



# COMPARISON OF SUBJECTIVE AND OBJECTIVE ASSESSMENT OF ACOUSTIC COMFORT IN A RESTAURANT

Lukáš Zelem<sup>1</sup>, Vojtech Chmelík<sup>1</sup>, and Monika Rychtáriková<sup>1,2</sup>

<sup>1</sup>STU Bratislava, Dep. of Civil Engineering, KKPS, Radlinského 11, 81005 Bratislava, Slovakia.  
Email: [zelem.lukas@stuba.sk](mailto:zelem.lukas@stuba.sk), [vojtech.chmelik@stuba.sk](mailto:vojtech.chmelik@stuba.sk)

<sup>2</sup> KU Leuven, Faculty of Architecture, A&T, Hoogstraat 51, 9000 Gent, Belgium.  
Email: [monika.rychtarikova@kuleuven.be](mailto:monika.rychtarikova@kuleuven.be).

## ABSTRACT

The assessment of acoustic conditions in restaurants is typically based on measured sound pressure level ( $L_p$ ), reverberation time ( $T$ ), speech to noise ratio ( $SNR$ ) and similar parameters. This article focuses on subjective assessment of acoustic condition in the Faculty restaurant Club STU Shupitoo at Civil Engineering Faculty of STU Bratislava from a point of view of employees of the restaurant. Results based on interviews with personal working in the restaurant are compared with objective acoustic measurements performed earlier. The measured objective parameters are not only quantities derived from Impulse responses in the room, but also from extended noise measurements.

## INTRODUCTION

When investigating a quality of restaurant different factors play role. Assessment of objective acoustic properties in rooms is prescribed in the ISO 3382. These measurements are rather straight forward and well prescribed, but they do not sufficiently cover all information about acoustic quality in the given place. In restaurant number of people, shape of the room and other factors play role as well and contribute to overall soundscape. Researchers that deal with noise in restaurants or other eating establishments often refer to work of Lazarus, who has suggested assessment based on verbal communication ( $SNR$  or  $STI$ ) [1-7].

This approach gives in general a very good view on the conditions in a room where many people talk at the same time. The Aim of this article is compare the objective assessments by acoustic parameters with subjective perception of the restaurant by waiters.

The objective assessment in this study is based on previous investigations in restaurant Club SvF Shupitoo [1], which are rated in accordance with objective parameters of ISO standards and objective assessments by Beranek, Kryter and others. Subjective assessment is based on an interview with an employee of Club SvF Shupitoo who refers to acoustic quality in her daily work in the restaurant.

## DESCRIPTION OF THE RESTAURANT

The investigated restaurant is localized in the building of the Faculty of Civil Engineering at Slovak University of Technology in Bratislava (Figure 1). The opening hours of the faculty club are 8:00 - 17:00. Breakfast is serviced typically until 10:00 am and lunch between 11:00 and 14:00. Restaurant is closed in evenings unless there is a special reservation for bigger group of guests. Volume of the shoebox shaped room

is 525 m<sup>3</sup>. Total surface area is around 486 m<sup>2</sup>, with floor area of about 150 m<sup>2</sup>. The floor is covered by red marble on concrete slab. Walls are constructed out of by bricks, covered by gypsum boards on the interior side. Part of walls is covered by blackboard similar to school blackboards, suitable for writing by chalk. Suspended ceiling height is 3,5 m above the floor.

The ceiling is formed from steel metal plates with perforation approximately 4 mm. The fiberboards are placed on metal plates. Whole structure of lowered ceiling is hanged 2 m bellow the reinforced slab. One wall contains windows along its full length, from 0,9 m above the floor till the ceiling. The total surface area of windows is 40,5 m<sup>2</sup>. The restaurant has a capacity of 18 tables, with about 80 seating places.

## ACOUSTIC ASSESSMENT BASED ON OBJECTIVE PARAMETERS

Two kinds of acoustic measurements have been performed previously in the room: /1/ Impulse response measurements, necessary for calculation of room acoustic parameters such as reverberation time for sake of characterisation of the room and /2/ noise measurements in order to understand how the activity in the room over the day/week and month influences the noise levels.

