Research Journal of Applied Sciences 9 (10): 680-683, 2014
ISSN: 1815-932X

High-Strength Decorative Complexes with Organo-Mineral Additives

Alexander Dmitrievich Tolstoy,
Valery Stanislavovich Lesovik and Irina Alexandrovna Kovaleva
Belgorod Shukhov State Technological University Named after V.G. Shukhov,
Kostyukov Street 46, 308012 Belgorod, Russia

Abstract: The study deals with various aspects of designing composition and technology of manufacturing products for decorative architectural forms and their significance nowadays. There are presented the results of analyzing composition and technologies of depositing the high-strength decoration materials with applying various additives of different chemical and mineralogical composition and genesis. There was ascertained the possibility of lowering the consumption of materials at depositing coatings due to the reduce of the number of layers; providing the lower consumption of material resources and energy, production areas and labor costs; using non-toxic and non-combustible materials, saving the environment.

Key words: Finishing decoration materials, high-strength concretes, organo-mineral complexes, stamped concrete, consumption of materials

INTRODUCTION

In the nearest future in the construction industry structures of conventional concretes are going to be gradually replaced by multicomponent ones. In the composition of these concretes, there are used both single chemical modifiers, improving the placeability of concrete mixtures and contributing to improving the physical and mechanical performance of concrete and complex additives including tens of single chemical admixtures of various functional purposes. The special role in modifying concrete structure is played by reactive finely-grained mineral components of natural and technogenic origin as well as micro-reinforcing elements (Bazhenov *et al*., 2006).

In recent decade in building industry of Russia the ever-widening application has been found by the High Strength Concretes (HSC) and among them the Self Compacting Concretes (SCC), especially at designing unique objects (Kaprielov *et al*., 2010; Kaprielov and Kardumyan, 2011). SCC make it possible to do concrete placement intensively and with minimum labor costs due to excluding the compaction of any structures, providing the high quality of surface after formwork removal.

MATERIALS AND METHODS

Manufacturing the test samples of artificial stone for ornamental purposes, their storage and testing was carried out according with the requirements of the commonly-accepted Computational-Experimental Method of concrete mix designing. This method consists in calculating the amount of source components according to the standard methodology (National State Standard, 1986), manufacturing and curing in normal conditions within 28 days.

In the composition of test samples there were used mineral additives, containing aluminate and carbonate components and standard polymer additives-Melflux 2651, Melment, C-3. The shaping was done at the laboratory vibroplate, in cube moulds 4×4×4 cm in size. After shaping the samples were kept in the moulds then the moulds were stripped off and the samples were moist-cured in climatic chamber during 28 days. The strength characteristics of the concrete were tested with the hydraulic press defined in the GOST standard 10180-90 (National State Standard, 1990). In the strength tests at the axial compression there were used three samples in a series.

The findings of the tests were calculated with statistical processing methods to confirm their probabilistic validity.

The main part: The present day practice of finishing works implies a widespread use of finely-dispersed complex Organo-Mineral Additives (OMA), Composite Binders (CB) of wide range in which as the siliceous component there are used raw materials of

Corresponding Author: Alexander Dmitrievich Tolstoy, Belgorod Shukhov State Technological University Named after V.G. Shukhov, Kostyukov Street 46, 308012 Belgorod, Russia

both natural and technogenich origin (Lesovik, 2006; Sheichenko *et al.*, 2011; Gridchin *et al.*, 2008), Microsilica (MS), smelter slags, along with superplasticizers. This approach has made a breakthrough in the technology of obtaining high-strength coatings of original texture and high durability. The high technological and building performance of these materials is nevertheless combined with the high cost of high-strength finishing compositions and technologies of their depositing. That is why, it is important to find large-tonnage mineral additives including those of technogenic origin which combined with superplasticizers would allow without lowering the high technological, building and decorative performance, improving the availability and economical efficiency of new high-strength compositions.

As fillers of high-strength concretes the large-tonnage foundry industry waste, recycled concrete waste, different sands and carbonates are known to be used.

Along with the structure formation processes of composites with technogenic components being understudied, optimization of the structure formation processes in the system «clinker minerals-silica-containing additive-superplasticizer-water» is of great current interest.

In researches, aimed at studying compositions and technologies of depositing of high-strength decoration materials as a siliceous component we have used the widely-applied nowadays microsilica, aluminum-containing additive, microquartz, quartz sand which have different chemical and mineral composition and genesis.

