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Water Absorption Properties of Rammed Earth Material with Montmorillonite Clay

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Abstract. This temple presents water absorption properties of rammed earth material. Earth material is very sensitive to moisture and water. Specimens of two recapture were produced in the laboratory using montmorillonite clay. Specimens were rammed in the moulds. Then they were putted in the covering of nylon. They were settled in the box with soft foam that was moistened. Fifteen pieces of them of each recipe were tested. The level of moistening was constant. The specimens were regularly measured and weighted. The weight growth is 11.21 % for GEM I and 13.05 %. The amount of the clay had an influence to the water absorption characteristics. The more clay is used, the more water can the final product absorb.

Introduction

This temple presents earth material as a modern building material based on the long history of using, but in last centuries it was replaced by modern materials. Due to the replacement the material characteristics were never fully researched. The demand for the earth material is increasing nowadays following the principles of sustainable buildings development [4, 5].

The main advantages of using earth as a building material are good air humidity balance, lower costs for material and construction, and also the fact that the earth based material has a positive effect on human health. Rammed earth is accessible, environmentally friendly and suitable for low-cost building in person. According to the sustainable buildings development not only the mechanical properties are important in the structure design. The quality of building material is also given by economic and socio-cultural criteria. For example the rammed earth primary energy consumption connected with production of building material is about 44 kWh/m^3. This is 18 times less than for prefabricated concrete material [1-3, 6, 7].

Table 1 Recipes of used specimens.

	Sand [%]	Clay [%]	Water –clay ratio [-]
GEM I	80	20	0.37
GEM II	75	25	0.37

The mechanical properties of the unfired earth depend mainly on the composition and the method of processing. The basic methods of using earth are mudwalls, rammed earth, earth bricks, earth infill in a timber frame construction etc. This research focuses on the rammed earth material. Nowadays, there are no standards for using earth as a building material in the civil engineering. It is necessary to search for more unfired earth characteristics in order the engineers could design the earth constructions more than today [2, 3, 6].

Testing of Unfired Earth Material

Rammed Earth and Water. The earth material is very sensitive to moisture and water that is why it is an important characteristic that needs to be examined. The structure of earth is widely un-homogeneous, porous and opened. It is capable to absorb water and transport it in the material itself.

Fig.1 The production of rammed earth specimens.

Preparing Material. The recipe for the specimen was designed of montmorillonite clay, sand and water. There are two recipes GEM I and GEM II, both of montmorillonite, but they differ in the sand/clay ratio as it is shown in Table 1. The amount of the components is expressed by weight per cent. The amount of water was settled as a water/clay ratio, same at both recipes. Fifteen specimens of each recipe were tested.

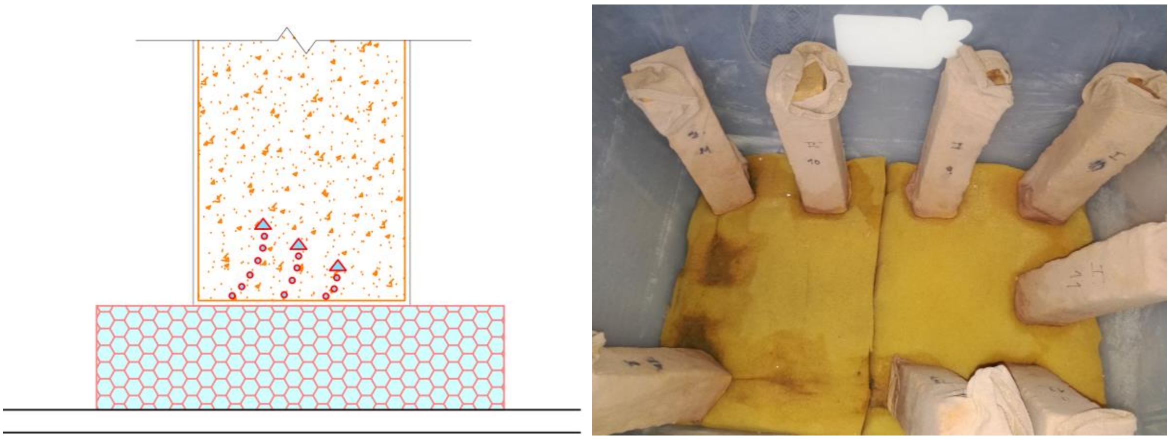

Fig.2 Theoretical process of moisture absorbing and the scheme of testing.

