Problems of magnesium oxide wallboard usage in construction

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Abstract. Magnesium oxide wallboard is the building and finishing material, which has a reputation of new generational ecological constructing material. It has a wide range of uses: as a revetment in ventilated facades' production, as a decorative material, as different types of formworks for a foundation filling and as a protector against a fire threat. During the study it was considered that magnesium oxide wallboards have some defects, such as moisture formation as a concentrated brine on the surface under special climatic conditions and absence of clear distinguishing between different types of magnesia boards. Usage of this material can become a cause of frame's corrosion and origin of mold on wooden details. Authors provide the information from a foreign data source about negative consequences of SML usage. In conclusion researchers state that it is necessary to provide a clear magnesium wallboards classification and define technical requirements, which will, in their opinion, lead to Russian standard formulation.

1. Introduction and Literature Review

Portland cement, the most common binder that is used in construction, has several substantial drawbacks, for example, necessity to spend 1 t of HRC to produce to 300 kg of fossil fuels (in this process exudes to 0.8 tons of CO and CO₂ – the root cause of the greenhouse effect). Therefore, people are searching the alternatives for this material, and one of them is magnesia binder. In its simplest form, it is a binder consisting of caustic magnesium oxide and magnesium salts aqueous solution, preferably chloride or sulfate.

Magnesium oxide wallboard is sheet construction and designing material based on magnesia binder. It consists of caustic magnesite, magnesium chloride, expanded perlite and glass fiber as a reinforcing material. Magnesia binder also named Sorel cement is based on magnesium oxide offered by the French engineer C. Sorel in 1866 [1-5].

Magnesium oxide wallboard are mainly used as a construction substrate in the manufacture of building facades both in new construction and in repair of already constructed objects. Also in some cases, magnesium sheets are used as facade materials or rain screen. Sometimes magnesium sheets can serve as a foundation for plaster application. The magnesia boards almost are not produced in Russia. The bulk of manufacturers are located in China, South Korea [6].

One of the most significant disadvantages of this compound is low water resistance of articles, turn to cause corrosion in franked steel constructions.
2. Results and Discussion
Typical chemical composition of magnesium sheets studied in the work [8]. In studies of the Danish Institute stated [7, 8]:

• the content of magnesium chloride salt (MgCl2) leads to the absorption of moisture;
• after about 7 days exudation of moisture is observed on the surface of the sheet (at 90% relative humidity);
• eventually binding substances, that are used in sheets construction for their connection, decompose with relative humidity increasing;
• magnesite sheets cause corrosion on adjoining non-stainless metal parts of structures;
• magnesium sheets lead to the fact that the adjoining wooden parts begin to absorb moisture more intensively than ordinary wood, so they may cause the spread of mold.

Negative moisture-absorbing features of magnesium sheets are associated with the fact that they contain free magnesium chloride (MgCl2), which is very hygroscopic. Furthermore, Sorel cement is unstable at a relative humidity of 93%. The presence of salt in the sheets leads to the fact that they begin to absorb moisture from the air when the relative humidity in environment reaches a certain level (figure 1).

Figure 1. The formation of traces of moisture on the surface

Theoretically, magnesium chloride already begins to absorb moisture at a relative humidity of 33%, but in practice, the panels begin to absorb moisture in a large amount at a high humidity.

In the technical literature clearly indicates that Sorel cement (magnesia binder) is not a moisture resistant at a high humidity. In 1947 has been found that the level of relative humidity of 93% is its critical limit. Materials on this subject were published in 2011.

In Denmark were done few experiments wherein magnesium sheets were placed in an environment with a relative humidity of 93%. Sheets absorb moisture from the air in considerable quantities and absorption process was observed within one month or more. Another important effect which can be stated as a result of the experiments is that on the surface of a sheet between the 7th to the 14th day with a relative humidity of 93% were formed water drops. The Danish Technical University conducted a series of samples for moisture, and these tests fully confirmed the results of initial experiments. Experiments were also carried out at a humidity of 85% - they have shown the similar results.

In experiments at a relative humidity of 95% magnesite binders and sheets decompose the material loses its cohesive force. Salts transferred from the sheet into the timber when magnesite sheets come into direct contact with a wood. Since, as mentioned, contain high amounts of magnesium chloride, which in turn leads to increased moisture absorption wood. This phenomenon has long been known in China and called the «crying boards», and there are special building materials brand «anti-crying boards». It is found that the mold can develop on magnesite sheets themselves, that including, caused by a relatively high content of wood fiber sheets (figure 2).
Figure 2. Dew drops on the wooden structures

Figure 3. Dew drops on the wooden structures

When magnesium sheets emit moisture, it absorbs by surrounding parts of the wood. That leads to its putrefaction and further damage. This applies to both: to remote sheets for covering the facades and to located underneath wooden core.

