Schallschutz WDVS

Modell und Prognose

DI Dr. Neusser Maximilian | maximilian.neusser@acom-research.eu | www.acom-research.eu

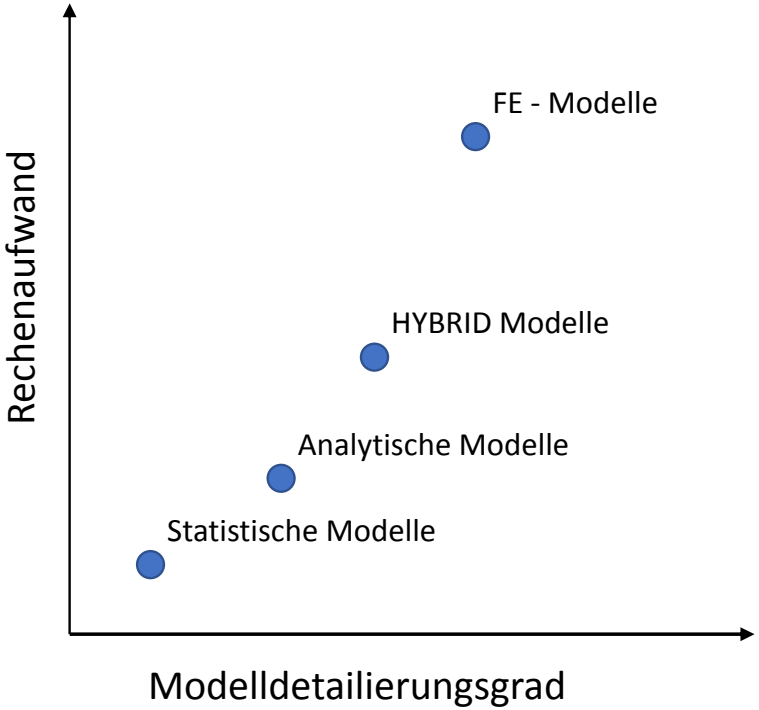
Motivation

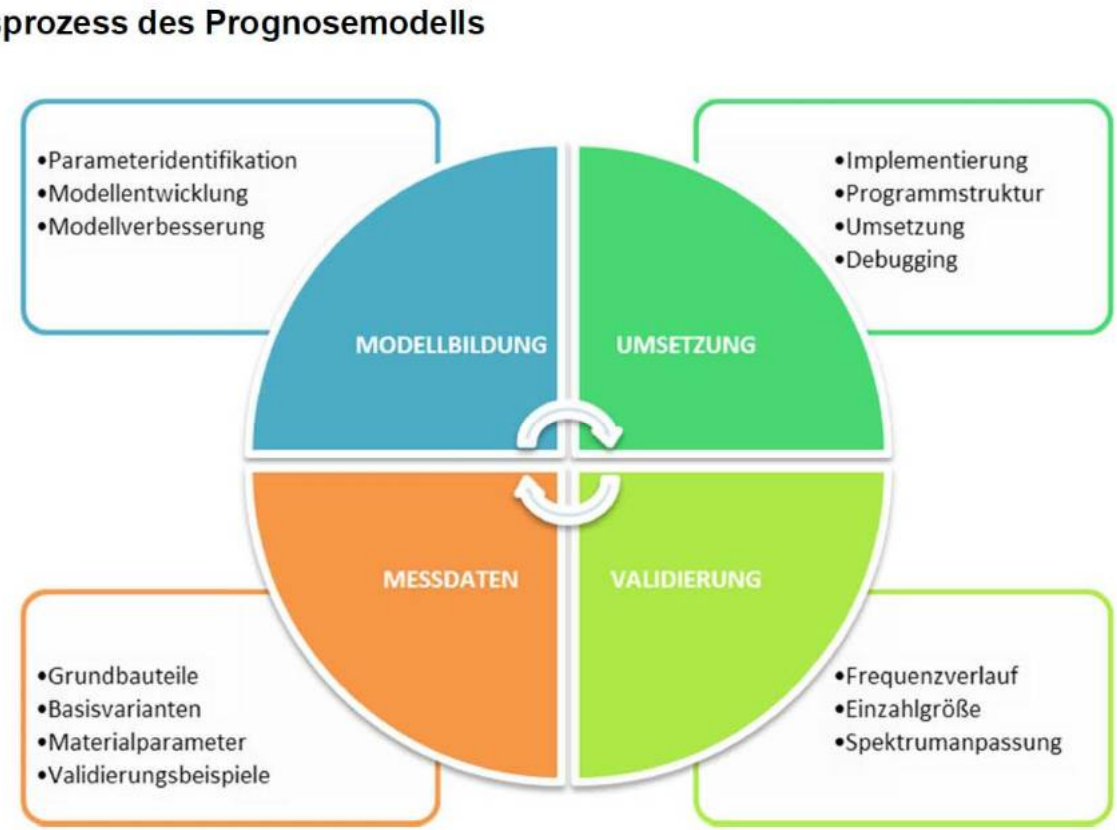
- Hohe Planungs- und Umsetzungsunsicherheit bezüglich Schalldämmung bei Außenwänden mit

Wärmedämmverbundsystemen

Vorhangfassaden

Motivation


FE - Modelle
HYBRID Modelle
Analytische Modelle
Statistische Modelle
Rechenaufwand
Modelldetailierungsgrad


Entwicklungsprozess des Prognosemodells
•Parameteridentifikation
•Modellentwicklung
•Modellverbesserung
•Implementierung
•Programmstruktur
•Umsetzung
•Debugging
MODELLBILDUNG
UMSETZUNG
MESSDATEN
VALIDIERUNG
•Grundbauteile
•Basisvarianten
•Materialparameter
•Validierungsbeispiele
•Frequenzverlauf
•Einzahlgröße
•Spektrumanpassung

SCHALL.HOCH.BAU

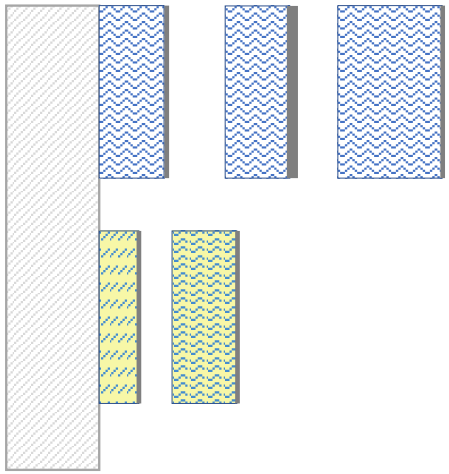
Projektpartner

LOIs

Versuchsaufbauten WDVS

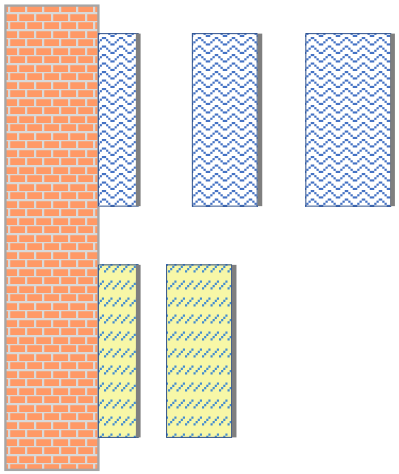
Gewinnung der empirischen Daten

normgemäße Messung an realen Wandaufbauten im Prüfstand (schematischer Überblick)



Betonwand

- Polystyrolsysteme
  unterschiedliche Dicke und „Qualität“
- Mineralwolle
  Unterschiedliche Dicke und „Qualität“
- geklebt und geklebt + gedübelt
  Klebefläche und Dübelanzahl variiert



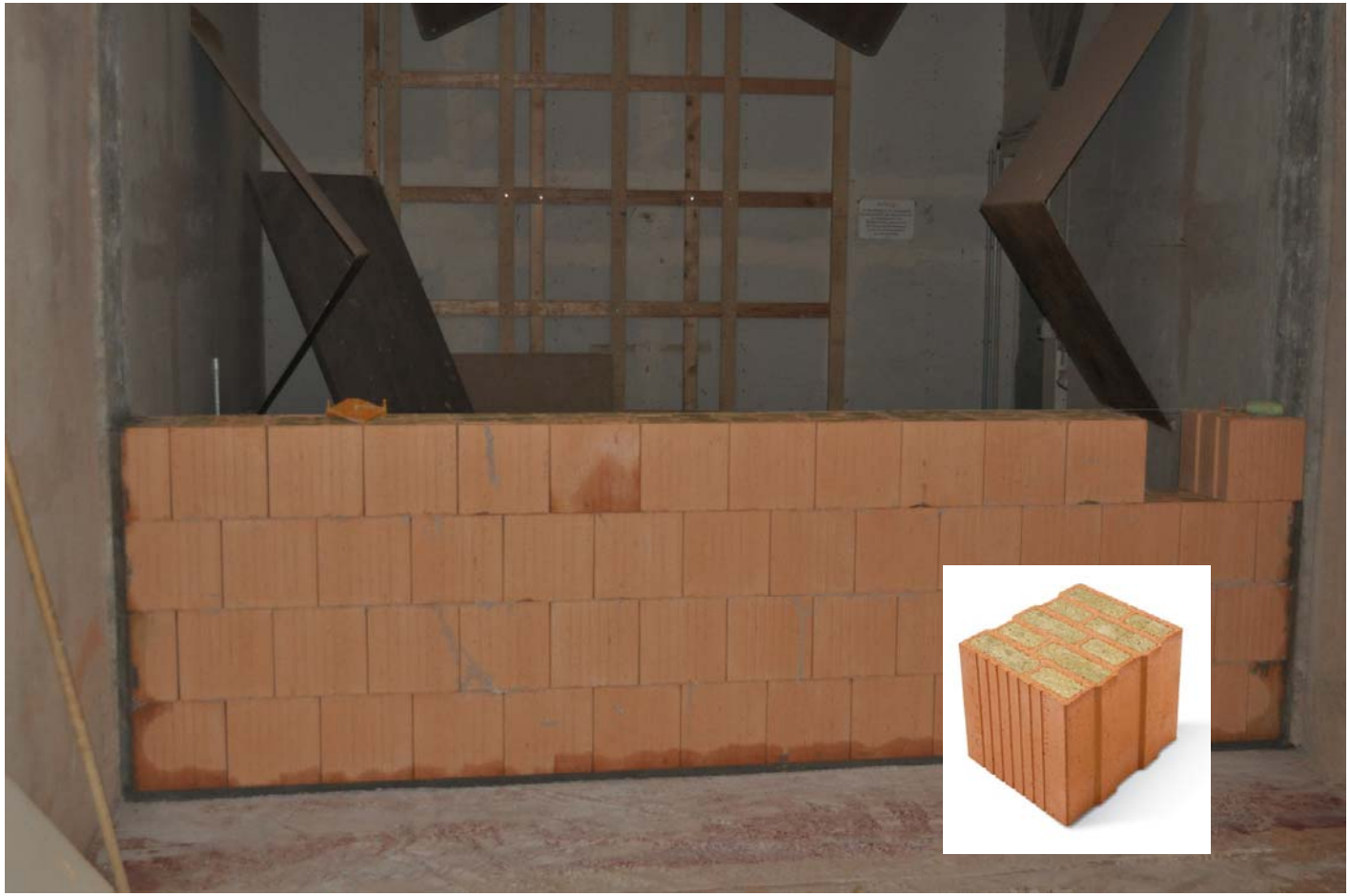
Trägerwand aus Hochlochziegel

- Polystyrolsysteme
  unterschiedliche Dicke und „Qualität“
- Mineralwollesysteme
  unterschiedliche Dicke

Messung der dynamischen Steifigkeit der eingesetzten Dämmplatten

Herstellen Betonwand TGM

Aufbau Ziegelwand



Schablone Klebefläche

Schablone Klebefläche 40%

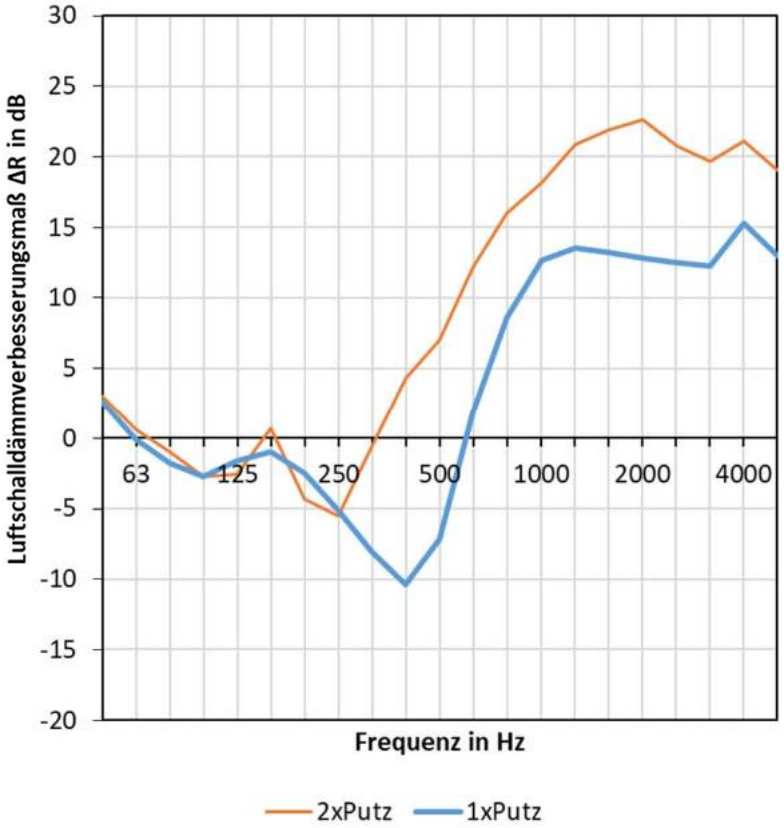
Dicke der Klebeschichte rd. 12 mm, Dichte des Klebers rd. 1400 kg/m^3