The main purpose consisted in designing such a material and such construction technology which would allow obtaining a high-strength finishing material, the use of which would allow reducing the weight of a building or construction without lowering their structural stiffness, stability and durability.

This purpose is achieved, first of all, by complexity of artificial stone materials and products structure. A lot of scientists and engineers in Russia and other countries.

We have carried out the research of organo-mineral compositions since 1993. Much attention in these researches was paid to products, based on a cement-free binder with carbonate filler. These works were continued by the research of high-strength decorative compositions, texturized by organic additives, containing reactive fine-dispersion fillers of various nature. These organo-mineral hardening compositions provide the fast strength development due to their interaction in the presence of water, both with each other and with the filler's surface.

According to the classification of the International Building Organization among the high-strength composite materials there are meant concretes having compression strength 60-130 MPa in cylinders. Among the high-quality compositions there are meant concretes with high performance properties at the water-binder ratio <0.4. Such materials find the ever-widening application in building industry in Japan, Norway, USA, France. The advantages of these concretes are their improved placeability and strength (Popkova, 1990).

Coatings made of high-strength (stamped) concrete look like brick, cobblestone or natural stone masonry, paving or even wood planks (Fig. 1). These coatings have a wide range of application: from garden paths and sidewalks, to making highways, town squares, alleys, floors in show-rooms, halls, restaurants and in living accommodations (Fig. 2) (Kazlitin and Lesovik, 2012). A large variety of forms, textures and colors makes it with

Fig. 1: Obtained surface

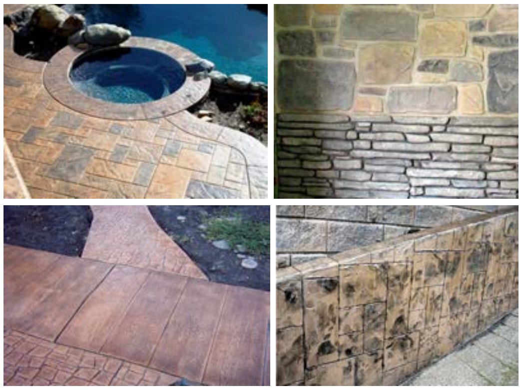

Fig. 2: The final form of the surface

Fig. 3: Variety stamp

possible to create unique surfaces and match them architectural style while providing the high technological and building performance: strength 60-100 MPa, improved wear-resistance, frost-resistance and rust resistance (Dolgopolov *et al.*, 1994).

Along with research, aimed at obtaining the optimal formulas of high-strength ornamental concretes, we carry out the research of processing technologies of depositing them on the prepared base. In practice, depositing of stamped (Fig. 3) concrete is done in several stages which include preparatory and finishing works.

Usually, the technical process of depositing the stamped concrete coating consists of 5-6 stages. The carried-out experiments have shown the possibility of combining the initial depositing of the adhesion composition with colorant onto the wet surface without the subsequent blowing-off or washing-off of the colorant remains from the surface. Depositing is done in a single layer. It is also supposed to exclude in future the treating the hardened surface with acid etchant.

The results have demonstrated the sufficient intensity and prominence of stamp after using a set of stamping tools, consisting of 5 hard and 2 flexible mats which can provide the continuous process of stamping by their re-arrangement.

To divide stamps and concrete there is used the colored greasing substance which also has the function of the color texture fixative. This consistent grease excludes dusting of the environment is odor-free and safe for plants and animals.

It is also possible to use as an additional colorant the color powder, intended for dyeing concrete mixture in the process of mixing it. The small amount of powder is dissolved in a solvent and sprayed uniformly onto the whole surface of the hardened stamped mixture. The colored powder would fill the pores and cavities of the surface and after drying of the solvent a certain relief is formed. After the complete hardening of the solvent the surface is made glossy with special sealing varnish.

RESULTS AND DISCUSSION

As a result of the carried-out work there were obtained new data about studying and designing formulas and technologies of using high-strength compositions for ornamental purposes, including small architectural forms. The main task which was solved in this regard was finding the way of reducing consumption of source materials and costs of carrying-out technological work.

