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EFFECT OF SPECIAL ACTIVATION MIXING TECHNOLOGY ON DEVELOPMENT OF NEW PROGRESSIVE GROUTING MATERIALS

Summary. The paper describes the possibilities of grouting strategy and especially the development of new progressive materials containing by-product (fly ash) under respecting the increase of quality. Attention was paid especially to properties of the fresh mixture namely to the setting time of modified materials and to the fulfilment of demanded physic-mechanical parameters of the hardened mixture. Particular formulae were designed following optimisation calculations for the broad utilization in practice. And special activation mixing technology was used and in results was compared with standard mixing technology.

WPŁYW SPECJALNEJ AKTYWACYJNEJ TECHNOLOGII MIESZANIA NA ROZWÓJ NOWYCH POSTĘPOWYCH INIEKCYJNYCH CEMENTOWYCH MATERIAŁÓW

Streszczenie. W referacie przedstawiono możliwości strategii postępowania przy wykonywaniu iniekcji cementowych, a szczególnie rozwój nowych postępowych materiałów, zawierających popiół lotny, stosowany ze względu na wzrost ich jakości. Szczególną uwagę zwrócono na właściwości świeżych mieszanek, mianowicie na czas osiadania modyfikowanych materiałów, w celu wypełniania żądanych fizykomechanicznych parametrów stwardniałej mieszanki. Zaproponowano szczególną formułę służącą optymalizacji obliczeń, w celu szerokiego wykorzystania w praktyce. Została zastosowana specjalna technologia aktywacji, a jej rezultaty zostały porównane ze standardową technologią mieszania.

1. Introduction

The classical technology of grouting is well known for some centuries. The principle of this technology is the filling of pores and cavities by the grouting mixture. The mixing of the grouting mixture with the original material forms a composite which has new physical

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properties. This is most frequently the way to improve the strength and the imperviousness of the material. The grouting can also secure the lasting position of unstable objects. Another typical application is the waterproofing of cracks and gaps (to secure the water tightness of cracks and gaps).

The grouting is the process of pumping the liquid with variable viscosity into the ground, into the fissured or loose ground, concrete or masonry in order to increase the density of these materials.

The problem of building structures subsoil hardening, of filling the cavities and the formed caverns became to be a very topical subject in the Czech Republic, especially after the year 2002, when the Czech Republic suffered under extensive floods, which caused the significant disturbance of foundation subsoil. These problems can be successfully solved by the utilization of grouting technologies. This concerns the application of large scale grouting and possibilities are looked for to decrease the final price under keeping the demanded parameters for the grout mixtures. Considering the fact, that the floods came also in last year 2006, though they were not so great, the subject of large scale grouting is in Czech Republic still very topical. The number of structures rehabilitated by grouting materials increases the demands on the research and development of new building materials.

Large-scale grouting in the ground work is connected with increasing demand to solve the question of large scale utilization of industrial wastes in the largest possible extent. The utilization of wastes would not only partially solve the problem with wastes disposal but the wastes application would have positive effect on the price of the work.

2. Aim of project

Aim of project was based on the development of new progressive grouting material with partly substitution of by product as filler and bonding material. As substitution was used fly ash. And special activation mixing technology were used and in result were compared this technology with standard mixing technology. Attention was paid especially to properties of the fresh mixture namely to the setting time of modified materials and to the fulfilment of demanded physic-mechanical parameters of the hardened mixture. Particular formulae were designed following optimisation calculations for the broad utilization in practice.

3. Description realized works

The research consisted of two main parts. First part solved the possibilities of filler substitution and the second stage was focused on bonding material substitution.

Formulae were designed with the substitution of filler by 10 till 50% of waste materials. The reference mixture was the concentrate mixture (cement, bentonite, special admixtures) and quartz sand. We have performed the experimental verification of the partial substitution effect of filler by the grouting mixture. The filler (quartz sand) was substituted. And in the second stage were particular formulae designed following optimization calculations for selected mixture which has the optimum properties. And these mixtures were modificated. The bonding material was substituted by fly ash. The fresh mixtures of all the selected formulae were tested by following basic tests: consistency of the mixture, initial and final setting time, bending strength on test pieces, compression strength on test pieces, volume mass, shrinkage during hardening on test pieces (40/40/160 mm). Special activation mixing technology was used. Activation mixture is based on high rotation – there are 2000 rotations per minute. Due to high rotation the penetration of water into cement grain is very intensive and also the high mechanical power caused increasing of specific surface of cement grain. And in the result were compared effect of activation technology and standard technology.

