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special rules and benefits of changing descriptors**

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Airborne sound insulation descriptors in the Nordic building regulations – Overview special rules and benefits of changing descriptors

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All Nordic countries have sound insulation requirements specified in the building regulations or in sound classification schemes, Class C, referred to in the regulations and published as national standards, which all originate from a common Nordic INSTA-B proposal from the 90's, thus having a lot of similarities. However, the descriptors and other rules differ more than what is obvious at the first glance. The present use of different descriptors and additional rules is partly a heritage from the past and partly caused by later national revisions without cooperation with the other Nordic countries. These national rules are not easy to find, unless all details of standards and other documents are known and studied carefully, and they cause problems since the building industry is not national anymore. This paper gives an overview of special national rules in the Nordic countries regarding airborne sound insulation requirements and is related to an equivalent paper about impact sound insulation requirements. The papers also describe the major benefits of reducing the number of special rules and of changing descriptors to those which best support protection of the residents and development of the building industry, both aspects in consideration of the European perspective and cooperation in COST Action TU0901.

1 Introduction

This paper deals with airborne sound insulation descriptors, requirements and special rules in the Nordic countries and is coordinated with another paper with a related main topic, impact sound insulation [1]. The two papers have the same main structure, some similar text paragraphs and the same introductory overview table. Both papers focus on multi-storey housing. In [1] is found brief information about rules for evaluation of compliance with requirements.

All Nordic countries have sound insulation requirements for different types of buildings, and since the mid 90's sound classification schemes have been implemented as national standards in all countries, one by one, in the period 1996 to 2004. In building codes and in classification schemes, different acoustic issues are addressed, like airborne and impact sound insulation, noise levels etc. An overview of regulations and sound classification schemes is found in Table 1.

Table 1: Sound insulation of dwellings.

Overview Building codes and sound classification schemes in the Nordic countries - Status March 2010

| Country | Building code (BC) | Classification scheme (CS) ⁽¹⁾ | BC link to CS | BC reference to CS | BC References | CS References |
|--------------|---------------------------------|---|---------------|---------------------|---------------|---------------|
| Denmark (DK) | BR 2008 | DS 490:2007 | + | Class C | [2] | [7] |
| Finland (FI) | RAKMK C1:1998 | SFS 5907:2004 | (+) | (Class C) | [3] | [8] |
| Iceland (IS) | Byggingarreglugerð Nr. 441/1998 | IST 45:2003 | (-) | Class C recommended | [4] | [9] |
| Norway (NO) | TEK'97 | NS 8175:2008 | + | Class C | [5] | [10] |
| Sweden (SE) | BBR 2008 | SS 25267:2004 | + | Class C | [6] | [11] |

(1) Class denotations A / B / C / D indicated in descending order, i.e. the best class first.

During different periods in history several attempts have been made to coordinate the sound insulation requirements in the Nordic building regulations. Last time an extensive attempt was made, was during the mid 90's. The work was partly funded by the Nordic Committee on Building Regulations, see reports [12-14], and by Inter Nordic STandardization – Building (INSTA – B), see [15]. At that time dedicated organizations existed in order to promote coordination between the Nordic countries. However, for different reasons, these organizations closed down, and the needs for updating requirements in the different Nordic countries were asynchronous. Combined with the fact that consensus was never reached, the consequence was that sound insulation requirements and classification schemes developed in different directions in the Nordic countries. Additionally, since the late 90's until today, several further national revisions have been made in each country, implying that current legislation in the Nordic countries is even more diversified today than 10-15 years ago. Instead of cooperation and coordination, all new revisions have been made from national experiences solely, and changes were not only made by changing numbers and by following the international standards [16-17], but additional special rules were made and included in the regulations or in the classification standards, for example as notes or rules explained somewhere in the document - not necessarily in the tables with limit values - or even in other documents like eg guidelines.

The Nordic building industry suffers from the differences in requirements and special rules, since their building systems have to be adapted to national regulations in a small market. The Nordic market is today an “open market”. However, with regard to building regulations, the market is indistinct, thus impeding exchange of building systems and products.

