Analysis of Scientific Problems and Technical Approaches to Sustainable Civil Engineering Structures

Feng Yong

Changchun University of Architecture and Civil Engineering, Changchun, Jilin, 130607, China

Keywords: Scientific problems and technical approaches, Sustainable civil, Engineering structures

Abstract: Civil engineering is the basis of people's survival, but it consumes a lot of resources in the development of modernization, which affects the development of civil engineering. To improve the quality of civil engineering construction and promote its sustainable development, it is necessary to analyze the special points of its development in time, optimize the development procedure of civil engineering, rationally analyze and understand the materials used in the development of civil engineering. Combined with the present situation of the development of civil engineering, this paper analyzes the evaluation indexes from the aspects of material structure, function, and sustainable development characteristics, hoping to promote the sustainable development of civil engineering.

1. Introduction

With the continuous increase in China's population and resource consumption, the national building data show that China's building energy consumption has reached about 28% of the total national energy consumption [1]. To achieve sustainable development, it is necessary to analyze the current situation of civil engineering buildings in time, discuss the scientific problems of civil engineering structures and put forward measures to promote the sustainable development of civil engineering [2]. Improve the technical level of civil engineering.

The sustainability of civil engineering involves many resources and has a great impact on the environment. Only by making scientific and rational use of relevant indicators to evaluate it, can we truly reflect the development and changes of civil engineering, generally using the following formula to judge [3,4].

$$J_{st} = \frac{\Sigma R_i}{T_1} \tag{1}$$

Formula (1) indicates the energy increased or generated in the process of construction, service, and scrapping, and the use of positive and negative represents the increase and consumption of energy respectively; it represents the total service time; it represents the resources consumed per unit time. However, from the perspective of the actual development of civil engineering, because the resources consumed in different stages have different impacts on human society, only after comprehensive and comprehensive planning can we evaluate the sustainability of civil engineering. Also, the above formula does not take into account the social benefits of functional changes in civil engineering service [5]. Also, the impact of different materials in the whole life of civil engineering on the environment is different, so it must be dealt with, at the same time, a variety of quantitative should be comprehensively considered to ensure the consistency of civil engineering evaluation.

2. Civil Engineering Materials

2.1 Civil Engineering Structural Materials

Civil engineering material is an important factor to promote the development of civil engineering. At present, with the development of modern science, many structural materials such as steel, concrete, wood and bamboo, fiber, and so on have been born. The steel structure is a recyclable

  DOI: 10.25236/ic3ec.2020.011

material with strong stiffness, ductility, and elasticity, and has become an excellent material for the development of civil engineering [6]. Concrete materials have high compressive strength, can be heated at high temperatures, and have little impact on the environment. How to prepare low energy consumption and green materials has become the main problem of current research. At present, two methods are mainly used to improve the quality of concrete, one is to replace part of the materials with industrial mineral admixtures, which not only reduces the non-renewable mineral admixtures, but also improves the performance of concrete; the other is the use of construction waste to reduce resource consumption, reduce the impact on the environment, and promote the sustainable development of civil engineering [7]. The preparation technology of green water with low energy consumption mainly uses the way of improving the performance of concrete to improve the ductility, crack resistance and mechanism of concrete as shown in Figure 1. at present, the preparation of renewable concrete, the utilization of construction waste and the whole life performance are the main scientific questions in the research of civil engineering materials. Fiber material has the characteristics of high strength and durability, especially in a special environment, it can avoid steel corrosion and prolong the life of civil engineering results [8]. However, the price of fiber review materials is expensive and the high-temperature resistance is poor, so it is necessary to make a comprehensive analysis of these materials in the future [9,10]. At present, the preparation of renewable green fibers from plant fibers and plant extraction materials has become one of the main research directions of fiber composites, and it will be studied continuously in the future.

