BUILDING MATERIALS AND PRODUCTS

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THE EFFECTS OF TURBULENT MIXING ON THE CHARACTERISTIC OF THE BINDER

Statement of the problem. It is necessary to identify the influence of the rate solution and a mixing time on the binder characteristics during the turbulent mixing.

Results. The analysis of the obtained results showed that activation of the binder material filled with cement during the mixing in the turbulent mixer tap results in the increase in the compressive strength of this bender in comparison with sampling tests.

Conclusions. The study revealed that mechanical activation of binder materials filled with cement mixing in the mode of the developed turbulence allows one to control its structuring. Mixing in optimal temperatures leads to a 20—34 % increase in cement plasticity and durability of cement stone increases by more than 50 % in the early stages of solidification.

Keywords: plasticity, cement paste, strength of samples, dispersion cement, turbulent mixing.

Introduction

A turbulent mixer is designed to prepare cement and lime, concrete mixes. This mixer is a high-speed vertical axis mixer with a turbine cylindrical activator fitted with high-profile blades. Turbulent mixing is based on producing high-speed gradients.

A fast rotating activator produces turbulent vortexes and the components of the mix are therefore influenced not by the activator (rotor) of the setup but rather by dynamic turbulence of the medium. This active effect enables the production of high-quality moving mixes with the least destructive effect on the fillers. The use of turbulent mixing enables the production of the binder and concrete mix in the same container and mechanical activation of a large filler and cement.

A separate principle of making a concrete mix is the foundation of the intensive separate technology. In the intensive separate technology in a high-speed mixer-activator cement paste is pre-made adding the filler (the binder) which is then placed in the standard container with the filler.

Turbulent mixing occurs in the optimum conditions due to intensive mechanical and physical effect and the even distribution of water contributes to better plasticity and results in a drop in the strength of coagulational structure of cement paste [6].

1. Identifying the plasticity of cement paste in turbulent mixing

The analysis of the data in Table 1 shows that cement paste with W\C (water-cement ratio) = 0.35 plasticifies to a larger degree than at a high W\C = 0.45. As a result, there is a wave-like change in plasticity depending on the speedy rotation of the concrete mixer drum and mixing time.

This can be due to the fact that intensive mechanic effect destroys the bonds between the particles and water of the diffusive layer is transferred shortly to standard free water with the surface energy release [1].

2. Identifying the plasticity of cement stone in turbulent mixing

The analysis of the results showed that activation of a cement binder while being mixed in a turbulent mixer causes an increase in the compression strength of a cement binder compared to the specimen.

The maximum strength growth reaches up to 90 % at W\C = 0.45 and 70 % at W\C = 0.35 in a 3-day life cycle, it is 54 % for a 28-day life cycle regardless of W\C. The identified change in the cement strength with a high dispersion (developed specific surface) is acquired by using re-crushing, as the data suggests [4, 5].

For visual purposes the strength of the cement stone specimens made as a result of turbulent mixing is presented in relation to the specimens.

The results of the study into the effect of the rotor speed and mixing time on the strength of cement stone are identified in Tables 2-4.

Table 1

Plasticity of cement paste

Water-cement ratio	Mixing time, min	Plasticity of paste, cm (Sittard viscometer spread), at the mixing rate, m/sec					
		Speci-men	5.7	17.0	28.4	39.8	51.1
0.35	0.5	-	13.6	16.5	18.5	19.2	19.2
	1.0	-	14	16.2	17.7	18.8	21
	2.0	-	15.1	16.4	18.5	20	21.5
	5.0	12	15.9	18.3	19.5	22.2	23.1
	15.0	-	16.6	17.2	17.9	18	-
0.45	0.5		23.1	24.2	25.1	26.5	30.6
	1.0	-	23.1	24.2	25.1	26.5	34.3
	2.0	-	23.1	24.2	25.1	26.5	35.6
	5.0	23	25.2	26.8	29.3	30.5	37.2
	15.0	-	26	23	25.3	26.5	-

Table 2

Strength of cement stone in a 3-day life cycle

Water-cement ratio	Mixing time, min	Strength of cement stone, MPa, at the mixing rate of cement stone, m/sec					
		Speci-men	5.7	17.0	28.4	39.8	51.1
0.35	0.5	-	332	423	378	349	368

End of Table 2

0.35	1.0	-	341	459	420	420	402
	2.0	-	346	511	432	370	421
	5.0	296	340	482	421	388	400
	15.0	-	347	462	433	407	-
0.45	0.5	-	138	230	147	117	178
	1.0	-	149	248	178	163	191
	2.0	-	172	301	193	137	218
	5.0	101	179	304	198	148	243
	15.0	-	174	290	221	162	-

