PROCEEDINGS of the
23rd International Congress on Acoustics

9 to 13 September 2019 in Aachen, Germany

# The acoustical assessment of the commercial buildings - design assumptions

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## ABSTRACT

Issues of interior acoustics include shaping appropriate acoustic conditions necessary to receive music or text spoken in the rooms. The purpose of the interiors is related to the relevant criteria of acoustic quality, which can be divided into subjective and objective ones. Subjective criteria are based on the opinions of the listeners and are very important for the assessment of the acoustic values of the room. Many authors of research works on this subject strive to find a connection between subjective assessment of acoustic properties of rooms and an objective one in order to connect the latter with methods of designing interior acoustics. The issues of the acoustic climate of commercial buildings include, among others, shaping the appropriate acoustic conditions necessary to receive the spoken text in these rooms, especially from sound alarm system. Designing acoustics must be considered at an early stage of the design process and re-analyzed and managed throughout the investment process. The paper discuss the acoustical assumptions important during designing process of the commercial buildings.

Keywords: Commercial buildings, designing, room acoustics,

## 1. INTRODUCTION

The acoustic quality of commercial buildings is often a problem that confronts many designers. Ensuring adequate speech reception in such spaces is one of the key factors determining the acoustic quality of a space.

The acoustic quality of public enclosures, including commercial buildings, is determined on the basis of the reception of speech sounds. There are numerous parameters and methods that express or determine the acoustic quality of spaces; however, they fail to take into account the special nature of commercial buildings.

Speech intelligibility is one of the key factors determining the acoustic quality of public commercial buildings spaces. Ensuring adequate speech reception in such spaces is often one of the key challenges that the designer has to tackle. Consequently, expertise necessary to select proper parameters to achieve best acoustic quality of a commercial buildings, at the design stage, is still insufficient.

Because of their intended use, commercial buildings are spaces with special acoustic requirements. The main problem that needs to be addressed with regard to such spaces is ensuring speech intelligibility that complies with applicable standards as well as low levels of interfering noise.

Reverberation time is one of key parameters considered in analyses of the acoustic properties of commercial buildings spaces. It has a strong influence on the perception of speech intelligibility. A preliminary determination of reverberation time based on calculations using a formula selected enables the designer to carry out an initial, general assessment of the acoustic properties of the enclosure being analyzed.

The science of interior space acoustics essentially consists in creating acoustic conditions that are necessary for adequate reception of speech or music in spaces. The intended use of an interior space is connected with specific, appropriate acoustic quality criteria which are divided in subjective and objectives ones. Subjective criteria are based on the opinions of spectators, and are very important in assessing the acoustic properties of a given space. On the other hand, objective criteria are based on acoustic measurements and play a very important role in the entire design process. Objective assessment criteria fall into the following categories:

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– criteria that can be taken into account and verified during the design stage,
– criteria that can be taken into account in a design, on the basis of model tests, computer simulations, and that can be verified by means of measurements at various stages of the project delivery (project stage control), and those that cannot be verified during the design stage,
– criteria that can only be verified after a given facility has been built.

At present no unambiguous criteria exist relating to factors significantly affecting the acoustic properties of spaces in enclosed sports facilities:

– special intended use of an interior space,
– geometric proportions of an interior space,
– fitting the interior space with sound-scattering objects, sound-absorbing components as well as those that channel sounds (noise),
– arrangement of noise sources in a long interior space, installing (or failure to install) a public address system in the interior space.

## 2. DESIGNING OF COMMERCIAL BUILDINGS

Many shopping spaces are full of sensory stimuli. Retailer tend to fill their stores with fixtures, furniture, decorations, displays and product stock to provide value to buyers. All of those elements influence the acoustical climate of the stores in commercial buildings. Environment can influence shopping behaviors including purchase intention, money or time spent in the store. Creating an appealing store environment as an essential job for retail designers and managers, as it allows a unique and easy to recognize store image for consumers. It also positively affects consumer satisfaction and loyalty by boosting the stores' attractiveness and value. Visual complexity is known to affect the attention, affective status and information processing rate. Conversely, when too little information is available, the stimulus may not be strong enough to attract observers' attention. Studies on visual complexity in the marketing industry have mostly focused on consumer response to products or packaging, logos and visual advertisement. Yet, the acoustical climate of physical store design is still underdeveloped. [4]

