

# Possibility of using sawdust in sawdust concrete

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**Abstract.** According to GOST 19222-84, the dependence of the physical-mechanical characteristics of sawdust concrete on the specific gravity of wet sawdust of coniferous species and ash-slag mixture in the composition was studied. A one-factor experiment was carried out in the laboratory of the Department of Reproduction and Processing of Forest Resources, Federal State Budgetary Educational Institution of Higher Education “Bratsk State University” in order to justify the specific share of wet sawdust in the composition of sawdust concrete, to determine the necessary number of observations and repetitions of the experiment. As a variable factor, the proportion of wet sawdust of coniferous species in the composition is assumed. The proportion varies from 17% to 37% in increments of 5%. The applicability of wet sawdust of coniferous species for the production of heat-insulating building materials is established. Samples of building materials were made; the necessary laboratory tests were carried out. The range of variation of sawdust content in the composition for sawdust concrete is determined (from 17 to 32%).

## 1 Introduction

The purpose of the conducted experimental studies is to examine the effect of various influences on the object of study. According to GOST 19222-84, the dependence of the physical-mechanical characteristics of sawdust concrete on the specific gravity of wet sawdust of coniferous species and ash-slag mixture in the composition was studied [1-7].

## 2 Materials and methods

A one-factor experiment was carried out in the laboratory of the Department of Reproduction and Processing of Forest Resources, Federal State Budgetary Educational Institution of Higher Education “Bratsk State University” in order to justify the specific share of wet sawdust in the composition of sawdust concrete, to determine the necessary number of observations and repetitions of the experiment. [8-12] As a variable factor, the proportion of wet sawdust of coniferous species in the composition is assumed. The proportion varies from 17% to 37% in increments of 5% [13-18].

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### 3 Results

The average density, humidity, compressive strength, and sorption moisture were taken as output parameters. Eight samples of various compositions were made (Table 1); experiments were duplicated. In parallel, control samples were made in compliance with the composition (sample 1) – sawdust concrete of grade M10, containing sawdust with specific gravity equal to 17%.

**Table 1.** Composition of pilot samples of sawdust concrete.

| Name of components     | Consumption for production of sawdust concrete samples with a size of 100x100x100 mm, g |                         |                         |                         |                         |
|------------------------|---|-------------------------|-------------------------|-------------------------|-------------------------|
|                        | Sample 1 (M10 control)  | Sample 2 (22 % sawdust) | Sample 3 (27 % sawdust) | Sample 4 (32 % sawdust) | Sample 5 (37 % sawdust) |
| Cement (M400 D20)      | 280.0   | 227.2                   | 174.3                   | 121.3                   | 68.4                    |
| Air-slaked lime        | 25.0  | 25.0                    | 25.0                    | 25.0                    | 25.0                    |
| Sand                   | 265.8   | 265.8                   | 265.8                   | 265.8                   | 265.8                   |
| Softwood sawdust (dry) | 180.0   | 233.0                   | 285.9                   | 338.9                   | 391.8                   |
| Water                  | 300.0   | 300.0                   | 300.0                   | 300.0                   | 300.0                   |
| Water glass            | 8.0   | 8.0                     | 8.0                     | 8.0                     | 8.0                     |

The constant factors of the experiment are fixed in the following values:

- air temperature  $22 \pm 1$  °C;
- air humidity  $45 \pm 5$  %;
- species composition of sawdust – coniferous;
- moisture content of sawdust –  $6.0 \pm 0.1$  %;
- fractional composition of sawdust – 0.5...5 mm;
- the size of the obtained samples – 100x100x100 mm;
- air-slaked lime consumption – 25.0 kg per 1 m<sup>3</sup> of the mixture;
- sand consumption – 265.8 kg per 1 m<sup>3</sup> of the mixture;
- water consumption – 300.0 l per 1 m<sup>3</sup> of the mixture;
- water glass consumption – 8.0 kg per 1 m<sup>3</sup> of the mixture.

The results of a separate series of  $m = 10$  experiments to determine the compressive strength of experimental samples are presented in Tab. 2.

