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GERMAN STANDARD DIN 4109 (SOUND INSULATION IN BUILDINGS) IN THE CONTEXT OF TECHNICAL, SCIENTIFIC AND SOCIAL DEVELOPMENTS

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ABSTRACT

For many years, the standard DIN 4109, which regulates sound insulation in buildings at a legally obligated level, has been the relevant standard for building acoustics in Germany. It not only specifies the requirements for sound insulation, but also regulates measurement procedures and calculative verifications. The origins of this standard date back to 1938. Since then, the content and form of this standard have constantly evolved. This standard has always been the subject of lively discussions. This contribution emphasises at the progress of this standard in view of the many technical, scientific and social developments from its origins to its current status. It can be shown that requirements on the one hand and acoustical verifications on the other have developed in different ways. At the same time, the history of DIN 4109 also shows the development of building acoustics in practical application.

Keywords: *standard, sound insulation, regulation, building acoustic*

1. INTRODUCTION

The German standard DIN 4109 (Sound insulation in buildings) is virtually an institution in Germany that plays a prominent role in building acoustics. It has a long history in which, on the one hand, it has always significantly influenced the development of building acoustics in Germany and, on the other hand, it has taken up developments from building acoustics practice and research. In this respect, it seems justified to give this standard the appropriate attention in the present historical context.

2. DIN 4109 AS THE CENTRAL SET OF RULES FOR BUILDING ACOUSTICS

DIN 4109 is the authoritative standard for building acoustics in Germany. From the very beginning, it has taken on the task of formulating the requirements for building sound insulation set by the state in the course of the building regulations. This is often seen as its most important task. As a standard, DIN 4109 is created in a regular standardisation process (in accordance with the statutes for standardisation work in DIN 820) at the German Institute for Standardisation (DIN), but it only attains the status of a legally binding specification through the subsequent "introduction by the building authorities". A special feature of DIN 4109 is that it not only specifies the requirements of building sound insulation, but also contains specifications on how compliance with them can be verified and gives advice on how they can be realised. In Germany, the verification of compliance with the requirements of DIN 4109 is usually carried out by calculation, but metrological verification is also regulated. In addition, DIN 4109 contains instructions for planning and implementation right from the start. Thus, DIN 4109 in its entirety is above all a comprehensive planning instrument that covers all areas of the design of structural sound insulation. It thus has a far-reaching effect on building practice.
This comprehensive claim actually makes DIN 4109 an institution of building acoustics of far-reaching importance in Germany. This central role within the framework of building acoustics standardisation is reinforced by the fact that it is closely linked to the building acoustics test procedures for laboratories and buildings via the verifications. These have been required since 1962 in DIN 4109 in order to be able to carry out the suitability and quality tests mentioned there. Thus, the measurement and assessment procedures defined at the German level,

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together with DIN 4109, formed a common and complete German standard concept of sound insulation in buildings. This was only dissolved when the building acoustics measurement procedures for Germany were also gradually internationalised by ISO and EN standards and the German measurement standards had to be (largely) withdrawn.
Since the 1962 version, DIN 4109 also provided for suitability and quality tests. It was stated: "Suitability tests are to be carried out by an officially recognised testing institute". Under the supervision of the then IfBt (Institut für Bautechnik, today DIBt), a separate verification system with Group I testing bodies approved for this purpose was created. For a long time, these bodies were heavily involved in the further development of DIN 4109 and in research projects related to DIN 4109. In addition, there were also the quality testing bodies to carry out the quality tests mentioned in DIN 4109 Blatt 2:1962 in the building inspection procedure. This inspection system of the quality inspection bodies still exists today. Separate qualification guidelines and quality assurance systems were established for the test centres, in which the IfBt and the Physikalisch Technische Bundesanstalt (PTB) were involved.
All in all, it can be seen that a comprehensive set of standards and verification systems was created for sound insulation in buildings, the centrepiece of which was DIN 4109. Only in this context the importance of DIN 4109 for building acoustics in Germany can be recognised.

