Report about

Smart Concrete

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Abstract:

Concrete is the second most globally consumed material in the world after water and the most used construction material. Yet, its benefits are masked with many ecological setbacks through the way it is produced, transported, or used. Concrete occurs in a brittle state characterized by low tensile strength, weak resistance to crack formation, and strain properties. Recent studies have focused on improving concrete properties by integrating it with innovative solutions such as fibers, admixtures, and supplementary cementitious components. The infrastructure of modern structures demands components with greater durability, and higher mechanical strength. This solution can only be achieved through the addition of nanomaterials to cement-based products, thus, enhancing their mechanical features. Examples of nanomaterials include carbon nanotubes (CNTs), nano-ferric oxide (nano - Fe_2O_3), and graphene oxide. Nanomaterials can be added to cement with the addition of other reinforcements such as glass, steel fibers, fly ash and rice hull powder. With optimum dosages, the compressive, tensile, and flexural strength of cement-based materials, workability and water absorption are improved. The use of nanomaterials enhances the performance and life cycle of concrete structures. This study looks at some of the recent concrete improvisations, analyzing them on the spectrum of technical performance, durability, ecological sustainability, and economic benefits.

1. Introduction:

Concrete has evolved beyond its traditional use as a basic building material and has transformed into a highly intelligent material. Thanks to recent technological advancements, concrete can now incorporate embedded sensors, wireless devices, and innovative self-healing materials that allow it to monitor its own health, detect issues, and autonomously repair any cracks or weaknesses. This revolutionary material is commonly referred to as smart concrete or self-healing concrete.

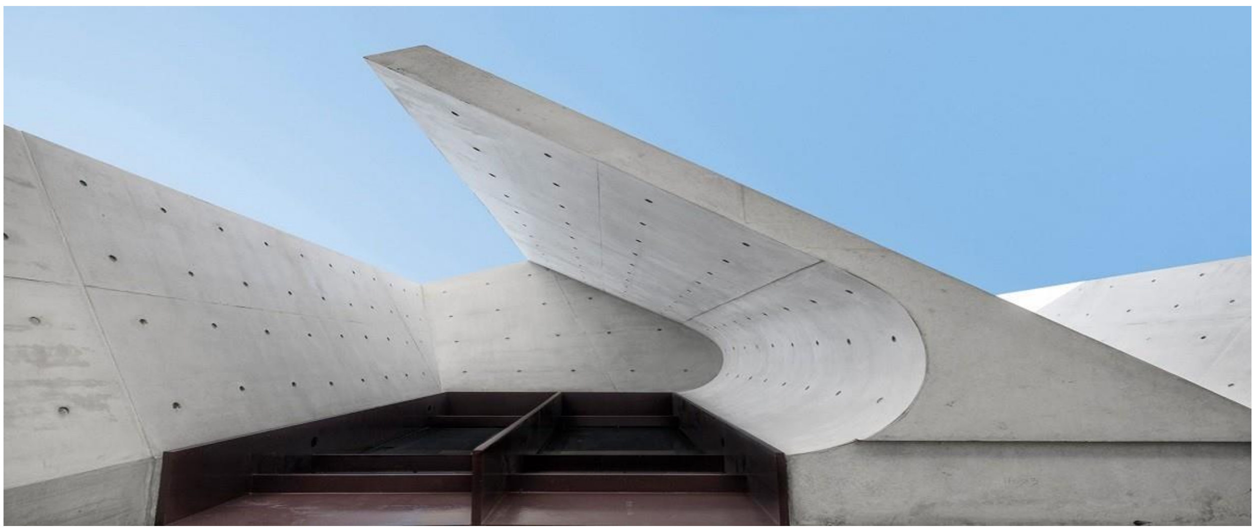

Figure 1 : Smart concrete

Smart concrete provides an impressive range of benefits, including cost savings on maintenance and repairs, as well as the creation of longer-lasting structures. This technology has completely transformed the world of construction and has had a significant positive impact on the environment. By reducing concrete waste and enhancing the sustainability of construction projects, smart concrete is paving the way for a more eco-friendly future.

