Impact of floor drain on floating floor acoustic performance

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In the context of the new regulation about handicap accessibility, a study on the implementation of Italian integrated shower system (flushed with the surrounding bathroom floor) has been performed. In this paper, the impact of floor drain when integrated in floating floor has been investigated. First, the EN ISO 140-8 standard was used to evaluate the floor drain effect on a full scale sample. In a second step, the ISO/CD 16251-1 draft standard was adapted to only assess the decoupling between the two parts of the floor drain installed in a floating screed system. Experimental results are presented and discussed. It is demonstrated that the proposed adapted technique based on the ISO/CD 16251-1 is good in evaluating the decoupling.

1 Introduction

In France, the new regulation concerning accessibility of residential building for physically handicapped persons is mandatory for all new buildings which construction permit has been delivered since the beginning of 2010; it requires eliminating obstacles at the building design stage. Indeed, residential buildings have now to be directly handicap accessible or easily adaptable to changing needs. Two technical issues have been identified and then investigated in particular with respect to acoustic problematic. These issues concerned accessibility to balcony and loggia as well as bathroom. This paper deals with the acoustic problem encountered during the construction of an accessible bathroom. The questions, on the acoustic point of view, are mainly related to the integration of the different types of accessible shower systems (creating an offset of less than 20 mm) as for example: floor drain, walk-in showerbase ready to tile, flat top shower tray.

During this study, the impact of different systems on acoustic performances, such as airborne sound insulation, impact noise level and equipement noise level (water outfall in the floor and water jet on the shower), has been investigated.

The first part of this paper presents the major results obtained during this investigation. The second one will be spared to analyze the acoustic consequences of the integration of a floor drain in a floating screed.

2 Type of acoustic issues in accessible bathroom

2.1 Working assumptions

This study financed by the French housing ministry had for goal to identify the issues and to find solutions to meet this new regulation on physically handicapped persons accessibility for multi-storey apartments building.

The acoustic key point was mainly the accessible shower and this even if in France buildings with accessible bathroom already exist (retirement home, hospital, etc…). The reasons are that first in most of these buildings, acoustic requirements are lower than multi-storey apartments building, and also that since there is only one owner, it is possible to use a vertical drainage channel running straight through the floor and to use a suspended ceiling to solve the acoustic issue.

Here in the context of multi-storey multi-family apartments building, solutions with horizontal drainage channel embedded in the floor slab (usually concrete in France) have to be developed.

2.2 Acoustic issues

In France, bathrooms in multi-storey apartments building have to reach several differents acoustic performances. The first one deals with airborne sound insulation: $D_{n,T,A} \geq 50$ dB between two bathrooms of different flat and 53 dB between bathroom and living or sleeping room of another flat. The second one concerns impact noise: $L'_{nT,w} \leq 58$ dB between the bathroom and any living or sleeping room of another flat. Finally, the last one is about the service equipment noise: $L_{nAT} \leq 30$ dB(A) between bathroom and any living or sleeping room of another flat and 35 dB(A) between bathroom and kitchen of another flat. This last point has been examined from two different perspectives: the noise generated by the water flow in floor embedded siphon and drainage channel, and the noise generated by water jet on the shower floor.

Discussions and evaluations have been performed on products already commercially available on the French market. Those available products are not necessarily fully adjusted to this new regulation.

To study all theses systems, a concrete floor slab of 15 m² in surface area and 180 mm in thickness including two pre-prepared shower installation hollowed zones (size 900x900x60 mm^3; see Figure 1) has been fabricated and acoustic measurements were carried out in reception room complying with the ISO 140-1 standard.