**Table 2.** Results of a separate series of sample testing.

| Experiment number                             | 1   | 2   | 3   | 4   | 5   | 6   | 7   | 8   | 9   | 10  |
|---|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Compressive strength, ( $\sigma_{cf}$ ), MPa; | 2.1 | 2.3 | 1.9 | 2.2 | 2.4 | 2.1 | 2.0 | 2.1 | 1.9 | 2.3 |

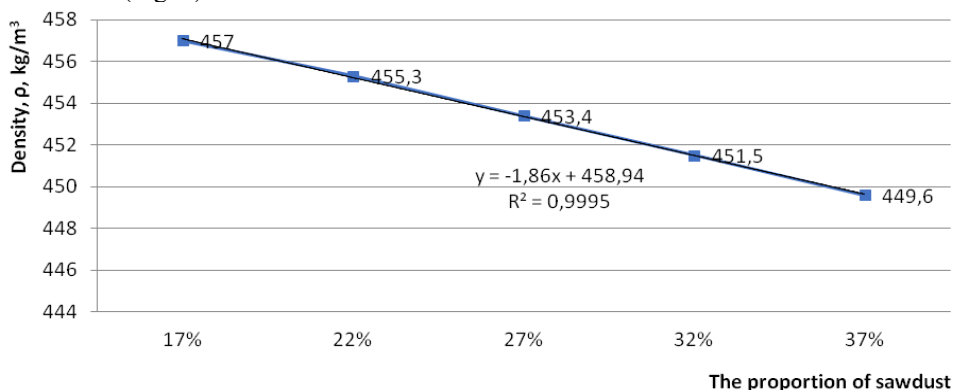
According to GOST 19222-84, the dependence of the physical-mechanical parameters of sawdust concrete of grade M10 (density, humidity, strength, sorption moisture) on the specific gravity (share) of wet sawdust of coniferous species in the composition was studied.

Density ( $\rho$ , kg/m<sup>3</sup>) is determined by measuring and weighing of samples.

**Table 3.** Values of the average density of experimental samples.

| Sample number            | Density ( $\rho_{avg}$ , kg/m <sup>3</sup> ) |
|--------------------------|--|
| Sample 1 (M10 – control) | 457  |
| Sample 2 (22 % sawdust)  | 455.3  |
| Sample 3 (27 % sawdust)  | 453.4  |
| Sample 4 (32 % sawdust)  | 451.5  |
| Sample 5 (37 % sawdust)  | 449.6  |

In accordance with the data obtained, a graph of the dependence of the average density of samples on the content of sawdust of coniferous species in their composition is constructed (Fig. 1).



**Fig. 1.** Graph of the average density of samples on the content of sawdust in their composition.

The graph shows that the density of the samples decreases with an increase of sawdust in the composition of the samples. It positively affects their heat-insulation properties. However, in accordance with regulatory requirements, samples with a content of sawdust of not more than 37% can be referred to heat-insulating materials.

Thereafter, the moisture content of sawdust concrete samples is determined by the formula:

$$W = (m1 - m0) / m0 * 100 \% \tag{1}$$

where  $m1$  – initial mass, kg;

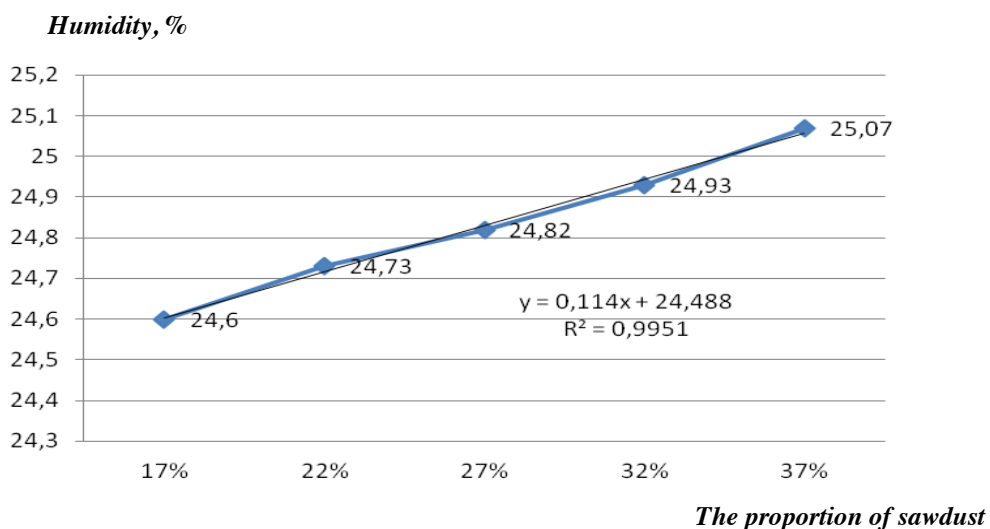
$m0$  – mass of samples in dry form, kg;

