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INFLUENCE OF MOISTURE TO MECHANICAL PROPERTIES OF MATERIALS

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Abstract: *This paper deals with the influence of moisture in determining the mechanical properties (dynamic modulus of elasticity) of porous building materials using nondestructive impulse excitation method. The gypsum specimens of dimensions 40×40×160 mm were dried and during their drying the basic natural frequencies of longitudinal vibration were measured in different time instants. Based on these frequencies, the dynamic moduli of elasticity were determined and their dependence on the moisture content of the gypsum specimens was evaluated.*

Keywords: ***Dynamic modulus, impulse excitation method.***

1. Introduction

The process of solid structure evolution relates with hardening of gypsum paste. As basic mechanical properties for characterization of gypsum properties are usually used compressive and bending strength, other mechanical gypsum properties, as modulus of elasticity, are tested less often. The strength characteristics correspond mainly with physical properties of hardened gypsum as total open porosity, arrangement of gypsum crystals, and type of used gypsum binder. On the other hand, properties of gypsum depend on conditions where the hardened gypsum is placed (Kuechler, 2002). Temperature and moisture (relative humidity but especially a liquid water content) prejudice mechanical properties of gypsum (Hájková, 2010).

The main aim of this research is to determine dependence of hardened gypsum mechanical properties on moisture content of tested specimens, respectively the effect of drying out of free water after hardening of gypsum pastes, which are placed at laboratory conditions with constant temperature 25 °C and relative humidity 50 %.

For the determination of dynamic modulus of elasticity, non-destructive method was used currently for a short preparation time and mainly for the matter of fact that it is possible to test one sample several times.

2. Materials and specimens

Tested specimens were prepared according to the Czech standard ČSN 72 23 01 Gypsum binders. Specimens with dimensions 40×40×160 mm were made from the “Grey calcined gypsum” which is produced by company Gypstrend. This gypsum binder is β-gypsum (β-calcium sulphate hemihydrate) and is calcined from two different calcium sulphate dihydrates (naturally gypsum and gypsum from a chemistry industry, ratio is 1:1). According to the ČSN 72 23 01 (1978), the Grey gypsum is classified as G2 BIII. Mark G2 means that compressive strength after two hours is at least 2 MPa, the gypsum is with normal-setting (B) determined using the Vicat device and partially corresponds to testing of cement materials. The last criterion is the fineness of grinding, where the tested gypsum is medium ground and the fineness of grinding is marked II in our case.

The tested specimens were prepared from a gypsum binder with a mass of 1.0 kg and water, where amount of water corresponded with the water/gypsum ratio 0.71. Gypsum was poured inside a beaker with water for 20 seconds. While it was poured and for 60 seconds after the whole amount of gypsum

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had been poured, the mixture was intensively stirred with a manual stirrer until a uniform paste was obtained. Then, the paste was poured inside the mould so that all three sections would be simultaneously filled. To remove air from a gypsum paste, the mould was shook 5 times after filling using a standard shake (the mould is lifted at its face side to a height of 10 mm and dropped). As soon as the paste started to set, its surface was cut off in the direction perpendicular to the bar surface. After 15 minutes, i.e. after the finish of setting, the mould was removed and the samples were marked and placed in the test room at an average temperature of 25 °C and a relative humidity of 50 %.

3. Impulse excitation method

The test procedure was performed in accordance with ASTM C215 (2008). At first, the dimensions of all specimens were measured and the mass were weighed. Then the basic natural frequency of longitudinal vibration of the tested specimens was measured using impulse excitation method.

Test specimen was supported in the middle of its longest dimension - the nodal line of the first longitudinal shape of natural vibration. Vibration has been energized by striking shock hammer on one side of the sample and the response was measured using acceleration transducer Bruel&Kjaer of Type 4519-003 on the opposite side (Fig. 1). The measured excitation force and the response, in our case acceleration, were transformed from time domain to the frequency domain using Fast Fourier Transform (FFT) (Tůma, 1997). The fundamental natural frequency of longitudinal vibration f_L [Hz] was determined as the basic resonant frequency of the Frequency Response Function (FRF). The dynamic modulus of elasticity E_d can be determined using the relation:

$$E_d = \frac{4lmf_L^{\ 2}}{bt} \qquad (1)$$

where l [m] is the length of the specimen, m [kg] is the mass of the specimen, f_L [Hz] is the fundamental natural frequency of the longitudinal vibration of the specimen, b [m] is the width of the specimen and t [m] is the thickness of the specimen.

