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Research on The Production and Application of Multifunctional Concrete

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Abstract. As the preparation of building materials can pollute the environment, and the manufacturing process is complicated and wastes materials, people are developing more advanced multi-functional concrete. This paper studies the development and application of two new types of concrete, as well as some of their shortcomings and development process. Firstly, electricity-based multifunctional concrete not only has the advantages of traditional concrete, but also has strong electrical conductivity, thermoelectricity and capacitance. This kind of concrete holds significant promise in a variety of engineering applications, such as structural health monitoring, traffic detection, and snowmelt. It not only makes people's life more convenient, but also ensures that the concrete preparation process can reduce the damage to the environment. Secondly, this paper analyzes a new type of concrete. The concrete can be made from seawater and carbon dioxide, which can reduce carbon emissions and be used to make wave-absorbing blocks. However, as this new concrete is newly developed, it is somewhat lacking in some aspects, such as it is not as strongly alkaline as ordinary concrete. Conclusion shows that the development of new multifunctional concrete can reduce the pollution to the environment and meet the needs of modern society for concrete, which has important practical significance.

Keywords: Multifunctional concrete; Electricity-based multifunctional concrete; New concrete.

1. Introduction

Multifunctional cement is a type of cement with special characteristics and functions that can play an important role in the construction industry and infrastructure [1]. Its production and widespread application are essential for a sustainable future. With the advancement of technology and the development of society, multifunctional cement is gradually becoming the focus of the construction field. When it comes to the production of multifunctional cement, it is not only necessary to consider quality and stability, but also to focus on environmental protection and sustainability. The use of advanced production processes and materials to produce multifunctional cement that meets various standards and needs will bring new possibilities to the construction industry. At the same time, reducing energy consumption and emissions in the production process and reducing resource waste are also the directions to focus on in the future of multi-functional cement production. When it comes to the application of multifunctional cement, its potential is undoubtedly enormous. This multi-functional cement can be used in a wide range of high-rise buildings, bridges, roads, and other infrastructure projects [2]. By utilizing multi-functional cement, the strength and durability of the building can be improved, maintenance costs can be reduced, and the service life can be extended. In addition, multifunctional cement can also play an active role in environmental protection, energy conservation and emission reduction, and contribute to the sustainable development of the construction field. With the acceleration of urbanization and the continuous improvement of people's requirements for building quality, multi-functional cement has surely been the mainstream in the field of building materials. Through continuous innovation and technological breakthroughs, the production of higher-performance multi-functional cement can promote its wide application in various construction projects, which brings greater development opportunities and space to the construction industry. The production and application of multi-functional cement is not only a technical issue, but also a major plan related to the development of human society and environmental

protection. Only by moving forward on the road of sustainable development can the important position and role of multi-functional cement in the construction industry be realized.

2. Electricity-based Multifunctional Concrete

Due to its durability and hardness, traditional concrete can meet the needs of many buildings, ensuring the foundation and safety of infrastructure. However, with the aggravation of environmental pollution, the continuous expansion of infrastructure, the continuous expansion of residential space and the improvement of the standard of people's residential places, traditional cement can no longer meet modern standards, and people have begun to look for an environmentally friendly and multi-functional concrete.

Electricity, as an invisible force to promote modern civilization, combined with tangible concrete that carries human civilization, has given birth to the emergence of electricity-based multifunctional concrete. Through structural-functional integration and functional-intelligent integration, this innovative composite exhibits excellent intrinsic properties as structural materials, including mechanical properties and durability, as well as superior electrical properties such as electrical conductivity, inductance, capacitance, impedance, thermoelectric, piezoelectric, among others. As a result, it holds significant promise in a variety of engineering applications such as structural health monitoring, traffic detection, energy conversion/storage, de-icing and snow melting, building heating, electromagnetic protection, cathodic protection, grounding, and electrostatic protection. Ongoing research on electricity-based multifunctional concrete establishes a fundamental material framework for the transformation of infrastructure, providing a way to enhance the safety, durability, functionality, and resilience of infrastructure.

The research on electricity-based multifunctional concrete was first developed in the 30s of the last centuries, and it was only possible to study it in the laboratory. Metal particles are incorporated into the concrete matrix to improve its electrical conductivity. It was not until the 60s and 80s of the 20th Century that the focus of research shifted to the use of more efficient conductive materials such as carbon fiber and graphite powder.

