

Application of Intelligent Materials in Construction Industry

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Abstract

Intelligent materials have become the focus of the material industry, which has a broad application prospect. This paper makes a brief introduction to intelligent materials, and focuses on the application of intelligent materials in the construction industry.

Keywords

Intelligent materials; green building; self repair; self diagnosis; intelligent concrete.

1. Introduction

With the continuous progress of material science, electronic technology and automatic control means, the future buildings and materials used will move towards intelligence. The concept of intelligent material appeared in the 1990s. The idea of intelligent material comes from bionics, which is to imitate some unique functions of creatures in nature to make tools for human use. Its goal is to develop a kind of material and make it a living material with various functions similar to creatures. Intelligent material is a kind of multi-functional material which has the ability of self sensing and memory, self adaptation and self repair. Different from structural materials and functional materials, intelligent materials can obtain external information through their own perception, make judgments and processing, send out instructions, and then adjust their own state to adapt to the changes of the external environment, so as to achieve self-detection, self diagnosis, self-regulation, self adaptation, self repair and other special functions similar to biological systems. Due to the special and excellent performance of intelligent materials compared with traditional materials, it has become a global research and development hotspot, and has been widely used in green building materials.

2. Classification of Intelligent Materials

2.1. Smart Sensing Materials

Intelligent sensing materials have the ability of monitoring, sensing and feedback to external signals such as heat, electricity and magnetism, which are necessary components of intelligent structures. Typical sensing materials include piezoelectric materials, microelectronic sensors, optical fibers, etc. Among them, optical fiber is the most commonly used sensing material in intelligent structures. It can sense and obtain all physical parameters of the structure under test, such as temperature, deformation, electric field or magnetic field, without damage.

2.2. Intelligent Driving Materials

Intelligent driving materials have the ability to generate shape, stiffness, position, natural frequency, humidity or other mechanical characteristics response to changes in temperature, electric field or magnetic field. At present, the commonly used intelligent driving materials are shape memory alloy and electric viscous liquid.

2.3. Intelligent Repair Materials

Intelligent repair material is a new kind of composite material, which imitates the bone tissue structure of animals and the mechanism of regeneration and recovery after injury. The composite method of bonding material and base material is adopted, which has the function of self healing and regeneration for the damage of material and can recover or even improve the performance of material.

2.4. Intelligent Control Materials

Intelligent control materials have the ability of memory, storage, judgment and decision-making for the feedback information of intelligent sensing materials, and control and modify the behavior of intelligent driving materials and intelligent repair materials. Microcomputer is the main representative of intelligent control material, and its control algorithm is provided by special program. In the manufacturing process of intelligent control materials, response control is stored at a higher level of integration. In practical application, the program simulates human brain, and has the ability to solve complex problems in multiple directions[1].

3. Application Examples of Intelligent Materials in Buildings

In order to detect the stress state and shape variable of concrete, Yoshida Boming et al. of Tokyo University embedded carbon fiber and glass fiber into concrete. The complementarity of the two kinds of fibers in the aspects of electrical and mechanical properties makes the fibers not only increase the strength, but also analyze the stress state, deformation degree and damage situation in the concrete through the change of fiber resistance, which plays the role of diagnosing crack, warning damage and even predicting service life. They have successfully applied the fiber-reinforced concrete intelligent material to the anti-theft alarm walls of important structural facilities such as banks. The Japanese expect that in the future, the expensive and important bridges and buildings will be able to use this intelligent material to realize on-the-spot real-time monitoring, and send out early warning when the structure is damaged or damaged[2].