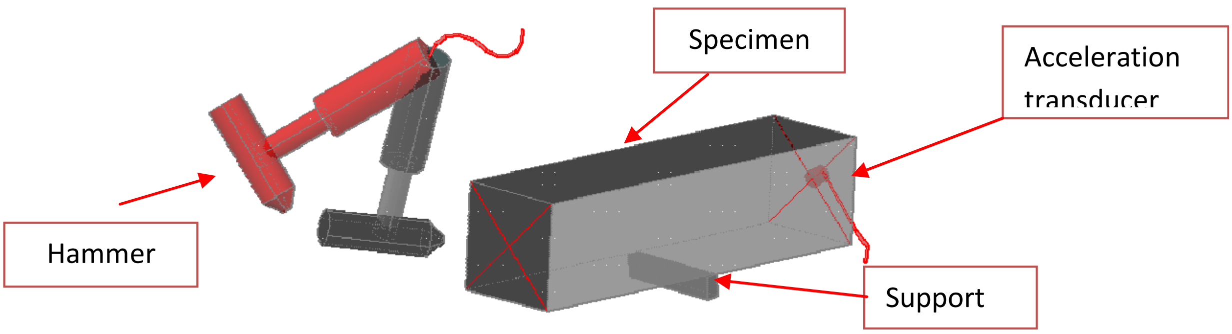

Fig. 1: Measurement of the natural frequency of longitudinal vibration.

4. Measurement results

The investigation was focused on two types of moisture content in the gypsum specimens: uniformly and non-uniformly distributed moisture.

In the first part of the experiment, the 70 days old specimens were put to the water bath for 10 days. After water saturation of the specimens, they were removed and put to the laboratory conditions (temperature 25 °C and relative humidity 50 %). During their drying, they were tested using impulse excitation method in different time instants with different moisture content. The Fig. 2 shows the dependence of the basic natural frequency of the tested specimens on their weight, respectively on their moisture content. The Fig. 3 shows the dependence of the dynamic modulus of elasticity of the tested specimens on their weight, respectively on their moisture content.

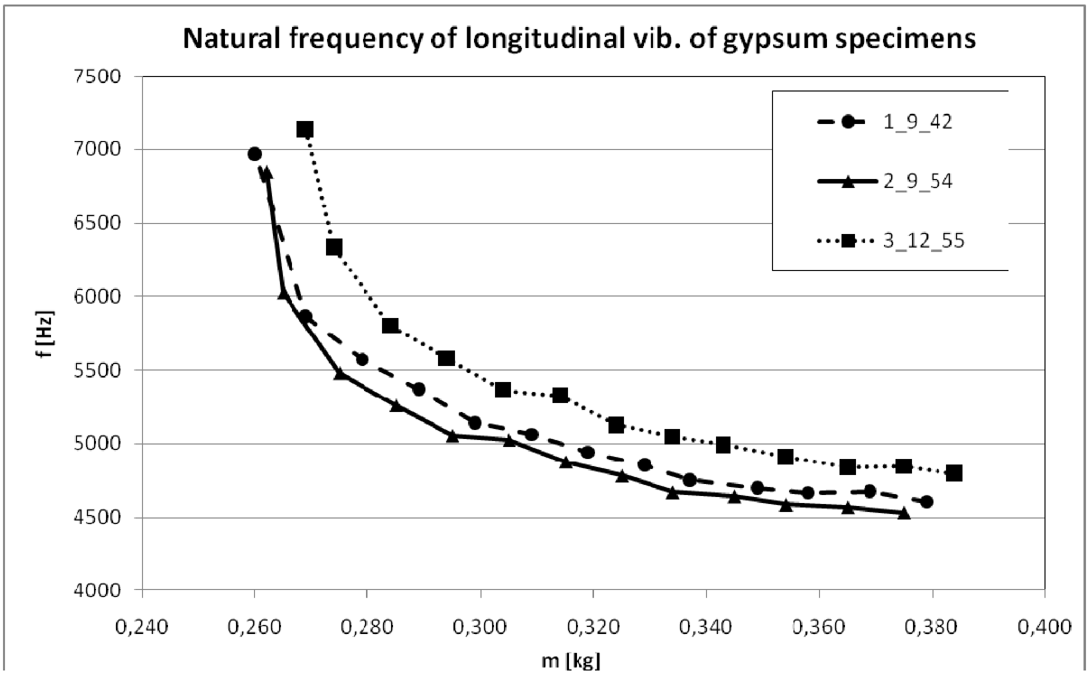

Fig. 2: Dependence of the 1st natural frequency of the tested specimens on their moisture content.

