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The Influence of Composite Materials on the Strength and Durability of Road and Bridge Construction

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Abstract: There are many stress conditions and constraint factors in road and bridge construction, and the working environments are relatively harsh. Traditional bridge building materials (such as steel bars and cement) have increasingly exposed their shortcomings such as difficulty in breaking through their crossing capacity, poor durability, and high maintenance and repair costs. As a new type of composite material with excellent comprehensive performance, it can well meet the needs of road and bridge engineering. Given this current situation, this article starts from the basic properties of fiber reinforced polymer (FRP), summarizes the advantages of FRP in bridges, focuses on the special use methods of FRP in bridges, and the future development direction was discussed.

Keywords: Fiber Reinforced Polymer; Road and Bridge; Influence

Introduction

Traditional materials such as concrete, steel bars, and masonry are no longer suitable for today's bridge construction requirements. With the continuous development of transportation, the traffic flow is increasing, and the testing environment is becoming increasingly demanding, which puts forward higher requirements for the performance of building structures. In this case, composite materials have become the forth major building materials after cement concrete, reinforced concrete, and masonry materials. Composite materials have many advantages such as corrosion resistance, fatigue resistance, light weight, high strength, good design-ability, and the ability to be suitable for specific occasions when combined with multiple materials. Therefore, they have received increasing attention in bridge construction.

1. Concept and Characteristics of Composite Materials

Composite material is a kind of multiphase material formed by composite processing of two or more materials. These materials can learn from each other and form synergistic effects, making their comprehensive performance surpass that of raw materials and meet various application needs. The primary phase with continuous characteristics in composite materials is called the matrix, which usually has stronger ductility and lower hardness. The strengthening phase is embedded in the matrix in a continuous or discontinuous form. Composite materials can be classified in different ways, including fiber reinforced, particle reinforced, and laminated composite materials. It can be divided according to its shape. According to the different matrix phases, it can be divided into polymer based, ceramic based, metal based, etc. From the perspective of material functions, composite materials can be divided into structural composite materials and functional composite materials.

2. Application Advantages of FRP Materials in Bridge Engineering

2.1 It can Achieve Larger Span Construction

Traditional reinforced concrete bridges are constrained by their own weight, and as the span increases, their own weight effect also increases, making it difficult to achieve the construction of large-span structures. As a lightweight and high-strength material, FRP not only significantly increases its span, but also has little influence on the weight of the bridge itself, making it a new type of structure suitable for large-span structures. Therefore, FRP composite materials have become an important means for the development of long span bridges.

2.2 Strong Corrosion Resistance

Corrosion and aging problems are very common in ordinary reinforced concrete road bridges, ranging from affecting their normal performance and traffic capacity to even causing major engineering quality and safety accidents. At the same time, FPR material has good corrosion resistance, and its fibers and matrix are both corrosion-resistant materials, which can ensure that the bridge does not rust for a long

time, ensure the reliable operation of the bridge for a long time and the safety of the bridge, and save a lot of later maintenance costs. It has obvious advantages in bridge engineering construction in China.

2.3 Strong Seismic Resistance

FRP materials have high bearing capacity, which greatly helps the seismic performance of bridges. At the same time, FRP materials have the characteristics of lightweight and high strength. Under the same load conditions, smaller cross-sectional dimensions can effectively reduce the weight of the bridge and seismic inertia force, and improve the seismic performance of the structure. In addition, FRP materials are convenient and easy to install in post earthquake bridge maintenance and reconstruction, which can effectively improve engineering efficiency and have obvious advantages in bridge construction in remote areas.

2.4 Resistance to Overload and Fatigue

Under load, fiber reinforced composite materials have elastic deformation ability and can recover to their original mechanical properties after overloading. At the same time, its fatigue limit is greatly improved, especially suitable for bridge construction under dynamic loads. Traditional bridge structures typically undergo ductile deformation after bearing a certain load, thereby achieving safety margin. The results indicate that under the same load, FRP bridges have better bearing capacity than conventional concrete bridges. Therefore, the overload and fatigue resistance of fiber composite materials can effectively improve the adjustment level of China's transportation system, which is of great significance in practical applications.

