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Tashkent state transport university

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# TASHKENT STATE TRANSPORT UNIVERSITY

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The “Journal of Transport” publishes the most significant results of scientific and applied research carried out in universities of transport profile, as well as other higher educational institutions, research institutes, and centers of the Republic of Uzbekistan and foreign countries.

The journal is published 4 times a year and contains publications in the following main areas:

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- Economics of Transport;
- Organization of the Transportation Process and Transport Logistics;
- Rolling Stock and Train Traction;
- Infrastructure;
- Research, Design, and Construction of Railways, Highways, and Airfields: Technology and Organization of Construction, Management Problems;
- Water Supply, Sewerage, Construction Systems for Water Protection;
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- Car Service;
- Information Technology and Information Security;
- Air Traffic Control;
- Aircraft Maintenance;
- Traffic Organization;
- Operation of Railways and Roads;

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Tashkent State Transport University had the opportunity to publish the scientific-technical and scientific innovation publication “Journal of Transport” based on the Certificate No. 1150 of the Information and Mass Communications Agency under the Administration of the President of the Republic of Uzbekistan. Articles in the journal are published in Uzbek, Russian and English languages.

CONTEXT / MUNDARIJA

# Analysis of the physical and mechanical properties of fine-grained concrete with superplasticizers and hydrophobic additives

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Abstract: This article focuses on the analysis of the results obtained through experimental testing. That is, changes in physical and mechanical properties of concrete by adding superplasticizer and hydrophobic additives (in dry and liquid state) to ordinary concrete are presented. For testing, 48 samples were prepared based on a total of 8 compositions. These samples were tested for bending and compression on 3, 7, 14, and 28 days, and the effect of the amount of the above additives on the physical and mechanical properties of concrete was highlighted.

Keywords: hydrophobic (liquid, dry), cement, water, fillers and additives (mineral and chemical), superplasticizer, strength, bending, compression.

## 1. Introduction

Concrete and reinforced concrete structures play a crucial role in modern buildings and infrastructure. Concrete is made up of cement, water, fillers, and additives, both mineral and chemical. These components influence the characteristics and makeup of concrete, which must be carefully considered when designing its composition.

By incorporating various additives, such as chemical or active mineral components, the properties of mixtures and itself can be regulated. This includes aspects like accelerating or delaying the setting time, improving its workability and ease of placement, enhancing its strength and durability, reducing water absorption, and minimizing deformation during the hardening process [1,5.].

## 2. Methodology and materials

In order to determine the composition of the complex modified concrete developed by us, as well as to study the physical and mechanical properties of the concrete with these additives, we will analyze it by adding them to the mixture in different proportions.

Samples prepared for experimental testing and their contents are listed below in Table 1. From the table we can see the following:

**Table 1**

**Composition of samples**

| № | Attachments | Cement, gr | Sand, gr | Water, l | Water/sem | Hydrophobic. gr | percent % | Sup. plas. | percent % |
|---|---|---|---|---|---|---|---|---|---|
| N1 | Ordinary concrete | 500 | 1500 | 245 | 0,49 | - | - | - | - |
| N2 | When 1% Superplasticizer is added | 500 | 1500 | 170 | 0,35 | - | - | 5 | 1 |
| N3 | 1% Superplasticizer and 1% hydrophobic (liquid) | 500 | 1500 | 165 | 0,35 | 5 | 1 | 5 | 1 |
| N4 | 1% Superplasticizer and 3% hydrophobic (liquid) | 500 | 1500 | 155 | 0,35 | 15 | 3 | | |
| N5 | 1% Superplasticizer and 6% Hydrophobic (liquid) | 500 | 1500 | 140 | 0,35 | 30 | 6 | | |
| N6 | 1% Superplasticizer and 1% Hydrophobic (dry) | 500 | 1495 | 170 | 0,34 | 5 | 1 | 5 | 1 |
| N7 | 1% Superplasticizer and 3% Hydrophobic (dry) | 500 | 1485 | 170 | 0,34 | 15 | 3 | | |
| N8 | 1% Superplasticizer and 6% Hydrophobic (dry) | 500 | 1470 | 170 | 0,34 | 30 | 6 | | |

**The amount of elements listed in the table above is selected for a 40x40x160 mm prismatic mold. Each composition is made for one set of molds (1 set consists of 3 molds).*

The experimental tests were carried out in the laboratory of the Tashkent State Transport University, "Construction of Buildings and Industrial Facilities" department, within the scope of scientific research.

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The samples prepared on the basis of the ingredients were compacted using a vibrating table during the molding process, then the sample-prisms were stored for 1 day in a natural environment, in a chamber that provides normal solidification and surface temperature of 20 °C and relative air humidity of 95% for 28 days.

For testing, special support equipment is used to place the sample on the press during the bending test. The procedure for placing the sample in the equipment is shown in Figure 1.

