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Full revision of the Swiss standard on building acoustics SIA181

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Abstract [827] The Swiss standard on building acoustics SIA181 was totally reviewed in 1999-2003. This paper presents the major changes made in the new version (to be published in 2004). The requirements, expressed in two classes ("minimal" and "standard"), are more severe than before and include the adaptation terms from ISO 717 (C for internal airborne noise insulation, C_{tr} for external sound insulation, C_i for impact noise). The standard includes also a new measurement methodology for equipment noise due to users, evaluation of structure-borne noise, insulation for public establishments with amplified music and recommendations for sound insulation inside dwelling, school, office, hospital, etc. The need of stricter requirement (about 2 dB for minimal and 5 dB for standard requirements) comes from the population complaining that existing minimal requirements ($D_{nT,w}$=52 dB, L'_{nTw}=55 dB) were not satisfactory. The additional cost of the building construction with the new standard is also evaluated (about 2.5% for minimal and 10% for standard requirements).

1 INTRODUCTION

The Swiss standard on building acoustics SIA181 edited in 1977 and 1988 [1] was totally reviewed in 1999-2003. This paper presents the major changes in the actual draft version already presented to public review (final version including correction will be published this year).

The main goals of the revision are:

- the improvement of sound insulation (new acoustic quality designation, new legal obligation, global increase of the requirements)
- the compatibility and the integration of new international standards (in particular the spectrum adaptation terms from ISO 717, the calculation methods from EN 12354, the reference reverberation time that varies in Switzerland according to the volume)
- the extension of the fields covered by the standard (structure borne sound, sound insulation inside an administrative entity, for public establishments open during night time, room acoustic requirements)
- improvement of equipment user noise measurement methodology
- improvement of editorial points

The need of stricter requirement (about 2 dB for minimal and 5 dB for standard requirements) comes from the population complaining that existing minimal requirements ($D_{nT,w}$ = 52 dB, L'_{nTw} = 55 dB for minimal acoustical quality, moderate noise pollution grade and medium noise sensitivity) were not satisfactory.

2 PRESENTATION OF THE STANDARD

2.1 Introduction

The SIA 181 intends to provide a protection against noise in new (or heavily transformed) buildings. The SIA 181, as all the standards published by the Swiss Society of Engineers and Architects, fits in the legal framework of the civil law. However, this particular standard is explicitly mentioned in the Federal Noise Abatement Ordinance [2] that confers to it a particular status: Minimal requirements are requested by the administrative law.

To achieve the compatibility with the international standards (ISO 140 and 717), the new standard uses a Swiss specific volume correction C_v (= 5*Log(V/100) when >200 m^2, but C_v<5 dB), which was previously integrated in the indexes. This correction is taken into account for reverberation time references that differ from 0.5 s (only this value is used in international standards) for large volume.
Exception made for some special case (public establishment), the frequency band considered in the standard is 100 Hz to 3150 Hz.

2.2 Sound classification scheme

The requirements presented in the SIA181 depends on the class of acoustic quality, the grade of noise pollution (emission) and the sensitivity to noise (reception).

Class of acoustic quality

The SIA181 considers 3 classes of acoustical quality:
Standard: this acoustic class (called in the past version of SIA181 “increased requirements”) represents the state of the art in the field. The requirements presented in the standard correspond to this class. When the SIA181 standard is mentioned, standard requirements should be applied, if no other contractual conditions (minimal, special) are specified. With these requirements just a small minority of persons (about 15%) are not satisfied with the acoustic quality of the building.
Minimal: this acoustic class, mentioned in the Federal Ordinance, must be fulfilled in every case. It must be specified in contractual dispositions or can be applied in absence of reference of the SIA181. In the previous version of the standard, the rule was when the SIA181 was mentioned, minimal requirement should be applied, if no other contractual dispositions (increased, special) were specified. With those minimal requirements (usually 3 dB lower than those for Standard acoustical class) an important minority of persons (about 25%) are not satisfied with the acoustic quality of the building.
Special: this acoustic class is intended in special cases (for example, with low background noise) to provide better acoustical comfort and must be specified with the desired requirements in contractual dispositions.

Grade of noise pollution (emission)

The requirements depend on the grade of noise pollution at the emission. For external sources it is expressed according to the evaluation level Lr defined in the Noise Abatement Ordinance [2]. For internal sources, the emission room is characterized by four noise pollution grades: **low, moderate (the most used), high, very high**. Each increase of the grade of noise pollution raises the requirements by 5 dB.

Noise sensitivity of the room (reception)

The requirements depend also on the noise sensitivity of the reception room.
Rooms with **low** noise sensitivity are used for manual activities or when used by many persons but for a short time (for example, workshop, restaurant, bathroom, etc.)
Rooms with **medium** noise sensitivity (the most used class) are used for intellectual activities or for housing (for example, bedroom or living room, office, etc.)
Rooms with **high** noise sensitivity especially need quietness (for example, restroom, room for reading or special therapy, etc.)
Each increase of the noise sensitivity class raises the requirements by 5 dB.

2.3 Airborne sound insulation of façades

The airborne insulation of façades is expressed according to the evaluation level Lr defined for external noise sources evaluation [2] during the day (Lr,j) and the night (Lr,n) periods. In new regulations, the requirements are smoothed (the 5 dB steps, used in the previous version of the standard, are abolished).
For standard acoustical quality and medium noise sensitivity (the most frequent case) we have the following requirement :

Room for sleeping: $D_{nT,w} + C_{tr} - C_v = L_{r,n}$ -20 dB (but >30 dB)
Other room purposes: $D_{nT,w} + C_{tr} - C_v = L_{r,j}$ -30 dB (but >30 dB)

This induces an indoor level (window closed) of approximately L_{Aeq} = 30 dB(A) during day light and 20 dB(A) for night sleeping.

