Journal of Engineering Research and Reports

Volume 23, Issue 12, Page 67-73, 2022; Article no.JERR.93773
ISSN: 2582-2926

Review on the Preparation of Grout from Quartz Sand

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Author's contribution

The sole author designed, analyzed, interpreted and prepared the manuscript.

Article Information

DOI: 10.9734/JERR/2022/v23i12764

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/93773

Review Article

Received: 17/09/2022
Accepted: 19/11/2022
Published: 22/11/2022

ABSTRACT

Cementitious grout is a paste made of cementitious materials, mineral admixtures, admixtures and water mixed in a certain ratio, which is widely used in construction projects. Due to its good physical and chemical properties, grout is now also playing great potential in the industrial field. As grout is often used in areas with high strength requirements such as repair and reinforcement of concrete, installation of large equipment, and grouting, the particle packing density has a great impact on its performance, so how to improve the particle packing density to enhance its strength is particularly important.

Keywords: Grout; particle buildup; rheology.

1. INTRODUCTION

1.1 Definition and Application Status of Grout

Grouting material is a kind of dry mix with cement as the basic cementitious material, with or without mineral admixture as the compound aggregate, and a small amount of admixture, etc., which is industrially processed with a reasonable gradation [1], and mixed with water in a certain ratio to form a high-strength, large fluid, slightly expanded construction material. Because of its good fluidity, high early strength, no water

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secretion, non-toxic and non-hazardous, simple operation, and good self-tightness, the grout can be used to change the force situation of some equipment bases, so that it can better withstand all the loads and thus meet the requirements of equipment installation, which is the ideal grout.

Cement-based grout first appeared during World War II and was often used to build fortifications because of its high early and late strength, but with the rapid development of the construction industry and the maturity of the technical route of cement-based grout application, grout is being used more and more widely, gradually moving from construction to industry and playing a huge potential in the industrial sector. Cement-based grout is mainly used in the choring of footing bolts and planting of reinforcement, reinforcement, and repair of concrete structures, installation of equipment foundations, and secondary grouting. Because cement-based grout has good profitability, high early strength, micro-expansion, and other excellent properties, it can be used for grouting reinforcement of aging buildings, and concrete cracks to fill [2], but also in the field of construction engineering for high-strength requirements of the key layer, can be anchored to the footing bolts but also used in bridge bearings, beam joints, and other key parts to play a good support role. Because of its good fluidity, cement-based grout is widely used for secondary grouting of equipment foundations [3]. Because cement-based grout has good working properties it is also widely used in assembly buildings, which promotes the rapid development of assembly buildings [4].

1.2 Performance Evaluation Index of Grout

Rheology is a discipline that studies the relationship between the deformation and flow of an object over time due to a variety of causes [5]. For solids, it is the study of the laws of deformation and for liquids, it is the study of the laws of fluidity, but for either material, time is an important factor. The rheological properties of cement-based grouts are inextricably linked to the mobility, yield stress, and plastic viscosity of the slurry. The greater the flow of the grout, the better the fluidity of the grout, and the better the workability of the slurry. The yield stress is the critical stress of the grout flow, the smaller the yield stress, the smaller the force required for the grout to flow, indicating that the slurry has good rheological properties. The greater the plastic viscosity, the stronger the bond within the grout, making the grout less likely to segregate and facilitating the flow of the slurry.

The Bingham model was the first model proposed to analyze the rheological properties of cement slurry. In recent years, many experts and scholars at home and abroad have also proposed many rheological models to analyze the rheological properties of the cement slurry to study its rheological properties [6], and also made a lot of experiments to analyze its rheological properties, and the conclusion shows that the yield stress is an important factor to evaluate the rheological properties of cement slurry. Xingfeng and Lv Jianfeng summarized the experience of their predecessors and more perfectly proposed the U-shaped flow method to evaluate the plastic viscosity of grout, and the theoretical analysis of the U-shaped method was done by rheology. The results show that there is a linear relationship between the parameters measured by this method and the plastic viscosity of grout at small shear stress yield values of grout, and this method is also used to rate the plastic viscosity of mortar for prefilled aggregate concrete and other Bingham bodies with small shear stress yield values [7].

1.3 Application and Research of High-Strength Grout

Since the reform and opening up, to meet the needs of some large equipment, our country started the development of grout [8]. After decades of practice, the grout developed in our country has been on par with the international level in all its performance indexes. The application of grout also tends to diversify from single. Traditionally, grout is mostly used in the secondary grouting of mechanical equipment, but now grout can also be used in the reinforcement and repair of concrete structures and has been more and more widely used. At present, high-strength grout is made of cement as cementitious material, mixed with high-strength material as compound aggregate, supplemented by low shrinkage, micro-expansion, high flow state, anti-diffusion, and other substances configuration, adding a certain amount of water, so that after mixing the slurry without floating slurry, no cracking, no bubbles can be used. Because the grout has high fluidity and self-tightness, it can directly pour the equipment foundation without vibrating and fill its gap quickly, so the grout has a high self-flowing state and can be used in the grouting of large equipment foundations; because of the characteristics of early strength and high strength, oil seepage resistance and good durability of grout, it can be put into use one day after pouring in general, and secondly, under some special complicated conditions, it can also ensure its strength without Secondly, under some special and complicated conditions, the strength can be guaranteed to have no significant changes, so it is widely used in road engineering repair; because the high strength grout has the characteristic of micro-expansion, it can ensure the tight connection between equipment and foundation, so it can be used in the buried load of reinforcement and anchor of concrete structure, reinforcement project, and transformation project.