2 Airborne sound insulation requirements in the Nordic countries

The minimum requirements are stated in national building regulations, either directly, as in Finland and Iceland, or indirectly by referring to the national classification scheme, as in Denmark, Norway and Sweden. However, in Finland, the limits are identical in the building code and in the classification scheme, Class C, but the use of classification schema is voluntary. It is expected that Iceland will refer to the sound classification scheme in the revised building regulations expected in year 2011. In some countries the requirements are stated in the building regulations in advisory notes, which are normally not mandatory. However, if these are not followed, it is necessary to prove that the overall mandatory requirements still are fulfilled. Hence, in practice, the advisory notes are mandatory.

2.1 Limits airborne sound

The airborne sound limits, which have to be complied with in the Nordic countries, are stated in Table 2. The requirements appear to be the same in Norway, Finland and Denmark, both in terms of descriptor and level. Sweden and Iceland differ from the three other countries. However, there are some remarks about national special evaluation rules deviating from current rules standardized in ISO 140-4 and ISO 717-1 [16-17], which actually make the figures differ from each other more than what could be expected, see Section 2.2.

Table 2: Regulatory requirements for airborne sound insulation between dwellings in the Nordic countries

| Country | Requirements found in | Requirements airborne sound insulation | |
|---------|--|--|---|
| | | Airborne sound insulation [dB] | Remarks |
| SE | CS (Class C) | $R'_w + C_{50-3150} \geq 53$ | National special rules (additional rules compared to ISO 140-4) |
| NO | CS (Class C) | $R'_w \geq 55$ | National special rules (additional rules compared to ISO 140-4) It is recommended to include $C_{50-5000}$ at the same level |
| FI | BC or CS (Class C) (Identical limits) | $R'_w \geq 55$ | National special rules (additional rules compared to ISO 140-4) |
| DK | CS (Class C) | $R'_w \geq 55$ | For light-weight constructions, it is recommended to apply the limit $R'_w + C_{50-3150} \geq 53$ dB (see Table 3) |
| IS | BC | $R'_w \geq 52/55$ | National special rules (additional rules compared to ISO 140-4) Classification scheme is not yet included in the BC |

Hence, when reading the text in each national document carefully, there are differences in many of these figures, even if they at a first glance appear to be equal. This causes unexpected problems and unnecessary costs for those who will comply with the class criteria or the regulations in the different countries. Norway, Finland and Denmark appear to apply the same level, however with all national additional rules they are rather different, so are Sweden and Iceland.

2.2 National special evaluation rules for airborne sound insulation

In some Nordic countries important exceptions are used. These exceptions are not immediately visible in the regulations, and for those who are not working in the building acoustic area, the exceptions and special evaluation rules are not fully clear and not easy to understand. Even specialists may sometimes fail to find all special rules. The special rules found by the authors and specialists from the other countries, [18], are summarized in Table 3 below.

Table 3: Special evaluation rules for airborne sound insulation

| Country | Special evaluation rules for airborne sound insulation | Remarks |
|---------|---|---|
| SE | 1. Relation V/S must not exceed 3.1 m when evaluating airborne sound (i.e. D_{nTw}). | R'_w in Sweden corresponds to $D_{nT,w}$ when $V/S > 3.1$ |
| NO | 1. Receiving room volume limitation in the evaluation, $V_{r,max} \leq 100 \text{ m}^3$ 2. If the dividing surface contains a door, and the total dividing surface is smaller than 10 m^2 , then $S = 10 \text{ m}^2$. If there is no shared dividing surface, then $S = 10 \text{ m}^2$. In this case, it is the normalised level difference, $D_{n,w}$, that is determined (see NS-EN ISO 140-4). The resulting value of $D_{n,w}$ is then compared with the limit value set for R'_w . | |
| FI | 1. Receiving room volume limitation in the evaluation, $V_{r,max} \leq 60 \text{ m}^3$ 2. Sleeping rooms max $L_{eq,1h}$ levels in 20-200 Hz in 1/3 octav bands 3. Sleeping rooms max 25 dB(A) from music from 22-02 h. | Rules are not in BC or CS, but in refs [21] and [22] |
| DK | 1. If the area of the common part of the partition between two rooms is less than 10 m^2 , the area applied is largest of the values of the actual area and the receiving room volume divided by 7.5. If there is no common area, the normalized level difference D_n is applied instead of R' . 2. For light-weight constructions (walls $< 100 \text{ kg/m}^2$ and floors $< 250 \text{ kg/m}^2$) it is recommended to extend the frequency range down to 50 Hz and apply $R'_w + C_{50-3150} \geq 53 \text{ dB}$. | This rule is found in SBi Guideline 217 [19] This recommendation is found in SBi Guideline 216 [20]. |
| IS | 1. R'_w is calculated with old 8 dB max rule as in old I_a -value. $R'_{w,8dB} = I_a$: Min. value 52 dB, recommended 55 dB for apartments, min. value 55 dB for row-houses | |

