ISSN: 1813-4890

Summary Of Concrete Material Research

Shaopu Jia, Zhinian Yang

1School of Architecture and Engineering, North China University of Science and Technology, Tangshan, 063210, China

Abstract

As a major building material, concrete plays an important role in modern construction. This paper reviews the research progress of concrete materials, including concrete composition, performance regulation and sustainable development. Through sorting and summarizing analysis, the latest progress of concrete material research is summarized.

Keywords

Concrete material, composition, performance, sustainability, research progress.

1. Introduction

Concrete is a composite material composed of cement, aggregate and admixture, with good strength and durability. In recent years, with the rapid development of engineering construction and the improvement of environmental protection awareness, the demand for concrete research is also increasing. This paper aims to review the research progress of concrete materials and provide a reference for other researchers.

2. Study on concrete composition

2.1. The influence of different types and proportions of cement on concrete performance

Common Portland cement: This is the most common type of cement, and its main components are limestone and clay. OPC cement is widely applicable and can be used in a variety of construction projects. It has higher early strength and lower economic cost, but its hardening process is relatively long, and it has higher carbon emissions.

High performance cement: HPC is a kind of cement that improves the performance of concrete by adding fine powder and chemical additives to ordinary Portland cement. HPC has high compressive strength, low permeability and better durability. It is often used in structures that require high strength and durability, such as bridges, dams, etc.

Slag cement: slag cement is made by mixing industrial slag with ordinary Portland cement. Common slag includes slag powder and fly ash. Slag cement has good comprehensive performance, such as high strength, low heat generation and better durability. It has advantages in improving concrete crack resistance and reducing alkali-aggregate reaction.

Starting sulfate cement: RSC is a special purpose cement that improves the chemical corrosion resistance of concrete by adding an appropriate amount of starting sulfate to an ordinary silicate cement. RSC is often used in some environments with the risk of chemical erosion, such as sewage treatment plants and chemical plants. White cement: White cement is a special type of cement, its main components are high purity limestone and kaolin. White cement has high whiteness and good light reflection performance, which is often used for decorative and beautiful buildings and structures.

ISSN: 1813-4890

2.2. The influence of different kinds and size aggregates on strength and durability of concrete

Gravel aggregate: Gravel aggregate is a common type of aggregate, which can be obtained by the crushing and screening of natural stone materials. The size of gravel aggregate can be adjusted as needed, with common ranges from 5mm to 20mm. Gravel aggregate has good mechanical properties in concrete and can provide high strength and durability.

Sand aggregate: the sand aggregate can be divided into two types of fine sand and coarse sand, and its particle size range is generally between 0.07mm and 5mm. Fine sand has a large surface area, which can enhance the working ability and fluidity of concrete, but contributes relatively little to the strength. Thick sand can increase the strength and toughness of concrete.

The selection of sand aggregate should be adjusted according to the use and performance requirements of concrete. Slag aggregate: Slag aggregate is broken and screened through industrial slag, such as fly ash and blast furnace slag. Slag aggregate can effectively improve the durability of concrete, reduce the generation and expansion of cracks, and resist chemical erosion.

Lightweight aggregate: lightweight aggregate including foam concrete particles, expanded clay particles, etc., its density is relatively low. Lightweight aggregate can reduce the weight of concrete, improve heat insulation performance, but also reduce the strength and durability of concrete.

2.3. Effect of adding different admixtures to concrete and its influence on properties

Mineral admixture: mineral admixture includes fly ash, slag powder, etc. Adding a proper amount of mineral admixture can improve the working performance and durability of concrete. They can fill the pore structure of concrete, reduce the water-cement ratio and moisture migration, and increase the compactness and durability of concrete.

Silicon ash: Silicon ash is a very fine amorphous silicate powder, usually in the form of fly ash, quartz powder, etc. Adding silicon ash can promote the hydration reaction of cement, form more hydration products, and improve the strength and durability of concrete.

