Improving physical and mechanical properties of bentonite clay from Navbahar clay deposit

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Abstract. Different compositions of mixtures of sand and clay with medium-grade bentonite for molding of critical large parts of a freight car bogie are examined in the article. Different compositions to improve bentonite's physical and mechanical properties, such as gas permeability and compressive strength with the addition of soda ash, are considered. As a material for the study of sand and clay mixtures were taken quartz sand grade 1K2O2025, medium strength bentonite Navbaharskogo birthplace, and for improving the physical and mechanical properties of bentonite - soda ash. One possible way to increase bentonite's stability at high temperatures is to treat it with sodium-containing powder like soda ash. The treatment is performed by adding soda ash in powder form to dried bentonite. Experimental results are given in the form of tables and diagrams. Experimental studies were carried out in the production conditions of the central plant laboratories at ES "Liteyno-mechanical plant". The experiments were carried out following the normative documents. The basis of the results was plotted, and the assumed composition of sand and clay mixtures was established.

1 Introduction

In mass production of parts from one to hundreds of kilograms and in production where several hundred molds are formed per shift (production of wagon parts), sand and clay mixtures are used. Bentonite is the most economically viable binder and thermal transfer material for mold making from sand-clay mixtures. Bentonite comes in a variety of compositions. To obtain sufficient physical and chemical properties of the mixture, such as durability in the condensation zone and thermal stability, bentonite containing sodium and soda ash should be treated. This process will replace some sodium cations with calcium and magnesium cations [1].

In the Republic of Uzbekistan, it is difficult to find bentonite of a higher quality required for producing sand and bentonite mixtures. The ES "Liteyno-mehanicheskiy zavod" of the Republic of Uzbekistan uses medium-grade bentonite from the Zarafshan deposit to produce parts for freight wagons.

One of the possible ways to increase bentonite resistance at high temperatures is to treat it with sodium-containing powder like soda ash. The treatment is performed by adding soda

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ash in powder form to dried bentonite. The resulting mixture is used to prepare samples for the experiment [1, 2].

2 Methods

Based on the requirements of regulatory documents and the possibility of SE "Liteyno-mehanicheskiy zavod" Republic of Uzbekistan and the program of localization of production was set, the task to develop a new composition of sand-clay mixtures for large critical parts of freight wagon bogies [3].

The experiment required the following materials to prepare 100% (3000 g) of the molding sand:

- silica sand grade 1K2O2025 indicated в GOST 2138-91;
- bentonite from the Navbahar deposit;
- soda ash;
- water of the required humidity (for cast parts, the humidity is between 3.5 - 4.2 % in winter and 3.5 - 4.4 % in summer).

To improve the quality of bentonite clay in industrial conditions, the optimal composition of molding-clay mixtures is set. Table 1 shows the experimental compositions of the molding clay mixtures.

To improve the strength and heat resistance characteristics of medium-grade bentonite mixtures were prepared following Table 1. Silica sand 1K2O2025, Navbahar bentonite, and water were added to the traditional mixture. Bentonite was dried in a muffle kiln at 200ºC for one hour to remove moisture.

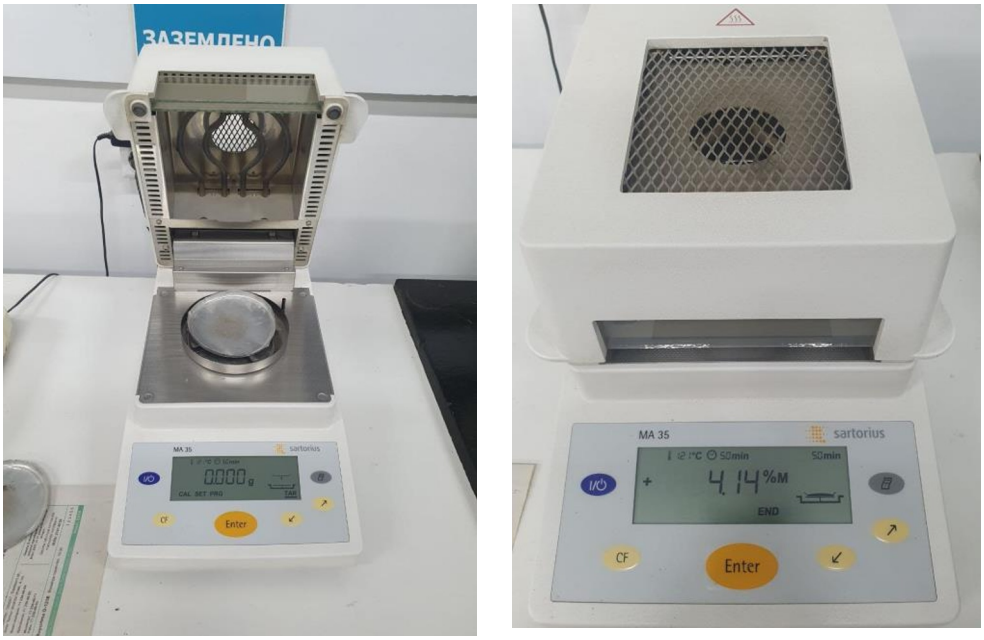
Table 1. Different compositions of molding sand