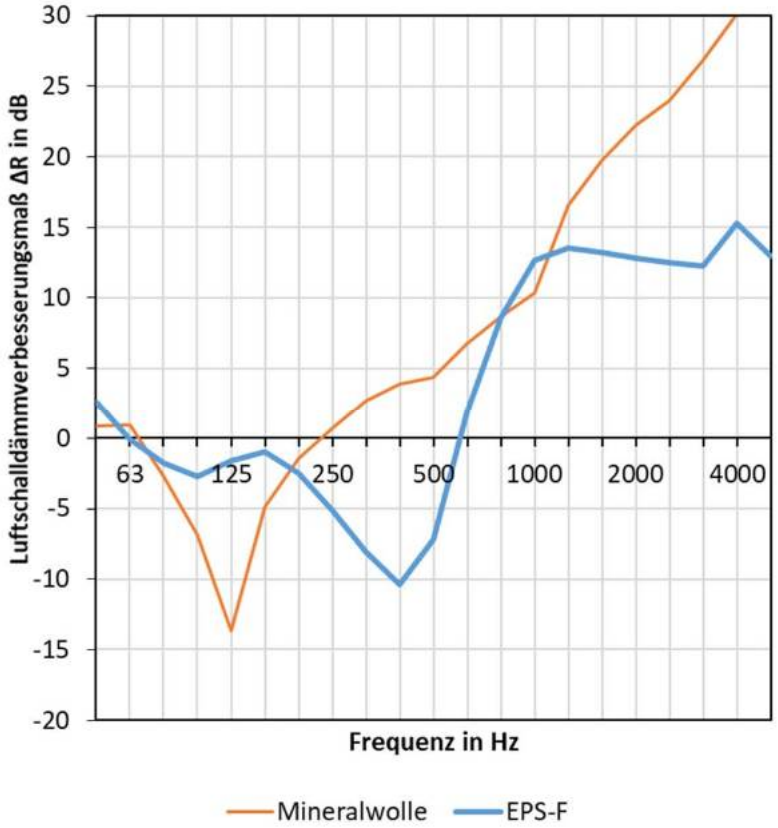
Aufbau WDVS

Aufbau WDVS

Verdübelung

Parameterstudie - Ergebnisse

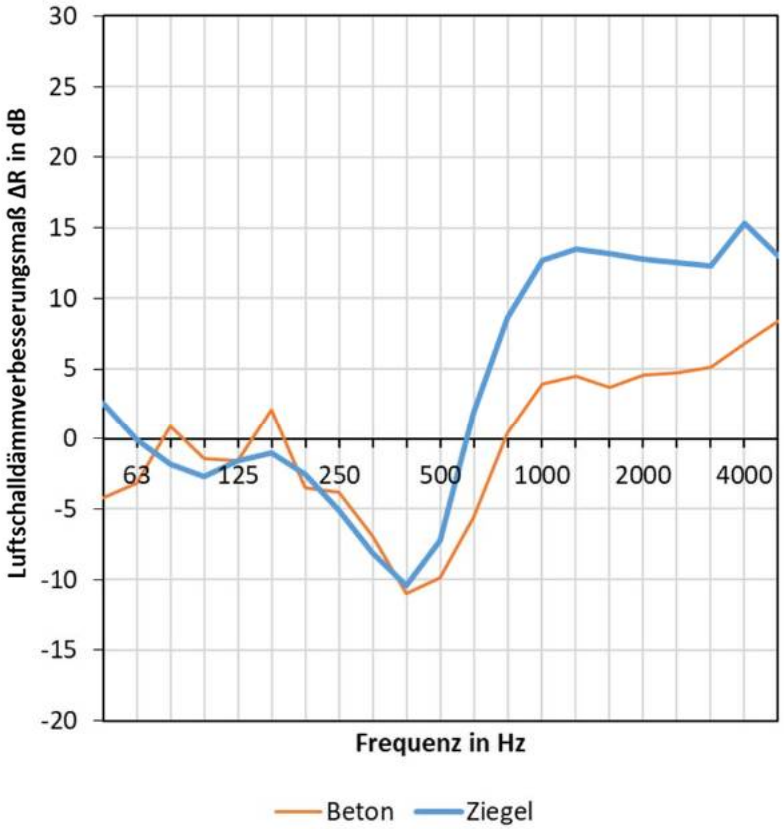


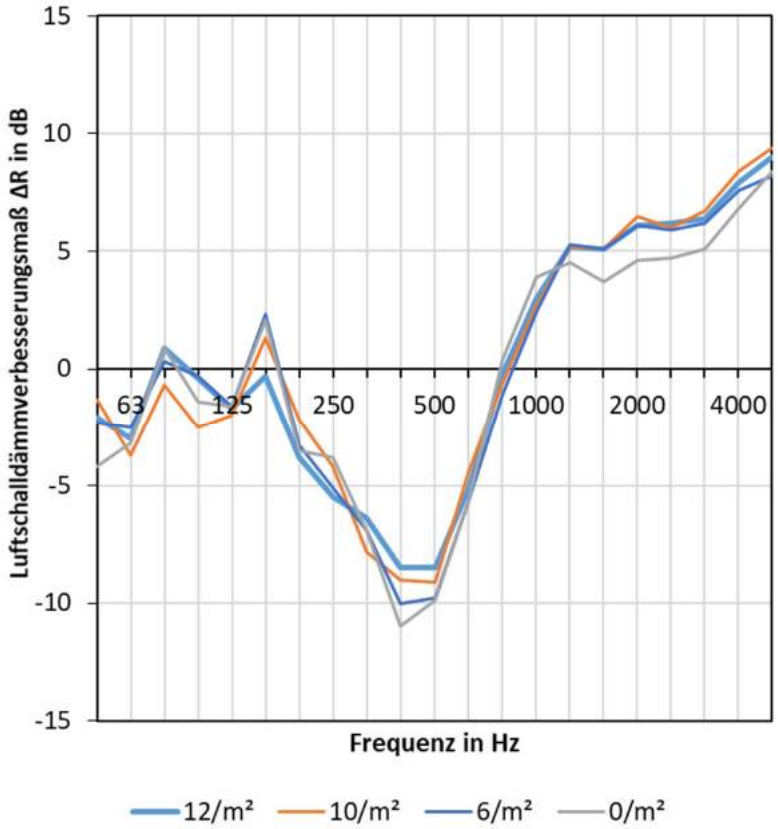


Putzddicke	f_0	ΔR_w
↑	↓	↑

s'	f_0	ΔR_w
↓	↓	↑

Parameterstudie - Ergebnisse



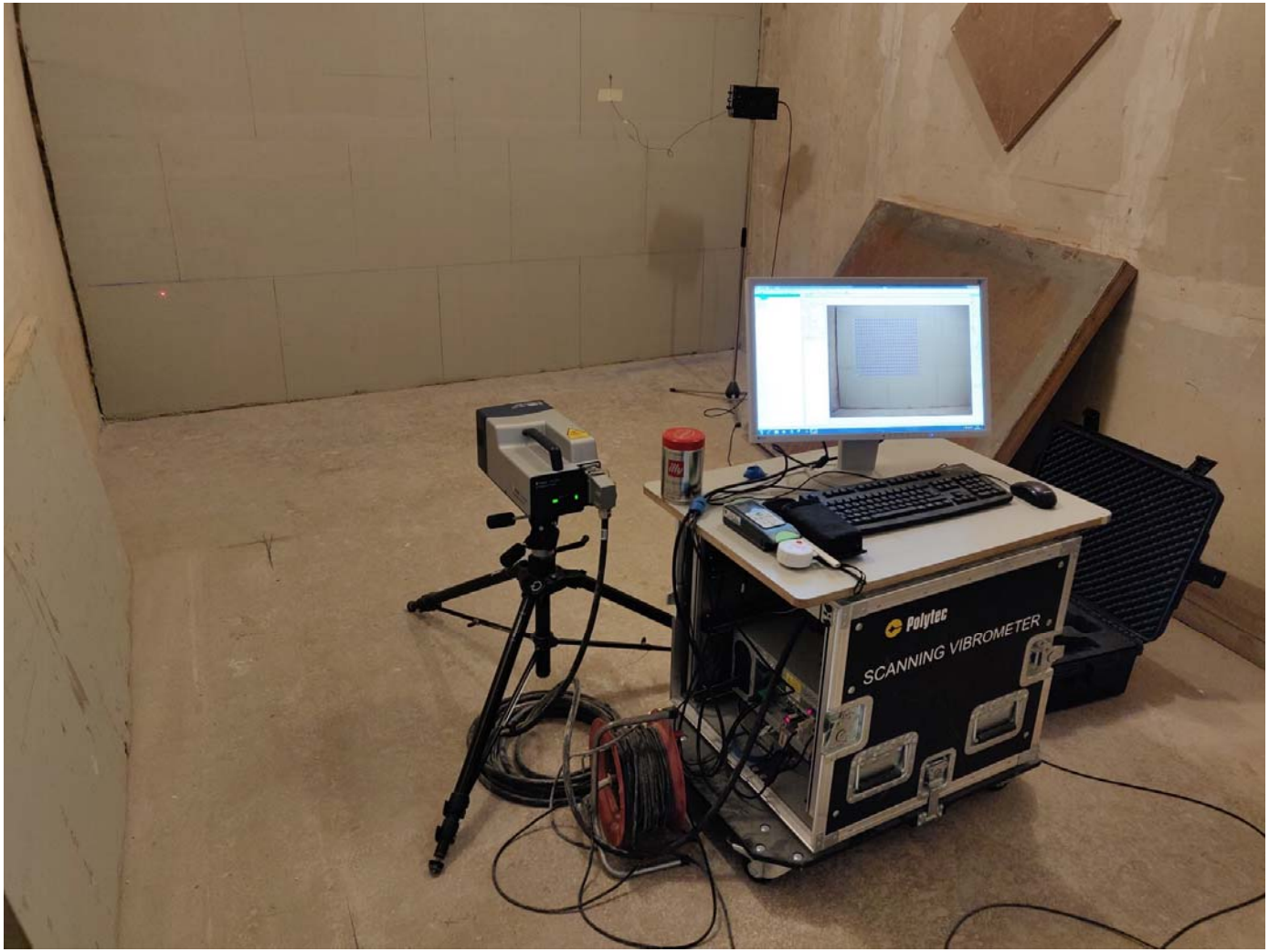


$R_{w,GB}$	f_0	ΔR_w
↑	↔	↓

Anzahl D	f_0	ΔR_w
↑	↔	↑

LDV - Schwingungsverhalten

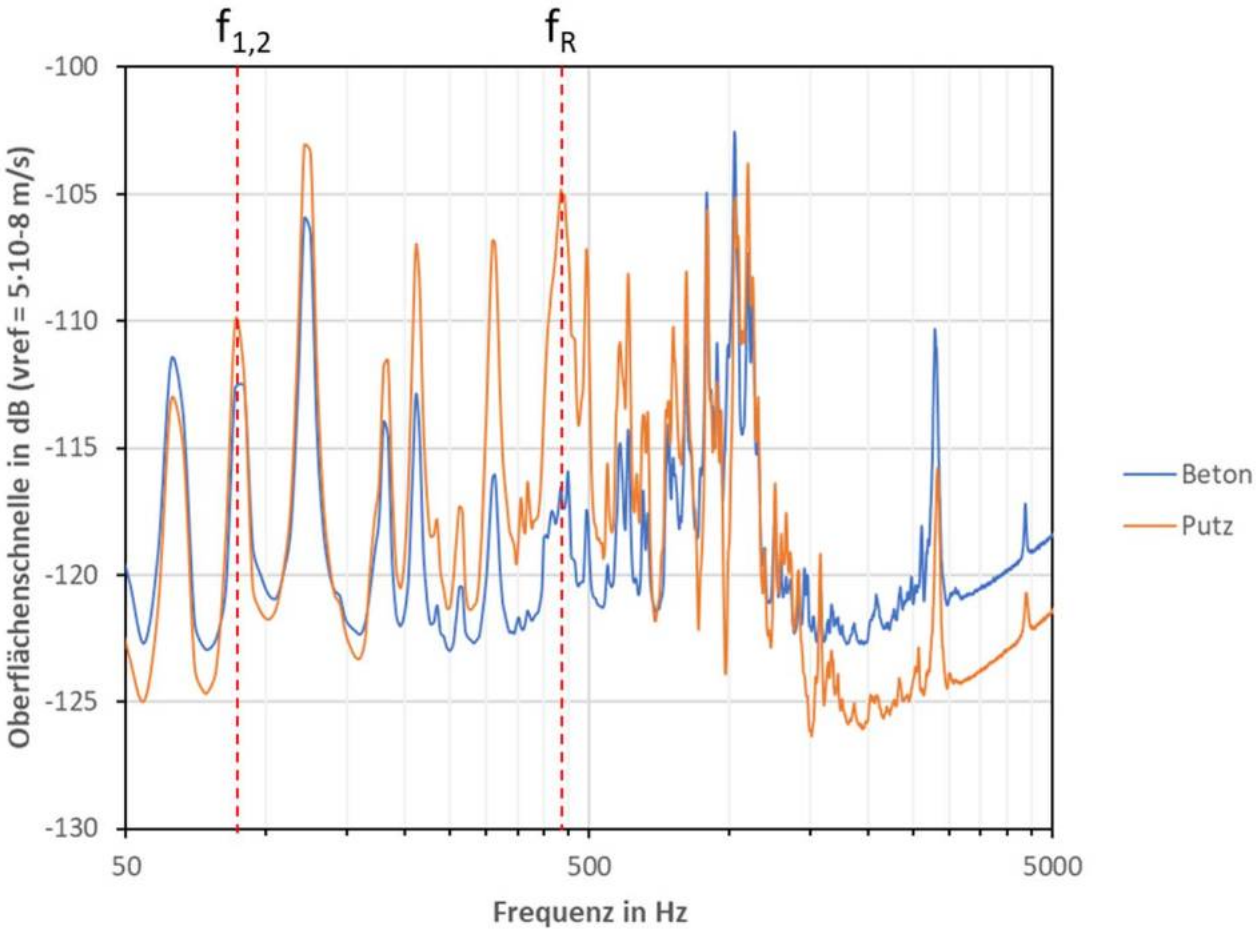
5mm Putz | 160mm EPS | 200/150mm Betonwand

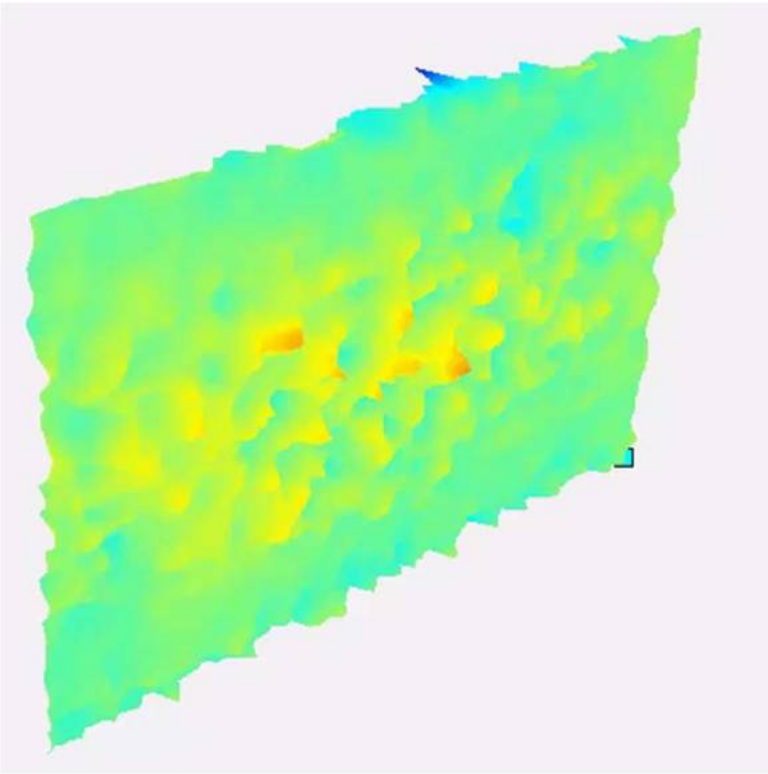


- 8 x 8, 4x4 cm Raster
- Körper- und Luftschallanregung
- Oberflächenschnelle
- Schallabstrahlverhalten
- Schwingungsverhalten
- Modalanalyse