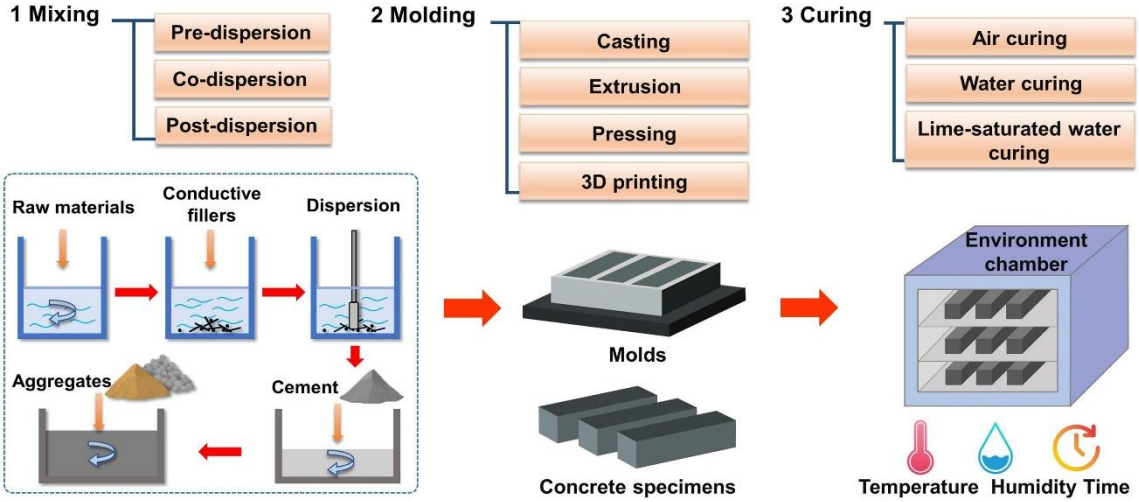

Figure 1. Fabrication process of electricity-based multifunctional concrete [3]

Fig. 1 shows the fabrication process of electricity-based multifunctional concrete. Mixing is a crucial step because it directly affects the uniform distribution of conductive fillers in the concrete, which in turn determines the electrical and mechanical properties of the concrete. The molding step is also critical, with existing technologies including traditional pouring, extrusion, pressing, and emerging 3D printing technologies. Due to its high degree of automation, speed and repeatability, 3D printing has shown great potential, especially in the manufacture of complex concrete components. The curing process is divided into standard curing, steam curing and lime saturated water curing according to the humidity and temperature conditions of the environment. The selection of the appropriate curing

method should be matched to the specific formulation of the concrete to ensure that the mechanical and electrical properties of the final hardened product meet expectations [4].

With the development of technology, wireless measurement technology has shown great potential in the evaluation of electrical properties of electricity-based multifunctional concrete. The wireless transmission system can receive and save the resistance signal from the concrete sensor. The experimental results show that the signal provided by the wireless system is comparable to that of the wired system in the cyclic compression test, which confirms its reliability and convenience. The improvement and optimization of these technologies indicate that the application prospect of electricity-based multifunctional concrete in intelligent infrastructure will be broader. By continuously optimizing the measurement method and electrode configuration, it is possible to more accurately evaluate the electrical resistance characteristics of electricity-based multifunctional concrete. This not only provides data support for the improvement of material properties, but also provides key technical support for the construction and maintenance of intelligent infrastructure.

Electricity-based multifunctional concrete plays a key role in structural health monitoring of civil engineering infrastructure. Fig. 2 shows the electricity-based multifunctional concrete for structural health monitoring in civil infrastructures. Structural health monitoring plays a vital role in ensuring the safety, reliability, and sustainability of infrastructure through real-time data monitoring. It enables early detection of structural defects and potential failures, allowing maintenance and repair work to be carried out in a timely manner, thereby improving public safety, reducing downtime, and significantly reducing the associated economic costs and carbon emissions. In addition, this approach helps to optimize resource allocation, enhance the resilience and longevity of infrastructure, and promote its long-term sustainability.

