

Literature Review of the Application of Conductive Carbon Fiber-graphite Concrete in floor heating

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ABSTRACT

The technical features of conductive carbon fiber-graphite concrete are reviewed in this paper, and its generation, development and the current technology condition are also introduced. According to the researches of conductive carbon fiber-graphite concrete material in recent years, the paper presents its application in all kinds of aspects especially floor heating engineering in which its advantages can be fully used. Finally, the paper summarized the developing trend of carbon fiber-graphite conductive concrete.

Key words-Conductive concrete, Carbon fiber, Graphite, Indoor heating, electrocaloric effect

I. INTRODUCTION

Concrete has experienced long-term development as main building material, from common structural materials to high strength structural materials, then high-performance concrete, now it develops to the intelligent concrete. The paper will introduce the conductive carbon fiber-graphite concrete which not only has high strength and good conductivity, but also provides indoor floor heating projects with rare excellent material^[1]. Carbon fiber (CF) is one kind of nonmetal fibrous material with high strength, high modulus, resistance to high temperature, resistance to acid and alkali corrosion and good conductivity, it possesses fine performance of carbon as well as the flexibility of fiber^[2]. And that graphite also has good conductivity and graphite concrete is easy to shape and has large heat capacity, moreover, its limited let-through current is large (reach up to 200A/cm²)^[3]. So that the concrete mixed with carbon fiber and graphite possesses good performances such as high strength, high elastic modulus, low dry shrinkage, tension resistance, bending resistance and impact resistance. What's more important is that it has conductivity and electrothermal effect, under the function of certain electric power carbon fiber-graphite concrete will rise its own temperature and release heat into surrounding^[4]. This function brings carbon fiber-graphite concrete extensive developing areas and application space.

II. DOMESTIC AND FOREIGN DEVELOPING STATUS OF CONDUCTIVE CONCRETE

Intelligent concrete is a researching branch of smart material, its origin dates from 1960s when the

Soviet Union scholars firstly used carbon black as conductive component to try preparing cement-based conductive composites. In the late 80s, researchers of Japanese civil engineering designed and set out to develop smart building materials of high intelligent structure which could perceive and control the changes of environment. Professor D.D.L.chung in America and her research group proposed the concept of smart-concrete in 1993 and devoted themselves to the researches of smart concrete for more than ten years after that^[5]. America, Canada and Northern European countries researched conductive concrete in order to solve the icy roads and bridge floors problem. China started the research of conductive concrete at late 1980s^[6]. In 1998, Li Renfu^[7] et al. made an attempt to utilize graphite cement paste to product indoor heating ground, and finally achieved satisfactory results. Hou Zuofu, Li Zhuoqiu and Tang Zuquan et al.^[8] in Wuhan University of technology carried out the research of applying carbon fiber concrete to deicing and snow melting, and proved the feasibility of this material being used in road deicing. Tumi-dajski et al.^[9] tested the current transport of the pavement structure which was composed of conductive base course and ordinary concrete overlay in snow melting process. All these research results account for that the electrothermal effect of conductive concrete can meet the demands for building heating and road deicing, and conductive concrete has utilizable perspective.

III. THE APPLICATION OF CARBON FIBER CONCRETE

Due to the excellent performance of conductive concrete, in 1982 carbon fiber concrete composite board was firstly used in a monument in Baghdad

city. In 1986, the carbon fiber concrete was applied to the ARK building, Tokyo Medical University in Tokyo, Japan.

In China, the smart structure of carbon fiber concrete was already used in the cofferdam of the Yangtze Three Gorges construction site, and good results were achieved. Huo Zuofu^[10] reported the development of carbon fiber conductive concrete slab, the results showed that the input power of the carbon fiber conductive concrete slab reached 2000W/m², met the requirement of melting ice. Su Jianbo and Li Sizhi^[11] introduced the wide application of carbon fiber concrete in our country since 1996, such as the east ring, west ring and south ring expressway pavement of Guangzhou city, not only solved the problem of the non-magnetic requirement in toll station, but also effectively met the demands for the crack resistance, abrasion resistance and impact resistance of pavement. In the oversize transforming layer girder of Chongqing world trade center, the application of PAN-based carbon fiber reinforced concrete successfully solved the crack resistance and promoting toughness problems of the construction of high-grade mass concrete.

In terms of floor heating, also has substantial progress, South Korean PTC company developed one kind of easy disassembling electrothermal heating floor which was named carbon fiber floor heating pad, and our country also developed our own Hobar electrothermal film.