Microporous anchors are not easy to vibrate conventional concrete because of their small aperture, as well as the poor effect of the dense chamber after vibrating and the inability to meet the requirements for strength, etc., so high-strength grout with high flow and micro-expansion is chosen to solve this problem [9]. The wind farm foundation beam-slab prestressed anchor bolt foundation is required to be different from the general grout because of the large pressure it has to bear and then transfer to the concrete, and it is subjected to fatigue loading, so the grout is required to be non-shrink, micro-expansion, self-leveling and other characteristics in terms of quality, which simply ensures that it is not easy to have problems in construction [10]. Currently, high-strength grouting materials are mainly used in the installation of mechanical equipment and the process of reinforcement repair. Because of the good reinforcement and repair of high-strength grouting materials, fast construction period, easy construction, good flow, micro-expansion, and other indicators can meet the quality requirements of reinforcement and repair works of beam and column structures, so the use of grouting materials also gradually developed from secondary grouting to the reinforcement and repair of structures and achieved remarkable results [11].

2. APPLICATION OF PARTICLE BUILDUP IN CONCRETE

2.1 Effect of Particle Accumulation on the Rheological Properties of Concrete

The rheology of grout plays a decisive role in the construction quality of concrete and the ease of construction and is one of the most important technical indicators in the design of concrete ratios. The rheological properties of concrete refer to the flow and deformation produced by the grout under the action of external loads, and in general two parameters, shear rate and viscosity, are used to analyze the fluidity of the slurry [12]. In recent years, particle stacking has received more and more attention in the preparation and research of concrete concretes, and concrete as a newconstruction material has also received much attention. In a way, concrete mixes can be seen as a system of different gradations of piles, which are wrapped and cemented by the hydration products as a whole. Because of the geometric role of particles between different sizes, smaller particles can be filled in the gaps between larger particles, and larger particles can be set in smaller particle voids, and the perfect combination between large and small particles can make the mixture as tight as possible, thus minimizing the voids between particles [13]. By maximizing the density of the particle buildup and thus improving its rheological properties [14]. A large amount of literature shows that there are a large number of voids between the cementitious materials, the particle size distribution is not uniform, and the slurry will be filled with a portion of water in the voids in addition to the amount of water required to ensure fluidity, but this water does not contribute to the rheological properties of the slurry, and a certain amount of mineral admixture can fill the voids of the structure instead of water so that the original water is released. Some data show that if the size distribution of the cementitious material is adjusted so that the mineral admixture reaches the optimal particle packing density, then the voids and water in the system will be reduced, which ensures the flow of the slurry and the thickness of the water film required for stable deformation, thus reducing the amount of water used and finally improving the fluidity of the slurry, which has a very good effect on the rheological properties of the slurry [15].

2.2 Effect of Particle Accumulation on the Strength of Concrete

In the production and design of concrete, the strength design of the control of the quality of the project should be considered as an important indicator of the stability and safety of the components that have a greater impact, but of course, the impact on the strength is also multifaceted [16]. Concrete strength generally refers to the compressive strength of concrete, which means the maximum stress that the specimen can resist.

A concrete specimen with higher packing density tends to show a harder and stronger particle skeleton structure. By changing the particle packing so that the concrete reaches the maximum packing density, the density of the internal microstructure of the concrete is increased, which in turn has a positive effect on the mechanical properties of the concrete. In addition, the voids between the particle piles depend on the particle structure of the mixture, and a reasonable state of particle pile will require less water to fill the voids and reduce the voids between the cement particles, thus reducing the water requirement and increasing the strength of the concrete. Optimization of the "Fuller curve" is a convenient way to constitute the concrete mix gradation, but it takes into account one-sided factors, ignoring the specific surface area of the particles and the difference in different sizes of particles. A large body of literature shows that the composition of concrete mixtures is essentially based on the gradation of the particles rather than on the bulk density of the particles [17].

2.3 Stacking Effect of Different Aggregates in Concrete

Concrete is the highest and most widely used construction building material in China at this stage. With the development of urbanization and the requirements for engineering structures, people's requirements for concrete strength and durability are getting higher and higher. Therefore higher and stronger is the inevitable trend of concrete development. Ultra-high performance concrete is a new type of cement-based grout with the characteristics of large flow state, ultra-high strength, micro-expansion, etc. It has more cementitious materials and a lower water-cement ratio than ordinary concrete. The preparation of ultra-high performance concrete is based on the principle of particle compact theory, which simply means optimizing the particle gradation and using mineral admixtures with smaller particles and higher activity to fill the voids between the cementitious materials, to optimize its internal microstructure, to improve the particle packing density and reduce the bubble content.