3. HISTORY OF DIN 4109

When DIN 4110 (Technical Regulations for the Approval of New Construction Methods, 2nd edition, Berlin July 1938) was published in 1938, it was the first German standard to deal with sound insulation in buildings and to make specifications for airborne and impact sound transmission. What started with a volume of about one page ended (for the time being) with DIN 4109:2016/2018 on more than 400 pages, distributed over ten individual parts of the standard. This quantitative consideration alone gives an idea that the normatively regulated sound insulation in buildings was subject to constant development and expansion of its scope of application. From the first specifications on sound insulation to the current status - then under the name DIN 4109 - a body of standards has developed that not only specifies the requirements, but also deals with metrological and computational verifications, specifies building element data ("implementation examples") and provides information for planning and implementation. Thus, this standard has gradually developed from ensuring the protection requirement from the state's point of view to the central set of rules for sound insulation in buildings, which not only provides the requirements and verification concept for the state-regulated area, but also represents a modern and efficient tool for building acoustics planning.
A short overview shows some important steps of the development:
-DIN 4110:1938 formed the beginning of normative regulations for sound insulation as "Technische Bestimmungen für die Zulassung neuer Bauweisen ".
-DIN 4109:1944 (Richtlinie für den Schallschutz im Hochbau) was the first separate standard for sound insulation in buildings and established the tradition of this standard under the name DIN 4109, which was used for the first time.
-DIN 4109:1962 (Schallschutz im Hochbau) led to the first major revision of DIN 4109 with a total of 5 sheets and was introduced by the building authorities.
-DIN 4109:1989, together with Supplements 1 and 2, was given a new structure and for the first time contained computational verifications for heavy and lightweight / timber construction. For this purpose, the required component data were supplied in the form of "design examples".
-With DIN 4109:2016, DIN 4109 was adapted to the European standards of sound insulation in buildings and underwent a complete redesign.
It can be seen that every 25 years or so (1938/1962/1989/2016) significant steps were taken to further develop the standard. In the current version, DIN 4109 has five standard parts: DIN 4109-1 with the minimum requirements, DIN 4109-2 with the calculation methods, DIN 4109- 31 to 36 with the building element catalogue, DIN 4109-4 with the building acoustic tests and DIN 410-5 with the increased requirements.
The building element catalogue forms the data basis for the computational verifications in DIN 4109-2. In view of new data not previously required (e.g. for direct sound reduction or vibration reduction index) and the updating of data (especially for timber and lightweight construction), the new building element catalogue reached such a volume that a thematic division into 6 parts was made. It is intended that the building components catalogue will be continuously developed. Further developments are also planned for the calculation methods in DIN 4109-2 in the ongoing revision. Thus, although DIN 4109 has a long history, it has not yet reached the end of its development - at least with regard to the calculation methods and the component catalogue. In its current state, it provides a consistent set of rules for requirements, verification, planning and execution of sound insulation and is thus the only set of rules in Germany that

completely covers this area. In addition to its significance under public law, it is also a contemporary instrument for the entire building acoustics planning and design that meets current expectations.

4. DIN 4109 IN THE CONTEXT OF SCIENTIFIC DEVELOPMENTS IN BUILDING ACOUSTICS

There is no doubt that DIN 4109 is involved in the scientific developments in building acoustics. On the one hand, it tried very early on to use the scientific input of the field for itself and to take up scientific results. For example, when the edition of the standard was introduced in 1962, the following comment was made: "The standard DIN 4109 is thus a typical example of the evaluation of scientific investigations for the direct work of building practice." On the other hand, DIN 4109 has also repeatedly provided impetus for building acoustics research and thus ensured further development of building acoustics. Among the people who have made a decisive contribution to the scientific development of building acoustics in recent times, Lothar Cremer and Karl Gösele are particularly worthy of mention. Their contributions will be highlighted by means of a few exemplary examples. In addition, it should not be forgotten that significant contributions were also made outside the scope of DIN 4109 and were taken note of in the context of DIN 4109. These include, for example, the work from the Bauakademie of the GDR around W. Fasold, the Reichardt'sche Schule with the Institute for Electrical and Building Acoustics at the TU Dresden and the work of J. Lang (Vienna).

