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The Technological Properties of Polymer Composites Containing Waste Sheep Wool Filler

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Abstract. New technologies are using natural fibres in composites materials in the industry. It is still often natural fibres in modern buildings, chemists, airports, sport and automotive. Using for construction pieces and their better properties than steel or traditional materials. New forward science and technic are recycled or decrease waste. The problem for central Europe is a waste of agricultural, invention relates to an epoxy resin filled with an organo-inorganic filler of natural origin, production especially plants and sheep wool as well as other usable wastes such as old textiles. New applications are in new construction types and industries finding cheaper materials. There is available modern technology for injection moulding granulate polypropylene with filler from sheep wool and plant fibres. For example, to make furniture or building cladding. This could reduce waste production, pollution of nature and emissions in the production of these products from new raw materials. The work presents the possibilities of using new polymer-based materials contain sheep wool as filler. The paper deals with the evaluation of the mechanical properties of the effect of the addition of sheep wool in a concentration of 3% to selected types of thermosetting matrices. In the experiments, the modulus of elasticity, tensile strength, ductility and deformation work were built on the sample set. The results are statistically processed and document the possibilities of adjusting the mechanical properties of composites with sheep wool.

Introduction

Sheep wool is natural fibre from fleece with coating safe before insect pests. For experiments, it was a good way because do not have to use many litres of water to clean raw sheep wool. This material is use in timbered buildings. Sheep wool has very good temperature resistant. Another use for temperature roof insulation family houses and similar applications. It is start material for our experiments. The problem of central Europe is a waste of agricultural. In the article [1] the authors describe invention relates to an epoxy resin filled with the organo-inorganic filler of natural origin. In the article [2] the authors describe production especially plants and sheep wool as well as other usable wastes such as old textiles. New applications are in new construction types and industries finding cheaper materials. For the filling of a matrix, it is almost an ideal filler. It is possible for some technics and without a special device. In the article [3] the authors describe there is available modern technology for injection moulding granulate polypropylene with filler from sheep wool and plant fibres. For application in less stressed parts, it is also possible to use another matrix with fillers from these waste materials for products daily needs in focus are green materials as well as materials where will be can recycle again. For example in the article [4] the authors describe, to make furniture or in the article [5] the authors describe building cladding. This could reduce waste production, pollution of nature and emissions in the production of these products from new raw materials. The work presents the possibilities of using new polymer-based materials contain sheep wool as filler. In the article [6] the authors describe destructive methods such as tensile and bending

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tests, water absorption, chemical absorption and biodegradable tests of woven sheep fibers reinforced with 40% and 50% epoxy composites under various operating conditions, where the research was focused on the physical and chemical characterization of composites made of polymer matrix reinforced with sheep wool. By this measurement, it was found that a 50% loading had a higher moisture absorption than a 40% loading that had a higher chemical absorption. Both tested fillings are biodegradable equally. Surfaces were examined by scanning electron microscope. In the article [7] the authors describe the possibility of using sheep wool as a filler in cement for mortar or gypsum production, which brings several environmental benefits, especially waste savings. The authors investigated the effect of wool fibres on the thermal conductivity and mechanical properties of cement, using samples from the Sicilian sheep breed with three lengths of 1; 6 and 20mm. They also tested the effect of fibre content prepared by weight change. The thermal conductivity of the samples was tested using a heat flux meter and the mechanical behaviour by compression tests. Experimental results have shown that wool fibres can be used in cement matrices for use in mortars and plasters, but with a significant reduction in compressive strength, which may be a new idea for future research. In the book [8] the author briefly presents the possibilities of their application in aviation, aerospace, floor coverings, railings, window and door frames, fencing, home furniture, sports equipment and last but not least the body parts of racing cars. In the article [9] the authors describe the quest for sustainability in construction material usage has made the use of more renewable resources in the construction industry a necessity. Plant-based natural fibres are low-cost renewable materials which can be found in abundant supply in many countries. This paper presents a summary of research progress on plant-based natural fibre reinforced cement-based composites. Fibre types, fibre characteristics and their effects on the properties of cement-based materials are reviewed. A significant part of the paper is then focused on future trends such as the use of plant-based natural fibres as internal curing agents and durability enhancement materials in cement-based composites. In the article [10] the authors describe innovative geotextiles designed for erosion control and made from meander arranged coarse ropes were produced. The ropes filled with sheep wool and wrapped with woollen nonwoven were buried in the local ground. During one year of soil exposure the progress of wool biodegradation was observed. During investigations, the morphology and chemical composition of wool and change of basic mechanical parameters of single fibres and woollen nonwoven were analysed. In the article [11] the authors describe natural degradation of PLA (polylactic acid) composites with natural fibre reinforcement in non-simulated conditions. The composite material was made of PLA and 6 different types of biodegradable fibres made from pulp, wool, bamboo, soy, flax and hemp. All samples had a 20% volume of fibres. In the article [12] the authors describe the properties and application of natural fibre composites in the automobile industries are discussed. Natural fibres are replacing the synthetic fibres in the various parts of automobiles due to their lightweight, low-cost, and environmental aspects.