First of all, the sand was well mixed with two thirds of water. Than the clay and the rest of water was added. It was mingled by drilling machine with a special ending. Specimens of size 40 x 40 x 160 mm were prefabricated for the testing in the laboratory. The production was made by ramming into moulds (Fig. 1) by hand and by drilling machine. The moulds were wiped by oil and the earth was rammed in four to five layers. The last one was always made by hand.

Practical Tests. Specimens were tested after four weeks from production. By this time the humidity from the prefabrication is stable and is not changing any more. The hardening process is based only on the drying out the mixed water and it is almost over.

Specimens were putted in the covering of nylon this was made not to lose the material during manipulation when the specimens were weighted. Specimens were settled in the box with soft foam that was moistened. The level of moistening was constant, the water was added during the test, but it was not for the purpose to have too much water, the specimens cannot stay in the height level of water, they just absorbed the moisture from the soft foam (Fig.2). The specimen were regularly measured and weighted.

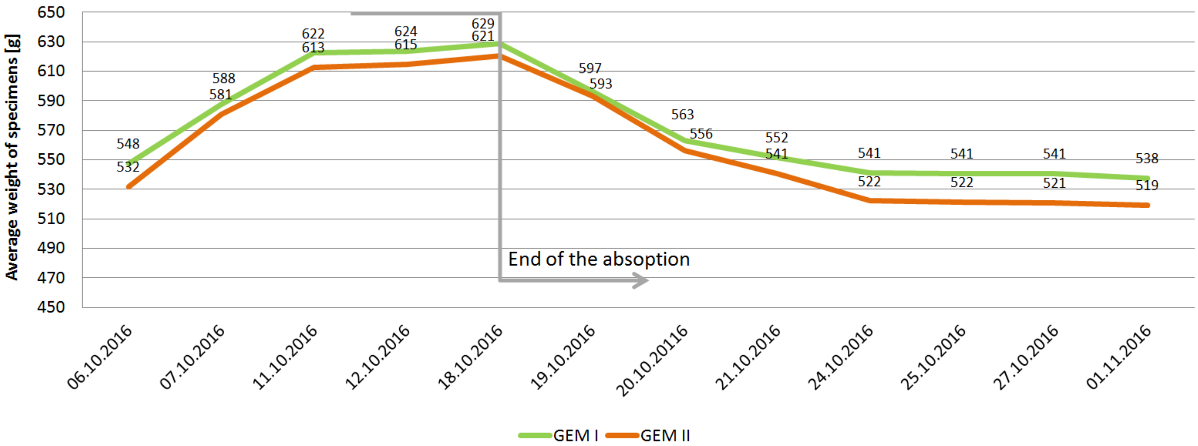

Fig. 3 Development of the weight in time (no broken specimen).

Specimens were measured and weighted then they were settled in the box. Regularly there was made a weighting and a measuring of dimensions. The test took place for twelve days, data was recorded. Some of the specimens were broken during the test, they were removed from the testing but they were still weighted because the leaving moisture was recorded too.

Evaluation of the Measurement

The Course of the Test. The weight and the sizes of the specimens were recorded. In the Fig. 3 the development of the weight in time is shown. These data represent the specimens that were not broken during the whole testing. In the same time they had the same conditions. At 6.10. the specimens were settled in the box with water and 18.10. were taken out.

