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Design of Hydrophobic Thermal Insulation Material Produced from Biomass Wastes: Utilization of Hazelnut Shells, Pinecones, Paper, and Sheep Wool

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AGENDA

- Introduction
- Materials and Methods
- Results and Discussion
- Conclusion

Introduction

This study aimed to produce a construction composite material that is environmentally friendly, easily accessible, inexpensive and renewable and provides thermal and water insulation.

Waste papers, hazelnut shells, pinecones and sheep wool were used at the production stage.

A completely environment-friendly, biodegradable and low-cost material was produced out of biomass wastes.

A B C D

Fig. 1. Filler materials used in specimen production (a-hazelnut shells, b-pinecone, c-waste sheep wool, d –wastepaper).

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Introduction

Rapid urbanization keeps people away from natural housing.

- Serious Economic Losses
- Environmental Pollution
- Declining Sustainability
- High Demand For Thermal And Electrical Energy
- CO_2 Emissions

Introduction

This study aimed to produce a wood alternative construction material that provides water and thermal insulation by using materials such as hazelnut shells, dried pinecones, wastepaper, and waste wool as an alternative to conventional construction materials. In addition, it is aimed to bring waste products such as paper, pinecone, and nutshell, which are generally used as fuel, to the economy.

The properties of the produced material such as thermal conductivity, water resistance, contact angle value, density and compression and bending strength were tested according to the ASTM and DIN standards.

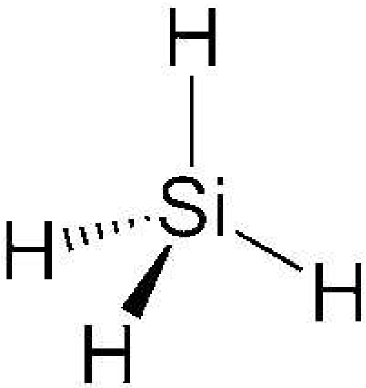
In this study, specimens were produced by using biological waste-filling material and fiber. In addition, binders and hydrophobic agents were used that are not harmful to nature and health. Since it was contains water-based binders, it was nature-friendly and because it was hydrophobic, specimens that are far from moisture and external factors such as mold and fungus formation.

Materials and Methods

Experimental Design

A B C D

Fig. 1. Filler materials used in specimen production (a-hazelnut shells, b-pinecone, c-waste sheep wool, d –wastepaper).

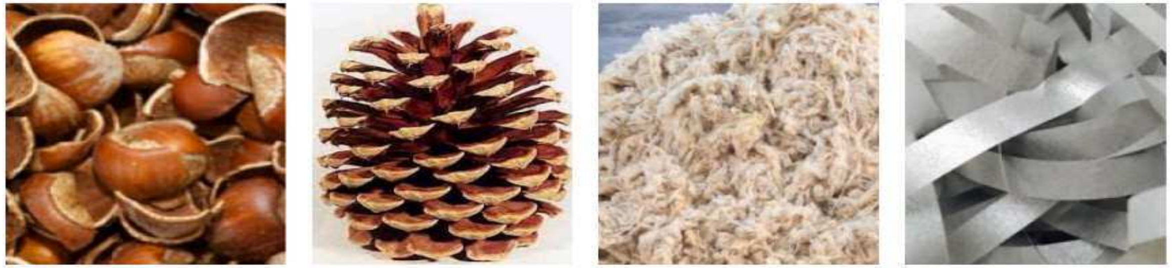


SiH_4 (Silan)

The performance of silane on sand

Materials and Methods

Experimental Design



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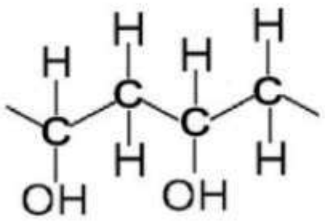

Molecular structure of the resin used

Technical properties of the resin

	Value	Standard
Solid ½ h 150 °C	%50±1	DIN EN ISO 3251
pH	7.0-9.0	DIN ISO 976
Viscosity Brookfield RVDV-II	8000-11000 Mpa	DIN EN ISO 2555
Density	1,04 g/cm³	ISO 8962
MFFT	17±2 °C	ISO 2115
Film appearance		
Tg	19±2 °C	DIN 53 765(DSC)
ionic charge	Anionic- nonionic	

Materials and Methods

Processing Experimental Data

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Table 1
Process parameters and their levels.

		Level		
Parameters	Factor	-1	0	1
Hazelnut Shell	A	18	21	24
Pinecone	B	18	21	24
Waste Paper	C	3	6	9

Experimental design Respond Surface Method (RSM) Box-Behnkem Dizayn BBD was used.