LDV - Schwingungsverhalten

5mm Putz | 160mm EPS | 150mm Betonwand

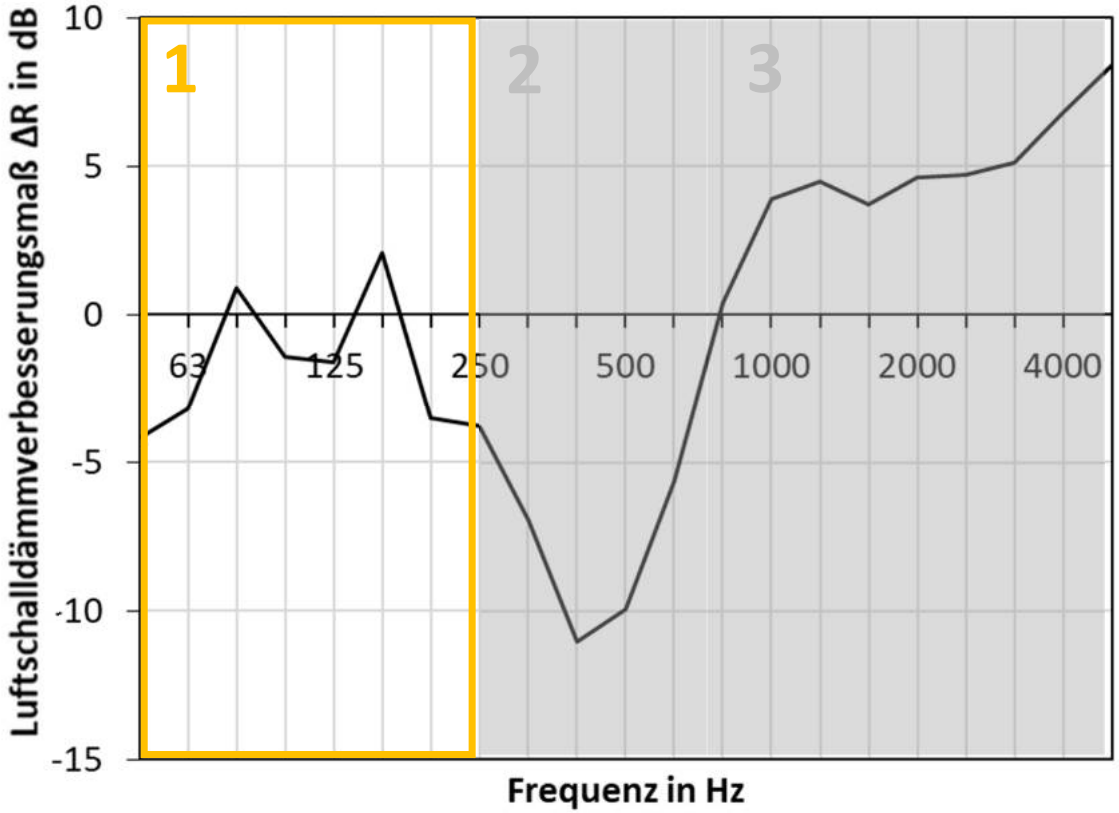




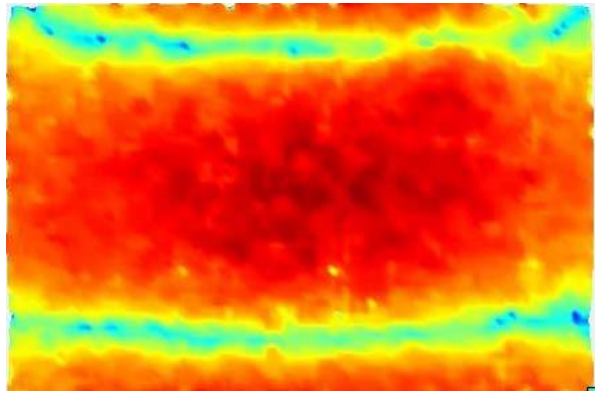
Putzoberfläche - Plattenmode $f_{1,2}$ = 85Hz

WDVS – Luftschalldämmverbesserungsmaß

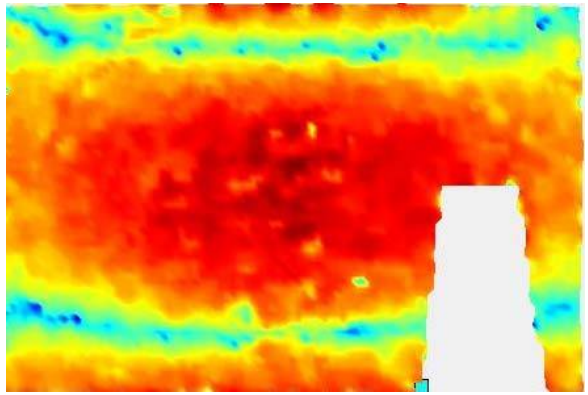
$f < f_R$



160mm EPS auf 200mm BETON



Putzoberfläche - Plattenmode $f_{1,2}$ = 85Hz



Betonoberfläche - Plattenmode $f_{1,2}$ = 85Hz

WDVS – Luftschalldämmverbesserungsmaß

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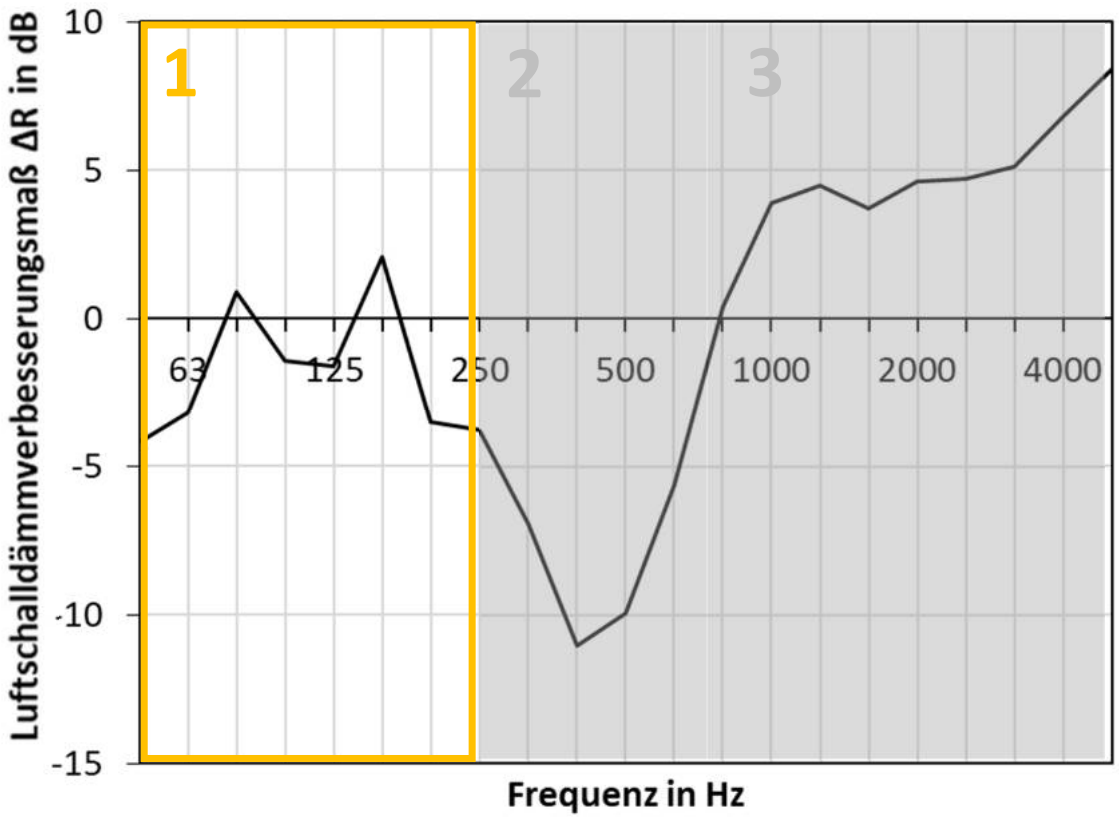
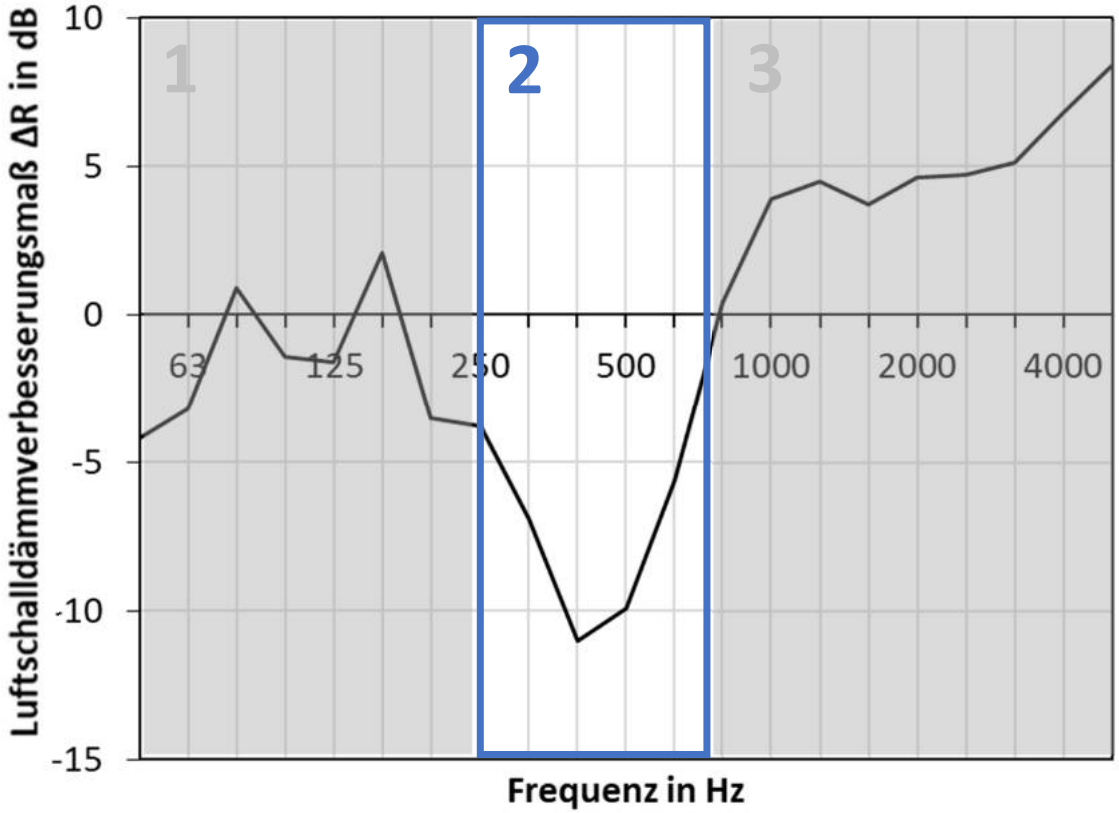


160mm EPS auf 200mm BETON

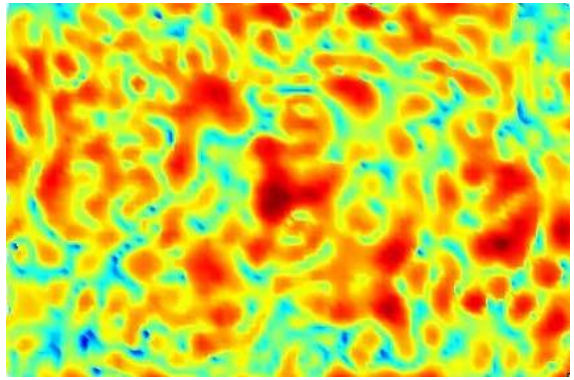
- Verbesserung in der resonanten Übertragung
- Verschlechterung in der nicht-resonanten Übertragung

WDVS – Luftschalldämmverbesserungsmaß

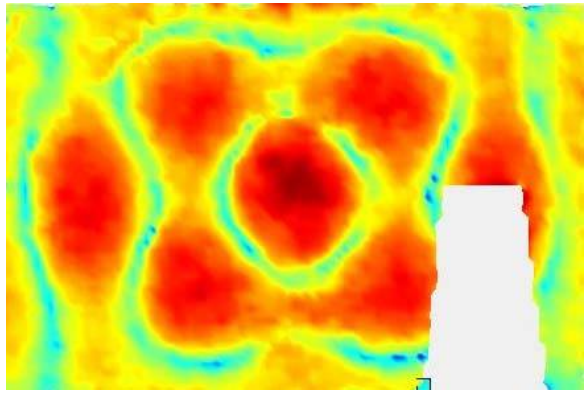
$f \approx f_R$



160mm EPS auf 200mm BETON



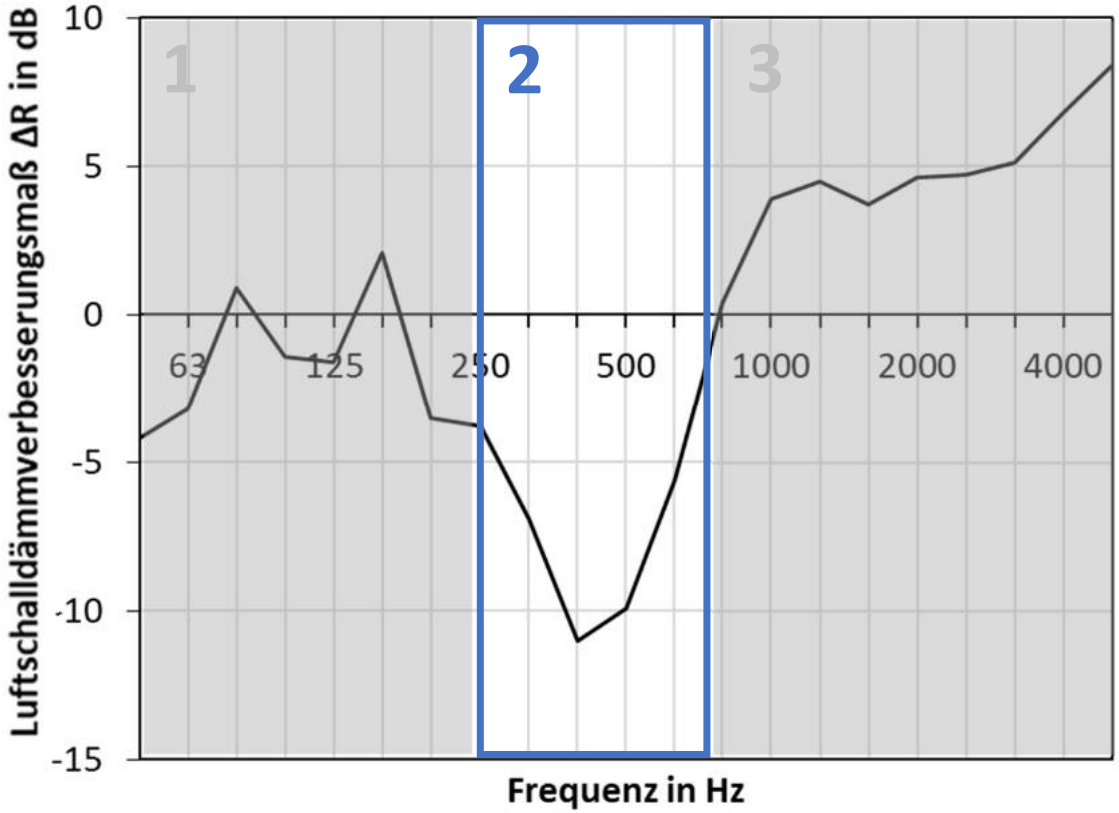
Putzoberfläche – Masse Feder Masse
Resonanz f_R = 417 Hz