Lothar Cremer was extremely active in the field of acoustic standardisation. In particular, he contributed to the national and international standardisation of building acoustics. Some of his most important contributions, which are directly related to the acoustic issues of DIN 4109, are mentioned here as examples.

In [1] Cremer deals with the theory of sound insulation of thin walls at oblique incidence. Together with M. Heckl, "computational and experimental investigations of sound bridges in double walls" are then also carried out [2]. Cremer also made essential contributions to impact sound. Especially known is the "Theory of Impact Sound" published in 1948 [3]. In the 1950s, when floating screeds became more important as a building acoustic solution, a comprehensive understanding of this construction method was needed and Cremer contributed a fundamental theory [4].

An important issue for building acoustics was the formation of single-number values for sound insulation on the basis of reference curves. Cremer made significant contributions to this [5]. Questions of sound insulation that are of importance in practical application and are relevant to DIN 4109 have also been reflected in Cremer's and Heckl's basic work on structure-borne sound [6]. There, for example, the generation of impact sound and the excitation by the standard tapping machine are dealt with. Continuous coupling through elastic intermediate layers, as occurs with floating screeds, or double walls with sound bridges are also discussed.

Karl Gösele's name is associated with building acoustics and DIN 4109 like hardly anyone else. Gösele himself was "an institution" in building acoustics standardisation. A basic constant of his work is that it was always oriented towards practical problems and claimed to be implemented in practice. Thus, one can justifiably claim that Gösele as an individual has influenced the development of DIN 4109 like hardly anyone else. The range of his activities can be illustrated with a few examples.

In 1968, he dealt with the airborne sound insulation of single layerd walls and ceilings in [7]. The investigations led to the derivation of a "mass curve", as it was later found in DIN 4109. A paper on the reduction of airborne sound insulation of walls by thickness resonances can be found in [8]. Again and again, it was doublewall building components that attracted his attention due to practical problems [9], [10], [11] and [12]. Gösele has also worked intensively on impact sound. Fundamental works include [13], [14] and [15]. He dealt also with the calculation of impact sound insulation of wooden beam ceilings in [16].

Like Cremer, Gösele also dealt with the formation of single-number values for sound insulation [17]. Of great influence on DIN 4109 was his work on flanking sound transmission, which not only deepened the understanding of the relevant processes, but was also the basis for new prediction methods for airborne sound insulation in buildings. As early as 1968, the "Untersuchungen zur Schall-Längsleitung in Bauten" [18] were published, in which - long before later in the EN 12354 and then also in the DIN 4109-2:2016 the vibration reduction at junctions appeared - these quantities were already examined in detail and made determinable with computational approaches. The method presented in 1984 for the calculation of airborne sound insulation in buildings considering flanking sound transmission [19,] was groundbreaking. It corresponded in its essential features to the method that was later also used in EN 12354-1 and DIN 4109-2:2016. As flanking walls became lighter and lighter in the course of changing construction methods, Gösele also dealt with this increasingly evident problem [20]. In numerous publications, Gösele, often together with C. A. Voigtsberger, has also taken up the then very acute valve and tap noises. At this point, reference should be made to [21] as an example of such work.

In addition to individuals, institutions involved in research should also be mentioned. These are mainly those institutions that belonged to the officially designated Group I test centres for proficiency testing, e.g.: Institute for Technical Physics Stuttgart (later Fraunhofer Institute for Building Physics) with K. Gösele, Institute for Technical Acoustics of the TU-Berlin with L. Cremer, Federal Institute for Materials Research and Testing (BAM) in Berlin with P. Schneider, Materialprüfungsamt NRW Dortmund with A. Eisenberg, Materialprüfanstalt für das Bauwesen Braunschweig (MPA Braunschweig) and Physikalisch-Technische Bundesanstalt Braunschweig (PTB). Time and again, significant contributions came from these institutions, which were reflected in DIN 4109.

