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Modern Trends in Innovative Construction Projects

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Abstract

The construction sector is extremely conservative. However, nowadays, no one sphere of economic activity can exist without any changes or innovations. There are a lot of different perspective technologies and materials for construction. It is possible to say that the main aim of the innovations construction sector is working faster, cheaper and better. Each company should be interested in the faster construction process, because of decreasing payback period and lowering risks, associated with almost every project. Also, companies should be interested in a better quality of houses and other buildings, for it gives a lot of benefits — higher demand, a better reputation and so on.

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It can be distinguished two types of technologies, which influence on the construction market. First of all, global innovations, such as the internet, changed all spheres. Construction process became much faster due to quick communication through the Internet. Future development of this innovation may be the Internet of Things (IoT). IoT might revolutionise construction sector once again. Secondly, it can provide specific technologies for sector. For example, the better quality of cement. These technologies help to get better quality at lower costs. [1]

There is a list of technologies:

Self-healing concrete;
Transparent aluminium;
3D printing construction;
Internet of things;
Robotics and swarm robotics;
Building Information Modelling.

The first technology is self-healing concrete. Concrete is the most commonly used human-made material on earth. It is a relevant construction material used extensively in buildings, bridges, roads and dams. Concrete is a composite material, consisting mainly of Portland cement, water and aggregate (gravel, sand or rock). When these materials are mixed, they form a workable paste, which then gradually hardens over time. The main reason for usage:

Cheap material with relatively long life;
It is strong in compression;
Very pliable substance before it hardens.

Millions of dollars are invested in maintaining, fixing and restoring roads, buildings, tunnels and bridges annually. It is because all concrete eventually cracks and needs to be restored. Self-healing concrete can change this situation and lower maintenance cost to almost zero.

Self-healing concrete is a product that will biologically produce limestone to heal cracks that appear on the surface of concrete structures. Specially selected types of the bacteria G*enus Bacillus*, along with a calcium-based nutrient known as calcium lactate, and nitrogen and phosphorus, are added to the ingredients of the concrete when it is being mixed. These self-healing agents can lie dormant within the concrete for up to 200 years.

However, when a concrete structure is damaged, and water starts to seep through the cracks that appear in the concrete, the spores of the bacteria germinate on contact with the water and nutrients. When activated, the bacteria start to feed on the calcium lactate. As the bacteria feed's oxygen is consumed and the soluble calcium lactate is converted to insoluble limestone. The limestone solidifies on the cracked surface, thereby sealing it up.

The other material, which can revolutionise the construction sector, is transparent aluminium. Nowadays, aluminium is widely used in construction. An enlargement of aluminium usage can be one of the drivers for its consumption. This metal is the second one after steel in the construction sector. Ceramic called aluminium oxynitride, composed of equal parts aluminium, oxygen, and nitrogen is known under the chemical formula AlON. [2]

Despite clearly not being a metal — and not a glass either; glasses are amorphous solids, while ceramics are crystalline — AlON and the other transparent ceramics that have been developed since have some amazing properties. AlON is marketed under the name ALON. Powdered ingredients are poured into a mould, compacted under tremendous pressure, and cooked at high temperatures for days. The resulting translucent material is ground and polished to transparency before use.

At the moment this material is used for military purposes — elements for sniper rifles, armour panels. On the downside, ALON is expensive — in the armoured glass market, it's about five times the price of traditional laminated glass. But it has so many benefits, not least of which is superior scratch resistance, that for some applications it's the material of choice.

In the case of a price decrease, transparent aluminium can be used in ordinary construction. For instance, it is interesting for typical business centres, which are covered with glass. It will decrease maintenance costs, and appearance will be better for a longer time. Also, it can be attractive for objects, such as an aquarium, because there is a lot of glass surfaces. And these surfaces may be damaged by visitors. Transparent aluminium might be a decision for this situation.

3D printing is a real trend in a lot of sectors. Nowadays, there are a lot of materials, which can be used in printing — more than five types of plastic and five types of metals (aluminium, titanium and other). Each 3D model begins from computer design, and only then special equipment (3D printer) brings the computer model to real life.

Printing in construction is a bright idea because it is much faster and cheaper than the standard process. Printers can make parts or the whole house. Partially printing is more suitable for bigger houses. But when the printer constructs the whole house, it is faster, but the house will be smaller. And it is not a future. Nowadays there are a lot of solutions on the market. [3].

It is possible to divide printers into three groups:

House 3D printer; there are printers, which everyone can be for personal usage. For instance, the price of Machines-3D is $ 395,000.

Prototype; these printers are now in development or testing phase, but these models can go on sale shortly.

Service.

Also, some companies provide 3D construction printing as the service. Customers can rent printers or get ready constructions from the company.

