Influence of type of modified fillers based on dune sand on properties of cement paste, stone, and on technological and strength properties of concrete

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Abstract. Industrial enterprises are being built on a large scale in the desert regions of Uzbekistan. Concrete remains the main material in construction to this day. However, there is an acute shortage of sand of normal size. In this regard, an urgent task is to find effective and affordable technological methods for improving the properties of cement paste, concrete mix, and concrete on dune sand and cement savings. Taking into account our previous studies, the main attention was paid to establishing quantitative dependencies, changing the properties of cement paste and concrete from the introduction of sand dune fillers modified with additives of acidic (SDFMAA) and basic (marl) nature into their composition and the influence of methods for preparing a mixture of conventional and separate.

1 Introduction

Concrete remains the main material in modern construction. However, in several regions of the Republic, there is a shortage of sands of medium size that meet the requirements, and the issue of using sand dunes is becoming more and more acute. In this regard, an urgent task is to find effective, simple, and affordable technological methods for improving the properties of cement paste, concrete mix, and concrete by introducing dune sand into their composition.

2 Methods of research

Numerous studies carried out abroad and in Uzbekistan have shown that the most promising direction is the improvement of sand dune concrete and its properties based on the use of effective plasticizing additives, fillers, and separate concrete preparation technology. The ongoing research aims to develop an economic cement consumption in concrete compositions through the use of modified dune sand fillers in combination with separate technology.

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Portland cement grade 400, Karakum dune sand was used as a reference binder. When choosing additives, we proceeded from the following requirements: the additive should be accessible, have a high diluting, preservative ability, and it turned out to be additive of an acidic nature calcium lignosulfonate (CL), and a basic nature of marly limestone.

The modified filler was obtained by grinding dune sand and introducing it during grinding. a) the addition of an acidic nature (AN) in an amount of 0.15, 0.3, and 0.45% by weight of crushed barkhan sand in terms of solid matter; b) an additive of basic nature (marl limestone) 5-9% by weight of crushed dune sand (Fig. 1).

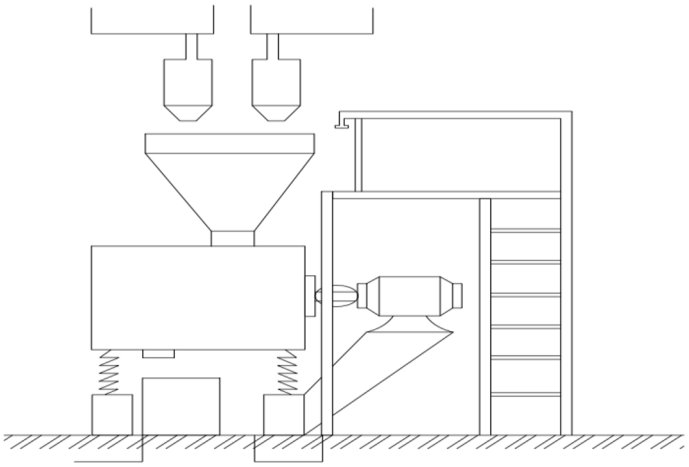

Fig.1. Technological scheme for the production of modified dune sand filler: 1. Vybromill, 2. Bunker, 3. Dune sand dispenser, 4. Dune sand accumulator, 5-6. Accumulators of additives, 7. Doser of additives, 8. Working area, 9. Hopper for modified filler

Studies have determined the effect of the dosage of SDFMAA additives on the physical and technical properties of cement paste and stone. The results obtained are shown in Table 1.

Table 1. Influence of SDFMAA additive on physical and technical properties of cement paste

№	Binder Composition	Normal density, %	Setting time, hour-min	
			Beginning	Finish
1	Controlling	26.0	1-15	5-35
2	Cement +15 % LST	24.5	1-30	6-00
3	Cement +0,3 % LST	22.5	1-45	6-25
4	Cement +0,45 % LST	23.5	1-30	6-10

As can be seen from the results obtained, the water demand decreases by 6-12%, probably due to the high adsorption activity and the plasticizing effect of the additive.

By increasing the melt of the cement paste cone by 60-80 cm, the beginning of setting increases by 15-45 minutes, and the end of setting by 22-50 minutes with a maximum at a dosage of 0.3% SDFMAA.

The addition of SDFMAA in a rational dosage of 0.3% lengthens the period of coagulation and crystallization structure formation of cement stone in the initial stages of hardening, which is confirmed by data on changes in the strength of cement paste of normal density.

Next, the effect of a filler modified with 0.3% SDFMAA on the properties of cement paste and stone was studied. The results obtained are shown in Table 2.

