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An Elaborate Study on Living Concrete

Concrete Can Alive !

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Abstract : Over the centuries, concrete production has basically remained unchanged: from the roman concrete to modern concrete production techniques, it includes a method of combining tough materials including sand with numerous binders, consisting of water and cement. Traditional concrete is a simple building materials. cheap, long lasting, secure and with a pretty predictable behaviour, its wear facilitates inspections. this is why It is not painted. despite the benefits of its physical behaviour, water can crack concrete and cause flaws at a structural level. However if we injected micro organism into it to restore the concrete because it cracks?The fundamental idea of living concrete is to alleviate the structural deficiencies of traditional concrete, by including a live, self-recovery component. In the aid of blending photosynthetic bacteria in with the sand, an interdisciplinary team at the university of Colorado, Boulder, has evolved living concrete which is capable of reproduction. well suited with concrete, their fundamental feature is that they dissolve in water.consequently, whilst the concrete cracks, the tablets open up, liberating their bacterial load.

***IndexTerms* - Living Concrete, Cyano Bacteria, Self-healing, Microbes**

I. INTRODUCTION

Concrete is a composite material consists of fine and coarse aggregate bonded together with a cement paste. Concrete is the most widely used building material now-a-day among all materials. Its usage worldwide, ton for ton, is twice that of steel, wood, plastics, and aluminum combined. It is estimated that the cement industry will generate revenue of $600 billion by 2025. This widespread usage of it, results in a number of environmental impacts. Mostly, the production process of cement produces large volumes of greenhouse gas emissions, leading to net 8% of global emissions. Other environmental concerns include widespread illegal sand mining, impacts on the surrounding environment such as increased surface runoff or urban heat effect, and potential public health conjugation from toxic ingredients. Significant research and development is being done to try to reduce these kinds of deleterious emissions and increase recycled and secondary raw materials content into the mix to achieve a circular economy.

However, concrete is expected to be a key material for structures resilient to climate disasters, as well as a solution to mitigate the pollution of other industries, capturing wastes such as fly ash or bauxite tailings and residue. In spite the advantages; there is some drawbacks of concrete like low tensile strength due to which micro-cracks are produced when the structure is subjected to loading. Then the condition will be exposed to the environment for which life of the structure become deteriorative. In the other hand, the maintenance & repair jobs of concrete structures are not cost effective. The method of using biology development to repair small cracks and pores was first suggested in year 1995 to get a new solution for the problem. Some researchers suggest using some microbes in cement or concrete that concrete has the capability of self-healing by investing the metabolic activity of microorganisms to provide bio-mineralization. It is biochemical process which includes a chain of biochemical reactions by microorganisms where calcium carbonate ($CaCO_3$) precipitation is one of the remedial products. After incorporating bacteria, the process of bio-mineralization occurs inside or outside of the microbial cell and result in a formation of bio-minerals (such as $CaCO_3$) which can block the cracks up-to certain extent and reduce the permeability of concrete. Also the bacteria consume the oxygen from air in the process which can help to prevent the corrosion of rebar in the concrete. This new type of concrete is known as Living Concrete or Bacterial concrete. Hence the objective of this lesson is to discuss about the effectiveness, future aspect of this living concrete with respect to some of its properties.

II. MAKING OF LIVING CONCRETE

The microbes haul carbon dioxide (CO_2) from the air and use it to grow by photosynthesis. Mineral product produced which helps to toughen the new concrete. The green-colored bacteria may be used to make environmentally “greener” concrete. Microbiologically induced calcite precipitation (MICP) is the process behind it.

A material scientist of University of Colorado viz. Wil Srubar & his team used the microbes together with sand and gelatin. Then they added nutrients, such as calcium & they choose ‘cyano bacteria’ as microbes. The bacteria photosynthesize which increase the pH of the mixture. A crystalline form of Calcium carbonate obtained which is an important ingredient in cement. This makes concrete tougher once it is shaped into bricks and cooled. Cooling the mixture also hardens the gelatin, similar to the process of making desserts in the kitchen.

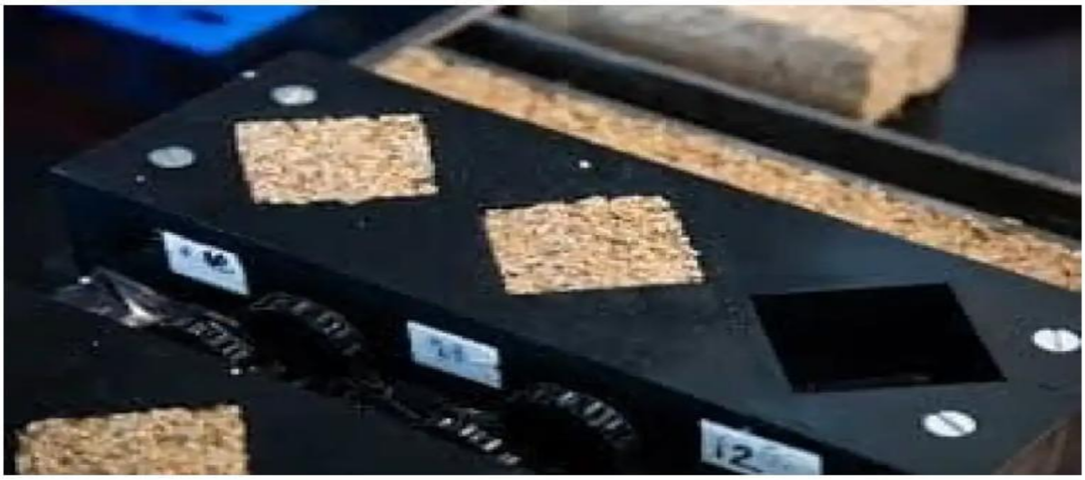

Fig 1: Cyanobacteria growing in the sand-hydrogel framework

III. SELF HEALING PROPERTIES

Self-healing of concrete is the process through which the small cracks or micro cracks are healed by the Calcium Carbonate precipitation on the concrete. The primary system can be based on physical, chemical or mechanical processes. However, it was reported that calcium carbonate precipitation has the most significant factor which can influence the self-healing of concrete. If the cracks are widened as well as the life and spread of bacterial effect decreases after a certain period, then self-healing capacity of concrete may also decrease. Enhancement of self-healing capacity of concrete may be done by using super plasticizer in bacterial concrete.