Figure 1: Concrete test floor (180mm in thickness)

Five different products have been evaluated:

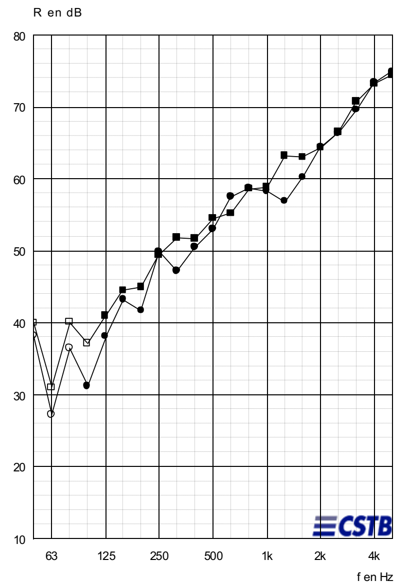
- One walk-in shower-base ready to tile
- Two floor drains (one with waterproofing membrane)
- Two flat top shower trays

2.3 Airborne sound insulation

For this problematic, it was decided to investigate the effect of different "holes" created in the floor slab in order to install the shower system:

- Floor drain body (up to 150 mm in diameter and 150 mm in depth)
- Horizontal drain channel (40-50 mm in diameter – around 1 m in length)
- Volume for systems such as a walk-in shower-base ready to tile or a flat top shower tray (different sizes exist but generally close to 900x900x60 mm^3)

No significant decrease of airborne sound insulation has been measured or calculated for these different cases. Figure 2 shows the effect of two different mounting conditions for the drainage channel and siphon body sealed or not with mortar in the floor shower installation hollowed zone (it should be noticed that the non sealed situation is not allowed). The basic floor slab of 180 mm in thickness was tested totally filling the pre-prepared shower installation hollowed zones with mortar and an acoustic performance corresponding to $R_w(C;C_{tr})$ =59(-2 ;-8) dB was obtained.



Code	■	●
f	R	R
50	40,0+ (49,7)	38,2+ (49,7)
63	31,0+ (47,5)	27,2+ (47,5)
80	40,1+ (54,9)	36,5+ (54,9)
100	37,1+ (51,6)	31,2
125	41,0	38,1
160	44,5	43,2
200	44,9	41,7
250	49,4	49,9
315	51,8	47,2
400	51,7	50,5
500	54,5	53,0
630	55,2	57,5
800	58,6	58,7
1k	58,8	58,3
1,25k	63,2	56,9
1,6k	63,0	60,2
2k	64,3	64,4
2,5k	66,5	66,4
3,15k	70,7	69,6
4k	73,2	73,4
5k	74,4	74,9
Hz	dB	dB

(*) : valeur corrigée. (+) : limite de poste.

■	R_w $(C;C_{tr})$ = 58(-1;-6) dB Pour information : $R_A = R_w+C$ = 57 dB $R_{A,tr} = R_w+C_{tr}$ = 52 dB
●	R_w $(C;C_{tr})$ = 56(-2;-8) dB Pour information : $R_A = R_w+C$ = 54 dB $R_{A,tr} = R_w+C_{tr}$ = 48 dB

Figure 2: Effect of floor drain body and outfall tube sealed with mortar or not (■ Sealed; ● not sealed).

2.4 Impact noise level

First of all, it should be mentioned that in France, impact noise level regulation takes into account the acoustic performances of the floor covering. Then, even if the French regulation is not so clear on the fact that impact noise requirement applies in such a shower, it has been considered that, the impact noise level requirement does not have to be reached inside a shower tray (well defined area), but had to be complied with for an integrated open shower with no zone limitation (walk-in shower-base ready to tile, floor drain+tiles or pvc floor covering…).

Then, different approaches for the integrated open shower were used since there exists in that case an interaction between the system chosen for the shower and the floor covering treatment (implemented for the impact noise issue) in the rest of the bathroom floor. Indeed both cannot be chosen separately. Therefore, among the three major types of floor covering treatments currently used in France for bathroom floors (floating concrete screed, floating tiles and PVC floor covering), only few of them are compatible (and have proof of this compatibility) with an accessible shower system. The systems validated today are some PVC Floor covering used with some floor drain (under CSTB technical approval procedure). Floating tiles systems (also under CSTB technical approval procedure) and floating concrete screed systems are only compatible with flat top shower tray mounted with closed shower enclosure. But for the floating concrete screed system, a complementary study was actually performed on the floor drain integration; this point will be the subject of the third part of this paper.

