The Application Research of Microbes in the Concrete

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Abstract: The application researches of microorganisms in the concrete are reviewed in three aspects. They include the microorganisms as additives are added to the concrete to improve its performance and it introduces the mechanism, application field, construction conditions and methods of microorganisms in the CBS (vegetation concrete greening additives) and in the BSC (Bio - substrate antonym); the research status of foaming agent of microorganisms and the advantages of it applied to lightweight foam concrete; the mechanism, field test and the repair effect of Microbial self-healing technology of concrete and common problems applied to practical engineering.

Keywords: Microbial; Concrete; Application Research

1. Introduction

In the 21st century, with the development of human science and technology, microorganisms have been used in many fields, such as environmental protection, medicine and human's daily life. While concerning the application of microorganisms to the concrete, the majority of experts and scholars are always paying more attention to the corrosion effect of microbial to the concrete. In the process of concrete mixture ratio designing, ecological concrete and the self-healing of concrete cracks, microorganisms still have a positive effect. The application of microorganisms in the concrete is the combination of inorganic and organic of nature, and it helps to regulate the ecological balance; to beautify the environment and to achieve the coordinated development of human and nature. The application of microbes in the concrete is not just to improve the functional role of concrete, but also to fuse with nature, moreover, it is also good to the keep environmental balance. At present, the main applications of microorganisms in the concrete are as additives; for example, BSC(Bio - substrate antonym) and microbial self-healing function of concrete cracks.

2. Biological Additives

Biological additive refers to mix a certain amount of microorganisms in the mixing process of concrete to improve concrete performance, and to meet the needs of practical engineering.

2.1. Biological Coagulant

Da Cheng Construction Company in Japan has explored a kind of biological coagulant called "biological solidifier 21" with Wu Tian Pharmaceutical Company, which has already been used in the main construction of Wood Park Bridge in the Tokyo Do Jiang area.

"Biological solidifier 21"[1] is a kind of polysaccharide "bio-polymeric" mixture produced by microbial fermentation. Traditional concretes need to use vibration mechanical to realize vibrating filling operations in construction process. But adding the concreting creature can make concrete produce separation effect and also maintain a certain fluidity, so it is no need to use mechanical vibration. This way not only reduces the concrete construction process and the disease caused by lacking of vibrating concrete but also indirectly reduces the construction cost. This concrete which added microbial solidifier improves the construction mechanization and automation; reduces the engineering cost, etc.

2.2. CBS Green Vegetation Concrete Additives

CBS (green vegetation concrete additive) is used in the protection of vegetation slope by being added into the concrete as a soil base material of active material. It is applied to the ecological slope protection project and after green project of high steep rocky slope such as mining quarry, etc. [2]

2.3. BSC (Bio - substrate Antonym)

BSC (Bio - substrate antonym) use biological matrix strength of concrete with high, the large size of the binder aggregate fixed molding, using continuous pore between aggregate storage can make plant growth substrate, by planting or other means to make various plants in the solid matrix layer growth in aggregate concrete, increase the plant coverage, to facilitate the development of ecological city.

BSC (Bio - substrate antonym) technology gradually formed a unique process and construction scheme by

furthering consideration of plant growth environment, biological survival conditions, the ecological environment coordinate; of reducing the environmental load; of beautifying the environment and other factors on the basis of keeping the normal concrete strength, porosity, and the durability.

The preparation method of BSC (Bio - substrate antonym)

The BSC (Bio - substrate antonym) technology developed by Hefei branch shun trade co., LTD. mainly through two kinds of measures to strengthen the environmental friendliness of body of water conservancy projects: one is to add BSC - J biologically active additives to the stromal layer which an effective microbial colony is the main component; the other one is the mature construction process and technology which regard adding BSC - WY series additives to the aggregate stromal layer as the main adjustment method.

The effect of BSC (Bio - substrate antonym)

Hefei branch trade co., LTD uses the BSC - J active additive which effective microorganisms are the main components in BSC (Bio - substrate antonym), to keep the activity of soil microenvironment between aggregate in the greatest degree; to adjust the pH change caused by the use of cement; and to promote plant roots' growth and nutrient absorption. BSC -j active additive is rich in effective microbial colonies which can decompose leaves, twigs, small animal bodies and other organisms, and can accelerate the decomposition of various pollutants in soil so that it indirect avoid water pollution and environmental pollution caused by chemical fertilizers, pesticides and other things. This can not only facilitate water security protection but protect the ecological environment.

3. Microbial Foaming Agent

Foaming agent is one can produce a large amount of foam material when its aqueous solution is introduced into the air under the condition of the mechanical force, this kind of material is surfactant or surface active substances. The former is, such as anionic surfactant, cationic surfactant, non-ionic surfactant, etc. The latter is, such as animal protein, plant protein, pulp waste liquid. Foaming agent is used for manufacturing foam concrete. Foam concrete refers to be able to reduce the liquid surface tension; produce a large number of homogeneous and stable foam. It is the admixtures for producing foam concrete.