Several bacteria have capacity to precipitate calcium carbonate like Cyanococcus bacteria as said above which is a cyano bacteria is recognized as being responsible for massive carbonate precipitations through photosynthesis. Photosynthesis leads to calcite precipitation by conducting an HCO_3^-/OH^- exchange process across the cell membrane, resulting in an increase of pH around cells. Na^+ and HCO_3^- are transported into cells by symporter; CO_2 enters into the cell wall by diffusion. CO_2 is synthesized to form organic matter through photosynthesis, and bicarbonate is converted into CO_2 and OH^-. The OH^- is then released into the solution, increasing the pH. The Carbon Concentration Mechanism resulted in a high HCO_3^- acceptance and an increase of the pH of the microenvironment around the cells, favoring the calcification process. The Ca^{2+} -ions later react with the HCO_3^- ions and reaction leads to the $CaCO_3$ precipitation at the cell surface. The primary chemical reactions involved:.

$NaHCO_3 \leftrightarrow Na^+ + HCO_3^-$

$2HCO_3^- + Ca^{2+} \rightarrow CH_2O + CaCO_3 + O_2$

Another process of calcium carbonate production for precipitation on the surface of concrete is there. Calcium Carbonate will be formed due to the reaction of CO_2 hauled by bacteria from environment with Calcium Hydroxide present in the concrete according to the following reaction:

$CO_2 + Ca(OH)_2 \rightarrow CaCO_3 + H_2O$

As $Ca(OH)_2$ is a soluble mineral, it gets dissolved in water and leach out from cracks. The self-healing process in bacteria incorporated concrete is much more efficient due to the active metabolic conversion of Calcium nutrients by the bacteria present in concrete:

$Ca(C_3H_5O_2)_2 + 7O_2 \rightarrow CaCO_3 + 5CO_2 + 5H_2O$

This process results in efficient bacteria-based crack sealing mechanism.

IV. APPLICATION OF LIVING CONCRETE

Application of Living Concrete: The use of Living concrete in construction industry has become increasingly popular. Some of the points are discussed as under;

1. Due to self-healing characteristics, it could seal the certain cracks generated into concrete.
2. Enhancement in durability of cementitious materials to improvement in sand properties.
3. Repair of limestone monuments.
4. Used in construction of low cost durable housing
5. Used in construction of low cost durable roads.

6. In multi-storey residential buildings, bricks are just another way of working the enclosure to provide structural stability. Even so, deterioration due to humidity is closely related to the energy efficiency of the buildings and there is a need to repair walls. Ecological materials are the basis of sustainable urban development. The use of living matter in construction of bioclimatic architecture has been using lower environmental impact materials, as well as solutions that increase the capillarity of soils and prevent problems such as flooding.
7. By growing new block materials from older blocks they'd melted, the living concrete might be recycled.
7. Living materials may also give off a scent. Hence this might be used for spreading perfume into the air by releasing small molecules that smell like a whiff of strawberries or kind of berries & also for hauling carbon from environment.

V. ADVANTAGES OF LIVING CONCRETE

1. It is a revolutionary concept because this concrete doesn't emit carbon dioxide, but absorbs it and releases oxygen. In this way, the blame for atmosphere depletion by the construction industry can be shifted.

2. The concrete can be used to construct in places where very few resources are available such as places like deserts or other planets like Mars.

3. The living concrete continues to grow if it is not dehydrated entirely. All we need to do is add some sand and nutrients, and more concrete can be produced from the existing concrete.

4. In multi-storey residential buildings, bricks are just another way of working the enclosure to provide structural stability. Even so, deterioration due to humidity is closely related to the energy efficiency of the buildings and the need to repair walls. Ecological materials are the basis of sustainable urban development. In recent years, we have seen how bioclimatic architecture has been using lower environmental impact materials, as well as solutions that increase the capillarity of soils and prevent problems such as flooding. The cities of the future will probably include biological technology.

VI. DISADVANTAGES

1. To attain the maximum strength, the concrete needs to be dried thoroughly. Due to this, the viability of bacteria will have to be compromised.

2. Humid conditions are not available in all parts of the world, so the scope of this concrete is not in the entire world. The living material has been linked with concrete, but actually, its properties match with mortar, which is not as strong as concrete.

VII. CONCLUSION

Concrete is the second one most-fed on material on the planet after water. The manufacturing of cement, the powder to make concrete, by alone is responsible for 6 percent of CO2 emissions, and concrete additionally releases CO2 whilst it treatments. The technique advanced via Srubar and his team member came up with a green alternative to modern building materials. however, there may be a change-off with this green material. The Concrete needs to be completely dried out to obtain the most structural ability (i.e., strength), but at the equal time, drying stresses the micro organism and compromises its viability. To hold structural characteristic and ensure microbial survivability, the concept of most appropriate relative humidity and garage situations is crucial. making use of the humidity and temperature as physical switches, the researchers can manipulate while the micro organism develop and while the materials stays dormant to serve structural functions.

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