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RAIN NOISE FROM AGRICULTURAL ROOFING

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Rain fall noise is an issue creating stress for animals. A recent series of tests have been conducted to classify the different solutions proposed for agricultural buildings. All those tests have been compared to a model using a transfer matrix method including orthotropic modules able to reproduce the impact of corrugated sheet on sound levels. It has shown good agreements with experiments.

Keywords: building acoustics, rain fall, agricultural, roof

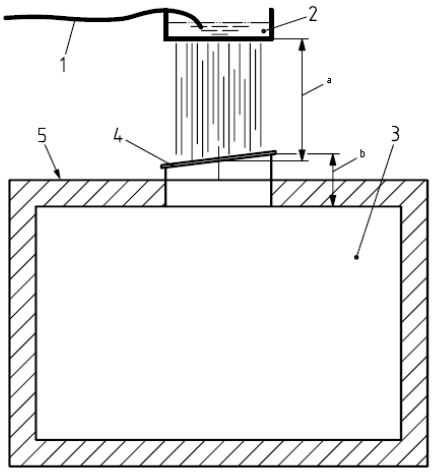
1. Introduction

In 2014 the National agricultural and food center from Slovakia published a report [1] on the effect of noise on cattle. Potentially the noise created by the rain fall affects the animal behaviors. The rain noise is also an issue for others buildings. For instance, for school buildings in UK , the BB93 [2] required to control the rain fall noise.

That is why a lot of work has been achieved in standardizing levels to propose a standard that is able to reproduce rainfall. We can compare the capacity to reduce rainfall noise of different roofing solutions. But it is also possible to use this new prediction model to better identify the leverages to reduce rainfall noise. It can help in the future to design roofing solutions with higher performances.

2. Experimental tests on roofing panels with and without thermal insulation

The standard EN ISO 1040-1 from November 2016 [3] and the EN ISO 10140-5 A1 [4] have been used to measure the performance of rainfall noise attenuation. The measurement set up is presented in Figure 1. The tests have been realized to understand the influence of typical solutions for agricultural roofing panels such as steel and corrugated fiber cement sheets. But also to evaluate the impact of the geometry of the stiffener and the influence of thermal layers. In the end, 6 configurations have been tested.



Key
1 water-supply system
2 tank with perforated base
3 test room
4 test specimen
5 water drainage (arranged by user)
a Fall height.
b Height of the niche.

Figure 1 On the left the experimental test set up from standard 1040-5 [4] - on the right photo the receiving room from CSTB [5].

Table 1 shows that corrugated fiber cement attenuates the rainfall noise more than corrugated steel sheets. The difference ranges from 8 to 12 dB(A). The performance is due to the higher mass of the fiber cement but also the shape of the corrugated sheet shows a better performance than a simple trapezoid profiled sheet. For configuration 4 and 5, mostly the corrugated shape may explain the 5 dB(A) difference. Thermal layers didn't influence the performance very much. The experiment shows that intrinsic properties and geometry are the main leverages to influence the reduction of rainfall noise.

Table 1 : Tests results

		Corrugated sheet	With thermal layers	Fiber cement	Steel sheet 0
1&2	Corrugated Fiber cement 6.5 mm	 L_{iA} 57dB(A)	 L_{iA} 58dB(A)	x	
3	Corrugated Fiber cement 6.5mm		 L_{iA} = 59 dB(A)	x	
4	Corrugated Steel sheet 0.75 mm	 L_{iA}=67 dB(A)			x
5	Corrugated Steel sheet 0.6 mm	 L_{iA}=72dB(A)			x
6	Corrugated Steel sheet 0.63 mm		 L_{iA}=70 dB(A)		x

3. Prediction approach evaluation

Recent models as D. Griffin and K. Ballagh [6] have been developed to predict the rain fall noise; those models include the corrugated geometry. More specifically, CSTB has developed a model [7] to predict the performance of rain fall and this prediction has been compared to the tests. The model is based on a transfer matrix method, already presented in [8]. In 2016 Chene & all [9] have implemented a new method to predict stiffeners and by the way the impact of the corrugated shapes. Table 2 presents the comparison between the tests for configuration 2 and 4. To evaluate the impact of the stiffeners, the two cases were simulated. At least for configuration 4, we see that homogenization [9] is a key element to predict the performances. The simulations are very close to the real tests. Graphics 1 shows that the predictions with stiffeners follow the curves of the tests.