Materials and Methods

Processing Experimental Data

Table 2

Experiment plan and results.

Stdorder	Runorder	Pttype	Blocks	Hazelnut Shell	Pinecone	Waste Paper	Thermal Conductivity
1	1	2	1	18	18	6	0.083
2	2	2	1	24	18	6	0.084
3	3	2	1	18	24	6	0.0861
4	4	2	1	24	24	6	0.0824
5	5	2	1	18	21	3	0.0825
6	6	2	1	24	21	3	0.079
7	7	2	1	18	21	9	0.0784
8	8	2	1	24	21	9	0.069
9	9	2	1	21	18	3	0.0634
10	10	2	1	21	24	3	0.078
11	11	2	1	21	18	9	0.069
12	12	2	1	21	24	9	0.0634
13	13	0	1	21	21	6	0.081
14	14	0	1	21	21	6	0.0808
15	15	0	1	21	21	6	0.0815

Materials and Methods

Processing Experimental Data

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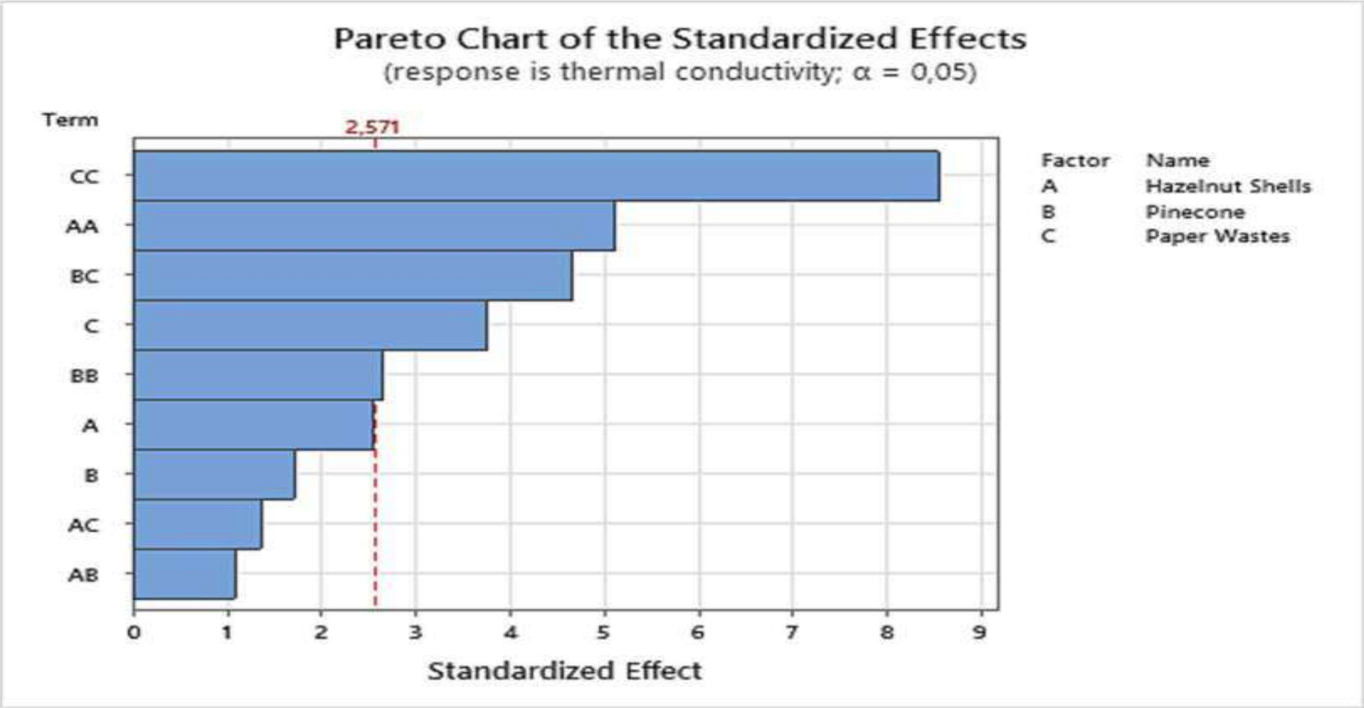


Fig. 2. Pareto chart of standardized effects filling materials.