Zhen Liu, Wufeng Wang et al. [18], used different amounts of silica fume and fly ash to replace part of the cement to explore the effect of different amounts of mineral admixtures on the rheological properties of the grout, and it was learned through experiments that with the increase of silica fume admixture, the viscosity of ultra-high performance grout continued to increase; with the increase of fly ash admixture, the viscosity of ultra-high performance grout first decreased and then increased. Wang Shu, Wu Xiong et al. [19] used a laser particle size analyzer to test the particle size of the ultra-sulfate cement to understand the distribution of the particle size of the ultra-sulfate cement, and the mechanical pressure method was used to prepare the dry powder compact, and the porosity of the dry powder of the ultra-sulfate cement can reflect the inter-particle stacking compactness from a macroscopic point of view. From the experimental results, it can be seen that the higher the correlation between the distribution of hyper-sulfate cement powder particles and the distribution of the most compactly packed particle population, the lower the porosity of the compacted solids and the higher the compressive strength. Zhang Yongjuan et al. [20] prepared fly ash cement powder by mixing finely ground fly ash with cement in different proportions, and used mathematical models and the principle of gray correlation analysis to conclude that when the correlation between the amount of fly ash admixture and the distribution of the most compactly packed particle population is high, the performance indexes of fly ash cement are the most ideal.

3. SUBSTITUTION AND OPTIMIZATION OFAGGREGATES IN GROUT

3.1 Current Status of Research on the Use of Different Aggregates in Grout

Cement-based grout is a kind of early-strength, high-strength, micro-expansion, large flow state slurry with cementitious materials, mineral admixtures, and water mixed in a certain ratio, which is widely used in construction projects and other fields.

At present, quartz sand as an aggregate for grout has faced the problem of insufficient supply, Sun Xiaowei and He Miao et al. [21] used steel slag sand instead of part of quartz sand in cement-based grout and explored the influence law of mixed aggregate grade on the working and mechanical properties of the grout. It not only avoids the pollution of the environment but also solves the problem of steel slag emission, which has good economic and environmental benefits. This experiment is carried out by using steel slag sand mixed with quartz sand of different particle sizes, changing its proportion, and adjusting the gradation of aggregates, which provides an experimental basis for the use of steel slag sand in a cement-based grout. Unfortunately, however, there are fewer studies on the use of steel slag sand as an aggregate for other cementitious materials.

Chen Tao [22] studied the inter-constrained relationship between the strength, vertical expansion rate, and flow rate of cement-based grout, preferably selecting the best ratio of cementitious materials and mineral admixtures in cement-based grout, selected the water-cement ratio and cement-sand ratio as the factors for the experiment, and finally analyzed the main and secondary factors affecting the performance of grout and proposed the best matching ratio. Tong-sheng Zhao [23] prepared a relatively new type of green grouting material by using waste clay brick powder and slag powder as the main materials, water glass as the alkali exciter, and mixing with an appropriate amount of admixtures. The optimal admixture amount was determined by observing the stability and workability of the grout and other indexes by using the method of controlled variables, and the effect of waste clay bricks instead of natural aggregates on cement-based grout was intensively studied on this basis. Dong Shuangquai and Wu Fufei [24] used industrial waste slag powder instead of fine aggregate and explored the effects of industrial waste slag type and substitution rate on the mechanical and hydration properties of the grout. From the experimental results, it can be seen that industrial waste slag powder can replace fine aggregates for the preparation of grout, and the appropriate amount of industrial waste slag powder replacing fine aggregates can improve the mechanical properties of grout [25] and enhance the compactness of grout, and also provide a new idea for industrial waste slag in recycling.

3.2 Application and Research of Quartz Sand in the Grout

Quartz sand is a hard, wear-resistant, physicochemically, and chemically stable mineral of hydrochloric acid, whether mixed with cement or with concrete is a very good molding material, more widely used in the construction industry. Its main component is silica, insoluble in acid, and is a tripartite crystal system of oxide mineral crystals, the appearance is mainly white or off-white.

Quartz sand is a common mineral admixture with a wide range of uses that affect our daily life. For example, its excellent characteristics such as high boiling point, high heat resistance, and low carbonization make it widely used in construction projects; it is often used to make important industrial mineral raw materials and fireproof materials due to its unique physical properties and non-chemical hazardous materials. As the core raw material of silicon raw material, quartz sand plays an irreplaceable and fundamental role in the production and making of silicon raw material. Quartz sand also has a wide range of roles in construction projects, for example, it is often used to make acid-resistant mortar because of its strong resistance to erosion by acidic media; it is often used to make secondary grout for foundations and aggregate for high-strength grout because of its characteristics such as high strength.

4. CONCLUSION

Quartz sand is a common mineral admixture with numerous applications in our daily lives. If the close accumulation is applied in quartz sand, it can be used as a good molding material in the grouting material.

COMPETING INTERESTS

Author has declared that no competing interests exist.

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Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/93773