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Experimental Stress Analysis

# Mechanical properties of gypsum blocks after fire

Pavel Tesárek,[1] Andrea Wilczynská,[2] Tomáš Korecký,[3] Pavel Padevět[4]

**Abstract:** Mechanical properties of gypsum blocks were determined after exposure of these ones by flames and high temperature during fire test in Mokrsko 2008. The maximum temperature of the fire ranged from 1 hour was about 935 °C and then there was a collapse of the experimental building. The gypsum wall was unlike other structures violated only on surface. The gypsum wall was dismantled during the demolition of the experimental building and the gypsum blocks were analyzed.

**Keywords:** Gypsum, Fire test, Gypsum Block

## 1. Introduction

Materials on gypsum basis have utility properties for building industry; one of these properties is a fire resistance of gypsum. Gypsum is a non-combustible material. Gypsum is used for safeguard of steel and woods constructions, first as plasterboards. The gypsum fire resistance is based on amount of chemical absorbed water. Hardened gypsum is thermal steady until a critical temperature. Value of this critical temperature is after published dates up 40 or 50 °C, but probably is higher over 70 °C [1]. After the critical temperature is overanged hardened gypsum – calcium sulfate dihydrate – is decompossitioned on gypsum – calcium sulfate hemihydrate. For higher temperatures over 200 °C is created calcium sulfate anhydrite in severaf forms. Described reactions proceed very slowly because the hardened gypsum has good thermal propertie and these proceses are endothermal [2].

## 2. Fire test in Mokrsko 2008 and an the experimental gypsum wall

The fire experiment was situated in Mokrsko district Příbram, realized was at 18 September 2008. This experiment followed several large fire tests in Cardington Laboratory between 1998 and 2003 and also the fire test in Ostrava. The new experimental building prepared in front of the CTU in Prague Educational Centre

[1] *Ing. Pavel Tesárek, Ph.D; Department of Mechanics, Faculty of Civil Engineering, Czech Technical University in Prague; Thákurova 7, 166 29 Prague 6, Czech Republic; tesarek@fsv.cvut.cz*
[2] *Bc. Andrea Wilczynská; Department of Mechanics, Faculty of Civil Engineering, Czech Technical University in Prague; Thákurova 7, 166 29 Prague 6, Czech Republic; andrea.wildczynska@fsv.cvut.cz*
[3] *Ing. Tomáš Korecký; Department of Materials Engineering and Chemistry, Faculty of Civil Engineering, Czech Technical University in Prague; Thákurova 7, 166 29 Prague 6, Czech Republic; tomas.korecky@fsv.cvut.cz*
[4] *Ing. Pavel Padevět, Ph.D.; Department of Mechanics, Faculty of Civil Engineering, Czech Technical University in Prague; Thákurova 7, 166 29 Prague 6, Czech Republic; pavel.padevet@fsv.cvut.cz*

Joseph Gallery. The structure presented one floor of the administrative building of size 18/12 m and building height was 4 m with different types of used materials components – a simple trapezoidal composite slab, prefabricated hollow panels Spiroll, beams with corrugated webs, concrete walls with thickness 250 mm made of concrete C 30/37, sandwich panels with mineral wool etc. The fire load was created 15 $m^3$ unwrought cribs 50/50 mm of length 1 m.

In 60 min was the maximal gas temperature under the composite slab 935 °C. The slab lost the resistance in compression in 62 minute of the experiment [4].

The experimental gypsum wall was situated inside the experimental building in front of a concrete wall. The wall was constructed from a gypsum block on two different material bases, both used gypsum material were modified by a plasticizer, a hydrofobization admixture and expanded vermiculite. These modified gypsum material were denoted as MS 84 and MS 86. The blocks dimensions were 600/300/150 mm, bulk density of this gypsum blocks is 550 $kg \cdot m^{-3}$. The blocks were fitted into a gypsum mortar and front side of the gypsum wall was trimmed by gypsum plaster with thickness 5 mm. The experimental gypsum wall was length 1.8 and high 3.7 m; a schematic view shows Fig. 1. The gypsum wall was built one month before the fire test.