The Federal Ministry of Construction and the German Institute for Building Technology (DIBT), which has operated under different names over the past decades, are the institutions that promote research in the field of building acoustics. Numerous research projects directly related to the issues of DIN 4109 were funded by these government agencies. The "Berichte aus der Bauforschung" (Reports on Building Research), which were published between 1956 and 1975 and document 20 years of state-funded application-related building research, are now historical records of the building acoustics research projects funded by the Federal Ministry. A total of 7 anthologies on building acoustics are listed, edited by L. Cremer, A. Eisenberg and M. Heckl. They demonstrate the variety of building acoustics issues that were dealt with in these research projects. It is easy to recognise the direct relationship of the topics to the issues of DIN 4109. Research received a new impulse with the European standardisation of sound insulation in buildings, which shook up some of the fundamentals of DIN 4109 and led to a hitherto unknown scope of research projects preparing and accompanying standards. The impending changes, especially due to the building acoustics measurement methods and the EN 12354 prediction methods, created a great deal of pressure on DIN 4109. It was significant that not only the public sponsors (Federal Ministry of Construction and DIBt), but above all the building materials industry and the construction industry (especially in the area of solid construction) participated in the projects to a very considerable extent.

Even today, European standardisation is still an important stimulus for building acoustics research in Germany. An outstanding example at the moment is building services equipment. Although DIN 4109 specifies sound insulation requirements for this area, it does not yet contain any computational verification methods.

Thus, since the mid-90s of the last century, building acoustics research has experienced an unprecedented intensification in the context of European standardisation and DIN 4109, which has made it possible to place the calculation and verification procedures of DIN 4109 on a completely new footing and to provide building acoustics planning with a modern and efficient instrument. Since the requirements for sound insulation are not affected by the European regulations and there was no will in the standards committee for DIN 4109 to carry out a modernisation here (e.g. a change of single number quantities for the requirements), the area of requirements has not benefited from this impulse.

5. DIN 4109 IN THE CONTEXT OF TECHNICAL DEVELOPMENTS IN BUILDING ACOUSTICS

Since DIN 4109, by definition, sees its scope of application in building acoustics practice, the reciprocal relationships between DIN 4109 and technical developments in building acoustics are particularly pronounced. In reality, a separation between the scientific developments discussed in the previous section and the technical developments is not clearly possible. There are always overlaps here.

DIN 4109 is constantly under obligation to reflect current construction methods and thus follow technical progress. However, in view of the long time intervals between the individual editions of the standard, it has only succeeded in doing so with great delays. However, the new structure of DIN 4109 from 2016 and the restructuring of the standardisation work on DIN 4109 since 2006 have changed this. The calculation methods, just like the building element catalogue, are now set out in separate parts of the standard, so that they can be supplemented and updated independently of other parts of the standard. This has already happened several times since the 2016 versions were published. In the opposite direction, however, DIN 4109 has also repeatedly supported, initiated or even forced technical developments in building acoustics. Examples are floating screeds, double-shell house partition walls, developments in flanking transmission in solid and timber construction, as well as developments in fittings and equipment for water installations. Some of these developments are discussed below others for example the metrological verifications or the development of an installation test stand have to be omitted.

