Ignitability is one of the parameters that characterize the behaviour of building materials on flame action. The Ignitability Small Attack Flame fire test is used for the classification of building products by their reaction to fire. On the basis of the Ignitability fire test it can be determined that the tested material will be classified into the class E by reaction to fire. The Ignitability Small Attack Flame fire test precede the Single Burning Item fire test, that is used for classification of building products to class D, C, B, A2. The results of the Ignitability fire test were carried out as part of the research on the properties of gypsum composite with natural fiber reinforcement. As part of the research series of ignitability tests on two types of gypsum composite were carried out. The first type was a gypsum composite reinforced with straw fibres. The second type was composite reinforced with wooden fibres. Developed composite materials could be used in the future as board materials and therefore the determination of their fire parameters is a very important part of research. The results of the fire tests have shown that the developed material has a very good flame resistance.

**Keywords:** reaction to fire, crushed straw, wooden fibre, ignitability, fire resistance, gypsum composite, natural fibres

### 1. Introduction

The gypsum or plaster is one of the most often used materials in the civil engineering. Usually it is applied in the form of plasterboards without any reinforcement, for example, cladding boards is unusable as supporting construction. To improve the mechanical properties of plasterboards, fibrous materials such as cellulose or glass fibre are added. The main purpose of the research is to clarify whether natural hemp fibres or straw could be used as the reinforced materials. The second purpose is to verify the use of non-standard types of natural materials such as starch. The research explores the impact of the natural fibre on mechanical properties of the plasterboards (compressive strength, tensile strength, flexural strength). Also, the most suitable type of binders in production technologies of reinforced composite materials and its mechanical properties is determined, for example, shape, length and amount of fibres, are tested. Finally, the research deals with the mechanical, fire, acoustic and thermal properties of the examined materials.

Buildings whose structures contain natural (organic) building materials tend to have lower fire resistance than buildings constructed of synthetic materials. The fire characteristics of natural (organic) materials are assessed by low degrees of fire resistance. In buildings where flammable natural materials are used, fire resistance can be increased by protecting flammable materials by covering with non-combustible materials. Usually gypsum boards are used to protect flammable materials. The fire resistance of building structures (walls, ceilings, roofs) is mainly influenced by the reaction to fire class of single-use materials. According to the Czech legislation, the fire resistance of building structures or constructions is characterized by the minimum fire resistance time – *REI* [1]. Fire characteristics of single building materials are characterized by their reaction to fire. Reaction to fire shows how this material contributes to fire, smoke and burning droplets. According to the European Union legislation and according to the standard ČSN EN 13501-1 [2] building materials are classified into seven classes. The determination of the reaction-to-fire class of building materials and the determination of the fire resistance of building structures shall be carried out on the basis of fire tests.
Within the scope of unification, it is necessary to specify requirements for the classification of building materials for products so as to comply with the fire safety according to ČSN EN 13501-1 Fire classification of construction products and building elements – Part 1: Classification using test data from reaction to fire tests [2] Table 1 [5].

Table 1. Classification using test data from reaction to fire tests [5]

| Class | Characteristic |
|-------|----------------|
| A1    | Class A1 products will not contribute in any stage of the fire including the fully developed fire. For that reason they are assumed to be capable of satisfying automatically all requirements of all lower classes. |
| A2    | Satisfying the same criteria as class B for the SBI-test according to EN 13823. In addition, under conditions of a fully developed fire these products will not significantly contribute to the fire load and fire growth. |
| B     | As class C but satisfying more stringent requirements. |
| C     | As class D but satisfying more stringent requirements. Additionally under the thermal attack by a single burning item they have limited lateral spread of flame. |
| D     | Products satisfying criteria for class E and capable of resisting, for a longer period, a small flame attack without substantial flame spread. In addition, they are also capable of undergoing thermal attack by a single burning item with sufficiently delayed and limited heat release. |
| E     | Products capable of resisting, for a short period, a small flame attack without substantial flame spread. |
| F     | Products for which no reaction to fire performances are determined or which cannot be classified in one of the classes A1, A2, B, C, D, E. |

Each material describes a classification report that provides a unification way of classifying.
allowed to act on the test material begins to be measured. Time of the fire test (flame effect) could be 15 seconds or 30 seconds. If the material could be classified in the class D by their reaction to fire, the test duration is 30 seconds. The time duration of crushed straw fire test was 15 seconds. During the fire test two criteria are checked. If the flame ignites the surface of the sample and if the flame spreads from the first horizontal axe (touchdown point) to second horizontal axe 150 mm above the touchdown point. If the flame spreads to the second horizontal axe the tested material does not meet the requirements of the fire test. Next time before the flame touches the second horizontal axe is measured. – Burning time track 150 mm criteria. The ignitability fire test is carried out on five test specimens. Crushed straw, used in this test is natural without any chemical additives. Bulk density of crushed straw filled into tested container was 90 kg·m⁻³. During test all five test samples met the test requirements. When the flame touched the crushed straw its surface ignited of orange flame. After 15 seconds the torch has been delayed from the touchdown point and the flame spread stopped 6.5 cm from the first horizontal axe. The test container and progress of fire test ignitability are shown in Figs 1, 3, 4. The results of the ignitability fire tests of crushed straw are shown in Table 2.

