English Version

Technical recommendation

Recommendation for the Usage of EN 12354-1

Empfehlung für die Handhabung der EN 12354-1
Récommendation pour l’usage de l’ EN12354-1

It has been drawn up by a working group of the eaaca.

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version: February 5th 2003

Contents

Foreword

The standard EN 12354-1:2000 [1] contains in the normative part the detailed model and the simplified model. The annexes B to G are informative and mainly sources of input data for the calculation. These informative annexes are in parts no longer up-to-date. This paper gives replacements at least for the simplified model. These replacements are the result of recent research projects [2],[3],[4]. Massive building elements of sand-lime bricks, lightweight concrete, concrete and AAC, all without perforation, were the object of the research.

Mass laws for weighted sound reduction index R_w (Annex B)

Annex B, part 2 of the standard contains a mass law which allows the calculation of the sound reduction index R_w[1] from the mass per area m‘ of the building element. Replace this single mass law by one of table 1 as applicable.

All these mass laws have been derived by regression from laboratory measurements converted to the average loss factor at site (equation (5)). No safety allowances were deducted.

An exception is the recommendation for concrete to use the same mass law as for sand-lime bricks. This assumption is based on the similarity of raw density but not on measurements.

[1] Note the difference between R_w without flanking transmission and R'_w including flanking transmission. R_w is input data to EN 12354-1. R'_w is the result of EN 12354-1 calculation.

	Material	Conditions	Mass law
1	Sand-lime or (steel reinforced) concrete	m‘ = 100 – 600 kg/m²	$R_{w,site} = 30.9\log\left(\frac{m'}{m'_0}\right) - 22.2\,[dB] \quad (1)$
2	Autoclaved Aerated Concrete[2]	m‘ = 80 – 300 kg/m²	$R_{w,site} = 26.1\log\left(\frac{m'}{m'_0}\right) - 8.4\,[dB] \quad (2)$
3	Lightweight Concrete	Dry density ≤ 1,0 kg/dm³; m‘ = 100 – 400 kg/m²	$R_{w,site} = 24.7\log\left(\frac{m'}{m'_0}\right) - 5.8\,[dB] \quad (3)$
4	Lightweight Concrete	Dry density > 1,0 kg/dm³	$R_{w,site} = 32.4\log\left(\frac{m'}{m'_0}\right) - 26.0\,[dB] \quad (4)$
m'_0 = 1 kg/m²			

table 1

Enhanced and simplified loss factor calculation (Annex C)

In the informative annex C of the standard it is suggested to calculate the loss factor from all the vibration reduction indices of the adjacent junctions of the element. This results in an enormous effort of calculation. Nevertheless, it has been shown that the deviation and mean error is bigger than using the simple equation (5).

$$10\log\eta_{\text{average site}} = -12.4 - 3.3\log(f/100); \quad f \text{ frequency} \quad (5)$$

Equation (5) reflects the fact that the loss factor of massive building elements at site differs very little. Again this is valid for sand-lime material, lightweight concrete, concrete and AAC, all without coring, and independent of the mass per area.

Sound reduction index improvement of additional layers (Annex D)

This has not been subject of the research projects. Use the Annex D of EN 12354.

Some more formulas for the calculation of the resonance frequency f_0 are given in table 2[3].

[2] Formula (2) is nearly the same as the RILEM mass law $R_w = 27.7\log\left(\frac{m'}{m'_0}\right) - 11.6\,[dB]$ published in [5]. In the range between 70 and 300 kg/m² the difference is smaller than 0.8 dB. It is recommended to use formula (2) in connection with EN 12354 and the RILEM mass law in whatever case it has been used before.

[3] Taken from the German standard DIN 4109 Annex 2 table 1

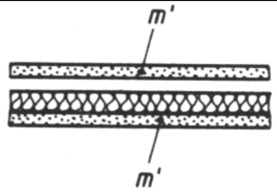
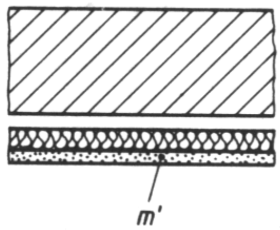
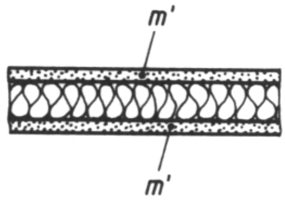
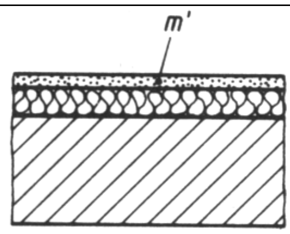
1	Two flexible layers Air filled gap with sound absorbing inlay		$f_0 \approx \frac{85}{\sqrt{m' \cdot d}}$
2	Flexible layer in front of heavy rigid wall or floor		$f_0 \approx \frac{60}{\sqrt{m' \cdot d}}$
3	Two flexible layers fully bonded to an insulation layer		$f_0 \approx 225\sqrt{\frac{s'}{m'}}$
4	Flexible layer fully bonded to a heavy rigid wall or floor		$f_0 \approx 160\sqrt{\frac{s'}{m'}}$
f_0 Eigenfrequency in Hz m' mass per area of a flexible layer in kg/m² d distance between layers in m s' dynamic stiffness of the insulation layer in MN/m³			