Microbial foaming agent belongs to the protein foaming agent. Compared with chemical foam concrete agent, the microbial foaming agent has the advantage of zero pollution to the environment.

3.1. Research Status of Microbial Foaming Agent

Wen Xiyuan and his colleagues find a method of preparating foaming agent of foam concrete through utilizing a kind of red mud to extract the sludge microbial protein. This method is to make this kind of industrial waste residue and sludge by red mud mix in a certain proportion, then to make it hydrolysis in artificial environment, and finally to filter to obtain microbial protein solution mixture. Then to put this mixture as raw material, through enrichment regulation in escrow protein content, preservative and stabilizer, preparation of foam concrete foaming agent [3].

QiuXiuWei and his colleagues made a modification to the sludge microbial protein foaming agent. Organic matter content in the sludge has the characteristics of high protein, low fat, so people can extract the protein and then to produce foaming agent. In order to improve the foam properties of the foaming agent, they did a series of experiments. They selected the organic macromolecules, small organic molecules and inorganic additives these three categories included a total of 12 kinds additives and observe their effect on protein solution to improving the performance of the bubble. By comparing with the foaming and foam stability of the protein liquid after adding additives, they summed up that zinc sulfate, Arabic gum and sugar cane these three kinds of additives have more significant on the activity of protein molecules, on the improvement of the liquid film strength, and on the increase of the liquid viscosity [4].

3.2. The Advantages of Microbial Foaming Agent

When handling the rivers' and lakes' desilting, it will produce large amounts of sludge and biological species. When cities' and enterprises' sewage treatment plants handling the sewage, it also can produce a large amount of sludge. Due to the sludge contains a lot of protein and pathogenic microorganism, toxic chemicals, etc., so it has a certain danger of biological pollution and chemical pollution. The one piled up in a city often intrusive stench, seriously affecting the urban environment. How to solve and use the wastewater to handle the sludge are generally the major social problems facing by the urban development, for it is not conducive to the construction of ecological city. Microbial foaming agent is a kind of foaming agent which sludge is raw material and extracted and preparated to protein foam concrete. The cost is low, once it achieve the actual implementation application, it can not only break the restriction of raw material of microbial protein concrete foaming agent but also provides a good solution for the sludge. It can make both economic benefits and environmental benefits, and it benefits to realize the harmony between people and the environment. Putting the foams generated by microbial foaming agent added into the water containing siliceous material, calcium material, and all kinds of admixtures, etc. and stir. In normal temperature condensation, porous gelled mix-

ture format to embryo body, or under the steam pressure, steam raising hydration reaction of silica, calcium material, forming gel material. Gradually become has certain strength and other physical properties of foam concrete [5].

4. Microbial Concrete Self-healing Technology

Microbes in nature generate some relatively insoluble inorganic and organic compounds inside or outside of the microbial cells. The most common compound is the calcium carbonate which carbonate based. These substances can effectively fill or bond in a porous medium with searches sex or cracks on the surface of the concrete.

4.1. The Mechanism of Microbial Concrete Self-healing

Microbial concrete self-healing technology is to use microbial metabolism to secrete the relevant materials which generate calcium carbonate through react with ion from the environment, and then they through the so-called method "mineral deposits" to repair cracks and restoring the performance of the concrete structure. Materials such as calcium oxide, silicon, metal ions Due to the low concentration, the materials such as calcium oxide, silicon, metal ions are generally not deposited, only when some microbes interact with these ions can they produce precipitation, cementing [6].

Anaerobic microorganisms

Anaerobic microorganisms generate urease through metabolism in damp environment. Urease hydrolyse Urea to generate ammonia and carbon dioxide, and then the carbon dioxide reacts with calcium ions in the surrounding solution to generate calcium carbonate and make precipitation. The effect of microorganisms is not only generate urease but also provides sites for the calcium carbonate sedimentary nucleation. The complex chemical reaction occurred in the process of mineral deposit caused by microorganisms as follow :

Ca2 + + cells and Ca2 +

Cells Ca2 + + CO32 - - - CaCO3 left

Aerobic Microorganisms

Aerobic microorganisms cause precipitation of calcium carbonate crystals through the respiration of metabolism. Cement base materials containing dormant aerobic microorganisms. When the cement base materials occurs cracking and there follows oxygen and water infiltration, generally the cracks are in the surface of the concrete structure. Due to the contact surface of the oxygen and water from the environment is large, the dormant microbes will be waked up and restore the function of its metabolism [7]. Jonkers prepared for a large amount of test by incorporating aerobic basophilic bud coli and confirmed that most of the sediment is calcite crystals [8].

