



Architectural Design Strategies to Enhance Acoustic Comfort in Modern Public Libraries: A Case Study of University of Birmingham Library

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Abstract

This study discusses the inclusion of acoustic comfort and methods into University library design. One of the primary focuses of acoustic theory and experimentation for decades has been to tackle architectural acoustic difficulties. Recent contributions from the soundscape method have emphasized broader positive aims that acoustic designers might pursue, such as fostering ecological thinking about the auditory system and its overall knowledge. This study exhibits the application of architectural acoustics and soundscape approaches into the area of architecture using references from literature, emphasizing the relevance of unique design conditions and auditory teaching tactics in learning situations. The study discovered that the inclusion of Acoustic comfort may be performed by architectural design rather than active measures, according to the conclusions of this study, and the literature review examines techniques of obtaining Acoustic comfort. This study investigates potential noise sources as well as techniques that may be implemented into the design of a public library to increase acoustic comfort. Noise sources include HVAC, ambient noise from outside the lecture room, low sound insulation building materials, and so on. The noise rating and the level of disturbances differed. Daytime sound pressure levels in the library vary depending on location, and most measurements exceed the suggested upper limit of 45 decibels. In addition to acoustic upgrades and library area classifications, it is proposed that a noise policy be developed for the library.

Keywords: *acoustic comfort, soundscape, ambient noise, university library, auditory system*

1. Introduction

Libraries require silence and cannot tolerate noise at any time of day. This is due to the fact that complete stillness is essential for understanding, skill development, and proofreading. Though libraries house book and non-book contents, modern libraries serve more essential functions as work, study, and meeting places, as well as low-cost public access points to the Internet and multimedia services (Markham, 2004). As a result, libraries and learning commons currently have more patronage than ever before, and additional physical facilities are frequently supplied to meet the demands of library customers. Environmental elements such as ventilation, noise, and physical amenities are likely to impact library use (Saka et al., 2012). Noise, in particular, has a strong potential to discourage library usage; in a learning setting, too little background noise can make even the smallest sound detectable, heightening distraction, while too much noise leads to low focus and discomfort (Hodgson and Moreno, 2008).

The explosion of modern practices in libraries has eventually resulted in the introduction of multiple types of sounds and sound sources, forcing architects and interior designers to rethink how to improve the user atmosphere in such spaces by dealing with the acoustic environment in a constructive rather than reactive manner. Controlling the sounds of various human movements and speech is particularly challenging in multi-function and modern spatial layouts with big open plan rooms. Acoustic specialists have advocated substantial separations between diverse jobs in some circumstances to lessen these auditory impacts, although this frequently conflicts with the architectural purpose of designing open-plan facilities. People visit libraries for a variety of purposes, including performances, children's programs, meeting new acquaintances, and eating lunch. Users now have varying expectations and perceptions of library rooms and their acoustic conditions, which traditional acoustic architectural techniques based on quantitative acoustic attributes cannot fulfill. Current acoustic architecture approaches try to provide accurate sound intensity thresholds and reverberation durations for target events by employing acoustic materials to record, disperse, and echo noises in surroundings, but they do not take user interactions into consideration. Such traditional techniques of acoustic comfort planning may be incapable of coping with behavioral noises, such as those produced by walking, laughing, flipping books, shifting seats, and so on, while also meeting growing user demands and the open-plan design of new public libraries.

A soundscape method, on the other hand, considers the human perceived acoustic ambiance of a site within its context and investigates acoustic comfort through empirical acoustic elements as well as human experiences. Meanwhile, this study contends that reading and learning are still vital purposes for libraries, despite the fact that they must include all of these seemingly conflicting acts in order to exist. It is critical to have 'suitable' soundscapes in sections of the Library where reading and learning take place. As a result, this study investigates the acoustic consistency of the University of Birmingham Library from a soundscape perspective, as well as design strategies for guaranteeing acoustic relaxation for reading and learning in multi-function, open-plan urban public libraries.