Betonutzoberfläche – Masse Feder Masse
Resonanz f_R = 417 Hz

WDVS – Luftschalldämmverbesserungsmaß

$f \approx f_R$



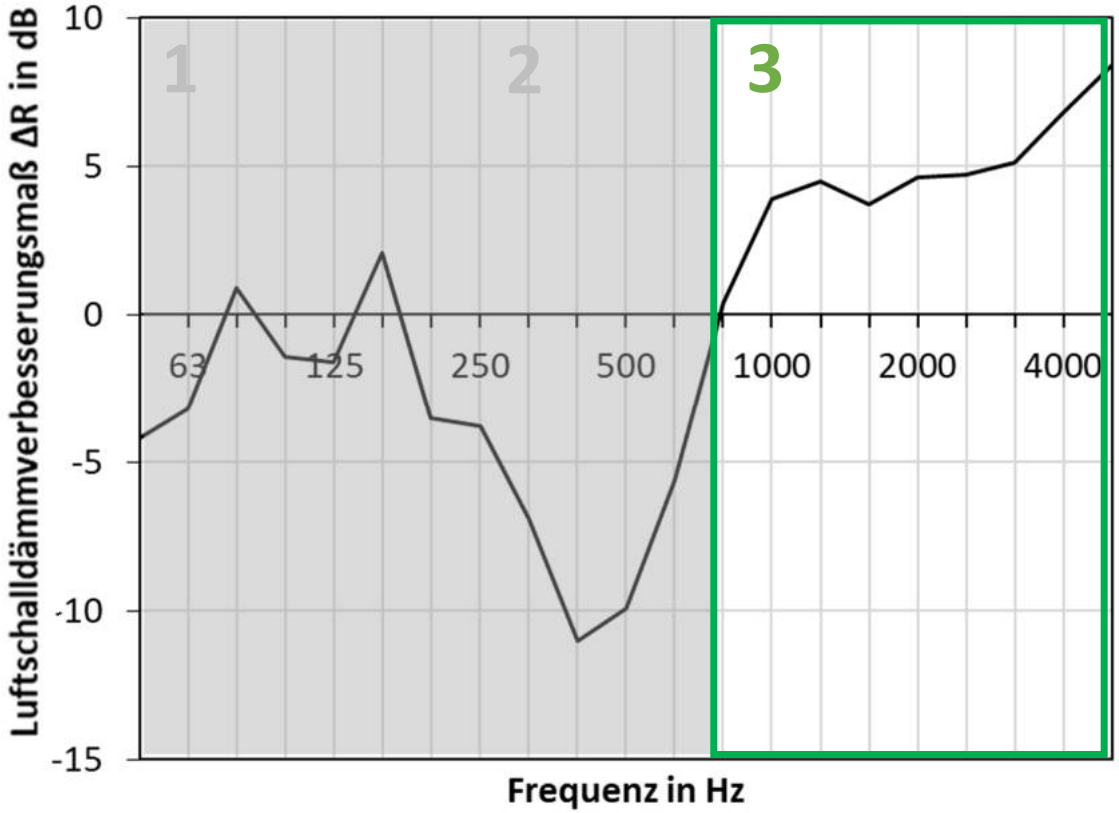
160mm EPS auf 200mm BETON

$$f_R = \frac{1}{2\pi}\sqrt{s'\left(\frac{1}{m'_P}+\frac{1}{m'_W}\right)}$$

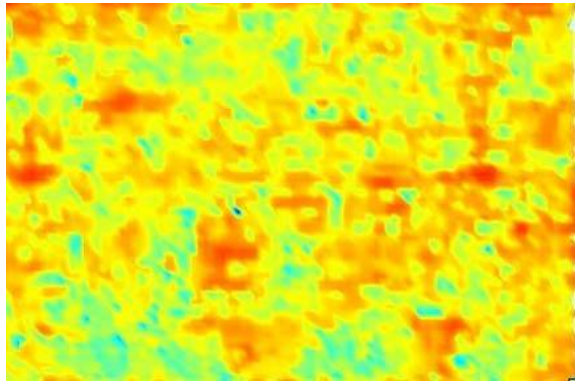
$$f_R \cong 160\sqrt{\frac{s'}{m'_P}}\,\text{Hz} = 160\sqrt{\frac{E_{dyn}}{d\,m'_P}}\,\text{Hz}$$