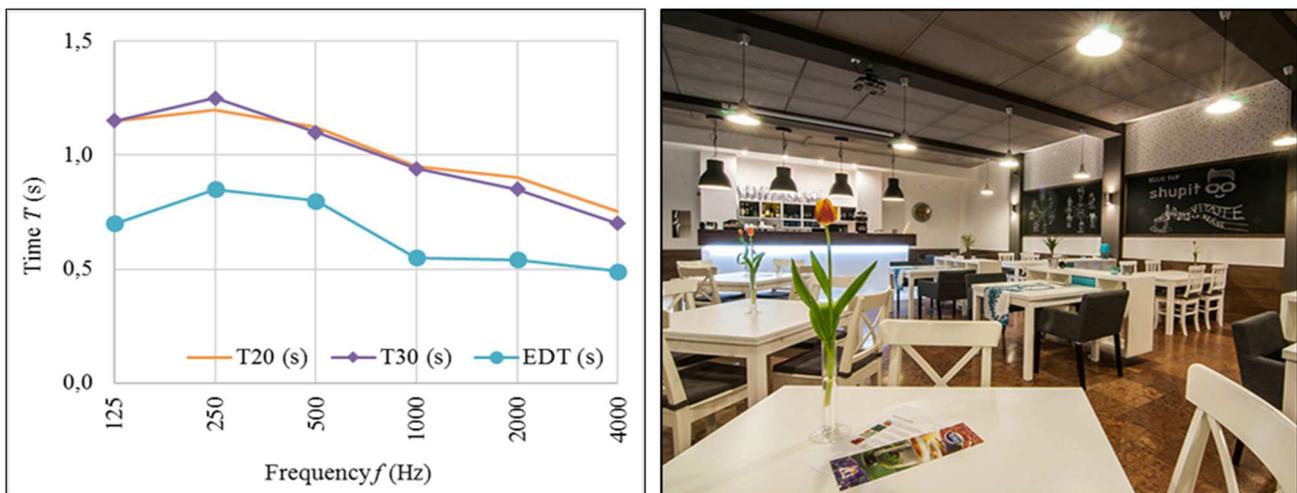


Figure 1 - Values of reverberation time (left), interior of the restaurant (right).

### /1/ Reverberation time

Results of reverberation time are given in the Figure 1 left. In accordance standard STN EN ISO 3382 – 1 [2], the optimal reverberation time (for speech intelligibility) in a given volume ( $V = 525 \text{ m}^3$ ) is approximately 1,0 s at 1000 Hz. The range of optimal values of reverberation time for whole frequency spectrum is given by (1) (2):

$$|\Delta T| \leq 0,1 \cdot T_{opt} \quad (1)$$

$$\Delta T = T - T_{opt} \quad (2)$$

Where  $T$  is reverberation time of frequency octave bands in seconds and  $T_{opt}$  is optimal reverberation time in accordance standard STN EN ISO 3382 [2]. Measured reverberation time  $T_{30}$  in the restaurant achieves values of  $T_{opt}$  for mentioned range i.e. 0,9 s to 1,1 s. In other words, measured values of reverberation time at frequency spectrum from 500 Hz to 2000 Hz are according to the standard in the range of optimal reverberation time. At low frequencies, values of  $T_{30}$  are slightly longer and at frequencies above 2000 Hz, values are slightly shorter then recommended.

