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On the Issue of Improving the Quality of Domestically Produced Building Mortars

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Abstract: Polymer additives of local and foreign production for application in dry building mixes technology were presented. The necessity of expanding the range of polymer additives produced in Russia for manufacturing ompetitive products was proved. It was shown that the use of local water-soluble polymers masonry mortars with additives (methylcellulose, hydroxyethyl cellulose) in the amount of 0.5-1% prevents softening and cracking of masonry at the junction of bricks, provides high adhesion to stone walling, increases the solidity of masonry. The load bearing strength of masonry cement-sand mortar with the addition of 0.5% methylcellulose increases by 20% compared with the brickwork on the traditional mortar without the addition of polymer. The generation of major cracks in case of central compression of masonry on on the basis of cement-polymer mortar occurs at higher intensities of breaking load. Additives of studied domestically manufactured water-soluble polymers are environmentally friendly products. The low percentage of polymer has positive effect on water resistance and cost of masonry. Designed masonry mortars can be recommended for buildings and structures subjected to dynamic effects.

Key words: Cement-polymer compositions, modification of constrution mortars, water-soluble polymers, water-retaining capacity, technological characteristics of mortars

INTRODUCTION

Due to the rise in production of wall materials there is a relevant problem of improving the reliability and durability of brick buildings and structures (Kolyada, 2007; Degtev and Lavrik, 2008). The problem of strengthening structures in the dynamic effects of natural and technogenic character has a special significance at the present time when seismic hazard is worldwide increasing, even where it did not previously exist. Earthquakes entail tremendous damage not only in the center but also in adjacent seismically quiet regions.

The devastating earthquake may lead to serious socio-economic shocks including through the implementation of secondary risks from industrial enterprises.

According to the global statistics, the vulnerability of society to the impacts of dangerous natural and anthropogenic processes increases annually on victims and economic losses.

The major social and economic losses are associated with damage and deformations of buildings and structures due to the lack of reliability and protection against earthquakes and secondary processes.

International and multiregion cooperation in the field of prevention and liquidation of consequences of earthquakes and emergency situations of natural and anthropogenic origin becomes one of the most important directions of the state policy.

One of the ways to solve their problems is to increase the reliability, durability and safety of buildings and structures from masonry wall materials through the use of high quality construction including masonry mortars.

Analysis of scientific literature and studies carried out in BSTU named after V.G. Shoukhov (Rakhimbaev *et al*., 2004; Degtev *et al*., 2010; Onoprienko *et al*., 2007) has shown that the integrity and load-bearing capacity of brickwork using conventional cement mortars is insufficient not only in the case of dynamic effects of various kinds but also in terms of static conditions of structures' expluatation.

Low adhesion strength of brick and mortar, significant shrinkage deformations of masonry mortars, different deformation characteristics of masonry elementsresults in decrease in strength and fracture toughness of brickwork.

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In this regard, measures are needed to strengthen the constructed buildings and structures of brick which have particular importance for the dynamic effects of different types.

THE MAIN PART

Known constructive measures to strengthen masonry with steel profiles, reinforced coatings can increase the lower limit of crack formation and cross sections but the complexity of production and material intensity would greatly increase.

Currently, in the direction of improving of bearing capacity of masonry through the use of high-strength materials there was achieved some success. However, the percentage of usage of rock material strength in the masonry remains low (strength of masonry is only 30% of the tensile strength of the brick). This is due to the mortar joints, occupying about 25% of the volume of masonry, reduce its strength, increase the deformability and the heterogeneity of the relatively large thickness of the layer of mortar (15 mm) and low adhesion of mortar with stone material. This particularly relates to the masonry of lime-sand bricks.

Researches of russian and foreign experts have shown that supplements of water soluble polymers and emulsions will significantly improve technological characteristics of mortars, physical and mechanical parameters of mortars and based on them constructions, increase the efficiency of masonry and brick strength usage percentage (Onoprienko *et al*., 2007; Rakhimbaev *et al*., 2004; Onopriyenko, 2012; Zhu and Chung, 1997; Pascal *et al*., 2004). In modern practice of construction including masonry work, dry mixes are increasingly used.

The advantage of dry mixes compared to the traditionally used mortars is a significant improve of the quality and level of construction process, reduction of material intensity and complexity of production.

Basis for dry building mixes is mostly cement-polymer compositions. Modification of mortars is carried with water-soluble cellulose ethers and redispersible polymer latexes powders. The polymer content in the mortar varies between 0.01-5% of the dry mix weight depending on the function of mortar.