5.1 Homogeneous building elements and flanking transmission

When in 1989, for the first time, computational verifications for sound insulation in buildings were introduced in DIN 4109, the verification for buildings in solid construction was based on two simplifications: the sound insulation of a (homogeneous) partitioning element was determined from its mass per unit area and a mean flanking sound transmission was already taken into account in the computed value $R'_{w,R}$. This $R'_{w,R}$ was a value for the sound insulation determined by measurement in a test stand with flanking transmission similar to that of the building in accordance with DIN 52210, which already contained an "average" flanking transmission. If necessary, this had to be corrected by correction factors ($K_{L,1}$ and $K_{L,2}$) if the conditions of the building differed from those of the test stand. For practical use, this was an extremely simple matter, which also led to reasonable results for homogeneous construction common at the time. However, later on, when construction had developed further, it also led to limitations, because not all constructive variants were sufficiently considered. The limitations of this method became particularly apparent in the case of light flanking walls and highly insulating perforated bricks in the outer wall. In these cases, planning errors occurred again and again due to the assumptions of the verification method no longer being fulfilled. In contrast, DIN 4109 has been progressive since 1989 in the treatment of buildings in timber and lightweight construction. The prediction procedure provided for there corresponded in essential approaches to today's procedure of EN 12354-1 on the basis of a complete model.
Based on investigations such as those presented by Gösele in [22], it was realised that thermal-insulating perforated bricks could not be considered as homogeneous building components due to their perforated structure, whose sound insulation value can be determined from the mass per unit area. Extensive investigations led to a fundamental understanding of the phenomena that occur and to constructional solutions in the form of acoustically optimised perforated bricks. But it was also possible to put the acoustic prediction for such constructions on a new footing, based on the procedures of EN 12354. DIN 4109 was thus the first set of acoustic regulations that made it possible to take such products into account in planning and to provide acoustic proof.
The old method had reached its limits of validity for the flanking transmission of light solid walls. The detailed consideration of the flanking sound transmission in accordance with the calculation methods according to EN 12354 made it clear that the component connections (joints) with the new K_{ij} parameter must also be considered and taken into account. In the run-up to the new DIN 4109, the implementation of the European calculation methods led to numerous research and development projects dealing with the acoustic behaviour of joints and the flanking transmission. This resulted in optimised joint solutions, e.g. for exterior walls in brick construction or for the decoupling of lightweight solid walls. Such constructive solutions have found their way into building practice and have also been partially anchored in DIN 4109 (calculation method and component catalogue) since 2016.

5.2 Floating screed

In building practice, it was clear very early that impact sound insulation could be achieved most easily with a floating screed and that high values of impact sound insulation could only be achieved with this. As with the double partition walls before, this construction method also proved to be extremely prone to errors due to the danger of sound bridges. Initially, it was not possible to calculate the expected impact sound insulation, but as early as 1952, in the draft of DIN 4109 Supplement, March 1952, DIN 4109 felt compelled to provide information on the correct building design and installation.
DIN 4109:1962-09 even published a part of the standard, Sheet 4 (Floating screeds on solid floors, guidelines for execution), which dealt exclusively with floating screeds and issued guidelines for their construction. DIN 4109 thus ensured that the floating screed could become a reliable standard construction. It was not until DIN 4109:1989 that a mathematical verification procedure could be implemented in DIN 4109. This contributed to the spread of floating screeds and their further technical development.

5.3 Noise of water installation

An outstanding example of the influence of DIN 4109 on the technical development of products as well as the development of suitable measurement methods is the noise of taps and devices in water installations. The starting point was that there were quite considerable problems with the noise of fittings in the 50s and 60s of the last century. The lack of suitable low-noise products corresponded with the lack of a suitable method for assessing noise generation. The only solution was quite rightly seen in the need to create a suitable test procedure for valve noise. Due to extensive research (P. Schneider and K. Gösele), an appropriate measurement procedure was developed, which was then published as a draft standard in November 1968 and finally in 1972 as the standard DIN 52218 (Testing of

the noise behaviour of appliances and water installation devices in the laboratory).
The DIN 52218 measurement procedure initiated by DIN 4109 can be considered extremely successful. Within a short period of time after the introduction of the new measurement procedure, the massive complaints decreased drastically and nowadays the actual fittings usually only play a subordinate role in sound insulation in practice. The measurement method of DIN 52128 was then adopted into international standardisation in 1977 as ISO 3822-1, where it is still the internationally applicable measurement method within the framework of the ISO 3822 series.

