Evolution of mechanical properties of gypsum in time

P. Padevět, P. Tesárek, T. Plachý

***Abstract*—** The paper presents time dependent changes of mechanical properties (Young's Modulus, strength and creep) of grey calcined gypsum. These material properties were measured in different time instants during hardening on the gypsum specimens of dimensions 40 x 40 x 160 mm using nondestructive and destructive methods. For the determination of Dynamic Young's Modulus, the nondestructive impulse excitation method was used. The destructive methods were used for bending strength and compression strength. At the end of the paper, the time evaluation of grey calcined gypsum mechanical properties is presented and discussed.

***Keywords*—** Calcined gypsum, mechanical properties, destructive methods, creep of gypsum, shrinkage.

I. Introduction

Hydration is basic process how made from gypsum (calcium sulphate hemihydrate $CaSO_4 \cdot ½H_2O$) the hardened gypsum (calcium sulphate dihydrate $CaSO_4 \cdot 2H_2O$). Hydration, it is typical effect for hydraulic binders. During this process, hydration heat is generated and the volume increases – expansion. Hydration is set off after mixing water with gypsum.

The process of gypsum hydration and setting relies on multiple factors:

- the temperature during preparing of the gypsum paste,
- the water-gypsum ratio,
- the method of gypsum mixing,
- the mixing intensity and time,
- the fineness of grinding,
- the purity of gypsum binder [1].

The water-gypsum ratio has an influence on the basic physical characteristics of hardened gypsum, such as its volume density, total open porosity and other related characteristics like its moisture, mechanical, thermal and sound insulation properties. The theoretical water-gypsum ratio necessary for the hydration of calcium sulphate hemihydrate into calcium sulphate dihydrate is 0.187. Additional water, in a so-called over-stoicheiometric quantity, is necessary for the processing of the hardening gypsum paste. Depending on the value of the water-gypsum ratio, the gypsum is made from a gypsum paste by pressing, vibrating or casting [2].

The purity of gypsum binder corresponds with a relationship between different phases of calcium sulphate-water system; it means a proportion between anhydrite, hemihydrate and dihydrate of calcium suplphate and impurities which every gypsum binder contains [3].

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 Young's Modulus, are tested less often [4]. 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 [5]. On the other hand, properties of gypsum depend on conditions where the hardened gypsum is placed. Temperature and moisture (relative humidity but especially a liquid water content) prejudice mechanical properties of gypsum. In a first phase of gypsum hydration, time dependence is observed.

Hurmanic and Roggendorf [6] made comparisons between natural gypsum and flue gas desulfurization gypsum. They also compared their mechanical and physical properties: hardness by Vickers, abrasive power, abrasive effect, compressive strength, the size and distribution of pores. These results showed that the artificially produced material had better characteristics than the natural material. More research projects of this type were carried out with the main objective of proving the suitability of artificially produced gypsum, or hardened gypsum respectively. Mechanical properties (compressive strength, tensile bending strength, Young's modulus, Poisson's ratio) are known from the following publications: Klein and Ruffer [7], Ghozh et al., [9]. Verbeek and du Plessis [4] measured the tensile bending strength and volume density of phosphogypsum with various gypsum-cement ratios. Tazawa [10] presents the tensile bending strength, compressive strength and the modulus of elasticity for three types of α- and β-gypsum. Acker [11] compares

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different methods of determining the mechanical properties (tensile bending strength and compressive strength) on gypsum wallboard. Singh and Garg [12] measured compressive strength in relation to pH values of gypsum. In the area of gypsum applied by dentists, Li et at. carry on experiments with cold pressing of gypsum (300 MPa for a time of 10 minutes and successive placement of samples in a water environment for one hour). The samples treated in this way reached strength values three times higher than the reference samples.

From presented results is visible clear that the mechanical characteristics (above all strength) of gypsum after its hydration rely on the above-mentioned conditions applied during the development of its own solid structure, but also on the successive placement of the unit (for example, the difference between a placement in a water environment and in the air etc.

The strength values of hardened gypsum significantly depend on the water-gypsum ratio, which commonly takes the value for pouring in the interval of 0.6 to 0.8.

Current standards as Czech standard ČSN 72 23 01 Gypsum binders – Classification, general technical specifications and test methods (1979) specify tested compressive strength after two hours (after gypsum was added into water) [6].

One of the important properties of hardened gypsum is the fact, that it is possible take out a gypsum samples from the mould twenty minutes after mixing the gypsum with water. After this time, the gypsum sample (with standardized normal consistence and without admixtures) is self-supporting; it is able to be manipulated and loaded.

After two hours (standard time), the compressive strength of the gypsum samples is approximately 1/5 of maximal compressive strength, which is developed after 28, respectively 14, days after mixing. Time 28 days is standardized for current building materials as plaster, cement or concrete. The laboratory conditions with relative humidity 50 % and temperature 20 °C are standard. In these conditions, gypsum samples are placed [6]. From conditions of a sample deposit, it is clear that the weight of the samples will decline in time. Question is how moisture affects the strength characteristics of gypsum samples during first days.

