Module 4

Introduction to Digital Technologies

Digitalisation in Construction

24 partners

12 countries

Date of Event

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Introduction to Digital Technologies | Summary

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To equip the learner with the basic knowledge required to understand the benefits and where to use digital technologies relevant to construction.

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Introduction to digital technologies | Objectives

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1. Identify and **list digitalised technologies** suitable for the purposes of construction
2. Identify and define digital technologies used **on the site**
3. Identify and define digital technologies used **off the site**
4. Outline **where digitalised technologies** are used for the purposes of construction
5. Outline and discuss the **benefits and opportunities** of the digitalised technologies for each of the phases of construction

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Introduction to digital technologies | Content

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Topic 1 – On site technologies

Topic 2 – Off site technologies

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1. On site technologies

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Digitalisation on-site

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- Design teams have moved from paper silos to digital tools and collaborative platforms and integrated ways of working.
- Workers on site should follow suit.
- When using BIM, the programming of tasks and trades can be recorded, analysed and communicated at every level of detail. “This means that complete, real-time and accurate information can be used on-site in the hands of the right people, when they need it”
- Digitalisation is changing the face of construction and is also supporting:
  - Lean Construction
  - Circular Economy and Green Deal (Reuse, Recycle, Restore)

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Lean Construction

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- The Lean Movement is gaining popularity in the construction world, and with good reason – it's about **cutting out waste** and increasing value-added activities.
- Lean construction is a way of realising projects by **maximising value and minimising costs**; during construction, project maintenance, design, planning, and handover using specific techniques.
- **Basically save on time, effort and a waste of materials**.
- Benefits include, **removing waste from the process to drive greater profits, reduced risk, improve safety, shorten schedules, and improve communication and relationships**. Some types of waste as defined by Lean include: 1) Excess Transportation, 2) Inventory, 3) Unnecessary Motion, 4) Waiting, 5) Over-processing, 6) Overproduction, 7) Defects and 8) Under-utilised Talent.

Six categories of techniques that you should be looking at:

1) Automated Scheduling and Workflows
2) Collaboration Software and Mobile Management
3) Digital design and construction/BIM
4) AR/VR Technology
5) Automated Technologies
6) Sensors and Wearable technologies

Circular Economy and the Green Deal

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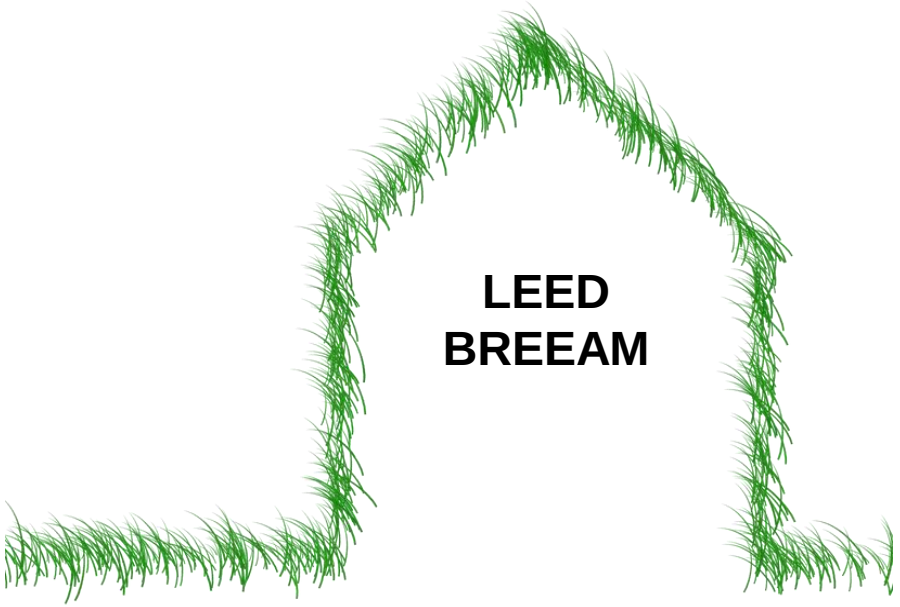
- **Technological advances in areas such as Nearly Zero Energy Buildings (NZEB) have reduced energy requirements during the operational phase**. This in turn is reducing embodied energy significantly to reduce the overall environmental impact of the building.
- Embodied energy is the energy and resultant emissions from all the activities involved in the creation and demolition of a building.
- A building's life cycle can be broken down into three distinct stages: construction, operation and deconstruction.
- **Life Cycle Assessment (LCA) is a methodology used to calculate the environmental impacts, including carbon footprint, of a product, service, or process.**
- There are various digital tools and green building rating schemes to assess the sustainability of a building's materials and performance. Most commonly used are LEED and BREEAM.