6. DEVELOPMENT OF THE VERIFICATION PROCEDURES IN DIN 4109

At first, there was no calculation at all in DIN 4109. It worked with descriptions of components and constructions with which compliance with the requirements could be expected. This did not change in DIN 4109:1962 either. In its Sheet 3 (Design Examples), however, the construction details explicitly named "Design Examples" for the first time were given a significantly larger scope.
With DIN 4109:1989 and its Supplement 1 (Design Examples and Calculation Methods), the verifications were carried out mathematically for the first time. New were the calculation procedures for sound insulation in skeleton structures and timber buildings and in solid construction. Since then, the usual verification in Germany has been the calculation. In the 1989 standard, care was taken to ensure that the calculation procedure was as simple as possible so that it could be mastered by the "verifiers", most of whom were architects or civil engineers. Logarithmic calculations were avoided as far as possible. Instead, tables, diagrams and correction values were used. In Supplement 1 to DIN 4109, in view of the newly included computational verifications, design examples with acoustic characteristic values were now also included. The component data now served as input data for the calculation procedures, which was a new approach in the history of DIN 4109. These verifications were simple and practicable for the standard situations of building in Germany at that time. However, these procedures could not keep up with the development of building technology, so that reliable verification was no longer possible for certain applications (e.g. for exterior walls made of thermal insulating perforated bricks or for lightweight homogeneous flanking components). These gaps could be closed with DIN 4109:2016, when the European prediction procedures of EN 12354 were implemented in DIN 4109. At the same time, this step led to the fact that more extensive calculation procedures now also had to be applied according to DIN 4109-2, for which, however, suitable calculation programs are available.
From "logarithm-free" verification to software-supported detailed calculation, DIN 4109 has thus undergone a major development and is thus at the technical level expected today.

7. DIN 4109 IN THE CONTEXT OF SOCIAL DEVELOPMENTS

A standard dealing with sound insulation in buildings is inevitably the focus of different social interests. This has been shown time and again in the history of DIN 4109. The protection of occupants and building users should be in the foreground. They expect contemporary sound insulation that is adapted to today's needs and to technical developments. The technical conditions must be taken into account in the realisation of sound insulation. In particular, the economic efficiency of building is a dominating force in the discussion about the specification of sound insulation requirements. Specific issues of jurisdiction have also played a significant role again and again in the history of DIN 4109. The legal certainty of the specified requirements (e.g. in the sense of generally recognised rules of technology) was repeatedly addressed. As a DIN standard, DIN 4109 is processed in the Building Standards Committee (NABau). The standardisation work is bound to the standardisation principles of DIN 820, according to which the "interested parties", i.e. not only acoustic experts, are to be involved in the standardisation process. In the standards committee for DIN 4109-1, the interested parties include building material manufacturers, building contractors, the scientific community, the housing industry, building inspectors, consulting engineers, architects and housing users.
Given the very different interests of these groups, it is no wonder that the standardisation work on DIN 4109 in the area of requirements has been controversial and tough again and again in recent decades. It is therefore not surprising that the time intervals between the respective new editions were long: 1944 - 1962 - 1989 - 2016.
In view of the long periods of time between the individual editions of DIN 4109, it is surprising that the requirements have hardly changed in essential points since 1938. When DIN 4110 appeared in 1938 as the predecessor of DIN 4109, it was about the provision of living space on a large scale. For flat partition walls, a mass per unit area of at least 450 kg/m² was required, which meant that a weighted sound reduction index R_w of about 54 to 56 dB could be

achieved with the construction conditions common at the time. For the partition wall, whose sound insulation is decisive for the sound insulation of a flat, virtually nothing has changed, as in DIN 4109 of 1989 and the latest version DIN 4109-1 of 2018, an R'_w of 53 dB is required for the minimum requirements. When drafting this currently valid version, it was explicitly stipulated in the standards committee for the requirements that "no significant changes to the level of requirements" should be made. This explains why, despite high public expectations, the sound insulation level of DIN 4109:2016 was not adapted to today's ideas of contemporary sound insulation to the desired extent 27 years after DIN 4109:1989 was published. Whereas DIN 4109 used to be one of the leading requirements in Europe in terms of sound insulation, it has long since lost this status. Due to developments in numerous other countries, DIN 4109 has lagged behind in this respect.