A pressure sensitive concrete material developed by Shen Rongda et al. has good properties and practicability. When they add 1% carbon short fiber into the concrete, the resistance will change obviously with the pressure. According to the characteristics of the change of resistance, the safe period, damage period and damage period of concrete materials can be determined to achieve the diagnosis effect. This kind of composite material is made into regular block sensor, embedded in large-scale concrete structure, supplemented by network structure system, which can determine the position of pressure and the size of stress area of large-scale components. If the internal temperature of each part is different, there will be electromotive force difference, and then the distribution of the internal temperature field of large-scale structural components can be judged by detecting the change of electromotive force of each part to form the so-called temperature sensitive concrete. It can also be used to heat concrete structure, which is called adaptive concrete by researchers. These structures, which combine carbon fiber composite materials with optical fiber sensors, are expected to be used in some important positions of large-scale projects such as the Three Gorges Project[3].

In order to ensure the safety of various bridges, American architect Caroline Drey began to study intelligent concrete that can call for help and repair itself in the early 1990s. His idea is to embed a large number of hollow fibers in concrete, which are filled with crack repairing agent in advance. When the concrete cracks, the hollow fiber will also crack, and flow out the adhesive to repair the cracks, firmly stick the cracks together, prevent the cracks from further expansion. This kind of intelligent material is called passive intelligent material. Other bridge experts in the United States are working on an active smart material. Their method is to embed optical

fiber or micro electronic chips and sensors in the concrete, which can make the bridge strengthen automatically when there is a problem in the bridge. For example, shape memory materials or electrorheological materials which can be transformed from liquid to solid under the action of voltage and reinforced automatically are embedded in bridge materials. When the sensor embedded in the concrete gets the signal of crack in some part, the computer will send out the instruction to make the tiny liquid drop embedded in the bridge in advance become solid and reinforce automatically or make the shape memory alloy change phase to increase the strength of the bridge. Ni Ti shape memory alloy wire, optical fiber and resistance strain wire sensor array are embedded in the glass fiber reinforced epoxy resin composite, which can detect the damaged parts in the material. Then, the shape memory alloy at the damaged position is heated by the computer-controlled executive system, and the phase transformation is generated, so that the stress state of the composite structure can automatically adapt to the original design stress conditions[4].

With the enhancement of the function of coating material, the new function of intelligent coating will be applied in ecological residence. Light heat sensitive coating will change the color of living room from light color in summer to warm dark color in winter when the temperature drops in winter. Smart coatings can also be used to absorb energy during the day and release it at night in the form of electricity or heat. Intelligent coating can also have health and hygiene functions. The antibacterial polymer implanted in the coating can kill the bacteria in the home. Coatings with absorptive properties can be used to eliminate smoke and other unpleasant taste, and the performance of dust repellent can also ensure improved sanitation.

The large-scale use of traditional glass curtain wall technology will bring serious light pollution, a large number of energy consumption, line of sight interference, indoor health quality degradation and other problems. In order to solve these problems, smart glass curtain wall technology has been developed in Germany, Britain and other Western European countries. In a broad sense, intelligent glass curtain wall includes glass curtain wall, ventilation system, air conditioning system, environmental monitoring system and building automatic control system. Its technical core is a kind of special curtain wall different from the traditional curtain wall - hot channel curtain wall. It is mainly composed of a single-layer glass curtain groove and a double-layer glass curtain wall. Compared with the traditional glass curtain wall, the intelligent glass curtain wall is a multi-functional system for coordination and cooperation of all disciplines in terms of design concept, content composition and working process. It not only has the glass supporting structure, but also includes the internal environment control and building service system of the building. Through the intelligent glass curtain wall, it can control the outdoor light and provide ventilation. Because the intelligent glass curtain wall is 3-layer glass and the outside is totally enclosed, the interference of external noise on the interior of the building can be greatly reduced[5].

4. Conclusion

Intelligence is the development trend of modern human civilization. To realize intelligence, intelligent material is an indispensable part. Intelligent material is an important direction of the development of material science, and it is also the necessity of the development of material science. Intelligent material structure is a new interdisciplinary comprehensive science. The research content of intelligent materials is very rich, and many cutting-edge disciplines and high-tech are designed. Intelligent materials play a very important role in industrial and agricultural production, science and technology, people's life, national economy and other aspects, and the more flexible the application is, the more widely. The research and application of intelligent material structure system will push human social civilization to a new height.

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