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Designing Of Mortar Compositions On The Basis Of Dry Mixes

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Abstract

Today mortars on the basis of dry mixes are used in the most various conditions. They shall meet a set of requirements to physico-mechanical and performance parameters, feature sufficient durability. The structural optimization and determination of the material composition of mortars are performed by means of the conventional design technique. In this context the paper suggests the new approaches to design of the mortar compositions made on the basis of dry mixes. The proposed approaches and assigned stages of design of composition of dry mortars of different functional purpose allow obtaining products with a more stable performance index that will

assure the high technical-and-economic efficiency of mortars and competitiveness at the construction materials market. The composition design technique allows determining, firstly, the rational ratio or percentage of components by which the required properties are maintained within the specified range and the structure of the hardened material is optimal; secondly, it describes the substantiated methods of property regulation improving the processability and guaranteed longevity.

Key words: design of dry mortar compositions, composition, raw materials, physico-mechanical performance.

Introduction

The end-use property of any material is formed by the set of the constituent components. Dry mortars represent a rather complex polymineral composition consisting of a great number of components and the physico-chemical processes in them are determined by interaction within the system "mineral binder – polymer binder – filler – modifying additives – water" [1].

As numerous studies have shown, the rational selection of ingredients of the mixed highly-filled dispersion system guarantees production of material featuring the desired performance specifications. Strict requirements are imposed on the raw materials of the mix: the right choice of the binding agent, fillers, their quantitative content, specifications, etc. [2, 3].

The above said requires a serious approach to scientific substantiation and design of the specific composition of dry mortar mixes of different purpose taking into account the chemical, mineralogical, granulometric and other features of the raw materials as well as compatibility of the components used in the mix in order to ensure the compliance with the required properties. Mortars on the basis of dry mixes differ from the conventional mortars completely which predetermines the specific approaches to the design technique ensuring all the stages of life cycle of the dry mix mortars: dry (powder) mixes, freshly-mixed mortar and hardened (cured) mortar.

Main part

By now no single methods of preparing the dry mortars of different functional purpose have been proposed, there are only separate odd bits of information relating to optimization of the granulometric content of different dry mortars; the options of improvement of performance specifications of mixes are considered, the mix compositions on the basis of the local raw materials and industrial materials are proposed, there is experience in reducing the cement consumption and using specific fillers, also certain expertise has been accumulated relating to the effect of various composite modifying additives on the properties of the dry mixes designed.

The existing regularities of fine-grained systems, in particular, theory and principles of design of conventional mortars and fine-grained concretes are carried over to mortars of different functional purpose on the basis of dry mixes, although the

conditions of service of dry mix mortars differ from the performance of fine-grained concretes in principle, they are complex and multifunctional [1].

The existing theoretical approaches to conventional mortars are absolutely not applicable to the dry mix mortars neither by composition nor by service load. Unfortunately, internal reserves of neither binding nor filling agents are used by design and preparation of dry mix mortars which reduces the technical-and-economic efficiency and durability of material produced.

One should clearly distinguish between the terms relating to analysis of dry mortar composition: selection and design. These terms refer to two different processes. However, the process is commonly considered to be single consisting only of selection of raw materials for a mortar in purely laboratory environment without accounting for many other factors. In real-life situations mortars are used in the most various conditions which impose on the mortars the requirements to durability and reliability, they shall meet a set of requirements to physico-mechanical and performance parameters. Experience has shown that the results of the construction material testing obtained in laboratory conditions hugely differ from the real environment. This is why by design of the dry mortar compositions one should clearly define their purpose of use, take into account the natural-and-climactic conditions of service and select the raw materials accordingly.

The structural optimization and scientifically substantiated analysis of the material composition of different artificial conglomerates are performed with the use of the common design method [2, 3]. There are also specific methods designed in respect to each dry mix kind. Production of construction materials of different application requires methods of individual design of their composition ensuring formation of the desired structures. The main scientific principles of design of dry mortars include: maximal compliance of the максимальное соответствие dry mortar compositions being designed and their properties obtained in laboratory conditions to the real industrial environment; assurance of high homogenization of mineral and organic components of a mix, optimal pore component, the surfaces of separation of the solid and liquid phases and other structural elements by the material volume; creation of the optimum material structure with the desired physico-mechanical and performance parameters; the use of the common objective regularities peculiar to conglomerate materials of the optimal structure including the law of congruence, law of alignment, law of strength, etc.; the use of the common method and mathematical methods of designing the optimal composition and manufacturing of high-quality products in a production environment [4].

The principle of selection of compositions of conventional mortars consist in determining the ratio between the components (cement, lime paste or puddle clay, sand and water) ensuring production of mortars with desired properties both in the freshly-mixed state and after the mix hardening under the specified conditions. Firstly, the mortar composition is determined by empiric formulas and according to the recommendations on estimated material consumption and depending on the mortar grade and recommended binders they initially calculate the material consumption per 1 sq. m. of sand with the moisture content of 3-7%. After preparation of the trial batch and mixture test the material consumption per 1 m^3 of mortar is estimated. The mortar

type and mobility are taken according to the project with account for the conditions of service.