After the bending test, half of the samples are immediately subjected to the compression test. Samples are placed between two plates with smooth surface sides according to the dimensions of the plate (Fig. 2).

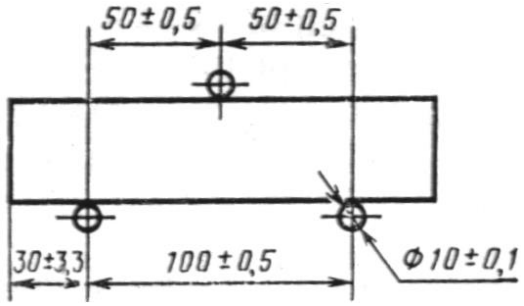


**Figure 1. Scheme of installation of samples for bending test**

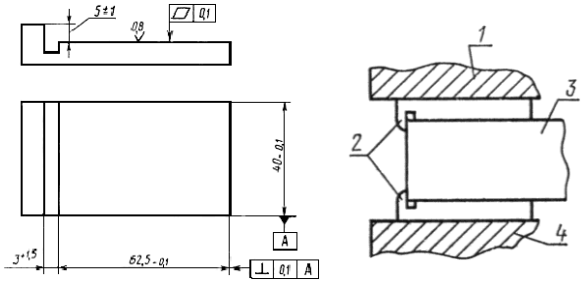


**Figure 2. Scheme of placement of specimens for compression testing**

## 3. Results

The samples were tested for bending and compression using a CT-D2000 press, these tests were conducted according to GOST 25192-2012.

When conducting compression tests, samples were continuously loaded in a sample press with a speed that ensured the increase of the calculated stress in the sample until its complete failure within the limits of 0.6 MPa/s.

**Figure 3. Bending test of specimens**

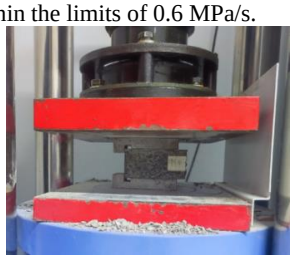

**Figure 4. Compression testing of samples**

The results of the experimental tests carried out on the samples are presented in the following tables and pictures.

**Table 2**

**Bending and compressive strength of samples**

| Samples | $R_{ben}$ | | | | $R_{com}$ | | | |
|---|---|---|---|---|---|---|---|---|
| | 3 | 7 | 14 | 28 | 3 | 7 | 14 | 28 |
| ***N1*** | 1,8 | 3,2 | 4,4 | 5,5 | 3,0 | 7,0 | 14,0 | 28,0 |
| ***N2*** | 2,2 | 3,9 | 5,2 | 6,6 | 37,7 | 66,8 | 98,4 | 124,3 |
| ***N3*** | 2,0 | 3,6 | 4,8 | 6,1 | 55,8 | 98,9 | 126,2 | 159,3 |
| ***N4*** | 2,1 | 3,7 | 5,0 | 6,3 | 51,8 | 91,8 | 122,8 | 155,1 |
| ***N5*** | 1,8 | 3,3 | 4,4 | 5,6 | 54,0 | 95,7 | 119,4 | 150,8 |
| ***N6*** | 2,1 | 3,7 | 5,0 | 6,3 | 43,1 | 76,3 | 112,1 | 141,6 |
| ***N7*** | 2,2 | 4,0 | 5,4 | 6,8 | 55,2 | 97,8 | 124,7 | 157,5 |
| ***N8*** | 2,0 | 3,6 | 4,9 | 6,2 | 62,5 | 110,8 | 142,3 | 179,7 |

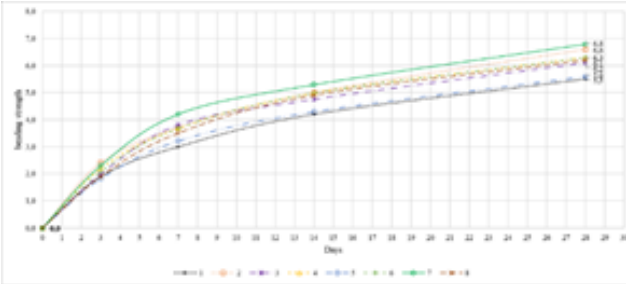

**Figure 5. Bending strength of samples on 3, 7, 14 and 28 days**

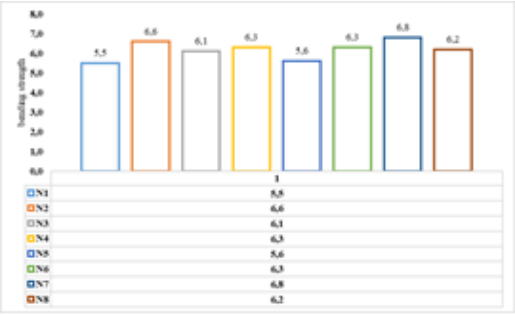

**Figure 6. Bending strength of samples**

Figures 5 and 6 present the analysis of flexural strength across different samples, illustrating their strength at 3, 7, 14, and 28 days. The analysis revealed that the sample composed of cement, water, sand, 1% cement superplasticizer, and 3% cement hydrophobic additives (in dry state) achieved notably high flexural strength. Specifically, its flexural strength was observed to be 24% higher compared to conventional concrete.

