Research on the Mix Ratio of High Performance Concrete

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Abstract. Large-volume high-strength concrete is a kind of concrete widely used at present. At present, the mainstream direction of domestic construction development is that the shape of the building is getting bigger and bigger, the number of floors is increasing, and the style of the building is getting more and more modern. Volumetric high-strength concrete is the future development trend. In the article, the author analyzes the historical background and development status of the development of large-volume high-strength concrete, introduces the current research results, and prospects the future development of large-volume high-strength concrete.

Keywords: Mass high-strength concrete, volume stability, durability.

1. Introduction
Humans have used concrete as a material in the construction process for a hundred years. Concrete is present in almost all modern buildings, such as roads, bridges, houses, water conservancy projects, etc. Concrete is mainly made of cement as a cement material. The man-made building materials that are indispensable in modern civil engineering, concrete has also made rapid progress in recent years, and the current mainstream development direction is large-volume high-strength concrete. In recent years, my country has vigorously promoted the process of urbanization and industrialization. [1-9] As the most important building material, concrete has huge development potential and market prospects. Since the beginning of the 21st century, human science and technology have made rapid progress, and building science has also achieved rapid development. There are more and more types of concrete. The performance index of a concrete will directly determine whether it has the meaning of existence. Performance parameters including strength, durability, workability, etc. must be excellent, which determines that the future development direction of concrete must be large-volume high-strength concrete.

At present, large-volume high-strength concrete is used in many construction projects. The performance of this concrete is currently the strongest in the world. In many types of construction projects, its performance advantages are unique and irreplaceable, including Large-volume high-strength concrete in seaports, bridges and some high-rise buildings has its own unique performance advantages. The proposal of this kind of concrete is mainly based on people's demanding requirements for the durability of concrete. The most important design index of large-volume high-strength concrete is its durability. Because of this, the service life of some large-volume high-strength concrete can even reach for centuries, in addition to its high workability and large volume characteristics, this concrete has stronger adaptability, higher economy and longer safe use period. Large-volume high-strength concrete has become the future trend of the concrete industry.
2. Mass high-strength concrete concept

At present, the international community generally believes that high durability is the basic indicator for judging whether a type of concrete is large-volume high-strength concrete, but technicians and scholars in different countries have different understandings of large-volume high-strength concrete. Europeans are more inclined to the durability of concrete, the Japanese pay more attention to the workability of concrete, while the Americans pay more attention to the volume stability and strength of concrete. The definition of large-volume high-strength concrete is not completely unified among countries. For example, the Chinese Society of Civil Engineering regards sustainable development and durability as basic performance indicators, and concrete that can be constructed and industrialized is called HPC; international prestressing the Concrete Association and the European Institute of Concrete and the concrete with a water-binder ratio less than 0.40 are called HPC; Japan defines HPC as vibration-free concrete (that is, high-fluid self-compacting concrete).

3. Mass high-strength concrete performance

HPC has the following practical properties that are different from conventional concrete:

(A). Volume stability

HPC has a low heat of hydration at the beginning of solidification, and its deformation and contraction amplitude is small in the later period of solidification, so there will be no large deformation during the hardening process of HPC, and it has high volume stability.

| Mother rock                  | Compressive strength /mm | Workability /mm |
|------------------------------|-------------------------|-----------------|
|                              | 3d          | 28d       | Slump | Expansion |
| Basalt machine-made sand     | 59.81       | 400       | 36.99 | 159        |
| Quartzite machine-made sand  | 61.20       | 51.47     | 148   | 195        |
| Natural yellow sand          | 62.20       | 56.11     | 479   | 209        |

(B). Mechanical properties

There are many factors that can affect the strength of concrete. The most important factor is the water-cement ratio of the concrete itself. Because the concrete itself is uneven, its compressive strength is inversely proportional to its own water-cement ratio. Because HPC contains superplasticizers Composition, this composition has high water reducing performance, can beat the cement very loose, and can greatly reduce the water consumption of concrete. And the mineral ultra-fine powder component in HPC can automatically fill the position between cement particles, optimize the structure and fill the gaps, further improve the overall density, and make the concrete stronger.

(C). Durability

The main purpose of people studying large-volume high-strength concrete is to extend the service life of concrete buildings. The addition of superfine mineral powder and water-reducing agent into the concrete formula can interact with each other to reduce the size of the internal voids of the concrete and reduce the water content. The amount of use makes the concrete structure safer and extends its actual use time.

