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Influence of Mechanical Deformation on Compressive Strength of Open and Closed Cells Resilient Materials

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The resilient materials are used in the floating floors constructions to reduce transmission of vibrations through the floor. The influence of mechanical deformation on compressive strength of two different type materials was examined in this research. Mechanical deformation was performed during compressibity test. Stone and glass wool (open cell material) and elastic polystyrene (closed cell material) were investigated. The research showed that mechanical deformation of resilient materials has different influence on its compressive strength. Open cell resilient materials compressive strength significantly decreased (about 85 %) in comparison with the values of materials, which were not mechanically deformed while closed cell resilient materials compressive strength decreased not so significant (about 14 %) in comparison with the values of materials, which were not mechanically deformed.
Keywords: mechanical deformation, resilient materials, compressive strength.

1. INTRODUCTION

Floating floors is the one of the mostly used floors construction for impact sound insulation in dwellings [1]. This floor construction reduces impact sound transmission from upper room to room below. The basic principle of floating floors is vibration isolation using resilient materials interlayer between upper floor layer (cement creed) and floor base. Different types of floating floors with different resilient materials are used for impact sound insulation [2 – 11]. Mineral wool [12] and elasticized polystyrene [13] are mostly used as resilient interlayer.

The dynamic stiffness and compressibility are the main parameters characterizing resilient materials used as interlayer in floating floor constructions. The recent research [14] showed that mechanical deformation significantly influenced the dynamic stiffness of resilient materials and this influence is positive in the sense of improving impact sound insulation of the floor construction. After this deformation dynamic stiffness significantly decreases. Another important feature of resilient materials used in floating floors construction is-compressive strength. In [1 – 13] it was not found any information about dependence of compressive strength from on mechanical deformation. The other authors [15 – 18], who investigated mechanical properties of mineral wool and polystyrene have presented only data of compression strength and have not investigated how mechanical deformation influences compression strength.

The change of compressive strength of open and closed cells resilient materials after compressibility test was examined in this research. Stone and glass wool (open cell material) and elastic polystyrene (closed cell material) were tested. This research showed that mechanical deformation has negative influence on the compressive strength of resilient materials in the sense of reduction its compressive strength and allowable maximum load of the floor construction.

2. METHODS AND MATERIALS

The two types ("A" and "B") of specimens were used for evaluation of the influence of mechanical deformation on compressive strength. "A" type specimens were affected by the mechanical deformation and "B" type specimens were not affected. The compressive strength of both types of specimens was measured.

Mechanical deformation of resilient materials was performed during compressibility test. Compressibility test was done according EN 12431 standard [19]. The universal test machine Zwick/Roell was used for this test. The sequence of applied load and the load duration on specimens during the test procedure is shown in Fig. 1.

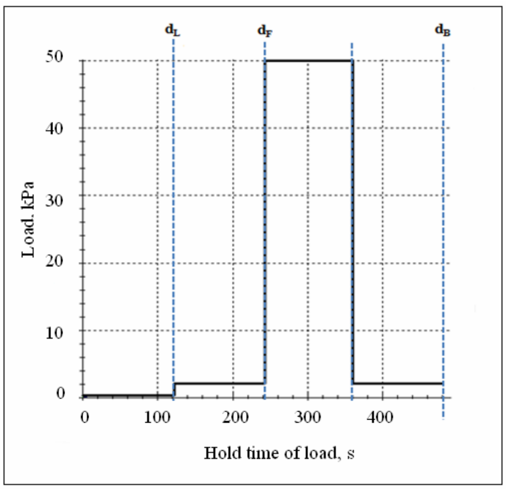

Fig. 1. Scheme of applying of mechanical deformation

The load was increased from 0.25 kPa until 50 kPa and afterwards the compressive strength of "A" type specimens was measured.

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The compressive strength of both type specimens was measured according procedure given in EN 826 standard [20]. The same universal test machine Zwick/Roell for determination of compressive strength was used. The measurement accuracy of the universal test machine is ±1 %.

The compressive strength σ_{10} was measured deforming the specimen up to 10 % of its initial thickness. The compressive strength σ_{10} was calculated according formula:

$$\sigma_{10} = 10^3 \cdot \frac{F_{10}}{A_0}, \text{ (kPa)}, \quad (1)$$

where F_{10} – is the force, required for 10 % deformation of the specimen, N; A_0 – is the initial cross-section area of specimen, mm^2.