At the first stage of this research the group of disperse fillers of Multicomponent Binder (MB) of technogenic genesis was enlarged and the use of ceramic industry waste was proposed. The mentioned waste as a result of preceding baking process, contains mullite-like calcium aluminosilicates and their mixture with dispersed quartz which are ready crystallization centers at the cement hardening. The used mining production waste was preliminary ground to the considerable specific surface ($S_{sp}\approx 20000$ m^2/kg), Microsilica (MS), produced according to technical specifications 14-139-121-89 to $S_{sp}\approx 350$ m^2/kg.

A high-strength composition was obtained by modifying its complex OMA, consisting of superplasticizer and fine-ground mineral ingredient. The content of complex OMA amounted to 30%. The share of superplasticizer Melflux 2651 amounted to ≈1.0% of cement consumption. The consumption of cement was reduced by ≈18%. The accurate materials consumption per 1 m^3 of the high-strength composition is a know-how.

So, improving the formula and technology of decorative stamped concrete coating makes it possible to improve a number of constructional and technology parameters:

- Lowering the consumption of materials by depositing coatings due to reducing the number of layers (to 10%)
- Providing the lower consumption of resources and energy (by 15%), production areas (by 15%) and labor costs (by 25%) per unit area
- Using mostly non-toxic and non-combustible materials contributes to minimizing the environmental pollution and harm to the human health (De Larrard, 1989)

CONCLUSION

It is safe to say, that decorative stamped concrete is becoming more and more popular in the present-day world and is aimed at changing the view on concrete as it allows creating beautiful, different, efficient and durable coatings.

The use of standard and technogenic products for producing this kind of concretes allows reducing material expenses and power consumption substantially as well as time of manufacturing decorative elements and structures. The research of this material system allows obtaining new data about the structure of products and methods of optimizing them.

REFERENCES

Bazhenov, Y.M., V.S. Demyanova and V.I. Kalashnikov, 2006. [Modified High-Quality Concretes]. Publishing House of Construction Higher Education Institutions Association, Moscow, Russia, Pages: 386, (In Russian).

De Larrard, F., 1989. Ultrafine particles for the making of very high strength concretes Cement Concrete Res., 19: 161-172.

Dolgopolov, N.N., L.A. Fender and M.A. Sukhanov, 1994. [Some issues of developing the building materials technology]. Build. Mater., 1: 5-6, (In Russian).

Gridchin, A.M., Y.M. Bazhenov, V.S. Lesovik, L.H. Zagorodnuk, A.S. Pushkarenko and A.V. Vasilenko, 2008. [Building Materials for Use in Extreme Conditions]. BGTU Publisher, Moscow, Russia, Pages: 595, (In Russian).

Kaprielov, S.S. and G.S. Kardumyan, 2011. [New modified concretes in modern buildings]. Concr. Ferroconcr. (Equip. Mater. Technol.), 1: 78-82, (In Russian).

Kaprielov, S.S., A.V. Sheinfeld and G.S. Kardumyan, 2010. [New Modified Concretes]. Tipografia Paradiz Publ., Moscow, Russia, Pages: 258, (In Russian).

Kazlitin, S.A. and R.V. Lesovik, 2012. [To the problem of designing concretes for industrial flooring. Bull. BSTU V.G. Shukhov, 2: 39-41, (In Russian).

Lesovik, V.S., 2006. [Improving the Efficiency of Building Materials Production Taking into Account the Rock Genesis]. ACB Publisher, Moscow, Russia, Pages: 524, (In Russian).

National State Standard, 1986. [Concretes. Rules for mix proportioning]. GOST 27006-86, Russia. http://www.xn------7cdchrjt7cdfagvrr1a.xn--p1ai/sites/default/files/beton-gost-27006-86.pdf, (In Russian).

National State Standard, 1990. [Concretes. Methods for strength determination using reference specimens]. GOST 10180-90, Russia. http://www.veraforma.ru/images/upload/ru/1685/GOST_10180-90_BETONY_PROCHNOST.pdf, (In Russian).

Popkova, O.M., 1990. Structures of buildings and constructions made of high-strength concrete: Building structures series. Survey Information, Issue 5. VNIITNPI Gosstroy USSR., pp: 77.

Sheichenko, M.S., V.S. Lesovik and N.I. Alfimova, 2011. [Composite binders with high-Mg waste deposits]. Bull. BSTU V.G. Shukhov, 1: 10-14, (In Russian).