Materials and Methods

Processing Experimental Data

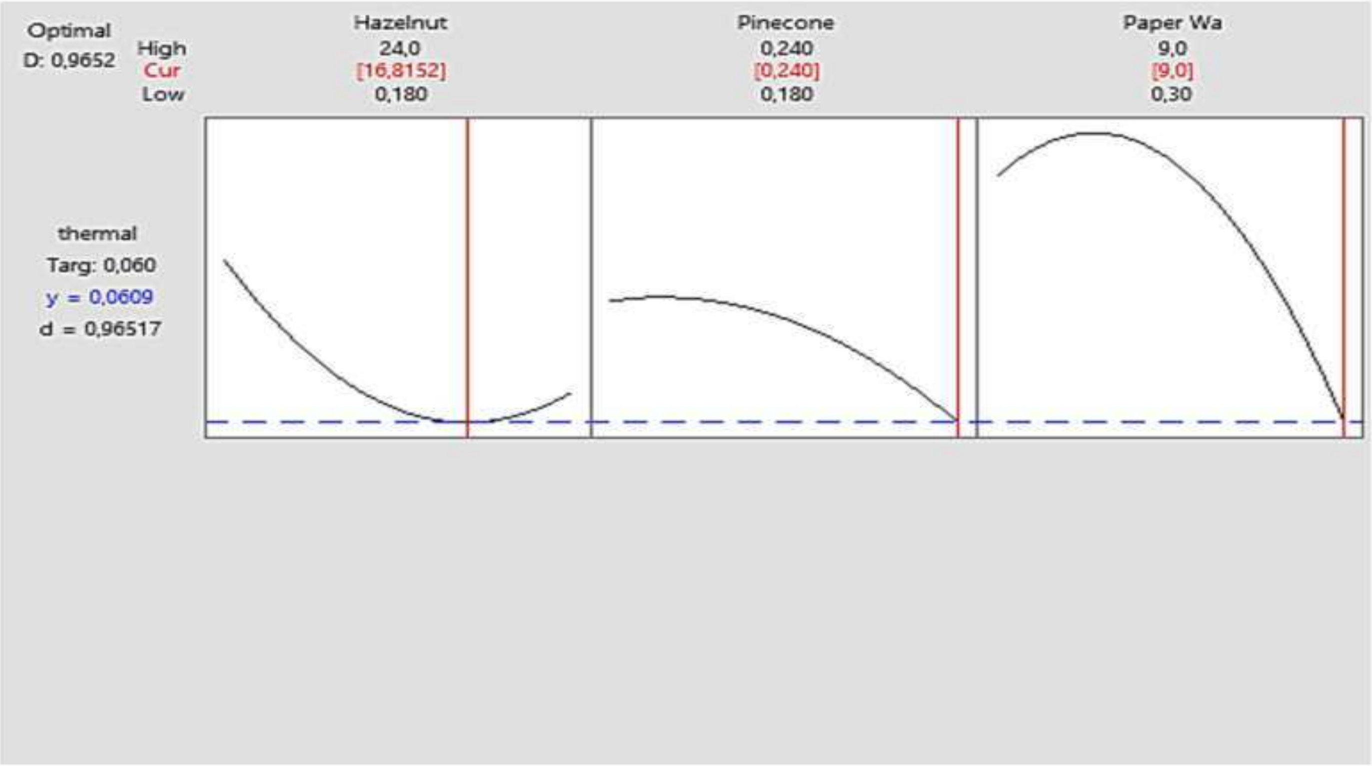


Fig. 3. The optimum data at the point where the thermal conductivity coefficient is 0.06 W/mK.