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A rapidly changing field

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- Construction technology is a rapidly changing field with the potential to remove incredible amounts of waste from the process.
- Companies will achieve huge efficiency gains over their competitors by using technology and digitalisations.
- Incorporating and understanding digital technologies, tools and sustainable green materials within your workplace, using innovative approaches is the way forward.
- Well trained, especially young talent, will want to work at the companies who use the most innovative systems and processes.

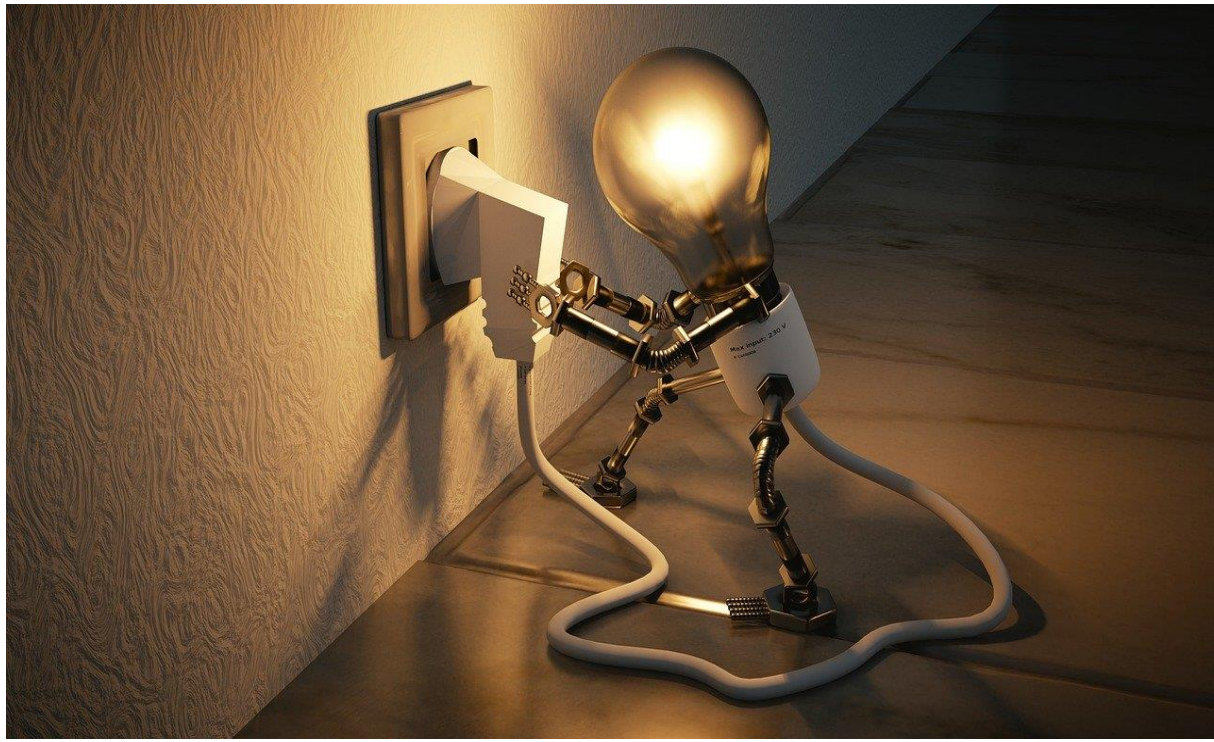

Image by Colin Behrens from Pixabay

Smart factory automation

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Adoption of Internet of Things (IoT) in construction to **advance and improve production, ensure quality energy efficient designs and achieve compliant healthy buildings.**

- We also need **better connectivity within the construction chain** – giving clear concise instructions and relevant information, efficient transfer of knowledge, working together (System Thinking) and communication between all parties involved from (Clients, Architects, Engineers, Site Supervisors, Contractors and operatives on site).
- **So what does IoT mean?**
- We will look at how IoT and digitalisation will help us on site

- connected cars,
- smart energy projects,
- home automation,
- smart modular manufacturing.
- knowledge transfer
- collaboration

Digital tools- Internet of Things (IOT)