1.1 Area of Study

The new main library, which opened in September 2016, cost about £50 million and has several learning zones, such as informal seats, thinking spaces, and individual work places. The Library is brimming with modern spaces, colors, and high-quality settings. There has been a significant general increase in the amenities for students who are eager to learn in the twenty-first century, including adaptable charging stations, a café, silent study zones, and a media center with video editing booths. The University Library is one of the UK's major academic libraries. It has a remarkable research collection, which includes 2.7 million volumes and scholarly magazines, as well as over 16,000 internet resources. The materials are generally housed in the Main Library, although subject-specific site libraries for medicine, fine art, and dentistry are also available.

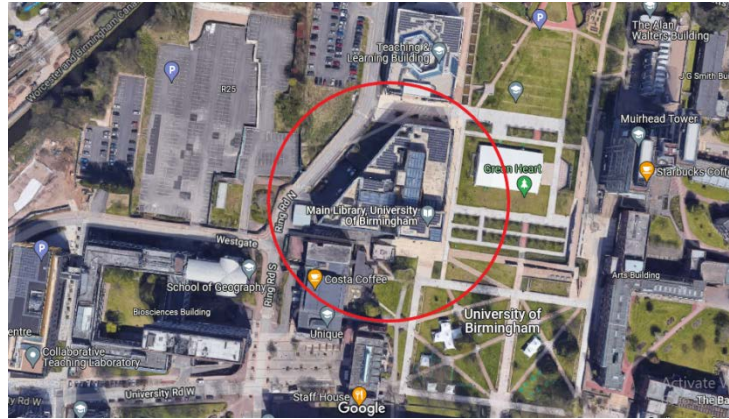


Figure 1: Location map (image source: Google Maps)

2. Literature Review

2.1 The significance of proper library acoustics

Libraries are more than simply book collections and academic journals; they play a vital role in cities and villages, colleges and universities, basic schools, and significant corporations. Libraries are as popular as they have always been, with a rising need for low-cost public Internet access and multimedia services. With so many different resources available in today's libraries, acoustic comfort is crucial, especially when libraries are crowded not just with people but also with loud technology (printers, copiers, and beeping bar-code scanners to name a few). Library designers and architects have long recognized the need of large open areas for people to stretch out, read, learn, or simply rest. Aside from the aforementioned library user spaces, libraries typically feature administration and user service facilities (e.g. reference desks, circulation desks, copy rooms, computer clusters, and other similar areas). These places are easily identified as noise-producing portions of the library, and they can have a negative impact on overall acoustic comfort, especially when placed in or near open study spaces in libraries. Acoustic comfort is essential for a library's success. What factors contribute to the acoustic comfort of a library? How can a subjective sense like "acoustic comfort" be assessed properly? What characteristics of library building design are required to ensure acoustic comfort?

3. Research Methodology: A Case Study of University of Birmingham Library

The dynamics of real-life events leading to soundscapes in a modern public library were investigated using a case study method. The Birmingham Public Library is located in the city center and was designed as a landmark to commemorate Birmingham's industrial background (see Figure 2). The remarkable presence and diversity of activities at Birmingham's Library attract a varied range of individuals, implying that the facility has a dynamic auditory atmosphere. With intuitive, natural circulation, a brief was designed that focused on the user rather than the collection.



Figure 2: Exterior photograph of University of Birmingham Library (image source: birmingham.ac.uk)

The Library of Birmingham is a typical example of a modern public library, featuring vast open-plan reading areas and a variety of activities such as a café, lecture rooms, a children's department, performance spaces, and so on. The areas are organized around a big atrium in the center of each level, which serves as a passive lighting, ventilation, and escalator access (see Figure 3). The Library contains 10 storeys, the top six of which include the Shakespeare Memorial Centre, staff offices, and places for keeping city cultural artifacts. Soundscapes were investigated for this study in the main Library space for reading and studying activities, which is located on the first four levels.



Figure 3: University of Birmingham Library Atrium (image source: birmingham.ac.uk)

The Ground Floor has the main welcome room, which has a double-floor height and houses a café, an open exhibition area, as well as circulation and waiting areas. The Lower Ground Floor houses children's materials and play areas, as well as access to the music and video collections. The primary reading and study areas are on the First and Second Floors.