Table 2. Influence of the filler modified with 0.3% SDFMAA on the properties of the cement paste

№	Binder Composition	Normal density, %	Setting time, hour-min	
			Beginning	Finish
1	Cement + 0.3% SDFMAA	23.0	1-45	5-15
2	80% cement + 20% modified with 0.3% SDFMAA filler	21.5	1-55	6-35
3	80% cement + 20% unmodified filler	25.5	1-20	6-05

Introducing a filler modified with 0.3% SDFMAA into the composition of the cement paste reduced the water demand and increased the setting time. This is probably due to clay impurities in the barkhan sand.

The increase in the strength of cement stone with a 20% filler modified with 0.3% SDFMAA up to 14 days lags behind the control one, but in the subsequent periods of hardening, it almost evens out (Fig. 2).

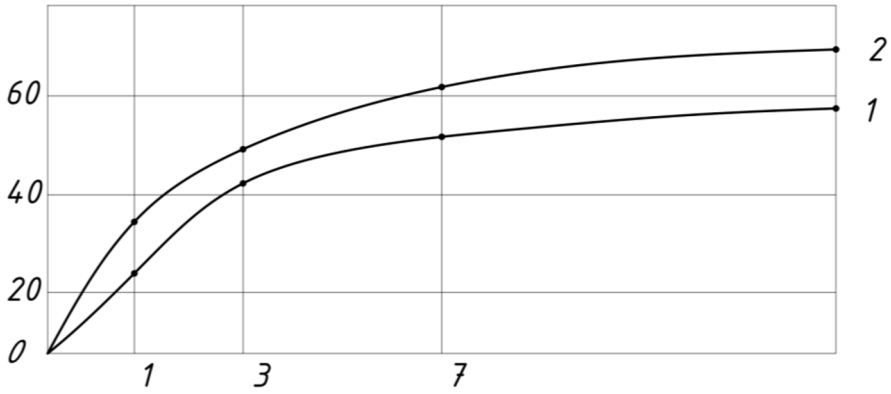

Fig. 2. 20% filler modified with 0.3% SDFMAA up to 14 days lags

Studies were carried out to determine the effect of a filler modified with 0.3% SDFMAA with the addition of the basic nature of marl on the physical and technical properties of cement paste and stone. The results obtained are shown in Table 3.

Table 3. Influence of marl additive on the properties of cement paste

№	Binder Composition	Normal density, %	Setting time, hour-min	
			Beginning	Finish
1	Controlling	26	1-15	5-35
2	80% cement + 20% modified with 5% marl	23	1-20	6-00
3	80% cement + 20% modified with 7% marl	23.5	1-00	5-50
4	80% cement + 20% modified with 9% marl	24	1-00	5-30

As can be seen in Table. 3, introducing a modified filler with marl improves the plasticity of the cement paste, providing a plasticizing effect during the coagulation period of the cement stone's structure formation, and the cement stone, and the strength of the cement stone has increased.

When using marl, the strength change curve has an extreme character with a maximum of 7% marl content. This amount of marl has a positive effect on accelerating the

coagulation and crystallization structure formation of the binder. It can be seen that the strength of cement stone with a filler modified with 7% marl is higher than with a filler modified with 0.3% SDFMAA. Under the action of the marl modifier, it accelerates the growth of the strength of the cement stone over time. This is due to the compaction and hardening of the contact zone, which increases the strength of the filled system.

Conducted research to determine the effect of modified fillers and the method of preparing the concrete mix on the physical and mechanical properties of the concrete mix and concrete.

The object of the study was a concrete mixture with a mobility of 8-10 cm and a concrete strength of class B-15. The concrete mixture was prepared in the usual and separate ways. With the separate method, the solution part was prepared in a high-speed turbulent mixer. In the conventional method, the mixing time was taken to be 60 seconds. With a separate method, all the water for the batch was sequentially introduced into the working laboratory mixer, all the binder and 20% of the modified 0.3 LST + 7% marl 20 seconds before the end of mixing, the mortar part from the turbulent mixer, was introduced into a conventional forced-action mixer at the place with coarse aggregate and continued mixing for 60 seconds. Samples were taken from the finished mixture to determine the workability, water demand, water separation, and mobile, and to determine the strength of concrete, cubes of 10x10x10 cm were formed.

The workability of the concrete mixture was evaluated indirectly by the change in the mobility of the draft of the standard cone. The results showed that the degree of increase in concrete mobility depends on the amount and type of modified additives and its preparation method. The results obtained are shown in Table 4.