WDVS – Luftschalldämmverbesserungsmaß

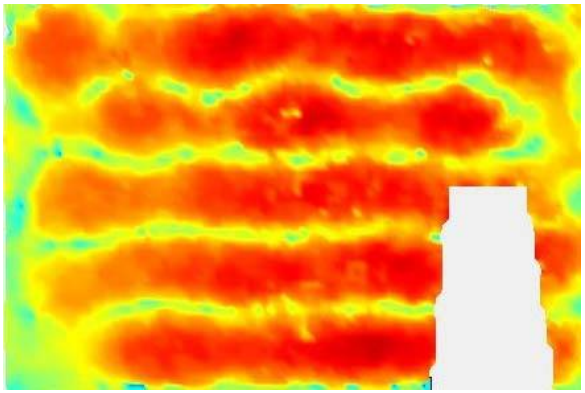
$f > f_R$



160mm EPS auf 200mm BETON



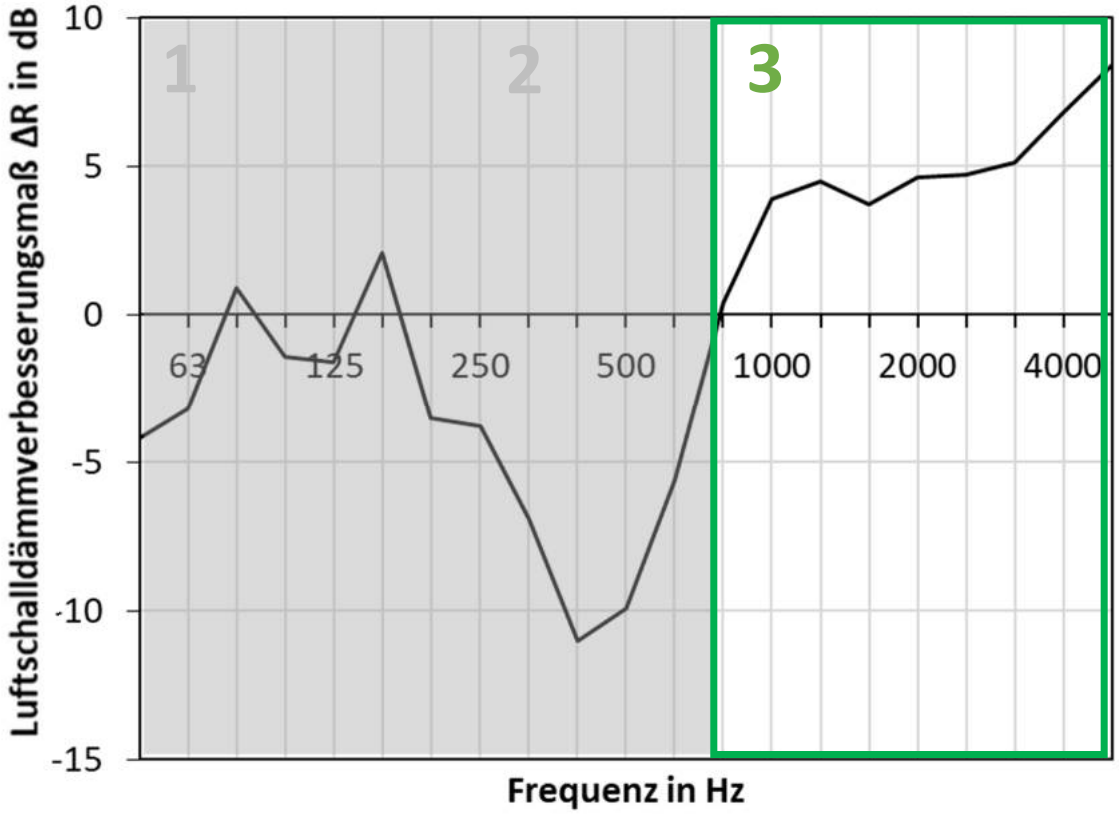
Putzoberfläche f=1023 Hz > f_R



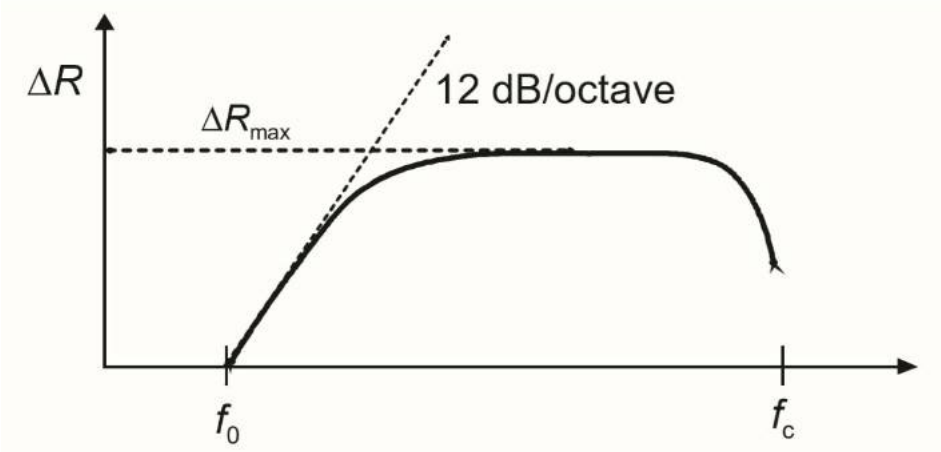
Betonoberfläche f=1023 Hz > f_R

WDVS – Luftschalldämmverbesserungsmaß

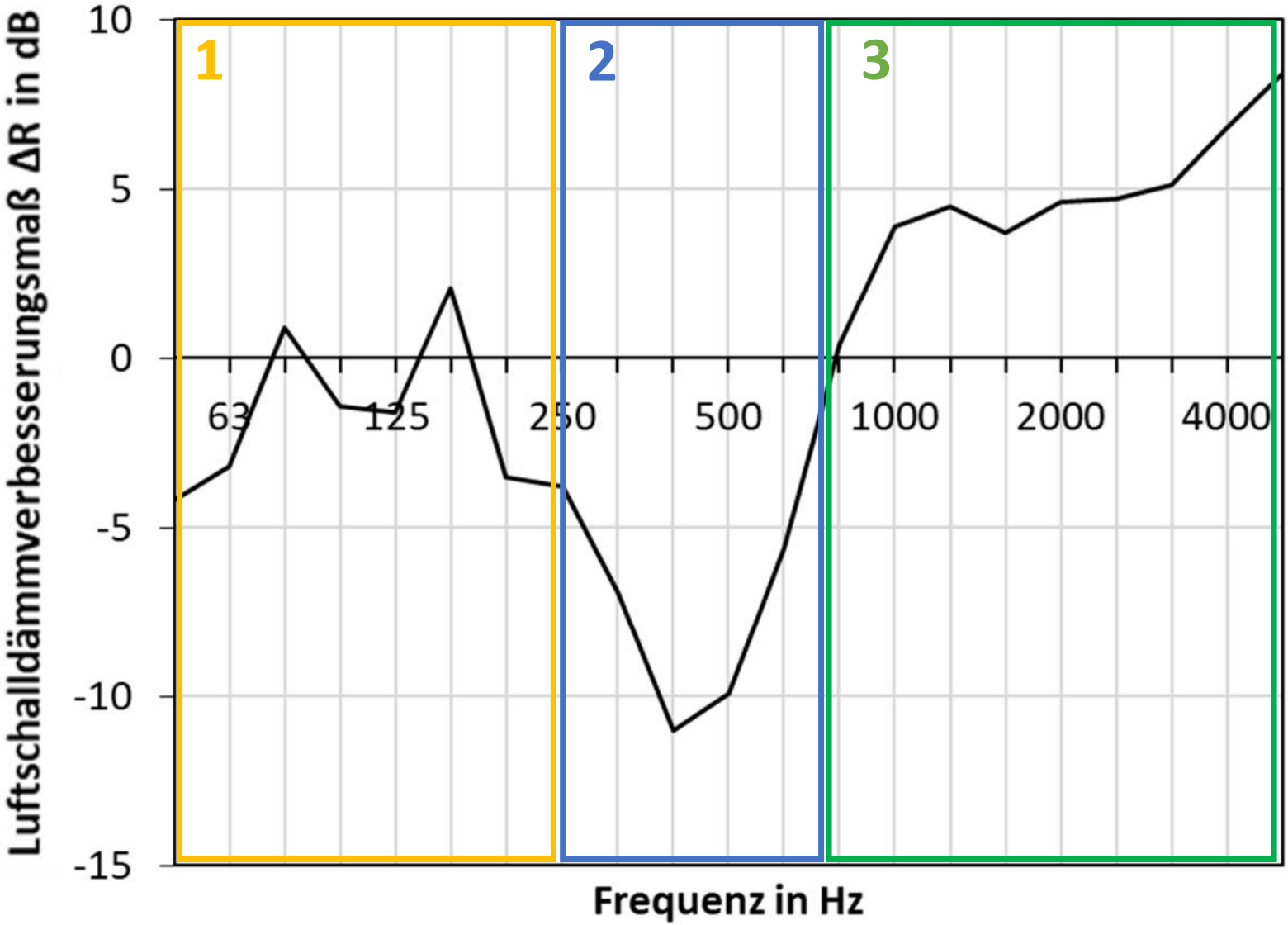
$f > f_R$



160mm EPS auf 200mm BETON



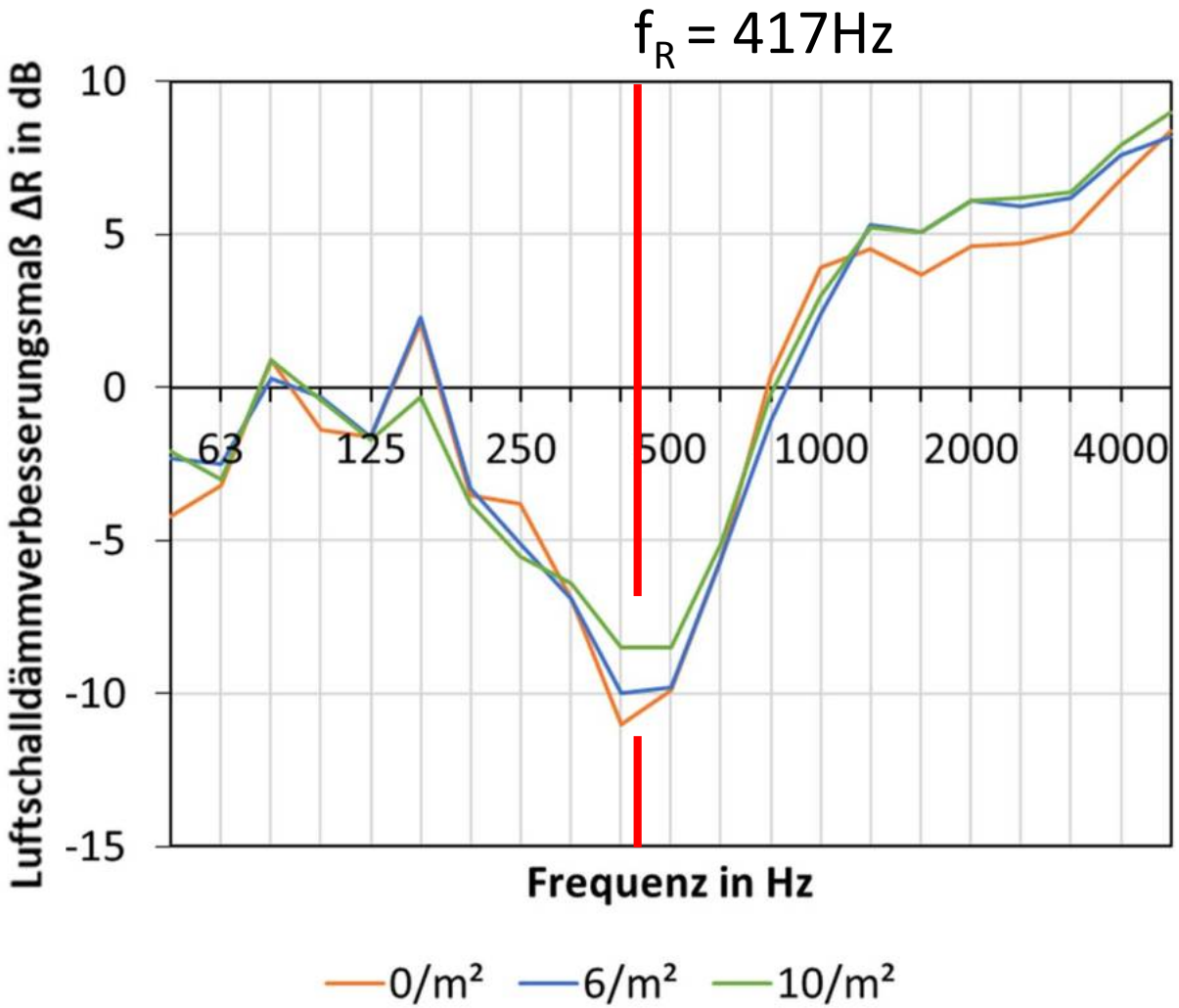
[VIGRAN08]