2.4 Airborne sound insulation between rooms

For standard acoustical quality, moderate noise pollution grade and medium noise sensitivity (the most frequent case) the SIA181 gives the following requirement for minimal airborne insulation between rooms:

$$D_{nT,w} + C - C_v = 54 \text{ dB}$$

Each increase of the grade of noise pollution or the noise sensitivity class raises the requirements by 5 dB. The airborne sound requirements range is then from 44 (low noise sensibility and noise pollution grade) to 69 dB (high noise sensibility and very high noise pollution grade).
The requirements are 3 dB lower for the “minimal” acoustic quality class.

2.5 Impact noise insulation between rooms

For standard acoustical quality, moderate noise pollution grade and medium noise sensitivity (the most frequent case) the SIA181 gives the following requirement for maximum impact noise level:

$$L'_{nT,w} + C_i + C_v = 50 \text{ dB}$$

Each increase of the grade of noise pollution or the noise sensitivity class induces a decrease of requirement of 5 dB. The impact sound requirements range is from 60 (low noise sensibility and noise pollution grade) to 35 dB (high noise sensibility and very high noise pollution grade).
The limit values are 3 dB higher for the minimal acoustic quality class.

The frequency band for the adaptation term C_i (according to ISO 717-2) is 100 to 2500 Hz.
To avoid an unjustified bonus for heavy floor (for example concrete with bad floating floor (manufacturing default)), only the positive value of C_i are considered (if Ci<0 the Ci=0)

2.6 Noise from equipment in building

The household equipment noise (mainly from kitchen and bathrooms), evaluated through the index $L_{r,H}$ + Cv, is divided according to:

- The temporal characteristics of the noise : continuous ($L_{r,H}$= L_{Aeq}) or short-time (duration<3 min., $L_{r,H}$= L_{Amax})) noise.
- The source of the sound : related ("user noise" for example impact in tub, dishes in sink or on shelves, closing doors) or unrelated ("functioning noise" for example flushing the WC, elevator, HVAC noise) to the action of users.

The following table gives the requirements of the equipment noise (evaluated with $L_{r,H}$ + C_v) for standard acoustical quality:

Table 1: *Requirements of the equipment noise (evaluated with $L_{r,H}$ + C_v) for standard acoustical quality*

Type of noise (emission)	Short-time noise		Continuous noise
	Functioning (F)	User (U)	F or U
Noise sensitivity (reception)	Requirements (dB(A))		
Low	35	40	30
Medium	30	35	25
High	25	30	25

When the noise occurs only during daytime, the limit values increase by 5 dB(A)
When the equipment noise is produced by industrial facility, the limit values decrease by 5 dB(A).
The limit values are 3 dB higher for the minimal acoustic quality class.

To increase the reproducibility of the measurement of "user noise", a new normalized hammer was developed [3].

2.7 Other requirements

Structure-borne sound

The standard includes requirements for structure-borne sound from outdoor or indoor source.
Since the Swiss Environmental Protection Agency (OFEFP) is actually developing a new Federal Ordinance on this subject (VEKS), the standard refers directly to this legal text that should be published shortly.

Airborne insulation from public establishment

A special normative annex (A) is devoted to the protection against noise during night period, from noisy public establishments diffusing music or industries located inside or adjoined to a building with dwellings.
The airborne sound insulation requirements are defined according to the expected level in the establishment ($L_{Aeq,1h}$) and the noise sensibility of the reception room.
For standard acoustical quality and medium noise sensitivity (most frequent case) we have the following requirement :

$$D_{nT,w} + C_{tr\ 50\text{-}3150} - C_v = L_{Aeq,1h} - 17\ \text{dB}$$

Insulation inside administrative entities

The standard includes an informative annex (H) concerning the recommendations for airborne and impact sound insulation inside administrative entities (dwelling, office, school, hotel, hospital).
This annex gives also limit values for equipment noise.
The requirements are presented for two acoustic quality classes (class 1 and class 2).

Subjective evaluation of sound insulation

The standard includes an informative annex (J) concerning the subjective evaluation of the airborne and impact insulation according to the background noise level (20 or 30 dB(A)), the audibility, and the intelligibility of speech.

Room acoustics

The standard will also include requirements concerning the reverberation time for particular rooms:
For classrooms : $RT = -0.17 + 0.32\ \text{Log}(V/V_0)$ with $V_0 = 1\ m^3$ and $V < 500\ m^3$
For sport halls : $RT = -2.49 + 1.27\ \text{Log}(V/V_0)$ with $V_0 = 1\ m^3$ and $2000 < V < 8500\ m^3$
The requirements are partly inspired from the new German regulation DIN 18041 [4].

3 COST ANALYSIS

To evaluate the additional cost due to the improvement of the requirements, a study was realized by two independent economists on two buildings with various requirements and adequate construction modifications. The results are summarized in the following table.

Table 2: *Additional cost due to the improvement of the requirements*

Insulation/Improvement	+ 2 dB (Minimal 1988 – Minimal 2003)	+ 5 dB (Minimal 1988 – Standard 2003)
Façade	0.98%	2.54%
Indoor (airborne + impact)	0.96%	5.52%
Equipment	0.53%	1.56%
Lost of available area	0.12%	0.28%
Total	2.59%	9.90%

We can conclude that with an improvement of about 2 dB (which corresponds to the average increase of the minimal quality class) the total construction cost becomes 2.59% more expensive.
If the improvement is about 5 dB (increase from old minimal to new standard), the additional cost is about 10%.

The main factors of influence in the additional cost are the improvement of airborne (façade and indoor) and impact noise. The reduction of equipment noise and available surface (wider walls and thicker floors) are less significant for the additional cost.

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