Table 2 : Prediction comparison with tests with and without homogenization

	Corru-gated	Test	Simulation with homogenization	Simulation without ho-mogenization
Configura-tion 2	Fiber cement	L_{iA}=59 dB(A)	L_{iA}=59 dB(A)	L_{iA}= 59 dB(A)
Configura-tion 4	Steel sheet	L_{iA}=67 dB(A)	L_{iA}=65 dB(A)	L_{iA} =57 dB(A)

Graphics 1 – Comparison between test and prediction with stiffer and without for 2 configurations

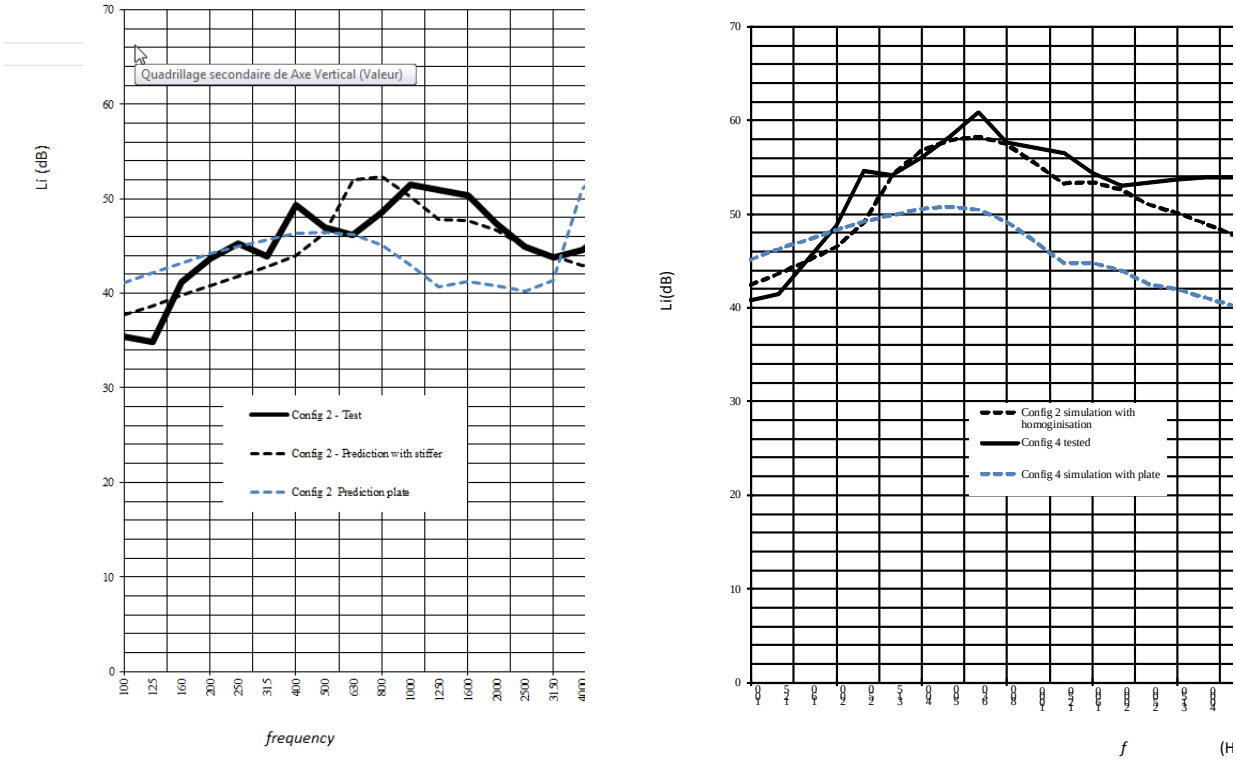
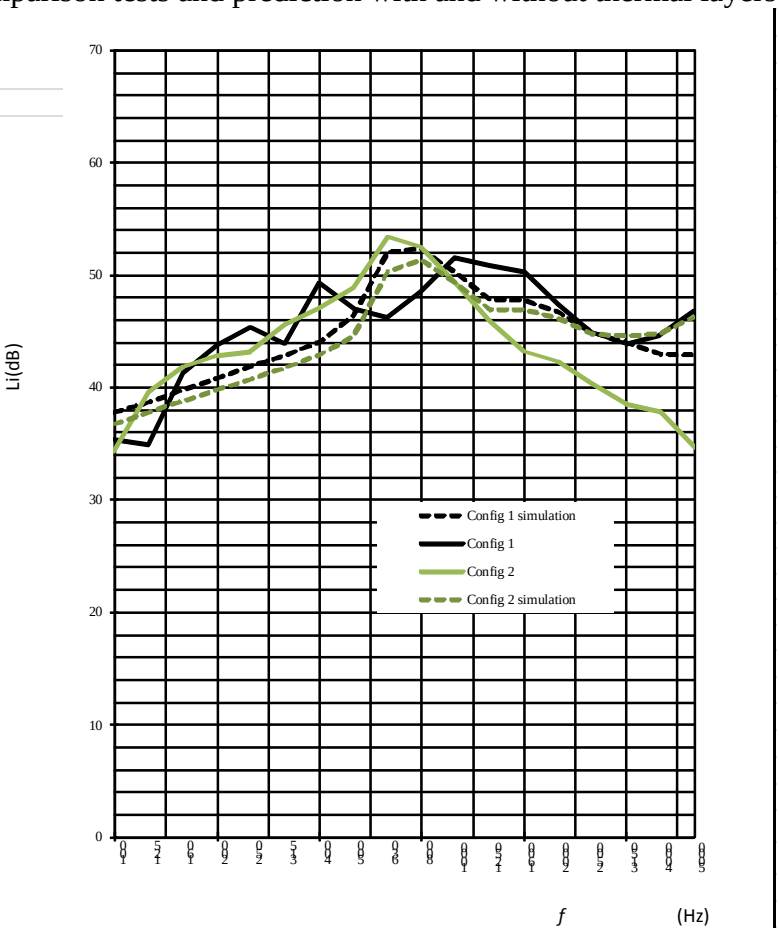


