CHEMIA
CZASOPISMO TECHNICZNE
TECHNICAL TRANSACTIONS
CHEMISTRY
WYDAWNICTWO POLITECHNIKI KRAKOWSKIEJ
1-Ch/2011
ZESZYT 8
ROK 108
ISSUE 8
YEAR 108

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APPLICATION OF HEMP IN PREPARATION OF BUILDING MATERIALS

WYKORZYSTANIE KONOPII W PRODUKCJI MATERIAŁÓW BUDOWLANYCH

Abstract

Composites based on natural materials and sustainable resources, especially cellulose, are increasing in importance due to their numerous applications in the preparation of building materials as well as their advantages, such as being cheap, lightweight, environmentally friendly and also biorenewable. Hemp is one of the most interesting renewable materials. This paper examines the use of hemp shives waste from the production of hemp fibres in combination with binding agents as building materials with regard to mechanical properties.

Keywords: hemp shives, water absorption, compressive strength

Streszczenie

Kompozyty, bazujące na materiałach naturalnych, w szczególności celulozie, znajdują coraz szersze zastosowanie w produkcji materiałów budowlanych ze względu na ich właściwości aplikacyjne, takie jak cena, gęstość, właściwości ekologiczne. Konopie należą do szczególnie interesujących materiałów odnawialnych. W pracy badano możliwość wykorzystania odpadów z produkcji włókien lnianych do wytwarzania materiałów budowlanych, z uwzględnieniem ich właściwości mechanicznych.

Słowa kluczowe: włókna lniane, absorbcja w wodzie, wytrzymałość mechaniczna

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1. Introduction

Materials based on natural fibres represent one of sustainable construction materials coming from recoverable material resources in agriculture. Hemp shives as industrial waste from the production of hemp fibres has the most important application mixed with an appropriate lime binder in the construction of both domestic and industrial buildings. The utilization of an alternative material, such as MgO-cement binder, is interesting for other applications of hemp shives.

Hemp concrete (composite) is more and more recommended by eco builders in sustainable development. This plant material has a low environmental impact [1]. All polymer composites absorb moisture in a humid atmosphere and when immersed in water. The effect of moisture leads to the degradation of fibre-matrix interface region creating a poor stress, and therefore transfers efficiencies resulting in a reduction of mechanical and dimensional properties [2].

Our previous studies show the mechanical and thermal degradation behaviour of hemp composites after different thermal loading [3, 4], and this paper is focused on the study of water influence on the mechanical properties of a composite material based on hemp shives.

2. Materials and Methods

Hemp shives originating from a Hungarian company were used as raw materials. The granulometric composition of the original hemp shives is represented by the cumulative granulometric curve in Fig. 1. Table 1 summarizes the granulometric composition of MgO and silica sand as components of the mixture. The composition of the mixture is given in Table 2.

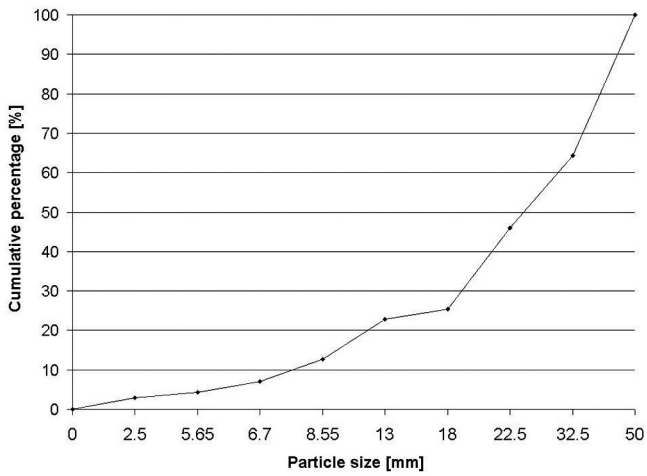

Fig. 1. Cumulative granulometric curve of hemp shives

Rys. 1. Krzywa granulometryczna odpadów lnianych

Table 1

Granulometric composition of caustic magnesite and silica sand

Fraction [mm]	Mass yield [wt.%]	
	MgO	silica sand
0.5–1	18.25	14.75
0.25–0.5	34.75	63
0.125–0.25	30	19.75
0.063–0.125	13.5	2
–0.063	3.5	0.5

Table 2

Composition of experimental mixture

Mixture components		Component content in experimental mixtures [vol.%]
Hemp shives		40
MgO–cement	milled MgO	9.5
	silica sand	9.5
	$NaHCO_3$	9.5
Water		31

The effect of MgO milling has been investigated in order to reduce its particles size [5]. Dry milling was carried out in the laboratory vibratory mill VM-4 within 5–60 minutes. The particle size analysis of the milled products was carried out on the laser granulometer Helios with a dry dispersion unit Rodos (Sympatec, Germany). The specific surface area of powders was determined by the standard BET method using the equipment Gemini 2360 (Sy-lab, Austria). The product of 5-minute milling was chosen as the most suitable for the next research; its mass yield for fraction under 5 μm was 53.02 wt.% and mean particle diameter was 6.852 μm. The mixture was prepared in a labour mixer and standard steel cube forms of 100mm x 100mm x 100mm in size were used for the preparation of specimens. The next day the composites were taken out of the forms and cured under laboratory conditions according to standard rules. The effect of water on the compressive strength which included the measurement of length, width, thickness and weight of the specimens was observed. Firstly, all the specimens were dried in an oven at 70°C and then cooled and weighed. Water absorption was carried out by immersing the hemp composites in de-ionised water bath (PE closed container) at laboratory temperature for different time durations. After the immersion for 7 days and 28 days, the specimens were taken out from water and all of the surface water was removed with a clean dry cloth. The specimens were reweighed, changes in dimensions were measured again, and afterwards the specimens were dried in an oven at 70°C up to a constant weight for the following measurement of density and compressive strength.

