Study of the Mechanical Properties of Concrete Based on Super Plasticizer PKAN-55

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**Abstract.** The study delves into the advancements made in technology by examining how different materials and compositions affect the properties of mixtures. The researchers utilized Portland cement alongside sand, limestone water, and chemical additives to analyze how they impact the formation of structures. They also experimented with types of materials, for concrete production to emphasize the importance of achieving an optimal grain size to reduce voids. Additionally, the process of creating a superplasticizer was explained in detail to improve the performance of concrete. Furthermore, the researchers conducted tests on the strength of cement samples to determine their strength after 7 and 28 days. The research highlighted the importance of elements such, as the ratio of water to cement and the quality of aggregates, in creating mixtures that exhibit varying degrees of mobility and strength properties when using concrete categories as test subjects.

**Keywords:** mix design. mix mobility, cement, strength of cement, high strength parameters

# INTRODUCTION

To date, concrete technology has come a long way from materials with limited capabilities to multi-component compositions with various properties, which significantly expanded the areas of application of concrete, their range and the achieved technical and economic results [1].

In recent decades, a significant step has been taken towards the emergence of the ability not only to control the properties of the concrete mixture, but also to actively influence the formation of the structure of concrete at different times [2].

High-quality concretes are multi-component materials in which composite binders, chemical modifiers of structure, properties and technology, active mineral components and expanding additives are used, and the multi-component nature of concrete allows you to control the formation of the structure at all stages of the technology [3].

From this point of view, it is promising to use compounds with a linear structure as highly effective plasticizers, including radicals such as naphthalene, melamine, anthracene, phenol, functionally active groups such as sulfo- and carboxy groups, mono- or polyoxycarboxylic acids, which can react with minerals of cement clinker and their hydration products [4].

Combining the compositions of new types of superplasticizers and their synthesis modes allows to increase the effects of the effect on the water content and rheological properties of cement compositions.

As a result of the research, it can be concluded that the role of water as a component of concrete decreases. When using new generation superplasticizers, the interstitial spaces between cement particles are wetted at the mixing stage, and due to the high density and water-tightness of the cement matrix, the strength and operational properties of the added concrete are higher than those of traditional cement compositions. Accordingly, the requirements for the mineral composition of cements and their other properties change [5].

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**METHODS**

To date, concrete technology is available in a limited number of different variants, from materials to compositions with various components, which has significantly expanded the possibilities of concrete production, their range, and achieved technical and economic results.

**MATERIALS**

In recent decades, a significant step has been taken towards the emergence of the opportunity not only to control the properties of the concrete mixture but also to actively influence the formation of the structure of concrete at different periods. Cement, sand, limestone, water, and other chemical additives were used in the experiments. Portland cement of Cement II/A-I 32.5 N brand of “Huaxin Cement Jizzakh” LLC was used in this test. In general, pebble stoneswere used in accordance with the requirements of the ISO 8267-93 standard. For example, if 3-8 mm and 5-20 mm fractional pebbles are usually used for concrete products, it is advisable to use 10-20 mm fractional pebbles to pour the foundations of buildings. For road construction, fractions of 25-60 mm and 40-70 mm were used, and fractions of not less than 25-60 mm were used for the railway bed layer. Crushed sand with a grain size of 0.16...5 mm was used as a fine filler for the concrete preparation. Crushed sand was obtained by crushing the rocks. The particles have sharp edges similar to those of mountain sand, and their surfaces are rough. Consequently, the consumption of cement and cost of concrete increase. Therefore, the best results will be obtained from sand with an optimal ratio of course, medium, and fine grains, and sand with this ratio will provide minimum voids. For the preparation of concrete, sand with small- and medium-sized grains is recommended. In such mixed grains, voids are reduced and the grain surface is not large. As a fine filler for this study was used crushed stone of LLC “Saihan Crusher”, located in Jizzak region, and as a coarse filler - crushed stone of this enterprise, its work”. Synthesis of super plasticizer PKAN-55. A total of 450 g of 37,0% formalin and 120 g of acetone were placed in a square flask equipped with a stirrer, reflux condenser, dropper, and thermometer. The mixture was stirred and heated to 45-52. Then, an aqueous solution of the alkaline catalyst (10% Na2SO3 solution) was added so that the pH of the reaction mixture was 10-11. The catalyst was then maintained at a constant pH of 11-12 for 2-3 hours. When the catalyst supply was finished, the temperature of the reaction mass was raised to 55-60, and condensation took place for 3-3.5 hours under constant stirring with a pH of 7,0 to 7,5. Subsequently, 1,5 parts of the active ingredient was placed in a vial and stirred for 55-60 minutes at 55-60. The resin dissolved in distilled water had a dry mass fraction of 84,9.