table 2

Vibration reduction index K_{ij} (Annex E)

Annex E gives empirical rules for rigid symmetric junctions. An important part of the concept is the ratio of the masses M.

$$M = \log\left(\frac{m'_{\perp i}}{m'_i}\right) \quad \text{(E.2) from annex E} \qquad (6)$$

m'_i is the mass per unit area of the sending element

$m'_{\perp i}$ is the mass per unit area of the other, perpendicular, element making up the junction.

Rigid junctions

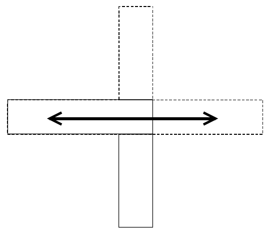
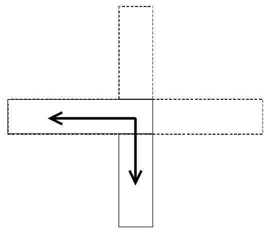
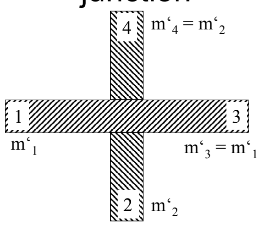
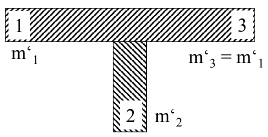
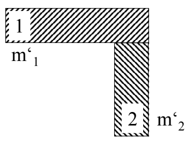
		1	2
	$M = \log\left(\frac{m'_{\perp i}}{m'_i}\right)$ (6)	Straight 	Around the corner 
1	Rigid cross-junction 	Instead of equation (E.3) m'1<1.52 m'2 (M < 0,182): $K_{13} = 8.7 + 17.1M + 5.7M^2$ (7a) m'1≥1.52 m'2 (M ≥ 0,182): $K_{13} = 10.6 + 6.4M$ (7b)	Instead of equation (E.3) $K_{12} = 5.7 + 15.4M^2$ (8)
2	Rigid T-junction 	Instead of equation (E.4) m'1<1.64 m'2 (M < 0,215): $K_{13} = 5.7 + 14.1M + 5.7M^2$ (9a) m'1≥1.52 m'2 (M ≥ 0,182): $K_{13} = 9.2 + 1.9M$ (9b)	Instead of equation (E.4) $K_{12} = 4.7 + 5.7M^2$ (10)
3	Edge 	Non applicable	$K_{12} = 15\lvert M\rvert - 3$ (E.9)(11) or $K_{12} = 2.7 + 2.7M^2$ (12)
4	Straight element 	$K_{13} = 5\log f_c - 15$ (13)	Non applicable

table 3

Notes:

1. Concerning K_{ij} in the straight forward direction it does make a difference whether the light or the heavy building element is the sending element. In the direction around the corner it does not make any difference.

2. In the straight direction for comparably light sending-/receiving walls (M ≥ log1.5 or log0,215) the slope is reduced. Increasing the vibration reduction index of the junction by lowering the mass of the light wall will not compensate the reduced sound reduction index completely. Be careful and keep up with changes, because the reduced slope at high mass ratios has been derived from quite few measurements.

Maximum value of K_{ij}

In practice the vibration reduction index K_{ij} is limited to about 20±5 dB in buildings due to so called second order junctions. Even if there is no transmission on the path via the junction under consideration there is transmission to the same receiving element on paths via two or more other junctions. As EN 12354 [1] only considers paths via one junction, second order transmission has to be treated as if caused by first order junctions. The consequence is that

1. there is a practical upper limit of K_{ij} that is not given exactly
2. the use of high vibration reduction indexes is no longer described in EN 12354-1. Calculations can only be done following the sense of EN 12354 but in an extended way.