Destructive methods, as their name predicates, are possible to be applied on tested specimens only once. Main problem is too many numbers of samples for a description of one problem, e.g. determination of compressive strength on moisture content of samples. A second problem is time, time-consuming preparation before and during own measurements. [7], [8].

II. Materials and Preparing of Specimens

Tested specimens were prepared according to the Czech standard ČSN 72 23 01 Gypsum binders [16]. Samples 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).

Standard ČSN 72 23 01 – Gypsum binders was used for classification of grey calcined gypsum. Fig. 1 shows a dependence of a spillage on a water-gypsum ratio. The water-gypsum ratio corresponded with the spillage 140 mm, this spillage achieved workability of a gypsum mixture from the point of view of the technological possibilities as e.g. casting. Water gypsum ratio 0.81 corresponded with standard spillage 180 mm.

Figure 2 shows the results for typical samples from grey calcined gypsum with water-gypsum ratio 0.71. According to the results of this test, the grey gypsum is normally cured binder in our case, which corresponds to the signed setting time, which is denoted as B (beginning of setting 7.0 minutes and end of setting 10.0 minutes.)

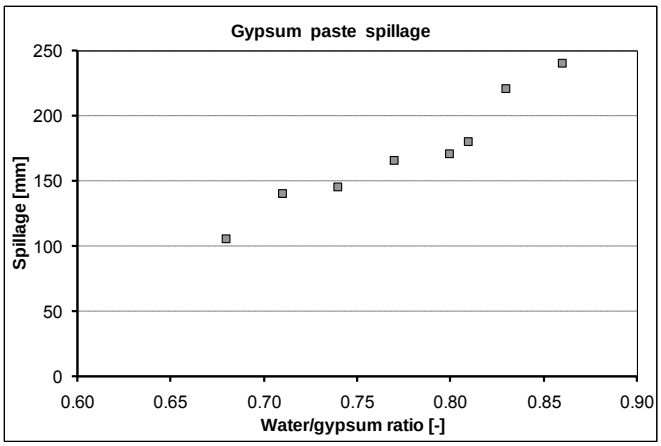


Fig. 1: Dependence of the gypsum paste spillage on a water/gypsum ratio

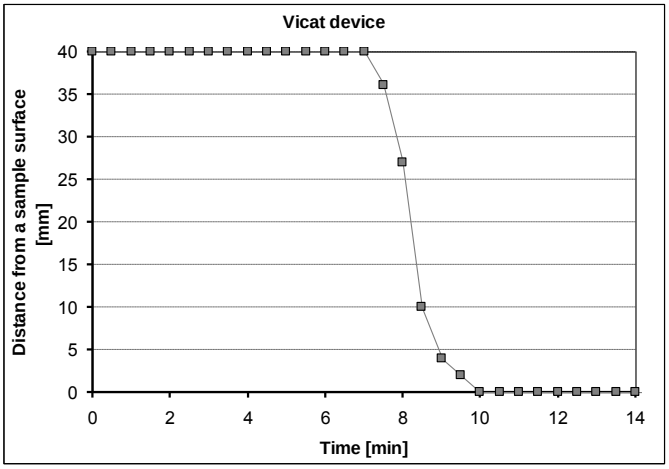


Fig. 2: Results from the Vicat device

Results from the classification according to ČSN 72 2301 are shown in the Table I. According to the ČSN 72 23 01, 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.

Criterion for tested samples is standard water/gypsum ratio, which corresponds to the gypsum paste with normal consistence with spillage 180 ± 5 mm. This term satisfies the tested gypsum samples water gypsum ratio 0.81 (Fig. 2). 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. Used water-gypsum ratio was 0.71 and corresponded with normal consistence of gypsum paste after standard ČSN 722301.

TABLE I
RESULTS OF CLASIFICATION OF GREY CALCINED GYPSUM ACCORDING TO CSN 722301

	Compressive strength (2 hours) [MPa]	Beginning of setting [minutes]	End of setting [minutes]	Residue on a sieve 0,2 mm [%]
Measured values	2.1	7	10	1.9
Limit values of ČSN	Minimum 2	6	30	2
Classification according to ČSN	G-2	B		II

Table II shows basic material properties of grey calcined gypsum as bulk density, density of matrix, thermal conductivity and volumetric heat capacity measured at laboratory conditions with temperatures 25 °C and relative humidity 50 %, water vapor diffusion resistance factor determined using cup method without temperature gradient (with two different conditions with 5 and 50 % of relative humidity a apparent moisture diffusivity of water), for more information see [22].

TABLE II
BASIC MATERIAL PROPERTIES OF SPECIMENS OF GREY CALCINED GYPSUM

Properties	Unit	Value	Variability
Bulk density	$kg \cdot m^{-3}$	1130	± 8 %
Density of matrix	$kg \cdot m^{-3}$	2090	± 9 %
Thermal conductivity (25°C, 50 % R.H.)	$W \cdot m^{-1} \cdot K^{-1}$	0.338	± 9 %
Volumetric heat capacity (25°C, 50 % R.H.)	$10^6 J \cdot m^{-3} \cdot K^{-1}$	0.149	± 12 %
Water vapor diffusion resistance factor (5/50 % R.H.)	-	19	± 15 %
Apparent moisture diffusivity of water	$10^{-7} m^2 \cdot s^{-1}$	2.96	± 7 %

The tested samples 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 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 %.