Within the gypsum wall were placed six thermopiles for determination of a temperature dependence on time and a depth during the fire test.

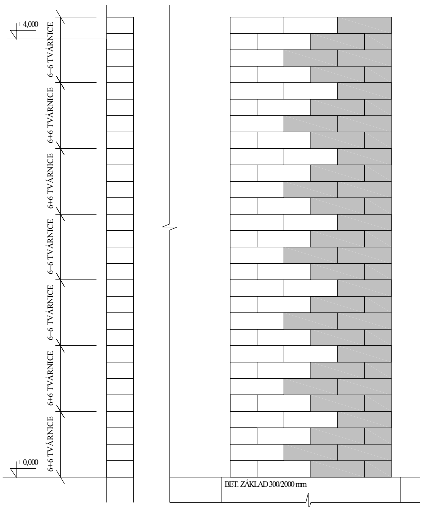


**Fig. 1.** A scheme of the gypsum wall with two materials variants MS 84 and MS 86.

**Fig. 2.** The gypsum wall after the experimental building collapsed.

## 3. Results after the fire test

The maximal temperature 10 mm prior to the gypsum wall was 800 °C at 60 min of the fire test, location of this measured point was 1.5 m upper the floor. The temperature for position 60 mm depth into the gypsum wall was 100 °C. After collapsed ¾ of the roof, the fallen prefabricated hollow panels Spiroll demolished partially an upper part of the gypsum wall. Destructed were approximately two lines of the gypsum block, see Fig. 2. Except noted damage the gypsum wall was not failures only into depth of 15 to 20 mm were crackled the gypsum plaster and part of the blocks front side, see Fig. 3 and 4. One month after the fire test the gypsum wall was dismantled during the demolition of the experimental building and the gypsum blocks were analyzed and storied for next experiments. The main damaged of the gypsum block were realized during dismantle of the wall.


**Fig. 3.** Detail view on a side of the gypsum block that was exposed by fire.


**Fig. 4.** View on a front side of the gypsum block. A part of applied gypsum plaster and the gypsum block were separated.

## 4. Mechanical properties of the gypsum blocks

From mechanical properties were determined the compressive and bending strength, which was determined on a gypsum specimens with dimensions 40×40×160 mm. The value of the F [N], corresponding to the press loading area of 40×50 mm was read on the devices, and the compressive strength was calculated using the known relations. The resulting compressive strength value of one set (4 times 2 sample halves) was calculated as the mean of the results of the six tests with the elimination of the highest and the lowest values reached. The test was performed on the device, with a scale of 0–10 kN. The test involved three-point bending, with a distance of the supporting rollers of 120 mm. The value of the force F [N] was read on the apparatus. The tensile bending strength was calculated using the standard evaluation procedure as the mean of three values.

Table 1 shows obtained results. Position is mean distance from the gypsum block side which was attached to fire. First 3 cm from the gypsum block were sawed off. We compared sets of samples I. and IV. A dependence of the samples positions is clearly visible. The set I. was at a part of the gypsum block, where temperature was 100 °C, set IV was without a temperature load. Differences between the mechanical properties for tested sets of the gypsum samples are evident from the obtained results; the compressive strength of set I. is 75 % from the value of the set IV., for bending strength is only 55 %.

**Table 1. Mechanical properties of the samples**

| Set of samples | *Position* [mm] | *Bending strength* [MPa] | *Compressive strength* [MPa] |
|---|---|---|---|
| I | 30-70 | 0.69 | 2.05 |
| IV | 165-205 | 1.25 | 2.72 |

Currently are possibilities for determination of gypsum mechanical properties using methods on nano-level e.g. see [4] or non-destructive methods [5].

## 5. Conclusions

Presented results of the gypsum block mechanical properties show that the gypsum blocks have good potential for their application in building industry. After the high thermal load (1000 °C) only 30 mm of the tested gypsum blocks have a minimal value of bending and compressive strength. A following part of the gypsum block (the position 30-70 mm) was influenced by the thermal load and mechanical properties reach to lower values than other parts of the gypsum block (e.g. the presented set of the samples for the position 165-205 mm).


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