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# BIO BASED LEVELING SCREED AN ECO - SUSTAINABLE SOLUTION FOR CONSTRUCTION INDUSTRY

BY

**LAURENȚIU ADAM* and DORINA NICOLINA ISOPESCU**

“Gheorghe Asachi” Technical University of Iasi, Faculty of Civil Engineering and Building Service, 1 Prof. Dimitrie Mangeron Bld., 70050, Iasi, Romania

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**Abstract.** In the current energy crisis, the focus on identifying eco-sustainable solutions for the construction industry is growing significantly. The materials used, the assembly technologies and the labor force are the main costs that are found in the final price of a new construction or in the rehabilitation of the old buildings. However, the interest in reducing costs must be accompanied equally by the concern to reduce the impact of human activities on natural ecosystems. The paper presents a possible technical solution for making leveling screeds based on biodegradable plant material obtained from the stem of the hemp. Two variants of making the leveling screed using hemp shive as the basic material are presented. The results obtained were compared with two current variants of pouring the leveling screed, such as pearlitic screeds or expanded clay screeds. The aim is to provide technical information verified by laboratory tests to change the perspective on construction materials obtained from vegetable waste.

**Keywords:** circular economy, bio-buildings materials, renewable resources, hemp shive, construction industry.

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*Corresponding author; *e-mail*: laurențiu.adam@student.tuiasi.ro

## 1. Introduction

Levelling screeds are necessary in all types of construction because they represent the interface, the connection layer between the structural element of the building - reinforced concrete slab - and the finished floor layer represented by finishes such as ceramic tiles, parquet, linoleum, epoxy solutions, etc.

Fig. 1 – Leveling screed made with cement, sand and water (https://www.betonexpert.ro/sapa-de-egalizare).

The main characteristics of equalizing screeds are:

- To allow obtaining a flat and horizontal surface at the required dimensions of the project;
- Speed in execution and reduced effort in implementation;
- To adhere to the substrate - reinforced concrete slab;
- Reduced drying time;
- Mechanical resistance, durability and stability over time;
- To allow the processing of the surface for the installation of the finished floor according to the future use of the building.

Types of levelling screeds depending on the casting method and the connection with the support layer:

- Wet screed - classic concrete recipe using cement, aggregates (washed sand granulation 0-4mm) and water, used in most applications under normal conditions of temperature and humidity;
- Semi-wet screed - part of the cement used is replaced with additives and hydraulic binders to limit the consumption of water so that the installation can be done in meteorological conditions especially low temperatures;
- Self-leveling screed - screed characterized by reduced thicknesses of up to 3-4 cm, of more liquid consistency characterized by the ability to take over the unevenness only by scattering and deaeration with a roller type device with spikes;

• Self-adhesive screed - screed that is poured directly on the substrate - reinforced concrete slab;

• Floating screed - between the concrete slab and the leveling screed there is an intermediate layer with specific sound-absorbing, waterproofing or thermal-insulating properties.

The most used types of leveling screeds are self-adhesive semi-wet screeds used in new constructions but also in the case of building renovations. The basic materials used in the recipe are identified: Portland cement with standard 28-day compressive strength of 42.5 N/mm$^2$, sand washed 0-4 mm and water with W/C ratio between 0.45-0.7 depends on the atmospheric conditions and the workability of the mixture. The basic recipe for self-adhesive screeds is shown in Table 1.

**Table 1**

*Basic recipe for levelling screed used now in most of the new or refurbished construction - quantities for 1m$^3$*

| Type of screed | Unit | Portland cement | Aggregate 0-4 mm | Water |
|---|---|---|---|---|
| *SLS – standard levelling screed* | *[kg]* | *240* | *1200* | *160* |

## 2. The materials used for pouring the test specimens and the technology for making the mixture

In order to reduce the specific weight of the standard/classic concrete leveling screeds and to increase the thermal-insulating performances, aiming at the same time to reduce the cement consumption so that the obtained material is sustainable, screeds with added perlite are currently used, Fig. 2a (left) with apparent density 90 kg/m$^3$ or leveling screeds with the addition of expanded clay Fig. 2b (center) with apparent density 520 kg/m$^3$.