Assuming a room volume of 134 m^3 which is not unusual, common area 18 m^2 (calculations are based on real measurement data) and a reverberation time equal to 0.6-0.7 s. It corresponds to a typical modern apartment with an open plan solution (kitchen and living room connected). Evaluating this according to ISO 717 and comparing this figure to results based on national special rules give results as stated in Table 4.

Table 4: Example of deviations, taking national special rules into account and comparing to evaluation according to ISO 140-4 and 717-1 (R'_w or $R'_w + C_{50-3150}$) for room volume 134 m^3 and room $T = 0.6-0.7 \text{ s}$

| Room, $V_r = 134 \text{ m}^3$ | Evaluation procedure | | | Remarks |
|---|---|---|---|---------|
| Requirement in each country R'_w or $R'_w + C_{50-3150}$ or both, see Table 2 | ISO 717 and national special rules, cf. Table 3 | Values – using ISO 140-4 and ISO 717-1 solely. [dB] | | |
| Sweden ($R'_w + C_{50-3150} \geq 53 \text{ dB}$) | $R'_w + C_{50-3150} = 53 \text{ dB}$ | $R'_w = 51$ $R'_w + C_{50-3150} = 50$ | $D_{nTw} = 55$ $D_{nT,w} + C_{50-3150} = 53$ | |
| Norway ($R'_w \geq 55 \text{ dB}$) | $R'_w = 52 \text{ dB}$ | $R'_w = 51$ $R'_w + C_{50-3150} = 50$ | $D_{nTw} = 55$ $D_{nT,w} + C_{50-3150} = 53$ | |
| Finland ($R'_w \geq 55 \text{ dB}$) | $R'_w = 55 \text{ dB}$ | $R'_w = 51$ $R'_w + C_{50-3150} = 50$ | $D_{nTw} = 55$ $D_{nT,w} + C_{50-3150} = 53$ | |
| Denmark ($R'_w \geq 55 \text{ dB}$) | $R'_w = 51 \text{ dB}$ | $R'_w = 51$ $R'_w + C_{50-3150} = 50$ | $D_{nTw} = 55$ $D_{nT,w} + C_{50-3150} = 53$ | |
| Iceland ($R'_w \geq 52/55 \text{ dB}$) | $R'_w = 51 \text{ dB}$ | $R'_w = 51$ $R'_w + C_{50-3150} = 50$ | $D_{nTw} = 55$ $D_{nT,w} + C_{50-3150} = 53$ | |

3 National plans for changing requirements

Changes of sound insulation requirements in the Nordic countries are not at standstill. In countries with the building code referring to a specific class in a classification scheme, in fact requirements can be revised, even with the text in the building code remaining the same. Special rules – if strictly necessary - could also be included in the classification scheme, implying no need for hiding such rules in other additional publications.

Brief information about known plans for changes of requirements in the Nordic countries is found in table 5.

Table 5: Future plans in Nordic countries

| Country | Future plans |
|---------|---|
| Sweden | Plan for revision of SS 25267, starting 2010 |
| Norway | NS 8175 and the regulations are in revision and there will be new requirements for universal design/accessibility for all. The new regulation is expected to be in force from July 2010 |
| Finland | Waiting for COST TU0901 results |
| Denmark | None |
| Iceland | The standard [9] is now in English and has the name: IST 45:2003 "Sound Classification of Dwellings". The standard is under revision and will probably be published in 2010 in Icelandic only. The new edition will also include various other types of buildings. The Classification Standard has been voluntary up till now, but this will change when Class C gets the status of the Building Code, probably in 2011. |

4 Discussion airborne sound insulation requirements and special rules

In addition to the before-mentioned special rules, there might be other national special rules related to airborne sound insulation limits. It is of course also relevant and probably even more important to review descriptors and limit values, cf. Table 2. Furthermore, there are differences in requirements between countries depending on the type of living accommodation, dwellings for elderly, normal dwellings etc. It is important to notice that while the original INSTA proposal for a Nordic classification scheme only included dwellings, Finland, Norway, Sweden now have sound classification standards that includes various types of buildings, and Iceland is expected to implement a similar standard in 2010.