Polymer additives in the content of dry mix, provide the required physical, mechanical and technological properties of the mortar: water-retaining capacity, workability, plasticity, high adhesive ability, hardening time, spreading stability of mortar.

Mortars, modified with polymers additives are currently used in a sufficiently promising thin-layer technologies, characterized by high aesthetic values.

From the standpoint of economics and competitiveness of the goods in the production of dry mixes it is appropriate to apply domestically produced materials with minimal cost (Onopriyenko, 2012). This primarily relates to polymeric additives which are known to be the most expensive component of the cement-polymer compositions.

In order to identify the most widely used polymer additives and their manufacturers we have analyzed the scientific literature which showed that the greatest use in the compositions of dry building mixes for different purposes have the following polymers (Korneev and Krasheninnikova, 1998; Demyanova and Kalashnikov, 2001; Maranhao *et al*., 2011):

- Ethers and esters of cellulose and their derivatives of anionic, nonionic nature different molecular weight and degree of etherificafion: methylcellulose, methylhydroxyethyl and methylhydroxypropyl cellulose, acethylphtalyl cellulose, hydroxyethyl and oxyethyl cellulose, oxypropylmethyl cellulose, oxybutylmethyl cellulose, carboxymethyl cellulose
- Polymers of ethylene and propylene oxides and their copolymers with amides of nonionic nature: polyethylene oxide, polyoxypropylene, polyoxy'thylenealkilamid, polyethyleneglycol, polyoxyethylenes tearatamid
- Polymers of acrylic acid and acrylamide of ionic and ampholytic nature: polyacrylic acid, polyacrylamide
- Low and high molecular weight polyvinylalcohol
- Polyvinyl acetate and copolymer latexes
- Natural polysaccharides and proteins of nonionic and ampholytic nature: proteins, starch ethers, dextrin, casein, bone glue

Currently, a wide variety of powders dispersions (dispersion powders) is produced:

- On the basis of the PVA and its copolymers with vinyl ester, ethylene, vinyl chloride, acrylics, maleates
- Homopolymers of polyacrylic esters
- Styrene-acrylic latexes
- Styrene-butadiene copolymers
- Different combinations

The most high-quality are latexes of acrylates copolymers. Along with the above listed polymeric additives chemical additives are used for special purposes: thickeners (starch ethers), anti-foaming agents, water repelling agents, cellulose fibers.

Initial modification of mortars is made by adding cellulose ethers and their derivatives in an amount of 0.01-1% by weight of the dry mixture, it is used for masonry and tile compositions, working in dry conditions. For materials, operating in difficult conditions, a higher level of modification which is achieved by the introduction of redispersible polymer powders into the mortar in an amount up to 5% by weight of the dry mixture either alone or in conjunction with cellulose ethers.

Table 1 shows the trademarks, the main components of polymer additives and names of domestic and foreign manufacturers of these supplements. Table 1 shows that the polymeric additives are mainly represented by expensive imported products. Information about these additives is limited with promotional information of manufactures.

Thus, there is an obvious need to expand the assortment of Russian polymer additives to produce competitive dry building mortars for various purposes. In (Onoprienko *et al*., 2007; Rakhimbaev *et al*., 2004) cement-polymer masonry mortars with additives of domestic water soluble polymers that allows improving the integrity and strength of masonry without significant changes in the technology of masonry work were studied.

Application of masonry mortars with additives of domestic water-soluble polymers (methylcellulose, hydroxyethyl cellulose) in an amount of 0.5-1% prevents softening and cracking of masonry at the junction of brick and mortar due to high ductility and low water-gain of these mortars their high adhesion to brick (Onoprienko *et al*., 2007; Rakhimbaev *et al*., 2004).