The present paper aims to present the mechanical and thermal properties of screeds made of hemp concrete, using as basic material hemp hurds, the woody part of industrial hemp stems, Fig. 2c (right) with apparent density around 100-110kg/m3. The major advantage of using this material derives from the source of origin, namely the fact that it is a secondary material obtained from mechanical peeling processing characteristic of obtaining technical hemp fibers. Therefore, it is a material whose use can significantly reduce energy consumption and due to its thermal-insulating properties reduces energy consumption by heating and cooling buildings.


a) b) c)

Fig. 2 – Materials used in tests.

**Table 2**

*Recipes used for casting the specimens - quantities for 1 m³*

| Recipe | Unit | SLS | PLS | ECL | HCLS | HCLS-M |
|---|---|---|---|---|---|---|
| *Portland Cement* | *kg* | *240* | *270* | *270* | *270* | *125* |
| *Hydraulic lime NHL3.5* | *kg* | - | - | - | - | *82* |
| *Sand 0-4mm* | *kg* | *1200* | *660* | *660* | *660* | *200* |
| *Hydrated Lime CL-80S* | *kg* | - | - | - | - | *255* |
| *Water 5% Sodium-Silicate* | *kg* | *160* | *180* | *170* | *230* | *330* |
| *Perlite 0-5mm* | *kg* | - | *75* | - | - | - |
| *Expanded Clay 8-16mm* | *kg* | - | - | *430* | - | - |
| *Hemp Hurds 0-25mm* | *kg* | - | - | - | *85* | *67* |
| *Saw-Dust 0-4mm* | *kg* | - | - | - | - | *50* |

It can be seen from Table 2 that for the PLS (perlite levelling screed), ECLS (expanded clay levelling screed) and HCLS (hempcrete levelling screed) recipes the quantities of cement and sand are constant and the water was varied depending on the degree of absorption of the material used - perlite, expanded clay or hemp hurds. The volume of perlite, expanded clay and hemp hurds was the same, respectively 25 litter in each recipe. Due to the differences in density, the mass for each material varies according to the values presented in Table 2.

The use of sawdust in the HCLS-M (hempcrete levelling screed with binder mix) recipe, was intended to replace an amount equal to 2/3 of the total mass of sand used in the HCLS recipe. At the same time, a binder mix was used in 1:1:1 volume proportions – PC (Portland cement) : NHL3.5 (hydraulic lime) : CL-80 S (hydrated lime), the total mass of the hydraulic binder being reduced by 23% compared to the HCLS recipe. If the results obtained will confirm the thermal-insulating performance, the recipe will highlight a first advantage of using hemp shive which derives from the reduction of the amount of cement used, by 23%. Another advantage is the low specific mass of the HCLS-M screed, the value of which is the second compared to HCLS that is the lighter mix between all four samples presented in Table 2.

The mixture was made by hand in the following order to reduce the water absorption of the hemp hurds:

- the sand was mixed with cement;
- add hurds and mix;
- add water with 5% sodium silicate.

## 3. Results obtained and discussions

Four samples of levelling screed were made with the dimensions: thickness 0.09m, width 0.425m and length 0.685m. The volume of each cast is $V = 0.0262m^3$ and the surface $S = 0.2913m^2$. The samples are shown in Fig. 3.

Fig. 3 – Casted samples for different recipe of levelling screed.
From left to right: HCLS, HCLS-M, PLS, ECLS.

For all the samples, a mechanical grinding of the rough surface was performed with an abrasive paper disc to observe the degree of finishing that can be obtained after 6-7 days from casting. The samples were also weighed to observe the variation of the mass during the drying process. In Table 3, the values of the mass were centralized after casting, and on 7, 21 and 40 days from the casting.