Results and Discussion

The İmpact Of The Hydrophobic Agent On The Material Surface

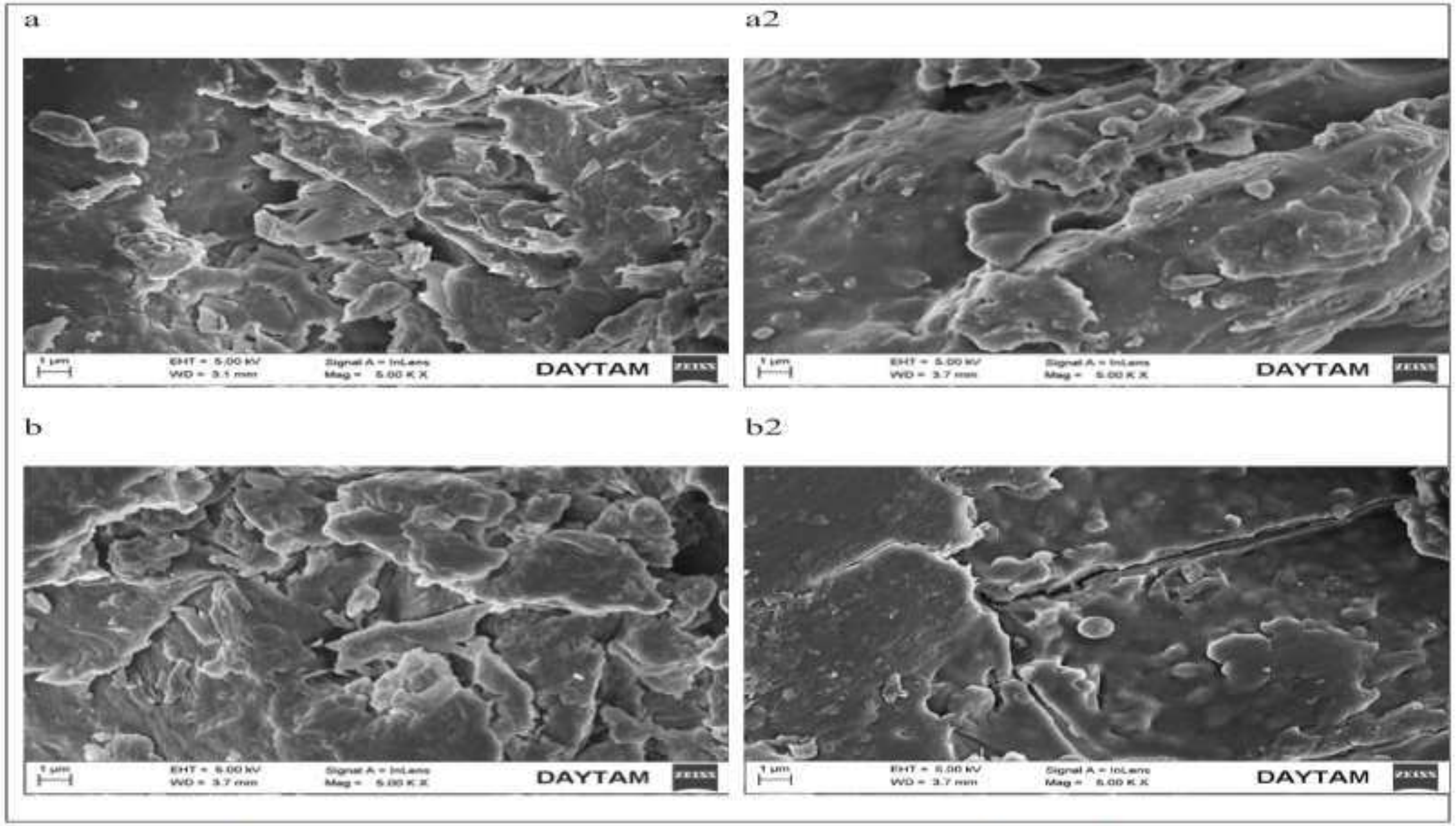


Fig. 4. SEM results of the unprocessed and hydrophobic forms of pinecone (a) and hazelnut sell (b) at (1 μm).