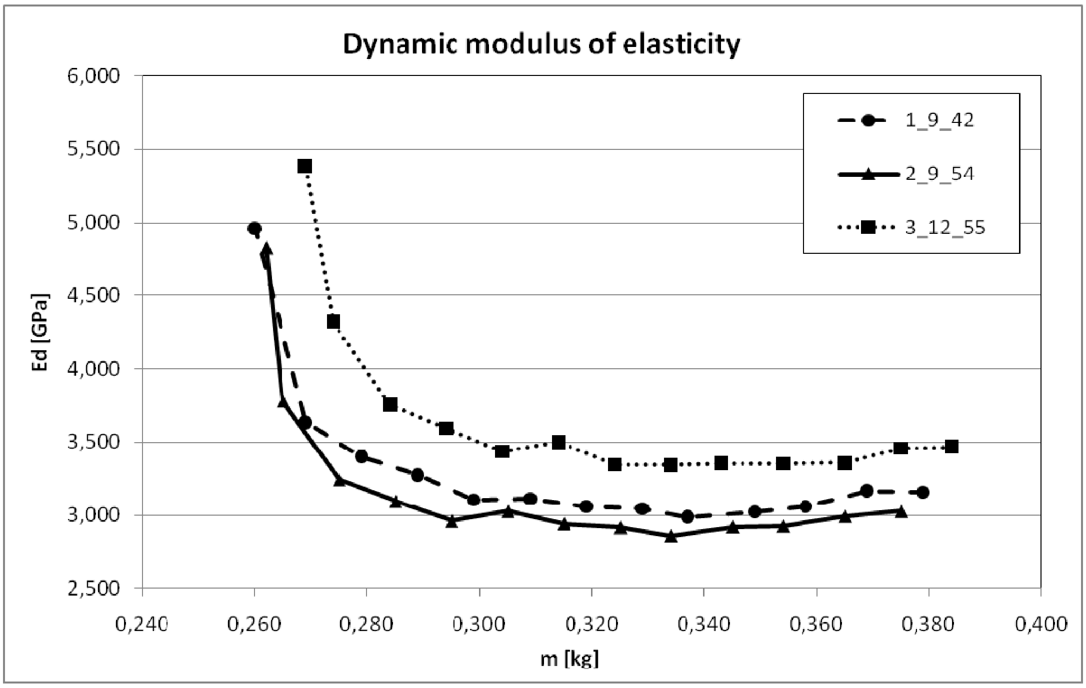

Fig. 3: Dependence of the dynamic modulus of elasticity of the specimens on their moisture content.

In the second part of the experiment, the dried specimens were rolled around its longest axis in the water bath to be the moisture non-uniformly distributed in the specimen. The whole process of dipping lasted approximately 10 s. The central part of the specimen was dry and edges were wet. The specimens were tested twice, in dried state and in the wet state. The comparison of these two states is done in the Fig. 4.

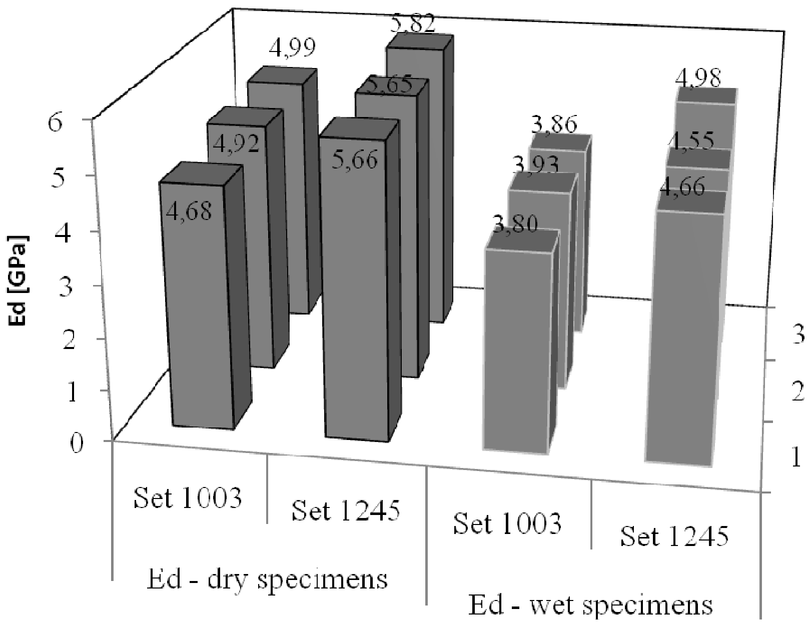

Fig. 4: The influence of the non-uniformly distributed moisture to the dynamic modulus of elasticity.

5. Conclusions

The paper presents the dependence of the dynamic modulus of elasticity on the moisture content of the gypsum specimens. From the measured data it is visible that dynamic modulus of elasticity increases especially at the end of the drying of the gypsum specimens (Fig. 3). There can be also seen that specimens made with same technology, with same materials and with the same water/gypsum ratio have different moduli of elasticity (Fig. 3, Fig. 4). Also the small amount of non-uniformly distributed water in the specimens has big influence to the values of dynamic modulus of elasticity, for the set 1003 the decrease is approximately 17% and for the set 1245 it is about 20%.

Acknowledgement

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