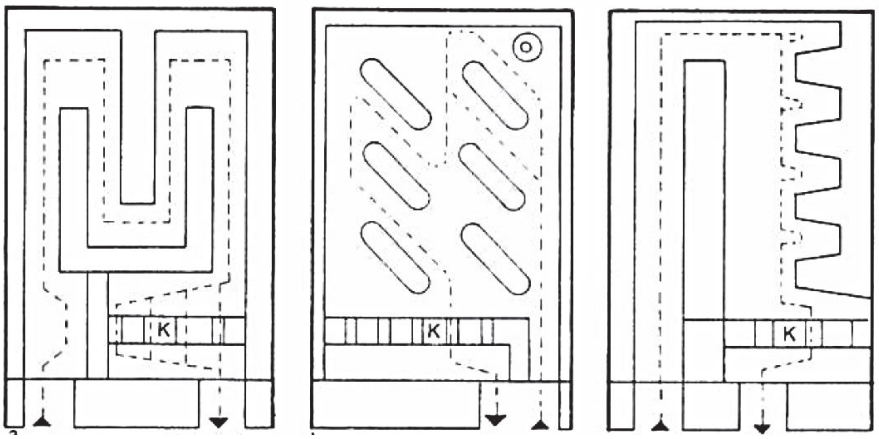


Figure. 1. Examples of different designing styles of commercial buildings' template [5]

Each designed public space has its own characteristic acoustic climate. The sound is invisible, however, it is always unconsciously picked up, which does not make it a less important architectural element than wood, glass, concrete, stone or light. It is shaped by the project, although most architects rarely think about it, except when their task is to create a concert hall and then the acoustics are called.

Acoustics have a huge role in everyday life and are able to decide whether users of the building can stay in it every day - at work or in the apartment. The role of sound in the workplace is well documented. Studies have shown that a well-designed office acoustically promotes concentration and effective communication. Noise in the workplace has a detrimental effect on stress levels, making it difficult for employees to perform their duties. In addition, work was linked in a relatively noisy environment with more complaints from employees and higher absences, resulting from back pain and other musculoskeletal ailments.

The acoustics of space will depend on the material and interior finish of the building and the room.

Noise can be classified as air noise and impact noise, which is generated by vibrations. The type of materials used in the building and the room and their sound-absorbing properties will have a huge impact on the acoustic quality. Ceilings, walls, floors, furniture and the number of people occupying space play a big role in this. It should also be remembered that people also have acoustic absorption properties and will influence the sound received in space.

Designing acoustics must be considered at an early stage of the design process and re-analyzed and managed throughout the investment process. There is no one-size-fits-all design solution in terms of acoustics and one cannot expect a single product to create the desired acoustic quality. The final results will depend to a large extent on the integration of a number of systems as well as their installation. Always recommends the use of building components that have been tested and documented.

The most important issue when designing the acoustics of space is its intended use. The restaurant and theater will have different acoustic needs, and people will behave differently in each of them.

Effective acoustic design depends on understanding the acoustic challenges of each individual space in its wider environment. It is not enough to understand the environment as an "office" or "restaurant", because in each of them there will be environments with definitely different requirements. For example, an office used as a call - center compared to a bank will have very different needs for the privacy of the call. In any environment there will be spaces requiring more acoustic control, for example in conference rooms and executive offices. The key to an acoustically pleasing environment is attention to detail.

## 3. OTHER IMPORTANT INFORMATION

In the acoustic literature there is a lot of parameters to assess the acoustic qualities of room. Architects and designers have some problems to choose a suitable one. The aim of this paper is to classify all parameters and methods by stages of design and to arrange them.

The room acoustics contains for example designing of acoustic conditions in rooms required to hearing sound of music and speech. With the destination of rooms there are combined suitable criteria of assessment of acoustic quality of rooms, which can be divided into two groups: subjective and objective.

Subjective criteria are founded on musicians' and listeners' opinion. This is very important for assessment of quality of room acoustics. A lot of researchers of this domain found the relationship between subjective methods of assessment of room acoustics and objective methods in order to combine them with the methods of designing room acoustics.

The objective criteria are founded on results of acoustic measures. They have an important significance in all designing procedure. Between objective criteria one can distinguishes:

- methods which can be taken into consideration and controlled in the designing stage,
- methods which can be taken into consideration on the basis of results of the modelling researches, simulation tests and can verified by measuring of room on a different stages of a realization,
- methods which can't be controlled on designing stage and can be controlled only on a measuring stage.

Architects and acoustic designers are mostly interested in parameters which can be useful during work at the designing stage. Figure 2 presents stages of room realization. There are distinguished two main stages: the design stage and the measuring stage. These stages are presented and discussed in the further paragraphs.

The designing stage contains preliminary drawings and sketches of characteristic views and intersections of room. It contains also indispensable calculations of acoustic parameters.

The most appropriate methods in designing stage are the geometry theory, the statistic theory and the wave theory. All of them are based on calculations and drawings of project of room. All these methods are founded on different formulas and concern different problems of an acoustic field in rooms.

The geometric theory establishes that a sound wave are propagated in accordance with rules of optical theory. Sound waves can be for example reflected in accordance with the reflection rule. On the basis of this theory geometric analysis of shape of room is made. For different sketches of room (views and intersections) the paths of sound waves are drawn.

The geometric theory is the most popular theory used in designing of acoustics for large halls appointed to music. It assures that sound field are the same in every point of room because this theory takes into consideration the shape of the room. The problems of early reflections, echoes, concentrations or scattering of sound can be resolved by this method.