IV. CF-GRAPHITE CONDUCTIVE CONCRETE FLOOR HEATING

4.1 DEVELOPMENT PROSPECT OF FLOOR HEATING

Floor heating is called for short floor radiant heating, its whole ground serves as radiator and heats the whole floor uniformly through the heating medium in floor radiant layer, utilizing the heat storage of the ground itself and the rules of heat radiating upward to conduct the heat from bottom up so as to achieve the purpose of heating. Floor heating (floor radiant heating) is divided into water heating and electric heating according to different heating modes. And there are pure electric heating and carbon fiber electric heating^[12]. Carbon fiber electric heating consists of electric heating plate, temperature controller (thermostat) and wire, electric heating plate is the core heating element which is made by special treatment of short carbon fiber and far-infrared emission agent, then scaled in insulating resin under high vacuum^[13]. CF-graphite electric floor heating is the joint of original carbon fiber electric floor heating and graphite, and the graphite makes heat source distributes more equably. CF-graphite electric floor heating is a new kind of electric heating mode originated abroad in recent years. This kind of floor heating is a new product with low cost, high

conversion efficiency of heat and energy and good energy-saving effect^[14]. The heating mode of carbon fiber electric heating is same as of pure electric heating. They both take electricity as heating source.

The floor heating in future is necessarily going to be more comfortable, more energy-saving and more diverse, and CF-graphite electric warming is complied with this development.

4.2 THE SUPERIORITY OF APPLYING CF-GRAPHITE CONDUCTIVE CONCRETE IN FLOOR HEATING

For a long time, the conductive performance of conductive concrete is gained often at the expense of its strength. Because that concrete itself is poor conductor, add much graphite into it in order to improve its conductivity, but at the same time of improving the conductivity its strength will sharply decrease. Although graphite has excellent physical and chemical properties, due to the small length to diameter ratio of powdered graphite it is difficult to form interconnected conductive network inside concrete^[15]. So must add high content graphite into concrete matrix only then it can form interconnected conductive network inside the base-body and make conductive concrete gain good electrical conductivity. Graphite powder demands plenty of water so that it will greatly increase the water consumption of concrete mixture, as a result the concrete strength declines rapidly with the increase of graphite powder^[16].

And the conductive concrete single doped carbon fiber also has shortages, on the one hand its price is high and on the other hand it is difficult for concrete to stir evenly when carbon fiber content is large and the clustering phenomenon of carbon fiber is easy to appear. Meanwhile, a large number of bubbles are introduced during stirring which makes the porosity of carbon fiber concrete increases. However, adding graphite can improve mixing performance of carbon fiber in the concrete at the same time carbon fiber can make up for the strength inadequacy of graphite. P.XIE used carbon fiber and carbon particle materials to prepare conductive concrete and utilizing it in deicing and snow melting in 1995. His experiment took carbon fiber and carbon particle as conductive phase and resistivity was 1.2Ω·cm, but the water-cement ratio was large, the compressive strength and bending strength were relatively low. As for only took carbon fiber as conductive phase, the resistivity was slightly higher for 1.6Ω·cm, but good mechanical properties was achieved.

Based on this, the combination of carbon fiber and carbon particles in a certain proportion can lead to a new kind of conductive concrete with resistivity being between 1~30Ω·cm, compressive strength being about 40MPa and bending strength being 6~11MPa. The resistivity of this kind of conductive

concrete that contains carbon fiber and carbonaceous particle is the lowest among current conductive concretes. And in combination with good mechanical performance, it has laid a good groundwork for its application in floor heating projects.

V. PROSPECTS

At present the researches of the application of conductive concrete focus on deicing & snow melting, traffic monitoring and building indoor heating. The research and development of the intellectualization of carbon fiber concrete will further broaden its application field, and bring huge benefits for the society. But as a new type of functional material, there are many problems of CF-graphite conductive concrete need further research in the actual applying engineering. Such as:

1. Dispersion of carbon fiber. It is easy to form cluster thus affects the strength of concrete. How to disperse the carbon fiber is an important problem.
2. The hydrophilic treatment of carbon fiber surface.
3. The selection of the standard proportioning of conductive concrete and its influence on concrete strength and electric conductivity.
4. The selection and design of electrode need improvement.

In our country, the application of carbon fiber concrete in practical construction engineering is still in its infancy, along with the continuous development of national economic and the increasing improvement of requirements to the project quality, the CF-graphite concrete will show its superior advantages.

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