Available online at www.sciencedirect.com

ScienceDirect

Procedia Manufacturing 22 (2018) 372–379

Procedia MANUFACTURING

www.elsevier.com/locate/procedia

11th International Conference Interdisciplinarity in Engineering, INTER-ENG 2017, 5-6 October 2017, Tirgu-Mures, Romania

X-ray diffraction study on new organic- natural building materials

Raluca Fernea[a,*], Iacob Florea[a], Daniela Lucia Manea[a], Petru Păşcuţă[a], Daniela Roxana Tămaş-Gavrea[a]

[a]*Technical University of Cluj-Napoca, 28 Memorandumului Street, 400114, Cluj-Napoca, Romania*

Abstract

Sustainable constructions aim to use recycled products and renewable natural materials to minimize resource consumption and primary energy, but also to enhance the quality of life. The development of new organic natural products based on renewable resources which connect the environment with buildings is a must. The reason for bringing new organic materials on the market is because of the building sector becoming the largest consumer of natural resources. The focus of this study is on the hemp based materials. The hemp plant is a renewable natural resource with an annual regeneration. Hemp has the capacity to absorb carbon dioxide from the atmosphere in the entire period of its existence. However, a deeper understanding of the interaction between the raw materials of the composites materials based on hemp shiv and white cement is needed. An X –ray diffraction for identifying the mineral composition was made on the raw materials, but also on the composite materials resulted.

Peer-review under responsibility of the scientific committee of the 11th International Conference Interdisciplinarity in Engineering.

Keywords: X-ray diffraction; sustainability; hemp; white cement; composite materials.

1. Introduction

The organic-natural building materials represent a solution for the construction sector, which can contribute to a better protection of the environment and to have a positive impact on human life. In the last years many

* Corresponding author.
E-mail address: ralucafernea@gmail.com, ralucafernea@ccm.utcluj.ro

2351-9789
Peer-review under responsibility of the scientific committee of the 11th International Conference Interdisciplinarity in Engineering.
10.1016/j.promfg.2018.03.056

research papers were made on new building materials that have in the composition raw or recycled materials. A special attention was placed on the study of agricultural plants mainly the technical plants as: hemp, flax, jute and so on. These plants are rich in fibres and are used, in principal, for reinforcing the materials. The fibbers of agricultural plants are unlimited, cheap, biodegradable, eco-friendly, non-abrasive, renewable resources that can be used in building materials as a polymers or to have different applications. The use of these fibres in construction sector receives a lot of attention due to their specific mechanical properties which are very close to the synthetic ones. Completing the advantages listed above, the natural fibres present good characteristics when are used in cement-based materials. In the process of developing new bio based composite materials, it is very important to know the chemical structure of the fibres. [1,2]

Hemp plant is known as Cannabis Sativa and the cultivation process is not complicated, because the chemical treatments for fertilize and herbicide are not necessary. There are two kinds of hemp fibres, the long ones- bast fibres and the small fibres called also the woody core fibres or hurds. The hemp plant consists of 20-40 % of long fibres and 60-80% of hurds. The bast fibres are usually used in the textile industry and paper and the woddy hemp core for animal bedding and a small percentage in construction industry. The chemical structure presented in the hemp plant is composed of cellulose 40-48 % in shivs and 57-77% in fibre, hemicellulose 18-24 % in shivs and 9-14% in long fibre, lignin 21-24% in woody core fibre and 5-9% in long fibres.[3] Cellulose offers the plants the strain stability, strength and rigidity. It is a natural polymer, a semi-crystalline polysaccharide with an increase amount of hydroxyl group which contribute to a low resistance of moisture absorption. Hemicelluloses are responsible for the hygroscopic character of the plant. It is polysaccharide and has an amorphous structure. Lignin is the element that gives to the plant the possibility of reaching high heights. It has an amorphous structure and it is defined by a hydrocarbon polymer. Pectin is responsible for the flexibility of the plant and it is a heteropolysaccharide. The wax decreases the adhesion properties of the fibres.[2]

According to [4] one tonne of harvested stem of hemp contains: 0.7 tonnes of cellulose (45% Carbon), 0.22 tonnes of hemicellulose (48% Carbon) and 0.06 tonnes of lignin (40% Carbon). Therefore one tonne of industrial hemp stems contains 0.445 tonnes Carbon absorbed from the atmosphere (44.46% of stem dry weight). [4] The process of retain the CO_2 is defines true the store of energy from sunlight in the chemical bonds of hemp plant. When the bonds between adjacent carbon, hydrogen and oxygen molecules are broken by combustion, or decomposition, these substances release their stored, chemical energy.[5]

The Portland cement is defined as a mixture of limestone and clay, which form the clinker and ground gypsum, responsible for the connection. A standard morphology and composition of cement compounds there is not exist the compounds differ from the manufacturing process to the raw material used. In the study [6] the principal chemical elements presented in cement are: Ca, Si, Al, Fe, Mg, Na and K, and they formed phases. [6] In the clinker composition there are more than 30 phases, but the most relevant are the following four:

- Alite $C_3S= Ca_3SiO_5$, is the most important compound of the cement, is a calcium silicate which has the highest speed of hydrolysis and a faster reaction, and it responsible for the short term resistance.
- Belite $C_2S= Ca_2SiO_4$, is a hydrated dicalcium silicate which helps the new material based on cement to obtains long- term resistance, reacts very easy in water.
- Celit $C_3A= Ca_3Al_2O_5$, as a cement compound celite has a rapid impact in the water which helps to obtaining an instantaneous setting of slurry.
- Bronwmilerit $C_4AF= Ca_4\ Al_2Fe_2O_{10,}$ contributes with a small percent in the final strength of the product. [6,7,8]

In the scientific literature, many researches have as a target the hemp based materials. Many of the studies reported to the hemp fibres and their characteristics. Regarding building materials the existing studies are based on hemp and lime and only a few of them treat the influence of the hemp hurds in the cement. For this reason the present study is focused only on the cement, as a binder; for the hemp based materials. It is a good model for understanding the reactions of the composite materials which are responsible for the early strength.