Materials from the market of Lithuania were used in this research. Four different types of wool and two different types' of elasticized polystyrene were tested: stone wool of densities 114 kg/m^3, 113 kg/m^3 and 119 kg/m^3 and glass wool of density 96 kg/m^3, polystyrene – 12 kg/m^3 and 18 kg/m^3. Four different thicknesses of resilient materials 20 mm, 30 mm, 40 mm and 50 mm were chosen for this test. The stone wool specimens were tested only of 30 mm thickness (density 114 kg/m^3) and 20 mm and 30 mm thicknesses (density 113 kg/m^3), glass wool 20 mm and 50 mm thicknesses (density 96 kg/m^3).

For determination of compressive strength (200 × 200) mm size specimens were prepared, four specimens of each type and thickness were used in this research.

3. RESULTS AND DISCUSSION

The compressive strength values (average of four specimens) of resilient materials are presented in Figs. 2–5.

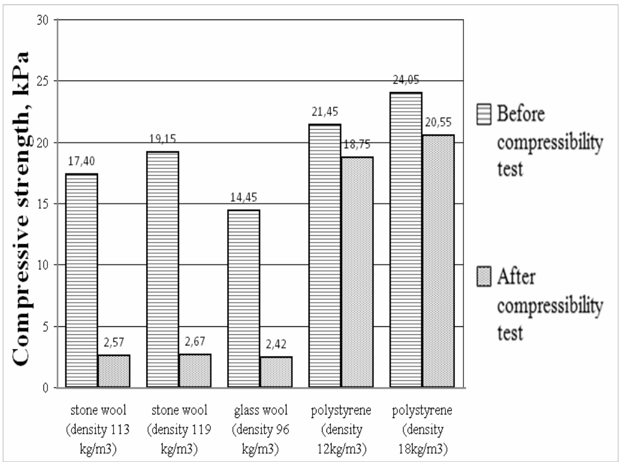

Fig. 2. Comparison of compressive strength values of 20 mm thickness specimens

From Fig. 2 we can see that mechanical deformation has different influence on compressive strength of resilient materials. The decrease of the compressive strength of mineral wool was significant. The strength of stone wool (density 113 kg/m^3 and 119 kg/m^3) decreased by 85 % and 86 % respectively and of the glass wool (density 96 kg/m^3) 83 % comparing with values of not mechanically affected specimens Variation coefficients are 4.43 %, 5.03 % and 4.79 % accordingly of "B" type specimen and 5.79 %, 5.94 % and 5.14 % accordingly of "A" type specimen. But for elasticized polystyrene mechanical deformation influence was not so significant. The strength of elasticized polystyrene (density 12 kg/m^3 and 18 kg/m^3) decreased by 13 % and 14 % respectively comparing with values of not mechanically affected specimens. Variation coefficients are 2.13 % and 1.86 % accordingly of "B" type specimen and 2.45 % and 2.01 % accordingly of "A" type specimen.