The liquid, which collects in the magnesite sheets and penetrates into their surface when they "cry" – is water with a high content of magnesium chloride. This fluid is very corrosive and causes corrosion on fasteners and metal plating (figure 4), which come in contact with the sheets.

Figure 4. Formation of the metal structure corrosion

In some product passports for magnesite sheets it is indicated that they have a sufficiently high pH – about 10.

Typically, the pH of 10 is considered as sufficient protection against mold.

Measurements made on magnesium sheets, however, have shown that they have a much lower pH, usually 7 – 8, and, accordingly, cannot be protected from the mold formation. This value also eventually decreases due to the fact that the sheets absorb carbon dioxide from the air. Magnesium sheets partially dry in summer, when the relative humidity slightly reduces. Magnesium sheets can create the risk of corrosion of steel skeleton that is located beneath the sheets and consists in thin galvanized sheets. In the long term, it will lead to the fact that the screws that hold the cover will lose their functionality.

Also, found moisturizing wooden window constructions in facades where magnesium sheets used as building substrates. Fireproof properties of magnesium sheets eventually reduce to the extent that they are decomposed by moisture.
Magnesite sheets with appropriate quality control and formulation are non-combustible. It has a low thermal conductivity and enhanced resistance to high temperatures, which allows their use as structural fire protection to enhance fire resistance of building structures. However, fasteners elements for wallboards should have high reliability and don’t deteriorate when exposed to extremes of temperature and humidity because sheets can quite change the geometrical dimensions and may cause corrosion on ferrous and non-ferrous metals fasteners (figure 5, 6).

Studies that were made by Bunch NGO institute about magnesium sheets in Denmark in 2015 had a great response. The study was initiated after collapse and corrosion of magnesium wallboards that were used as facade panels for Dokk1 library. The library was opened in June 2015 and become the largest in Scandinavia. It has an area of 35.6 thousand m² (figure 7). In June 2016, the media reported that the construction of the external facade of the building is damaged by corrosion. About 3.000-4.000 m² facades’ surface fell into disrepair. The cost of replacement is estimated at 19 – 26 million kroones (figure 8). Experts believe that the cause in marine and wet climate of Denmark.

Problems arise with magnesium sheets due to the weather conditions in which they are used. Thus, the ski complex in Rezh Sverdlovsk region was constructed using magnesium oxide wallboards as the facing material (figure 9).
Organization that was implementing construction did not consider climatic conditions of this region. Magnesium oxide wallboards absorbed moisture and after turning on the heating system were destroyed. Therefore, the ski complex was not even put into operation (figure 10, 11).

![Figure 10. Cracked ceiling](image)

![Figure 11. Destroyed wallboards](image)

3. Conclusions

Naturally, complexity of using this material will exist in other territories with analogous climatic conditions. Negative impact of magnesium oxide wallboard's exploitation on building structures calls into question of expediency of it's usage. Especially, if it is exploited in conditions of high humidity. It is necessary to undertake a fundamental and long-term study based on full-scaled observations and material exposition in near-operational conditions. It is advisable to create normative documents constituting magnesium oxide wallboard's classification, terminology, study methods and quality specifications for different makes of the wallboards. Specifications should contain clear indications for exploitation regime and control methods to avoid low-quality magnesium oxide wallboards' import.

Order of Ros Standard No. 2034 dated 30 December 2016 formed the Technical Standardization Committee TC 144 "Construction materials, products and engineering structures", particularly Subcommittee SC4 with insulating and finishing materials and products falling within its' competence. These Committee and Subcommittee were formed on the basis of the Institute of Civil Engineering of The Federal State Autonomous Educational Institution of Higher Education "Peter the Great St. Petersburg Polytechnic University". It is envisaged that major Russian scientific groups in construction field will be involved in standards evaluating. Also, in order to harmonize Russian and international standards in particular export oriented industries, leading foreign scientific centers are planning to be involved. The development of standard, harmonized with Chinese standard PRC JC688-2006, considering climatic zones of Russia and national regulatory requirements about finishing materials, is the necessary orientation keeping in mind the current situation with the perspective but insufficiently explored new finishing material - magnesium oxide wallboards.

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