Expansion agent: expansion agent is a kind of substance that can make concrete volume expansion, among which the commonly used expansion agent includes calcium hydroxide, calcium chloride, etc. Adding an appropriate amount of expansion agent can increase the volume stability and xu degeneration resistance of concrete, and reduce the risk of concrete cracking under thermal stress or hot and humid environment.

Porous aggregate: porous aggregate such as expanded perlite, expanded clay can reduce the density of concrete, reduce dead weight, improve heat insulation performance and reduce the structural load, but also reduce the strength of concrete.

Chemical admixture: Chemical admixture includes retarder, water reducing agent, plasticizer, etc. They can improve the fluidity, plasticity and crack resistance of concrete, and improve the working performance and construction efficiency of concrete. It should be noted that the addition amount and use mode of different admixtures should be adjusted according to the specific requirements of concrete and the target performance.

3. Research on concrete performance control

3.1. Strength performance: the control means of concrete strength and the corresponding research results

Water ash ratio control: water ash ratio refers to the amount of water in concrete and the amount of cement ratio. The purpose of regulating the concrete strength can be achieved by

reasonably controlling the water-cement ratio. A lower water-cement ratio can improve the strength of concrete, but it will increase the viscosity of concrete and the difficulty of construction. Studies have shown that a lower water-cement ratio can improve the early and long-term strength of concrete and improve its durability.

Concrete mix ratio design: concrete mix ratio refers to the proportion of water, cement, aggregate and admixture in concrete. The strength and performance of concrete can be improved by reasonable design of mix ratio. The study shows that the strength of concrete can be improved by appropriately improving the use of appropriate aggregate size and the appropriate amount of admixture. Use high strength cement and aggregates: high strength cement and aggregates have high strength, and using them can improve the strength of concrete. High strength cement mainly includes Portland cement and fly ash cement, while high strength aggregate mainly includes high hardness gravel and sand. Studies have shown that the use of high-strength cement and aggregate can significantly improve the compressive strength and tensile strength of concrete.

Add chemical admixture: chemical admixture is to point to one or more kinds of chemical materials added in concrete, such as retarder, plasticizer, water reducing agent, etc. These chemical admixtures can change the hydration process of concrete and improve the strength of concrete. Studies show that the moderate use of chemical admixture can improve the working performance and durability of concrete, and improve its strength.

3.2. Crack resistance: the improvement method of crack resistance of concrete and the experimental analysis results

Use appropriate admixture: add the right amount of admixture in concrete, such as fly ash, silicon ash, slag powder, etc., can increase the fine pore structure and internal grain boundary of concrete, improve the crack resistance. Experimental studies show that appropriate admixture can effectively slow down the shrinkage deformation of concrete and enhance the crack resistance.

Choose the right fiber material: adding the fiber material to the concrete can improve its crack resistance. Common fiber materials include steel fiber, polypropylene fiber, glass fiber, etc. Experimental studies show that the appropriate amount of added fiber material can effectively control the crack expansion of concrete and improve its toughness and crack resistance.

Control the water glue ratio of concrete: reasonable control of the water glue ratio of concrete can reduce dry shrinkage and temperature contraction, thus reducing the formation of cracks. Experimental studies show that a lower water-glue ratio can significantly improve the crack resistance of concrete.

Optimization of construction technology: reasonable construction technology plays a vital role in the crack resistance of concrete. For example, reasonable control of pouring temperature, construction pouring mode and curing conditions can reduce the plastic shrinkage and dry shrinkage of concrete, improve the crack resistance.

Experimental analysis results: The crack resistance of concrete can be evaluated and analyzed through experimental research. For example, using tensile test, bending test and crack extension test can obtain concrete crack resistance parameters, such as tensile strength, toughness index, crack width, etc. The experimental analysis results can provide a basis for the improvement and optimization of the crack resistance of concrete.