Table 1: Polymer additives in compositions of modern dry building mixes

Trade mark (brand name) (1)	Basic component (2)	Manufacturing company, country (3)
Tylose	Ethyl cellulose	Clariant, Germany
Tylose	Methylhydroxyethil cellulose	Closed joint-stock company “Euro Chim-1”, Russia
Metocell	Methylhydroxypropil cellulose	Closed joint-stock company “Euro Chim-1”, Russia
Mecellose	-//-	Dow Chemical, USA
Culminal	Methylhydroxyethil cellulose	Hercules, USA
Bermocoll	Ethylhydroxyethyl cellulose	Akzo Nobel, Sweden
	Ethyl (oxyethyl) cellulose	Akzo Nobel, Sweden
Methyl cellulose	Methylcellulose	Production enterprise “ChimProm”, Uskolje-Sibirskoe, Russia
Metocell	-//-	USA
Tylose	-//-	Germany
Metolose	-//-	Japan
Metofas	-//-	England
Cellacol	-//-	
Oxyethil cellulose	Oxyethil cellulose	Pilot-production plant of All-Russian Research Institute of sugarbeet and sugar, Vladimir, Russia
Polyoxyethylene	Polyoxyethylene	Production enterprise “Orgsintes”, Kazan, Russia
Polyox	Polyoxyethylene	USA
Polyacrylamide	Polyacrylamide	Russia
Na-CMC	Na-carboxymethyl cellulose	Russia
Amilotex	Starch ether	Hercules, USA
Amitrolit	Hydroxy propyl starch	Dow Chemical, USA
Tylovis	Starch ether	Closed joint-stock company “Euro Chim-1”, Russia
Stavinor CaPSE	Hydrophobing agent	Closed joint-stock company “Euro Chim-1”, Russia
Technocel	Cellulose fibers	-//-
Hostaput OSB	Pore agent	-//-
Genapol PF80 pulver	Disperser	-//-
PVA	Latex dispersion	Joint-stock company “Acron”, Novgorod
DLP 100	PVA	DOW Chemical Co, USA
DLP 950,110-120	Vinyl acetate with vinyl versatate vinyl	-//- , Germany
DLP 210	Acetate with ethylene	-//-
DLP 550	Styrene-acrylate	-//-
Mowilith	Redispersable powder	Clariant, Germany
	Vinyl acetate with vinyl versatate, other copolymers	Closed joint-stock company “Euro Chim-1”, Russia
Rhoximat PAV 22,29, Др	Vinyl acetate with vinyl versatate	Rhodia, France
LL 5820	Copolymer of ethylene vinyl chloride and vinyl laurate	Germany
STROFAN	Butadiene-styrene water dispersions	BASF, Germany
АДИНГКОЛОр	Redispersable powder	Adding, Macedonia (Scopje)
РеПараТур	Redispersable powder	Adding, Macedonia
ХИДрОНОЛ-С	Redispersable powder	ВаНКер-ХеМИ ГМбХ, Germany
ВИННаПаС	Dispersions, dispersion powders	Elotex

The load bearing strength of masonry on the basis of cement-sand mortar supplemented with 0.5% of methylcellulose was by 20% higher than that of a traditional mortar without the addition of polymer. It was also noted that the appearance of main cracks in case of central compression of masonry based on cement-polymer mortar occurs at the intensity of 0.75 of the breaking load while for the traditional mortar at 0.55. This indicates the increased solidity and crack resistanse of masonry on the developed mortars (Onoprienko *et al*., 2007; Rakhimbaev *et al*., 2004; Onopriyenko, 2012).

SUMMARY

Modern polymer additives are mainly represented by expensive imported products. Thus, the need to expand the assortment of polymer additives manufactured in Russia to produce competitive dry building mixes for various purposes. Research in the direction of increasing the effectiveness of the cement-polymer compositions using polymeric additives of domestic production showed the following facts.

Additives of studied water-soluble polymers are environmentally friendly products of domestic production. Their intensity in compositions of masonry mortar for providing the necessary processing and physical and mechanical characteristics is 10-20 times less than that of other commonly used polymer additives such as polyvinylacetate emulsions. The low percentage of polymer has a positive effect on water resistance and cost of masonry.

Designed masonry mortars (Onoprienko *et al*., 2007) also correspond to the requirements of Construction norms and rules (SNIP II-7-81) "Construction in seismic regions": temporary resistance to axial tension of masonry (normal grip between mortar and brick) is not <180 kPa (0.18 MPa). Considering that vibrations occur near railways, shallow undergrounds as well as during operational and terrorist bombings designed masonry mortars are recommended for buildings subjected to such influences.

In this connection, it is recommended to use the developed cement-polymer compositions in order to increase the reliability of buildings and structures including the terms of dynamic effects of different origin. Their application is especially effective in order to improve the earthquake resistance of buildings and structures.

CONCLUSION

Thus, the use water-soluble polymers additives of domestic production in the cement-polymer compositions is effective and appropriate technological and economic points of view.

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