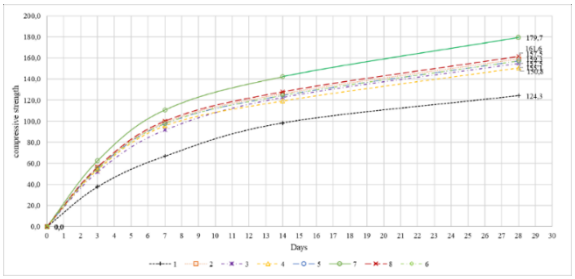


**Figure 7. Compressive strength of samples on 3, 7, 14 and 28 days**

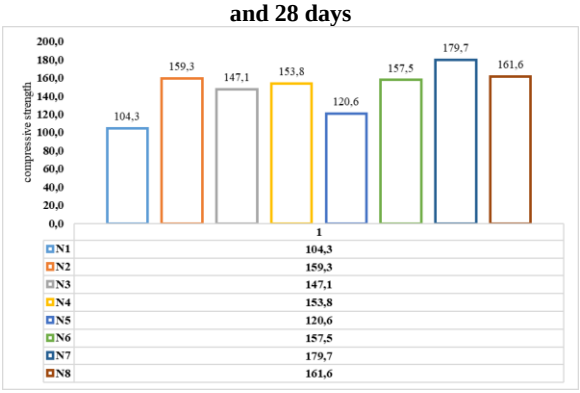


**Figure 8. Compressive strength of samples**

Figures 7 and 8 depicted the analysis of compressive strength across various samples, showcasing their strength at 3, 7, 14, and 28 days. Notably high compressive strength was attained in the sample comprising cement, water, sand, 1% cement superplasticizer, and 3% cement hydrophobic additives (in dry state). Comparatively, its compressive strength was observed to be 65% higher than that of conventional concrete.

We can see the influence of the amount of hydrophobic additives in concrete on concrete strength from the following figures 9, 10.

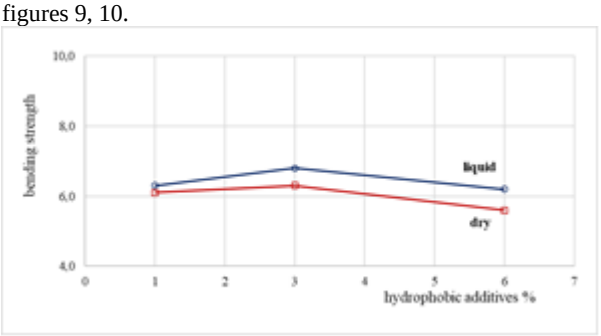


**Figure 9. The effect of the amount of hydrophobic additives on concrete bending strength**

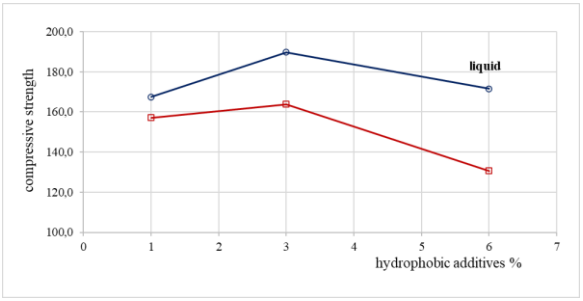


**Figure 10. The effect of the amount of hydrophobic additives on concrete compressive strength**

## 4. Conclusion

The inclusion of a superplasticizer in the concrete mixture resulted in a 30% reduction in water usage compared to regular concrete.

When comparing the strengths of the samples, the following results were obtained compared to ordinary concrete:

| | N2 | N3 | N4 | N5 | N6 | N7 | N8 |
|---|---|---|---|---|---|---|---|
| compression | 159,3 | 155,1 | 150,8 | 141,6 | 157,5 | 179,7 | 161,6 |
| % | 28% | 25% | 21% | 14% | 27% | 45% | 30% |
| bend | 6,6 | 6,1 | 6,3 | 5,6 | 6,3 | 6,8 | 6,2 |
| % | 20% | 11% | 15% | 2% | 15% | 24% | 13% |

From the analysis of the results, it can be inferred that sample N7, consisting of cement, water, sand, 1% cement superplasticizer, and 1.3.6% cement hydrophobic additive (dry), exhibited notably higher flexural and compressive strengths compared to the previous year.

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