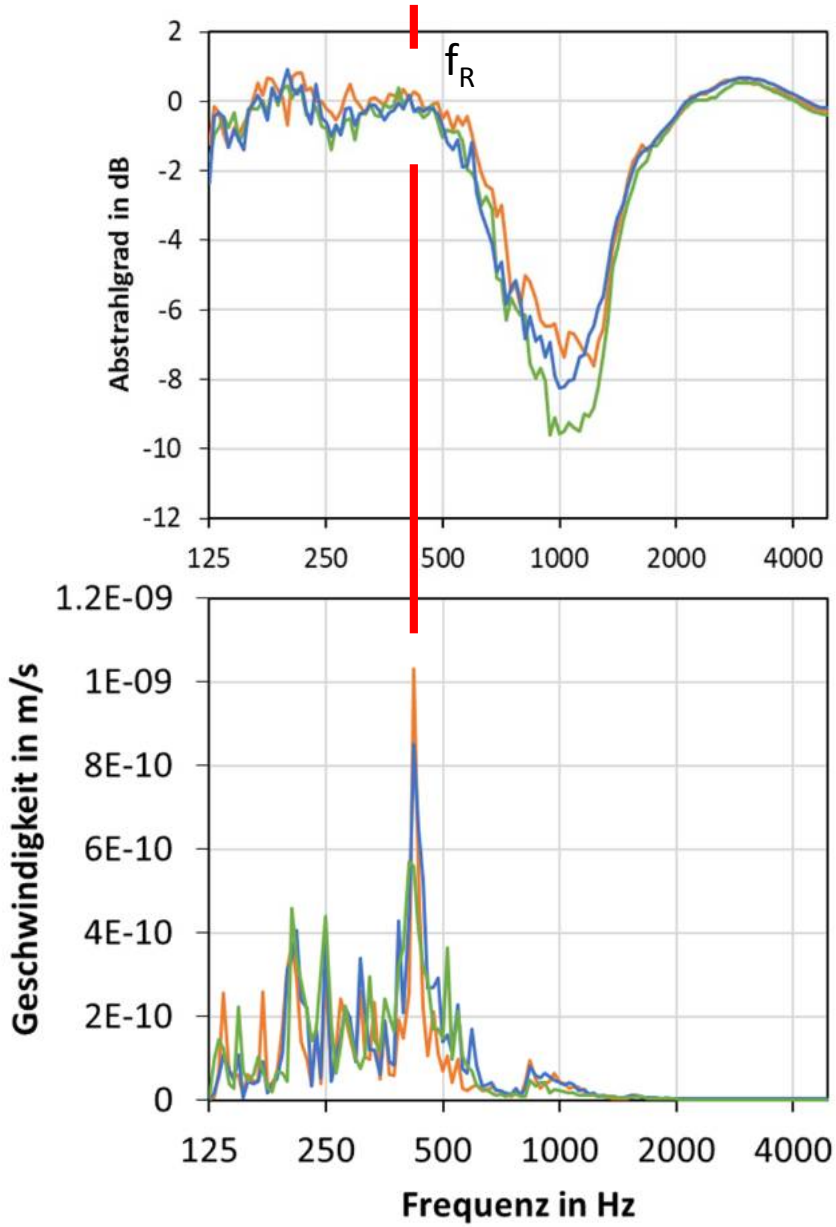


160mm EPS auf 200mm BETON, 6 Dübel / m²

Masse – Feder – Masse Resonanz

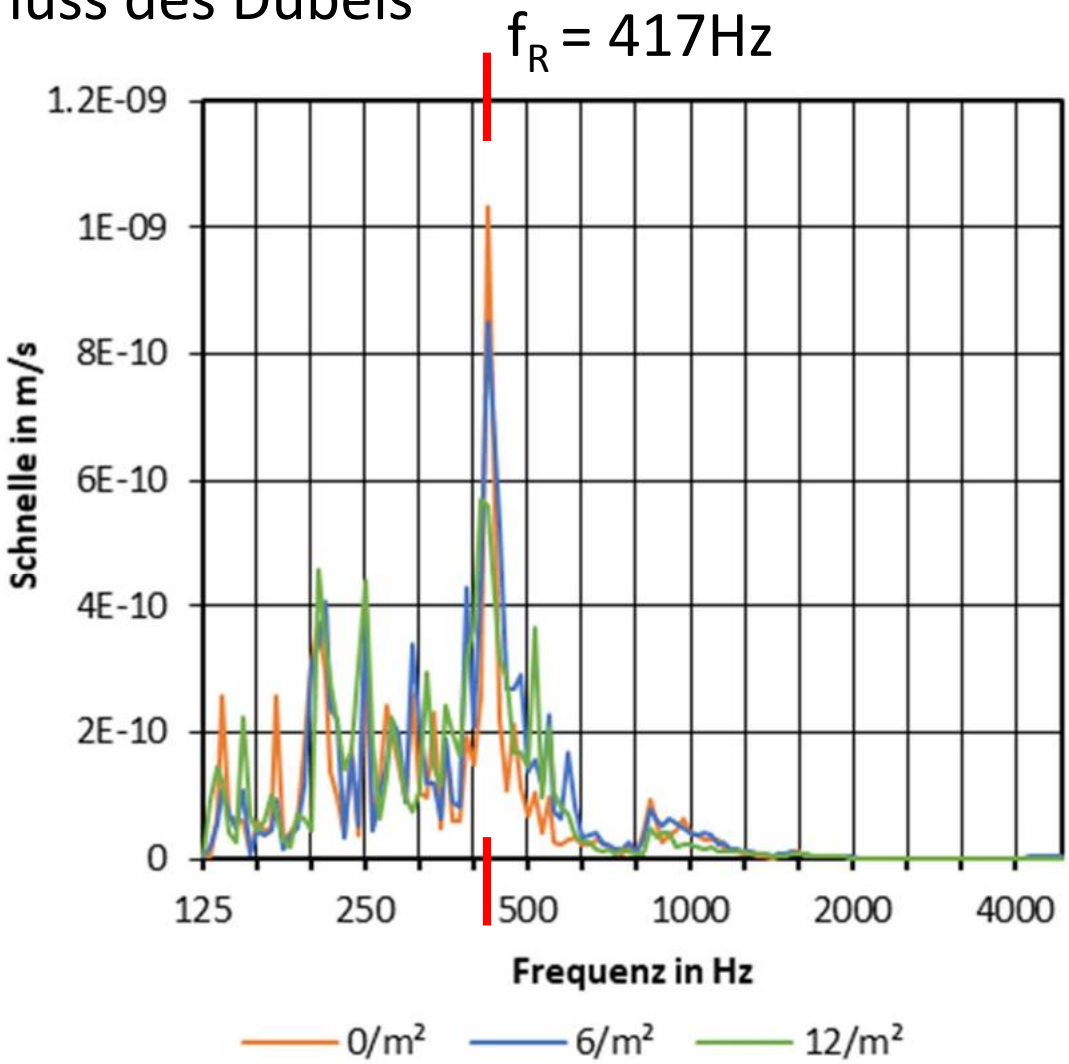
Einfluss des Dübels

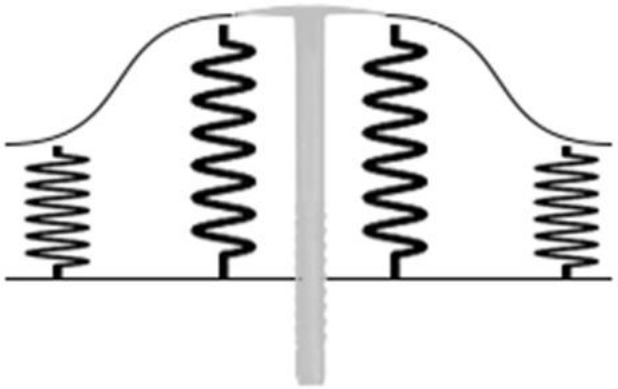




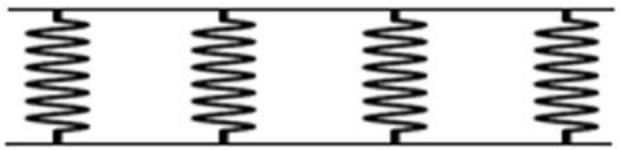
Masse – Feder – Masse Resonanz

Einfluss des Dübels





mit Dübel

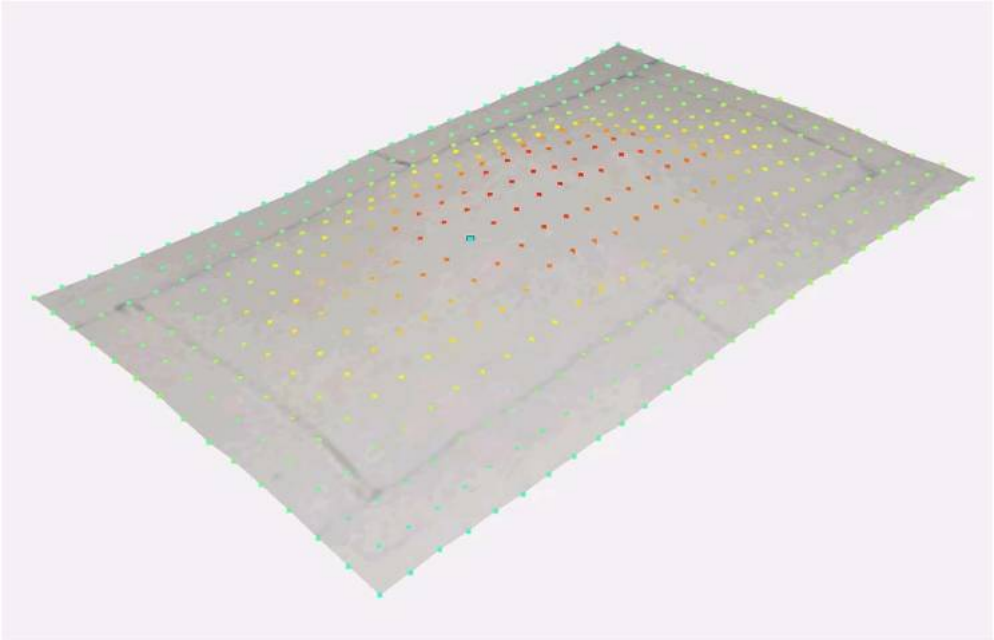


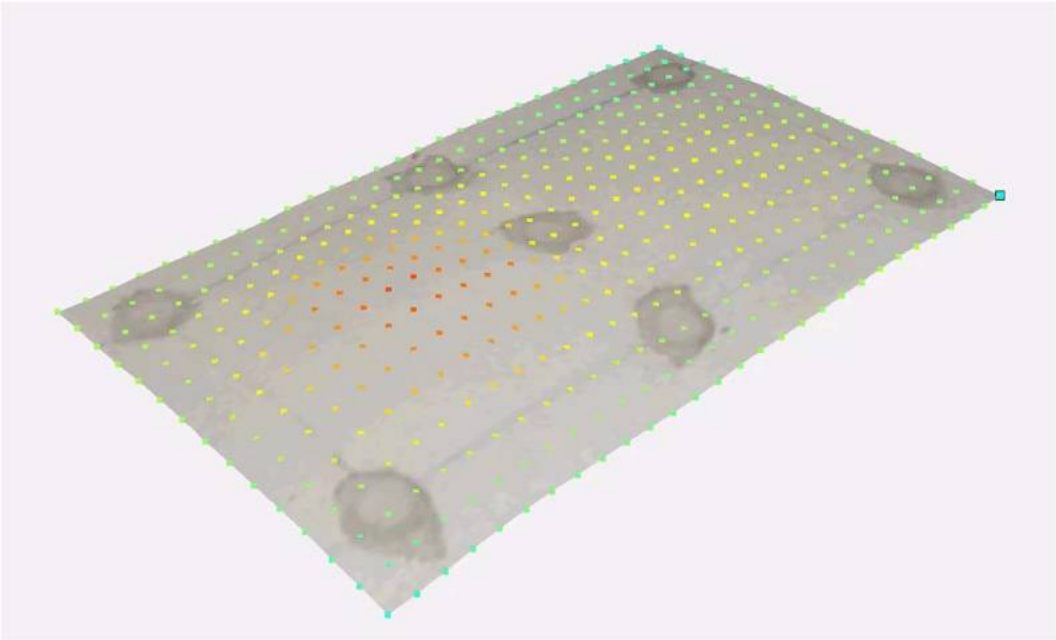
ohne Dübel

WDVS – Luftschalldämmverbesserungsmaß

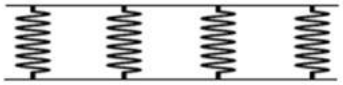
Einfluss des Dübels

Masse-Feder-Masse Resonanz f_0 = 417Hz

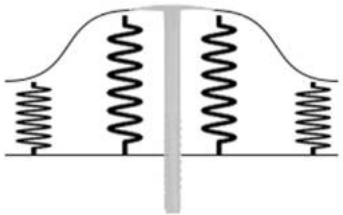




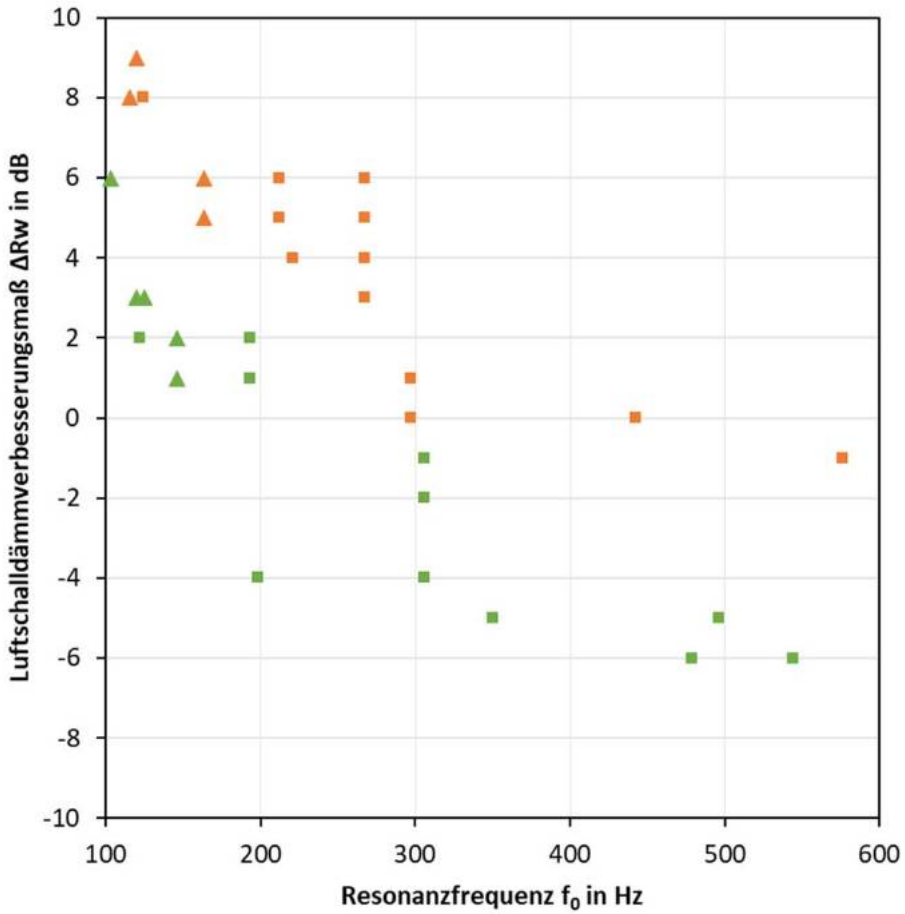
Keine Dübel



6 Dübel/m²



Modellierung
Messergebnisse - Einzahlwerte



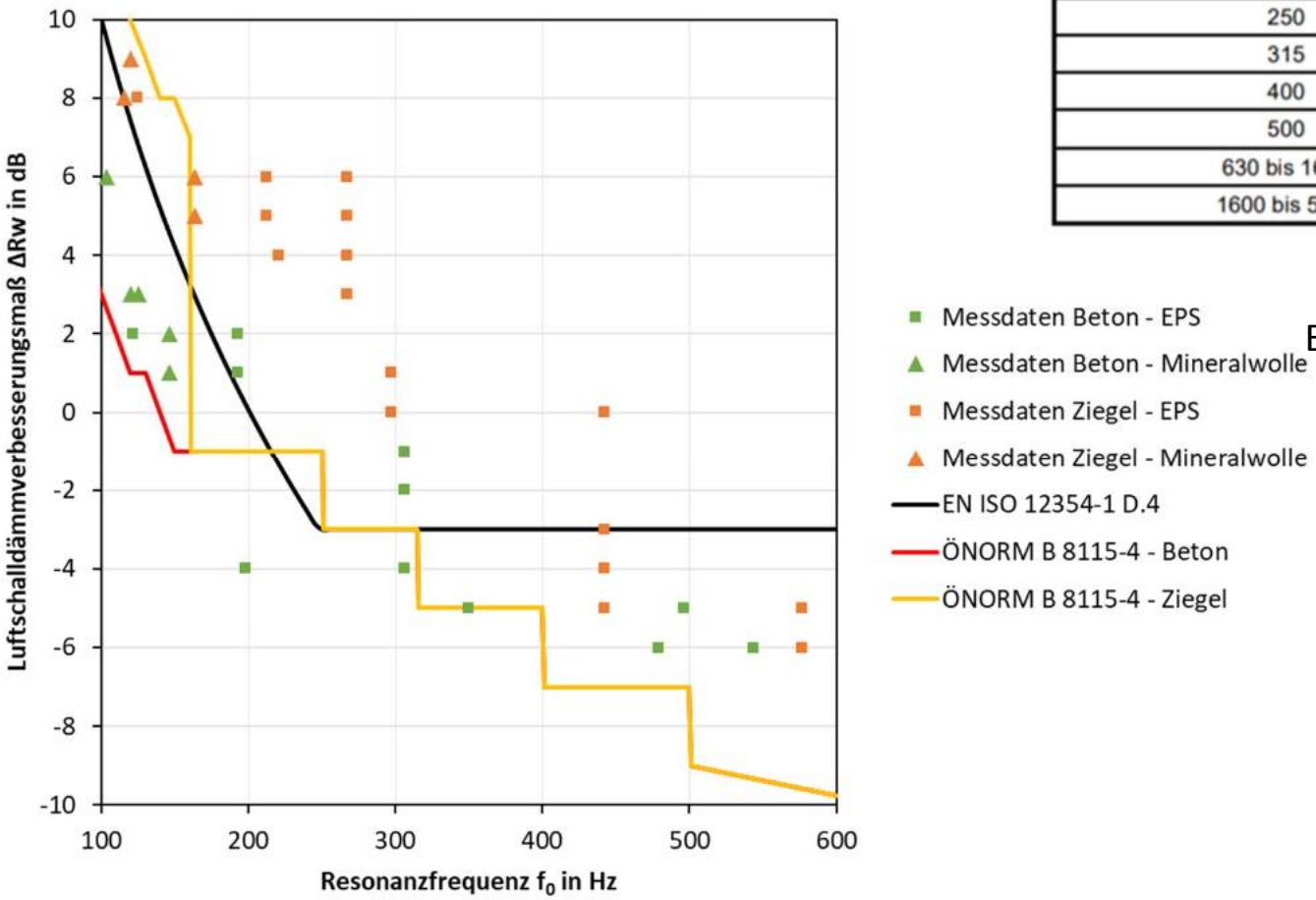
- Messdaten Beton - EPS
- Messdaten Beton - Mineralwolle
- Messdaten Ziegel - EPS
- Messdaten Ziegel - Mineralwolle

Grundwand	Dämmstoff	Putzdicke in mm	Dübelanzahl je m²
Beton (150mm, 200mm)	EPS (120-300mmm)	5-10	0-12
	MW (120-300mmm)	5-10	0-12
Ziegel (320mm)	EPS (120-300mmm)	5-10	0-12
	MW (120-300mmm)	5-10	0-12

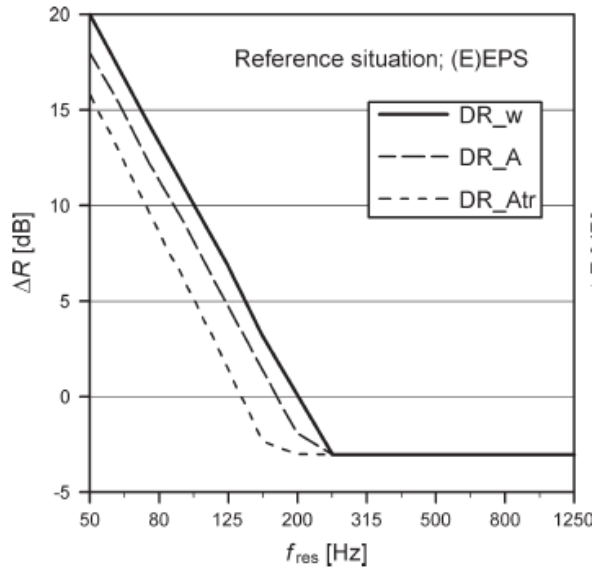
Modellierung
Stand der Normung

ÖNORM B 8115-4:2003

Resonanzfrequenz f_0 der Vorsatzschale in Hz	ΔR_w in dB
30 bis 160	$74{,}4 - 20 \log (f_0) - R_w/2$
200	-1
250	-3
315	-5
400	-7
500	-9
630 bis 1600	-10
1600 bis 5000	-5