Experimental

An insulating strip made of sheep wool fleece sold under the trade name Naturwool A500 by Naturwool s.r.o. was used to prepare the composite material. This material was cut with scissors and milled through a 1mm mesh screen. The mould for the production of specimens was made of silicone rubber sold under the trade name Lukopren N 1522 by the company Lučební závody Kolín. In preparing the matrices, the necessary amount of resin/hardener mixture was mixed in the containers and specimens were formed without the use of sheep wool filler. These specimens are labelled "PU 0%" and "EP 0%". Besides, filled matrices were prepared with the addition of 3 volume percentages sheep wool filler. These specimens are labelled "PU 3%" and "EP 3%". The matrices used are sold by Dawex Chemical s.r.o. The PU is a polyurethane resin with the trade name Gaform R30. Marking EP is an epoxy resin EPOX G20. Test specimens were prepared at room temperature. The orientation of the filler is random in the matrices and was done manually. The specimens have a length of 80 mm, a width of 10 mm and a thickness of 4 mm. The specimens were not heat treated.

The test specimens produced in this way were tested by the three-point bending method according to the standard ČSN EN ISO 14125 and ISO 178 on the universal testing machine ZWICK 1456. The measured values are completely different depending on the type of matrix used.

Table 1 Properties Gaform R30 polyurethane casting resin

Properties		Processing temperature	Standard
Viscosity of component A	285 mPa.s	20 °C	DIN 53211
Viscosity of component B	150 mPa.s	20 °C	DIN 53019
Density of component A	1,05 g/cm³	20 °C	DIN 51757
Density of component B	1,126 g/cm³	20 °C	DIN 51757
Color component A	white		
Color component B	brown		
Mixing ratio	of 100 parts resin to 100 parts hardener		
Pot life	3 - 4 minutes		
Workability	for 20-30 minutes at 20 °C and 200 g		
Hardness	83 Shore D		

Table 2 Properties EPOX G20 transparent epoxy casting system

Properties		Processing temperature
Viscosity of component A	450 mPa.s	23 °C
Viscosity of component B	30 mPa.s	23 °C
Tensile strength	55 Mpa	
Compressive strength	65 Mpa	
Color component A	clear, blue, black	
Color component B	clear, blue, black	
Mixing ratio	of 100 parts resin to 23 parts hardener	
Workability	for 10 - 20 minutes at 23°C and 200 g	

Table 3 Properties Naturwool A 500

Properties	Value (applies to one layer of insulation)
composition	90% sheep wool 10% bicomponent fiber
Density	500 g/m^2
Coefficient of thermal conductivity	0.042 (when pressed to 1/3 0.034)
Thermal resistance	1.20
Diffusion resistance factor	1.50
Heat transfer coefficient	1.07
Sorption mass moisture	20 %
Reaction to fire	E
Maximum operating temperature	170 °C

