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ACOUSTIC QUALITIES OF A CEILING FROM PREFABRICATED TIMBER – CONCRETE COMPOSITE PANELS

AKUSTICKÉ VLASTNOSTI STROPU Z PREFABRIKOVANÝCH DŘEVO – BETONOVÝCH SPŘAŽENÝCH PANELŮ

Abstract

This article describes the acoustic qualities (sound insulation and a level of acoustic pressure of impact sound) composite construction, composite timber - concrete ceiling. The qualities of the ceiling construction were discovered in the experimental measurements in the acoustic testing laboratory certified by CSI Zlin on a sample of a 3 x 3,6 m size. One type of a floor composition was created. Three phases of measurement have been performed on the tested floor. The aim of the experiment was to determine whether the devised ceiling can be used as a separating element between apartments.

Keywords

Building acoustics, composite, timber, concrete, ceiling, floor, sound, insulation.

Abstrakt

Článek popisuje akustické vlastnosti tj. vzduchovou neprůzvučnost a hladinu akustického tlaku kročejového zvuku kompozitní konstrukce, spřaženého dřevo – betonového stropu. Vlastnosti stropní konstrukce byly experimentálně zjišťovány v akustické laboratoři certifikované zkušebny CSI Zlín na vzorku o velikosti 3,0 x 3,6 m. Byl proveden jeden typ skladby podlahy, z kterého vzešly tři fáze měření. Cílem experimentu bylo zjistit, zda navrhovaný strop obstojí z hlediska akustiky pro použití jako dělicí konstrukce mezi byty.

Klíčová slova

Stavební akustika, kompozit, dřevo, beton, strop, podlaha, zvuk, izolace.

1 INTRODUCTION

1.1 Implementation of the wood into the construction

At present, with the growing demand for wooden buildings (mostly houses, but also residential and office buildings) there are increasing tendencies to improve their qualities. These are mainly focused on weaknesses of traditional wooden buildings:

a) Firmness of a construction.

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b) Resistance to fire.

c) Acoustic qualities.

The biggest advantage of wood-based structures is a speed of building, as well as sustainability of a construction associated with the use of natural character materials [1, 2]. The ways to suppress the deficiencies of wooden buildings and keep the speed of a construction without wet technological processes are different (eg insertion of solid walls, fireproof coatings and structural adjustments, input materials with greater density in a floor, etc.).

Another possible category to enhance the qualities of wood structures is the use of composite materials [3]. This category includes composite timber - concrete structures that are currently getting into builders and manufacturers awareness in the Czech Republic. To keep the speed of a construction of wooden houses, composite timber - concrete panels must be a subject of prefabrication, so that the advantages of offered characteristics can be fully used.

In our case, we focused on the acoustic qualities of the composite timber - concrete ceiling structure, which has not been detected in any laboratory yet.

A type of timber and concrete has been known since 1921, according to German patent of Paul Müller. A pioneer in this area is considered a Swiss engineer and inventor Otto Schauba, who extended their patents in Europe and the USA [4]. The essence of this composite is the way of coupling (solid, semisolid, with a sliding joint), which is constantly in developing.

1.2 New technical solution

The acoustic qualities depend on a composition and a type of materials [5]. Our choice of technical solutions was based on the need and demand for improved acoustic qualities of wooden buildings. The design of the floor composition was optimized in cooperation with the firms listed at the end of this paper. For the framing of the timber - concrete ceiling was selected the coupling of steel plates with the pressed spines T150-1315 – Fig. 1. The pressing of the steel plates on the wooden beams KVH was performed.

Fig. 1: Detail of coupling of timber and concrete

Fig. 2: Concreting of panels

1.3 Types of ceiling construction

Depending on the production and transport possibilities the ceiling structure is consisted of two panels, size 1.5 × 3.6 m – Fig. 4. The key part consists of two wooden beams KVH profile 140/80 mm rigidly connected with the iron - concrete panel from a concrete type C 20/25 XO reinforced with a steel mesh 100/100/5. On the timber - concrete panel was placed a panel from mineral wool ROCKWOOL STEPROCK HD 4F thickness 50 mm. This was followed by a layer of gypsum boards FERMACELL 2E22 thickness 25 mm joined on a stop. In the stop the plates were bonded with a polyurethane adhesive (the glue applies to 12-hour technology break) and mechanically connected by screwing. The last layer (floor finish) was MEISTER flooring LC 100S.

The floor was dilated around by a STEPROCK strip thickness 12 mm and height 80 mm and properly sealed to suppress lateral noise transmission.