Suspended metal acoustic baffles are installed above the perimeter study areas to prevent sound from entering the atria. Other study rooms differ in purpose from solo study, group workspaces, and silent study spaces, thus they are addressed locally with a combination of suspended baffles and acoustic ceilings to assist offer comfortable working environments for students. Overall, this case study suggests that it is useful to explore the acoustic environment of public libraries from a

soundscape perspective in order to understand which architectural solutions may be used to increase users' acoustic happiness in those places.

The overall consistency of the aural environment was judged by participants in this study based on their notions of space rather than the appropriateness of settings. Participants appear to have more stringent acoustic requirements for reading and imagining' areas than for 'interacting and conversing.' Meeting points, the reception room, the foyer, the guided research area, and the café are undoubtedly areas for 'interacting and talking,' but the silent study area and reading space are unquestionably spaces for reading and thinking.'

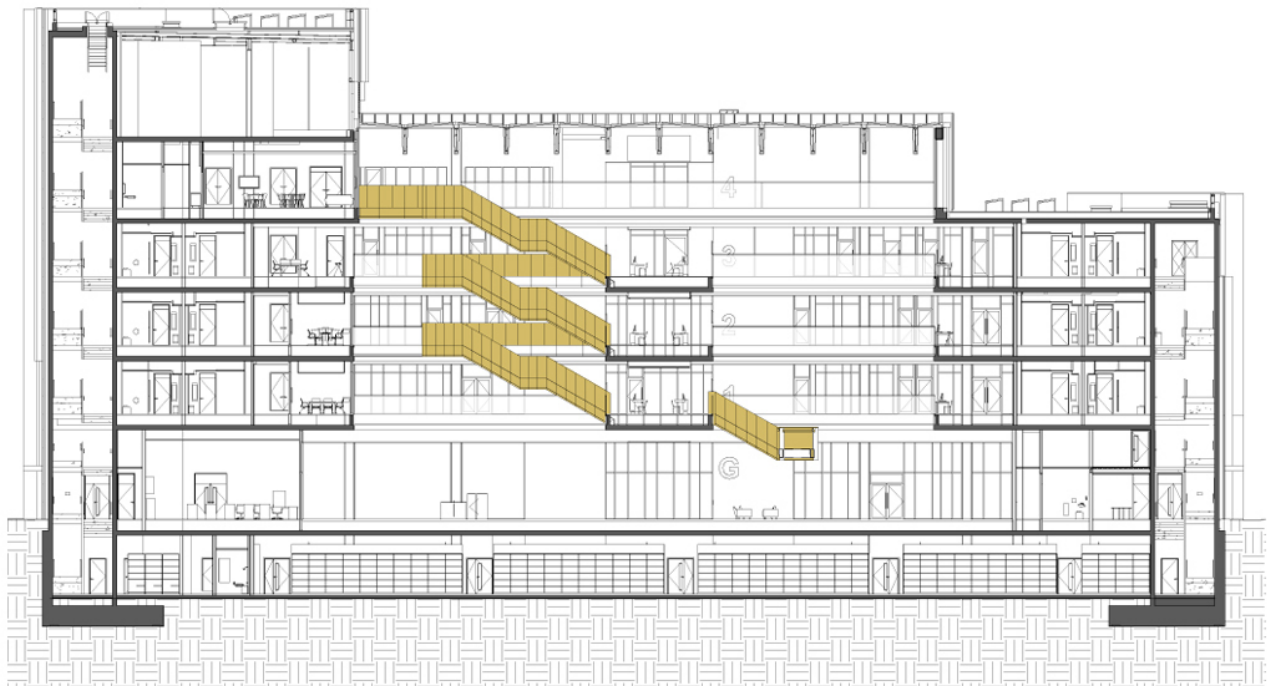


Figure 4: Technical section of University of Birmingham library (image source: Archdaily)