III. Nondestructive and Destructive Methods

The following characteristics were determined using consequently described destructive methods:

- bending strength
- compressive strength
- Young's Modulus

Before starting the destructive tests, the specimens were tested using nondestructive method - the impulse excitation method for Dynamic Young's Modulus determination of the gypsum specimens. This method is based on measuring the fundamental resonant frequencies [19], [20]. The test arrangement was done for longitudinal vibration (Fig. 3).

Fig. 3: The test arrangement for measuring the fundamental longitudinal resonant frequency of the gypsum specimen

The specimen was supported in the middle of its span (Fig. 3), the fundamental longitudinal nodal position. The acceleration transducer Bruel&Kjaer of Type 4519-003 was placed at the centre of one of the end faces of the specimen (Fig. 3- the left end face). The end face of the specimen opposite to the face, where the transducer was located, was struck by the impact hammer Bruel&Kjaer of Type 8206. Both signals, the excitation force and the acceleration, were recorded and transformed using Fast Fourier Transform (FFT) to the frequency domain and the Frequency Response Function

(FRF) were evaluated from these signals using the vibration control station Bruel&Kjaer Front-end 3560-B-120 and program PULSE 14.0. The test was repeated five times for each specimen and resultant readings were averaged. From an averaged FRF, the fundamental longitudinal resonant frequency was determined for each specimen. Based on the equation for longitudinal vibration of the beam with continuously distributed mass with free-free boundary condition, the Dynamic Young's Modulus can be determined using the relation

$$E = \frac{4lmf^2}{bt}, \qquad (1)$$

where:
l is the length of the specimen,
m is the mass of the specimen,
f is the fundamental longitudinal resonant frequency of the specimen,
b is the width of the specimen,
t is the thickness of the specimen.

The compressive strength was tested on six sample halves, obtained after the bending test, which was finished at first. The samples were placed between two steel plates (with dimensions 40×50 mm) in such way that the lateral edges, which adjoined the longitudinal mould walls during the sample preparation, would be situated on the plate planes. This restricted the effect of the geometry imperfections on the sample surfaces, which had been cut off. The test itself was made in compliance with the corresponding standard procedures. A typical output of the compression test is stress-strain diagram.

In the second case, cylindrical specimens were used for creep tests. Measurement of creep or shrinkage of homogenous material is accompanying by limitations in size of specimens. The length of specimens for testing gypsum creep is depended on the size of gauges. By the optoelectronic probe it is possible to achieve good results in measuring the creep. Optoelectronic probes are used for measuring of deformation because of their high sensitivity. Their sensitivity is 0.2 μm.

Cylindrical specimens are made in the plastic moulds. Lengths of specimen made in the moulds were between 90 and 100 mm. Specimens with the length of 70mm were cut from the origin length, for tests in creep (Fig. 4). Diameter of all specimens in the moulds was 10 mm. Area for application of load is 78 mm^2.

Strength of hardened gypsum is influenced by type of ground gypsum, fineness of grinding, additives, etc.

The same specimens are used for the creep tests and compression tests.

All specimens for the creep tests were placed in ordinary laboratory environment before testing, where temperature was 20 °C and relative humidity 50 %.

Fig. 4: Specimens prepared for creep tests.

IV. Instrumentation of the Tests

Measuring of the material properties [3] was realized in the MTS Alliance RT 30 tensile testing machine, with the range 30 kN. The three-point bending test was realized with distance of the supports 120 mm (Fig. 5). The signals like time, load, and deformation of whole specimen were recorded to the PC. The tensile bending strength was calculated using the standard evaluation procedure as the average of three values. The distance of supports, load, dimensions of cross-section are necessary parameters for evaluation procedure.

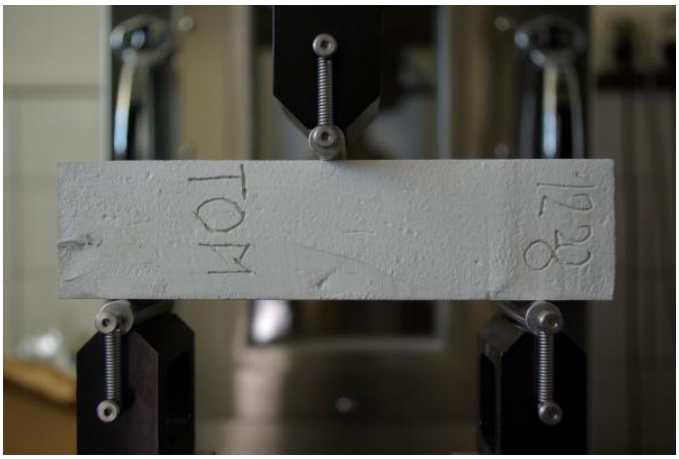


Fig. 5: Specimen in three-point bending test.