**Table 3**
*Mass variation during drying time for all specimens*

| Specimen | Unit | Mass after casting | Mass after 7 days | Mass after 21 days | Mass after 40 days | Mass loss % |
|---|---|---|---|---|---|---|
| *PLS – perlite* | *kg* | *31.25* | *29.9* | *29.4* | *29.2* | *6.56* |
| *ECLS – expanded clay* | *kg* | *44.74* | *37.7* | *37.2* | *37.0* | *17.29* |
| *HCLS – hempcrete* | *kg* | *31.480* | *27.7* | *26.5* | *26.0* | *17.41* |
| *HCLS-M – hempcrete with NHL3.5* | *kg* | *34.56* | *32.5* | *28.7* | *27.4* | *20.72* |

According to the measurements presented in Table 3, the highest loose of mass was obtained for HCLS-M sample. In Fig. 4, is represented the variation of mass during 40 days of drying time.

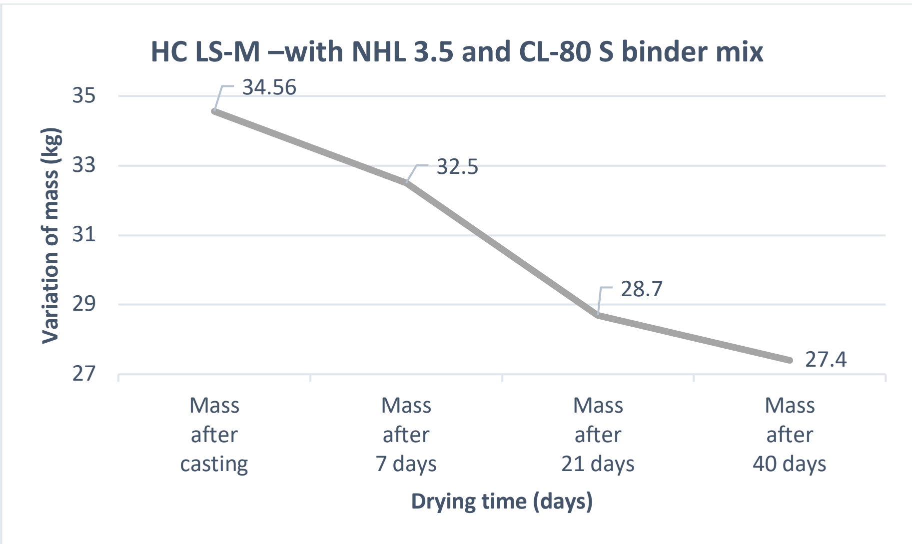


Fig. 4 – Variation of mass specimen in 40 days of drying for HCLS-M specimen.

All the samples where weighted and the density vas calculated in Table 4 to observe the differences. ECLS has reached the highest value of density 1412.21kg/m$^3$. Even if the HCLS-M has a density of 1030kg/m$^3$ with an optimization it cand reach values below 1000kg/m$^3$ the limit of the light weight concrete. The same characteristic of low density is obtained in case of HCLS sample. Is important to understand and make the comparation between these two samples casted using hemp hurds when the heat transfer coefficient will be measured. The HCLS-M is denser then HCLS because the reducing of the hemp hurds amount with 21% and the amount of sand with 69% in the same time increasing the total mass of binder mix, has resulting in an increase of compaction degree.

**Table 4**
*Density of the specimens after 40 days from casting*

| Specimen | Mass kg | Volume $m^3$ | Density $kg/m^3$ |
|---|---|---|---|
| *PLS – perlite* | *29.2* | *0.0262* | *1114.50* |
| *ECLS – expanded clay* | *37.0* | *0.0262* | *1412.21* |
| *HCLS – hempcrete* | *26.0* | *0.0262* | *992.37* |
| *HCLS-M – hempcrete binder mix* | *27.4* | *0.0262* | *1030.53* |

### 3.1. Heat transfer coefficient

To determine the heat transfer coefficient, 3 measurements were performed for each of the 4 specimens. The measurements were made, as it shown in Fig. 5, using ISOMET 2114 – a portable system for measurement of heat transfer properties of materials. The values are presented in Table 5.