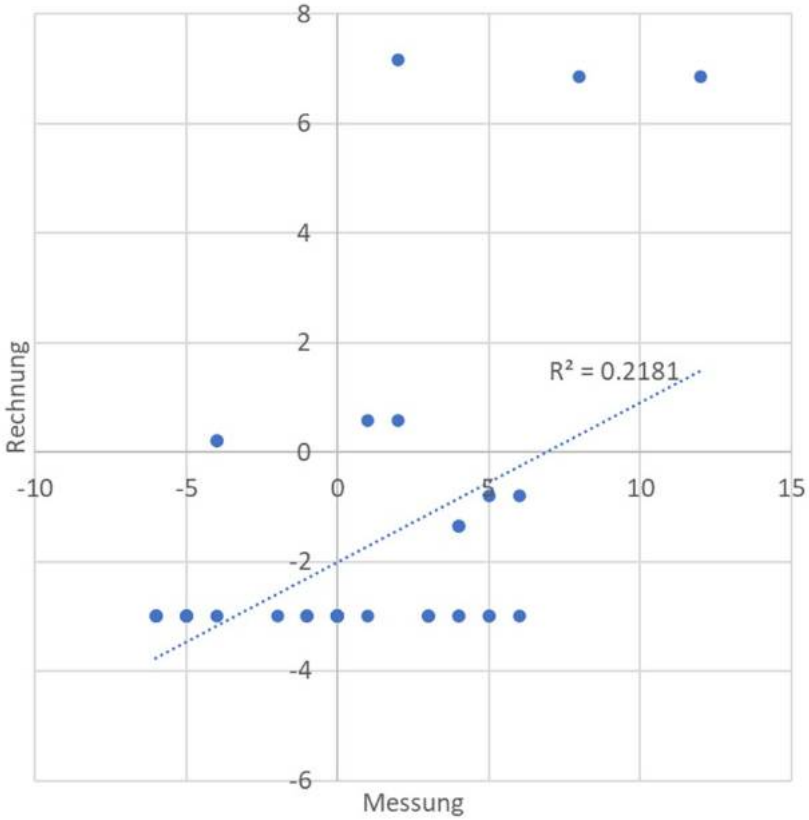


EN ISO 12354-1 Anhang D - Formel D.4

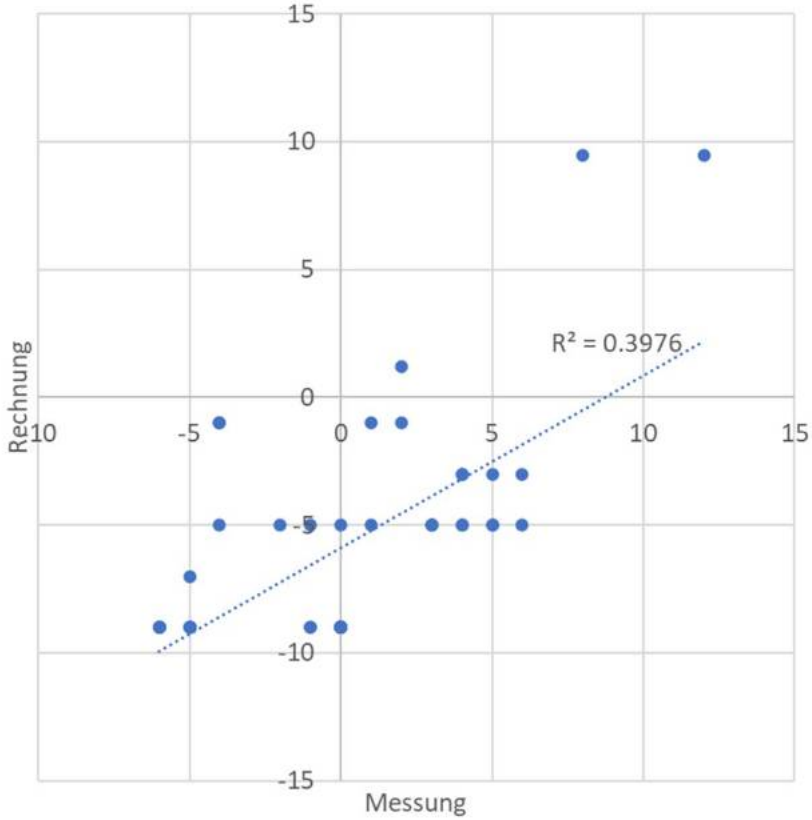


Modellierung
Stand der Normung

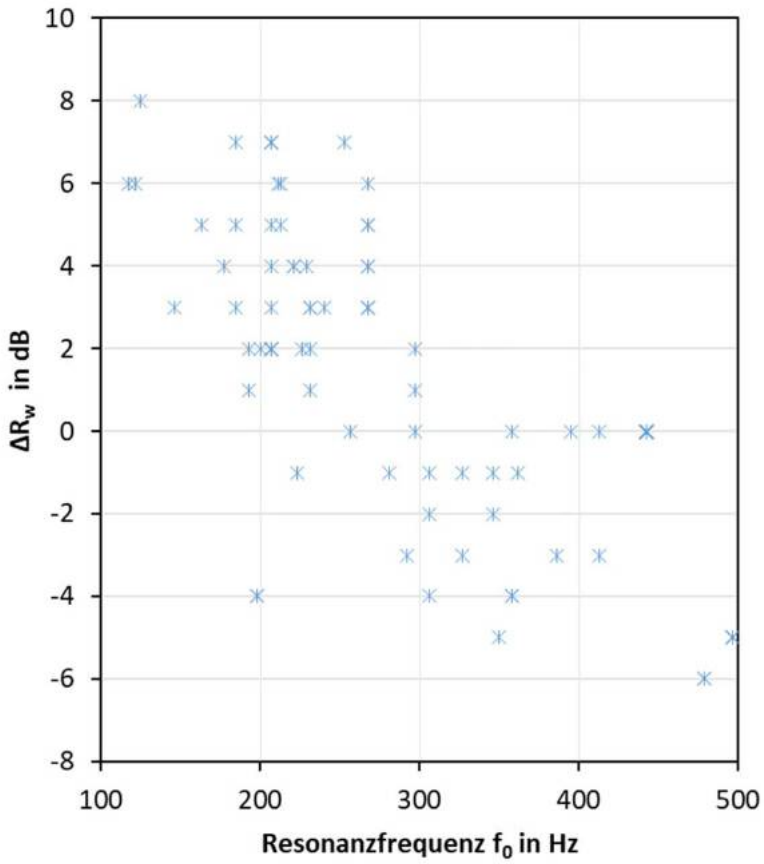
ÖNORM B 8115-4



EN ISO 12354-1



Modellierung
Modellansatz



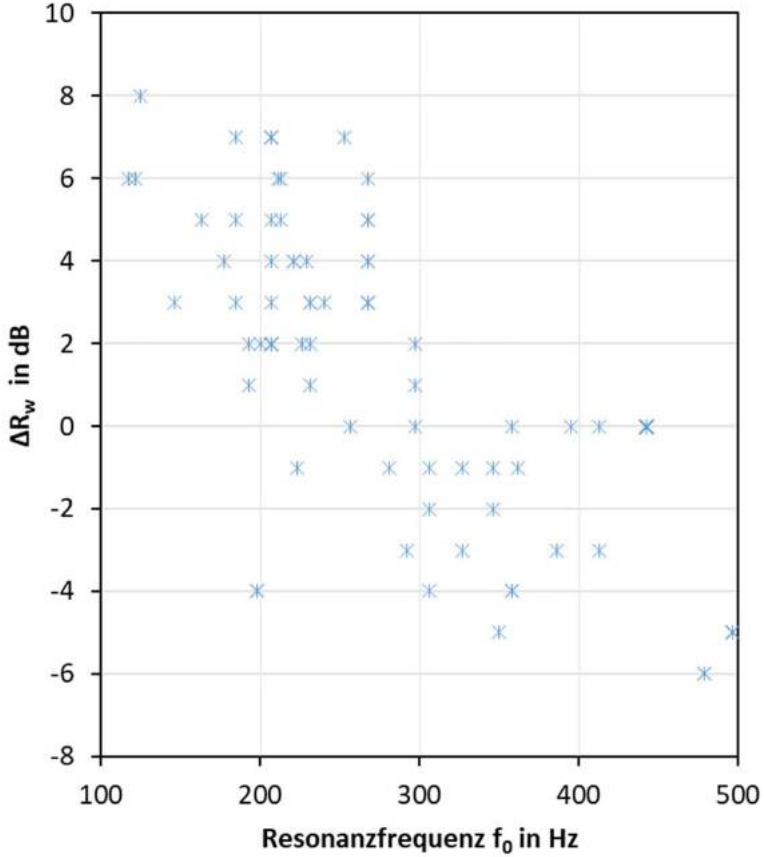
$$\Delta R_{w,Prognose,ohne\ GB} = a \cdot log_{10}(f_0) + b - x(R_{w,GB})$$

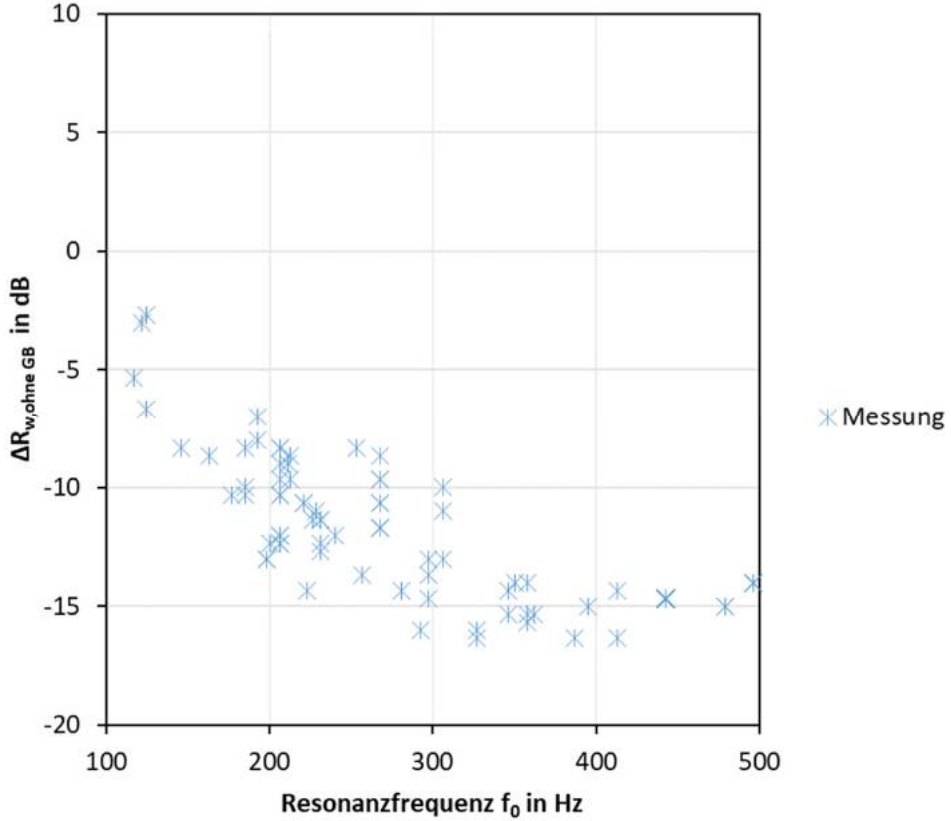
$$\Delta R_{w,Messung,ohne\ GB} = \Delta R_{w,Messung} - x(R_{w,GB})$$

Modellierung
Modellansatz

Subtraktion des Einflusses des Grundbauteils

$$x(R_{w,GB}) = \frac{R_{w,GB}}{3} - 30$$





Modellierung
Modellansatz

$$\Delta R_{w,Prognose,ohne\ GB} = a \cdot log_{10}(f_0) + b$$

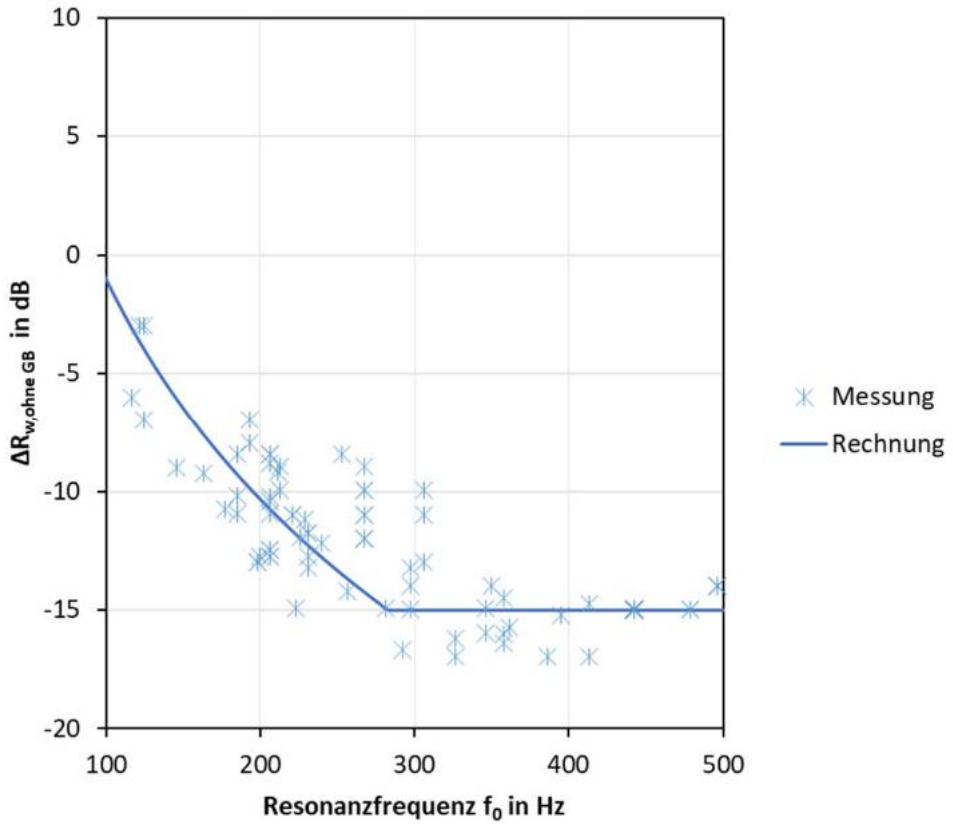
$$\Delta R_{w,Messung,ohne\ GB} = \Delta R_{w,Messung} + x(R_{w,GB})$$

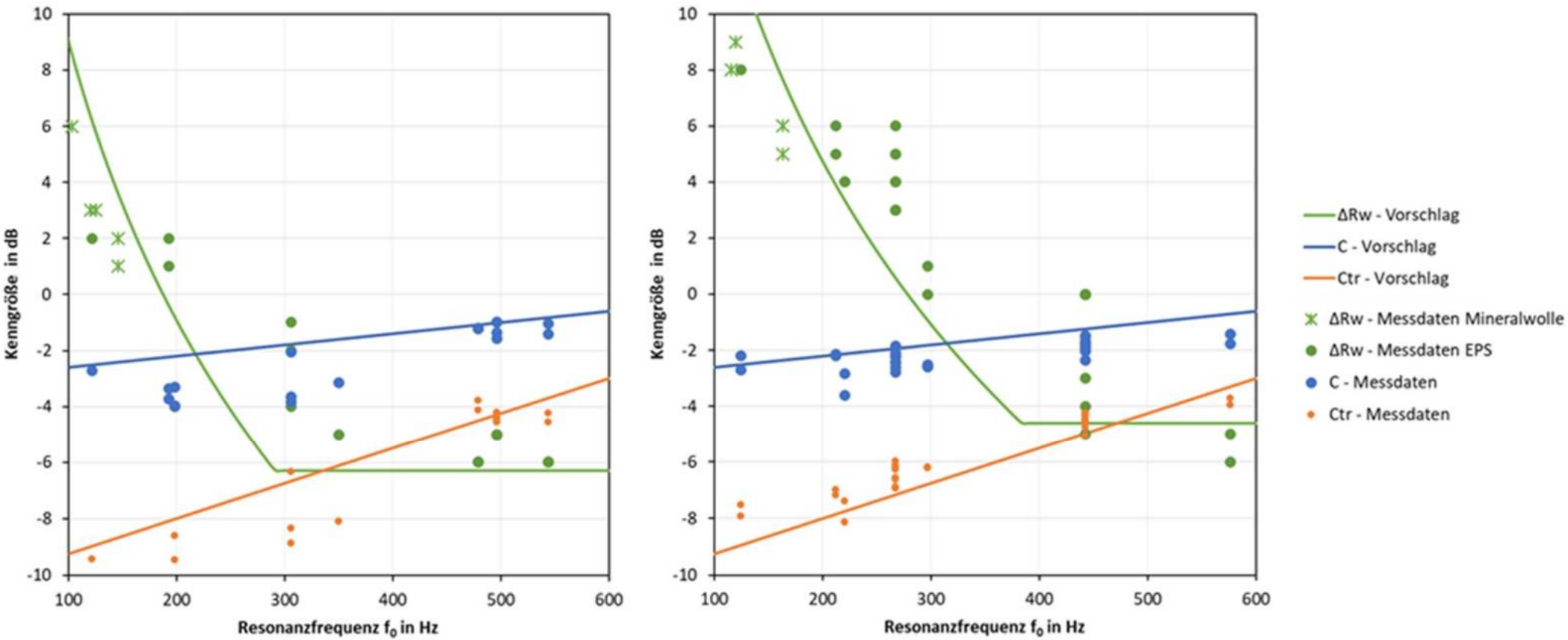
$$x(R_{w,GB}) = -\frac{R_{w,GB}}{3} + 30$$