For evaluation of the compression test was necessary to record signals like load and strain to the PC. Rate of test was defined before its realization. Values of compression strength were calculated from these signals, which corresponded with time of testing. The goal of measuring was to observe the compression strength evolution.

Stress, which was calculated from load and loading area, and measured strain were used for evaluation of stress-strain diagram. The Young's Modulus of Elasticity was calculated from the stress-strain curve.

Lever mechanism (Fig. 6) [13], equipment for creep measuring and shrinkage of homogenous materials was used

for gray gypsum, too. Stationary load was applied to the specimen. A size of the applied load depends on the weight of a plumb and location of a plumb at the lever. The measuring of deformation is realized by three optoelectronic probes. The length of deformation is whole length of a specimen, which was placed in the lever mechanism. Axial deformations were measured by the gauges. The average deformation was calculated after termination of measuring.

Specimens with diameter 10 mm were used in executed experiments.. The applied loads were approximately 74N for the first sets of specimens. The second set of specimens was loaded by force 116 N. Force 74N corresponds with the weight of equipment above the specimen. The loading of specimens were constant for whole period of measuring, which was 37 days.

At first, the specimens were placed into the lever mechanism and then the systems were loaded by plumbs. Measuring the deformation started after placing the specimens into the lever mechanism. The plumbs were taken off before finishing the measurement, as it can be seen in Fig. 10 (unloading part of the graph). Then, all specimens were taken out of lever mechanisms and prepared for compression tests.

In compression tests were checked the material properties of hardened gypsum.

Fig.6: Lever mechanism – device for testing creep of homogenous materials.

The Modulus of Elasticity and compression strength was computed from data of measuring. Young's Modulus of Elasticity was calculated like a secant, linking the start and value at stress-strain curve which correspond to the 1/3 of the strength.

One extensometer applied on surface of cylindrical specimen, with measurement length 25 mm, was used for measuring of strain.

V. Nondestructive Methods - Results

The time dependent changes of Dynamic Young's Modulus were monitored during tests. The first five hours after preparation of specimens, they were tested approximately every 20 minutes. After five hours, the specimens were tested daily and after five days, they were tested after 7 days and 14 days. At each test time, the same six specimens were tested using impulse excitation method and time dependent changes of the Dynamic Young's Modulus were monitored. Three more specimens were tested using the same non-destructive method at each test time and then these specimens were tested using destructive methods (e.g. bending tests, compression tests). The dimensions and weight of every tested specimen were measured before starting each testing.

The results of Dynamic Young's Modulus of chosen six specimens in dependence on weight of the specimens are visible in Fig. 7. Fig. 8 shows the time dependent changes of Dynamic Young's Modulus of chosen six specimens. After the 7th day the value of Dynamic Young's Modulus has not changed significantly.

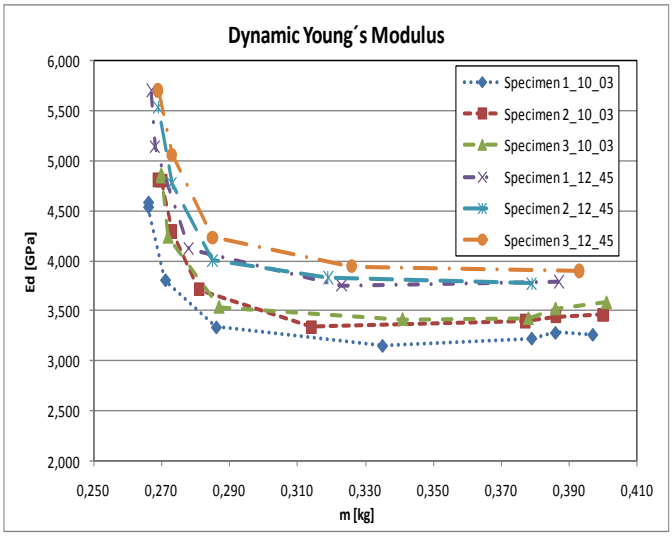


Fig.7: The changes of Dynamic Young's Modulus of chosen six specimens in dependence on weight of the specimens

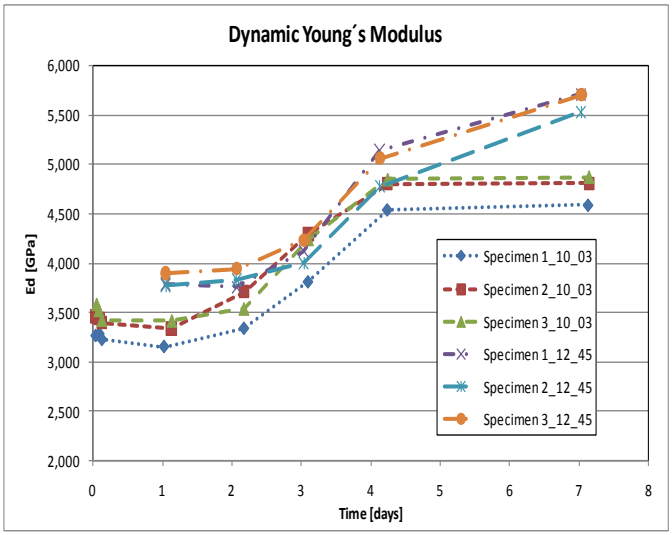


Fig.8: The time dependent changes of Dynamic Young's Modulus of chosen six specimens

VI. Destructive Methods - Results

The specimens were tested from the 1st to the 6th month of their hardening by destructive methods. At first, the specimens were tested in three point bending test. In all sets (the moment of testing), three specimens were tested in the measuring equipment. Compression tests were realized using the fragments from bending tests. The results from three-point bending tests are displayed in Fig. 9.

