

Innovating the Construction Sector

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Abstract – The construction sector for long has been considered to be a laggard in terms of productivity and its ability to suffice the ever increasing needs of our developing world. Although it remains to be among the sectors that has the maximum potential for development, the pace of growth is stunted. The call of the day is to invest skills and technology into the sector in order to pillar the foundation of a growth story that is both commercially scalable and futuristic in nature. The intention of this paper is to shed light on two pivotal factors that are the legs of this industry: a) material and b) technology. While the study of material has always been unparalleled in terms of innovation, its application in our everyday lives is often underutilized. The other founding stone is the power of technology with its galloping advancements that can deliver us a reinvented world ahead. The paper discusses the scope of these domains in innovating the construction sector and elaborates on different scientific studies and specialized techniques that can be incorporated. The solutions can be applied across a vast range of projects, from those that are capital intensive to those that are domestically deployed.

Key Words: Construction, Infrastructure, Technology, Materials, Digital, Automation, Futuristic, Development

1. INTRODUCTION

The construction sector has been very conventional in its operations. This, in addition to the aftermaths of the financial crisis, has left the sector in shackles in terms of productivity growth. The success rate of projects has been dismal with most projects not even guaranteeing an opening date. A number of issues plague the sector and are elaborated below.

1.1 Current Problems and a State of Alarm

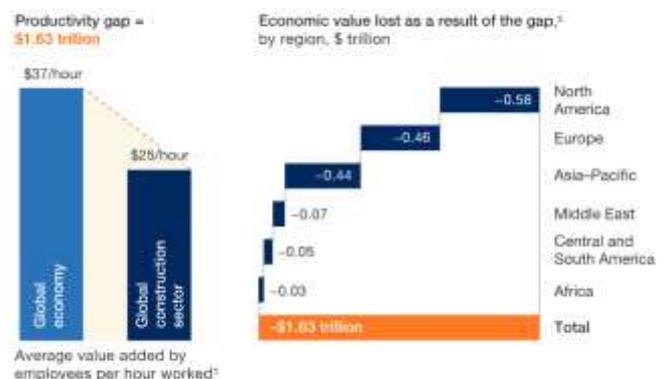
- 1) More than 90 percent of the world’s infrastructure projects are facing the risks of going over-budget or project delays
- 2) Transparency in the supply chain and financial security of the sector has been a dominant issue of concern among most investors. An example of this has been many real estate companies filing for bankruptcy and not being able to deliver their projects
- 3) Construction is among the least digitized sectors in the world. According to a study, In a sample of

countries analyzed over the past years, less than one-quarter of construction firms have matched the productivity growth achieved by the overall economies in which they function

- 4) A dated survey by the United Nations estimated that over 100 million people are homeless worldwide. A major cause of this is techniques of construction and material not suiting the economies of scale. Technology and scientific research can open up vast potentials of viable development here
- 5) Labor safety, ergonomics of construction and environmental impact are troubling issues that have hazardous effects if not scientifically countered

An expansive study published by the McKinsey Global Institute discusses the impact of the stagnancy that prevails in the sector. The same is illustrated below:

Lagging construction productivity costs the global economy \$1.6 trillion a year.



¹2015 data in real 2005 dollars.
²Assumes construction productivity catches up with total economy productivity and current workers are reemployed at the total economy productivity rate.

Fig -1: Lagging Construction Productivity

1.2 The Path Ahead

Advancement in materials and technology has great significance, from utilitarian to high-performance applications, spanning across all fields. Innovations for the construction industry that have been described ahead have benefits that cover social, economic and commercial aspects.

2. INNOVATIONS

The research is segregated into innovations in Technology and Materials. The technology prospects can be further

subdivided into hard and soft robotics. Real-time applications are elucidated below.

2.1 Technology

2.1.1 Hololens (Virtual/Augmented Reality)

HoloLens is a wearable technology and is one of the implementation of Immersive Projection Display and LiDAR. It allows the user to wear a headset and integrate what is seen in the real world with the virtual world and create 3D models and 4D visualizations. An app allows the user to take a picture and upload it to the device which then instantly creates a virtual environment for the same. Operators can assess the ease of construction and assembly and provides them with a safe and foolproof on-site environment without the excessive study of drawings. Another application is the ease of welding operations wherein the welder does not need to constantly refer drawings for locating the joints. The figure below depicts its real-time implementation:



Fig -2: Virtually Integrated Construction

2.1.2 IoT Enabled Safety Helmet

These safety helmets have integrated sensors and are used as a base to hold miniature positioning and communication instruments along with gas permeable vents. These sensors can flag an alarm in unsafe units of the site and ensure operator safety using bidirectional communication channels.

2.1.3 Computer Integrated Construction

This involves a wide range of technologies. One of the most disruptive one in terms of construction methodology has been additive manufacturing or 3D printing. Current advancements have witnessed large-scale 3D printers that can produce an entire house at costs as low as \$4000. These houses can be either prefabricated or constructed entirely at site and have been seen to withstand extreme conditions such as snow.

2.1.4 GPS Enabled Earthquake Monitoring

Dense GPS networks can be installed in large numbers across potential seismic prone terrains and the live data such as

surface displacements can be constantly analyzed hence providing a proactive approach to the study of green field sites and a warning system for existing settlements.

2.1.5 Technologically Enhanced Supply Chains

Micro-chips of sizes as small as 0.4mm*0.4mm can be installed on all parts that are procured for the construction sector. These chips are integrated into the mobile tracking systems and can keep the project managers aware of operational flow. Hitachi has already developed such chips that work on RFID sensors and are VPN enabled leading to enhanced tracking that boosts the transportation and logistics domains of the construction sector. This technology is best implemented with dynamic improvements in the soft robotics domain. Improved schedule management and remote monitoring systems can take account of the actual progress situation of the project and when a difference arises between the present state and the master schedule, the algorithm adjusts the supply chain autonomously.