EXPERIMENTS AND RESULTS

To determine the strength of the cement, 1500 g of sand, complying with the requirements of ISO 6139, 500 g of cement and 200 g of water (Water/Cement =0,40) were taken and sampled according to ISO 310.4-81. To determine the cement grade, the bending and compressive strengths of the grab samples were taken as a basis, and the samples were made from the mixture prepared in the ratio of cement-sand mass 1:3, size 40×40×160 mm, and tested 28 d after reaching the standard strength (Figure 1).

Determining the result of cement testing after 7 days in a hydraulic press (1)

(1)

Determining the result of cement testing after 28 days in a hydraulic press (2)

(2)

 

**FIGURE 1.** The process of testing the strength of Portland cement using a MIG-1000 hydraulic press involves applying controlled pressure to the cement samples

This cement, selected on the basis of results, complies with ISO 31108-2020 “Cements for general construction. Compliance with “Requirements for physical and mechanical parameters of cements” specified in “Technical Specifications” was established. Developing the optimal composition of heavy concrete involves the following steps:

* Defining the requirements for the concrete based on the type of construction, the conditions under which it will be used, and the method of preparation.
* Selecting materials for the concrete and gathering necessary information about their properties.
* Determining the primary composition of the concrete mix.
* Verifying the composition of the prepared concrete mix through samples.
* Monitoring the concrete preparation process.
* Making adjustments to the composition when factors such as curing time, aggregate properties, and other conditions change.

At the same time, the specific characteristics of heavy concrete must be taken into account:

* the water-cement ratio should be less than 0.4,
* A high cement consumption (over 400 kg),
* High water demand of the mixture,
* As the concrete grade increases, the proportion of sand in the aggregate mix decreases.

When selecting the concrete composition, it is important to reduce cement consumption by introducing plasticizing additives. This not only ensures the efficiency of the concrete but also reduces its shrinkage and expansion, improves its crack resistance, and enhances other properties of the concrete. Once the following initial data is defined, the composition of the concrete can be calculated [6]:

* The design grade of the concrete;
* The design class (grade) of the concrete;
* The workability of the mixture;
* The characteristics of the raw materials (the activity or grade of the cement, the true and bulk densities of the materials, the specific gravity and bulk density of sand and gravel, as well as the porosity and water demand of fine and coarse aggregates, among others).

These parameters are important for improving the properties of concrete

**Methodology for calculating the content of 1m3 of Heavy Concrete**

1. The Water/Cement ratio is determined based on the condition for obtaining the required concrete strength at the activity of the given cement (3):

(3)

here: -activity of cement, MPa, -strength of concrete, MPa, А- coefficient taking into account the quality of fillers (table 1)

**TABLE I:** Coefficient Taking into Account the Quality of Fillers

|  |  |
| --- | --- |
| **Materials for Concrete** | **A Value** |
| High Quality | 0.55 |
| Normal Quality | 0.60 |
| Low Quality | 0.65 |

2. Based on the determined water-cement ratio and amount of water, the amount of cement used to prepare the concrete mix (kg) was determined as follows (4):

(4)

3. For 1m3 of concrete mix, determine the consumption of coarse aggregate (crushed stone) as follows (5):

(5)

4. The consumption of fine aggregate (sand) for the preparation of 1m3 of the concrete mixture was determined as follows (6):

(6)

5. Volumetric weight per 1m3 of concrete mix (7):

(7)

The initial concrete composition was determined based on the dependence of concrete strength on cement activity, water-cement ratio, quality of materials used, mobility of the concrete mix, water consumption, and other factors [7]. The mobility of a concrete mixture is understood as the ability of the concrete mixture to fill the form of the object being concreted, as well as the ability to compact in the form under the action of gravity or external mechanical forces. This is one of the basic properties of concrete, tested according to ISO 7473-2010 As a result of the laboratory analysis, the   
3, 7- and 28-day compressive strength limits of concrete of classes B30 and B25 without chemical admixtures were verified. According to results, the selected concrete sample contains super plasticizer PKAN-55 in terms of cement mass, respectively 0,6; 0,7; 0,8; 0,9; 1,0%. As a result of the addition, specimens were prepared (Figures 2) and their strength was determined at 3,7 and 28 days.