№ samples	Sand, g	Bentonite, g	Soda, g
1	2500	500	0
2	2495	500	5
3	2490	500	10
4	2485	500	15
5	2480	500	20
6	2475	500	25
7	2470	500	30
8	2465	500	35
9	2460	500	40
10	2455	500	45
11	2450	500	50
12	2445	500	55
13	2440	500	60

After drying bentonite, firstly, powdered components were mixed, and by adding water in the required quantity, the moisture content was obtained according to the technical instruction. Moisture content was determined with PWG MA35M mini-laboratory equipment (figure1), a method based on mass loss of mixture after drying to constant mass given in formula (1).

$$\omega = \frac{m_1 - m_2}{m_1} \cdot 100\% \qquad (1)$$

where m_1 is the mass of the mixture before drying, g; m_2 is mass of the mixture after drying, g.



a) *b)*

Fig. 1. Device for measuring humidity PWG MA35M: a is general view; b is test results

After that, with the help of the mini-laboratory device PVF-C (figure 2, a), samples in the form of a cylinder with a diameter of 50 and height of 50 mm according to GOST 23409.7-78 were made (Figure 3).

a) *b)*

Fig. 2. PVF-C mini-laboratory equipment for adaptability: a) general view; b) a sleeve with a mixture.

At the reception of samples, it has been fixed density of a mix with the method of change of height of the form in a sleeve. It took 155 g of the molding compound to obtain the required mold size [4, 5].

Fig. 3. Prepared specimens according to GOST 23409-78 with dimensions 50 x 50 for testing

After fabrication, the specimens were tested for compressive strength. The test was carried out on a PVF-C minilaboratory (Figure 2, b). The specimens were installed in the equipment and pressed, the results detected, and the arithmetic mean value calculated. After identifying the strength of the mixture with dried bentonite, the strength of the mixture with calcined bentonite was obtained using a similar method.
The process of obtaining calcined bentonite was carried out in a mini-laboratory muffle electric furnace at 550 ºC temperature for an hour. After cooling, weighed for making the molding mixture.
The heat resistance of bentonite clay was calculated using formula (2).

$$T = \frac{\sigma_{cal}}{\sigma_{mois.}} \qquad (2)$$

where $\sigma_{cal.}$ is compressive strength of medium-grade calcined bentonite mixture, MPa; $\sigma_{mois.}$ is compressive strength of the mixture with medium-grade bentonite, MPa.

3 Results and discussion

The results obtained by the above method are shown in Table 2 and Figure 4.

Table 2. Experimental and calculated data study

№	Quantity of soda ash, g	$\sigma_{mois.}$	$\sigma_{cal.}$	T	Gas permeability, units.
1	0	0.59	0.58	0.98	87
2	5	0.60	0.58	0.97	95
3	10	0.62	0.58	0.94	103
4	15	0.65	0.58	0.89	116
5	20	0.68	0.58	0.85	132
6	25	0.72	0.58	0.80	150
7	30	0.77	0.57	0.74	171
8	35	0.82	0.56	0.68	185
9	40	0.87	0.56	0.64	195
10	45	0.91	0.56	0.61	201
11	50	0.93	0.56	0.60	203
12	55	0.94	0.55	0.59	197
13	60	0.94	0.55	0.58	187

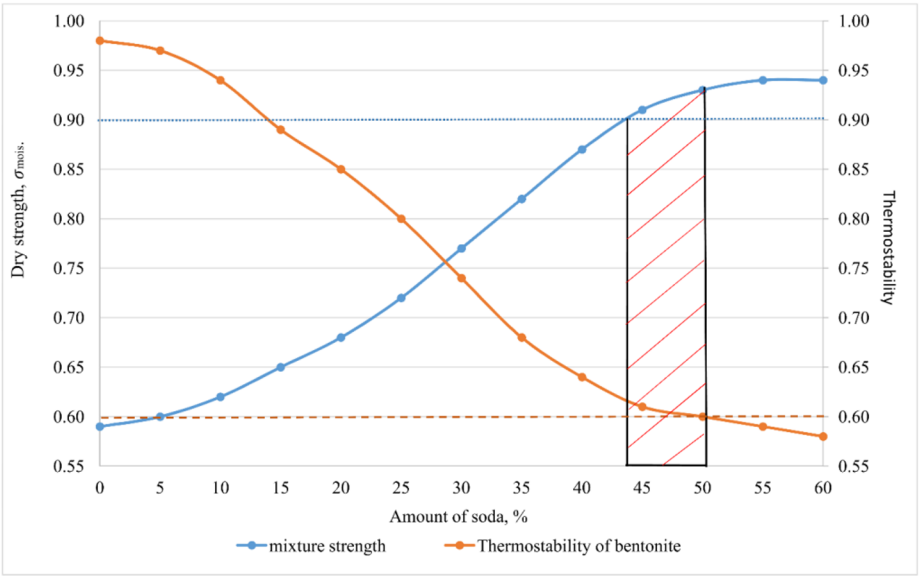


Fig. 4. Physical and mechanical properties of bentonite clay

As shown in Figure 4, the strength of the mixture increases as the amount of soda increases. Figure 4 shows the quantitative range of additives used to obtain the required properties of a mixture with medium-grade bentonite for large freight car parts.

