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Speech privacy as a harmonizing factor in rating the sound insulation between dwellings

Miomir MIJIĆ[1]; Dragana ŠUMARAC PAVLOVIĆ[2]; Miloš BJELIĆ[3], Tatjana MILJKOVIĆ[4]

Faculty of Electrical Engineering, University of Belgrade, Serbia

ABSTRACT

Recent consulting practice has shown an increase in the number of complaints concerned with insufficient sound isolation between dwellings. In some of them the sound reduction index value was above the value proposed in legislation, but the neighbours' conversation was heard too clear. Comprehensive analysis has shown that in new buildings there is an extremely low ambient noise level, often below 20 dBA. The energy efficiency obligation in architecture today introduced extremely good façade windows as a rule, and in the same time home appliances and equipment have become too quiet. Such environment enable clear recognition of the neighbours' speech even with enhanced sound insulation. The conclusion is that in evaluation of sound insulation between dwellings it is suitable to include somehow, besides R_w or D_{nT}, the ambient noise level as an embedded factor. A parameter called Speech privacy class as a measure of privacy had been already introduced in the literature. It is defined as the sum of frequency restricted values of D and ambient noise level. The paper discusses the possibility of introducing such information regarding privacy in assessment of the sound isolation between dwellings and discuss the methods for dwelling soundscape control.

Keywords: ambient noise, sound insulation, speech privacy

1. INTRODUCTION

Privacy is an essential element of acoustic comfort in apartments. In multi-dwelling buildings this implies that speech originating inside apartment being difficult to hear or understand in the adjoining dwellings. In architectural design of buildings speech privacy is considered by selecting appropriate values of weighted apparent sound reduction index R'_w or sound level difference D_{nT} in all directions to adjacent apartments. At that early stage of a building development this is the only physical aspect that can be considered concerned with acoustic comfort.

One can find in literature what degree of speech privacy can be expected with different amount of sound isolation. As an illustration, one can see the explanations given in an earlier standard proposal for the acoustic classification of buildings [1]. It was stated there that with apparent sound reduction index of 54 dB loud speech can be "audible, but hardly understandable" or normal speech can be "just audible, but not intelligible".

A number of information in literature shows that speech privacy is a multi-dimensional concept. It does not depend only on the partitions' insulation properties, but also on some other factors. Among them the most influencing is the ambient noise level at listener's position. Descriptions taken from the cited document reflects „reasonable quiet environment" with comment that quieter or noisier environment can change that. According to the same document a reasonable quiet environment can be understood as the circumstance in which requirement $L_{den,indoor} \leq 30$ dBA is met. Practically the same requirement for ambient noise in dwelling is specified in Serbian legislation, and probably in

[1] emijic@etf.rs
[2] dsumarac@etf.rs
[3] bjelic@etf.rs
[4] tm@etf.rs

legislations of other countries.

However, control of noise level during sound insulation measurements performed in various new buildings or in retrofitted apartments revel that one can expect the value of ambient noise level in rooms within wide limits. It was stated that the average level of ambient noise in the living rooms is significantly below 30 dB. In Belgrade the most frequent value of ambient noise level in new or renovated buildings is below 25 dBA during the day, and the buildings were found were the equivalent noise level is about 17 dBA during evening. That implies a different status of speech privacy with the same partitions between dwellings.

Accordingly, the standard data obtained by sound insulation measurement in a building does not show to apartments users what kind of property they can expect. Sound insulation measurements show the value of the apparent sound reduction index R'_w or sound level difference D_{nT}, but do not indicate whether this is "reasonable quiet environment", "extremely quiet environment" or "absolute quiet" in living rooms. The apparent noise conditions depend on many factors: the noise in the ambient where building is positioned, the quality of windows, the concept and quality of installations in the building, the proposed level of thermal efficiency (which reflects on windows quality), even the workmanship. In the same part of the city noise condition can be different in different buildings.

Thus the information that can announced to people the expected level of privacy, at least in Serbia, remains unknown in the evaluation of buildings' acoustic quality. Only after the building is moved tenants in some circumstances address the problem of privacy. Then the first issue arises as how to express the state of acoustic comfort in a more complex way, beside R'_w or D_{nT}, and second is the ways in which noise level can be controlled in order to adjust the speech privacy.

2. A SUGGESTIVE CASE STUDY

An example discovered during sound insulation measurement in a residential building is schematically explained in Figure 1. Testing of sound insulation quality in a building was made on tenant's request. The measured value of weighted sound reduction index between two apartments was 52 dB, as indicated in the Figure. The value is prescribed as requirement in actual legislation [2] which is applied as a criterion in buildings design. This means that sound insulation between apartments meets the requirement.