The next technology — the Internet of Things or Io T. The IoT is a system of interrelated computing devices, mechanical and digital machines, objects, animals or people that are provided with unique identifiers and the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction. Simple example — coffee machine knows when you wake up and make coffee in time. [4] But IoT may change a lot of process in construction. There are several possible applications:

Real-time reporting; different department of construction companies can get data from building site in real-time. It can help in a lot of processes — from planning to operational micro-management. As a consequence, all processes will be more effective.

Continuous improvement; this point is close to the previous. A lot of new actual data help to improve different sides. Only through IoT

company can make some real predictions and adapt to new market situation.

Worker safety; one network on building site may prevent mortality through early warning. Also, wearable gadgets might check all health parameters and send notifications to medical service in emergency cases.

Automated Workflows.

Sensors and RFID tags on materials and equipment can help in proactive ordering materials and servicing equipment. When an employee checks out or ships material to a job site, he scans the item. The system detects low inventory and notifies an employee to place an order for more material. Similarly, sensors on equipment monitor usage levels to potential flag issues for preventive maintenance. These measures will lower the human factor and mortality at work.

But each technology has its weak links. In the case of IoT, weak points are linked with the transfer of a massive amount of data. First of all, it is difficult enough to construct the Internet and unity all things. And, of course, it's massive investments. Secondly, data have to be encrypted. But it is difficult to encrypt each piece of information. Otherwise, data can be stolen.

Robotization of various industries began a couple of years ago. And now a lot of manufactures works without colossal personnel. These factories need only a few operators that track all the operating parameters. And they can call specialists in the event of emergencies. On the other hand, the construction industry is one of the least automated industries that feature manual-intensive labour as a primary source of productivity. And it is possible to point out development and growth for the construction sector. But the main problem for robotics integration — construction demand a lot of different operations, which may differ from hour to hour. And robots cannot change the program so fast. It means that only several operations may be upgraded by robots.

There are a few types of robots:

3D robotics printers; this type of robots, we overviewed above in this part of work.

Masonry robots; it is one of the most perspective types. There are construction robots for brick-laying and masonry, and even robots that lay an entire street at one time. These types of robots dramatically improve the speed and quality of construction work.

Demolition robots; it is a highly interesting type due to a new level of safety for building site crew. While they are slower than demolition crews, they're far safer and cheaper when it comes to demolishing concrete and structural components of a building at the end of its lifecycle.

Remote control (RC) and autonomous vehicles; it can be as gadgets for existing vehicles. For instance, special device can give remote control of bulldozer on the territories where the ground may fall. We suppose that this type of robots is the first step of building site automatization.

As for the swarm robotics, it's special branch of robotics. Swarm robotics is the use of numerous, autonomous robotics to accomplish a task. Robot swarms coordinate the behaviours of a large number of relatively simple robots in a decentralised manner. Researchers at Harvard's self-organising systems research group have built small construction robotics programmed to work together as a swarm. The four-wheeled robots can build brick-like walls by lifting each brick, climbing the wall and laying the brick in an open spot. They have sensors to detect the presence of other robots and rules for getting out of each other's way. Like termites, no one is "controlling" them, but they are programmed to build a specific design collectively. The other possible application of swarm robots is building maintenance. Swarm can inspect construction from time to time. It can help find small cracks before it will be a problem. And this swarm might do it without any additional tasks from personnel.

Robotics and swarm robotics also have some disadvantages. First of all, all innovations are required investments. And this innovation might be the most expensive from the list above because most of the projects are on the research phase. And no one knows which project will be commercially successful. Secondly, robotics can not only solve the problem of skill shortage, but it can increase unemployment. And it concerns not only the construction industry. Thirdly, robotics needs high-skilled professionals. We

suppose that the supply of this professional will be low in comparison with the high demand from a lot of construction companies.

To sum up, all innovation can revolutionise the construction sector. The construction sector of the future will combine different technologies to solve new market challenges. For instance, a 3D printer might use self-healing concrete. Or swarm robots can be programmed through the BIM system. There is a possible outcome that no one innovation will be implemented in the sector.

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Современные тенденции в инновационных строительных проектах

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Аннотация. В статье рассматриваются проблемы строительного сектора, который является чрезвычайно консервативным. Дана характеристика значимости влияния на экономику строительного сектора современных технологий и материалов. Исследованы особенности применения инноваций, позволяющих строить быстрее, дешевле и качественнее. Обобщены принципы и подходы строительных компаний к экономической обоснованности их применения в строительном процессе. Предложены рекомендации по повышению окупаемости и снижению рисков, связанных с каждым строительным проектом, а также обеспечению более высокого спроса, улучшению репутации строительной компании и повышению ее конкурентоспособности.

Ключевые слова: глобальные инновации; инвестиции; строительные проекты; строительная технология