**FIGURE 2.** Super plasticizer PKAN-55 is measured in the amount of 0,8 percent of cement

As a result of laboratory analysis, 3,7- and 28-day compressive strength limits of concrete of classes B30 and B25 with chemical admixtures were checked, and the composition with the highest index was selected(Figures 3-4).

**FIGURE 3.** Compressive strength of concrete without chemical admixtures and with chemical admixtures of class B30

**FIGURE 4.** Compressive strength of concrete without chemical admixtures and with chemical admixtures of class B25

**CONCLUSION**

Based on the results obtained, the following conclusions can be drawn regarding the strength properties of high-strength heavy concrete.

1. 28-day strength of heavy concrete of classes B30 and B25 reached 42,32 MPa and 30,84 MPa, respectively.

2. Based on the experimental findings, the compressive strength of B25 class heavy concrete at 3, 7, and 28 days was recorded as 20,34 MPa, 30,8 MPa, and 30,84 MPa, respectively. Similarly, for B30 class heavy concrete, the strength at the same time intervals was 25,19 MPa, 32,26 MPa, and 41,14 MPa. With the incorporation of 0,8% (by cement weight) of the chemical admixture “PKAN-55”, the strength of B25 class concrete increased to 28,61 MPa, 35,36 MPa, and 41,35 MPa at 3, 7, and 28 days, respectively. Likewise, the strength of B30 class concrete improved to 32,40 MPa, 36,40 MPa, and 43,41 MPa over the same curing periods.

3. It was observed that the strength of B25 class heavy concrete with 0.8% (of cement weight) of chemical admixture “PKAN-55” was up to 40, 14, 34% on all days, respectively, and the strength of B30 class heavy concrete was higher on all days up to 29, 13, 5%, respectively.

4. Based on scientific research, the optimal composition of heavy concrete in terms of strength parameters was selected and tested.

# REFERENCES

* 1. B. L. Karihaloo, *Fracture Mechanics and Structural Concrete*, International Journal of Fracture **71**, 1–38 (1995). doi:10.1007/BF00035376.
  2. N. M. Al-Akhras, *Durability of Metakaolin Concrete to Sulfate Attack*, Cement and Concrete Research **36**, 1727–1734 (2006). doi:10.1016/j.cemconres.2006.03.026.
  3. S. Mindess, *Developments in the Formulation and Reinforcement of Concrete* (Woodhead Publishing, Cambridge, 2008). doi:10.1016/j.cemconres.2006.03.026.
  4. E. R. Turaev, E. S. Sottikulov, and A. T. Djalilov, *Physico-mechanical properties of composites based on polypropylene*, Chemistry and Chemical Engineering **2018**(2), 27–33 (2019). doi:10.70189/1992-9498.1028.
  5. O. Berdiyev, Z. Kurbanov, E. Tilavov, N. Rasulova, S. Boboqulova, I. Jumanov, R. Ametov, O. O‘Roqboyev, N. Parsaeva, and B. Botirov, *The calculation of reinforced concrete conical dome shells considering concrete creep*, E3S Web of Conferences **587**, 03001 (2024). doi:10.1051/e3sconf/202458703001.
  6. N. Parsaeva and Z. Kurbanov, *Study of the process of determination of chemically contained water in the concentration of additional cement made on the basis of peroxine waste*, AIP Conference Proceedings (2023). doi:10.1063/5.0145712.
  7. Z. Kurbanov and N. Parsaeva, *Strong grinding based on local raw materials getting stones*, AIP Conference Proceedings (2022). doi:10.1063/5.0089995.