Minimum value of K_{ij}

The vibration reduction index has also a lower limit according to

$$K_{ij,\min} = 10\log\left[l_f l_0 \left(\frac{1}{S_i} + \frac{1}{S_j}\right)\right] \quad \text{[dB]} \qquad (14).$$

In equation (14) l_f is the length of the junction, l_0 is 1 m and S_i is the area of element i. This minimum value often applies to the vibration reduction index in straight forward direction between the flanking walls if the separating element is uncoupled.

Partly uncoupled junctions

Let us consider junctions with some building elements having negligible transmission to the remaining part of the junction. This is the case for example if there is no connection to the remaining part at all. In this case the remaining part must be treated as rigid junction (see above). For example, a cross-junction with one element separated has to be treated as a T-junction. And a T-junction with one element separated has to be treated as an edge or straight junction.

Take into account the second-order-junctions problem.

Flexible interlayers

No Information in addition to the standard can be given up to now. Again take due notice of the second-order-junctions problem mentioned above.

Stepped situations and staggered rooms

Section 4.2.4 of EN 12354-1 [1] gives some rules for dealing with these cases.

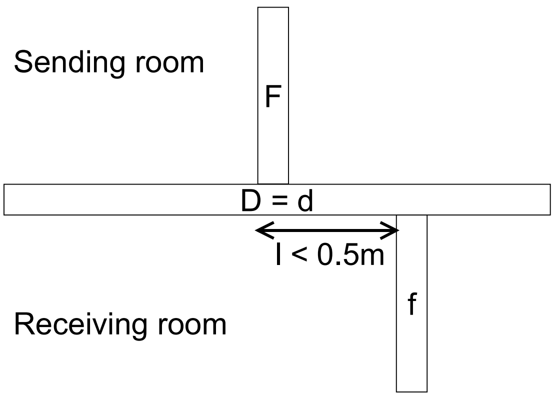
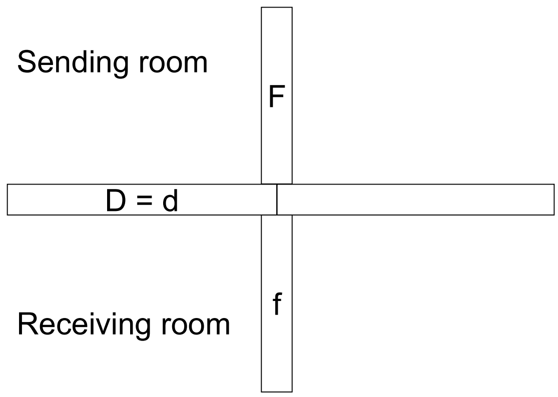
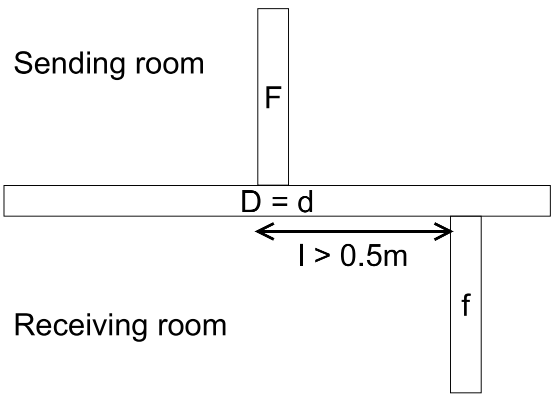
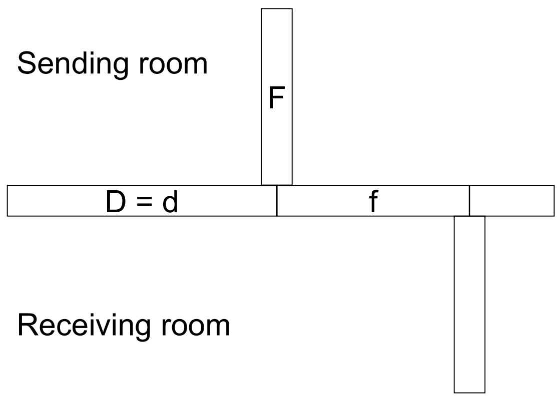
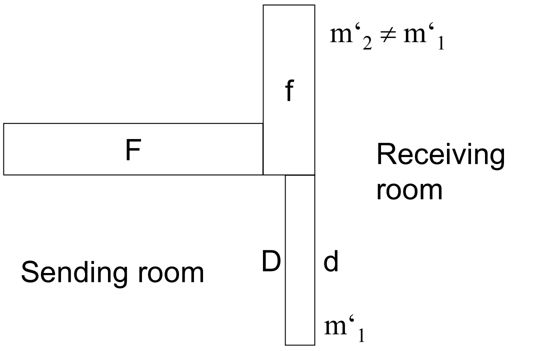
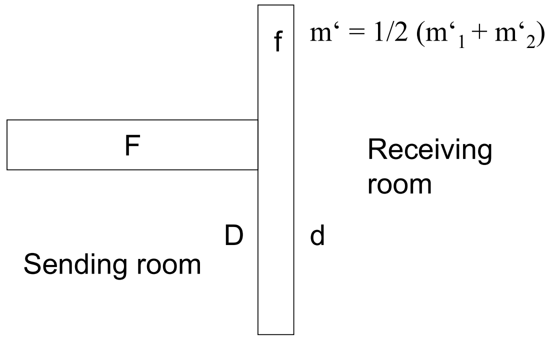
	1	2
	Real situation	Calculate as
1		
2		
3		