The benefits of smart concrete extend beyond cost and environmental savings. By applying this technology to buildings, bridges, and highways, we can greatly prolong the lifespan of structures and minimize the need for costly repairs. This means that smart concrete is not only a smart investment but a sustainable one, making it a win-win situation for everyone involved.

2. Materials Used for Smart Concrete :

1. Cement – Ordinary Portland cement of grade 53 available in local market is used in the investigation. The cement used has been tested and having specific gravity of 3.0.

2. Coarse Aggregate – Crushed granite angular aggregate of size 20 mm nominal size from local source having specific gravity of 2.71 is used as coarse aggregate.

3. Fine Aggregate – Natural river sand having specific gravity of 2.60 .

4. Water – Locally available portable water confirming to standards specified is used.

5. Microorganisms – Any of the following bacteria may be used for the process:

- Bacillus sphaericus
- Bacillus cohnii
- Bacillus halodurans
- Bacillus pseudofirmus
- Bacillus subtilis

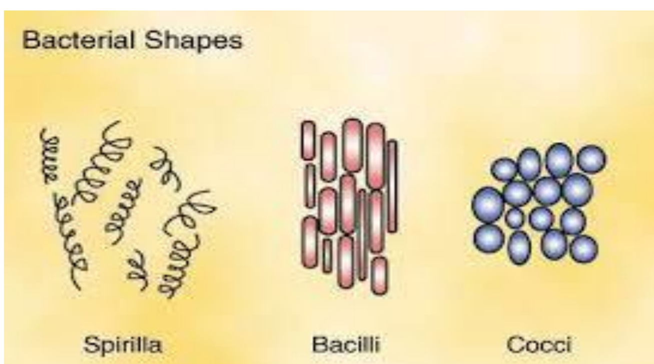

Figure 2 : Bacteria Shapes

3. Classification of Smart Concrete :

The use of modern technology in building materials, such as smart concrete, allows them to achieve higher structural properties than traditional concrete. It is still quite far from being used on a wide scale, and it is still in the laboratory. This paper has also discussed how different admixtures were used to overcome numerous drawbacks involved in developing this material. Based on literature reviews, several types of smart concrete have been developed using different materials and criteria. Matrix and function-based methods are among the most used among the various criteria Han et al.

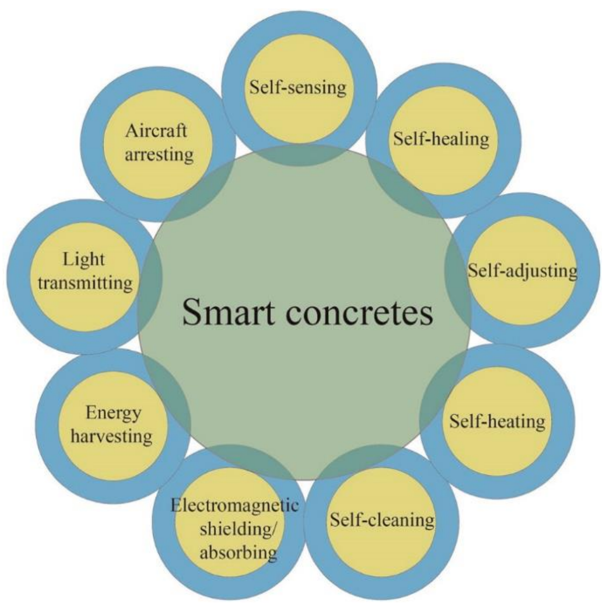

Figure 3 : Smart Concrete Classification

Table 1. Classification of smart concrete using different criteria as presented by Han et al. [36]

Criteria	Classification
Matrix materials	Cement-based materials Asphalt-based materials Polymer-based materials
Smartness or function	Self-compacting Smartness Self-expanding Self-curing Self-shaping Self-sensing Self-healing Self-adjusting Self-cleaning Self-damping Self-heating Self-light-emitting Damping Mechanical function Anti-spalling Water-resisting Aircraft arresting Electrical conductive Electrical function Electrothermal

4. Benefits of smart concrete in construction :

Smart concrete, in all its forms, has several advantages over traditional materials. Here are five of the most significant benefits for commercial and residential construction projects.