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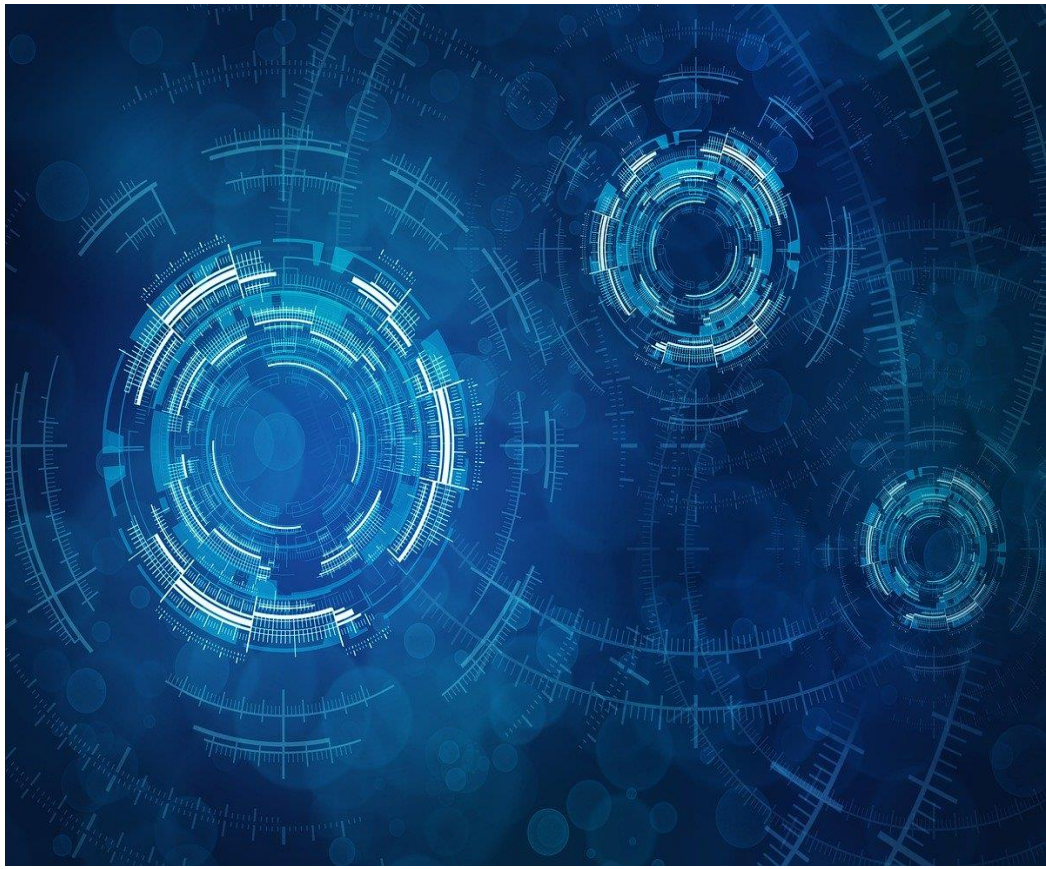
- **IoT helps to connect smart devices together, sharing data between each other**. Smart devices, such as sensors, smartphones, and wearable technology all collect the necessary data.
- The adoption of IoT technology across all industries, such as manufacturing, automotive, and healthcare, is driving the market's growth positively.
- The construction industry is starting to adopt this IoT technology, so we need to be ready.
- With the traditional construction sector in the middle of a digital transformation, IoT is fuelling the next industrial revolution of intelligent connectivity.
- This is changing the way we approach complex processes of systems and technologies to improve efficiency and reduce downtime.



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Digital tools- mobile technology

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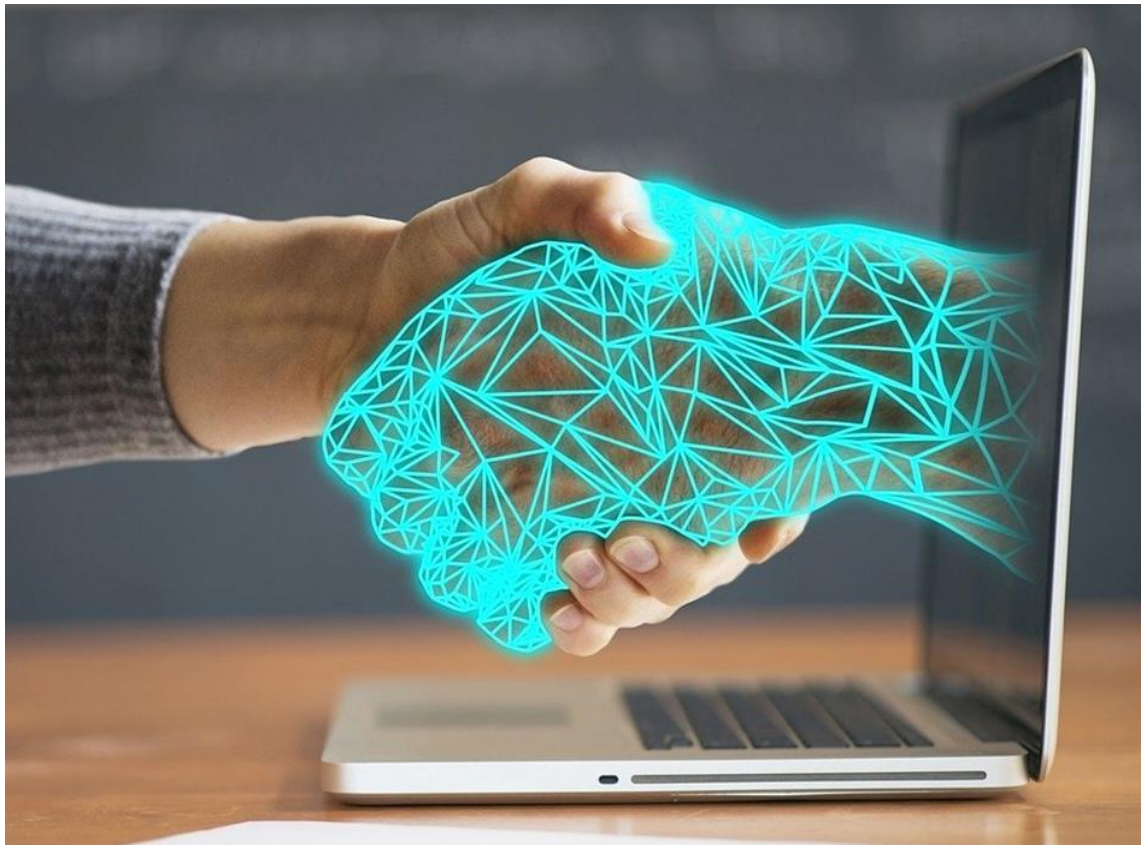
Collaboration

