and multiple devices are often triggered simultaneously by different visitors, resulting in a chaotic sound effect within the scene. Some high-decibel production machines completely overshadowed the sound of smaller devices, affecting the overall atmosphere of the scene. Therefore, controlling the interference from other soundscapes becomes particularly important. Designers should ensure that the volume of the sound is moderate to allow visitors to hear the lower-volume sounds. For mechanical sounds, physical isolation measures can be considered, such as increasing the distance between devices, installing soundproof barriers, or using sound-absorbing foam, to reduce the noise transmission of mechanical sounds to other areas and maintain the clarity and audibility of the sound in the target area. For multimedia sounds, audio processing equipment or software can be utilized to enhance the decibel levels of lower-volume sounds, making them more prominent amidst ambient noise. Alternatively, providing personal audio devices such as headphones or personal audio guide systems allows visitors to be in an independent audio space, where they can adjust the volume according to personal preferences or choose whether to receive multimedia sounds, avoiding interference or conflicts with other soundscapes and ensuring that visitors can experience the soundscape in a comfortable and convenient environment

Lastly, designing richer and more authentic soundscapes can enhance the appeal and interest of the soundscape. In terms of increasing the attractiveness and amusement of the soundscape, designers can achieve this by introducing a diverse range of sound elements. These sound elements are not limited to mechanical operation sounds but also include other sounds related to the industrial heritage site, such as workers' conversations or the sounds of industrial equipment malfunctions. Diversifying sound elements can effectively enrich visitors' sensory experiences and the overall visiting process. However, when designing the soundscape, particular attention must be given to ensuring the authenticity of the introduced sounds in order to recreate the sound environment of the industrial heritage site as closely as possible, thereby enhancing its realism and quality. Consideration can even be given to implementing 3D spatial audio technologies to increase the sense of depth and atmosphere in the soundscape. Through such rich and authentic soundscape design, visitors can immerse themselves more effectively in the history and culture embedded in the industrial heritage site. In addition to achieving authentic and immersive soundscape design, the coherence of the soundscape is also of utmost importance. Taking the Bologna Industrial Heritage Museum as an example, the sounds heard along the visitor flow do not exhibit coherence. Narrations, music, and machine operation sounds are distributed across different sections, lacking a strong sense of continuity and completeness. Therefore, it is necessary to identify the core themes of the soundscape during the design process and differentiate them from secondary sounds to determine which sounds are crucial and prominent, and which sounds play a supporting and embellishing role. Additionally, the interaction between sounds in other areas should be considered complementary rather than chaotic or disruptive to the main soundscape. By conducting primary and secondary analysis and employing a diverse soundscape design, a soundscape with greater depth and clarity can be created, enhancing visitors' understanding and perception of the site.

VI. Discussion

This study explores soundscape as a tool for creating a sense of place in industrial heritage sites and validates the positive impact of soundscape through a comprehensive review of relevant research and on-site investigations conducted at the Industrial Heritage Museum in Bologna, Italy.

The research findings indicate that the creation of a soundscape plays a significant role in enhancing public visits to industrial heritage sites, particularly in terms of perception and place experience. At the perception level, the integration of soundscape captures visitors' attention and enriches their sensory experience, establishing a connection between visitors and the historical, cultural, and spatial context of the industrial heritage. Moreover, soundscape design within industrial heritage sites can evoke memories and emotions associated with the city's industrial development history to a certain extent. On the level of enriching the place experience, the introduction of soundscape enhances the authenticity and narrative of the visitor experience. By engaging the senses, it fosters an atmosphere conducive to place-making, increases public engagement and place experience, and ultimately cultivates a sense of place within the heritage site. Regarding soundscape design, this study proposes the following strategies: firstly, ensuring that the public can hear and fully perceive the designed soundscape; secondly, enhancing public engagement and enriching the place experience; thirdly, paying attention to the control of sound levels; and finally, designing more diverse and realistic soundscapes. In addition, during the implementation process, careful consideration should be given to the design of the auditory landscape, adhering to the historical and cultural background of the heritage and preserving its authenticity and integrity. It is crucial to ensure harmony between the soundscape of industrial heritage sites and other acoustic environments and to adhere to the principles of sustainable development. Furthermore, integrating new technologies and innovative forms into soundscape design can optimize its effectiveness in creating a sense of place within industrial sites.

Lastly, as a means of place-making, soundscape design should complement the protective measures of industrial heritage, jointly preserving its integrity and uniqueness. Attracting public visits to industrial heritage sites, contributes to the conservation and sustainable development of industrial heritage.

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