Results and Discussion

Changes in Water Resistance

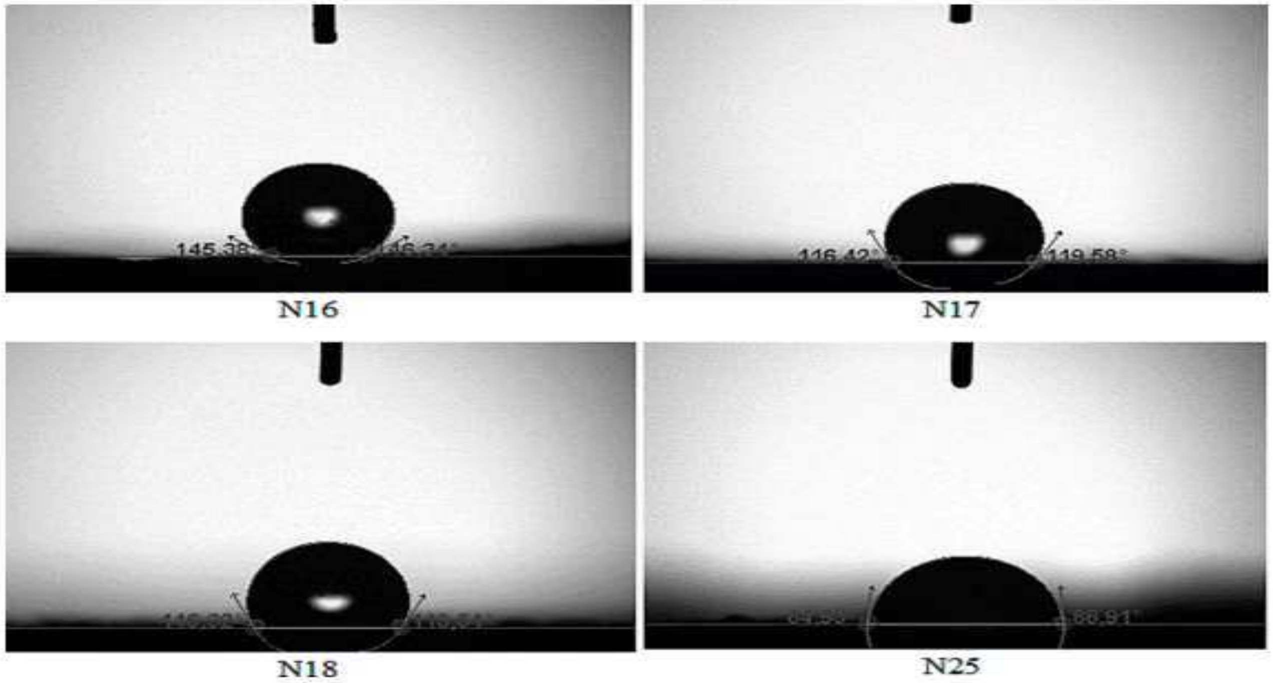
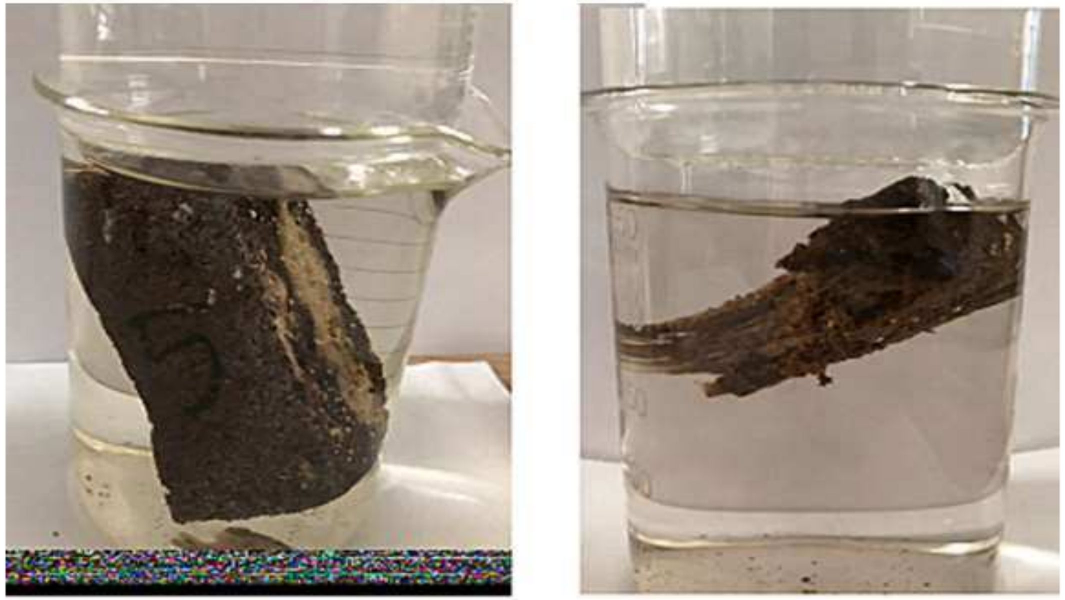


Fig. 5. Contact angle results of hydrophobic specimens N16, N17, N18 and non-hydrophobic specimen N5.

Results and Discussion

Changes in Water Resistance



N16 N25

Fig. 6. Appearances of the N16 hydrophobic and N25 non-hydrophobic specimens after 24 h in water.