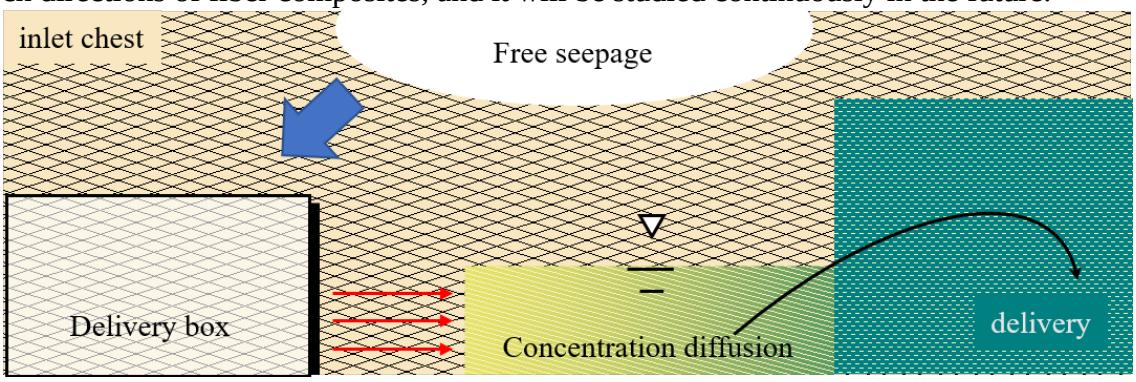

Fig.1 The Performance of Concrete to Improve the Ductility

2.2 Civil Functional Materials

How to improve the mechanical properties of original materials by mixing materials has become an important direction of the sustainable development of civil engineering. At the present stage, the concept of “intelligent material and structure system” has been put forward, which has various properties such as self-repair, self-adaptation, and so on. The main characteristic of this kind of material is that it has strong recognition of light, sound, force, electricity, and so on as shown in Table 1, and can make use of external resources to improve the function of the material. Adding conductive nano or carbon fiber into cement slurry can not only improve its mechanical properties but also have myocardial infarction such as piezoelectric and piezoresistive, which can warn the damage of concrete structure, improve engineering safety and reduce the cost. Adding piezoelectric material to concrete can form self-integrated concrete material, which can realize the transformation from mechanical energy to electric energy and maintain the junction self-power supply. The coupling and transformation of intelligent civil engineering with sound, light, and heat have become the core issue of structural science.

Table 1 the Main Characteristic of These Kinds of Materials

No.	Functional Materials	Main Characteristics
1	Transparent Ceramic	Light
2	Composite Ceramic	Sound
3	Nanophase Ceramic	Force
4	Piezoceramics	Piezoelectric
5	Conductive Ceramics	Electricity

The combination of nano-materials and nano-technology can change the characteristics of materials, realize the combination of concrete materials and nano-materials, and have the properties of anti-impact, anti-electromagnetic shielding, and so on. Nano-concrete materials with more functions can be prepared by mixing nano-materials and non-conductive nanoparticles into the concrete. At present, nanomaterials and nanotechnology have become important technologies applied in the development of civil engineering and become the research direction of scientific problems.

3. Understand the Structural System of Civil Engineering

3.1 Structural System with High Performance and Long Life

From the practical use of civil engineering, it is very easy to be affected by natural factors such as earthquake, rain, snow, ice and so on, and it is easy to cause structural damage, and when it is serious, it will lose structural energy, resulting in more construction waste problems and affecting the development of civil engineering, so it is necessary to build a high-performance and long-life structural system. In general, high-performance long-life structures must have strong mechanical properties, durability, and disaster resistance, and prolong the service life of the structure. For example, nano-concrete has high anti-fatigue and wear resistance, so it can be used as the laying of roads such as airport wharf to reduce structural damage and prolong life. At the same time, the system can also be realized with the help of the new structural system, such as automatically restoring the seismic structural system, reducing the impact of natural disasters, and promoting the development of the structural system. A new type of structural system with high performance and long life has become the main research direction of structural analysis and the basic problem of the suitable long-life structural system.

3.2 Theory of Structural Monitoring and Evaluation in Civil Engineering

Civil engineering is easily affected by various factors in practical application, so it is necessary to strengthen monitoring. Inspired by biology, traditional civil engineering is mainly based on mechanical variables, which realizes the cross-development of multi-disciplines and has many internal applications, which has become an important direction of civil engineering research. Civil engineering structure monitoring mainly includes environmental action, overall structural response, physical and chemical variables, and so on. In the actual monitoring, a large number of data and structural characteristics need to be obtained, so the traditional methods can not complete the data structure monitoring at all, and structural monitoring has become the main problem discussed by people. Combined with the development of civil engineering at the present stage, new sensing technology, sensing principle, structural health monitoring data graphics, signal processing, field prototype monitoring, and laboratory models have become the main issues in the sustainable monitoring of civil engineering.