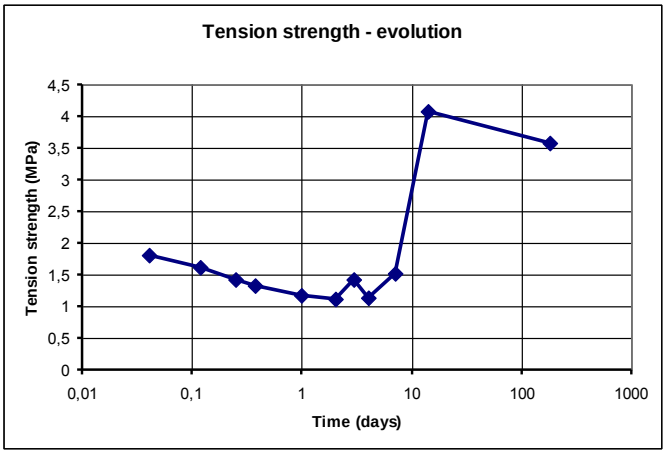


Fig.9: Tension strength and its evolution in time.

It is possible to see in the graph decreasing trend during the first 3 days. The tension strength quickly increased between the 5th and the 14th day. After the 14th day, the values of tension strength stabilized at values in the range from 3.6 MPa to 4.1 MPa. A rapid increasing trend of tension strength is interesting to compare with evolution of the weight of specimens (Fig. 10).

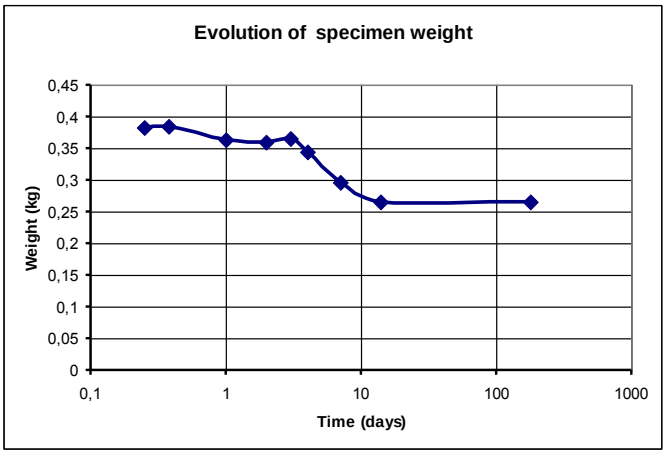


Fig.10: Evolution of the specimen weight in time.

Between the 5th and the 14th day specimens quickly dry out. Tension and compression strength increased (Fig. 11) in the identical time. The results of compression and tension testing are summarized in the Table III. Strengths are supplemented by standard deviation of sets of data. Measurement in the time instant 1hour and 30minutes after mixing water and gypsum was not realized.

TABLE III
COMPRESSION AND TENSION STRENGTH FROM DESTRUCTIVE TESTING

Time (days)	Compression strength (MPa)	Standard deviation	Tension strength (MPa)	Standard deviation
0.041	3.02	0.526	1.81	0.101
0.0625	3.65	0.088	-	-
0.125	3.01	0.052	1.61	0.122
0.25	2.31	0.348	1.43	0.085
0.375	2.21	0.042	1.32	0.030
1	1.86	0.225	1.17	0.040
2	1.94	0.141	1.12	0.044
3	2.63	0.103	1.42	0.128
4	2.18	0.065	1.13	0.057
7	3.47	0.752	1.51	0.109
14	9.42	0.321	4.07	0.449
180	9.62	0.685	3.58	0.354

Compression strength was stabilized between 9.42 MPa and 9.62 MPa in age from the 14th to the 180th day. From the 5th day the compression strength steeply increased to 9.42 MPa at the 14th day. Compression strength decreased in the first days like tension strength (Fig. 10 and Fig. 11).

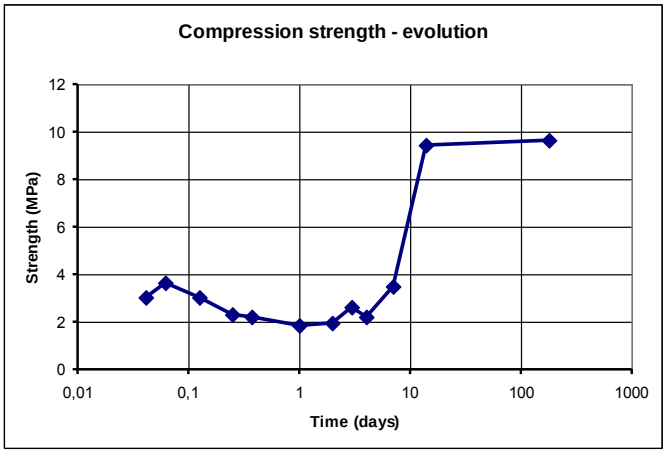


Fig.11: Compression strength and its evolution in time.