Table 3

Strength of cement stone in a 7-day life cycle

Water-cement ratio	Mixing time, min	Strength of cement stone, MPA, at the mixing rate of cement paste, m/sec					
		Specimen	5.7	17.0	28.4	39.8	51.1
0.35	0.5	-	389	499	428	421	443
	1.0	-	404	553	483	487	460
	2.0	-	401	559	496	424	471
	5.0	355	412	515	487	462	462
	15.0	-	402	491	486	482	-
0.45	0.5	-	228	342	259	227	282

End of Table 3

Water-cement ratio	Mixing time, min	Strength of cement stone, MPA, at the mixing rate of cement paste, m/sec					
		Specimen	5.7	17.0	28.4	39.8	51.1
0.45	1.0	-	289	387	340	315	317
	2.0	-	298	410	352	276	323
	5.0	197	308	454	357	290	344
	15.0	-	229	376	386	299	-

Table 4

Strength of cement stone in a 28-day life cycle

Water-cement ratio	Mixing time, min	Strength of cement stone, MPA, at the mixing rate of cement paste, m/sec					
		Speci-men	5.7	17.0	28.4	39.8	51.1
0.35	0.5	-	509	648	590	564	580
	1.0	-	538	749	662	640	606
	2.0	-	541	735	673	575	633
0.35	5.0	484	544	697	663	591	619
	15.0	-	539	633	627	602	-
0.45	0.5	-	378	518	436	377	399
	1.0	-	401	530	493	491	404
	2.0	-	442	529	520	392	429
	5.0	347	446	528	509	404	445
	15.0	-	380	522	502	432	-

As Table 2 suggests, the largest growth in the strength in turbulent mixing is attained at the rotational speeds of the rotor ranging from 12 to 24 m/sec. At the speed of over 24 m/sec and mixing time of over 2…5 minutes there is a rapid decline in the growth of the strength, which is more manifested as there is an increase in W/C.

The strength of cement stone specimens made at considerably high speeds which are lower than of the specimens made at ΰ = 5.7 m/sec. This can be explained by the formation of a crystal structure in cement stone. If a mechanic effect is high, obviously the dispersion of new formations becomes so high that there is a rise in the optimal concentration of new formations in the volume unit and adversely affects the strength of cement stone. The assumption is proved in the papers [1—3].

3. Identifying the plasticity of cement stone in turbulent mixing

Turbulent mixing is found to influence not only the microstructure of new hydrate formations. Even distribution of water and high homogeneity of a cement binder cause lower porosity of cement stone and a rise in its strength respectively. Change in porosity is indirectly indicative of lower porosity. As the comparison suggests, at the optimal mixing rate ΰ = 17 m/sec compared to the specimen, the density of cement stone increases by 5…6 % and strength by over 50 %, which is in agreement with the results of the study identified in Table 5 [4].

Table 5

Density of cement stone

Water-cement ratio	Mixing time, min	Density of cement stone, g/cm^3, at the mixing rate of cement paste, m/sec					
		Specimen	5.7	17.0	28.4	39.8	51.1
0.35	0.5	-	2.11	2.17	2.14	2.12	2.18
	1.0	-	2.12	2.21	2.16	2.18	2.20
	2.0	-	2.13	2.21	2.17	2.14	2.18
	5.0	2.08	2.13	2.17	2.16	2.13	2.13
	15.0	-	2.10	2.18	2.16	2.15	-

End of Table 5

Water-cement ratio	Mixing time, min	Density of cement stone, g/cm^3, at the mixing rate of cement paste, m/sec					
		Specimen	5.7	17.0	28.4	39.8	51.1
0.45	0.5	-	1.99	2.08	2.05	1.99	2.00
	1.0	-	2.00	2.11	2.07	2.06	2.00
	2.0	-	2.05	2.11	2.09	1.99	2.01
	5.0	1.97	2.04	2.10	2.09	2.01	2.01
	15.0	-	2.00	2.08	2.06	2.01	-

Conclusions

1. Mechanic activation of a cement binder mixed in developed turbulence was found to be capable of governing its structure formation with the optimum parameters being in agreement with the time of activation for 1 minute at the circular rotational speed of the turbulent mixer rotor 12 … 24 m/sec. Mixing in optimum modes results in a 20—34 % increase in the plasticity of cement paste.

2. High homogeneity of the binder and even distribution of water was shown to contribute to a 5…6 % increase in the strength of cement stone. The strength of cement stone sees a 54% increase, a higher relative growth is observed in the earlier hardening stages as well as in mixes with a high W\C ratio.

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