3.3. Durability performance: the research progress of concrete durability performance and its influencing factors

Research progress: For the research of concrete durability, people mainly pay attention to the following aspects: performance evaluation of concrete material: through accelerated

ISSN: 1813-4890

experiment, natural exposure test and other methods of concrete material performance evaluation and prediction, in order to understand its long-term durability performance.

Durability parameters: study the chloride permeability, carbonization, sulfate erosion and other durability parameters in concrete, in order to evaluate the corrosion resistance and durability of concrete.

Research on crack resistance: by studying the mechanism of crack formation and expansion mechanism of concrete, the method and strategy of crack control are proposed to improve the durability of concrete.

Application of new materials and technologies: to develop new concrete, additives and construction technologies to improve the durability of concrete, such as high-performance concrete, self-repair concrete, etc.

Influencing factors: the durability of concrete is affected by many factors, including: the variety and mix ratio of concrete materials: different material combination and mix ratio will affect the compaction of concrete, impermeability, crack resistance and other durability performance.

Environment factors: including climate conditions, temperature changes, humidity, chemical substances, etc., these factors will cause concrete corrosion, carbonization and other problems.

Structural design and construction technology: reasonable structural design and construction technology can reduce the possibility of stress concentration and crack formation of concrete, and improve its durability performance.

Curing method: appropriate curing measures can promote the early strength development and durability improvement of concrete.

4. .Research on concrete sustainability

4.1. Assessment method of concrete carbon emission and the strategy to reduce carbon emission.

Carbon emission assessment method: Overall assessment method: The life cycle assessment method is adopted to comprehensively assess the carbon emission situation of concrete from the raw material acquisition, production, use, end of use and other stages.

Fine-grained assessment method: Carbon footprint method is used to assess concrete carbon emissions by calculating carbon emissions per unit of product

Boundary determination method: Determine assessment boundaries, including raw material production, concrete production process and subsequent use stages.

Strategies to reduce carbon emissions: Material optimization: choose alternative materials such as low-carbon cement, admixture and fly ash to reduce the amount of cement used in concrete and reduce carbon emissions.

Energy efficiency improvement: optimize the production process, adopt efficient equipment and technology, reduce energy consumption, and reduce carbon emissions.

Carbon capture and utilization: research and development of carbon capture, carbon curing and other technologies to capture and use the carbon dioxide produced in the concrete production process to reduce carbon emissions.

Concrete recycling: promote the recycling of waste concrete, reduce the production demand of new concrete, reduce carbon emissions.

Carbon trading and tax policy: introduce carbon trading market or impose carbon tax on high carbon concrete, and encourage to reduce concrete carbon emissions by economic means.

ISSN: 1813-4890

4.2. Energy utilization efficiency and energy-saving improvement measures of concrete materials

Energy efficiency: Material selection: select concrete materials that can provide higher strength to reduce the amount of concrete used and energy consumption required during construction.

Production process optimization: optimize the design and operation of concrete production facilities, improve the energy efficiency and operation efficiency of equipment, and reduce energy consumption.

Heat recovery and utilization: the heat recovery technology is adopted to convert the waste heat in the concrete production process into heat energy or electric energy to improve the energy utilization efficiency.

Cement clinker replacement: explore the use of alternative materials, such as slag, fly ash, to replace part of cement clinker, reduce the cement production process with high energy consumption.

Energy-saving improvement measures: Energy-saving equipment: install efficient energy equipment, such as energy-saving motor, frequency converter and efficient lighting equipment, to reduce the energy consumption in the concrete production process.

Environmental control: improve the production process, control the indoor temperature and humidity, and reduce the energy consumption for heating, cooling and ventilation.

Waste heat utilization: carry out waste heat recovery and utilization, and use the waste heat released in the concrete production process for heating water or air to improve energy utilization efficiency.

Environmentally friendly fuel replacement: Consider using alternative fuels, such as biomass fuels or municipal waste fuels, to reduce energy consumption and carbon emissions during concrete production.

Automation and intelligence: apply automation and intelligent technology, optimize the production process, make energy use more efficient, reduce energy waste.