$$a = -33$$

$$b = 67$$

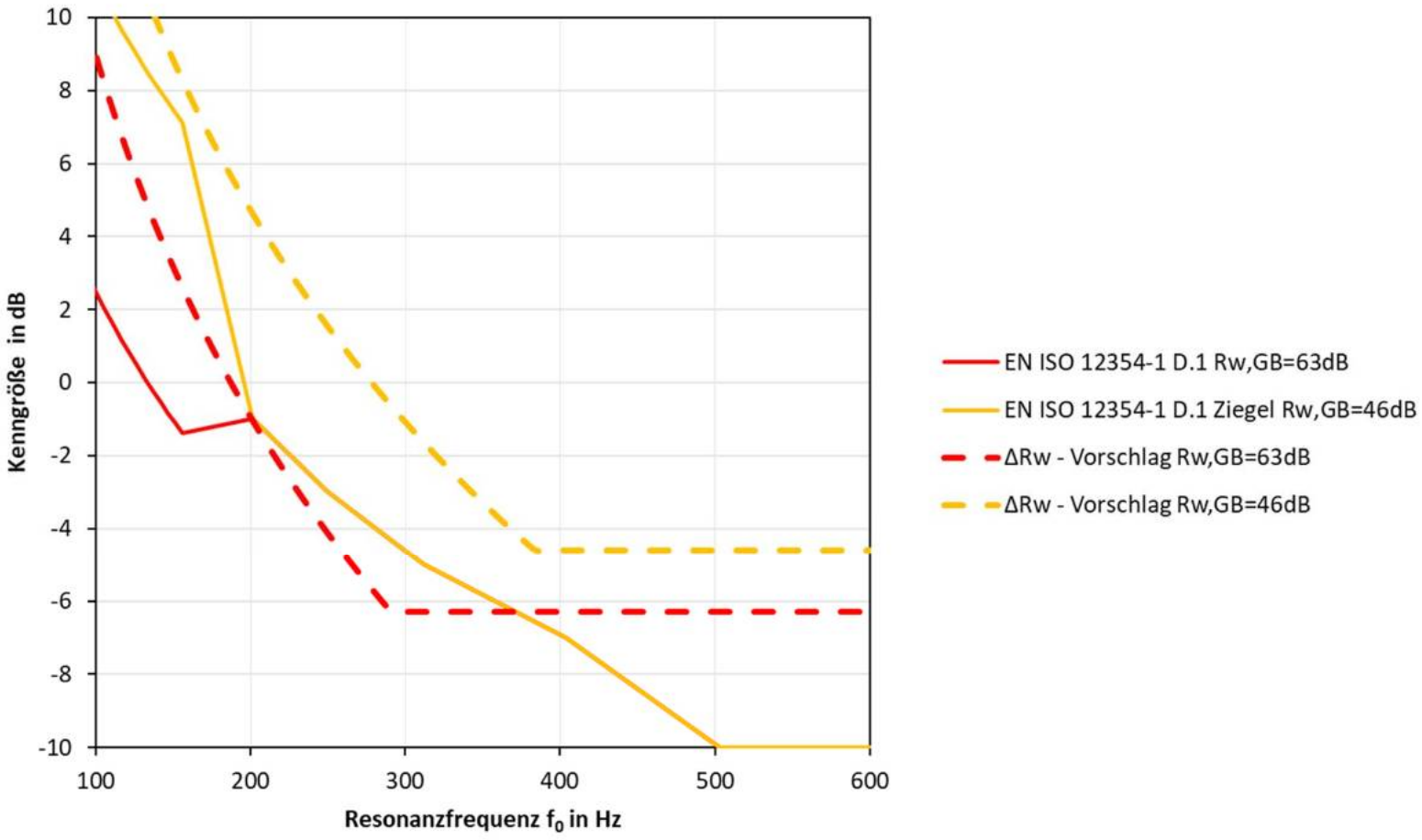
Identifizierte Parameter





$$\Delta R_w = max\begin{pmatrix} \frac{-R_{w,GB}}{10} \\ -33 \cdot log_{10}(f_0) - \frac{R_{w,GB}}{3} + 97 \end{pmatrix} \qquad \Delta C = \frac{f_0}{70} - 6 \qquad \Delta Ctr = \frac{f_0}{50} - 10$$

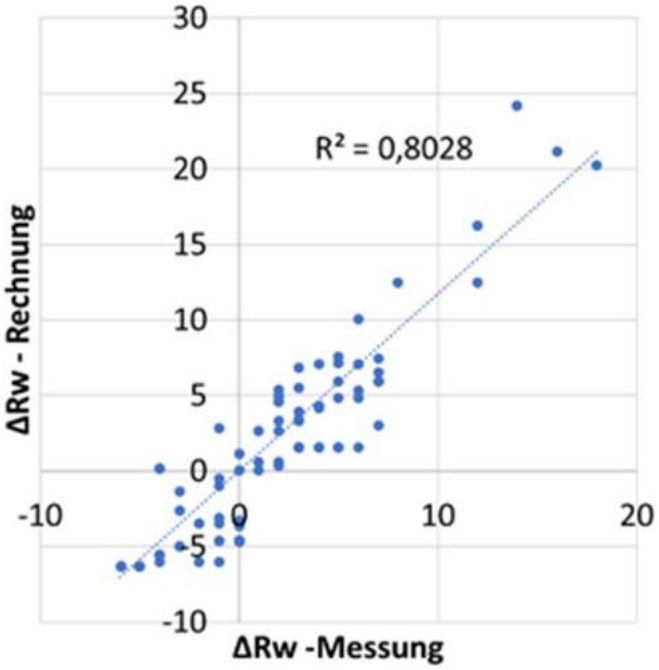
Modellierung
Vergleich



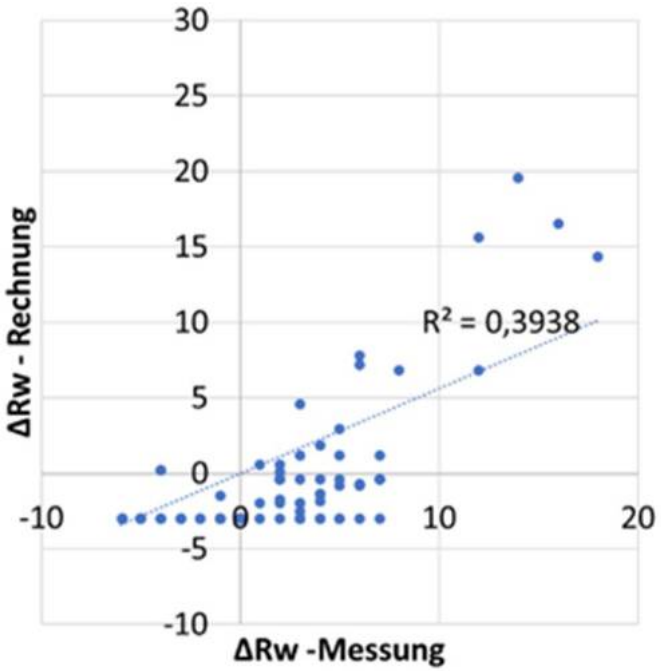
Modellierung

Vergleich

Vorschlag ÖNORM B 8115-4 **NEU**

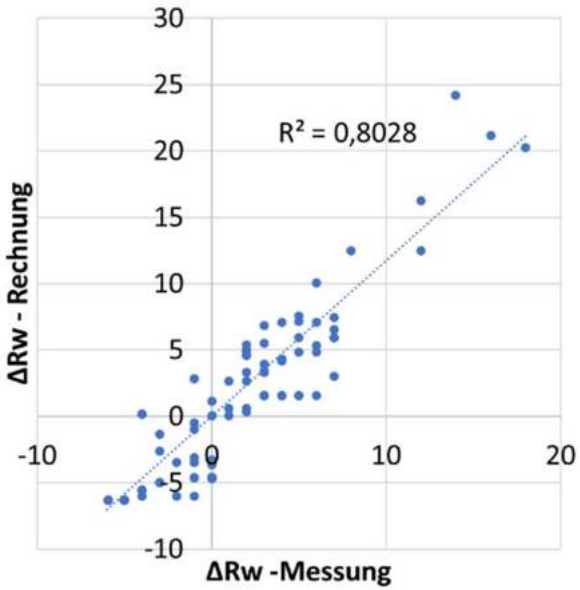


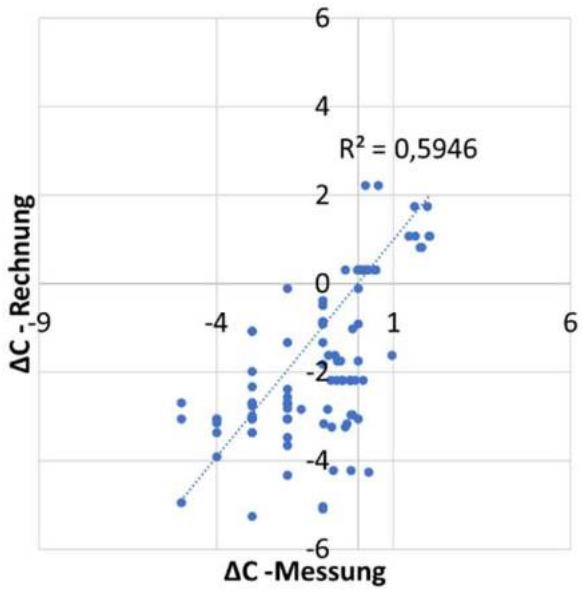
EN ISO 12354-1 D2.2 **ALT**

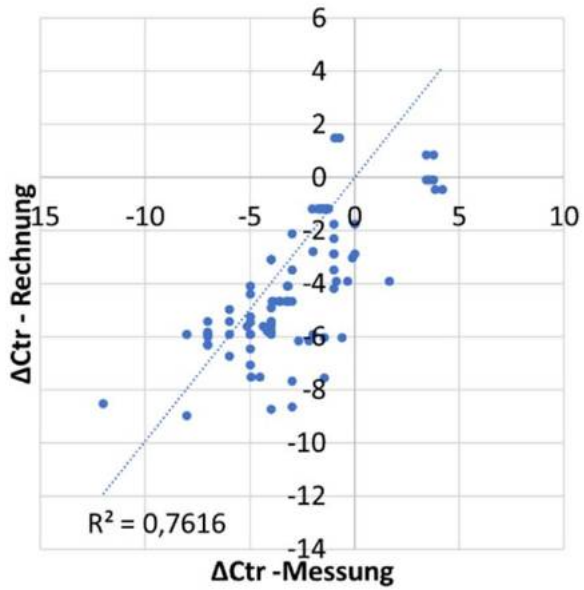


NEU:

(Vorschlag 8115-4)

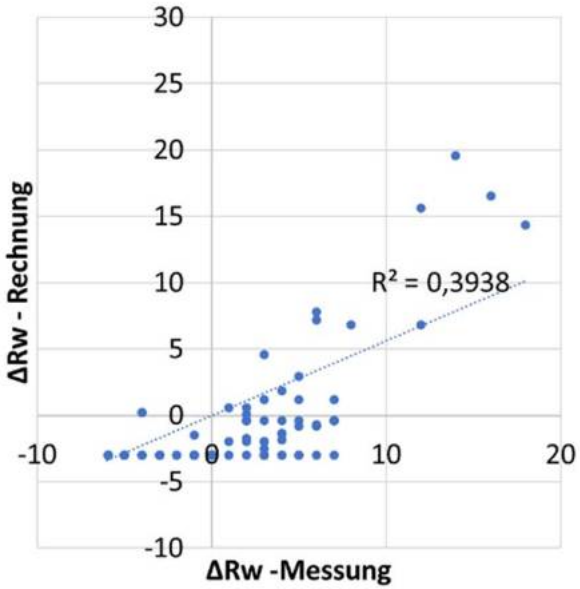


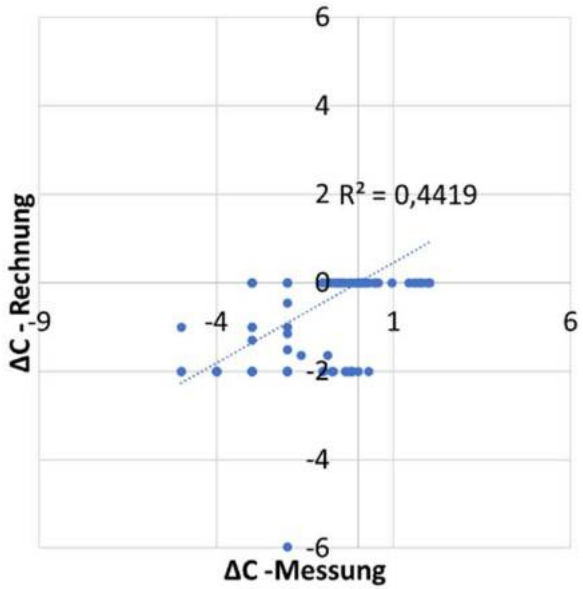


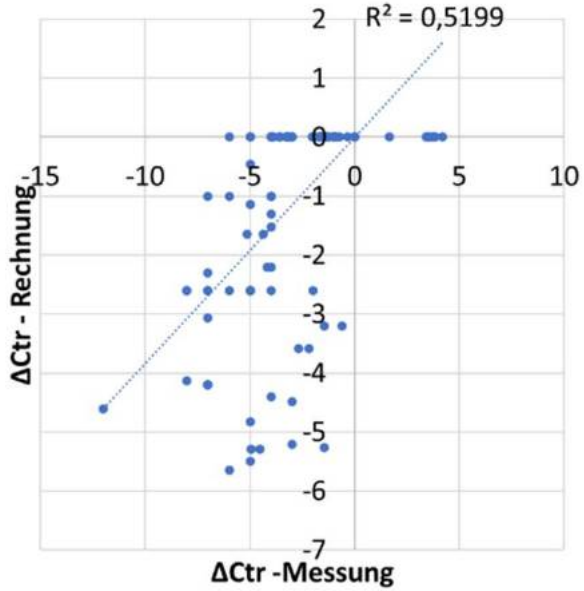


ALT:

(EN ISO 12354-1 D2.2)







Zusammenfassung

- Einfluss des Dübels auf das Luftschalldämmverbesserungsmaß in Frequenzbereichen $f \approx f_R$ erkennbar
- Mit steigender Dübel Anzahl steigt ΔR_w
- Einfluss des Schalldämmmaßes des Grundbauteils erkennbar und wesentlich $f > f_R$ gering
- Mit steigendem Schalldämmmaß des Grundbauteils sinkt ΔR_w
- Vorschlag ÖNORM B 8115-4 bringt verbesserte Prognosesicherheit und Prognose von ΔC und ΔC_{tr}

Abweichung in dB		Vorschlag Neu	ÖNORM B 8115:4 (Tabelle 2)	ÖNORM EN ISO 12354-1 (Formel 4)
ΔR_w	Standardfehler $\sigma_{\bar{x}}$	1,8	2,8	3,1
	Mittlerer Fehler $\bar{x}$	2,0	5,9	3,4
ΔC	Standardfehler $\sigma_{\bar{x}}$	1,2	n.m.*	1,4
	Mittlerer Fehler $\bar{x}$	1,2	n.m.*	1,6
ΔC_{tr}	Standardfehler $\sigma_{\bar{x}}$	1,6	n.m.*	2,6
	Mittlerer Fehler $\bar{x}$	1,8	n.m.*	1,9

n.m.* = Prognose nicht möglich, da das Modell diesen Output nicht liefert