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Research on the Application of New Polylactic Acid (PLA) Fiber Concrete Materials in Urban and Rural Flood Resistance

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ABSTRACT

This paper aims to study and apply new polylactic acid (PLA) fiber concrete materials to improve urban and rural flood resistance, enhance flood control and drainage capabilities, and promote sponge city construction. Through the analysis of the characteristics, proportion optimization and performance of PLA fiber concrete in actual projects, it is found that the material has good mechanical properties, environmental adaptability, economy and environmental protection, and has important application prospects in urban and rural flood control and drainage. By adjusting the proportion, selecting the appropriate fiber type and addition amount, the flood resistance and drainage capacity of concrete can be improved. Combined with 3D printing technology and modern scientific and technological means, the application and development of PLA fiber concrete will be further promoted to achieve a win-win situation of continuous improvement of urban and rural flood resistance and environmental protection. With the support of relevant technologies and policies, PLA fiber concrete has broad application prospects in sponge city construction and urban and rural flood control and drainage, and will make important contributions to improving the level of urban and rural disaster prevention and mitigation.

KEYWORDS

New polylactic acid (PLA); Fiber concrete; Urban and rural flood control resilience

1. INTRODUCTION

Polylactic acid (PLA) is a thermoplastic polyester that has attracted widespread attention for its environmentally friendly source and excellent performance. In recent years, scholars have conducted a lot of toughening modification research on PLA, and the main methods include compounding, copolymerization, plasticization and blending. These modification methods significantly improve the mechanical properties of PLA, making it more suitable for high-strength and high-toughness application scenarios.

PLA fiber concrete combines the environmental protection characteristics of PLA with the high strength and high toughness of concrete. By adding fibers to PLA, its mechanical properties can be further improved, making its application in flood control and drainage more extensive and effective. In addition, PLA fiber concrete also has good degradability, which helps to reduce environmental pollution.

With global climate change, urban rainstorms are frequent, and urban and rural flood control and drainage capabilities face huge challenges. For example, the heavy rainstorms in Zhengzhou, Henan in 2021 caused serious casualties and property losses, highlighting the urgent need to improve urban and rural flood control resilience. Therefore, the development of new high-performance materials,

such as PLA fiber concrete, is of great significance for enhancing the flood control and drainage capacity of cities.

The Ministry of Housing and Urban-Rural Development actively promotes the construction of sponge cities, aiming to enhance the flood control and drainage capacity of cities. Sponge cities use green infrastructure (such as rain gardens, permeable pavement, etc.) to absorb and infiltrate rainwater by simulating natural terrain and ecosystems, thereby alleviating urban waterlogging problems. As a new material, PLA fiber concrete can play an important role in the construction of sponge cities and improve the overall flood control and drainage capacity.

The application of modern technology in flood control and flood fighting is becoming more and more extensive. "Black technology" such as 5G and drones has been used to improve the intelligence level of flood control and flood fighting. Combined with the high-performance characteristics of PLA fiber concrete, the efficiency and effect of flood control and flood fighting can be further improved. In the future, with the continuous advancement of relevant technologies and the support of policies, the application of PLA fiber concrete in urban and rural waterlogging resilience will be more widely promoted and applied.

The application of new polylactic acid (PLA) fiber concrete materials in urban and rural waterlogging resilience has significant advantages and broad development prospects. By combining modern scientific and technological means, the city's flood control and drainage capacity can be effectively improved, the impact of natural disasters can be reduced, and the safety of people's lives and property can be protected.

2. CHARACTERISTICS OF PLA FIBER CONCRETE

Material properties: Polylactic acid (PLA) is a biodegradable fiber. Its application research in sand control and sand control shows that PLA fiber has good mechanical properties and environmental adaptability. This provides a basis for the application of PLA fiber in concrete. At the same time, fiber-reinforced concrete has been proven to improve the fracture toughness, crack resistance and impermeability of concrete.

Construction process: The construction process of fiber concrete has an important influence on its final performance. For example, the application of polypropylene fiber concrete in engineering waterproofing systems shows that the use of this concrete as a protective layer can effectively solve the problem of insufficient crack resistance and impermeability of ordinary concrete. In addition, the development, research and application of polymer cement-based flexible anti-seepage and anti-cracking coatings also show the application prospects of this type of material in engineering.

Environmental adaptability: The biodegradable properties of PLA fiber give it unique advantages in specific environments. For example, in sand prevention and control, PLA sand barriers can not only effectively improve the surface erosion, but also promote vegetation recovery and increase the water content of deep soil, which has a promoting effect on vegetation recovery. This is particularly important for improving urban and rural waterlogging resilience, because it can not only improve the durability of concrete structures, but also improve the surrounding environment.

Economic and environmental protection: PLA fiber concrete materials have high costs, but low transportation and construction costs, long service life, and low maintenance costs. This makes PLA fiber concrete materials have obvious advantages in terms of economy and environmental protection.

The application of new polylactic acid (PLA) fiber concrete materials in urban and rural waterlogging resilience has significant potential. By optimizing material ratios, construction processes, and making full use of their environmental adaptability and economic and environmental protection, the waterlogging resilience of concrete structures can be effectively improved, while having a positive impact on the environment. However, it should be noted that although PLA fiber concrete materials

have many advantages, their effectiveness in practical applications still needs to be verified through more field tests and long-term observations.