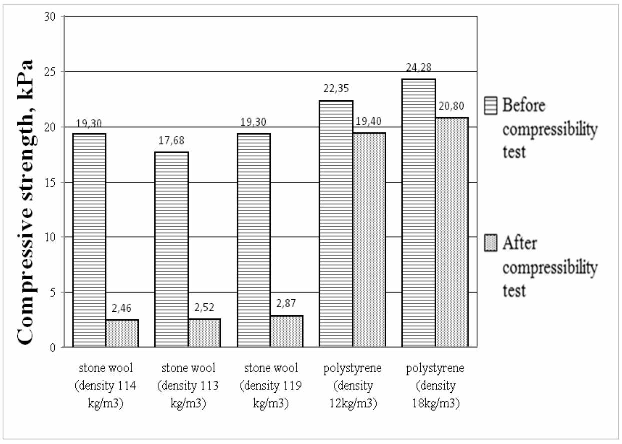

Fig. 3. Comparison of compressive strength values of 30 mm thickness specimens

From Fig. 3 we can see that decrease of compressive strength of mineral wool was significant. The strength of stone wool (density 114 kg/m^3, 113 kg/m^3 and 119 kg/m^3) decreased by 87 %, 86 % and 85 % appropriately comparing with values of not mechanically affected specimens. Variation coefficients are 4.57 %, 4.86 % and 4.94 % accordingly of "B" type specimen and 4.97 %, 5.14 % and 5.21 % accordingly of "A" type specimen. For elasticized polystyrene mechanical deformation influence was not so significant. The strength of elasticized polystyrene (density 12 kg/m^3 and 18 kg/m^3) decreased by 13 % and 14 % accordingly comparing with values of not mechanically affected specimens. Variation coefficients are 2.31 % and 2.03 % accordingly of "B" type specimen and 2.63 % and 2.40 % accordingly of "A" type specimen.

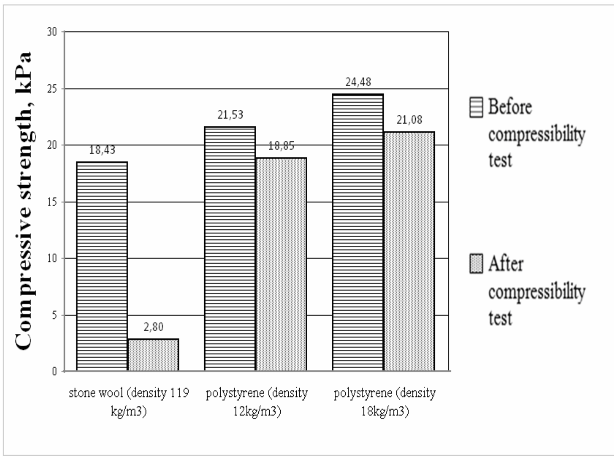

Fig. 4. Comparison of compressive strength values of 40 mm thickness specimens

From Fig. 4 we can see that mechanical deformation has different influence on compressive strength of mineral wool and polystyrene. The compressive strength of stone wool (density 119 kg/m^3) decreased by 85 % comparing with values of not mechanically affected specimen.

Variation coefficient is 5.23 % of "B" type specimen and 5.48 % of "A" type specimen. But for elasticized polystyrene mechanical deformation influence was not so significant. The strength of elasticized polystyrene (density 12 kg/m^3 and 18 kg/m^3) decreased by 12 % and 14 % accordingly after mechanical deformation. Variation coefficients are 2.19 % and 1.94 % accordingly of "B" type specimen and 2.35 % and 2.24 % accordingly of "A" type specimen.

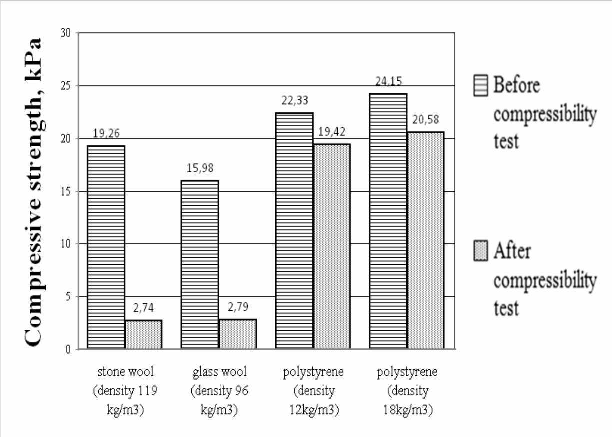

Fig. 5. Comparison of compressive strength values of 50 mm thickness specimens

From Fig. 5 we can see that mechanical deformation has different affect on the compressive strength of resilient materials. The decrease of compressive strength of mineral wool was significant. The strength of stone wool (density 119 kg/m^3) decreased by 86 % and of the glass wool (density 96 kg/m^3) 83 % comparing with values of the specimens with no mechanical deformation. Variation coefficients are 5.01 % and 4.67 % accordingly of "B" type specimen and 5.32 % and 5.09 % accordingly of "A" type specimen.The strength of elasticized polystyrene (density 12 kg/m^3 and 18 kg/m^3) decreased by 13 % and 14 % accordingly in comparison with values of not deformed specimens. Variation coefficients are 2.07 % and 1.89 % accordingly of "B" type specimen and 2.28 % and 2.14 % accordingly of "A" type specimen.