**Table 5**
*Values measured for the heat transfer coefficient*

| Probe | Specimen | $\lambda_1$ W/m·K | $\lambda_2$ W/m·K | $\lambda_3$ W/m·K | Average | Density $kg/m^3$ |
|---|---|---|---|---|---|---|
| *P 1* | *HCLS* | *0.2857* | *0.2854* | *0.2848* | *0.2853* | *992.37* |
| *P 2* | *HCLS-M* | *0.3304* | *0.3309* | *0.3310* | *0.3308* | *1030.53* |
| *P 3* | *PLS* | *0.6892* | *0.6884* | *0.6897* | *0.6891* | *1114.50* |
| *P 4* | *ECLS* | *0.7129* | *0.7181* | *0.7173* | *0.7161* | *1412.21* |


Fig. 5 – Measurement for the heat transfer coefficient.

The lowest value for the heating transfer coefficient was obtained by HCLS sample with average of 0.2853W/m·K at a density of 992.37kg/m$^3$. Close values were obtained in the case of HCLS-M sample with an average of 0.3308W/m·K and a density of 1030.53kg/m$^3$. More than double values were measured in the case of ECLS with an average of 0.7161W/m·K at a density of 1412.21kg/m$^3$.

### 3.2. Mechanical behavior – Force-Displacement curve comparation between HCLS and HCLS-M sample

In Fig. 6 is compared the Force-Displacement curve between HCLS and HCLS-M sample to observe the difference between recipes.

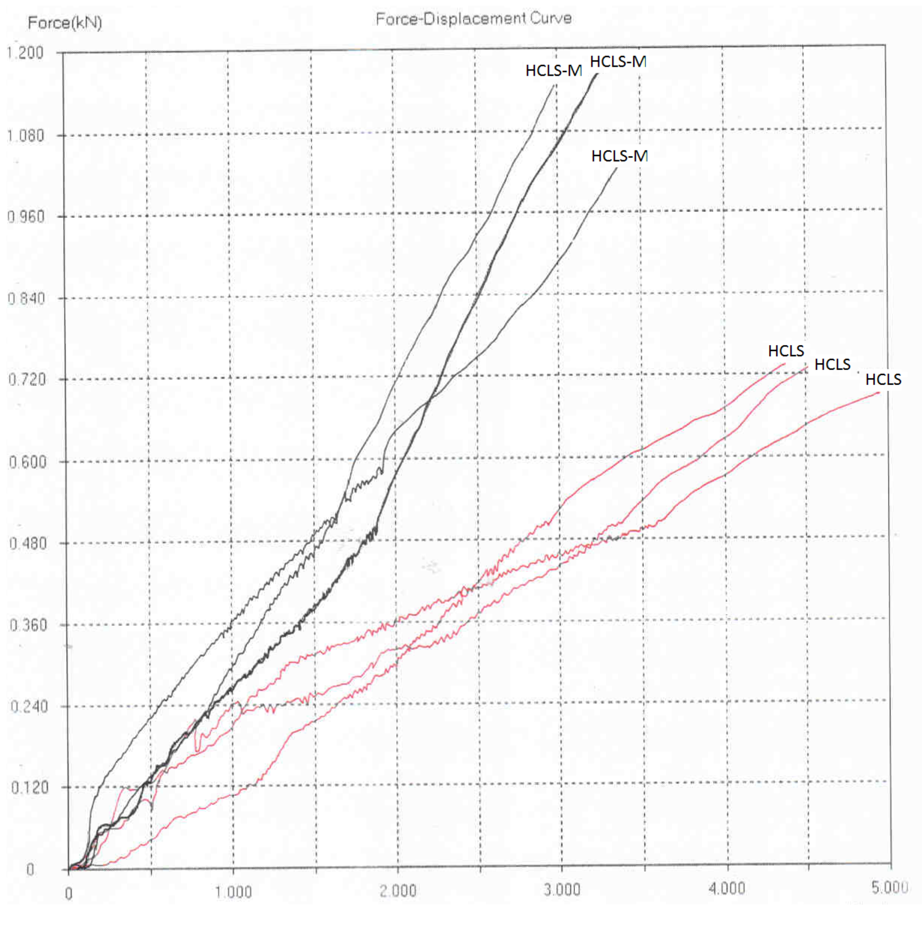


Fig. 6 – Comparation between HCLS-M and HCLS samples by the Force-Displacement curve.