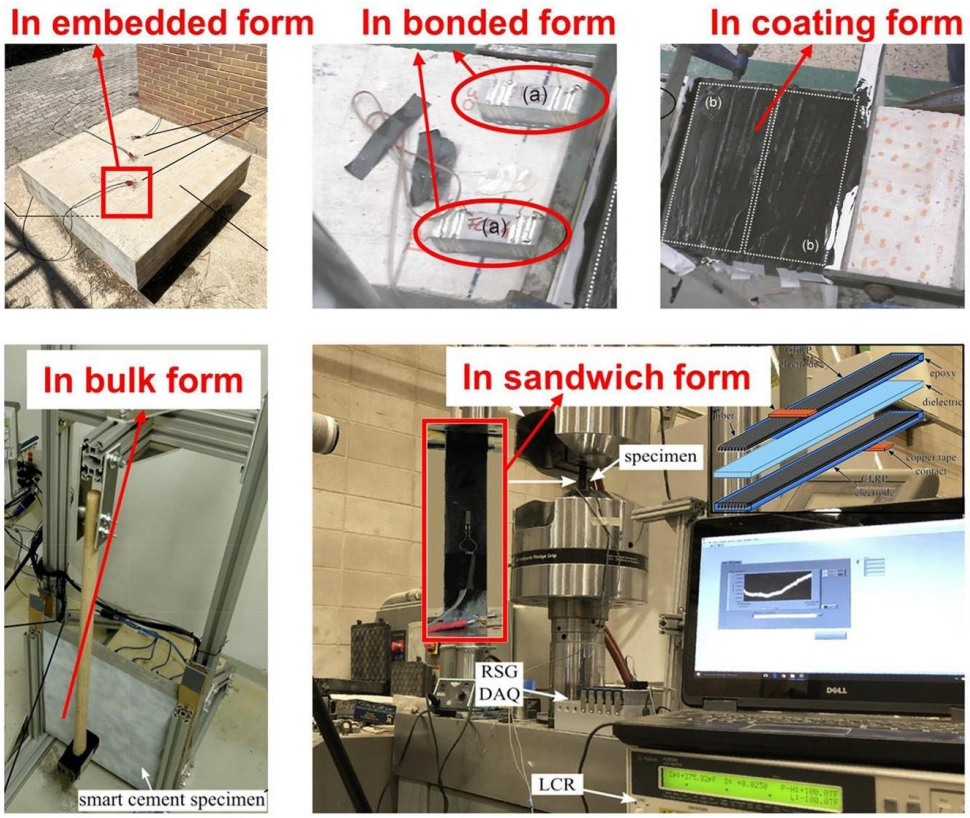

Figure 2. Electricity-based multifunctional concrete for structural health monitoring in civil infrastructures [3]

3. A New Type of Concrete Made from Seawater and Carbon Dioxide

Due to the increasing awareness of the environmental protection, people are trying to find a new king of concrete which is environmental-friendly. Recently, Japan has developed a new type of concrete

using seawater and carbon dioxide as raw materials, which can not only does the new material achieve the short setting time and good compressive strength required as a building material, but it also solidifies and sequesters carbon dioxide during the production process, contributing to carbon neutrality [5].

The sequestration of carbon dioxide in the form of solid carbonates is attracting attention as an achievable carbon sequestration technology. Basic oxides suitable for sequestering carbon dioxide include calcium oxide, magnesium oxide, etc., and calcium and magnesium are abundant in seawater in ionic form. The team has been working on the development of magnesium carbonate applications, they extract magnesium chloride hydrate from seawater and produce magnesium carbonate from the thermal decomposition of magnesium chloride hydrate. Powered by green electricity, the process produces between 20 and 110 kilograms of CO_2 per cubic metre of magnesium carbonate. At present, ordinary Portland cement is generally used in the preparation of concrete, and the production of this cement requires the use of cement clinker whose main component contains calcium oxide, and calcium oxide is generated by the thermal decomposition of limestone, and its products include carbon dioxide. Therefore, even if the energy source of thermal decomposition is not fossil fuels, it still causes carbon emissions [5].

The team came up with the idea of using magnesium carbonate from seawater and carbon dioxide as cement raw materials to make concrete to reduce carbon emissions. However, if only magnesium carbonate is mixed into ordinary Portland cement, the construction performance of the prepared concrete will be reduced, the compressive strength is not enough, and it is easy to crack and other phenomena.

Inspired by the traditional non-hydraulic magnesium oxychloride cement production technology, they developed a new type of concrete with both efficiency and compressive strength, with a setting time of 1 to 2 hours and a compressive strength of more than 25 mega-pascals by adjusting the magnesium oxide generation conditions and carbonate conditions to control the mixed magnesium carbonate crystals, and then adding a unique ratio of coarse aggregate and fine aggregate made of magnesium oxychloride cement.

It is predicted that it can be used to make concrete products such as wave-absorbing blocks and interlocking blocks. However, this material is not as strongly alkaline as ordinary concrete, so it is not suitable for ordinary carbon steel reinforced concrete pouring.

4. Conclusion

This paper mainly studies the background and reasons for the development of multifunctional concrete, the manufacture and application of different types of multifunctional concrete, and mentions the advantages and disadvantages of each concrete.

(1) Electricity-based multifunctional concrete is more in line with modern requirements for concrete due to larger housing and other reasons, its properties are much more than traditional concrete and can conduct electricity, and have better prospects in engineering, this paragraph talks about its design, composition, basic principles, performance and its application in infrastructure. The current technical challenges and future prospects for the application of electric multifunctional concrete in infrastructure are also discussed.

(2) The new type of concrete mentioned in this paragraph can reduce carbon emissions in the re-manufacturing process, which is more in line with people's requirements for modern concrete, and the researchers were inspired by other technologies in the preparation process, and finally developed a new type of concrete that can be used to produce wave-absorbing blocks. However, as it is a newly developed product, this concrete has some shortcomings that have not been discovered.

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