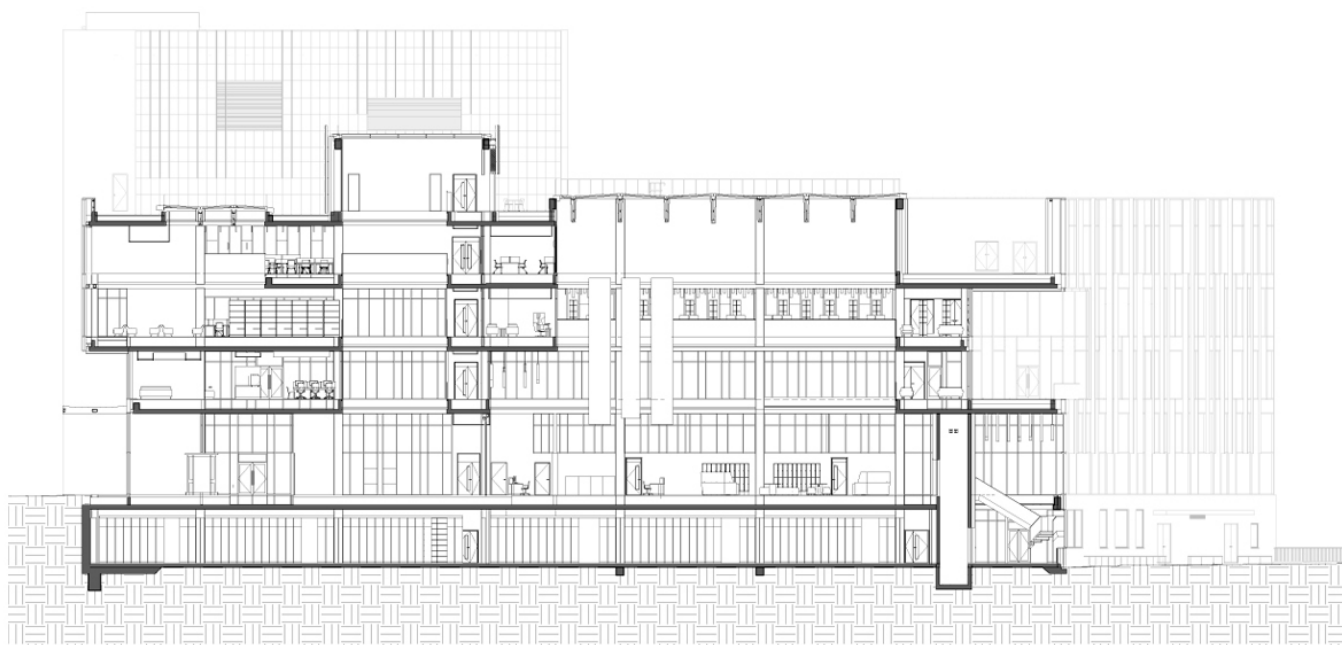


Figure 5: Technical section of University of Birmingham library (image source: Archdaily)