According to Table 2, the amount of Portland cement was reduced in HCLS-M recipe compared with HCLS-M recipe. In the Fig. 6 the mechanical behavior of the HCLS-M shows and optimization of the Force-Displacement curve even if the binder mix has a lower amount of Portland cement. The use of saw dust shows that replacing the sand from the HCLS recipe has increasing the mechanical resistance and doesn't alter the thermal insulating properties.

### 3.3. Degree of surface finish

To justify the advantage of using HCLS-M hempcrete levelling screed with natural binder mix, the surface of the sample was grinded with sand paper after 7 days of drying. The result is shown in Fig. 7.

Fig. 7 – HCLS-M sample finished with sand paper and applied a water base stain protection.

The highest degree of finishing was obtained in the case of the HCLS-M recipe. The surface is smooth, continuous, without loose elements, without air gaps, without cracks. In terms of texture and color, the appearance resembles OSB type chipboard. In order to improve the appearance and obtain a superior texture in terms of design with influences and in increasing the mechanical and thermal resistance, quantities of hemp fiber up to 10% of the hemp hurds mass can be used. The granularity of the hemp particles can be varied so as to achieve a higher density of wood mass per volume of the sample. Pigments can be used for mass coloring of the material made during mixing.

Advantages of using hemp concrete for leveling screeds are:

- Reduction of the load on the resistance structure as a result of the decrease of the specific mass;
- Reducing the amount of cement and implicitly the emissions of CO2 into the atmosphere;
- Increasing the degree of thermal and sound insulation with a role in the thermal efficiency of constructions.

## 4. Conclusions

Considering that HCLS-M sample has a lower amount of Portland cement, the heating transfer coefficient is at the limit of thermally insulating materials with a value a little over 0.3W/m·K, with real possibilities to optimize the thermal behavior and taking in to account that has a good mechanical resistance and it can be finished so that it can reduce the amount of working process and materials need for construction industry it can be concluded that hempcrete levelling screed with natural hydraulic binder mix can be a viable alternative to standard levelling screed.

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## ȘAPĂ DE EGALIZARE DIN BETON ECOLOGIC, O SOLUȚIE SUSTENABILĂ PENTRU INDUSTRIA CONSTRUCȚIILOR

În contextul actualei crize energetice, accentul pus pe identificarea de soluții eco-sustenabile pentru industria construcțiilor crește semnificativ. Materialele utilizate, tehnologiile de asamblare și forța de muncă sunt principalele costuri care se regăsesc în prețul final al unei construcții noi sau în reabilitarea clădirilor vechi. Cu toate acestea, interesul pentru reducerea costurilor trebuie să fie însoțit în egală măsură de preocuparea pentru reducerea impactului activităților umane asupra ecosistemelor naturale. Lucrarea prezintă o posibilă soluție tehnică pentru realizarea șapei de nivelare pe bază de material vegetal biodegradabil obținut din tulpina cânepii industriale. Sunt prezentate două variante de realizare a șapei de nivelare folosind ca material de bază tocătura obținută din partea lemnoasă a tulpinii de cânepă. Rezultatele obținute au fost comparate cu două variante actuale de turnare a șapei de nivelare, cum ar fi șapele perlitice sau șapele din argilă expandată. Scopul este acela de a furniza informații tehnice verificate prin teste de laborator pentru a schimba perspectiva asupra materialelor de construcție obținute din deșeuri vegetale și adoptarea acestor tipuri de materiale ca soluții viabile pentru decarbonatarea industriei de profil.