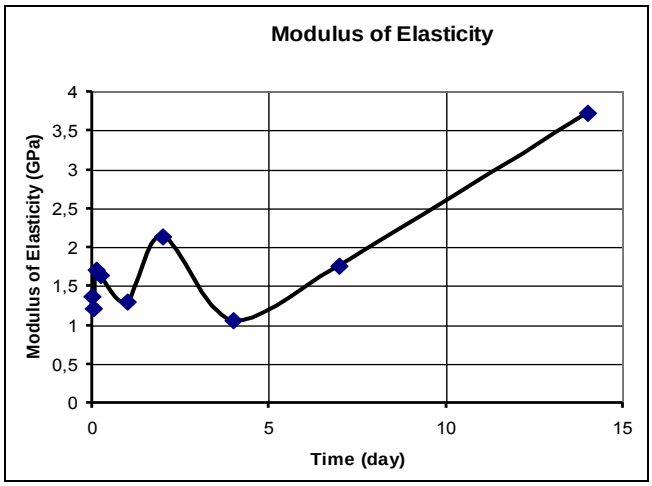


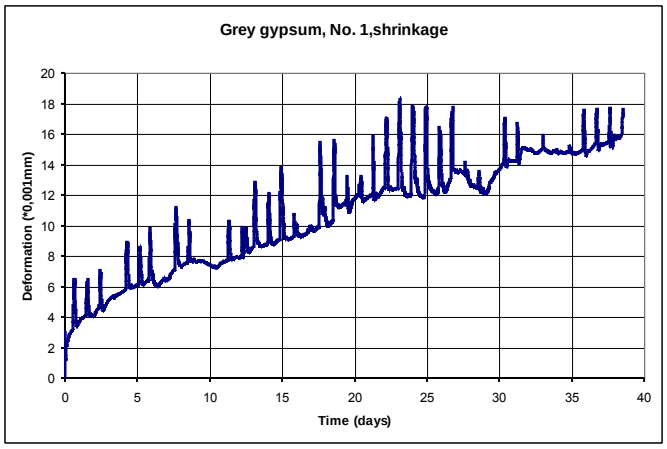
Fig.12: Evolution of Young's Modulus of grey calcined gypsum.

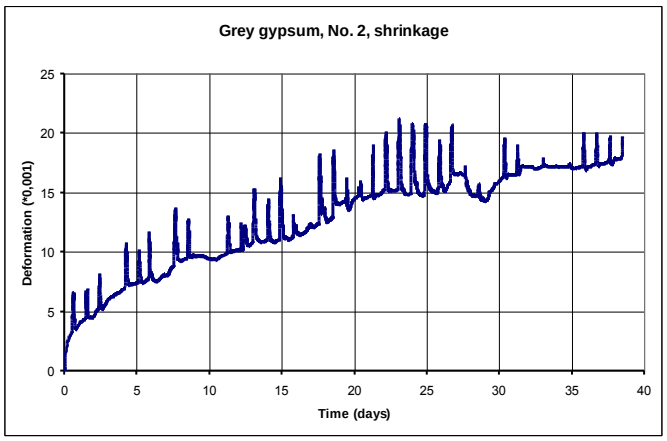
VII. Creep Tests - Results

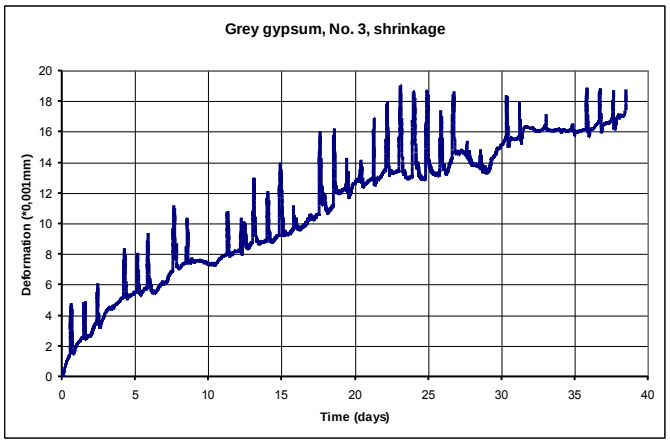
Second set of specimens was tested in lever mechanisms [14]. One set of specimens, which included 6 specimens, was used for testing. Three specimens were loaded by weight of part of a lever mechanism. Next three specimens were loaded by plumbs, placed on the lever. All specimens were 14 days old, when the tests started. Specimens maturing process continued in laboratory conditions at temperature 20 °C and relative humidity 50 %. Specimens were covered by plastic wrap before start of creep test.