Increased strength and resiliency

All concrete is strong, which is part of its popularity, but smart concrete can often withstand even more. Interestingly, this strength is often a convenient side effect of other changes instead of the primary goal of new materials. Just as pumped concrete can withstand more force than poured concrete because it contains less water, adding new components to these mixtures often boosts its strength.

Many smart mixtures, including self-sensing and conductive concrete, contain materials like carbon fiber or graphite. These more rigid elements act as internal rebar, providing more structure once the concrete solidifies. As a result, buildings made of these materials are more resistant to shocks like earthquakes and high winds.

Plain concrete has relatively low shear strength compared to its compressive strength, so these forces can endanger occupants. The presence of rigid carbon fiber and graphite counteract that weakness without needing additional rebar, which is sometimes prone to corrosion. Consequently, this increased strength has considerable safety advantages.

Other mixtures provide added resiliency against the elements, such as water. One popular type is crystalline waterproof concrete, which offers hydrophobic qualities, repelling water to keep occupants dry or prevent damage to water-sensitive components like rebar.

Damage detection and reporting

Another advantage of smart concrete is that many types can act as sensors. Carbon fiber, steel shavings or similar materials can let it conduct electricity. Engineers can use this conductivity to inspect structures for damage by running an electrical current through the concrete.

When conductive concrete in a building warps, cracks or suffers other damage, its electrical resistance will change. These changes will appear on noninvasive tests, enabling faster responses to prevent further issues. Because these tests don't require drilling, teams can monitor and address damage without affecting the strength of the concrete, improving safety all around.

Recent innovations take this damage detection a step further. One solution embeds wireless sensors in the concrete that sends updates on its condition via a smartphone app. Once the mixture reaches its full strength or starts degrading, it will alert relevant authorities. Workers can then repair the structure before it causes a major disruption.

Fast responses are essential to damage mitigation. While prevention is always better than a cure, some degradation is inevitable with time and use. Smart concrete's real-time damage reporting lets teams fix it as soon as possible to avoid more dangerous and harder-to-repair issues.

Self-repairing

Some smart concrete can even repair itself from minor cracks and imperfections, protecting building occupants without interference. All concrete contains some self-healing properties, thanks to its materials remixing and hardening through ongoing hydration. Smart solutions add extra materials for more dramatic self-repairing.

There are many ways to make self-healing concrete, but one of the most popular is to use shape memory polymers (SMPs). SMPs change their shape in response to stimuli like stress or temperature shifts. Concrete with these materials in the mixture can automatically fill cracks or fix warping as soon as these imperfections arise and trigger the SMP.

Self-repairing concrete is particularly helpful for public infrastructure like highways. Authorities don't have to close them off to address the issue if these structures can heal themselves. Preventing these disruptions can improve traffic, minimize transportation emissions and make travel more convenient without sacrificing the safety of everybody on the road.

Heating properties

Smart concrete has advantages beyond maintenance, too. Conductive concrete can heat up through an electrical current or in response to natural elements like sunlight. These heating properties can boost buildings' sustainability and improve road safety.

More than 70% of the nation's roads are in snowy areas, and 24% of weather-related crashes stem from affected pavement. However, salting, plowing and otherwise de-icing roads is a slow process. Conductive concrete offers a solution. Roads made of this material can heat themselves to melt snow and ice, providing a safer driving surface in less time.

Response teams that don't have to salt or plow some roads can clear more of the area in a fraction of the time it would otherwise take them. Everyone can experience the same safety improvements, regardless of where they live.

