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EXTENDED ABSTRACT

A plaster based on gypsum and investigation of its thermal insulation properties

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1. Introduction

Considering the increasing consumption and decreasing of energy on the planet, creating new methods to reduce energy consumption by humans is one of the necessary priorities for continuation and survival. In civil engineering, many researchers are trying to reduce energy consumption by conducting laboratory and theoretical research on building materials (Ajouguim et al., 2021; Singh et al., 2022) especially linings and plaster trodes (Touil et al., 2022). In the present paper, an attempt has been made to present a plaster based on a combination of new and old materials, which can be a step in the development of the thermal insulation industry, both in terms of quality and cost. The purpose of this research is to reach a plaster with characteristics similar to thatch, but with the elimination of defects such as cracking due to continuous cold and heat, erosion due to rain and moisture, and continuous drying. In the production of this plaster, which is based on gypsum, in the first step, some investigations and tests were carried out on different materials, including traditional thatch mixtures. In the end, the final product was obtained by adding materials such as gypsum, clay, wood powder, glass wool and some nano materials with the aim of producing a plaster with a thermal conductivity coefficient lower than the existing ones. This plaster will be used for plastering inside the building like gypsum plaster and has advantages such as not having a thermal bridge on the entire surface, not having seams and cracks, as well as not destroying and falling over time due to its high adhesion. This research has tried to increase the quality of thermal insulation in the construction industry and by taking the idea from the behavior of straw, to produce a much more optimal coating, both in terms of efficiency, availability and saving energy consumption, as well as in terms of costs.

2. Methods

The plaster introduced in this research was obtained by combining available materials such as gypsum, clay, wood powder, glass wool and some nano materials with the aim of producing a coating with a lower thermal conductivity than existing coatings. First, each of the components of the coating has been increased or decreased several times and the resulting coating has been applied on a standard block (Razavi Hablex) and after 24 hours (drying of the surface), the effects created such as adhesion, cracks, durability on the surface of the wall and the final color after drying have been examined. Then, to ensure the thermal superiority of the coating presented in this research, two types of tests have been performed on the samples: the test to determine the thermal conductivity coefficient and the test to determine the thermal durability.

2.1. Thermal conductivity test

The coefficient of thermal conductivity is the amount of energy that passes through the material per unit of thickness and per unit of time at a certain temperature. This test was performed using the KD2 Probe device

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and based on ASTM D5334 regulations. After making the sample and drying it, the thermal conductivity coefficient was first tested, with the aim of obtaining a material with a thermal conductivity coefficient lower than that of straw coating.

2.2. Thermal durability test

In this research, the glass cube test was used to determine the thermal durability, which is a simple method to determine the thermal performance of various materials. This experiment was taken from the simulation project of combined convection and radiation heat transfer in a closed square enclosure in Ansys-Fluent software. To perform this test, a glass cube with dimensions of one meter was used, only in its upper part, a hole with dimensions of 4 x 10 cm was created for the passage of digital thermometer and hygrometer.

2.3. Constituent materials of plaster

To prepare laboratory samples, the use of available materials has the first priority. It is worth noting that each of the ingredients is included in the coated composition based on a specific feature. Each of the components of the coating was repeatedly increased or decreased, and the resulting coating was applied on a standard block (Hablex Razavi) and after 24 hours (drying of the surface), the created effects such as adhesion, cracks, durability on the surface of the wall and the final color after drying were investigated.

3. Results and discussion

The results of the tests performed on the plaster should be considered from two perspectives; First, checking the laboratory results with the aim of evaluating the efficiency and achieving the research goal, and secondly, estimating and comparing the price with the aim of ensuring its economic efficiency, which is very important and necessary in addition to the efficiency. After conducting the necessary tests with the aim of evaluating the efficiency and financial estimates, the results were obtained that led to the determination of the appropriate amount of each material in the plaster as well as the properties of the plaster.

As a result, the final plaster has the best results both in terms of the laboratory in terms of thermal conductivity insulation properties and in terms of performance. After conducting laboratory tests, the results obtained from different coatings and mortars were compared. It should be noted that the most significant properties of the plaster made in this research include colorability, better performance in terms of thermal insulation, and economic efficiency.

3.1. Experimental Results

The laboratory results show that the plaster presented in this research compared to other mortars (in the case of samples with equal dimensions) has a lower thermal conductivity coefficient and also the ability to retain more energy in the room. The reason for the lower thermal conductivity coefficient and higher thermal durability of the plaster introduced in this research can be related to the presence of thermal insulation materials in the construction of this plaster. For example, the straw in the thatch, which is used in the villages to cool the room in the summer and stay warm in the winter, is one of the materials that alone greatly reduces the thermal conductivity coefficient and increases the thermal durability and causes the plaster to be insulated; On the other hand, the presence of nano materials and stone wool, which alone reduce thermal conductivity, in the combination of the plaster introduced in this research with straw and other materials, by creating a suitable correlation, produces a coating with a lower thermal conductivity coefficient and greater thermal durability.

3.2. Price estimation and comparison

Another important goal of making this plaster is its economic efficiency. It is worth mentioning that here, economic efficiency is considered at the end of the work. On the other hand, a significant increase in execution speed and longer durability should be considered in order to reduce costs. The noteworthy point besides the mentioned priorities is the effort to make a widely used plaster compared to similar coatings. This plaster can show its good performance in many cases. Among these things, there is a lot of help during execution, which summarizes several steps in one step and several products are placed in one product. It is worth mentioning that this plaster, by using new and old materials, has been able to show its value in various ways, including availability, cheaper and faster implementation.

4. Conclusions

The summary of the results of the tests and investigations carried out on the plaster introduced in this research is as follows:

1. The plaster presented in this research has a lower thermal conductivity coefficient (0.21 w/m.k) compared to other mortars (in the case of samples with equal dimensions).

2. The thermal durability of this plaster is higher (10 hours) compared to other mortars investigated in this research.

3. The comparison of the finished price of this plaster with the different coatings examined in this research shows that the finished price and the number of days required for the implementation of mentioned plaster are lower than all other common coatings.

4. The plaster introduced in this research, in addition to having the above characteristics, can be a suitable proposal to increase the speed of implementation, reasonable price and better efficiency than the conventional coatings in the construction industry and a new step to reduce energy consumption. It is worth noting that mass production of this plaster can be economically justified in addition to providing all the mentioned benefits.

5. References

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