Table 1 shows that the thermal layers tested didn't influence the rainfall noise for all configurations tested. Table 3 shows that the simulations indicate the same performance as the tests. But in Graphics 2, we observe that the simulation can't reproduce the impact of the thermal layers above 1000 Hz.

Table 3 : Prediction comparison on the influence of the thermal layers

			Test	Simulation with homogeni-zation
Configuration 1		Without	LiA=59 dB(A)	LiA=59 dB(A)
Configuration 2		Thermal layers	LiA=58dB(A)	LiA=58 dB(A)

Graphics 2 – Comparison tests and prediction with and without thermal layers



4. Conclusion

The last version of the test methods [3] and [4] are more and more used to easily compare different corrugated roofing solutions used for agricultural building. The results of the 6 experimental tests show that because of intrinsic properties, fiber cement delivers better performance than a classical steel sheet.

The new models, taking into account the design of the corrugated sheet, give a good accuracy that was not possible if the corrugated sheet was modeled as flat sheet. The thermal layers do not influence the rain fall noise performances. The possibility to integrate corrugated geometry in a transfer matrix model can help to predict the impact of new corrugated design.

Corrugated fiber cement sheets show a better performance concerning noise levels during rain fall, which will benefit by reducing the stress of the animals and to improve agricultural production

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2 Building Bulletin 93 (BB93) explains minimum performance standards for the acoustics of school buildings.

3 ISO 10140-1:2016 Acoustics -- Laboratory measurement of sound insulation of building elements -- Part 1: Application rules for specific products

4 ISO 10140-5:2010 Acoustics -- Laboratory measurement of sound insulation of building elements -- Part 5: Requirements for test facilities and equipment.

5 http://www.cstb.fr/archives/webzines/editions/mai-2007/bruit-de-pluie-sur-le-batiment-le-cstb-se-mouille.html

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8 Mesure et prediction de pluie sur des systemes multicouches – Jean Baptiste Chéné, Catherine Guigou-Cartern, Remy Foret at Mikel Larsen

9 De l'usage des techniques d'homogénéisation afin d'étendre la portée des méthodes de matrices de transfert pour la modélisation de systèmes du bâtiment : Trois techniques, trois études de trois cas, J.-B. Chéné , C. Guigou Carter, P. Jean, T. Blinet et G. Jacqusc