Results and Discussion

Changes in Water Resistance

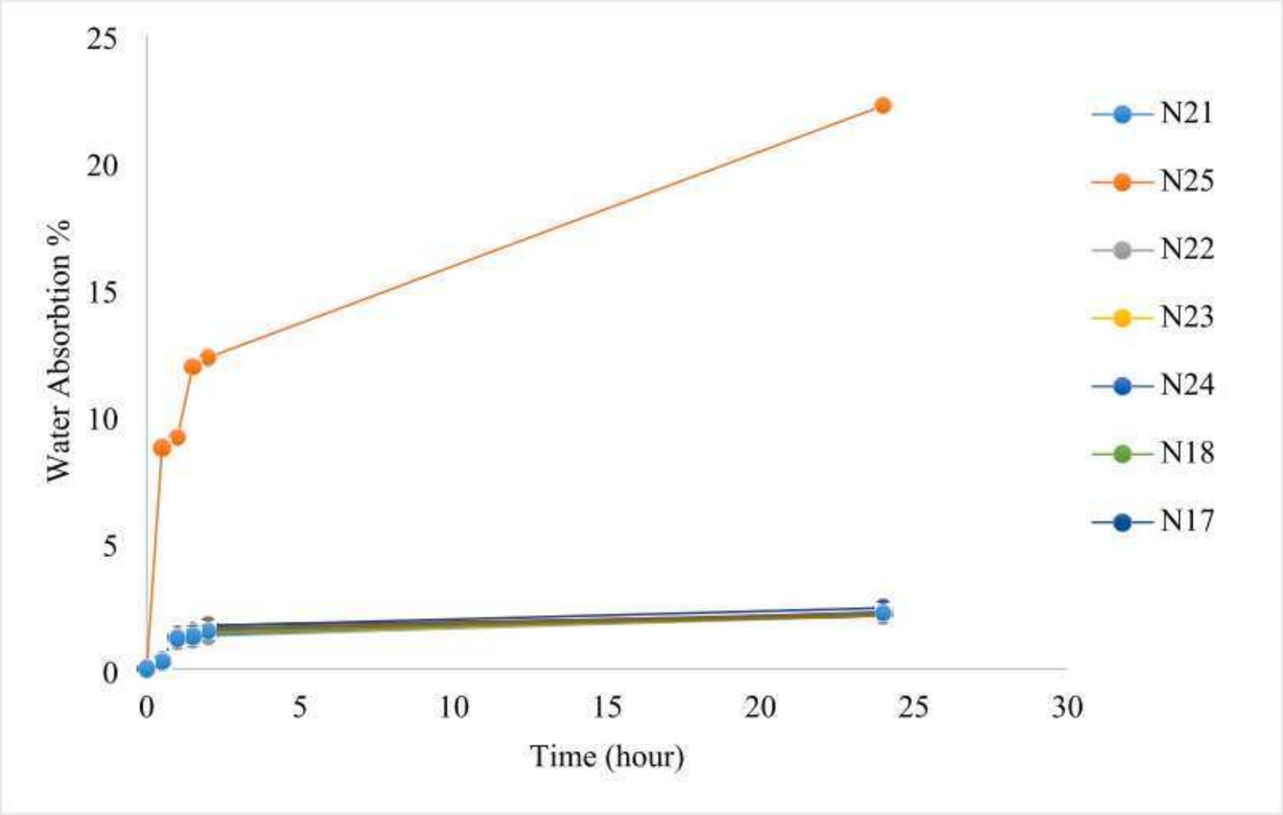


Fig. 7. Water absorption test results of hydrophobic specimens and N25 non-hydrophobic specimen.