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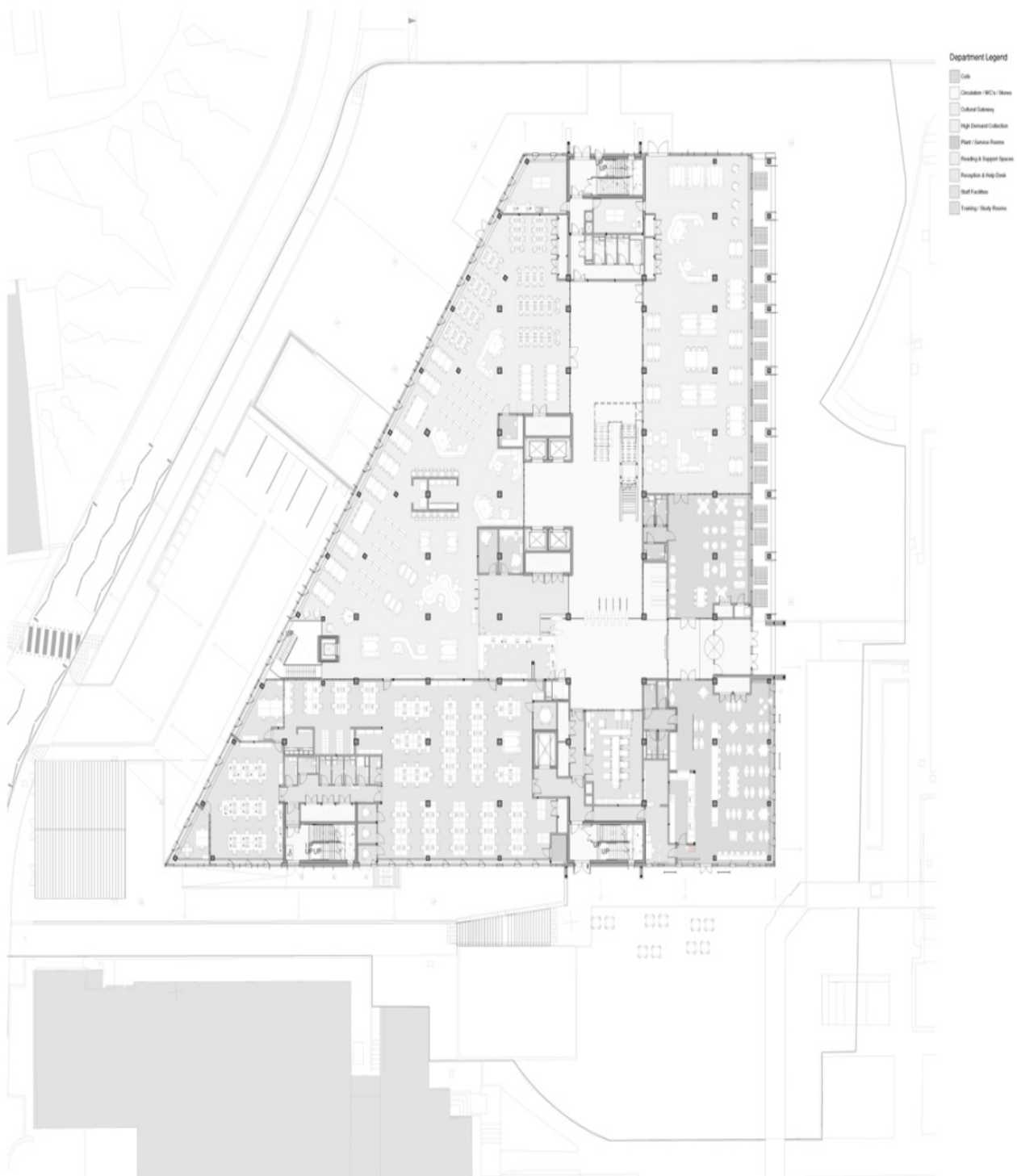


Figure 6: Ground floor plan of Birmingham library (image source: Archdaily)



Figure 7: First floor plan of Birmingham library (image source: Archdaily)

3.1 The acoustical structure of the Library

Sound source identification and recognition is critical in the soundscape method to understanding the acoustic environment. The acoustic structure of a library is determined by the kind of sounds heard and how dominating they are in vacuum. The Figure below displays the mix of sound sources experienced at each stop on all examined levels, with spoken and nonverbal noises identified more frequently, indicating a hearing environment dominated by human sounds. The sound source profiles on each level are summarized in Figure 8 by averaging the sound source dominance ratings from the various stopping positions.