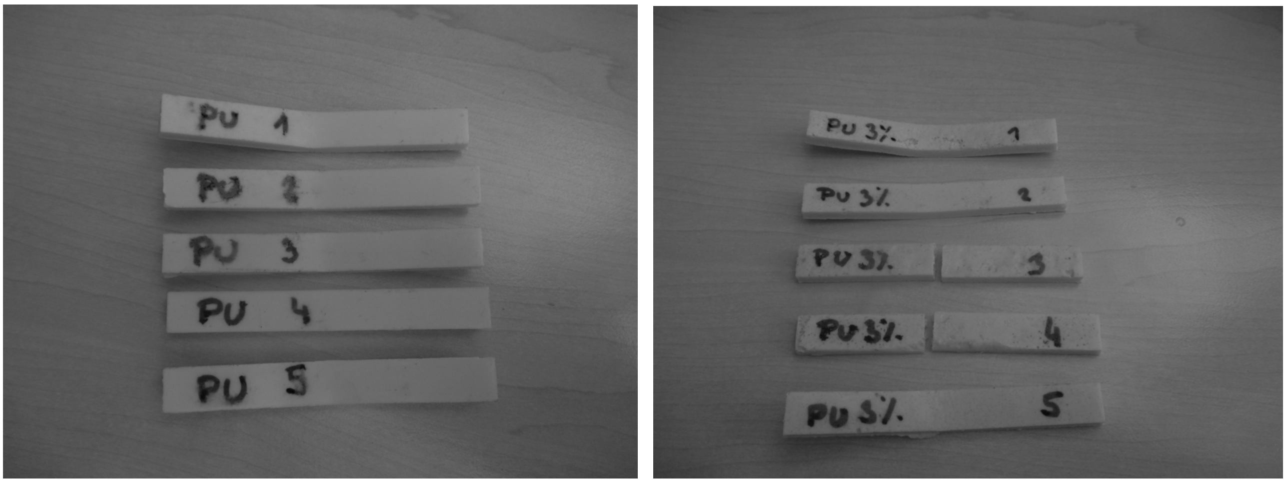

Fig. 1 Tested samples PU 0% and 3%

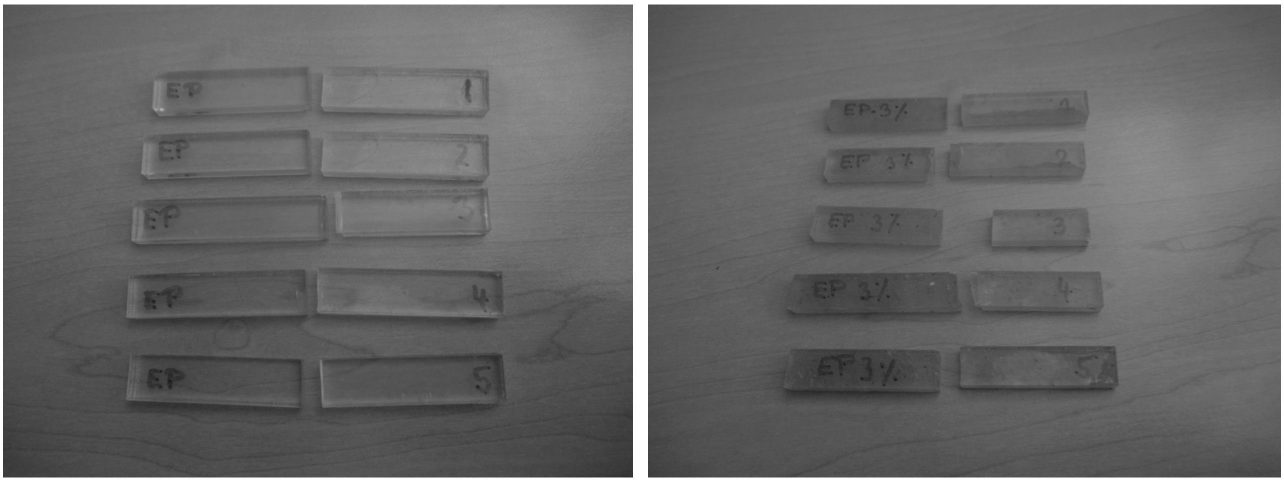

Fig. 2 Tested samples EP 0% and 3%

In Fig. 1 and 2, we see the failure during the bending test PU and EP samples.