Table 4. Indicators of mobility of concrete mix with fillers

№	Binder Composition	Filler quantity	Mobility, cm	
			Disposition method	
			Conventional technology	Separate technology
1	Controlling	-	8	10
2	80% cement + 20% filler modified with 0.3% SDFMAA	20	14	17
3	70% cement + 30% filler modified with 0.3% SDFMAA marl	30	16	19

The data analysis shows that the greatest increase in the mobility of the concrete mixture is observed by introducing a filler modified with 0.3% SDFMAA, which is exchanged for its greater surface activity. Depending on the preparation method, the concrete mixture's mobility increases by 4-9 cm. The somewhat greater mobility of the concrete mixture prepared using separate technology is exchanged for some air entrainment in mixtures due to its high-speed mixing.

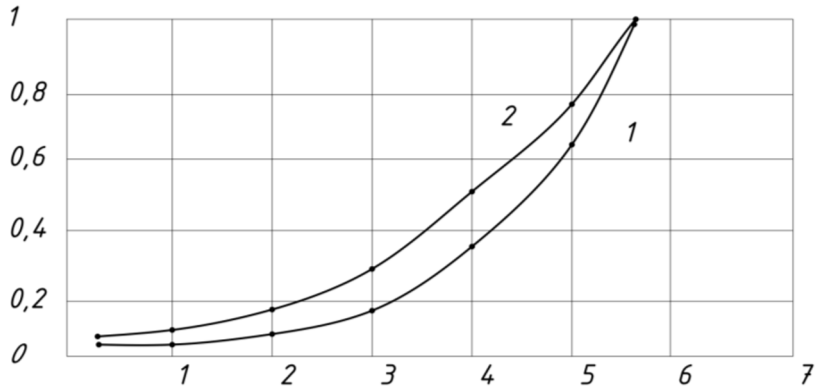

Fig.3. Filler modified with 0.3% SDFMAA

The introduction of a filler modified with 0.3% SDFMAA had a positive effect on reducing the water demand of the concrete mix (Fig.3). Studies have established that the introduction of a filler modified with 0.3% SDFMAA + 7% marl and separate technology reduces the water demand of the concrete mixture by 10-14%.

Table 5. Change in the water demand of the concrete mix

№	Binder Composition	Filler quantity	Water demand of concrete mix and prepared	
			With conventional technology	With separate technology
1	Controlling	-	240	236
2	80% cement + 20% filler modified with 0.3% LST	20	216	206
3	87% cement + 30% filler modified with 0.3% LST + 7% marl	30	217	208

This is explained by the fact that during the joint grinding of dune sand with marl, the main centers prevail on the surface of the particles. As a result, the adsorption activity of the surface of the filler particles increases. A natural consequence of the decrease in water demand is a decrease in the water separation of the concrete mixture (Fig.4).

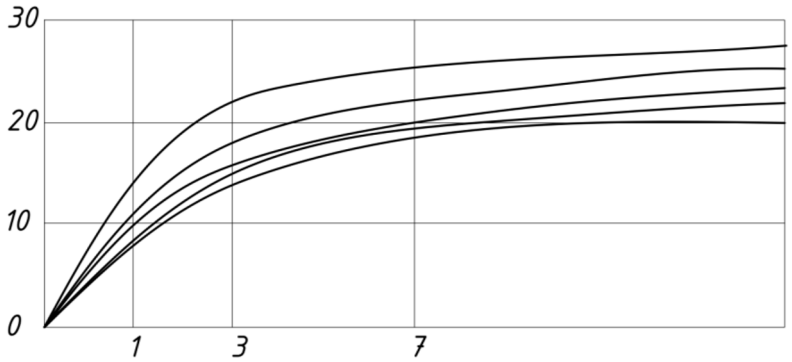

Fig.4. Filler modified with 0.3% SDFMAA

Experiments have established that the modified sand filler, 7% marl, and separate technology for preparing the concrete mixture help to reduce the water separation of the concrete mixture by 1.5-1.8 times. Since the main technological property of the concrete mixture is workability at the time of its placement in the structure, the question of changing the mobility of the mixture depending on the amount of filler and the type of modifying additive, as well as the ambient temperature, is of interest. In summer, the temperature in Uzbekistan can reach up to 43-45°C with a relative humidity of 80-90%. Changes in the mobility of the concrete mixture to the loss of workability were determined with an interval of 15 minutes at a temperature of 20 ± 2°C and 40 ± 2°C. The results obtained are shown in Table 6.

Table 6. Change in the mobility of the concrete mixture over time and at different temperatures

№	Type and content of binder	Filler quantity %	Initial mobility, cm	Concrete mix flow rates depending on ambient temperature, after, min, numerator at 40 °C				
				Time in minutes				
				15	30	45	60	7.5
1	Controlling	-	8/8	6/4	0/–	–/–	–/–	–/–
2	80% cement + 20% filler modified with 0.3% SDFMAA	20	9/9	9/8	8/6	7/4	6/3	4/1
3	70% cement + 30% filler modified with 0.3% SDFMAA + 7% marl	30	8/8	8/8	8/7	7/5	5/2	3/1

Table 6 shows that the control mixture loses its workability after 30 minutes, and with the proposed additives, it remains for 60-75 minutes at 20 °C and 45-60 minutes at 40 °C.

