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BIOCOMPOSITES FROM TANNED LEATHER FIBRES WITH APPLICATIONS IN CONSTRUCTIONS

ABSTRACT. In tanneries, only approx. one-third of the total mass of raw hides and skins is converted to finished leather, while two-thirds become either dissolved or solid waste. As part of the natural materials category, usually considered waste, leather fibers introduced into cement mortar panels play a fundamental role in construction due to both insulation properties and mechanical strength. Waste is introduced as a powder or filler or as aggregates in the concrete mix, with energy, economic and environmental benefits. The originality and innovative contribution of the scientific paper consists in re-evaluation of tanned leather waste from the leather sector by turning them into raw materials with added value and using them in construction materials industry, by developing new production concepts for new biocomposite materials. **KEY WORDS:** tanned leather fibres, biocomposites, Portland cement

BIOCOMPOZITE DIN FIBRE DE PIELE TĂBĂCITĂ CU APLICAȚII ÎN CONSTRUCȚII

REZUMAT. În tăbăcării, doar cca. o treime din masa totală a pieilor brute de animale mari și mici este transformată în piele finită, în timp ce două treimi devin fie deșeuri dizolvate, fie solide. Făcând parte din categoria materialelor naturale, considerate de obicei deșeuri, fibrele de piei introduse în panouri din mortar de ciment, joacă un rol fundamental în construcții datorită atât proprietăților de izolare, cât și de rezistență mecanică. Deșeurile sunt introduse ca pulbere sau umplutură sau ca agregate în amestecul de beton, având avantaje din punct de vedere energetic, economic și de protecție a mediului. Originalitatea și contribuția inovatoare a lucrării științifice constă în reevaluarea deșeurilor din piele tăbăcită din sectorul de pielărie prin transformarea acestora în materii prime cu valoare adăugată și prin utilizarea în industria materialelor de construcție prin dezvoltarea unor noi concepte de producție pentru materiale biocompozite noi. **CUVINTE CHEIE:** fibre de piele tăbăcită, biocompozite, ciment Portland

BIOCOMPOSITES DE FIBRES DE CUIR AVEC APPLICATIONS DANS L'INDUSTRIE DE LA CONSTRUCTION

RÉSUMÉ. Dans les tanneries, seulement env. un tiers de la masse totale des peaux bruts est converti en cuir fini, tandis que deux tiers deviennent des déchets solides ou dissous. Faisant partie de la catégorie des matériaux naturels, généralement considérés comme des déchets, les fibres de cuir introduites dans les panneaux de mortier de ciment jouent un rôle fondamental dans la construction en raison à la fois des propriétés d'isolation et de la résistance mécanique. Les déchets sont introduits sous forme de poudre ou de charge ou sous forme d'agregats dans le mélange de béton, avec des avantages énergétiques, économiques et environnementaux. L'originalité et la contribution innovante de l'article scientifique consistent à réévaluer les déchets de cuir tannés du secteur du cuir en les transformant en matières premières à valeur ajoutée et en les utilisant dans l'industrie des matériaux de construction pour développer de nouveaux concepts de production pour de nouveaux matériaux biocomposites. **MOTS CLÉS :** fibres de cuir, biocomposites, ciment Portland

INTRODUCTION

The leather processing industry has made significant efforts in recent years on the improved efficiency in using energy and materials, as well as in discarding the use of hazardous materials in production phases [1]. Solid waste (from raw hide and tanned leather, residual wool and sludge from wastewater treatment) is a significant issue of the leather sector [2-3].

Nowadays, the cement industry is responsible for 5-7% of global CO₂ emissions. To reduce them, new technological solutions and new building materials have recently been developed to protect natural resources. Thus, the concept of "green" materials involved both natural fibers and a large amount of waste. Natural fibers are used to improve the mechanical performance of cement-based composites instead of synthetic ones (e.g.

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PVA or polypropylene) as they provide greater tensile strength, ductility and post-cracking behavior and, at the same time, are increasingly appreciated due to their specific properties, low prices, health benefits and recyclability.

A ton of wet salted hide produces over 100 kg of waste of tanned leather waste [4]. The leather shaving process is done in tanneries in order to obtain a uniform leather thickness, but due to its low specific weight, a large amount of waste is accumulated in tanneries.