Table 4 Measured values for EP samples 0%

i	E_i [MPa]	$σ_M$ [MPa]	$ε_{F\ max}$ [%]	W_M [N.mm]
1	2450	65.7	2.6	254.93
2	2280	51.3	2.1	157.3
3	1640	30.8	1.7	78.86
4	2120	43.4	1.9	118.52
5	2500	55.4	2	165.81

Table 5 Measured values for EP samples 3%

i	E_i [MPa]	$σ_M$ [MPa]	$ε_{F\ max}$ [%]	W_M [N.mm]
1	2560	60.3	2.3	205.75
2	3110	71	2.3	255.59
3	2290	53.1	2	160.01
4	2900	60.6	1.9	168.21
5	1780	46.5	2.4	169.03

Table 6 Measured values for PU samples 0%

i	E_i [MPa]	$σ_M$ [MPa]	$ε_{F\,max}$ [%]	W_M [N.mm]
1	1280	41	5.1	409.71
2	1180	38.3	5.1	380.19
3	1480	47.7	5.2	479.17
4	835	30.5	5.6	330.12
5	1200	39.5	5.1	386.75

Table 7 Measured values for PU samples 3%

i	E_i [MPa]	$σ_M$ [MPa]	$ε_{F\,max}$ [%]	W_M [N.mm]
1	1040	28.9	4.9	283.84
2	1080	32.5	5.3	344.12
3	1300	37.8	4.3	312.51
4	541	16.9	4.1	132.58
5	1240	37.4	4.9	355.73

Table 8 Evaluation values for samples EP 0%

n = 5	E_i [MPa]	$σ_M$ [MPa]	$ε_{F\,max}$ [%]	W_M [N.mm]
$\bar{x}$	2200	49.3	2.1	155.08
$\bar{s}$	347	13.1	0.3	65.64
η	15.81	26.51	15.87	42.33

Table 9 Evaluation values for samples EP 3%

n = 5	E_i [MPa]	$σ_M$ [MPa]	$ε_{F\,max}$ [%]	W_M [N.mm]
$\bar{x}$	2530	58.3	2.2	191.72
$\bar{s}$	523	9.18	0.2	39.84
η	20.67	15.75	9.97	20.78

Table 10 Evaluation values for samples PU 0%

n = 5	E_i [MPa]	$σ_M$ [MPa]	$ε_{F\,max}$ [%]	W_M [N.mm]
$\bar{x}$	1190	39.4	5.2	397.19
$\bar{s}$	233	6.17	0.2	54.26
η	19.55	15.67	4.3	13.66

Table 11 Evaluation values for samples PU 3%

n = 5	E_i [MPa]	$σ_M$ [MPa]	$ε_{F\,max}$ [%]	W_M [N.mm]
$\bar{x}$	1040	30.7	4.7	285.76
$\bar{s}$	300	8.55	0.5	90.12
η	28.78	27.87	9.98	31.54

Tables (4-11) show the effect on the modulus of elasticity (E_i), adding sheep fibre to increase the variance of the values. In the case of the epoxy matrix (EP), the fibres increased the modulus of elasticity (E_i), in the case of the polyurethane matrix (PU) the addition of wool decreased the values.