2.5 Service equipment noise level (water flow in drainage channel embedded in the floor slab)

For the evaluation of the service equipment noise level from either the water flow in drainage channel embedded in the floor slab or the water jet exciting the shower area, the ACOUBAT V6.0 software based on the EN 12354-5 standard method was used. Indeed, the service equipment noise level L_{nAT} can be calculated from the structural power level associated to the structure-borne noise source. In order to determine the structural power level, the reception room sound pressure level, the floor slab velocity level, the floor slab mobility at the water jet impact location as well as the floor slab loss factor were measured.

For the service equipment noise level associated to the water flow in the drainage channel embedded in the floor slab, the horizontal drainage channel was included with a 1.5% slope in the floor slab; the water flow velocity was very slow and water flow rate was small.

In this situation, it was impossible to measure significant pressure and velocity levels for the five tested systems. Indeed, in that case, no specific acoustic issue was identified.

2.6 Service equipment noise level (Water jet on the shower area)

A lot of attention was paid to the acoustic issue related to service equipment noise associated to water jet hitting the shower area, since the measured levels on the five considered systems did not meet the French regulation requirement. Figure 3 shows the measurement setup.

Figure 3: Measurement setup for evaluating the water jet noise level (source: reference water jet (INS) at 2 m oriented to the center of the shower area).

The water jet was produced with the reference water jet source (INS) at a pressure of 3 bars (flow rate of 0.22 l/s) as defined by the EN 15657-1draft standard. However, it is questionable that it represents a realistic source. Therefore, the measurements were also performed with a standardized hand shower head used to test if shower enclosures are waterproof. Indeed, the measurement results with both sources were very close; so the water jet generator was found to be an appropriate excitation source.

In order to understand if the obtained noise level was specific or not to accessible shower systems, similar measurements were performed on traditional ceramic shower tray. Indeed, the measured noise levels were in the same order of magnitude. It should be mentioned that in France, there are no traditional mounting rules for a shower system, thus the specifications in the mounting guide published by the sanitary equipment manufacturer association were followed. In fact, the mounting involved decoupling at the shower tray perimeter and gluing the shower tray with a kind of mortar on the floor (rigid).

Figure 4 presents the main measurement results in terms of service equipment noise L_{nAT} calculated for a small bedroom (10 m² in surface area) located diagonally below the bathroom.

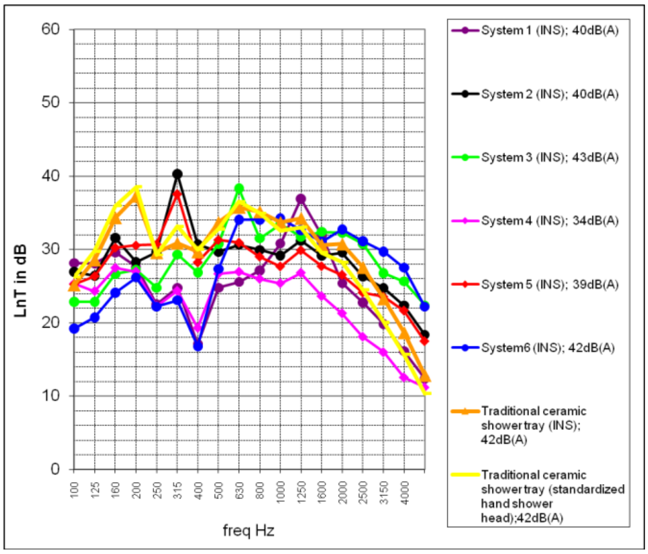


Figure 4: Calculated L_{nAT} for several shower systems under water jet excitation.

Indeed, this noise problem generated by the water jet hitting the shower area is not specific to the accessible shower systems; a full decoupling would be necessary to solve that problem.

Next section describes an integrated approach in order to find solutions for the identified major issues: the impact noise level and the water jet noise.

3 Integration of a shower floor drain in a concrete floating screed.

3.1 Problem description

A simple solution (on the paper) to solve at the same time the impact noise and the water jet noise issues is the use of a floor drain in a concrete floating screed. However, it quickly appears that it is not such an easy solution, since it needs to combine accessibility with waterproof, acoustic, and screed mechanical aspects. ,…

The first question was the position of the waterproof layer regarding to the acoustic resilient underlay. Since no acoustic resilient underlay is, at this time, compatible with water, the only solution was to put the waterproofing layer on the floating screed and the acoustic resilient underlay under the floating screed as expected. This is shown in Figure 5.