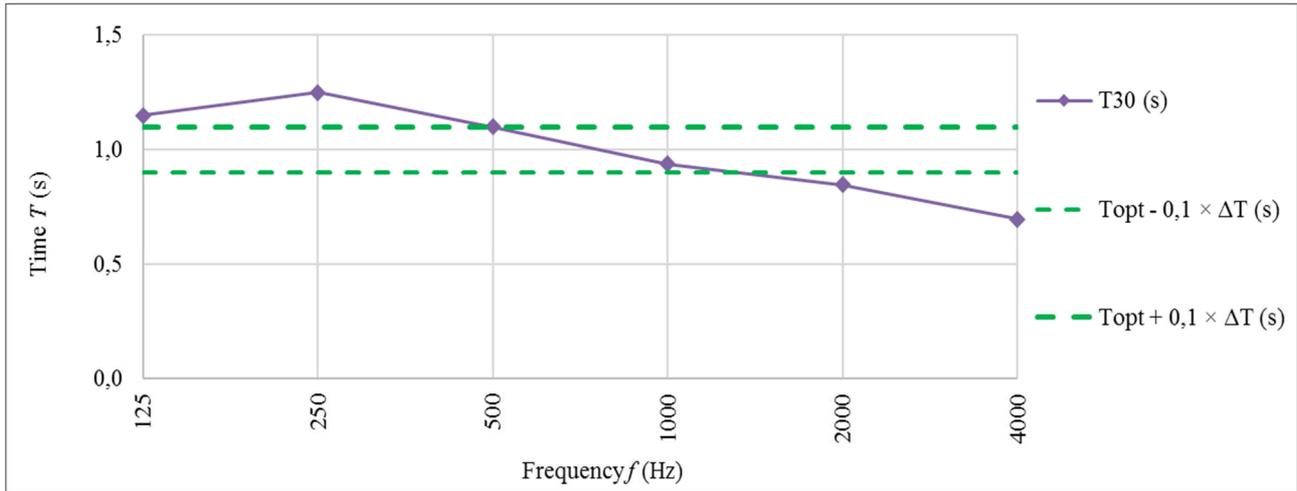


Figure 2 - Optimal reverberation time  $T_{opt}$  (s) in accordance standard STN EN ISO 3382 and measured values of reverberation time  $T_{30}$  (s).

SNR (dB)	-12	-9	-6	-3	0
<b>Beranek 1947</b>	Unsatisfactory			Acctable dependent on the spectrum	
<b>Beranek 1949 podl'a Krytera 1972</b>	Impossible to diffult			Slightly aggravated to satisfactory	
<b>Görlich 1978</b>	Vary bad	Unsatisfactory		Sufficient	
<b>Houtgast a Steeneken 1978</b>	Unsatisfactory			Satisfactory	
<b>Kryter 1978 (p. 90)</b>	Normally not acctable	Acctabl for some purposes		Good	
<b>ISO 4870 1975</b>	Bad		Satisfactory		Good

Table 1 - Objective assesment of quality of verbal communication on base of SNR [3].

Based on literature we know, that distance, at which  $L_{P,direct} = L_{P,diffuse}$  (3), is less than 30 cm, in case of approximately 20 speaking persons. This means that in this situation, the signal to noise ratio (SNR) during a conversation between nearest neighbours (~30 cm) is around 0 dB and for conversations across a table in the presence of 20 talkers at other tables, the SNR is therefore about - 10 dB or worse [1]. In the Table 1 an objective assesment of quality of verbal communication on base of SNR is shown [3] [4].

$$r_{diffuse=direct} = \sqrt{\frac{24 \ln(10) V}{16\pi \cdot N_S \cdot c \cdot RT}} \tag{3}$$

Since frequencies between 500 Hz and 2000 Hz, are most dominant in case of human speech. the verbal communication in this restaurant can be from objective point of view considered as very comfortable.

**(2) Noise measurements**

The measured values of equivalent sound pressure level during day in the intervals of 15 s was in the range from 52 dB to 75 dB. The values of background noise, composed from background music and equipment noise in the restaurant is between 50 - 52 dB.

The vocal effort of normal speaking person at the distance of 1 m in front of the mouth is defined as  $L_{P,1person} \cong 54$  dB(A) [5] and it is slightly higher than a background noise.

Sound pressure level increases with increasing number of people present in the room from 52 dB to 75 dB depending on a situation [1], since people increase their voice in noisy environment with the aim to improve the signal to noise ratio [6].

## APPRECIATION OF ACOUSTIC ENVIRONMENT ON BASE OF SUBJECTIVE VIEW

Subjective assessment of the acoustic environment in the Faculty club SvF Shupitoo is based on an interview with an employee Zuzana (Figure 3). She works here as a waitress and she is in club nearly every working day during the opening hours. The questions in the interview were formed with the aim to understand better the perception of acoustic comfort by employees.