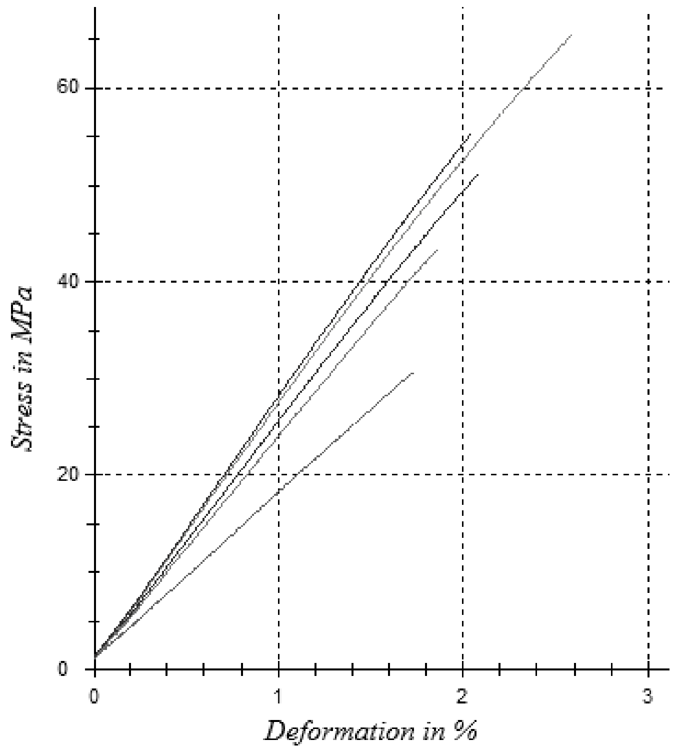

Fig. 3 Stress strain diagram for samples EP 0%

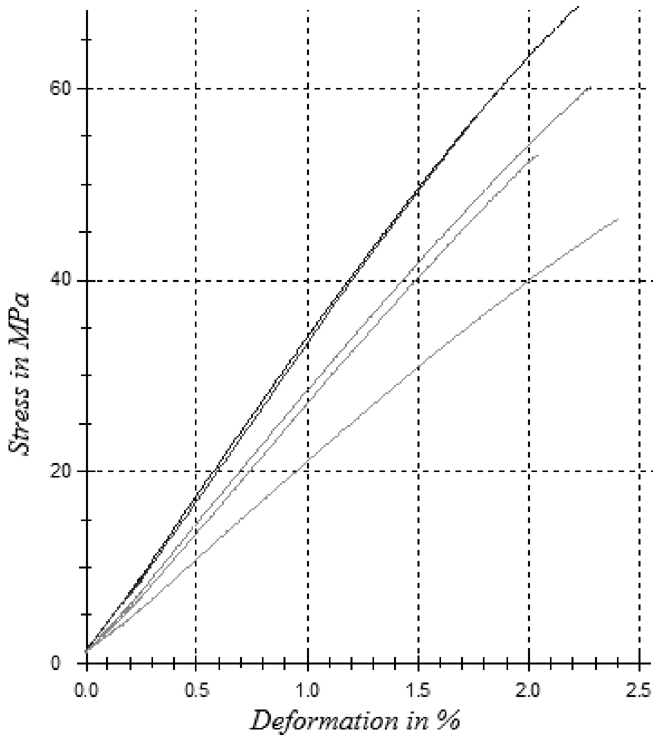

Fig. 4 Stress strain diagram for samples EP 3%

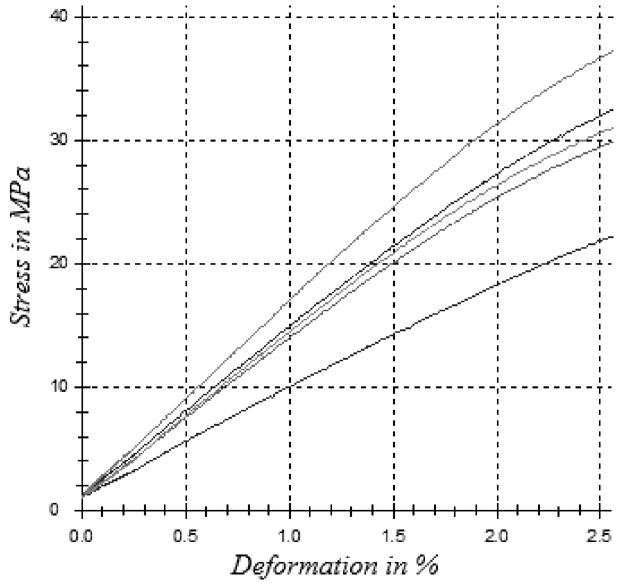

Fig. 5 Stress strain diagram for samples PU 0%

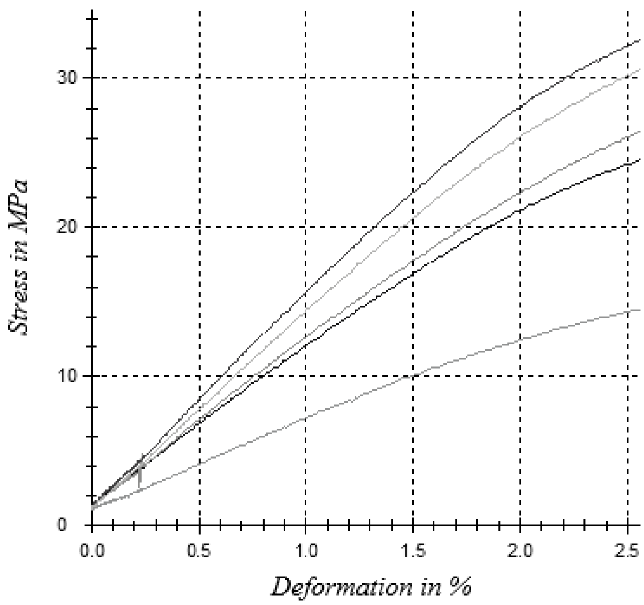

Fig. 6 Stress strain diagram for samples PU 3%

Results

Based on the described experiments the basic characteristics of the measured samples were determined. The modulus of elasticity generally shows the internal resistance of the material to elastic deformation. The greater the modulus of elasticity, the greater the stress that is required to produce the specified deformation. Tables 4 to 11 show the tensile modulus values for Gaform R30 and EPOX G20 resins. Each samples were subjected to external loads begins to deformation. Its shape and deformation characteristics depend on the nature of the applied force and thus on the stress in the cross-section. Tensile stresses are generated when tensile force is applied, which results in an increase in the dimension of the body in the direction of the applied force.

Discussion

The measurement was performed on test samples of two matrices without filler and with 3% filler. The measured values of the difference are in the matrices used. The advantage of the polyurethane matrix is the elastic recovery of the unfilled matrix, with the filled matrix of 3% sheep wool with a fibre length of 1 mm, two out of five bending specimens burst. Filled and unfilled test specimens cracked on the epoxy matrix. For energy applications, there are many applications to save expensive solutions by appropriately recycling existing biodegradable waste not only for its physical and chemical properties, but especially for its heat resistance. For the measured values, testXpert evaluated the arithmetic mean, standard deviation, and variation median for the measured bending forces. On the basis of the measured