The conflict between the residents' expectations of sound insulation and the demand for economic efficiency from the building and real estate industry is as old as the specification of sound insulation requirements and runs through the entire development of DIN 4109. Time and again it could be seen that in the end economic interests were given priority. An example of this is the draft standard DIN 4109 from 1979.

There, after a long time, a contemporary adjustment of the sound insulation level had been planned. This was withdrawn again in the 1984 draft standard. In the remarkable explanations of the chairman on the changes made in principle, the following was mentioned in the draft for Part 2: *"... the abandonment of the planned increase in the requirements for airborne sound insulation of partition walls and ceilings in dwellings compared to DIN 4109, 1962 edition, due to the comments received on this draft standard, which were directed in particular against the increases in construction costs associated with the increases in the requirements*".

As a conclusion, it can be stated that DIN 4109 is not an impulse generator in terms of requirements. It does not follow social developments and does not consistently take up developments in building technology. In the described field of conflict, it cannot be expected that the requirements of DIN 4109 per se reflect contemporary sound insulation. One must rather attest them a retarding status. Requirements in other countries (e.g. Switzerland, Austria) are now much more advanced. As a result of the existing dissatisfaction with the requirements of DIN 4109, further sets of rules on the requirements in sound insulation in buildings have therefore emerged in Germany, e.g. in 1994 the VDI 4100 (Sound insulation of dwellings; criteria for planning and assessment], in 2009 the DEGA sound insulation certificate (DEGA Empfehlung 103, Schallschutz im Wohnungsbau–Schallschutzausweis), in 2015 the DEGA Memorandum BR 0104 on sound insulation in one's own living area (Schallschutz im eigenen Wohnbereich) and in 2020 the DIN 4109-5 (Erhöhte Anforderungen). All of the above-mentioned regulations are not relevant for building inspectorates.

Further potential for conflict is provided by the existing law in Germany, which distinguishes between state requirements in the sense of requirements under public law and the properties of a building owed under contract and private law, whereby the so-called generally recognised rules of technology are of particular importance. Both areas are not necessarily identical in the derivable requirements. Therefore, conflict situations arose again and again in the historical development of DIN 4109. These led several times to "adjustments" because the discrepancy between the minimum sound insulation according to DIN 4109 and a sound insulation corresponding to the generally recognised rules of technology had become too great. This was the case, for example, with the requirements for impact sound, which could be significantly increased in the 1989 edition due to the floating screeds that have become standard in the meantime. A comparable situation occurred in 2016 for the sound insulation of house partition walls, for which the minimum requirements were also raised compared to the 1989 edition due to double-wall construction that has become the norm.

8. SUMMARY AND OUTLOOK

DIN 4109 represents the central set of regulations for building acoustics in Germany. It is integrated into a comprehensive standardisation concept of sound insulation in buildings and forms its core. It formulates the minimum requirements to be met by the state and regulates the verification of compliance. In addition, however, in its historical development it has become a comprehensive planning instrument for building acoustics, which represents the most current status, especially through the implementation of the European calculation methods of EN 12354. In view of its importance, it is subject to manifold influences, but on the other hand it also exerts great influence. These mutual relationships are discussed in this article under the aspects of historical, scientific, technical and social developments. From this it can be seen what an outstanding role DIN 4109 has played for a long time in building acoustics in Germany. It can be considered an "institution" of building acoustics for good reason and well known acoustions like Cremer, Heckl or Gösele promote the building acoustic standartisation in DIN 4109. When assessing the development of the content of this standard, a divided picture emerges: the computational procedures for the verification of the required sound insulation in conjunction with an efficient building element catalogue have constantly developed further by gradually taking up and implementing the scientific and technical advances in building acoustics. They are thus up to date and are constantly being further developed. The situation is different with the requirements. The formulation of requirements has stagnated for decades. Adaptations to social developments have hardly taken place. Moderate changes in the level of requirements have only been made in some areas, and only when forced by external requirements (e.g. jurisdiction). In view of the controversial interests in the level of noise protection, no significant changes are to be expected.

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