SMART BUILDING MATERIALS EXPECTED TO IMPACT CONSTRUCTION INDUSTRY

Innovation in material science plays a significant role in structural design and development

In the past decade, considerable focus has been placed on the creation and application of responsive smart materials. These smart materials can adapt to thermal, optical, structural, and environmental stimuli. Their incorporation in structural design improves safety and durability while conserving energy.

Over the next five years, usage of smart materials in building design and construction is expected to increase by 34 percent annually. Experts predict that smart materials will reach a total market value of nearly $25 billion by the year 2021. The following is an overview of the types of smart materials beginning to proliferate in the construction industry.

1. Smart concrete

One of the most exciting innovations of recent years is the advent of smart concrete. Several different types of smart concrete are under development. One involves the inclusion of carbon fibers that conduct electricity, enabling the concrete to effectively act as a sensor by responding to damage. Once it has detected cracking or stress, the structure can automatically alert engineers to weak spots long before a fracture is visible to the human eye. Possible uses of carbon-fiber-infused smart concrete include traffic monitoring, border monitoring, weighing vehicles in motion, and building security.

Another type of smart concrete involves the use of specialized substances to render it watertight. Such materials are able to respond to moisture entering the structure by growing more crystals to seal the concrete and stop leakage, a major advancement that's revolutionizing the way we design and build structures today.

Scientists are also developing an abrasion-resistant and corrosion-resistant smart concrete – up to six times more durable than traditional concrete. This highly durable material is being used for industrial floors, roadways, hydro spillways, and many other applications in transportation, agriculture, power generation, and marine structures.

In the future, look for new sensors, monitoring devices, and adaptive materials that will be built into concrete. These devices will be able to report anomalies in structural integrity long before they would otherwise be observed, while also communicating with equipment and vehicles using the Internet of Things (IoT).

2. Shape-shifting smart metal

A new class of highly-promising materials under development are smart metals that can be manipulated in their liquid state using electrical charges. The liquid metal can be formed into various shapes, such as letters or numbers. Shape-shifting smart metals are expected to open new possibilities in soft robotics technology and in a variety of displays that currently leverage more traditional tech. Applications may include reprogrammable cards, reproductive ink, and advanced intelligent electronics and robotics.

3. Self-healing coatings

"Self-healing materials" are synthetic materials that can restore their structural integrity. Self-healing can be automatic or requiring human intervention. Plastics, polymers, paints, coatings, metals, alloys, ceramic and concrete have all demonstrated the capacity for self-healing mechanisms. Liquid active agents that trigger self-healing events include monomers, dyes, catalysts and hardeners containing microcapsules, hollow fibers and channels embedded into polymeric systems during manufacturing. The announcement of self-healing paints by Nissan for use on automobile bodies illustrates an example of how self-healing coatings have immediate commercial applications.

4. Smart structures and nanomaterials for thermal insulation

Buildings consume the highest percentage of global energy, emit the highest levels of greenhouse gases, and generate the most solid waste materials. This is due, in part, to inefficient thermal insulation systems.

There is tremendous untapped potential for saving energy in the building sector. In North America, the largest portion of energy is consumed in the process of heating buildings. A critical goal of energy conservation is reducing heat loss through walls. Energy management can be improved by increasing the thickness of outside walls or by reorienting high-tech, super insulation materials using nanotechnology. Aerogels and vacuum-insulated panels are two types of nanotechnologies currently being used in this way.

5. Smart glass

Electrochromic glass (also called "smart glass") changes from light to dark and back again, at the push of a button. This solves the problem of glass being transparent all the time, even when it's inconvenient. During the summer, significant resources are spent to keep buildings cool. This expenditure would decrease precipitously with the widespread implementation of electrochromic glass, which is capable of adapting to the opacity necessary to maintain optimal interior building temperature. Currently most smart glass leverages metal-oxide coating, but there are several other technologies in development to this end.

6. Shape-memory materials

Shape-memory materials, such as shape-memory alloy, are a combination of metals bonded together that remember their original shape when heated. Such materials are lightweight and solid, making them useful for hydraulic, pneumatic, and motor-based applications. Most shape-memory alloys in use today are copper-aluminum-nickel or nickel-titanium. Shape-memory alloys are also used in the construction of bridges and buildings. For example, intelligent reinforced concrete is designed using shape-memory wires that are embedded into the concrete. These wires will then "remember" their original shape in the event of a major disaster such as an earthquake. Shape-memory couplings have been built for industrial purposes, including the construction of superior oil pipes and water pipes. Many new applications are being fabricated for the robotics, automotive, aerospace, construction, and biomedical industries.

7. Smart geosynthetic materials for road pavement

Asphalt reinforcement using geosynthetic materials has received considerable attention within the transportation industry. This is because the reinforcement of asphalt for road construction and repair has been shown to significantly improve the performance of roads, even when burdened with heavy traffic use. Geosynthetic materials can better resist moisture, absorb more stress, and increase the overall durability of the road.

8. Smart materials for shallow geothermal systems

Shallow geothermal energy is the process of supplying heating, cooling and hot water to homes and businesses using the energy just a few hundred feet beneath us. Energy savings on heating alone average well over 40%. For cooling, as much as a 90% savings is possible. Vibrational harvesters can be harnessed to convert mechanical energy into electrical energy for use in geothermal deployment. There are several different types and designs of vibrational energy harvesters but most use either smart piezoelectric materials or carbon nanotubes to capture mechanical energy and deliver it to transducers that generate the electrical energy.

Smart building technology will automate many building functions that humans currently perform. Smart materials will handle operations using sensors and artificial intelligence. In the future, expect smart technology to function without human intervention in areas like security and surveillance systems, energy management, and infrastructure applications such as parking systems and elevator/escalator management. New, paradigm-shifting technologies offer the promise of a safer place to live and work, while providing a positive impact on our environment. •

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