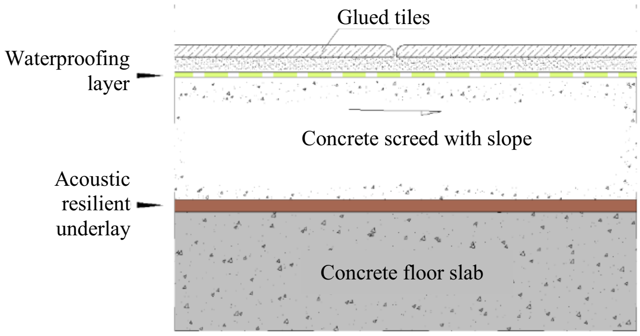


Figure 5: Position of the waterproof layer and of the acoustic resilient underlay.

Then two main questions arise. The first one concerns the structural short cut that could exist between the floor drain body (sealed in the supporting floor slab) and the floor drain upper part sealed in the floating screed (see Figure 6). The second one is associated to the peripheral treatment that should include the four sides upstand of both the acoustic resilient layer and the waterproofing layer. A solution is proposed in Figure 7.

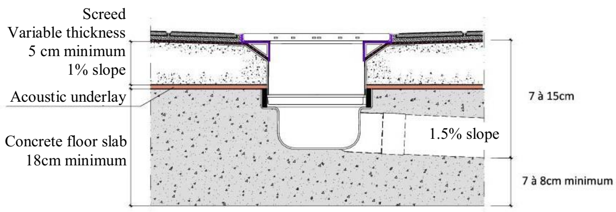
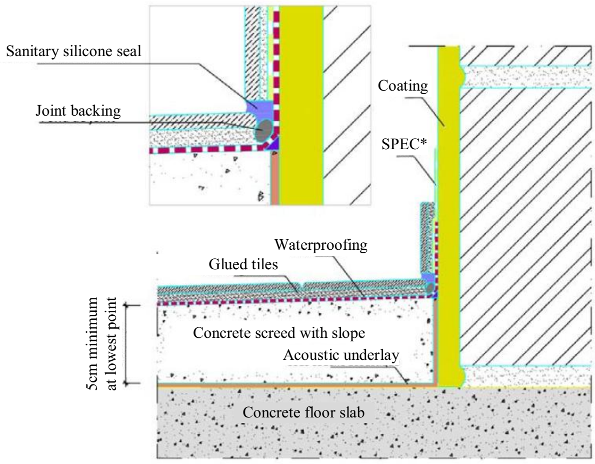


Figure 6: Mounting example of a floor drain with a concrete floating screed [1].



* under tile water protection system

Figure 7: Example of a peripheral treatment including both acoustic and waterproof aspects [1].

To find solutions to these two questions, two complete systems (floor slab, acoustic resilient underlay, concrete floating screed, floor drain, waterproofing layer, tiles and baseboard) were built. Since the supporting floor slab was 15 m² in dimensions, it was decided to include 4 floor drains in each concrete floating screed to increase the structural shortcut density per square meter, more representative of an actual bathroom.

The first system tested was composed of a floor drain with an upper part threaded on the body, coupled with a waterproofing membrane. The second one was a floor drain with an O-ring joint between the body and the upper part mounted with a liquid waterproofing system.

Impact noise and airborne sound insulations were tested at the same time on these complete systems, and then the same systems without the baseboard (cutting the waterproofing upstand) before making a last measurement without the floor drain upper part.

3.2 Peripheral treatment

On the two systems tested, the mounting conditions were very good, and therefore no decrease in measured performance was obtained with the peripheral treatment. However, it is believed to be a key issue since bad mounting conditions could greatly affect the acoustic performance (decreasing it). Figure 7 shows a good mounting solution but it does require a really good skill in order to realize it correctly.

3.3 Possible structural shortcut through the floor drain

Only one of the tested floor drains was fully adapted to the selected mounting conditions. It was the one with O-ring joint, since as expected it does not have any effect on the acoustique performance of the concrete floating screed.