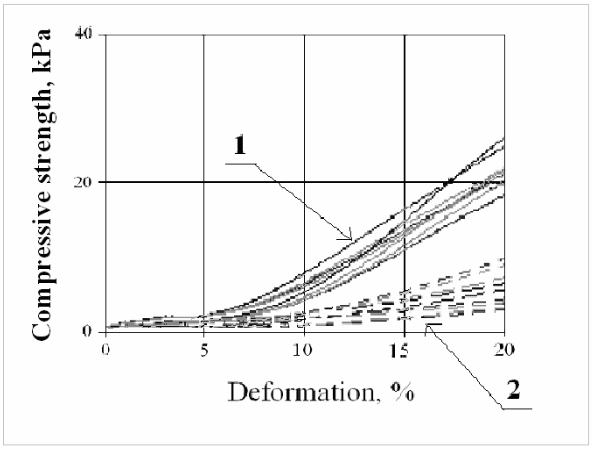

Fig. 6. Compressive strength curves comparison of wool: 1 – "A" type specimen; 2 – "B" type specimen

The dependence of the compressive strength (of all specimen of wool) on deformation degree (%) of the "A" (continuous line) and the "B" (dotted line) type specimens of the open cell materials (stone and glass wool) are shown in Fig. 6. From the graph we can see that compressive strength of both types ("A" and "B") specimens until 5 % of deformation is similar and significantly differs with increment of deformation.

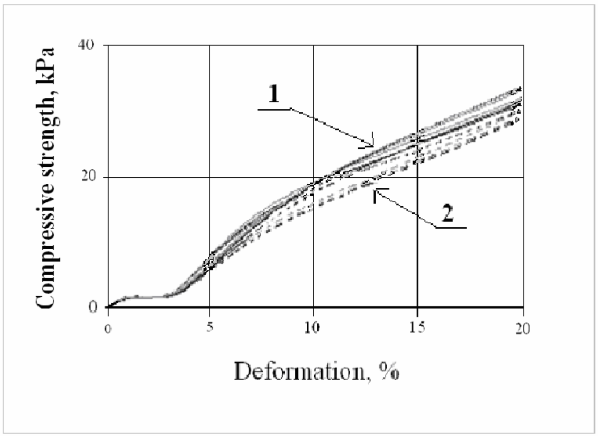

Fig. 7. Compressive strength curves comparison of polystyrene: 1 – "A" type specimen; 2 – "B" type specimen

The dependence of the compressive strength (of all specimen of polystyrene) from deformation degree (%) of the "A" (continuous line) and the "B" (dotted line) type specimens of the closed cell materials (elasticized polystyrene) are shown in Fig. 7. From the graph we can see that dependences of the compressive strength of both types ("A" and "B") from specimen deformation are very similar.

This different dependence between mechanical deformation and compressive strength of mineral wool and elasticized polystyrene could be explained by different structure of these materials. The structure of mineral wool deforms more than structure of polystyrene and materials more losses its strength. It should be noted that although the mineral wool significantly looses strength it could still be used in floating floors constructions because its strength is still higher than nominal load (2 kPa) of floors and furniture.

From those different decrements of compressive strength of mineral wool and polystyrene we can see that mineral wool very easily losses its strength and mineral wool skeleton deforms more than polystyrene skeleton. From the results we can do conclusion that it is better to use polystyrene in floating floors constructions than mineral wool.

4. CONCLUSIONS

1. Compressibility strength values of the open cell resilient materials (stone and glass wool) after compressibility test decreased average by 85 % comparing with values of specimens which were not mechanically affected. This show that fiber structure materials purely resist to mechanical influence and quickly lose their strengths.
2. Compressibility strength values of the closed cell resilient materials (elasticized polystyrene) after

compressibility test decreased average by 14 % comparing with values of specimens which were not mechanically affected. This show that materials with the grating structure better resists to mechanical deformation and did not lose their strengths.

3. The difference between the mineral wool (open cells material) and elasticized polystyrene (closed cells material) compressive strength values lie in the range of 14 % – 38 % of not mechanically affected specimens and lie in the range 84 % – 86 % of mechanically affected specimens.
4. Although the mechanical deformation has positive influence on dynamic stiffness values but it has negative influence on compressibility strength of resilient materials.

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