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ACOUSTICS OF CONTEMPORARY CHURCHES IN POLAND

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ABSTRACT[*]

The investigation involved 18 contemporary churches in Poznań, Poland. Out of all the facilities, 5 are of the two-storey type, which constitutes 23 investigated interiors in total. E-sweep signal was generated and parameters that the literature considers basic were measured to assess acoustic properties of the sacred interior: RT, EDT, T_s, C_{80}, C_{50}, D_{50}, STI. A gunshot was applied as an additional sound source, and a control measurement was taken in selected points.
The timeframe of the construction of the selected churches covers facilities erected after 1965 until 2018. Another criterion for the selection was different internal volumes, which vary from 315 m³ to 16 800 m³. Also, the layout of the interiors varies; longitudinal, axial and central-plan churches were selected. Acoustics of the sacred interior are very much dependent on its architectural style, which, to a great extent, determines acoustic properties of the interior. Many contemporary churches have bad acoustics, which raises a question how it is possible, while so much is known about acoustics these days, to erect public utility buildings that practically serve no useful purpose in the sound sphere. The main research issues discussed in the context of relations of architecture with interior acoustics are the scale of the facility, finishes and structure of the contemporary church.

Keywords: *church acoustics*, *reverberance, contemporary church*

1. INTRODUCTION

The acoustics of a church interior are very much dependent on its architectural style, which largely determines the acoustic properties of the interior. There are numerous churches built in recent years featuring good architecture and poor acoustic properties [1]. This means that issues of architectural acoustics in religious buildings require research. The question arises as to how it is possible, given the current state of knowledge of the subject, to erect acoustically non-functional public utility buildings. The issue of functionality of a sacred facility in the sonic aspect is an issue on the cusp of two fields – architecture and acoustics. The research must therefore take both aspects into account. Out of the numerous works on church acoustics, a number of publications have been devoted specifically to contemporary Catholic churches. Churches in Poland were studied and acoustic treatments for problematic issues were proposed [2]. Excessive reverberation time is a common occurrence in contemporary Catholic churches [3-4]. A study of two contemporary Italian churches built after 2000 indicated the beginning of a new acoustic trend towards designing churches with significantly reduced reverberation time [5].

2. ACOUSTIC INVESTIGATIONS

Acoustic tests were carried out using an omni-directional sound source, the DIRAC programme, together with a Brüel & Kjær ZE-0948 USB sound card. An e-sweep signal was generated and the parameters considered in the literature [6] to be crucial for the assessment of the acoustic properties of a sacred interior were measured: RT, EDT, T_s, C_{80}, C_{50}, D_{50}, STI. A gunshot was applied as an additional sound source, and a control measurement was taken in selected points. All the investigations were conducted in the absence of people. Eighteen contemporary churches in Poznan, Poland, were investigated. Five of the churches are

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two-storey, i.e. 23 interiors in total were investigated. The churches selected for the study varied in volume, ranging from 315 m³ to 16 800 m³. The time span of the churches selected for the investigation includes buildings erected after 1965 until 2018.

3. RESULTS

The results of the research were compared with the literature recommendations [7].

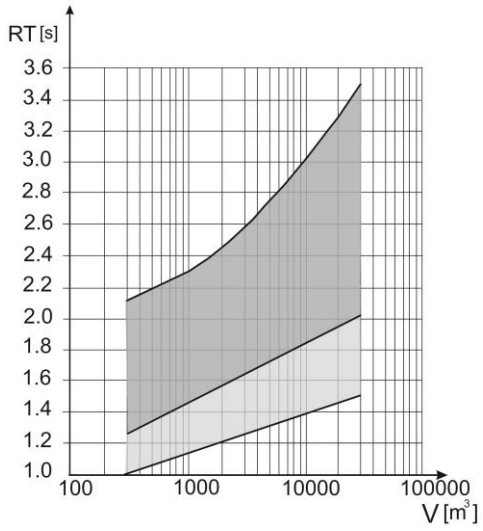

Figure 1. Recommended reverberation time for churches [7].

Figure 1 shows a diagram illustrating the recommended value of reverberation time for churches depending on their internal volume. The light grey colour represents reverberation time for churches where speech prevails. Recommendations for churches with organ music performances are marked in dark grey. A majority of the investigated churches fall outside the range of acceptable RT values, with as many as 15 sacred interiors out of 23. The scope of the reverberation time in the investigated churches is within RT=1.6 s to RT=5.9 s.