Results and Discussion

Changes in Water Resistance

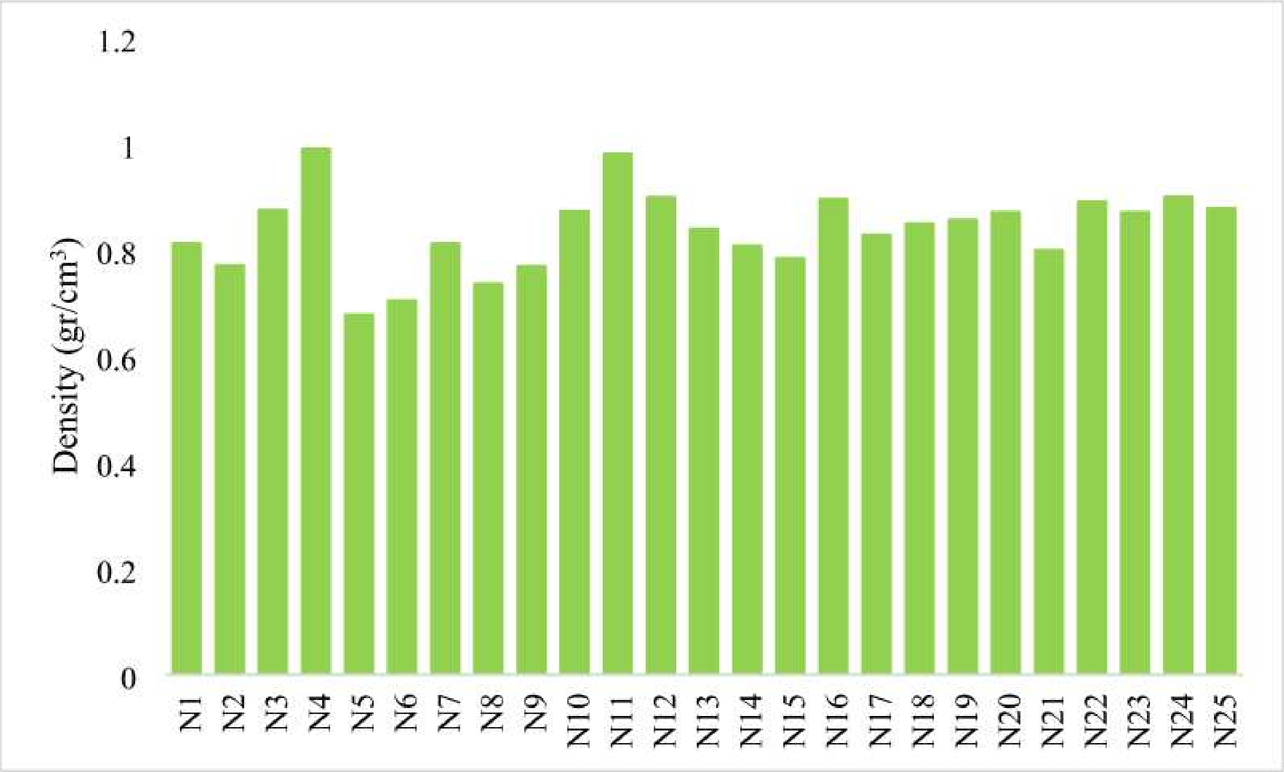


Fig. 8. Density values of all specimens.

Results and Discussion

Fig.9. Thermal conductivity coefficients of all specimens (thermal equilibrium criteria: temperature equilibrium: 1.00 °C, between block heat flow meter equilibrium: 200 μV, heat flow meter percent change: 2.0 %, minimum number of bloks: 12, calculate blocks: 3, mean temperature 10.01 °C).

Results and Discussion

Table 4
Composition ratios of the all specimens by weight and form of compression.

No	Resin	Water	Hazelnut Shell	Pinecone	Paper	Sheep Wool	Hydrophobic Agent	Form of Compression
N1	35	10	18	18	6	–	–	Compression by layers
N2	35	10	24	18	6	–	–	Compression by layers
N3	35	10	18	24	6	–	–	Compression by layers
N4	35	10	24	24	6	–	–	Compression by layers
N5	35	10	18	21	3	–	–	Compression by layers
N6	35	10	24	21	3	–	–	Compression by layers
N7	35	10	18	21	9	–	–	Compression by layers
N8	35	10	24	21	9	–	–	Compression by layers
N9	35	10	21	18	3	–	–	Compression by layers
N10	35	10	21	24	3	–	–	Compression by layers
N11	35	10	21	18	9	–	–	Compression by layers
N12	35	10	21	24	9	–	–	Compression by layers
N12	35	10	21	21	6	–	–	Compression by layers
N14	35	10	21	21	6	–	–	Compression by layers
N15	35	10	21	21	6	–	–	Compression by layers
N16	35	10	22.19	24	9	1	9	Compression by layers
N17	35	10	22.19	24	9	3	8	Compression by layers
N18	35	10	22.19	24	9	5	7	Compression by layers
N19	35	10	22.19	24	9	9	6	Compression by layers
N20	35	10	22.19	24	9	9	–	Compression by layers
N21	35	10	22.19	24	9	1	9	Compression by Mix
N22	35	10	22.19	24	9	3	8	Compression by Mix
N23	35	10	22.19	24	9	5	7	Compression by Mix
N24	35	10	22.19	24	9	9	6	Compression by Mix
N25	35	10	22.19	24	9	9	–	Compression by Mix

Results and Discussion

Fig. 10. Appearances of the some specimens as a result of the compression test (initial sample 6 cm diameter and thickness 2 cm).