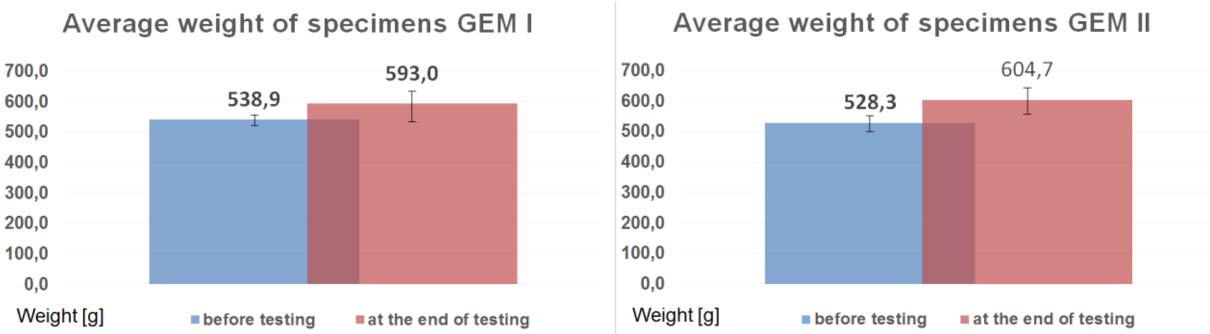

Fig. 4 Average weight of specimens GEM I and GEM II.

Results from Testing. The average weight for each recipe was calculated from the maximal weight of the specimen. If the specimen was broken and taken earlier from the testing box, the maximal weight in the moment was considered. It is shown in the Fig. 4. The blue column represents the average starting weight of GEM I and GEM II and the red one is the average weight at the taking out. The black line segments represent the maximal and minimal weight in the relevant category, the range of scatter of the measured data can be seen from this. At Fig. 5 is shown the bulk density in the same way. The starting weight and also the bulk density are higher for GEM II than GEM I.

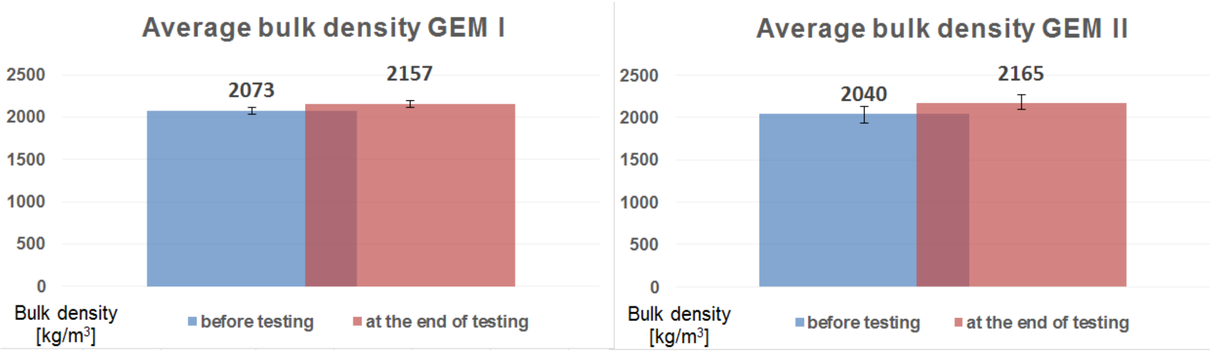

Fig. 5 Average bulk density of specimens GEM I and GEM II.

Evaluation of Measured Data. The average weight of GEM I specimens at the start was 539 g, at the end of water absorption the weight is 593 g, for GEM II the weights are 528 g and 605 g. The weight growth is 11.21 % for GEM I and 13.05 % for GEM II. The percentage growth of the bulk density is 4.06 % for GEM I and 6.12 % for GEM II. The capability for water absorbing is higher at the recipe GEM II with higher volume of clay. In this way the clay negatively influences the characteristic of the final product despite the fact that for the bulk density it is reversely.

Conclusion

Earth material is very sensitive to moisture and water, that why it is an important characteristic. The recipe with the higher volume of clay have higher lever of bulk density. The weight growth is 11.21 % for GEM I and 13.05 % for GEM II. This number is not negligible. The amount of the clay has an influence to the water absorption characteristics. The more clay is use, the more water can the final product absorbs.

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