3. Results and Discussion

The changes in dimensions of specimens before and after the experiment (T1, T2 – after 7 days and T3, T4 – after 28 days) are presented in Fig. 2. As it can be seen, dilatation changes of 0.11% on average occur after 7 days of immersing in water, and up to 1.05% after 28 days. The water content in hemp composites was 21.38%. After 7 or 28 days of immersion these were 28.3% or 24.7%, respectively. The porous structure of the fibre has an impact on water absorption and also on changes of density.

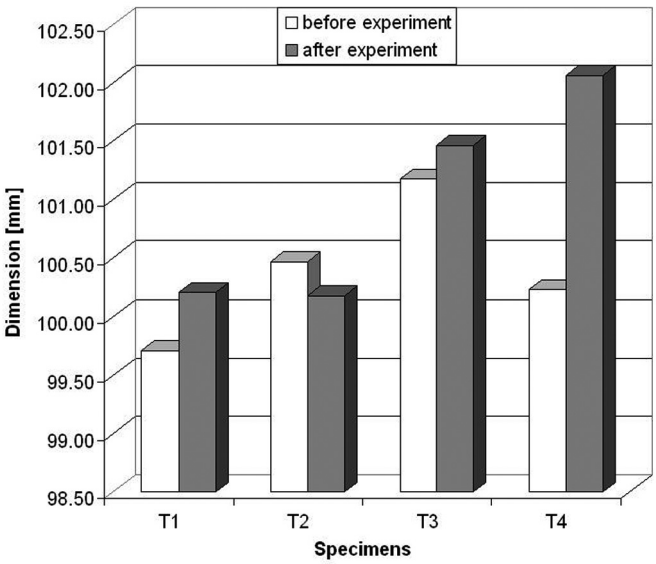

Fig. 2. Changes of specimens dimensions

Rys. 2. Zmiany wymiarów próbek

The results for density of hemp composites (Fig. 3) show that the values are partially reduced after 7 days compared with the reference sample (990 kg/m^3), but density is partially increased after 28 days. The compressive strengths of experimental composites reached lower values after 7 and 28 days (2.51 and 1.59 MPa, respectively) in comparison to the reference specimens (2.54 MPa). The alkaline reaction changes of leachate composites were also evaluated (Fig. 4). The pH of de-ionized water was estimated before the experiment, and afterwards the pH values of leachates (solutions) in containers (composites T1 to T9) were determined by the potentiometric method. During the first 7 days, the pH of leachates was determined at regular intervals until the pH stopped changing further. Fig. 4 graphically shows the comparison of changes in the pH values of leachate samples T1-T4 and an average pH value calculated for all 9 samples. As it can be seen, the pH value was still stabilized at the value of 11.65 after 48 hours. The experiment continued for 90 and 180 days.

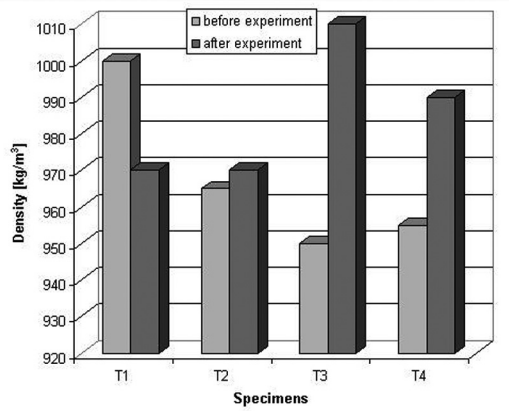

Fig. 3. Density of composites

Rys. 3. Gęstość kompozytów

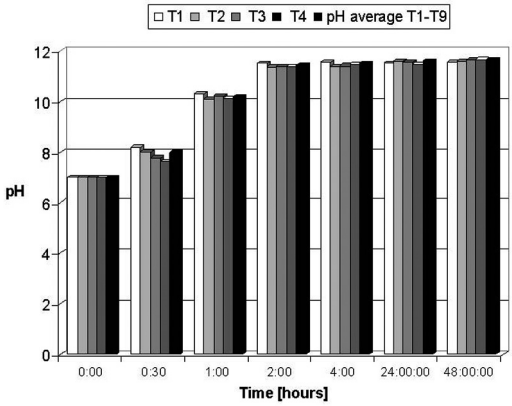

Fig. 4. pH changes of leachates

Rys. 4. Zmiany pH odcieków wodnych

4. Conclusions

It can be noted from the results of the assessment of composites durability based on an organic filler that the dilatation changes, but also a change in compressive strength occurs just after 7 days of static exposure of composites in the water environment. The changes in compressive strength were significant after 28 days. The following experiments aiming to develop treatment methodologies or to ensure secondary protection of final products in order to eliminate the negative effects of water absorption will address the character of the filler (hemp shives).

The authors are grateful to the Slovak Grant Agency for Science (Grant No. 1/0498/09) for the financial support of this work.

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