4. Description of applied materials

For useful interpretation of the used materials were outlining the individual properties of these raw materials

4.1. Cement

Cement CEM III/A 32,5 R, company „Českomoravský cement, spol. s.r.o." Czech republic

Table 1

Main properties of applied cement

properties	unity	value
Specific surface	$cm^2.g^{-1}$	375
Initial setting time	min.	160
Final setting time	min.	230
Compressive strength 2days	N/mm^2	15.4
Compressive strength - 28 days	N/mm^2	38.6

cd. tabeli 1

contain C_3A in clinker	[%]	<= 8,0
SO_3	[%]	<=4,0
C3A in cement	[%]	<=4,0
chlorides	[%]	<=0,10
loss by ignition	[%]	<=5,0

4.2. Bentonite

Table 2

Chemical analysis of bentonite

SiO_2	50.0 - 57.0 %
Al_2O_3	15.7 - 17.3 %
Fe_2O_3	8.8 – 17.0 %
H_2O	5.3 – 6.3 %
TiO_2	3.8 – 6.3 %
MgO	3.8 – 6.3 %
CaO	1.7 – 3.1 %
K_2O	0.3 – 1.2 %
FeO	0.1 – 1.0 %

4.3. Quartz sand

Mass density: 2 500 kg/m^3, apparent density: 1 650 kg/m^3

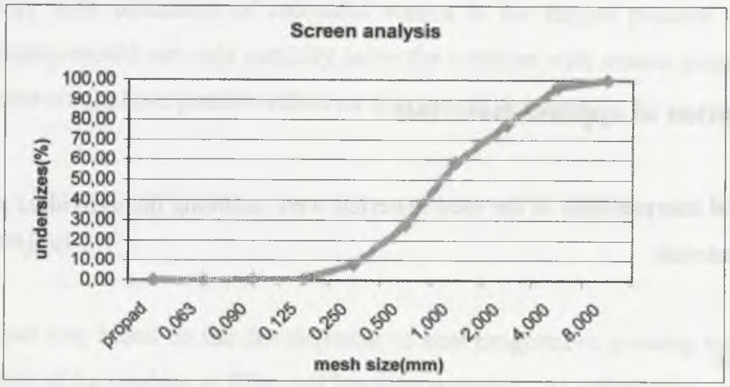

Fig. 1. Grain size distribution [4]
Rys. 1. Krzywa przesiewu [4]

4.4. Fly ash

Fossil-fuel power station Chvaletice Czech Rep. Mass density: 2060 kg/m^3, specific surface: 270 m^2/kg. The density was tested in laboratory. [4]

Table 3

Chemical analysis of fly ash

CaO	1.79%
MnO	0.03%
Al_2O_3	28.93%
Fe_2O_3	6.08%
sulphates	0.2%
SiO_2	56.82%
Na_2O	0.32%
MgO	1.31%
K_2O	1.79%
TiO_2	2.02%

5. Experimental part

In the experimental part were particular formulae designed following optimization calculations for selected mixture which had the best properties. And this mixture was modified. The bonding material was partially substituted by fly ash. For mixing were used special activation mixing technology and also were tested samples which were prepared by standard mixing technology.

Activation mixture is based on high rotation – there are 2000 rotations per minute. Due to high rotation the penetration of water into cement grain is very intensive and also the high mechanical power caused increasing of specific surface of cement grain. [2]

Table 4

Mixtures proportion – bonding and filler material was substituted by fly ash

sample	cement [kg]	additives - bentonite [kg]	Fly ash (bending material) [kg]	quartz sand [kg]	Fly ash (filler)[kg]	water [kg]
ref. sample	533	40	–	1066	–	430
P80	426	40	–	729	253	381
P80-10	383	40	43	729	253	381
P80-20	341	40	85	729	253	381
P80-30	298	40	128	729	253	381
P80-40	256	40	170	729	253	381

- P80-cement was reduced up to 80%
- P80-10 cement was reduced up to 80% and 10% of reduced amount was supplied by fly ash
- P80-20 cement was reduced up to 80% and 20% of reduced amount was supplied by fly ash
- P80-30 cement was reduced up to 80% and 30% of reduced amount was supplied by fly ash (atc.)

Table 5

Results of the tests after 7 and 28 days

sample	7 days			28 days		
	bulk density [kg/m^3]	bending strength [N/mm^2]	compression strength [N/mm^2]	bulk density [kg/m^3]	bending strength [N/mm^2]	compression strength [N/mm^2]
ref. sample	1920	2,2	9,6	1890	5,0	14,9
SP80	1870	2,5	12,8	1845	3,8	18,0
P80-10	1850	2,2	10,3	1815	3,3	16,5
P80-20	1835	2,0	9,2	1805	3,1	15,2
P80-30	1815	1,9	6,6	1795	3,0	11,6
P80-40	1800	1,9	6,0	1780	2,8	9,3

Table 6

Water/cement ratio and setting time

sample	bending material/ref. mixture [%]	water [kg]	w/r [-]	Initial setting time [min]	Final setting time [min]
ref. sample	100	475	0,83	25	75
P80	80	425	0,59	25	60
P80-10	72	425	0,59	25	60
P80-20	64	425	0,59	25	65
P80-30	56	425	0,59	30	65
P80-40	48	425	0,59	30	65