The other floor drain (with the threaded upper part) had a connection with the waterproofing layer at the floor drain body level (instead of the upper part for such mounting conditions). So the screwing thread was quite loose to collect the leaking water in the floor drain. However as for the other floor drain, no significant decrease of acoustic performance has been measured.

But, since the market of such floor drains is just developing, it can be expected that new products will appears on the market to answer this new need. Therefore, it was decided to investigate the impact of a potentially future floor drain where the floor drain upper part and body would be rigidly connected. To this end, one centimeter of the upper part of the O-ring joint floor drain was sealed with plaster to the body.

Figure 8 shows the impact noise improvement ΔL obtained with the O-ring joint system; the curve marked with crosses corresponds to the case when the floor drain upper part is sealed with plaster to the body ; a 4 dB decrease in obtained on the global value.

Furthermore, it should be noticed that the measurement test on a concrete floating screed of 15m² in surface area including four floor drains to validate the drain floor decoupling is not quite practical; it is indeed time and money consuming. Therefore, manufacturers as well as the state representative involved in the project did request to replace the testing procedure by a simplified one if possible. It is the subject of the next part of this paper.

4 Development of simplified method to evaluate floor drain upper part decoupling

The effect of the drain floor upper part short-cut as shown in Figure 8 appears mainly in the middle and high frequency range. Therefore it was decided to try using the new alternative method for the evaluation of the impact noise improvement ΔL of floor covering (EN 16251-1 draft standard). Indeed, this method is not applicable for the evaluation of a concrete floating screed due to the low frequency system behavior; however as shown in Figure 9 [2] it is possibly usable in the middle and high frequency range.

Therefore, the floor drain was mounted in a similar way (without waterproofing layer and tiles) in the concrete slab corresponding to the facility scale of the ISO 16251-1 draft standard [3] (i.e. a concrete slab of 1200x800x200 mm^3), as seen in Figure 10.

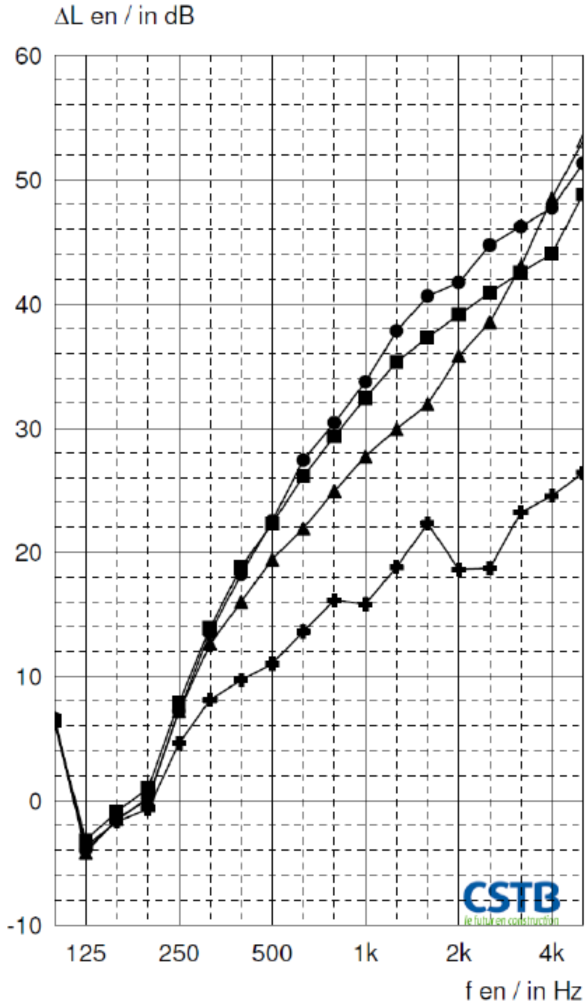


Figure 8: Impact on ΔL of floor drain upper part rigidly connected with floor drain body.

With this new method, the measurements were again performed with the two different floor drain systems considered and tested on full scale concrete slab (15 m^2). Results are very interesting since the same behavior is observed for the two different measurement setups, even if in the reduced size experimental setup the tiles and the waterproof layer were not implemented. Figure 11 presents the measurement results on O-ring joint floor drain system with the plaster seal between the floor drain upper part and the body obtained with the two different methods (full and limited setups). Behaviors are in good agreement and it seems possible to use the ISO 16251-1 draft standard approach to obtain a decoupling criteria for floor drain mounted with a concrete floating screed system.