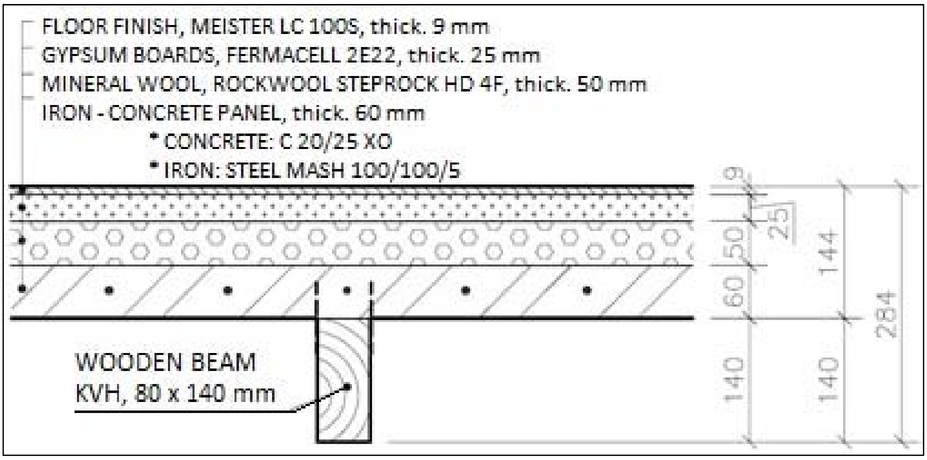


Fig. 3: Types of ceiling construction

Statistical data of the timber – concrete ceiling supporting construction:

– Surface of the plate 10.8 m^2, weight 2400 kg.
– Consumption of timber for the formwork – 0.32 m^3.
– Consumption of concrete C 20/25 X0 – 0.75 m^3.
– Consumption of welded meshes, size of 2000 x 3000 mm with wires 5 × 100 × 100 mm – 3 pcs.
– Wooden glued lamellate beams KVH 80 × 140 × 3600 mm – 4 pcs.
– Connector panels with stamped spines T150-1315 – 40 pcs.

2 ACOUSTIC MEASUREMENTS

Experimental measurements ran in three different ways. In each variant, airborne and impact sound insulation were measured, the total of 6 laboratory measurements were carried out [6].

Airborne sound insulation is a property of a building construction manifested by loss of acoustic power in the transmission of sound through air by a construction. Requirements for sound insulation between rooms and building cladding provides CSN 73 0532. The values for airborne sound insulation should not be less than the required values in the standard, therefore it must be that $R'_w \geq R_w$, the values are measured in decibels (dB).