The paper presents the obtaining of biocomposites using leather shavings, with application in constructions. Three types of biocomposites were obtained by mixing 1% of 3 types of leather fibers: leather fibers treated with concentrated sulfuric acid (FPA); leather fibers neutralized with calcium hydroxide (FPN) and leather fibers immersed in a polymer binder (FP) with common Portland cement commercially known as Structo Plus®.

EXPERIMENTAL PART

Materials and Methods

Leather shavings used in this work comes

from the shaving process of 35 kg of hides from the SC PIELOREX SA tannery in Jilava, Ilfov County.

Leather shavings were chemically treated to immobilize the chromium ion in the common Portland cement matrix.

Obtaining of Leather Fibers

Tanned leather waste (shaving and small pieces) was defibrated with a knife mill used in the rubber industry, resulting in about 100 kg of tanned leather fibers. 600 g of leather fibers were hydrolyzed with 2% concentrated sulfuric acid solution at 80°C for 60 minutes resulting in FPA fibers. Then some of these fibers were neutralized with a 10% sodium hydroxide solution, so the pH increased from 1.78 to 6.12 (FPN fibers). Also, 330 g of leather fibers were immersed in a 3.5% polymer binder solution used in the pulp and paper industry (FP fibers).

Table 1 shows the physicochemical analyses of leather fibers treated with concentrated sulfuric acid and neutralized with calcium hydroxide (FPA and FPN).

Table 1: Physicochemical characterisation of tanned leather fibres

No.	Characteristics	UM	Sample code/ determined values		Method standard
			FPA	FPN	
1	Dry substance	%	8.53	12.12	SR EN ISO 4684 : 2006
2	Ash	%	18.29	21.70	SR EN ISO 4047 : 2002
3	Total nitrogen	%	12.66	12.71	SR ISO 5397 : 1996
4	Dermal substance	%	71.15	71.43	SR ISO 5397 : 1996
5	Chromium oxide	%	5.16	4.37	SR EN ISO 5398/1 :2008
6	pH	pH unit	1.78	6.12	STAS 8619/3 :1990
7	Calcium oxide	%	0.23	0.25	

Values of ash, total nitrogen and dermal substance are reported free of volatile matter.

Obtaining of Biocomposites

In the laboratory phase, cement composites reinforced with tanned leather fibers were obtained at a content of 1% by weight (replacing cement with leather fibers) which have been studied physically and mechanically.

The biocomposites were made by mixing 1% leather fibres with composite additivated Portland cement (Structo Plus®). This cement is made in Romania for residential and commercial

buildings, interior and exterior elements (paving blocks) and contains a component (Duraditiv®) whose action improves the properties of concrete ensuring durability of the final product.

Physicomechanical Characterisation of Biocomposites with Leather Fibres and Portland Cement

Characterisation of biocomposites was conducted at the Technical University of Civil Engineering of Bucharest (UTCB).

Determination of mechanical strengths (compressive and flexural strength) was conducted according to the following standards: STAS 4606-1980 «Natural heavy weight aggregates for mortars and concrete with mineral binding material. Testing methods», and EN 196-1:2016 «Methods of testing cement. Determination of strength».

The samples were made in metal moulds of 40x40x160 mm on solid brick, according to STAS 2634-80. The samples were evaluated after 7 and 28 days in terms of physicomechanical properties (compressive and flexural strength).

Compressive strength of biocomposites was determined after 7 and 28 days and results were compared with the control containing only cement. Charts are the average of 3 determinations of compressive strength.