table 4

If the length of the staggering is below 0.5 m, the staggered junction has to be treated as a simple cross junction (see row 1 of table 4). Otherwise the situation has to be treated as T-junction. The part of the separating element between the flanking elements F and f has then to be considered as a flanking element (see row 2 of table 4).

Quite often opposite walls have not the same mass per unit area m‘. These situations have not yet been subject to measurements. Hence there is only one suggested solution. Simply take the average mass per unit area of both sides for each side (see row 3 of table 4).

Field-alike flanking transmission (Annex G)

Annex G gives a conversion of laboratory values measured in transmission suites according to the obsolete German standard DIN 52210:1984 [6] into values according to EN ISO 20140-3 [7]. At least in the German translation of the EN 12354-1 a minus „-„ has been placed incorrectly. Replace equation (G.1) with

$$R'_w = -10\log\left(10^{-R_w/10} + 10^{-(R_{Ff,w}+\delta)/10}\right) \qquad (15)$$

and equation (G.2) with

$$R_w = -10\log\left(10^{-R'_w/10} - 10^{-(R_{Ff,w}+\delta)/10}\right) \qquad (16)$$

Software

There is some software to do the calculations according to EN 12354-1. The problem with third party software is that you cannot see how it works internally. This is a disadvantage as long as not all the details of the calculation are standardised. The following table is not intended to be complete and up to date nor is it a recommendation.

	1	2	3	4	5
	Name	Latest Version	Language	Publisher	Note
1	Acoubat		French	CSTB, France	Good prediction
2	Bastian	2.0	German	ISOVER, Germany, www.isover.de	Overestimates sound reduction
3	KS Schallschutz Rechner	2.0 (Dec. 2001)	German	KS-Info GmbH, Germany, www.kalksandstein.de	Up-to-date with this paper. For sand-lime elements only. Freeware
4	ILUCO		Dutch	Technische Hochschule Delft	
5	BASluco	> 1.32	Dutch	Hochschule Delft	

table 5

Literature

[1] EN 12354-1:2000,
Building acoustics – Estimation of acoustic performance of buildings from the performance of elements – Part 1: Airborne sound insulation between rooms

[2] Blessing, S.; Schneider, M.; Späh, M.; Fischer, H.M.:
Bericht 1370 Abschlussbericht zum AIF Vorhaben 11593/1 Ermittlung und Verifizierung Schalltechnischer Grundlagendaten für Wandkonstruktionen aus Kalksandsteinmauerwerk auf der Grundlage neuer europäischer Normen des baulichen Schallschutzes, Fachhochschule Stuttgart

[3] Blessing, S.; Schneider, M.; Späh, M.; Fischer, H.M.:
Bericht Nr. 1372 Abschlussbericht zum AIF Vorhaben Nr. 11642 N/1 Umsetzung der europ. Normen des baulichen Schallschutzes für die Leichtbetonindustrie, Fachhochschule Stuttgart

[4] Blessing, S.; Schneider, M.; Späh, M.; Fischer, H.M.:
Bericht Nr. 1371 Abschlussbericht zum AIF Vorhaben Nr. 11640 N/1 Umsetzung der europäischen Normen des baulichen Schallschutzes für die Porenbetonindustrie, Fachhochschule Stuttgart

[5] Editor Aroni S. et al.:
Autoclaved Aerated Concrete. Properties, Testing and Design. RILEM Recommended Practice
Spon, London 1993, p. 37-40

[6] DIN 52210-2,
Bauakustische Prüfungen – Luft- und Trittschalldämmung: Prüfstände für Schalldämm-Messungen an Bauteilen

[7] EN ISO 20140-3:1995,
Acoustics – Measurement of sound insulation in buildings and of building elements – Part 3: Laboratory measurements of airborne sound insulation of building elements (ISO 140-3:1995)