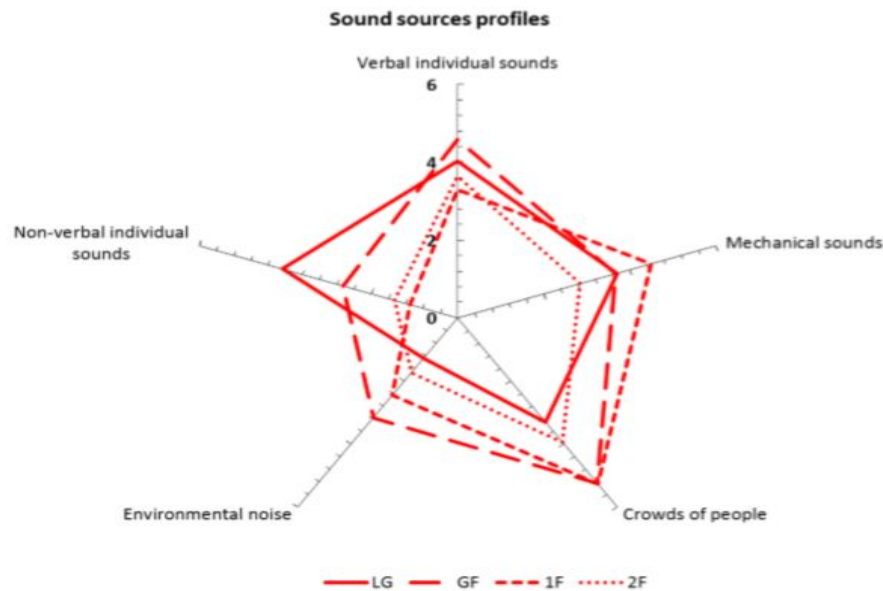


Figure 8: Aggregated Sound source profiles for each floor.

The arrangement of space is crucial for influencing people's behaviors and dividing various user groups to increase acoustic comfort, especially in big open-plan library rooms with few solid separations. Hierarchizing sonic spaces is a method of organizing library areas to create a suitable sound environment. According to the findings of this study, identifying acoustic places in big open-plan public libraries by types of sounds or sound pressure levels is challenging since they were shown to be comparable across all stops and levels. Visual differentiation is another kind of zoning, which involves employing distinct patterns and colored acoustic materials on surfaces to suggest different cognitions of spaces, such as screens, walls, floors, and ceilings. People's preferences for specific sounds and the overall soundscape are influenced by the visual aesthetics of their physical environment. Colors, in example, have been found to affect many psychological emotions, acoustic expectations, and perceptions: red denotes a noisy setting, whereas blue represents a calmer and quieter atmosphere. Carpets can be used to minimize noise from footfall, patterned acoustic foams on walls, acoustic wood slat panels, metal decks, tiles, and baffles on ceilings can be used to absorb noises and reduce reverberations in libraries.

The visual appearances of these acoustic materials influence various acoustic cognitions. Treated wood slat panels, for example, provide a warm color and a homey environment, while aluminum acoustic tiles provide a white neutral color and a modern finish, and colorful suspended acoustic baffles provide a creative and lively mood. To reinforce the illusion of zoning and to control people's pathways in vast open-plan rooms, the shapes and colors of carpets on floors must also match the colors and patterns of the ceilings. A soundscape approach would enable architects and interior designers to investigate user experiences and design for a high-quality acoustic environment in modern public libraries for both reading and other public activities. However, people's perceptions of acoustic environments may differ in different circumstances and alter when new design concepts and technologies emerge.

4. Results and discussion:

Acoustic comfort in public libraries is ensured by the following design measures.

Space layout is crucial for influencing people's behaviors and dividing various user groups to increase acoustic comfort, particularly in big open-plan library rooms with few solid separations. Arranging acoustic spaces in a Hierarchy is a strategy of structuring library spaces to provide a healthy listening experience.

1. An acceptable amount of background noise; and
2. A physical separation between noise-producing and noise-sensitive portions.
3. Adequate sound-absorbing substance dispersed throughout the space to provide a comfortable acoustic environment. These design options are strongly connected to the Articulation Index calculation results: a library room would have an acceptable low Articulation Index if these three design solutions were used.

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1. Library Background Noise Level

Background sound is required in an open-plan setting to mask unwanted and possibly disruptive speech and other disturbances. The intensity and spectral properties of the background noise should be suitable with its sound masking function: it should not be a distraction in and of itself. Background noise may be distracting if it includes too much low-frequency energy ("rumble"), too much high-frequency energy ("hiss"), or is excessively loud overall. Similarly, if background noise is dominated by intermittent or cyclical HVAC equipment that abruptly alters the noise level, it will become bothersome.

HVAC systems may also be irritating if they are spatially non-uniform, allowing customers to rapidly locate the source of the sound. In open research areas in libraries, the background noise level is excellent in speech frequencies and fairly weak in frequencies above and below the most common speech frequencies. A sound masking spectrum may be sufficient in open research sections of libraries. A comparable range may be sufficient in open research sections of libraries. A strong background sound has a consistent quality and range in both space and time.