RESULTS AND DISCUSSIONS

The analysis of experimental data showed that the values of compressive strength of FPA, FPN and FP biocomposites are higher compared to the control sample (without leather fibers), after 7 days, by 36÷48,7%, and after 28 days, they are 11,6÷13,2% higher. (Fig. 1 and 2)

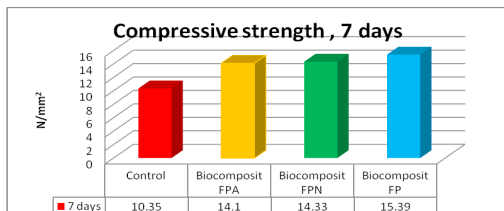


Figure 1. Compressive strength of biocomposites after 7 days

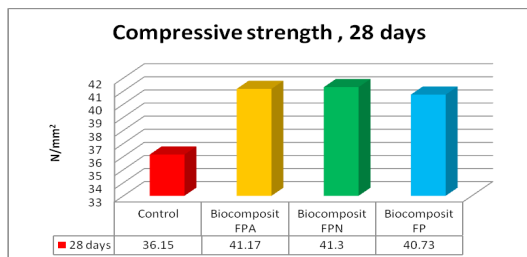


Figure 2. Compressive strength of biocomposites after 28 days

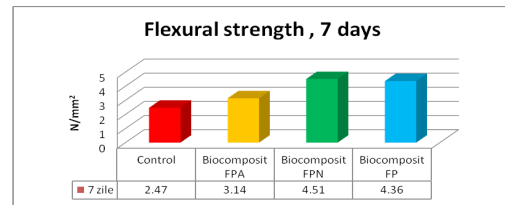


Figure 3. Flexural strength of biocomposites after 7 days

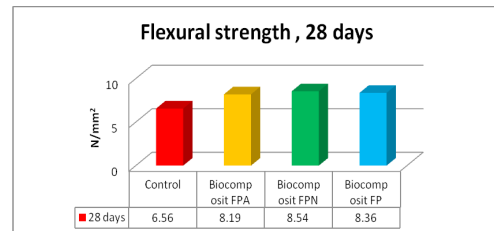


Figure 4. Flexural strength of biocomposites after 28 days

Flexural strength of biocomposites was determined after 7 and 28 days and results are presented in comparison with the control containing only cement (Fig. 3 and 4).

Analysis of charts 3 and 4 shows that flexural strength of FPA, FPN and FP biocomposites are higher compared to the control (without leather fibers), after 7 days by 27,1÷82,6%, and 28 days, values are 24,8÷30,2% higher.

Technology of Obtaining Biocomposites - Conceptual Model

In order to make an accurate conceptual model a series of tools are used for modelling, among which the most frequently used is the entity-relationship diagram.

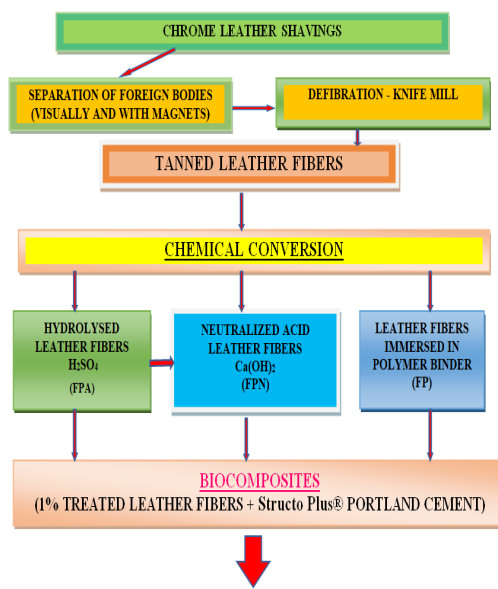


Figure 5. Technology for obtaining biocomposites with leather fibers – conceptual model

CONCLUSIONS

Experiments were carried out to obtain biocomposites from leather waste with applications in the building materials industry. Three kinds of fibres were obtained, namely acid-treated leather fibres (FPA), calcium hydroxide-neutralized leather fibers (FPN) and leather fibres immersed in a polymer binder (FP). Biocomposites were made by blending 1% of treated leather fibers and conventional Portland cement with the trade name Structo Plus®.

The effect of adding chemically treated leather shavings on the characteristics and microstructure of biocomposites has been studied. The addition of low-pH treated leather waste (sulfuric acid) minimizes Portlandite formation and favours the formation of calcium sulphate.

The results obtained for mechanical strength (compressive and flexural strength) of FPA, FPN and FP leather fibers biocomposites both after 7 days and 28 days are higher than the control (no fibre).

In conclusion, the shavings waste resulting from leather processing can be used to obtain biocomposites with applications in the construction industry.

Acknowledgment

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