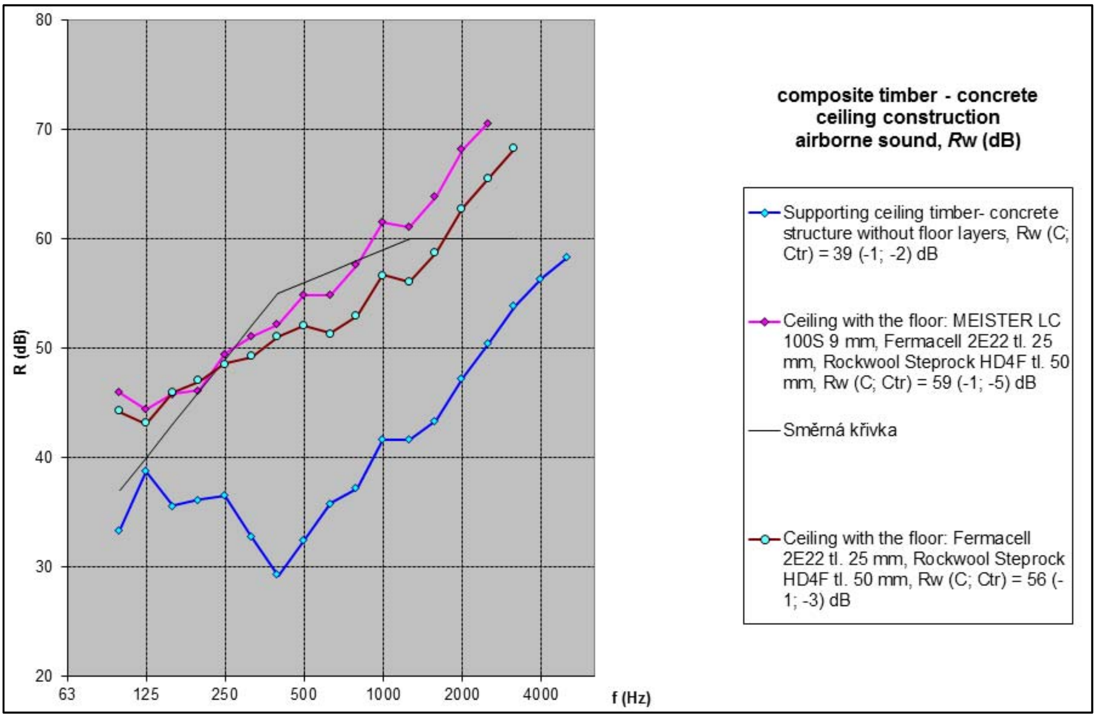
Fig. 4: Panels in the laboratory

Fig. 5: Lower part of the ceiling construction

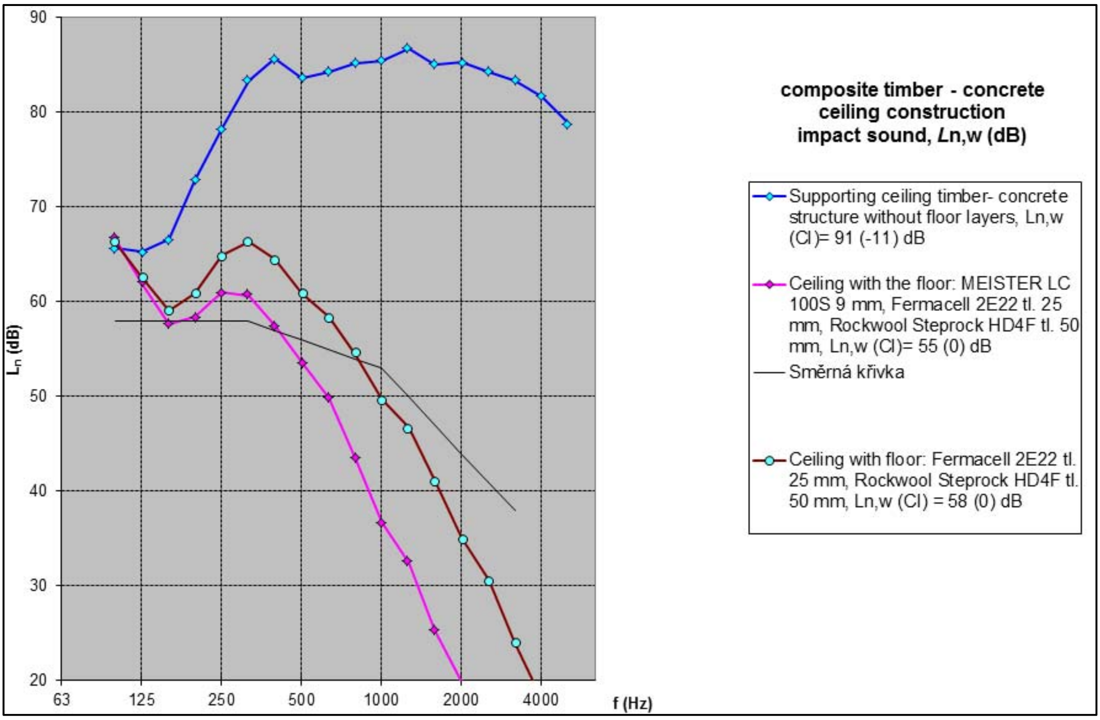
Fig. 6: Positioning of the source of impact noise

Fig. 7: View of the finished floor in the room

Impact sound insulation is defined as a property of a ceiling construction to resist the noise produced by mechanical impacts on the construction (walking, falling objects, etc.). Requirements for impact sound insulation between rooms provides CSN 73 0532. The standardized levels of acoustic impact of sound insulation should not exceed the required values indicated in the standard, therefore it must be that the $L'_{n,w} \leq L_{n,w}$ values are measured in decibels (dB).



Graf 1: Course of values - airborne sound, R_w (dB)



Graf 2: Course of values - impact sound, L_{nw} (dB)

Variants of the solution (measurements):

1. Supporting ceiling timber- concrete structure without floor layers.
2. Supporting ceiling construction with the floor surface including a wear layer – composition, Fig. 3.
3. Supporting ceiling construction with the floor without a wear layer (Fig.3 without flooring).

Table 1: Results of the measurement

Variant	Airborne sound R_w (dB)	Impact sound L_{nw} (dB)
1	39	89
2	59	55
3	56	58

Note: It was determined the "laboratory" values, airborne sound insulation R_w, impact sound insulation $L_{n,w}$. In the laboratory, there are eliminated lateral sound spreading ways.

3 CONCLUSION

The acoustic properties of the newly proposed type of the coupled timber - concrete ceiling were laboratory tested by the experimental measurements. At present, we can see a slight aversion of the Czech producers of wooden buildings to the constructions of this type, because the wet process in the manufacture of concrete is not in accordance with a dry-prefabricated building and it causes an extension of a construction.

It is necessary to perceive the irreplaceable benefits of using composite timber - concrete structures in constructions of wooden buildings. Material with a large surface weight - reinforced concrete positively affects the acoustic qualities of the structure. In conjunction with our proposed structure of the floor (see Fig. 3), we achieved the laboratory value of airborne sound insulation R_w = 59 dB and a level of acoustic pressure of impact sound $L_{n,w}$ = 55 dB and a construction thickness of 144 mm (without the wooden beam, the dimensions of a beam depends on a structural design). The experiment confirmed the potential usefulness of the composite timber - concrete ceiling structures in a multi-storey construction, where other benefits are reflected such as fire resistance and an increase of a torsional consistence of a skeletal supporting structure.

Based on the experiment we can claim that this composite is in terms of acoustics very suitable for use in constructions.

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