The results of the relevant calculations are given in Tab. 4.

**Table 4.** Values of moisture content of experimental samples.

| Sample number            | Humidity ( $W$ ), % |
|--------------------------|---------------------|
| Sample 1 (M10 – control) | 24.6                |
| Sample 2 (22 % sawdust)  | 24.73               |
| Sample 3 (27 % sawdust)  | 24.82               |
| Sample 4 (32 % sawdust)  | 24.93               |
| Sample 5 (37 % sawdust)  | 25.07               |

Based on the data obtained, a graph of the dependence of moisture content of the samples on the content of sawdust of coniferous species in their composition is constructed (Fig. 2).



**Fig. 2.** Graph of the dependence of moisture content of the samples on the content of sawdust in their composition.

The graph shows that the moisture content of the samples increases with a growth of sawdust in their composition. All tested samples in which the specific gravity of wet sawdust of coniferous species does not exceed 32% correspond to regulatory requirements on humidity.

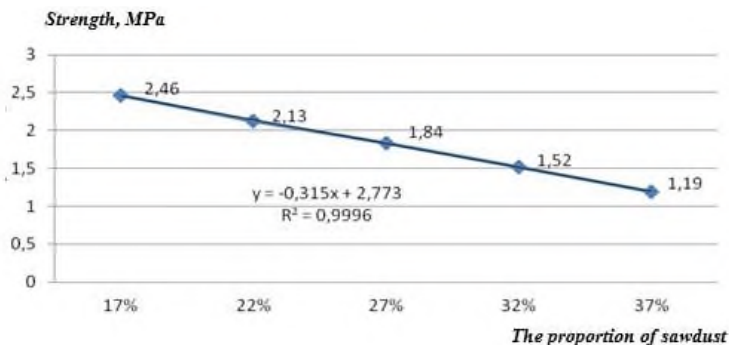
The strength of the experimental samples is determined. Finished samples of sawdust concrete were tested for strength at the age of 46 days on the press. The compressive strength class is set as the arithmetic mean of the results of 3 destroyed samples. The calculation results are presented in Tab. 5.

**Table 5.** Strength values of experimental samples.

| Sample number            | Strength ( $\sigma_{cf}$ ), MPa |
|--------------------------|---------------------------------|
| Sample 1 (M10 – control) | 2.46                            |
| Sample 2 (22 % sawdust)  | 2.13                            |
| Sample 3 (27 % sawdust)  | 1.84                            |
| Sample 4 (32 % sawdust)  | 1.52                            |
| Sample 5 (37 % sawdust)  | 1.19                            |

In accordance with the data obtained, a graph of the dependence of the strength of the samples on the content of sawdust of coniferous species in their composition is constructed (Fig. 3).

The obtained experimental data shows that an increase of specific gravity of sawdust in the samples leads to a decrease in their strength. All samples, except the fifth, meet the requirements for heat-insulating materials established by GOST 19222-84.