4.3. Research progress of concrete production using waste replacement materials

Fly ash: Fly ash is a kind of waste produced in the process of coal burning. Taking fly ash as an alternative material for some cement clinker can reduce the demand for cement in the concrete production process. The study shows that the addition of fly ash can improve the strength and crack resistance of concrete, and improve the durability of concrete.

Slag powder : slag powder is a waste produced in the metallurgical process. Taking slag powder as an alternative material of cement clinker can reduce the demand for cement in the concrete production process. The addition of slag powder can improve the working performance and durability of concrete, and improve the long-term strength and durability of concrete.

Stone powder:Stone powder is a kind of waste produced in the processing process of the quarry. Stone powder can partially replace natural sand, playing a role of filling and lubrication in concrete. The study shows that the proper addition of stone powder can improve the compressive strength and durability of concrete.

Waste glass powder: Waste glass powder is a kind of waste produced in the processing or recycling process of waste glass. Waste glass powder can replace part of the cement or aggregate, and react with other components in the concrete to form a cementitious material. The study shows that the addition of waste glass powder can improve the compressive strength, durability and chemical corrosion resistance of concrete.

ISSN: 1813-4890

5. Conclusion

Through the review of concrete materials, the following conclusions can be drawn:

The reasonable control of concrete composition can significantly affect the performance and durability of concrete.

Through the scientific concrete ratio and add the right amount of admixture, can improve the strength and durability of concrete.

In the pursuit of high-performance concrete, it is also very important to pay attention to the sustainable development of concrete materials.

In the field of concrete research, there are still some challenges that require further research and innovation.

This paper reviews the research progress of concrete materials, covering concrete composition, performance regulation and sustainability development. Through the analysis and summary of the existing literature, the latest progress and trend of concrete material research are deeply discussed. These studies provide guidance and reference for the application and development of concrete materials, and also provide directions and ideas for in-depth exploration for subsequent researchers. With the further development of science and technology, it is believed that the research of concrete materials will achieve more remarkable results in the future.

References

[1]Shi Zhenhai, Shi Xudong edited;. Principles and Analysis of reinforced Concrete [M]. Tsinghua University Press, 2003

[2]Zhao Youjun. Mix Ratio Design Analysis of Concrete Materials in Construction Engineering [J]. Bulk cement, 2024, (02): 210-212

[3]Design and Application of Durability of Concrete Structure [M]. By Xing Feng. China State Construction, Engineering and Construction Industry Press. 2011

[4]Composite Material Mechanics [M]. Shen Guanlin, Hu Gengkai edited. Tsinghua University Press. 2006

[5]Concrete Structure Durability [M]. Jin Weiliang, Zhao Yu Xi wrote. Science Press. 2002

[6]Mechanical Properties and Determination of Concrete [M]. By Jiang Fukuda. China Railway Publishing House. 1989

[7]Green Concrete and its Engineering Applications [J]. Shi Bo, Li Jianfeng. Building Technology, 2004 (01)

[8]Discussion of “Strength Evaluation of Concrete Columns with Cross-Sectional Holes” by Muayad M. Kassim and Shahin A. Ahmad[J]. Jianwei Huang. Practice Periodical on Structural Design and Construction.

[9]Digital Concrete: A Review[J]. Timothy Wangler,Nicolas Roussel,Freek P. Bos,Theo A.M. Salet,Robert J. Flatt. Cement and Concrete Research.

[10]Information Technology in the Development of the Polish Construction Industry[J]. Oleg Kapliński. Technological and Economic Development of Economy.

[11]The Development Status of Construction Equipment and Technology in China[J]. J Sun,L Y Zhu,J Wu. IOP Conference Series: Materials Science and Engineering.

[12]Effect of Elevated Temperatures on the Mechanical Properties of Concrete[J]. Krishna D. Anupama,Priyadarsini R S,Narayanan S.Procedia Structural Integrity.