2.1.6 Inspection Sensors and Drone Applications

Robots that are mechanically actuated using grippers, electromagnetic suction cups, etc. or drones that are remotely operated can be integrated with sensors such as laser telemeters, color cameras and gas detectors. These can assist in inspection activities and transmit the live field data to the ground systems.

2.1.7 Smart Roads

Advancements in road construction can facilitate development of roads that are capable of storing and transmitting energy. Roads can be integrated with electronic chips and cables that can be used to power electronic vehicles by generating electromagnetic fields. Roads can also be used to store energy by incorporating piezoelectric crystals that can generate energy whenever mechanical stress is applied during regular travel.

2.1.8 Programmable Swarm Robots

This is an immensely futuristic application that is termite inspired and works on the principle of collective adaptive behavior. A target structure is fed to the robot control system along with the algorithm. On-board sensors enable the swarm robots to dynamically adjust to their environment and the micro robots then work together to build a structure. A unique benefit of swarm robotics is also seen in the field of underwater construction and other extreme applications where human involvement is at a risk. The below figure depicts the application of swarm robots conducted by Harvard University.



Fig -3: Swarm Robots at Work

2.2 Materials

2.2.1 Carbon Nanotubes

These are carbon tubes of nano-thickness that are formed using electron beam lithography. These fine additions to regular materials such as concrete and asphalt can help increase the surface area/mass ratio and the strength/weight ratio hence providing a strong and elastic material that possesses immense structural strength and longevity of roads, foundations, load-bearing components, etc.

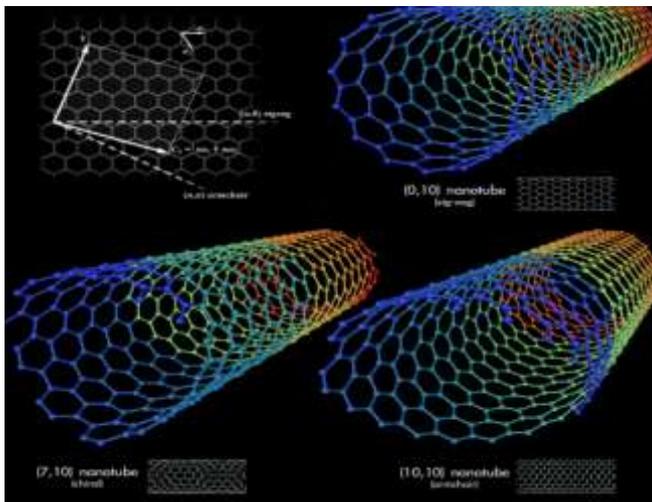


Fig -4: Types of CNT structures

2.2.2 Accelerated use of FRP

Usage of FRP material if accelerated has huge benefits such as reduced carbon footprint, reusability, modular construction, set up in limited spaces and reduced costs. Integrating the material with glass fibers and resins that are flame and chemical resistant can help facilitate use in extreme services as well.

2.2.3 Self-Healing Concrete

Tiny capsules of sodium silicate can be mixed with regular concrete. Upon stress and cracks, these capsules burst releasing binding medium that can help the concrete heal itself. Cultures of bacteria are also being investigated for this usage. The biggest advantage of this is that it drastically helps reduce the carbon footprint that refilling of concrete otherwise generates.

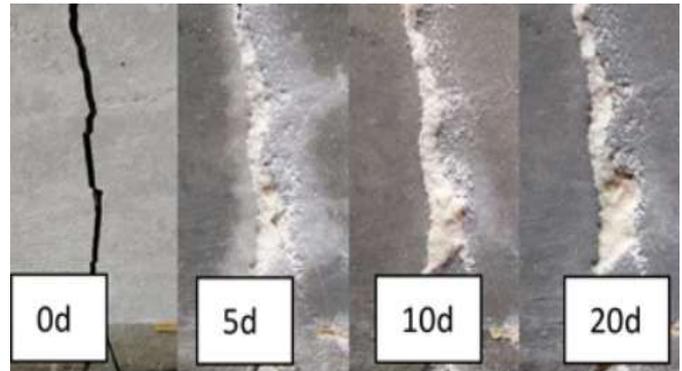


Fig -5: Day-wise effect of self-healing concrete

2.2.4 Aerogel Insulation

Said to be as light as air, this ultralight insulation is synthetically derived by removing the liquid component from a gel hence leaving behind a highly porous substance. It is of extremely low density and thermal conductivity and performs 2-4 times better than traditional foam and fiberglass insulation.

2.2.4 Building with Carbon Dioxide

Roughly 30 billion metric tons of CO₂ waste is generated every year. In response, genetically modified yeast or abalones can be used to mineralize CO₂ waste by creating solid carbon waste threads and materials similar to calcium carbonate. This material can be further used for construction activities hence reducing the carbon footprint that would have otherwise had adverse impacts on the environment.

3. CONCLUSION

The need of the hour is to bring about multiple advancements in the construction sector. Commercially, more transparent and agile synergy between owners, contractors and vendors can lead to better project actualization. Socially, alternate materials and technologies if scaled, can be used to develop even cheaper housing and infrastructure but not at the cost of quality. Economically and environmentally, above described techniques can lead to cleaner societies that can generate financial and aesthetic profits benefitting the entire community. The base denominator of all these conclusions is that a scientific rediscovery should be kept at the helm of affairs. The intent

of the paper is to bring this to light and promote a research environment that is conducive for the same.

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