5.1. Results in graphs

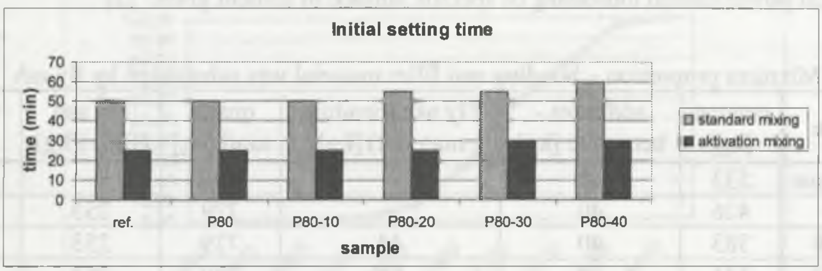

Fig. 2. Initial setting time standard and activation mixing
Rys. 2. Początek czasu wiązania standardowej i zmodyfikowanej mieszanki

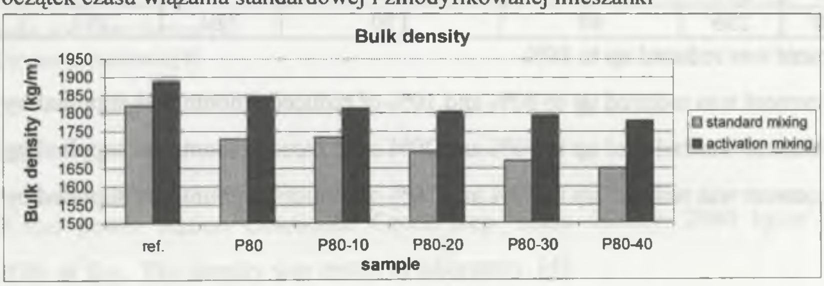

Fig. 3. Bulk density
Rys. 3. Gęstość objętościowa

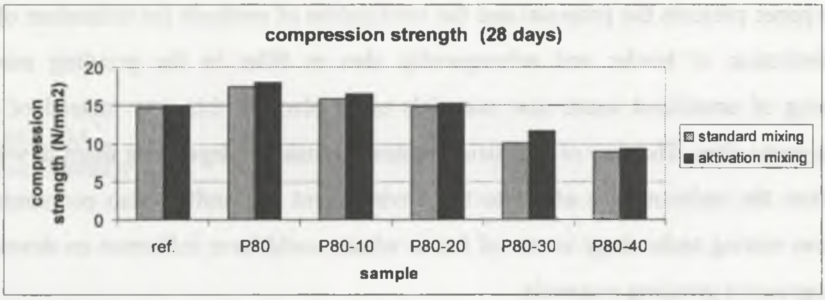

Fig. 4. Compression strength
Rys. 4. Wytrzymałość na ściskanie

6. Conclusion

As seen in fig. 3, the increase in density was determinated, that the application of secondary raw materials caused the decrease in volume mass in the case of all mixtures. The water cement ratio of modified mixtures must have been modified with the rising portion of fine particles (finely ground waste materials) in order to achieve the demanded workability. For this reason a significant increase in the w/c ratio was determined in the case of all mixtures with waste raw materials. It was first off all necessary to solve the question of filler substitution in grouting materials under maintaining the demanded physical-mechanical properties.

The grouting materials containing waste materials fulfil the demanded values, expressed by the reference material.

It was determined that it is possible to reduce amount of cement about 30% by the suitable proportion and technology. Increasing of compressive strength in the modificated grouting mixture is caused by the grain size composition of the filler (the nearer is this composition to the ideal grain size curve) and also by the perfect distribution of the grains (no sedimentation takes place).

Due to high rotation the penetration of water into cement grain is very intensive and also the high mechanical power caused increasing of specific surface of cement grain.

Activation mixing caused faster cement hydration and faster setting time, which could be sometimes by realization of work an advance. Compression strength was increasing when activation technology was used.

The paper presents the proposal and the verification of methods for utilization of fly ash as the substitution of binder and subsequently also as filler in the grouting mixture. The processing of unutilized waste raw materials takes place in this way instead of depositing them in waste sites. The way of industrial wastes disposal by depositing them in waste sites is apart from the unfavourable effect to the environment demanding also economically. And activation mixing technology is one of factor which could have influence on development of new progressive grouting materials.

Research is still continue and keeping developing. The advantage of grouting mixtures filled by waste raw materials is the lower price and in the same time also the disposal of industrial waste.

The given problems are solved in the framework of the research project MSM 0021630511 called: "Progressive Building Materials with Utilization of Secondary Raw Materials and their Effect on Service Life of Structures" and project FT-TA3/139 Complex system of rehabilitation of soil imperfections outside of building structures by the waste material based new grouting material. And project FRVS G1/1560/2007 Research of modification filer and bonding material of grouting systems with utilization of by product. This support is gratefully appreciated.

LITERATURE

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