However, it has been established that the speech privacy in the two adjacent rooms is different. In one direction it was established that the speech from the neighbour could be heard, thus initiated the tenant's urge, whereas in the opposite direction such an occurrence was not noticed and the tenants had no complaint about privacy. This difference in voice transfer is indicated in the figure. In analysis of the speech detection difference in two directions, that is, on two sides of the same wall, the same group of people was used as the source of speech at both sides and the same group of listeners was at both rooms, thus eliminating the possible influence of individual differences between speakers and listeners.

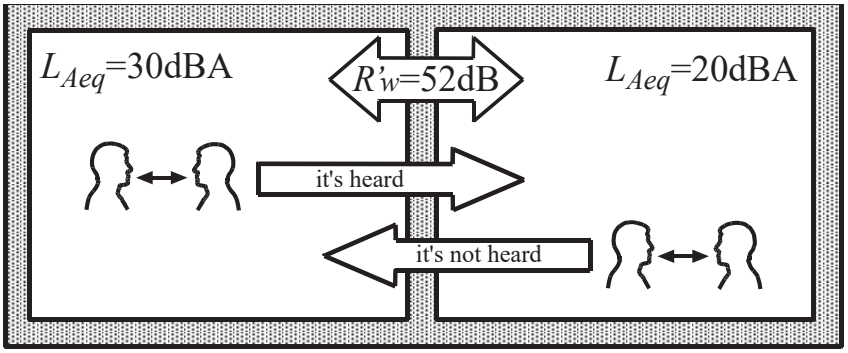

Figure 1 – Illustration of an example that was analysed

In order to explain this phenomenon, beside sound insulation, an equivalent ambient noise level was measured in both rooms, as well. The results are also shown in the Figure 1. In a room where it was not reported to hear the speech from the neighbour, the value of equivalent noise level was about 30 dBA. It is the value stated in the legislation as the maximum noise level during the night in

apartment. The value is consequence of the existing windows' sound insulation properties, as well as some unknown noise sources distributed somewhere in the apartment. In the adjacent apartment, behind the partition, where the speech from the neighbours was recognized, the value of the equivalent noise level was only about 20 dBA. It was discovered that new façade windows of high value of the sound reduction index were installed, and all home appliances were brand new and very low noise. This difference between two apartments has made the difference between signal-to-noise ratio in two rooms. Therefore the speech privacy on two sides of common partition is different even though the sound isolation is unique.

Hence, the speech privacy as an important element of the acoustic comfort is not determined only by the value of R'_w or D_{nT}, but also by the ambient noise around a potential listener. In addition, in two phases of sound insulation testing – in building design by calculation and by measurement of sound isolation after buildings is completed – only sound insulation is consider. In order to obtain a more reliable insight in acoustic comfort the analysis must be extended to include information concerned with ambient noise in the relevant rooms. Only then the expected speech privacy in the building can be evaluated more reliable.

Testing the building acoustic quality today includes only the sound insulation measurement, so only the parameters in that domain are available for the building evaluation. The fact is that the ambient noise is not the subject of measurements in finished buildings, until some problem occurs as with excessive noise of nearby mechanical equipment. The fact is also that in this moment there is no data on ambient noise level statistics in dwellings today during period of noiseless activity, like during the night. Therefore, no relevant conclusions about the expected speech privacy in buildings. The only available dwelling noise data is concerned with some noisy activities like cooking, family gathering, listening music, playing musical instrument, etc. [3].

3. QUANTIFYING THE EFFECT OF "SILENCE" ON SPEECH PRIVACY

For better understanding the influence of "silence", i.e. ambient noise, on speech privacy it is important to discover some method for measuring the event. A possible solution one can find in an US standard. Document ASTM E2638 introduces the parameter called Speech Privacy Class (SPC) [4]. The standard is based on results published by Bradley et all [5]. SPC is obtaining by measurement in building and represents the degree of speech privacy provided by a closed room for conversations occurring inside. Its value is a sum of two basic elements that determine the speech communication between the room and its surrounding: sound isolation provided by the room envelope and background noise at the receiving point. Value of SPC is expressed as the sum of sound level difference D and ambient noise level L_{amb}, both in dB:

$$\mathrm{SPC} = D + L_{amb} \tag{1}$$

Both element on right side in Eq (1) are unweighted average of 1/3 octave band values from 160 Hz to 5 kHz, 16 values in total. Thus the SPC value is defined as a sum of two factors that both have influence on speech audibility and intelligibility.