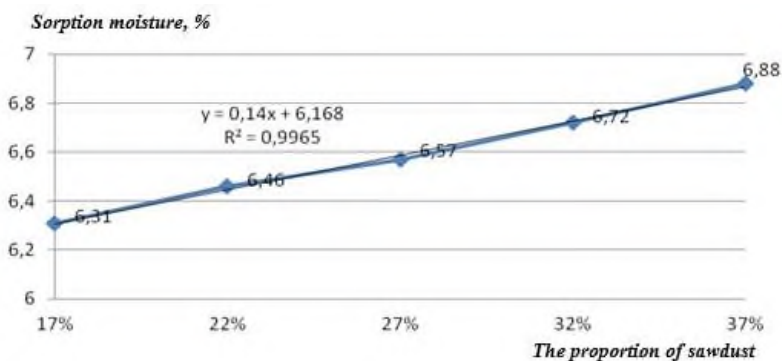
**Fig. 3.** Graph of the dependence of the strength of the samples on the content of sawdust in their composition.

Thereafter, the sorption moisture is determined. For this purpose, the samples are desiccated in an oven until completely dry. Then the samples are placed in desiccators above the water and weighed every 2 days within 14 days. The relevant calculations of the sorption moisture of the experimental samples are presented in Tab. 6.

**Table 6.** Values of sorption moisture of samples.

| Sample number            | Sorption moisture ( $A_c$ ), % |
|--------------------------|--------------------------------|
| Sample 1 (M10 – control) | 6.31                           |
| Sample 2 (22 % sawdust)  | 6.46                           |
| Sample 3 (27 % sawdust)  | 6.57                           |
| Sample 4 (32 % sawdust)  | 6.72                           |
| Sample 5 (37 % sawdust)  | 6.88                           |

In accordance with the data obtained, a graph of the dependence of the strength of the samples on the content of sawdust of coniferous species in their composition is constructed (Fig. 4).



**Fig. 4.** Graph of the dependence of sorption moisture of samples on the content of sawdust in their composition.

The obtained data shows that the sorption moisture of the samples increases with an increase of sawdust in their composition (in percentage). All samples meet the requirements for heat-insulating materials established by GOST 19222-84.

The results of determining the physical-mechanical properties of the samples are summarized in Tab. 7. The requirements of GOST 19222 are also given in the Tab. 7.

**Table 7.** Physical-mechanical properties of samples of sawdust concrete.

| Sample number               | Strength, MPa |      | Humidity, % |       | Density, kg/m <sup>3</sup> |       | Sorption moisture, % |      |
|-----------------------------|---------------|------|-------------|-------|----------------------------|-------|----------------------|------|
|                             | norm          | fact | norm        | fact  | norm                       | fact  | norm                 | fact |
| Sample 1<br>(M10 – control) | 1.5-2.5       | 2.46 | ≤ 25        | 24.60 | 450-500                    | 457.0 | 4-8                  | 6.31 |
| Sample 2<br>(22% sawdust)   | 1.5-2.5       | 2.13 | ≤ 25        | 24.73 | 450-500                    | 455.3 | 4-8                  | 6.46 |
| Sample 3<br>(27% sawdust)   | 1.5-2.5       | 1.84 | ≤ 25        | 24.82 | 450-500                    | 453.4 | 4-8                  | 6.57 |
| Sample 4<br>(32% sawdust)   | 1.5-2.5       | 1.52 | ≤ 25        | 24.93 | 450-500                    | 451.5 | 4-8                  | 6.72 |
| Sample 5<br>(37% sawdust)   | 1.5-2.5       | 1.19 | ≤ 25        | 25.07 | 450-500                    | 449.6 | 4-8                  | 6.88 |

Analyzing the results of experimental studies, it is possible to recommend the applying of wet coniferous sawdust for the production of heat-insulating sawdust concrete with a specific gravity of not more than 32% in the composition. The production of building blocks made of concrete of the proposed composition makes it possible to produce a heat-insulating building material that fully complies with the requirements of physical-mechanical parameters established by GOST 19222 for sawdust concrete of grade M10. Moreover, it reduces the consumption of expensive mineral binder in the production of this building material.

## 4 Conclusions

1. The applicability of wet sawdust of coniferous species for the production of heat-insulating building materials is established.
2. Samples of building materials were made; the necessary laboratory tests were carried out.
3. The range of variation of sawdust content in the composition for sawdust concrete is determined (from 17 to 32%).

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