Results and Discussion

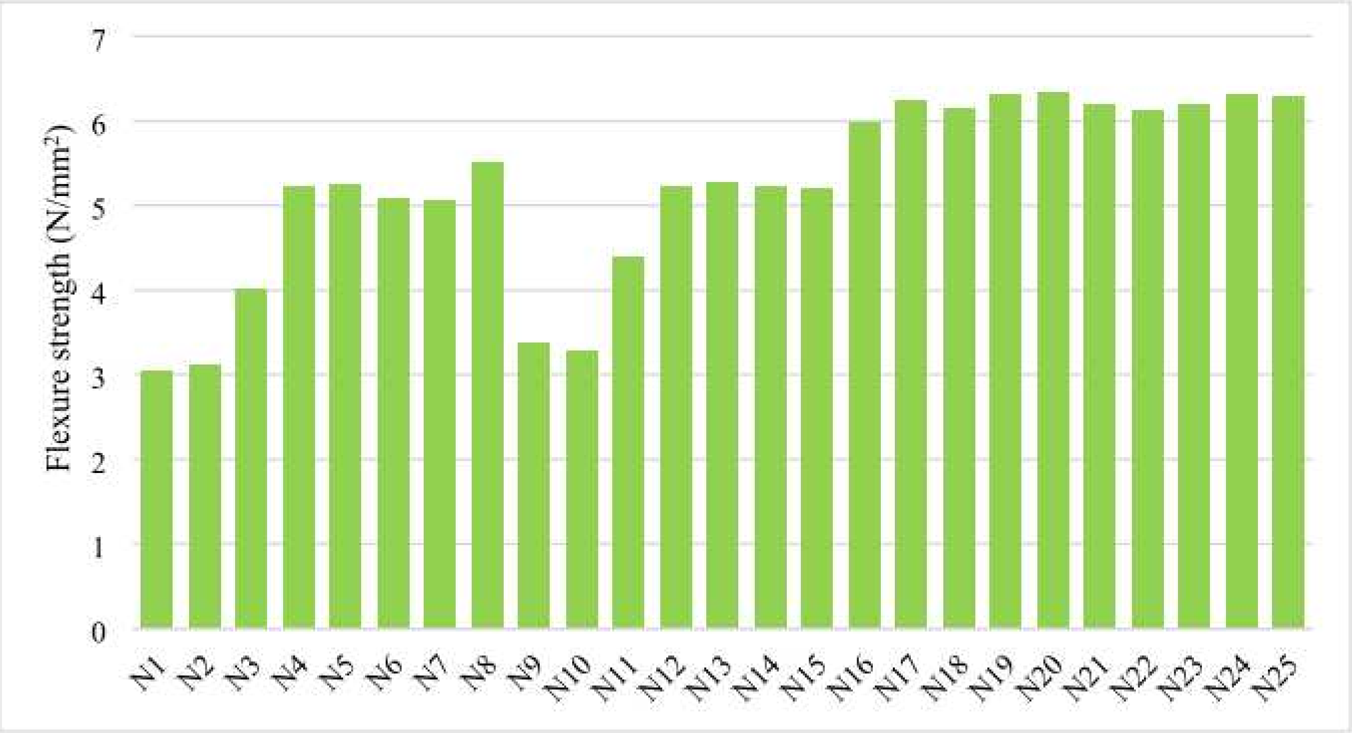


Fig. 11. Flexure strength of all specimens.

Conclusion

Surface analysis revealed a decrease in the surface areas of filler materials made hydrophobic using an anionic surfactant by a range of 43.08% to 47.78%.

Contact angle measurements and water absorption tests demonstrated that hydrophobic specimens had higher contact angles and lower water absorption capacities.

The thermal conductivity coefficients of the produced specimens ranged from 0.0511 W/mK to 0.0861 W/mK.

Conclusion

The densities of the specimens varied between 0.678 and 0.99 gr/cm3, which were lower than those of normal wooden composites.

The compressive strengths of the specimens were significantly high, and there was no breaking or damage observed in the tests.

Specimens produced from natural plant and animal wastes emerged as alternative, environmentally friendly construction materials that pose no threat to health.

Conclusion

The low thermal conductivity coefficients, low water absorption capacity, and high compressive strength of these materials offer an environmentally friendly, economical alternative to traditional construction materials.

Due to their natural content, the produced materials do not generate greenhouse gas emissions.

In adherence to principles of clean production, the process of transforming environmental wastes into a product that is not harmful to health represents a significant win-win situation in today's world.

REFERENCES

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Hydrophobic thermal insulation material designed from hazelnut shells, pinecone, paper and sheep wool

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ABSTRACT

This study aimed to produce a construction composite material that is environmentally friendly, easily accessible, inexpensive and renewable and provides thermal and water insulation. Waste papers, hazelnut shells, pinecones and sheep wool were used at the production stage. The filling rates of the materials were optimized using the RSM. A hydrophobic surface-active substance was used to reduce water absorbability, microbial activity and mold formation. It was observed that these specimens' contact angles were 84° to 146°, thermal conductivity were 0.0511 to 0.0861 W/mK and densities were 0.678 to 0.99 g/cm^3. As a result of the compressive and flexural strength tests, it was found that the compressive strength of the specimens was very high, the highest compressive strength was found as 32.8093 N/mm^2 in the specimen N25, and the highest flexure strength was found as 6.352 N/mm^2 in the specimen N20. A completely environment-friendly, biodegradable and low-cost material was produced out of biomass wastes.

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THANK YOU…