3.3 Discussion on Theory and Technology of Whole Life Control of Civil Engineering Structure

The effective method for the sustainability of the civil engineering structure is to analyze the design goal and construction performance of civil engineering in time. When the load is large, fatigue damage, structural damage or collapse will occur due to vibration, so structural control must be used to reduce the dynamic effect of the structure, improve the safety of the structure and prolong its service life. Usually, fluid vibration can be used to control vibration to change structural vibration. For example, the flow field control of bridges based on biological drag reduction and intelligent materials has become an important topic in fluid research. The cumulative damage can not be avoided in the long-term use of civil engineering. To prolong the service life of civil engineering, the damaged parts must be repaired in time. At present, civil engineering mainly studies repair materials, repair technology, and repair performance in a harsh environment, and self-repair has become the main trend of civil engineering development in the future. For example,

the image memory polymer is applied to the explosion impact of the structure, and the compound concrete structure is used to repair the crack damage of the composite structure.

The multi-functional civil engineering structure system has broken through the traditional engineering structure, has become the most active field of civil engineering research, and has become an important way for the sustainable development of civil engineering. The combination of wind energy, solar energy, and civil engineering has become the main form of civil engineering structure. For example, the installation of a wind power generation system on the Shanghai oil production platform meets the power demand of the offshore platform and will not consume other energy; the building structure is designed as a convenient Taiyang structure, so that the building has two functions at the same time. To realize the structure of intelligent materials and structural materials, we can not only use the electric structure to realize the conversion from mechanical energy to electric energy but also provide electric energy to the structure and save the source of capital. For example, adding piezoelectric materials to concrete can make concrete have a self-sensing function and realize the transformation from structural vibration energy to electric energy as shown in Figure 2. Nanomaterials are also used in some civil engineering facilities, which can apply high electrical conductivity, piezoelectric materials, and thermal conductive nanomaterials to pavement structures. when vehicles pass through the road, vibrating mechanical energy can be converted into electrical energy, which can be provided to nanomaterials. Nanomaterials melt the pathology on the ground and reduce environmental pollution.

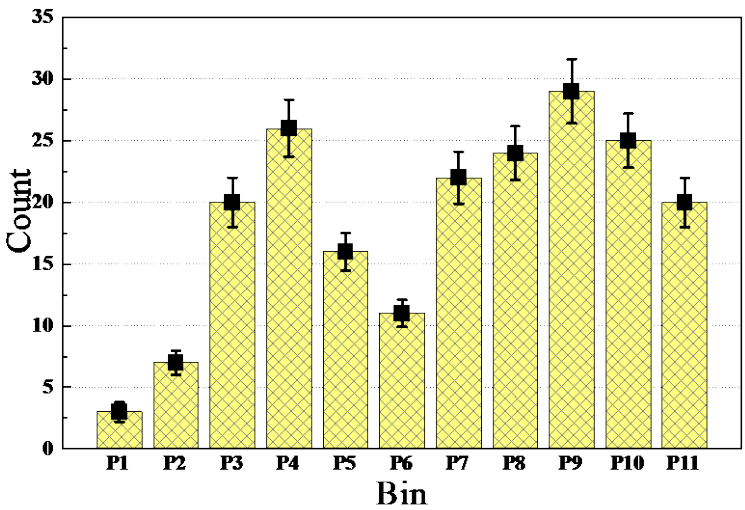

Fig.2 The Transformation from Structural Vibration Energy to Electric Energy

At present, the theory of civil engineering design has gone through a long stage of development, which shows the transformation from elastic design to elastic theory, from single-objective control to multivariable, which promotes the development of civil structure life design theory. The theory of structural whole-life design comprehensively analyzes the concept of structural economy and life, which is a method of sustainable development. Although many foreign scholars have conducted in-depth research on the whole-life design theory, but affected by various factors, there are still some scientific problems, such as structural reliability, structural scrapping post-treatment, and so on. With the development of the social economy, people have realized the influence of civil engineering structure in the development, which promotes the development of civil engineering structure life-cycle risk analysis and control theory. Through analysis, it is found that the main goal of civil engineering structure life-design theory, control design theory, and risk analysis theory is to realize the sustainable development of civil engineering and form a complete design theory of sustainable development of civil engineering structure. to improve the reliable theoretical basis for the practical operation of civil engineering.

4. Conclusion

With the development of science and technology, people's use of resources is also increasing. To realize the sustainable development of civil engineering, it is necessary to make a comprehensive evaluation of civil engineering structural materials, functional materials, nano, and stagnant water, long-life structural system, etc., promote the realization of structural sustainability theory, analyze multidisciplinary problems, and lay a foundation for the future development of civil engineering.

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