2. Library Space Planning and Geometric Arrangement

The presentation of the study examines various well-known noise-producing components in libraries. These include circulation and reference tables, noisy copiers or printers, hallways, and other circulation paths. A physical barrier between these known noise-producing places and known noise-sensitive areas, such as open research spaces, reduces the Articulation Index and thereby improves acoustic comfort. The most common impediment in library environments is the prudent use of library book shelves or shelving.

3. Finishes and Materials for a Library

In an acoustically friendly library, absorbent finishes are evenly distributed around open research spaces. In addition to increasing the Articulation Index, absorbent finishes reduce reverberation time and noise build-up in library rooms. Movement noise can collect in a library and provide an uncomfortable increased ambient noise level during typical usage if the reverberation period is very lengthy.

5. Conclusion

The standard for acoustic comfort should be used from the design stage all the way through installation to particularly exploit the available Nature and an acceptable variety of Materials, facilities, and finishes. According to the survey, people's perceptions of the appropriateness and comfort of soundscapes in multi-functional public libraries may be more dependent on their soundscape cognition and the motivations for utilizing the space. Separating places in a design can be done by hierarchizing acoustic spaces for user types and their auditory cognitions. Furthermore, varied colored and patterned acoustic materials with suitable forms, as well as colored carpets generating distinct zonings for established soundscape cognitions, might be useful in directing user behavior. Overall, this case study suggests that it is useful to explore the acoustic environment of public libraries from a soundscape perspective in order to understand which architectural solutions may be used to increase users' acoustic happiness in those places.

References

- Adekalu, Oluwasayo & Alibaba, Halil. (2018). Achieving Acoustic Comfort in the Architectural Design of a Lecture Hall. 161-184.
- Aremu, A. S., Omoniyi, J.O. and Saka, T. (2015) Indoor noise in academic libraries: A case study of University of Ilorin Main Library, Nigeria, *African Journal of Library, Archives & Information Science*, 25(1), 5–14.
- AS/NZS 2107. (2000). *Acoustics - Recommended Design Sound Levels and Reverberation Times for building Interiors*. Sydney: Standards Australia.
- Associated Architects (2016) *University of Birmingham's Library / Associated Architects*
- B. Markham, (2003) “A survey of the acoustical quality of seventeen libraries at Princeton University”, in *Journal of the Acoustical Society of America* 114, No 4, Pt 2 of 2, paper n. 2aAA11.
- Babisch (2011), W. Cardiovascular effects of noise. *Noise Health* 13(52): 201–204.
- C.M. Salter, *Acoustics for Libraries*. (2002) Project Document. The project is supported by the U.S. Institute of Museum and Library Services under the provisions of the Library Services and Technology Act, administered in California by the State Librarian.

- D. Menzel, T. Dauenhauer(2009), T. and H. Fast, Crying Colours and their influence on loudness judgments In Proceedings of International Conference on Acoustics.
- F.Aletta,and J.Kang(2015),Soundscape approach integrating noise mapping techniques :a case study in Brighton ,UK .NoiseMapping2(1) pp.1–12.
- J. Liu, J. Kang, H. Behm, and T. Luo(2014), Effects of landscape on soundscape perception: Soundwalks in city parks, Landscape andUrbanPlanning12 ,pp.30–40.
- J.L.Xiao, F. Aletta. (2016)"A soundscape approach to exploring design strategies for acoustic comfort in modern public libraries: a case study of the Library of Birmingham", Noise Mapping 3-1:264-273.
- L.M. Aiello, R. Schifanella, D. Quercia, and F. Aletta, Chatty Maps: Constructing soundmaps of urban areas from social media data. Royal Society Open Science, 3(3), p.150 -690
- S. Mattern, (2007) resonant text: Sounds of the American public library. The Senses and society pp. 277-302
- S. Monteiro da Silva, M. Guedes de Almeida (2010). Thermal and Acoustic Comfort in buildings, pp.1-10
- Saint-Gobain designs. Acoustic Comfort (2018). <https://multicomfort.saint-gobain.com/comforts-and-solutions /acoustic-comfort>.
- T. Houtgast, et al., (1980) "Predicting Speech Intelligibility in Rooms from the Modulation Transfer Function; I: General Room Acoustics", Acoustical 46, pp. 60-72.