3 Results

The effect of additional air entrainment with the introduction of the LST additive is explained by a decrease in surface tension at the boundary of the "surfactant-air" solution, which positively affected the mobility of the concrete mixture and increases the duration of its preservation and also, under certain conditions of structure formation, positively affected the performance of concrete.

Studies were carried out to determine the effect of the number of fillers modified with 0.3% SDFMAA, marl additives, and the method of preparing the concrete mixture on the strength of the concrete.

Concrete mixtures were prepared from a predetermined optimal composition. Samples of 10x10x10 cm were molded from these mixtures to determine the kinetics of strength growth; samples were tested after 1,3,7, and 28 days of normal hardening. The results obtained are shown in Fig. 6 and 7. As can be seen from the obtained data, the increase in the strength of concrete samples molded from a concrete mixture of optimal composition, 80% cement + 20% and 30% modified with 0.3% SDFMAA filler + 7% marl, prepared by conventional technology, was 16-18%, and the strength of samples molded from a concrete mixture of this composition, prepared by separate technology, was 21-24% higher compared to control samples.

The strength of concrete samples from a concrete mixture prepared separately is higher compared to that prepared in the usual way because during the preparation of the mortar

part of concrete in a high-speed turbulent mixer, an additional amount of air is involved in the concrete mixture, which increases the volume of gel transitional and capillary pores and this is especially noticeable with the introduction of 0.3% SDFMAA.

It has been established that to obtain the same strength as a control sample, up to 17-19% of cement can be saved when using modified dune sand fillers.

4 Conclusion

Studies have found that when preparing cement paste, the introduction of a 0.3% additive of the acidic nature LST into the composition of the mixture has a positive effect on the physical and technical properties of the cement paste, reduced water demand by 6-12% due to the large adsorption activity of the additive, increased the melt of the cement paste by 60-100 mm, increasing the beginning of setting by 15-45 minutes, and the end of the setting of the cement paste by 22-25 minutes. The increase in the cement stone's strength from the additive's content is an extreme character with a maximum dosage of 0.3% LST due to a decrease in water demand. The addition of LST acid rock stabilized the coagulation period of structure formation, which contributed to an increase in strength; this is confirmed by the data on the plastic strength of cement stone.

The influence of the modified sand filler on the properties of cement paste and stone was investigated. Modified fillers were obtained by grinding dune sand with the addition of 0.3% SDFMAA. Introducing a filler modified with 0.3% LST in an amount of 20% reduced the water demand of the cement paste and increased the setting time. This is due to the presence of clay impurities in dune sand. The sand filler increased the periods of coagulation and crystallization structure formation, which slightly reduced the plastic strength of the binder. Considering this, studies were carried out to determine the effect of sand filler modified by adding the basic nature of marl limestone.

The introduction of 7% marl modified with the addition of a basic nature into the cement paste increased the water demand, reduced the setting time, and improved the plasticity of the cement paste. In addition to the filler modified with 0.3% LST, a 7% additive of the main nature was introduced into its composition to improve the strength properties. From the results obtained, it became known that the hardening of the filled binder is activated under the action of the marl modifier, and the growth of the strength of the cement stone has accelerated. This can be explained by the compaction and hardening of the contact zone, which increases the strength of the filled system.

With the introduction of modifying fillers and additives of the main nature into the composition of the concrete mixture, it positively affected the properties of the concrete mixture, and the mobility increased by 5-9 cm.

Slightly greater mobility of the concrete mixture, prepared in a separated way due to air entrainment, reduced water demand by 12-14% and decreased water separation. A legitimate consequence of a decrease in water demand is a decrease in water separation. The loss of mobility of the concrete mixture was determined depending on the ambient temperature; the concrete control mixture lost its mobility after 30 minutes, and with the proposed additives for 60-75 at a temperature of 20 ° C and after 45-25 minutes at 40 ° C.

The increase in the strength of concrete samples molded from a concrete mixture, the optimal composition of 80% cement + 20% and 30% modified with 0.3% SDFMAA filler + 7% marl, prepared according to conventional technology, was 16-18%, and the strength of samples molded from a concrete mixture of the same composition, but prepared using a separate technology, was 21-24% higher compared to control samples. To obtain strength with benchmarks, it is possible to save up to 17-19% of cement when using modified dune sand fillers.

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