In spite of different building practices, there seems to be no scientific reason for various national requirements and special rules, since people in the Nordic countries are considered to have approximately the same living habits and equal expectations of their home environment. The reason is rather lack of cooperation during the last decade.

Complaints from residents in light-weight housing indicate a need to include lower frequencies in the evaluation for such construction types.

4.1 Benefits of reviewing airborne sound insulation descriptors, limits and rules

More work on the findings stated in this paper, cooperation and implementation would have the following benefits:

1. Increased exchange of knowledge – better understanding regarding the basis for national special rules
2. Less complicated national adaptations - some adaptations might be unnecessary with regard to subjective response
3. Facilitate and encourage more cross country trade between the Nordic countries
4. Lower costs for the building industry
5. Less risk for mistakes due to the fact that some special rules may not be discovered by consultants

The need for some of the special rules may be caused by a non-optimal choice of descriptors. Thus, it is important to understand the reasons and to investigate if other descriptors are more optimal.

The building industry today is not national any more. Almost all building companies and manufacturers are working at least on the Nordic market. Each company makes their own investigations and expensive, national adaptations in order to enter the market or to market new products. Besides, if the national adaptations are not discovered when transferring building systems or building products from one country to another, the costs will raise even more afterwards. Often, it is necessary to involve consultants from each country in order to understand and clarify the differences for the developer.

Previous studies and the development in Europe [23-28] as well as the revision of ISO 717 [29-30] seem to indicate that instead of the present R'_w as the basic descriptor for airborne sound insulation limits in the Nordic countries, the preferred descriptor could be $D'_{nT,w}$ combined with a low-frequency adaptation term.

4.2 Reviving the Nordic cooperation?

There is a lot more to do until the differences between the sound insulation requirements and the classification schemes in the Nordic countries are fully described. However, this paper and the corresponding paper describing impact sound insulation might be used as a first basis in order to identify the main differences in descriptors, limits and rules. It would be of great benefit to sort out unnecessary additional rules and keep special rules to a minimum.

In a revived Nordic cooperation the most important rules could be identified and other differences discussed. There should also be a close cooperation with the Baltic countries, because their regulations to a wide extent are inspired by the Nordic countries. Part of the work could be done in the Swedish-Danish Interreg IV project Silent Spaces [31].

The results of revived Nordic cooperation could provide input for revision of ISO 717 [29-30], and for cooperation in COST Action TU0901 [32] aiming at harmonization of descriptors and classification schemes in Europe.

5 Summary

This paper is summarizing national special rules for airborne sound insulation requirements in the building regulations in the Nordic countries and is coordinated with a corresponding paper about impact sound insulation [1].

Nordic countries were rather close to meet an agreement in the mid 90's. However, lack of consensus and the asynchronous revisions of building regulations led to stop of cooperation soon after. Since then, differences between the Nordic countries have increased. Descriptors and other rules differ more than what is obvious at the first glance, when comparing the regulations or classification standards. When comparing the diversified requirements and standards existing now - about 15 years after- it seems to be time to reconsider the situation and reopen cooperation to the benefit of the residents of dwellings, building industry and development of building constructions. The present situation impedes development and creates trade barriers, and there seems to be a high interest for all parties involved in the building process to change the situation.

It is concluded that a revived Nordic cooperation could contribute to identify the most important special rules, and it is proposed to prepare a common Nordic document with an overview of all national building acoustic requirements and classes in the Nordic countries, starting with dwellings. The results of such work, parts of which could be done in the Interreg IV project Silent Spaces [31], could provide useful input for the revision of ISO 717 [29-30], and for the work within the COST Action TU 0901 [32] aiming at harmonization of descriptors and classification schemes in Europe.

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