Microbes of Urine Solution ?

Microorganisms not only can generate urease through metabolism but also can induce calcium carbonate's precipitation through no urine solution. Xu Jing and others using the mineralization of no urine solution of aerobic basophilic bud coli achieved the calcium carbonate's precipitation induced by microorganisms in the medium contained two different mineralization of organic calcium source. The results show that the lower the initial concentration of calcium ions, the higher the conversion percent of organic calcium source. And the change calcium source types has a great influence on the dynamics of calcium carbonate sedimentary and the types, morphologies of calcium carbonate crystal. In the mineralization medium of calcium lactate and calcium glutamate, they posited poor crystallization calcite and poor stability vaterite in respectively and the latter posited yield is higher, and even early 100%. It is confirmed that the way of basophilic bacteria inducing calcium carbonate's precipitation has potential applied to the protection and repair of concrete [9].

4.2. Microbial Self-healing Effect of Concrete Crack

Chunxiang Qian and others using the crack width gauge, scanning electron microscopy (sem) and thermogravimetric analysis technology carried on studied of microbial self-healing effect of concrete crack respectively. The research shows that the self-healing effect is related to crack's geometry size, depth, and the time of microbial self-healing: After the 40 days of microbial self-healing, the concrete cracks can be filled in by calcium carbonate generated by the microbial mineralization with a remarkable self-healing effect. The largest filling width of test is more than 1mm. The calcium carbonate generated by microbial mineralization are mainly on the surface of crack's opening, and gradually reduce its content with the increase of crack's depth. When concrete crack's depth is more than 1 cm, the calcium carbonate generated by microorganisms are not found. When it is more than 1.5 mm, due to the microbial mineralization need oxygen and moisture to deposit, therefore, as the distance from the crack fracture surface more far and the closer the cement matrix, the content of calcium carbonate generated by microbial mineralization more less [10].

4.3. The Common Problems of the Application of Microbial Self-healing

(1) Microorganisms generate ammonia during the process of self-healing and the ammonia generate ammonia when they soluble in water. The production of ammonia can increase the alkaline of environment surrounding the microorganisms. Whether the alkaline environment can produce adverse effect to the microbial self-healing, it is still need to do further study.

(2) The microbial self-healing aging: due to the microbial crack self-healing speed is too slow, and its self-healing

surrounding environmental condition is also should to be considered, the self-healing is not a day or two day thing. So the microbial crack self-healing is not suitable for urgent self-healing induced by emergency.

(3) Microbial crack self-healing technology is not suitable for the part of the water, because the bioremediation is depend mainly on the deposition of calcite crystals to fill cracks, but the calcite cementation effect is quite weak and the compressive strength in the specimens of the microbial remediation has larger growth, nevertheless the tensile strength has no ascension. Microbial crack self-healing technology is also not applicable to repair the crack with a large width, because it is associated with the aging of microbial self-healing. If crack's width is too large, the outside factors, such as the rain wash, the intrusion of acid, the influence may far exceed to the microbial self-healing effect. Microbial self-healing effect should not only consider the crack's own factors, but also take the surrounding environmental factors into account.

4.4. The Field Test of Microbial Crack Self-healing

Jia Qiang and others using the microbial enzymatic action to induced calcium carbonate's precipitation so that repair concrete cracks and it is applied to the plugging in the basement project. Through microbial grouting leak test to the horizontal, vertical cracks can demonstrate that microbial crack self-healing plugging effect is good.

The products calcium carbonate deposited by microorganisms is in accordance with the original concrete component and they are all not easy to crack after self-healing; Grouting material, for it is liquid, easily penetrate inside to seam and deposited in seam, is an ideal material to fill the concrete structure crack [11].

5. Conclusions

(1) Microorganisms as additives added to the concrete, which can improve the performance of concrete in the construction of mixing and curing, especially as the active additives of CBS (vegetation concrete)and BSC (Bio - substrate antonym) can decompose all kinds of organic matters, and also can accelerate effective decomposition of soil pollutants. It is beneficial to the plant growth and it promoted the effective combination and coordinated development of the concrete structure and the natural environment.

(2) The use of microbial foaming agent can avoid the human greater use of chemical foaming agent, and also can reduce the damage to the natural environment and human beings from using chemical foaming agent. The produced lightweight foaming concrete is a kind of building materials according with ecological energy saving and resource utilization and it has good performance and a wide application prospect.

(3) Microbial self-healing technology is a hotspot of research now. Because the mineral deposit is caused by the microbial metabolism and it has the characteristics of the pure natural pollution-free. Using microbial self-healing technology and artificial polymer to repair the crack are good to the environmental protection; has no damage to the environment and human itself, and can fix in sustainable for a long time. So, under the background which advocating the harmonious development of man and nature, it has a very wide research and application prospect.

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