Construction teams can also use this concrete to boost their eco-friendliness. Building homes or businesses with self-heating floors offers a more energy-efficient solution to conventional warming systems. Concrete radiates heat well, and it only takes a small amount of energy to produce significant temperature differences.

Enabling smart cities

New concrete mixtures can also help enable the smart city movement. Urban areas need a vast network of Internet of Things (IoT) sensors for adaptive traffic systems and self-driving car navigation to work. Conductive concrete can turn roads themselves into these sensors.

Smart roads can detect traffic patterns based on the weight of the vehicles that populate them. This infrastructure could send this information to other systems like connected stoplights or navigation apps to reduce congestion and improve transportation efficiency. IoT systems that work more efficiently can ensure roads, parking lots and sidewalks are safer by preventing accidents and improving response times.

Similar connectivity in the concrete throughout a city could offer real-time updates about when buildings or roads need maintenance. The municipality can then adapt to these changes to prevent accidents while avoiding mass disruption and complicated schedules.

Smart concrete is a revolutionary innovation

Smart concrete is still in its early phases, but its potential keeps growing. This technology could reshape the construction industry entirely as it becomes more accessible. Buildings and public infrastructure would become safer, more efficient and convenient for everyone that relies on or works with them.

5.METHODOLOGY

: The following steps are involved in the implementation of the project and are not limited to

- Literature Survey
- Collection of Required RAW materials
- Designing of concrete M20 Grade mix as per IS 10262-2009
- Culturing of Calcite Depositing Bacteria
- Casting and curing of controlled concrete cubes, beams and cylinders
- Creating a fault plane for bacterial concrete application
- Application of cultured bacteria for cracked Surface
- Strength and durability tests on healed concrete
- Comparison of strength and durability characteristics of controlled M20 grade concrete and bacteria healed concrete
- Discussions and conclusions to be done on the results obtained.

6.Advantages of Smart Concrete:

- Helpful to reduce leakage of residential building.
- Helps to reduce permeability in concrete.
- It increases durability of concrete.
- Real-time monitoring can be done
    - Smart concrete is stronger than the conventional concrete
    - The cost of construction would be higher than the conventional concrete. However, the total cost together with sensing equipment to be installed in the conventional concrete would be higher than the smart concrete.
    - Its self-healing properties cannot be achieved with conventional methods. It helps to heal the cracks
    - Reduce the corrosion of the reinforcements
    - Reduce the repairs in the concrete with low concrete deterioration.

7.Disadvantages of Smart Concrete:

- It is quite costly than normal concrete so becomes uneconomical.
- It is not suitable for atmospheric condition.
- It gives better results only if comes in contact with water.
- Process of activation of bacteria is tedious.
- It takes more time for working of bacteria in concrete.

8. Applications of smart Concrete :

- Buildings.
- Bridges.
- Flyovers.
- Roads.
- Floating Structures.
- Foundations.
- Marine Structures.

9. Conclusions :

Smart concrete is a very broad category of material that includes self-sensing concrete, self-adjusting concrete, self-healing concrete, etc. Self-sensing concrete is a branch of smart concrete, which was the earliest proposed and has been systematically and deeply investigated. self-sensing concrete mainly has excellent mechanical property and durability, long service life, and easy installation and maintenance. Self-sensing concrete has a wide application in civil infrastructures such as high-rise buildings, highway, bridges, runways for airport, continuous slab-type sleepers for high-speed trains, dams, and nuclear power plants, and especially has great potential in the field of structural health monitoring, traffic detection, and border/military security. This would be helpful for ensuring structural integrity and safety, extending the life span of structures, improving the traffic safety and efficiency, guiding the structural and traffic design, decreasing the resource and energy consumption, etc. Self-sensing concrete is a “smart” choice for maintaining sustainable development in concrete materials and structures. It will bring a deep revolution to the field of conventional concrete materials, which should have a beneficial impact on economics, society, and environment.

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