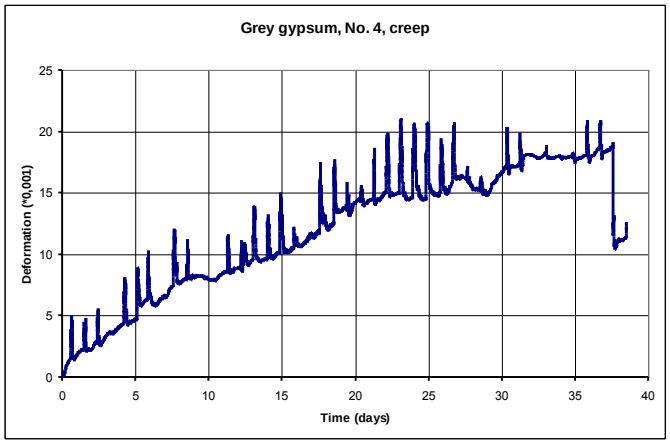
Table IV describes deformations from testing of creep and shrinkage. Data are displayed for the 37th day after starting the tests.

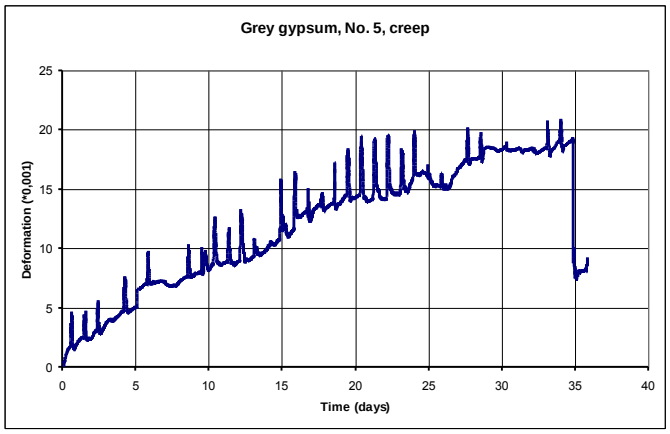
The evolution of deformation of 6 specimens in time is displayed in 6 graphs in Fig. 13.











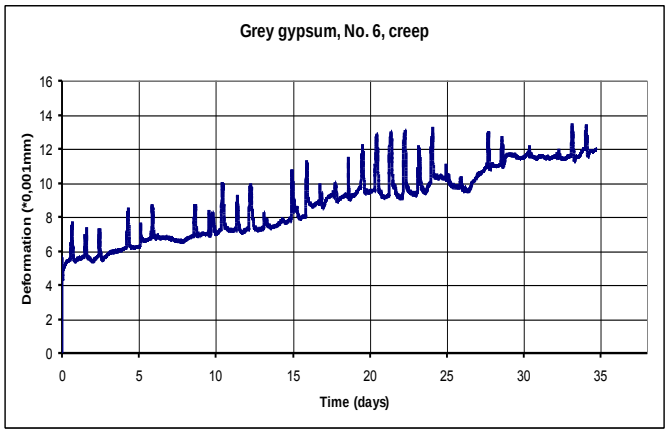


Fig.13: Creep of gray gypsum specimens.

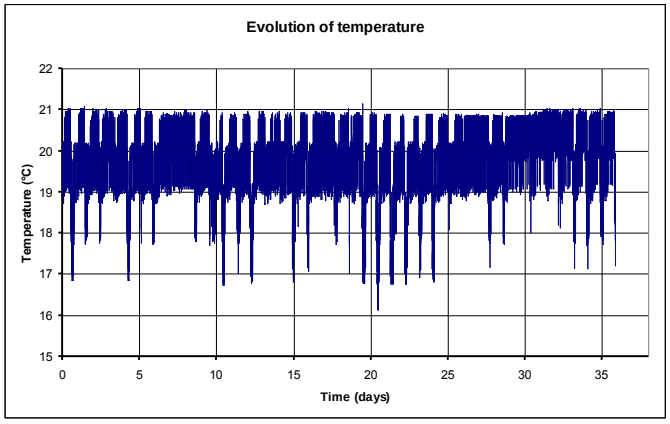


Fig.14: Temperature during the creep test.

The trend of increasing the specimen deformation can be seen in the graphs. Rate of increased deformation was steady after the 4th day. The deformation increased faster for more loaded specimens (No. 4 – 6) than for specimens loaded only by weight of the lever. In case of exclusion of specimen No.6, difference between deformations of the first and the second sets is only 3 μm (Table IV).

Temperature in laboratory was between 19 and 20 °C but in Fig. 8 it is possible to see deviations from steady value of temperature. Temperature deviation was the influencing factor for deviations of deformations (Fig. 14).

TABLE IV
DEFORMATION OF SPECIMENS AFTER 37 DAYS

Specimen	Deformation (μm)
1	14.7
2	17.0
3	15.9
4	17,5
5	19,2
6	12.4

VIII. Conclusions

The changes of the Dynamic Young's Modulus in dependence on time were presented in the first part of this paper. From the time dependence of the changes (Fig. 8), it is obvious that Dynamic Young's Modulus of gypsum specimens increases in time, especially during the first week. Nevertheless, differences between the Dynamic Young's Moduli of the two sets of three specimens at the same time instant are not negligible (Fig. 8).