Future work will evaluate how to use these measurements on the limited size setup to determine SEA parameters in order to model the structural short-cut associated to the floor drain on real size bathroom floor systems.

5 Conclusions

In this study, it has firstly been possible to better understand the issues associated to an accessible bathroom for physically handicapped persons as well as to identify the corresponding major acoustic problems that are the impact noise level and water jet noise on the shower area.

In a second time, a specific technique has been investigated in details: a floor drain integrated in a concrete floating screed. The treatment of the two key points associated with this solution, i.e. the peripheral treatment and the floor drain structural short-cut, has been examined.

Finally, a new specific evaluation of the water drain decoupling from a floating screed has been proposed and validated. This novel testing method should make easier the future evaluation of such products.

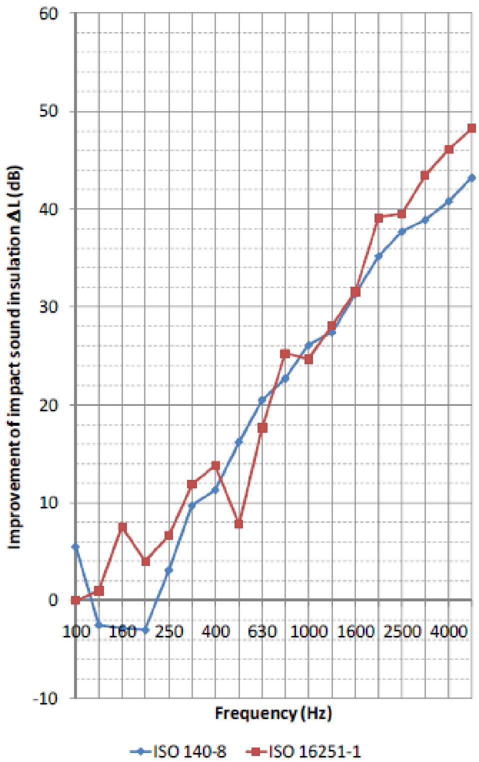


Figure 9: Comparison of impact noise improvement obtained with ISO 140-8 standard and ISO 16251-1 draft standard for a concrete floating screed.

Figure 10: Test setup for the ISO 16251-1 draft standard adapted to integrate a floor drain.

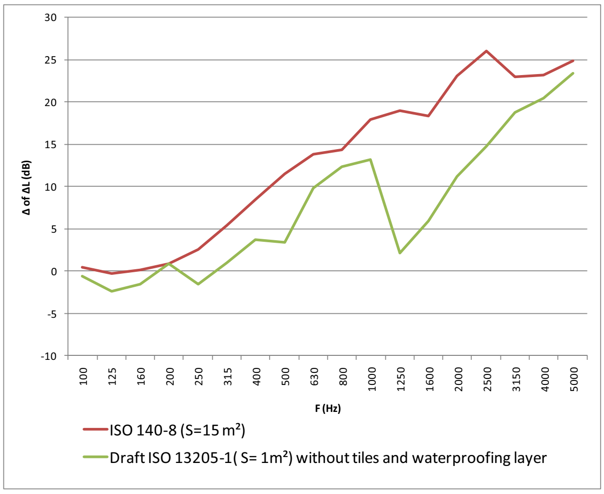


Figure 11: Effect of the floor drain upper part sealing tested both with ISO 140-8 standard and ISO 16251-1 draft standard.

Acknowledgments

We gratefully acknowledge the DHUP (French ministry for Housing, Urban planning and Landscape Department) for financially supporting this project as well as all the other French actors who have contributed to the succes of this work.

References

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[2] R. Foret, J.B. Chéné, C. Guigou-Carter, “A comparison of the reduction of transmitted impact noise by floor coverings measured using ISO 140-8 and ISO/CD 16251-1”, *Forum acousticum – Aalborg* (2011)

[3] ISO/CD 16251-1: Acoustics – Laboratory measurement of the reduction of transmitted impact noise by floor coverings on a small floor mock-up – Part 1: Heavyweight compact floor.