The short reverberation time RT=1,6 s was found only in one interior, which is the lower church of the two-storey church, with internal volume V=315 m². Such an internal volume is more typical of a chapel than a church. The churches with RT values that comply with the recommendations are churches where reverberation is suitable for organ music. The reverberation time in such interiors is up to RT =2.7 s. In this group of churches, only two churches have acoustic adaptations. The internal volume of the larger of these two is 7 258 m³; it is also the largest church in the group of churches within the range of acceptable reverberation time.

The maximum reverberation time RT = 5.9 s is found in two churches. Too long reverberation time is found mainly in interiors with reinforced concrete ceilings. The largest internal volume in this group of churches is 16 800 m³. The reverberation time is also exceeded in interiors with smaller internal volumes; it was registered in eight interiors with internal volumes not exceeding 5 000 m³.

4. DISCUSSION

In terms of scale, the modern Catholic church in Poland has an extensive internal volume, which is conducive to reverberation noise. The architectural style is characterised by austerity and limited use of spatial detailing, while the materials used such as plaster, concrete and glass are sound reflective. In addition, contemporary churches are mostly single-space buildings. In contrast, historic churches mostly have sub-spaces, which have a beneficial effect on reducing reverberation. The introduction of new structural solutions such as reinforced concrete and steel render it possible to cover large spans without the use of intermediate supports. The extensive space of a modern church is conducive to a number of acoustic disadvantages. When a modern church is designed, either a reinforced concrete ceiling or a truss ceiling is adopted, depending on the layout of the plan. In churches with truss ceilings, reverberation time complies with the recommendations [8]. Interior acoustics were not specially designed for the investigated Polish churches, which were built between the 1970s and 1990s. The main factor that creates good acoustic conditions is the truss ceiling. Currently, there is an emerging trend to take acoustics into account in the design of sacred buildings. In addition to the materials traditionally used in this type of facilities, materials with sound-absorbing properties are applied. However, out of the churches investigated in Poznan, acoustic solutions were designed only for two of them, and these two were built after year 2000. Despite the noticeable new tendency to design church interiors taking into account acoustic conditions, church buildings are still being erected without any conscious solutions in the sonic aspect.

5. CONCLUSION

Acoustic design of a church to accommodate both speech and music must be a challenge, and a compromise will be needed to combine the different acoustic requirements. An interior with short reverberation time suitable for the speech function is not perceived as providing sacred ambience. Despite much higher permissible reverberation time values than for other public utility buildings, reverberation in contemporary sacred facilities is long enough to be perceived as reverberant noise (i.e. undesirable strong reverberation, sounds that cause interference with verbal communication). The research topic proved important because the issue of architectural acoustics is still not sufficiently addressed in the design of contemporary churches. It is therefore important to consider acoustic functionality as early as at the conceptual stage of the design.

6. REFERENCES

[1] M. Niemas, J. Sadowski and Z. Engel, "Acoustic issues of sacral structures", *Archives of Acoustics*, 23, 1, pp. 87-104, 1998.

[2] D. Wróblewska and A. Kulowski, *Czynniki akustyki w architektonicznym projektowaniu kościołów*, Wydawnictwo Politechniki Gdańskiej, Gdańsk, 2007

[3] K. Kosała and T. Kamisiński, Akustyka wielofunkcyjna wnętrz sakralnych, *Czasopismo Techniczne,* 11, pp. 115 -122, 2011.

[4] A. M. Buenó, A. L. León, M. Galindo, Acoustic Rehabilitation of the Church of Santa Ana in Moratalaz, Madrid, *Archives of Acoustics,* 37, 4, pp. 435–446, 2012

[5] M. Cairoli, Identification of a new acoustic sound field trend in modern catholic churches, *Applied Acoustics*, 168, 1, pp. 1-8, 2020.

[6] F. Martellotta, E. Cirillo, A. Carbonari, P. Ricciardi, Guidelines for acoustical measurements in churches, *Applied Acoustics*,70, pp. 378–388, 2009.

[7] F. A. Everest, K. C. Pohlmann, *Master handbook of acoustics*, Fifth edition, Mc Graw Hill, USA, 2009

[8] A. Sygulska, The study of the influence of the ceiling structure on acoustics in contemporary churches, *Archives of Acoustics*, 44, 1, pp. 169-184, 2019.