From the weight measurement of the specimens during the time, it results that specimens dried differently. Therefore the graphs of the changes of the Dynamic Young's Moduli of the specimens in dependence on their weight were made (Fig. 7). From these graphs, it results that the Dynamic Young's Moduli of the specimens increases especially at the end of their drying.

From the results of the static tests, it results that values of mechanical properties of the gypsum started to increase especially after four days of hardening and they stabilized after 14 days. Important influence to the hardening of gypsum is included in saturation of mature gypsum. In the comparison of the dried specimens with the saturated specimens, it is evident adverse influence of moisture to the strength (compressive and tensile) of gypsum. Paper describes the case when moisture of specimens was non-regulated. Amount of evaporated water was not controlled. Part of water was used to chemical reaction of the gypsum and the second part was evaporated from the material. Process of evaporation of water from hardened gypsum is viewable from Figure 9, 10 and 11. Water leaves the specimen in time and the strength of the material slowly increases to the expected value of the strength of the material. Compression strength of mature gypsum is approximately 2.5 times higher than strength in bending tension. Trend of relation between strengths is visible during the hardening of gypsum. Noted, that the samples were placed freely in a laboratory condition with average temperatures 25 °C and relative humidity 50 %.

If we look on evolution of monitored properties of the investigated gypsum binder in detail, it is evident from the Fig. 2 that the gypsum setting starts seven minutes after mixing water with gypsum and the setting process of the gypsum paste (in our case with water/gypsum ratio 0.71) is finished after ten minutes. The preparation of one set of samples (3 samples with dimensions 40×40×160 mm) - filling the forms and smoothing the upper faces of beams – takes approximately 4 minutes.

Ten minutes after spillage the gypsum to the water, we can suppose that the solid structure of the material is made – hardened gypsum, which is able to be minimally loaded. Twenty minutes after mixing the gypsum with water, it is possible to take out beams from the form and work with them. In this time, it was also possible to test investigated mechanical properties using destructive and also non-destructive methods. For example, from the results of the strength determined from compression tests (Fig. 11) it is visible that tested samples after 20 minutes have compressive strength about 4 MPa. With respect to the obtained results, then the decrease of the compressive strength occurs. After two hours (time prescribed in standard), the mean value about 3 MPa was measured for the compressive strength. In comparison with standard two-hours values of samples made with water/gypsum ratio 0.81, for which the compressive strength was 2.1 MPa, our measured values are higher. With respect to the lower water/gypsum ratio, it was evident and expectable effect. In next time, all values of investigated mechanical properties decreased. After about two days, all values of investigated mechanical properties started to increase. The most values of strengths were not changing after 14 days and were the same as strengths after 28 days.

Creep of dry gypsum is measurable and its values are relatively low. Sensitivity of gypsum on changes of temperature is visible from results of creep tests.

The fact, that evolution of the mechanical properties of the hardened gypsum is depending on different conditions, was proved unambiguously by two independent methods for determination of Young's Modulus, static one by destructive method and dynamic one by non-destructive method.

The influence of moisture on mechanical properties of structural pores materials is known generally. In our case, it was unambiguously proved in Fig. 7.

If we suppose that our samples were put to the place with constant temperature and humidity but the samples are placed too close, it is still important to answer two questions: How does the time dependence of the mechanical properties look like? How does moisture influence these parameters?

The decrease of the investigated mechanical properties of the samples after the 1st and the 2nd days could be related to the final creation of the inner structure of the material but

unambiguous confirmation of these conclusions we do not have at present time.

One way, how to separate influence of time and moisture during monitoring of evolution of mechanical properties of gypsum samples, is transparent definition of conditions of sample storage during or immediately after hydratation of the gypsum paste to the hardened gypsum. For example, if samples will be put into the water bath immediately after taking them out of the form, the influence of the changing moisture will be eliminated. Then the changes of mechanical properties will be related only to the processes inside hardened gypsum. In contrary to previous, if samples will be put into the drier with forced airing, where the temperature will be set to constant value, e.g. 40 °C, the process of evaporation of free water from the gypsum samples will be several times accelerated and the conditions of storage of the samples will be unambiguously defined.

The problem of the samples storage in the exactly defined conditions is also concerned to concrete samples, which are stored in the water bath after their preparation, where the conditions of their storage are unambiguously defined. In the standard [16] about gypsum, according which we prepared samples, there are not unambiguously defined storage conditions and even though we satisfied all conditions prescribed in standard, the speed of evaporation was different for different samples.

The next possibility of verification and approximation of the exact processes inside the structure of the hardened gypsum, which have influence on mechanical properties, could be storage of the samples older than 28 days in the water bath.

Comparison of experimental results obtained by different and independent methods and processes is in any case very beneficial and in many cases it can find mistakes, which can occur during evaluation of material properties, especially if the conditions are changing during measurement, e.g. conditions of the placement of the samples, which influence the content of moisture in the samples. Especially, it is important for determination of material properties of porous materials.

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