values of the maximum stress σ_M and the modulus of elasticity E_i, graphs were compared comparing properties depending on the type of matrix used and the amount of filler, number of samples n, relative elongation ε and work required to maximize specimen deflection W_M. Further research will be directed to testing in the area of sound absorption and reflectance, furthermore, it seems to be an interesting area of the possible application of the electrical industry, so it would be appropriate to test materials also for the conductivity of electric current.

Conclusion

The composite materials were tested for bending stress, where it was found that a proportion of 3% by volume of filler did not significantly affect the mechanical properties of the epoxy and polyurethane matrix used, which made the products cheaper relative to the cost of the matrices used. The Gaform R30 polyurethane die casting system is sold for 10 € per 1 kg of the mix. The epoxy resin casting system EPOX G20 is sold for € 11.56 per 1kg of the compound. The Naturwool A500 / P100 insulating strip is sold for approximately € 4.9 per 1kg. With a composite weight of 1 kg with 3% by volume and an epoxy matrix, the price is € 11. At a composite weight of 1 kg with 3% by volume and a polyurethane matrix, the price is € 9.8. For higher cost savings, it is also possible to use a larger proportion of filler while maintaining the mechanical properties of the matrices used.

For a more detailed specification of the possible use of sheep wool composites in the automotive industry or the construction industry for the production of acoustic components and panels, it is advisable to test these materials for acoustic absorption and acoustic insulation and/or conductivity. electric current. This research aims to utilize not only sheep wool but also fur from other animals for widespread use without adversely affecting nature.

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