3. OPTIMIZING THE MIX RATIO OF POLYLACTIC ACID (PLA) FIBER CONCRETE TO IMPROVE ITS RESILIENCE AGAINST WATERLOGGING IN URBAN AND RURAL AREAS

Considering the effect of water-binder ratio on concrete performance, it is very important to maintain an appropriate water-binder ratio. In the evidence, the water-binder ratio was maintained at 0.23, which indicates that when designing PLA fiber concrete, an appropriate water-binder ratio should also be selected to ensure good workability and final mechanical properties of the concrete. Regarding the amount of fiber added, the evidence shows that the optimal amount of steel fiber added is 1.5% by volume, while for polypropylene fiber it is 3 kg per cubic meter. This shows that in PLA fiber concrete, by adjusting the type and amount of fiber added, the mechanical properties of concrete, such as compressive strength, flexural strength, toughness, energy absorption capacity, etc., can be significantly improved. Therefore, when optimizing the mix ratio of PLA fiber concrete, the type and amount of fiber added should be taken into account, and how they affect the overall performance of concrete. In addition, considering the specific environmental conditions that PLA fiber concrete may face, such as the different degrees of water level changes and erosion problems that may be encountered in urban and rural areas, it is also crucial to select fiber types with high wear resistance and erosion resistance. Although PLA fiber is not directly mentioned in the evidence, it may be a promising option based on its biodegradability and sustainability characteristics, especially when environmental impact is a concern.

4. MAINTENANCE AND LIFE PERFORMANCE OF POLYLACTIC ACID (PLA) FIBER CONCRETE IN ACTUAL ENGINEERING APPLICATIONS

Mechanical properties: According to studies, hybrid fiber-polymer modified concrete shows reliable workability, high stiffness, and an elastic modulus of up to 35.23 GPa. In addition, the material's compressive strength is 52.82 MPa, which is 31.2% higher than ordinary C40 concrete; its flexural strength is 11.51 MPa, which is 191.4% higher than ordinary concrete. This shows that the mechanical properties of concrete can be significantly improved by adding fibers and polymers.

Durability: Studies have pointed out that the appropriate addition of steel or non-metallic fibers can increase the tensile capacity and ductility of FRC, thus improving its durability. This is because fiber bridging and crack control mainly contribute to the durability improvement of FRC. In addition, Zhejiang and Zhejiang also demonstrated the advantages of PVA fiber, carbon fiber, and aramid fiber-reinforced concrete in terms of carbonation resistance, which further proved the effectiveness of fiber reinforcement technology in improving the durability of concrete.

Environmental erosion resistance: It is mentioned in that untreated sisal fiber is not a favorable factor in improving the durability of fiber concrete structures in any form. This shows that fiber selection is critical to improving the resistance of concrete to environmental erosion. Therefore, for PLA fiber concrete, its resistance to environmental erosion will depend on the characteristics of the PLA fiber and its interaction with the concrete matrix.

Maintenance requirements: Although the maintenance requirements of PLA fiber concrete are not directly mentioned in the literature, according to the report, the durability of the repair material can be significantly improved by adding SB latex polymer and wollastonite mineral fibers. This implies that through appropriate material selection and proportioning, the maintenance needs of concrete structures can be effectively reduced, thereby extending their service life.

Although there is no direct research evidence on polylactic acid (PLA) fiber concrete, by comparing the research results of other types of fiber-reinforced concrete, it can be inferred that polylactic acid (PLA) fiber concrete has good mechanical properties and durability in practical engineering applications.

5. SUMMARY

As a synthetic polymer material, PLA fiber has excellent biodegradability, which gives it significant advantages in environmental protection and sustainable development. This characteristic is in line with the high requirements for environmental protection of materials in sponge city construction. The theory and application technology of fiber concrete have gradually matured, especially as the engineering community has increasingly higher requirements for the mechanical properties and durability of concrete, fiber concrete will definitely become a future development trend. PLA fiber concrete has significantly improved many properties such as tensile strength, bending resistance, crack resistance, high temperature resistance and durability. These advantages have made it widely recognized and used in the construction industry.

The application of 3D printing technology in PLA fiber concrete will further promote its development. By adding carbon-based additives, metal additives, plant fibers and other composite modifications to PLA, its mechanical properties and application range can be significantly improved. In addition, advances in 3D printing technology also provide new possibilities for the manufacturing of PLA fiber concrete. As the advantages of PLA fiber concrete in terms of mechanical properties and durability are gradually recognized, its application in sponge city construction will become more widespread. Especially in terms of flood control, drainage, anti-seepage, etc., PLA fiber concrete will play an important role.

The application status of PLA fiber concrete in sponge city construction is good, and the future development trend is also very optimistic. my country has made significant progress in the research and application of synthetic fiber concrete. The enhancing effects of various types of synthetic fibers on mechanical properties such as strength and toughness of concrete, as well as their effects on other physical properties such as impermeability and durability, have been fully discussed and verified.

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