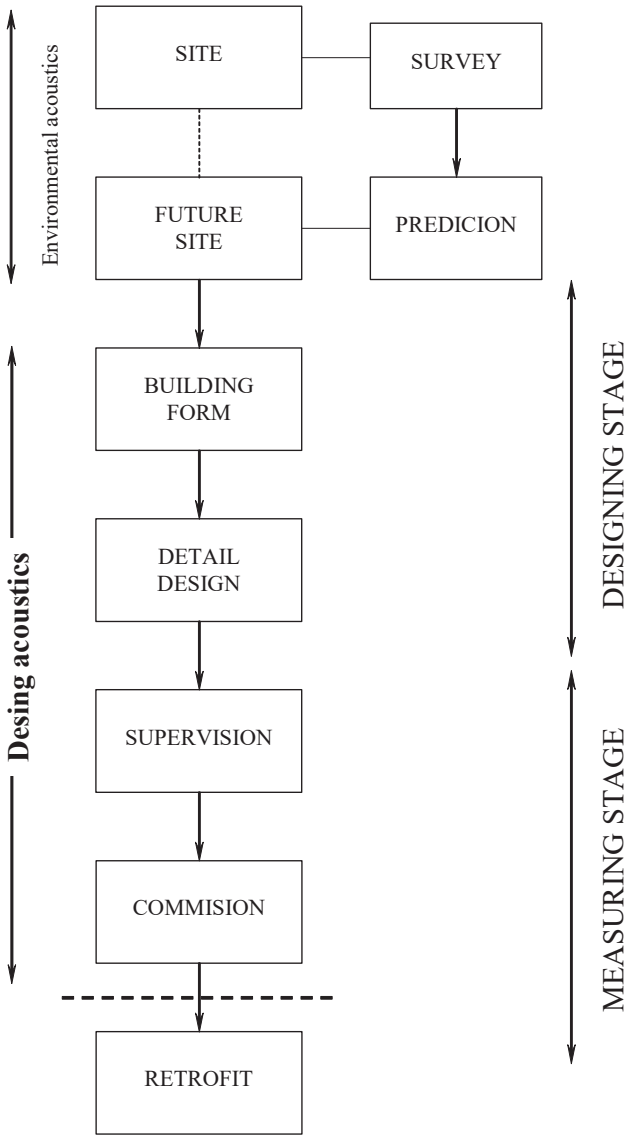


Figure 2. Stages of design in relation to acoustical climate assessment [1]

The wave theory is the most precise method based on mathematical calculations for small, rectangular rooms. Some modes of vibrations are calculated which influence on a reverberation time.

From the statistic theory the formulas of absorption coefficient and reverberation time can be obtained. This method is also the only one which can be controlled and checked in the further stages of realization of rooms. One can measures an absorption coefficient and a reverberation time in finished space. Some remedial work can be introduced after this measures and ones more checked by this values.

The STI method is also this one, which can be used in the designing stage. It is very important because the speech intelligibility can be calculated before finishing of room. This method is also used in measuring stage of realization of rooms so speech intelligibility can controlled by this method on the every stage of realization of building.

These methods are most appropriate for designing stage because they gives an opportunity to check acoustic field at the designing stage of first sketches. The first corrections can be introduce on the paper. These methods are also very easy for using, specially geometric theory. It can be used by all architects and acoustic designers.

Measuring stage contains controlling measures during supervision of realization of room and measures testing acoustic conditions in finished room, which are basis for retrofit and remedial wo rks.

In this stage all parameters obtained from impulse response of room are appropriate. Early decay time gives some information about speech intelligibility in room, relative strength approximates

subjective sense of loudness, early inter – aural cross correlation coefficient gives information about subjective attribute of spaciousness. This parameters can be obtained only by measurements in existing, finished room and can't be calculated in designing stage. But in the time of modelling and aural simulations some of them can be obtained by computer calculations.

Computer calculations do not give any information about subjective parameters of room. It can be obtained only by measurement with musicians and listeners. Some of them, like intimacy, warmth or clarity can't be obtained by calculations.

The measuring stage of realization of room is very difficult stage because there is very small opportunity to make some corrections or remedial work. That's why architects and acoustic designer should lay stress on the design stage to make all necessary corrections before finishing building .

## 4. CONCLUSIONS

Between all parameters and methods and criteria of objective assessment of room acoustics, the main significance in the point of view of architects has reverberation time. It is the most authoritative parameters because it can be obtain by calculations on designing stage and also by measuring. Results of measured reverberation times are values on the basis of which the other parameters can be obtained, such as STI factor defining the speech intelligibility.

In the different rooms there are used many criteria and methods of assessment of room acoustics. In the paper they were presented and classified by the stages of designing and realisation of rooms.

All above design assumptions will be taken into account to develop a simplified method to assess the acoustical climate of the commercial buildings at the designing stage. Method will be intended for architects and designers to help them to choose the best solutions from acoustical point of view.

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