### 1. *Why did you decide to work in Club SvF Shupitoo and what work did you do before?*

Before, I worked in Žilina in a small pension, but the work shift was not optimal for me and therefore I have changed my work in pension and have worked in bar. But there, a problem was smoking.

I don't like smoking. So I tried to find a new work and I found it in Bratislava in the Faculty club SvF Shupitoo.

This work is perfect for me, because I am working in a good and nice team of people and I also have an ideal work shift (8 hours) in a no smoking environment.

### 2. *How long do you work in Club SvF Shupitoo?*

I work in Club SvF Shupitoo from the beginning, after it has been renovated. It is approximately one year and six months now.



Figure 3 - Zuzana – a waitress

### 3. *How would you compare acoustic situation in past job with your current job?*

In the pension, it was different. That place was much smaller. You could easily hear, that the room was small. When comparing it with this restaurant, I can hear that this space is bigger.

The loudness of background music was acceptable and pleasant. The same it is in the Club SvF Shupitoo.

### 4. *Do you turn on radio or television after coming home?*

Yes, I turn on my computer and I listen music from internet. I listen music rather loud. I don't like silence.

### 5. *What type of holiday do you prefer?*

I prefer relax holiday, to lie on the beach. During holiday, I like to “switch off” after all year work and to enjoy doing nothing.

### 6. *Do you dedicate a special attention to the choice of music?*

Yes, we were deciding between more music types or more radio stations, but the best for us and for customers was Radio Tuned Café de Paris. Customers are satisfied with this type of music and they don't notice this music during conversation as disturbing.

### 7. *Do you change level of background music with increased number of people present or with increasing background noise level?*

Yes, sometimes there are requirements to low the music level, but it is in situation with a little people, when they have some private negotiation and consultation. But when they have negotiation, and they are not alone here, they require a music. In case a lot of people, I had never had a request to put music level lower.

### 8. *Did you notice a situation in which people suddenly stopped talking, or vice versa, i.e. that noise increased rapidly because of speaking people? If yes, when this has happend?*

Yes, it happens rather often, because we have internet radio, and we use a free version. So, this radio every 30 minutes turns off itself. In this time is possible to observe, that people stop talking, or they talk very quiet suddenly.

**9. Have you ever had a problem with your voice because of work?**

No, I never had a problem with voice because of work. I don't have to increase my voice, only in cases, that we have action like celebration for example, it happens, that I have to ask maybe three times, but it is because people are talking to each other.

**10. Which places are occupied first, or do customers have their preferred places?**

Customers typically occupy first the double desks. People go here to talk to each other, and in most cases they come here first in pairs.

## DISCUSSION AND CONCLUSIONS

We can rate the acoustic situation in Club SvF Shupitoo from more points of view on bases of objective measurement and assessment of acoustic comfort and quality of verbal communication. The measured values of reverberation time are in recommended range of reverberation time in accordance STN EN ISO 3382 (2). From point of view of sound pressure level, we can rate the verbal communication of two nearest neighbours sitting at one table on bases of *SNR* (*SNR*, depends on a distance between talker and listener, and in our case it is typically from 0 to -10 or worse) as "slightly aggravated to satisfactory" (Görlich 1978) to "Good" (Kryter 1978, ISO 4870) [3].

If we consider a situation in which the communication occurs across the table under presence of 20 talking people in a room, then the quality of verbal communications is in a range from "impossible to difficult" (Beranek 1949 and Kryter 1978) to "acceptable for some purposes" [3].

On the basis of the interview with employee Zuzana, we can rate the verbal communications at larger distances than  $r_{diffuse} = r_{direct}$  as "good" and maybe better. If we consider an objective parameter such as signal to noise ratio, this rating corresponds to the value of  $SNR < 0$ .

The assessment of *SNR* or optimal reverberation time seems strict from point of subjective assessment of quality of verbal communication based on interview with employee. The value of background noise level (which is mainly the background music) is 52 dB, and it apparently provides sufficient speech privacy also in cases with low density of occupancy. This can be caused by the fact that tables are sufficiently far from each other. Employees increase the level of background music by increasing number of people present in order to keep a good speech privacy

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