(D). Economy

HPC has many practical and stable excellent characteristics. These good properties can greatly improve its economic efficiency. For example, because large-volume high-strength concrete has strong durability, that is to say, almost no maintenance is required during use. This can save a lot of maintenance and convenience expenses. In addition, large-volume high-strength concrete has good working performance, which can greatly reduce the work intensity of workers and save labor costs. The high strength of HPC allows it to reduce the volume of the overall structure, has higher practical value in a limited space and can reduce the weight of the component itself. The price of large-volume high-strength concrete itself is relatively high, but the economic benefits brought by its excellent...
performance can completely cover the difference in cost. Some experts have found that HPC with models C110–C137 is used instead of traditional concrete (model C40) ~C60), can reduce the use of steel by about 15% to 25% and reduce the use of cement by about 30% to 70%.

(E). Workability

An important indicator to measure the actual working performance of a concrete is its slump. Large-volume high-strength concrete has very excellent slump performance indicators. Due to the relatively high viscosity of HPC, when vibrating, the vibration time is the same. Because HPC coarse aggregate sinks slowly, the sinking distance is relatively short, which means it has better uniformity and stability.

In general, HPC can not only reduce construction costs, extend the service life of integral components and building structures, but also meet all requirements for construction technology and structural functions.

4. Characteristics of large volume high strength concrete

(A). High performance

HPC has excellent rheological properties, strong fluidity, less segregation and leakage, and the uniformity and compactness of the concrete structure during conventional construction can be guaranteed. For certain locations where the steel bar density is relatively high (such as beams), artesian concrete should be used to flow to the designated location to ensure the compactness of this location. If this is done, the labor intensity of the workers will be reduced and the construction energy consumption will be reduced. Also drastically reduced. HPC has intentional properties in many aspects, and these properties have a great effect on improving its volume stability, resistance to deformation, compression, and tension. For example, HPC has strong toughness and will not cause self-shrinkage, low-temperature shrinkage, and initial cracking. Because HPC contains high-efficiency water-reducing agent components, this component has a high water-reducing performance, can beat the cement very loose, and can greatly reduce the water consumption of concrete. And the mineral ultra-fine powder component in HPC can automatically fill the position between cement particles, optimize the structure and fill the gaps, further improve the overall density, and make the concrete stronger. After the concrete is poured and compacted, it is covered by wet grass curtains or wet cloth to prevent wind and direct sunlight and reduce the level of water evaporation. This is the most effective way to prevent the early cracking of HPC. At present, studies have shown that for HPC and 40% aerated concrete, the degree of shrinkage (uniform stress variable value) is less than that of ordinary concrete with the same strength level, whether it is under ordinary combined conditions or under autoclaved conditions. It is half of ordinary concrete. The construction environment in which HPC is located has long required it to have strong resistance to destruction and physical and mechanical properties, such as tensile and compressive strength and elastic modulus.

(B). Key points of mix design control

As people’s understanding becomes more and more comprehensive, the requirements for calculating the water-cement ratio are gradually transformed from the previous concrete strength grade to the current durability data. The correct electric flux index is selected according to the effect grade of the surrounding environment, and the minimum is determined Control the amount of cementitious material, concrete water-binder ratio and admixture ratio. Because the invert and lining of the tunnel along the passenger dedicated line have their own design strength levels, in order to meet the relevant requirements and design needs, super-strong concrete is usually selected.

In the actual design process, the content of cementitious material in concrete must be strictly controlled within the applicable range to ensure that the durability of concrete is not affected. This range not only has a minimum content, but also a content limit. C30 and below concrete should be less than 400kg per cubic meter, and the total amount of C35 ~ C40 cementing materials should be less than 450kg per cubic meter. Not only that, in addition to using ordinary Portland cement as the cementing material, the railway passenger station also advocates the use of slag powder and fly ash as
admixtures. This can not only reduce construction costs, but also improve stability, and also improve its resistance to chemical attack. At most, general fly ash can be added to concrete. In recent years, some domestic and foreign studies have shown that when 20% fly ash is added, concrete can achieve the strongest durability. The "Interim Provisions for the Durability Design of Railway Concrete Structures" accurately describe the amount of mineral admixtures. Normally, the amount should be greater than 20% of the total cementitious material, but once the amount exceeds 30. The water-binder ratio should be controlled below 0.45.