Figure 5 shows that with increasing additives in the mix, the entrainment of compressive strength is directly proportional, and the thermal resistance of bentonite decreased.

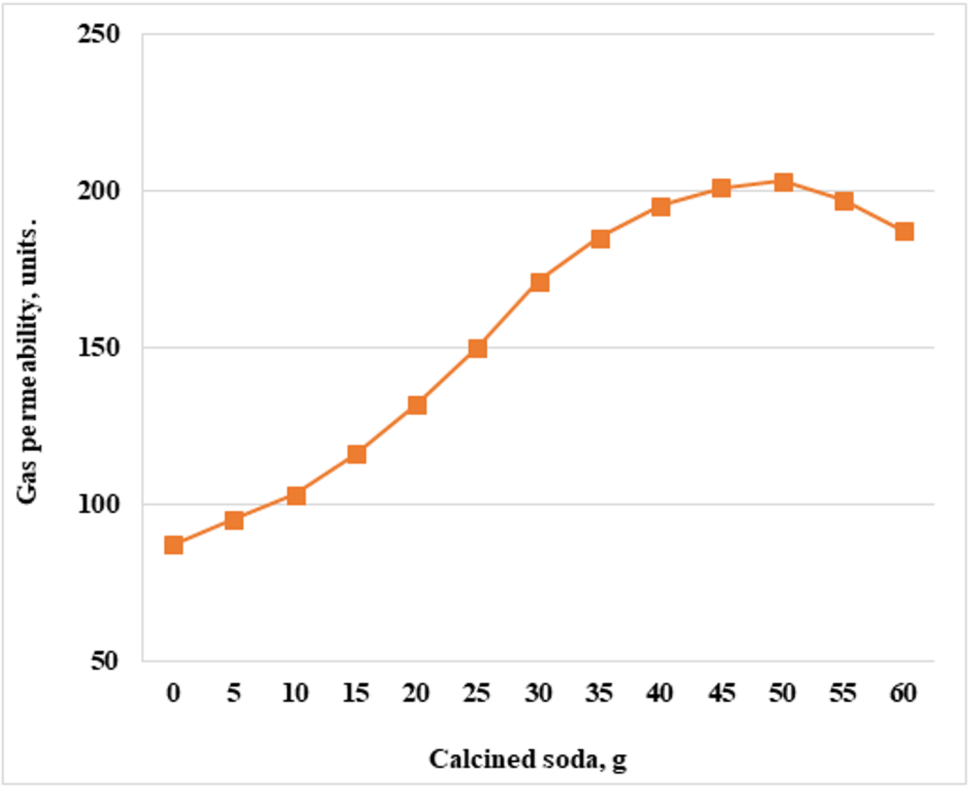


Fig. 5. Influence of amount of soda ash on gas permeability of mixture

Based on the requirements for molds made of sand-clay mixtures, technical instructions, and regulatory documents for large-sized freight car parts, the experimental interval of adding soda ash in the mixture was obtained. If you add 45-50 grams of soda ash to the traditional mixture with medium-grade bentonite, you can get a mixture that meets the requirements on the properties of the technical instructions and regulations of the large-sized parts of the cargo car.

The figure shows the effect of soda ash on the compressive strength of the mixture when wet. When more than 5 g of soda ash is added to the mixture, the gas permeability exceeds the 100 allowable limits. With the addition of caustic soda, the gas permeability increases monotonically, and at 50 g of caustic soda reaches a maximum of 203 units. When more than 50 g of soda ash is added, the gas permeability decreases from the maximum.

4 Conclusions

Research has been carried out to improve the physical and mechanical properties of bentonite molding clay of Navbahar birth. It is shown that with an increasing amount of soda, the strength of the mixture increases, and the heat resistance decreases. The best results were observed by adding 45 to 50 grams of soda ash. The strength of the mixture was over 90 kgf/cm2. The effect of the amount of soda ash on the gas permeability of the mixture was shown. Satisfactory results were observed at 45 g. Based on experimental studies, rational technology for improving physical and mechanical properties was

developed. At the same time, the gas permeability of the molding sand increased by 30 % and the wet strength by 45 % for the existing technology. The annual economic effect of introducing the technology of adding soda to the molding sand is 1.7 billion soums.

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