3. Application Methods of FRP Materials in Bridge Engineering

3.1 FRP Components

By reasonably designing and combining this composite material with other building materials (such as steel bars, concrete, etc.), a new composite material structure that combines the advantages of multiple materials can be obtained. In FRP composite components, FRP has various properties, including bearing loads, serving as a building template, and protecting steel bars and concrete. In commonly used FRP composite structures, FRP pipe concrete is made by pouring concrete into the FRP pipe, and its sound insulation effect is better than that of ordinary steel pipes. The FRP concrete composite beam combines the advantages of FRP material, as well as the compressive strength and low cost of concrete. Its box beam has been widely concerned in the industry. FRP composite material structure is a new type of structure that can have excellent mechanical performance through reasonable design and combination. The research in this area started relatively late in China, although there is a certain research foundation, there is still a significant gap from large-scale practicality.

3.2 FRP Lightweight Bridge

FRP material has its unique advantages in the construction of long-span bridges, and has also shown good application effects in the construction of small and medium-sized light bridges. Currently, truss bridges and beam slab bridges are mainly used. Due to its lightweight and high-strength characteristics, FRP materials can be designed according to the specific needs of the bridge. At the same time, when there are no large-scale lifting equipment on the construction site, they can also be assembled manually. FRP materials are generally prefabricated with corresponding parts in the factory and then transported to the construction site for assembly, greatly accelerating the progress of the project. In addition, FRP material has good plasticity and flexibility, and can design various novel shapes according to different engineering needs. Combined with its powerful coloring ability, it can create a light landscape bridge with rich colors and unique shapes, which has good application prospects in construction bridges, military roads, and corrosive environments.

4. Development Prospects of FRP Bridges

Fiber reinforced polymer material is a new type of bridge structure and load-bearing component, with good performance and broad development prospects. New types of bridge construction materials have continuously improved their construction techniques. Fiber reinforced

concrete has the characteristics of corrosion resistance, light weight, and high strength. With the continuous improvement of FRP material technology, its cost will also become lower and will receive more support in future development.

FRP materials have high tensile strength and can effectively exert their tensile performance in cable-stayed bridge cables, making them an important method in bridge construction.

Firstly, in the repair and reinforcement of damaged bridges, FRP materials have the advantages of low cost, obvious reinforcement effect, and high yield strength.

Secondly, FRP materials have the advantages of lightweight and high-strength, and will not have a significant impact on the weight of the bridge itself. They are expected to play an important role in achieving breakthroughs in the span of ultra large span bridges in the future.

5. Practical Application of FRP Materials in Bridge Construction

In bridge construction, both new and existing structures represented by carbon fiber composite materials (CFRP) have good adaptability. At the beginning, carbon fiber reinforced plastic was mainly used as a sheet material to strengthen concrete components. However, CFRP can only serve as a reinforcement for existing structures and has little effect on the safety reserve of existing structures. Carbon fiber composite materials are widely used in bridge structures due to their low density and low linear expansion coefficient (only 1/12 of steel). During the construction process, carbon fiber cables and corresponding anchoring techniques are used. In addition, composite materials are also applied to bridge panels and edge components. For example, the Netherlands has a large number of roads, railways, and waterways, so it has numerous bridges. Due to the increasing traffic pressure, the standards for bridge construction, especially the requirements for building materials, have also increased. In the process of building new bridges, traditional cement and steel structures have been greatly challenged in terms of aesthetics and practicality. Because of this, in the past 20 years, the Netherlands has only begun to apply fiber reinforced composite materials on a large scale for bridge construction.

6. Conclusion

In summary, bridge construction is the key to overcoming various obstacles and is related to the development of society, economy, culture, and science and technology. According to the bridge testing environment and usage scenarios, the bridge testing environment in China presents characteristics such as ocean, mountainous areas, and various extreme weather conditions, while road traffic has characteristics such as heavy load, fast speed, and large flow. With the widespread application of various high-strength and high-performance FRP materials in bridge construction, the development of new technologies such as bridge construction reinforcement has been promoted.

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