It should be noted that according to the old tradition the composition of different conventional mortars in the specification documents [5-7] is expressed in volume ratio, however, no information concerning the bulk density of cements and other components recommended for use in the mortar mixes is presented in the above-mentioned documents which makes the recalculation of compositions into mass fractions to be inaccurate with deviations of the component weight content that may exceed 30% [8] which will surely impair the quality and durability of the hardened mortar.

Mortars on the basis of dry mixes represent a material with a wide range of action of complex additives warranting specific processing and performance properties. Depending on the purpose of use: masonry film adhesives, heat-insulating plasters, smoothing, waterproofing and other mix compositions differ substantially. In order to ensure the guaranteed quality and durability of mortars on the basis of dry mixes it is needed to develop the robust principles of the composition design.

Design of the optimum composition of dry mixes is one of the main production operations. Each kind of a dry mix has a certain functional purpose this is why its composition is designed with account for structural features determined by area of application. The method of the composition design allows determining: firstly, the rational ratio or percentage of components by which the required properties are maintained within the specified range and the structure of the hardened material is optimal; secondly, it describes the substantiated methods of property regulation improving the processability and guaranteed longevity.

A number of researchers deal with the issues of selection of compositions of dry mortars of different application [9-11], these researchers have designed the compositions and proposed their approaches to selection of compositions of dry mortars with wide range of application.

Taking into consideration the peculiar features of the dry mortars we establishing the following design principles: 1) in case of the correctly assigned composition the hardened mortar shall feature the optimum structure; 2) along with increase in the binder amount in the hardened mortar of optimal structure the phase ratio (liquid-to-solid weight ratio) is reduced; 3) the consumption of binding agents is reduced when fillers are used; 4) the optimum composition and structure of the hardened mortar substantially depend on the processing properties of the dry mix, preparation and application of the mortar to the structure.

By design of dry mixes composition in laboratory environment one should simulate the real-life service conditions as accurately as possible.

We propose the method of design of mortars on the basis of dry mixes that consists of six stages:

1. Composing the task for design (design assignment) of the mortar on the basis of a dry mix with substantiation of the main specifications: processing, physico-mechanical, and engineering-performance ones.
2. Selection of raw materials from the perspective of availability, appropriateness and assurance of the required level of finished product quality.

3. Specifying the main properties of the raw components and substantiation of their use.
4. Design of mineral composition of dry mortars.
5. Modifying the dry mortars by means of different organic, organo-mineral additives according to the specified technical properties of the dry mix, processing parameters of the mortar mix and specifications of the hardened mortar.
6. Trial batches made in laboratory conditions and sample testing with simulation of natural conditions along with defining the optimum compositions and composition adjustment according to the rational consumption of raw components;
7. Testing and adjustment of the specified composition in a production environment.

The design assignment includes the main indicators of the engineering-performance properties with account for the detailed analysis of conditions of the dry mortar service in a structure or facility. In addition to the above one should take into consideration the characteristics of the natural-climatic area of construction, area of application and conditions of the material service, mix specifications, requirements to durability, etc. If the required data is not available one should collect the relevant information determining the real service conditions during the summer and winter periods, the rate and range of temperature falls, humidity conditions of the material service, potential aggressive exposure, etc. The listed data will be accounted for by assignment of the testing methods for the material being designed to be used in a physical structure.

Acceptance of raw materials is a vital part of the composition design. By selection of materials one shall rely on the material availability in the particular region, economic efficiency of their use, regulatory documents concerning the raw materials as well as non-standard methods reflecting the specific properties of the dry mortar materials. The peculiar features of mineral components, preparation thereof for the use provides the important basis of the physico-mechanical and physico-chemical specification of the mortar and hardened mineral stone and the durability of the finished material after all. The rational choice of raw components and their interactions within the created system determines the engineering-processing and performance specifications of the mortar.

Selection of the dry mortar components, determination of the main properties of raw ingredients and substantiation of their use assures output of production of the stable quality with the required level of engineering-technical properties that complies with the requirement of the modern construction materials market. The system testing of the required specifications of the source raw components shall be performed with the use of the standard specifications, substantiation of the use and preparation for selection of the mortar compositions on the basis of dry mixes.

Design of the mineralogical composition of dry mortars is based on the rather complex regularities characterizing the processes of physico-chemical interaction between the dry mortar taking place during preparation of dry compositions; in dry

mixes tempered with water as well as by formation of the mineral stone from the hardened mortar. Design of the mix compositions shall be performed on the basis of theory and experimental data obtained by the example of the specific raw materials by means of step-by-step approximation of the required parameters to the specifications requirements. The “binder – filler” ratio is determinative for construction of the frame of artificial stone with the desired strength characteristics that is formed as the result of hydration of the binding agent. It makes sense to study the wide range of compositions in order to find the optimum compositions ensuring the required strength and density parameters. Depending on the mix density and strength the selection of the optimum granulometric composition of fillers for dry mortars is performed in order to design the densest package for high-density mortar mixes [12] or the less dense package ensuring the maximum porosity for thermal insulating mortars [13].