(C). High durability
The cement interface structure in concrete and its compactness directly determine the impermeability of concrete, and impermeability is the main reference parameter of concrete durability. HPC has a very low level of superplasticizer because of its own high-efficiency water-reducing agent components. After hydration, the capillary pores in the concrete have been filled, there is no extra space for water seepage, and the pore size is very low, which determines that HPC has strong durability. In addition, the HPC is added with mineral ultra-fine powder, which can significantly change the pore structure of the cement stone, greatly reduce the amount of pores with a pore size of not less than 100 microns, and significantly reduce the cement stone and aggregate gap in the middle position improves the crack resistance of the overall component, and greatly improves the concrete's ability to resist acid and alkali, thawing, sulfate, neutralization and other harsh environmental conditions.

5. The development prospect of large volume high strength concrete
In recent years, there have been more and more applications of HPC in the construction field. At the same time, social attention to the ecological environment has always been high, and the impact of construction projects on it has gradually attracted attention. As we all know, whether it is in the construction of buildings or in use When building, all need to consume energy, even natural resources, and the demand is large. Cement is the most common and most important raw material when constructing buildings, and it has the characteristics of unsustainable development. This shows that if sustainable development is to be the basic principle of technological development, HPC should limit the proportion of cement in concrete as much as possible while ensuring high strength and large volume. Wu Zhongwei et al. put forward the concept of green concrete on the basis of HPC, which mainly includes the following aspects: a). No damage to the environment, even beneficial to the environment. b). Save energy and reduce resource consumption. c). Take sustainable development as the principle. Compared with ordinary concrete, the research and application of the combination of HPC and green concrete to obtain concrete with excellent performance has practical value. This has a profound impact on the future development of concrete, and can even be an important direction for concrete development.

6. Conclusion
In summary, starting from the technical approach and basic requirements, this article mainly discusses the optimal mix design of HPC, including how to select raw materials and determine a reasonable mix. Among them, mineral fine powder is incorporated in the selection of raw materials, and chemical admixtures are added as a technical way to formulate HPC. First, it can reduce production costs and also obtain concrete with excellent performance. This is very important for the application and promotion of HPC. Favorable. The concrete design method in this article is more advanced with outstanding features. Compared with the previous method, it is more accurate, more convenient, procedural and has a wider application range. After the concrete is prepared according to this design method, the mechanical properties, workability and durability are all more excellent. Frost resistance performance tests were carried out during the research process. After analysis, it was found that the frost resistance of high-strength and large-volume concrete is related to many factors. Among them, the major influencing factors are the quality of introduced air bubbles, the content of air introduced, and the mixing ratio of water glue generally speaking, the optimum air content is 2.0% to 4.0%, and
concrete strength, etc., and the concrete is prepared according to this method, and the frost resistance can reach more than 200 times. In addition, the addition of admixtures also has a certain impact on the antifreeze performance. In this study, it was found that the optimal proportion of admixtures was 0.95% to 1.00%. At this stage, HPC has a strong domestic development momentum, but there are still not many HPCs used in construction projects, and this still needs a process of promotion. In our country, building infrastructure has a broad development space, and HPC will definitely become an important raw material used in construction projects in the future. Due to its excellent performance in all aspects of high-strength and large-volume concrete, it has become an important development direction in the field of concrete in my country, which is worthy of vigorous development and application.

References
[1] Ding Yong. Analysis of high-performance concrete mix design and construction technology [J]. Sichuan Cement. 2020 (03)
[2] Zhang Xiaojing. Research on specific measures for optimizing the mix ratio of high performance concrete [J]. Building Materials and Decoration. 2020 (06)
[3] Wang Denghui. Durability quality control measures for the main bridge of Quanzhou Anhaiwan Bridge [J]. Fujian Transportation Science and Technology. 2020 (01)
[4] Xin Rongxing. Design points and quality control of high performance concrete mix ratio [J]. Ju She. 2020 (05)
[5] Wang Kewei, Gao Wenda, Zhu Wei, Xu Zhimin, Zhu Bingxi. High-performance concrete preparation technology for Jiuxianghe Gate Station Project [J]. Comprehensive Utilization of Fly Ash. 2020 (01)
[6] Ji Youming. Talking about the preparation and application of high-performance C50 concrete [J]. Value Engineering. 2020 (04)
[7] Zhang Baolan, Li Chao, Liu Xing, Xu Yan. Research and application of key technologies of immersed pipe concrete for Hong Kong-Zhuhai-Macao Bridge [J]. Concrete. 2020 (01)
[8] Gu Yijia. Research on the construction and application of high performance concrete for transmission line tower foundation [J]. Communication World. 2020 (01)
[9] Hong Guijing. Analysis of high performance concrete mix design [J]. Jiangxi Building Materials. 2019 (12)