The SPC is defined in the standard as the security and confidentiality measure for the speech in meeting rooms, i.e. for leakage of speech signal from meeting room interior to some points outside it where the potential listeners may be located [4]. Although developed for such particular purpose, that concept has the potential to be applied for privacy assessments in residential buildings, too.

Effort to describe expected level of speech privacy for different values of the SPC parameter one can find in literature [4,5]. Description specifies probable level of speech audibility and intelligibility. For example, at values SPC > 85 speech sounds becomes inaudible, and for SPC between 65 and 70 speech sounds is „frequently audible" and „brief phrases expected to be rarely intelligible" [5].

In the part of the world where ISO standardization is preferred, determination of building's acoustic quality is based on measurement of the apparent sound reduction index R' according to ISO 16283-1 [6] and the equivalent ambient noise level L_{Aeq} expressed in dBA according to ISO 1996-1 standard [7]. The result of the soundproofing measurement is expressed by the relevant value of the isolating power R'w calculated according to the standard IS0 717-l [8]. The authors of this paper in an earlier work proposed a modification in the SPC concept introducing the values obtained by measurement procedures according to ISO standards applied in Europe [9]. A parameter equivalent to SPC was introduced, named Speech privacy index (IPR) and defined as:

$$\mathrm{IPG} = R'_w + L_{A,eq} \tag{2}$$

In a previous study by this authors it has been experimentally shown that the IPG estimate with appropriate accuracy the value of SPC, which means that it can also be used in the same way to evaluate the speech privacy between the rooms, but using parameters defined by ISO and routinely measured in buildings [9]

The importance of ambient noise for speech privacy is also recognized in evaluation of open space offices acoustic quality. In an ISO standard where all relevant parameters for these specific areas quality evaluation is defined, the equivalent ambient noise level is also proposed as an important parameter[10]. In the evaluation procedure described in this standard the effect of noise is observed indirectly by means of Speech transmission index (STI) decay with distance form speaker. There is a distance from the speaker where the voice immerse into the existing ambient noise and thus the speech intelligibility practically disappear. It was shown that speech become unintelligible when STI reach the value 0,2 [10]. That distance is named “privacy distance”. In many circumstances some supporting systems for controlling the level of ambient noise are used for that purpose.

Although the SPC was originally defined as a parameter that should show the possibility of leaking the conversations from the business meeting rooms, such of concept can be used to estimate acoustic comfort in other circumstances, like in residential buildings. Thus IPG, or just equivalent noise level, can be used for making statement about speech privacy, along with regular parameters used for characterization of sound insulation in the building.

4. CONCLUSIONS

Idea for this paper was initiated during several investigations of complaints by tenants in new and renovated residential buildings addressed to inadequate level of privacy. The problems are identified as unwarranted audibility and intelligibility of speech coming from the neighbours. The problem appears despite the fact that measured values of the parameters showing the sound insulation quality are in line with design’s goals and proposals in legislation. The presentation in this paper discusses the need for some changes in engineering practice that can relax the problem to some extent, as well as open some topics for future consideration. Some suggestions are defined based on these authors experience in attempting to solve somehow the reported problems. In conclusion, three main topic found important for further consideration are explained below.

1. The basic goal of any sound insulation measurement in buildings is to obtain relevant information about the acoustic comfort that tenants can expect. However, the speech privacy does not depend only on sound insulation, but also on the existing ambient noise level. Therefore, it would be informative to show in the R 'or D_{nt} measurement reports the measured values of the equivalent noise level in the source and receiving room, as well. The time interval of the noise measurement can be discussed. It can be, for example, an interval of 15 minutes with keeping under control possible accidental acoustical events in the surroundings.

2. Setting the ambient noise level at the design stage by selecting window sound insulation is not an action with a controllable results. So, it is easy to achieve the condition of an "excessive silent" in the dwellings, which enables the audibility and intelligibility of speech coming from the neighbours. It is therefore reasonable to concern the research of soundscape in dwellings, i.e. research of the ambient sound character that could adjust the level of masking without disturbance and which would allow normal activities, even the dream. Then the "excessive silent" in the dwellings would be only one tenants’ option, not a permanent status.

3. Research in the domain of sound masking in dwellings have to include design of equipment with physical characteristics appropriate for application in dwellings. Unlike the equipment used in the offices, in dwelling that have to fit sophisticatedly into the ambient, remaining sufficiently invisible and without the possibility for people to detect the position of the sound source. Today's audio technology offers sufficient solutions that just need to be combined in the right way. This means that the concept present from a long time ago in offices has to be adapted and used in dwellings.

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