Using of wheat straw as natural reinforcement of earth plaster for straw bale buildings

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Introduction

Natural earth plasters are experiencing a renaissance in sustainable building. Earth plasters may fulfill many functions in straw bale wall system, such as protecting the underlying surface, enhancing or preventing the migration of vapor or liquid moisture, mitigating the migration of air currents and carrying structural loads. Earthen plasters incorporating chopped straw are commonly used in the construction of straw bale walls because the straw provides tensile strength and is readily available. Earth plaster usually comprises three components, namely binder, aggregate and reinforcement. On the other hand, faced with the worldwide shortage of forest resources, the construction industry is showing interest in the production of particleboard from agricultural residues.

Materials and Methods:

In this research work three materials are used in our tests, i.e. cohesive soil, sand and reinforcement fibres. The composition of the cohesive soil texture is as follows: 31% clay (<2 mm), 22% silt (20-63 mm) and 47% sand (63-2000 mm). The wheat straw particle length of straw was about 5cm. The mixing ratios for wheat straw fibres were 0, 25, 50 and 75%. An extensive test program was carried out for earth plaster reinforced with wheat straw fibres. This program includes compression tests, thermal conductivity, erosion, shrinkage and equilibrium moisture content "EMC".

Thermal conductivity:

Thermal conductivity tests were measured by using λ-Meter EP 500 (Fig.1). The tests were done in accordance with different standard methods such as, ISO 8302, DIN EN 1946-2, EN 12664, DIN EN 12667, BS EN 12939, ASTM C 177, DIN 52612, DIN EN1266 and DIN EN ISO 12570.

The results showed that thermal conductivity of dry basis at 10°C (λ_{10dry}) is 0.16210, 0.22660 and 0.27890 W/mK for plaster reinforcement fibres percentages 75, 50 and 25 % respectively. While the thermal conductivity at dry basis (λ_{dry}) of plasters reinforced by wheat straw fibre is 0.19448, 0.27189 and 0.33468 W/mK for the same plasters (Fig.2). This study revealed that increasing of wheat straw fibers percentages to 75% lead to increase thermal insulation percent to 44.4%.

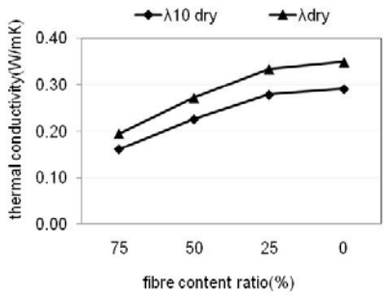

Fig. 2. Thermal conductivity of wheat straw plasters

Erosion test:

A simple testing device was set up in the laboratory to simulate the erosion process by rain drops (Fig.3). Water drops dripped out of a nozzle at a constant rate of approximately 65 cm^3/min.

The results indicated that, increasing of wheat straw fibres percentages from 0 to 75 % caused a decreasing in erosion rate from 12 to 0.11 cm/hr. It can be noticed, at starting the test erosion rate was very high and after this erosion rate decrease. This due to the reinforcement fibres content at the sample surface is lower than sand and clay content. The subsurface layer is high content from fibres, so its highly resistant as shown in Fig.4.

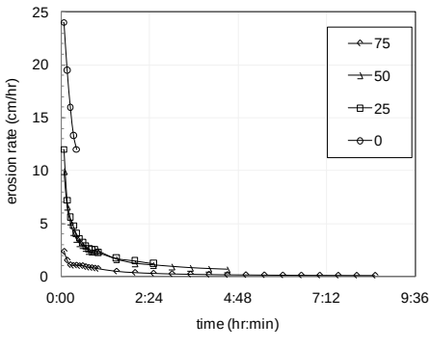

Fig. 4. Erosion rate of plaster reinforced with wheat straw fibres

Shrinkage test:

The reinforcement fiber has greater effect on the drying shrinkage. The study recommended that using the plaster with 30°C drying temperature with a lot of quantity of straw amount lead to decrease the shrinkage and cracks. The results are summarized in Fig. 5.

On the other hand, the average of compressive strength of earth plaster reinforced with wheat straw fibres are 0.329, 0.795, 0.819 and 0.824 MPa for reinforcement fibers percentages 0, 25, 50, and 75% respectively. Also the results indicate that the EMC is lower than 7% for all materials, which shows why plaster materials are so useful for straw bale buildings by protecting the straw bale walls against the harsh external conditions.

Fig.1. Thermal conductivity instrument

Fig.3. Erosion test set up

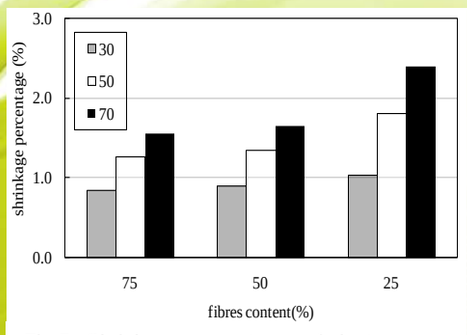

Fig.5. Shrinkage percentages of plaster reinforced by wheat straw fibres

Conclusions:

The results recommended that using plaster with a lot of wheat straw resulting in decreasing in the shrinkage and cracks percent. Also, the increase of wheat straw fibre from 0 to 75% lead to increase the thermal insulation from 0% to 44.4 %. Finally, the results confirmed that erosion rate decreased with increasing reinforcement fibres.

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