Taking into account that dry mortars are multi-component systems the further optimization – modification of dry mortars with the use of different organic, organo-mineral additives according to specified dry mix specifications as well as processing parameters of the mortar mix and specifications of the finished product – hardened mortar – shall be performed by means of mathematical planning according to multifactor design [14]. One should take into consideration the effect of separate functional additives as increased dosage of separate additives may result in changing of properties of the entire system, the system components exhibit their properties according to the linear dependences of changes in properties with change in the component concentration. The use of this method allows on the assumption of the technological and economic feasibility to establish by varying the consumption of functional additives the minimum use ensuring production of the material with the desired properties and reduction in the cost of the modified additives [15, 16].

Production of the trial batches of the design composition is performed in laboratory environment on the basis of the mathematical estimates. When necessary, the qualifying experiments are conducted. By means of laboratory testing the quality of the dry mix, mortar mix and molded mortar with respect to all the required properties is determined depending on the purpose of use. If mathematical values and actual practical results match the work on design of the specified composition is considered to be completed.

The composition being designed and tested in laboratory conditions shall be subjected to testing in a production environment. The composition meeting all the specifications requirements is tested at the production line. A trial batch is produced that passes all the tests in an independent laboratory. If a favorable conclusion is received the composition designed goes into production.

Summary

The proposed technique of design of dry mortar compositions of different functional purpose allowed getting production with the guaranteed and stable quality figures along with the optimum consumption of mineral and organic components ensuring the

high technical-and-economic efficiency of mortars and competitiveness at the construction materials market.

Conclusions

The designed and tested technique of design of mortars on the basis of dry mixes of different functional purpose will allow getting products with the stable quality and durability properties which warrants the high technical-and-economic efficiency of mortars and competitiveness at the construction materials market.

References

1. V. S. Lesovik, L. H. Zagorodnyuk, R. Gaynutdinov, 2014. Specifics of hardening of mortars on the basis of dry mixes. Bulletin of the Central Regional Department of RAASN. Belgorod: RAASN, BGTU named after V. G. Shukhov: 93-98.
2. H. Ross, F. Stahl, 2006. Plaster: Practical guidance. Materials, work performance procedure, defect prevention. SPb.: RIA “Quintet”, pp.:173
3. Zozulya. P. V., 2003. Optimization of granulometric content and properties of fillers and aggregates for dry mortars. Dry mortars for the 21st century: Technologies and business. 2003. Collection of abstracts of the 3d International Conference, pp.:12–13.
4. Rybyev, I. A., 2002. Construction material engineering: Textbook for Engineering Higher Educational Institutions. M.: Higher School, pp.: 701.
5. Chekhov, A. P., A. M. Sergeyev, G. D. Dibrov, 1979. Reference book on concretes and mortars. Revised and enlarged edition. Kiev, Budivelnyk, (2) pp.: 256.
6. GOST 28013-98 “Mortars. General specifications”. M.: Standardinform, 2007.
7. Set of rules (SP) 82-101-98 “Preparation and use of mortars in construction”. M.: Standardinform, 2007.
8. SNiP II-22-81 “Stone and reinforces cement structures”. M.: Standardinform, 2007.
9. Korneyev, V. I., 2003. Main conditions of design of dry mortar compositions. Stroyklub, (10-11), pp.: 30-31.
10. Dergunov, S. A., 2005. Construction. Design of dry mortar compositions. News of Higher Educational Institutions, (11): 34-41.
11. Korneyev, V. I., P. V. Zozulya, I. N. Medvedeva, G. A. Bogoyavlenskaya, N. I. Nuzhdina, 2010. Dry mortar formulary. SPb.: RIA “Quintet”, pp.: 318.
12. Harhardin, A. N., 2011. Structural topology of dispersed materials: workshop: instructions. Belgorod, BGTU Publishing House, pp.:139.
13. Zagorodnyuk, L. H., Shirina N. V., 2010. Efficient mortars for thermal-insulating works: monograph. Belgorod: BGTU Publishing House, pp.:181.
14. Zagorodnyuk, L. H., 2014. Dry heat-insulating mortars on the basis of composite binders: monograph. Belgorod: BGTU Publishing House, pp.:216.

15. Lesovik, V. S., L. H. Zagorodnyuk, A. V. Shamshurov, D. A. Belikov, 2014. Composite binders on the basis of the complex organo-mineral modifying agent for dry mortars. Bulletin of BGTU named after V. G. Shukhov, (5):25-31.
16. Lesovik, V. S., L. H. Zagorodnyuk, A.S. Kolomatsky, G. G. Ilyinskaya, 2012. Dry mortars for finishing work on the basis of composite binders. Bulletin of BGTU named after V. G. Shukhov, (4):15-19.