4. The ignitability fire test by a small-time attack flame of gypsum composite

The test of flammability of the gypsum composite was performed on eight test specimens. Four test specimens were made with straw and four with wooden fiber com-

| Table 2. Results of the ignitability fire test by a small-time attack flame of crushed straw |
|---|

| Units | The measurement results of the test specimen No. |
|---|---|---|---|---|---|
| Ignitability Yes/No | – | Yes | Yes | Yes | Yes |
| Achieving the flame to the mark 150 mm Yes/No | – | No | No | No | No |
| Burning time track 150 mm | s | – | – | – | – |

| Table 3. Percentage and weight proportions of tested series |
|---|

| Series | Gypsum | Reinforcing straw/wooden fibres |
|---|---|---|
| | Percentage proportions [%] | Weight [kg] | Percentage proportions [%] | Weight [kg] |
| 1 | 97.5 | 1.17 | 2.5 | 0.03 |
| 2 | 95.0 | 1.14 | 5.0 | 0.06 |
| 3 | 92.5 | 1.11 | 7.5 | 0.09 |
| 4 | 90.0 | 1.08 | 10.0 | 0.12 |
The fiber content was 2.5%, 5%, 7.5% and 10% of the total weight of the test specimen. The weight ratios of the individual components are shown in Table 3. The preparation of the test samples was started by weighing the single components. Subsequently, the plaster and fibers were mixed in the vessel. Water was then added to the mixture. The direction was mixed by hand or electric stirrer. Once the optimum consistency has been achieved, the mixture was manually placed into the mold. When filling the mold, the mixture was compacted and pierced to avoid airborne pores. After filling the test form, the mixture was allowed to become quenched. The freezing time for all samples was approximately 15 minutes. After the test sample was tainted, the mold was removed. The same procedure was repeated for all the samples tested. Samples were allowed to cure at 21 °C and relative humidity of 50 ± 5%. Thereafter, the test specimens were placed in the furnace. The furnace was dried at 40 °C to remove excess water. The oven drying time was three days. After drying, the samples were left in a laboratory at 21 °C and relative humidity of 50 ± 5% for four days [5]. The dimensions of the test samples conformed to the requirements of the standard. The overall dimensions of test specimens were 230 mm × 90 mm × 15 mm. For samples preparing the building plaster (bonding material), which is a powdered mixture of hemihydrate of calcium sulphate (CaSO₄· 0.5 H₂O) with strength G₂ (2 MPa) was used. The stalks of straw (filler) were previously crushed with average length of straw stalks within the range of 5 to 10 mm. Diameter of straw fibres is about 0.5 mm to 1 mm. Length of wooden fibres is maximally 4 mm and diameter of fibres is about 25 μm. In a fire laboratory, the test specimens were clamped into a test furnace. Flame calibration was performed with a special dipstick. After calibration of the flame, a fire test was performed on all test specimens. The burner was moved to the position where the flame touched the test specimen surface. Allowing the flame to run for 30 seconds on the surface of the test specimen, no specimen during the test has ignited the surface. For all test specimens, therefore, the requirements were met of the ignitability fire test by a small-time attack flame. Results of ignitability fire test of tested samples are listed in Table 4. Testing specimens after fire test are shown in Figs 4 and 5.

Table 4. Results of the ignitability fire test by a small-time attack flame of composite

| Composite with straw fibers | Unit | The measurement results of the test specimen No. |
|-----------------------------|------|-----------------------------------------------|
| Percentage                  |      | S1    | S2    | S3    | S4    |
| Ignitability Yes/No         |      | –     | No    | No    | No    |
| Achieving the flame to the mark 150 mm Yes/No | | –     | No    | No    | No    |
| Burning time track 150 mm   | s    | –     | –     | –     | –     |

| Composite with wooden fibers | Unit | The measurement results of the test specimen No. |
|------------------------------|------|-----------------------------------------------|
| Percentage                   |      | W1    | W2    | W3    | W4    |
| Ignitability Yes/No          |      | –     | No    | No    | No    |
| Achieving the flame to the mark 150 mm Yes/No | | –     | No    | No    | No    |
| Burning time track 150 mm    | s    | –     | –     | –     | –     |

Fig. 4. Test specimens with crushed straw after fire test

Fig. 5. Test specimens with wooden fibres after fire test
5. Conclusion

The ignitability fire test by a small-time attack flame is part of a comprehensive research of the characteristics of gypsum composites with natural fibres. Fire tests build on the tests of mechanical physical properties. As expected, the gypsum composite has met all fire test requirements. The composite with straw and wood fibers can be classified as better than class $E$ according to their reaction to fire. As part of the further research on gypsum composite, more detailed fire tests will be carried out, which will be able to accurately verify the fire characteristics of the developed composite. On the basis of comparison with similar materials, it can be assumed that the developed composite will be classified into class $A2$ according to their reaction to fire.

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