- One of the major issues with construction projects is having a highly fragmented industry. With workers, engineers, and equipment distributed around a site, plus offsite architects and clients, it can be hard to get everyone on the same page when a decision needs to be made.

Mobile Technology

- Smartphones and mobile apps have made communication and collaboration on projects easier. Instead of attending the office for meetings, companies now hold meetings using mobile technology, sync in real-time, add notes, change drawings and respond to RFIs instantly and then share that information with everyone involved with the project at the same time



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Digital tools- software and mobile solutions

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- Today there are software and mobile solutions to help manage every aspect of a construction project. From preconstruction to scheduling, from project management and field reporting to managing your back office,
- **Most software solutions are cloud-based, allowing changes and updates to documents, schedules, and other management tools to be made in real time, facilitating better communication, collaboration and productivity.**
- This can save hundreds of hours per year in data entry and automatically organises critical files—no more shuffling through files looking for old reports or drawings

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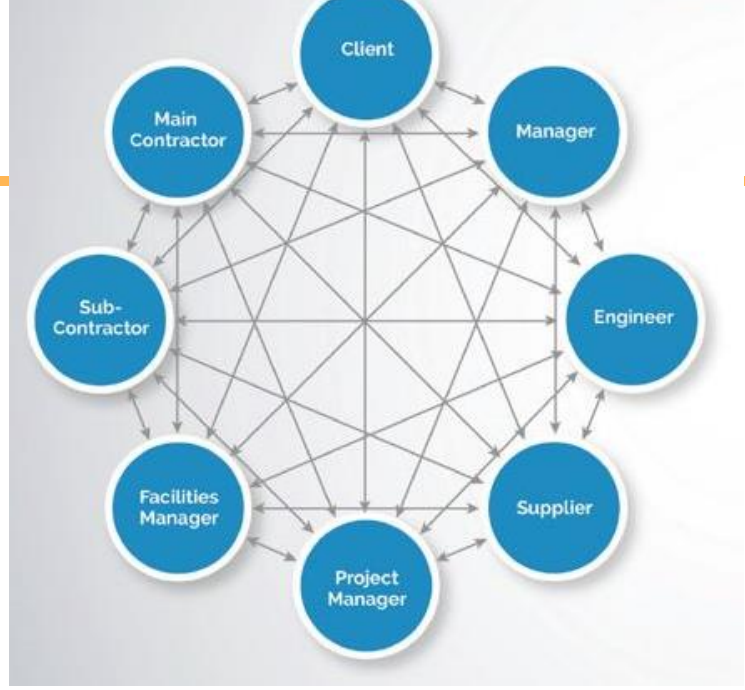
Digital Tools- Building Information Modelling (BIM)

- BIM is a process that incorporates both the digital representations of buildings in 3D models and relevant information inside the model.

1. Allows for **better collaboration** among all teams on a project.
2. Can lead to **better design and quality construction** of buildings.
3. **Real time changes** to the BIM model, so any changes or updates to the model are instantly communicated to all team members when they access the model.
4. Everyone is working with the most **up-to-date information** at all times.
5. Allows for a **Simulated Schedule** of the construction process which allows team members to plan out each phase of construction.



Artificial Intelligence and Extended Reality

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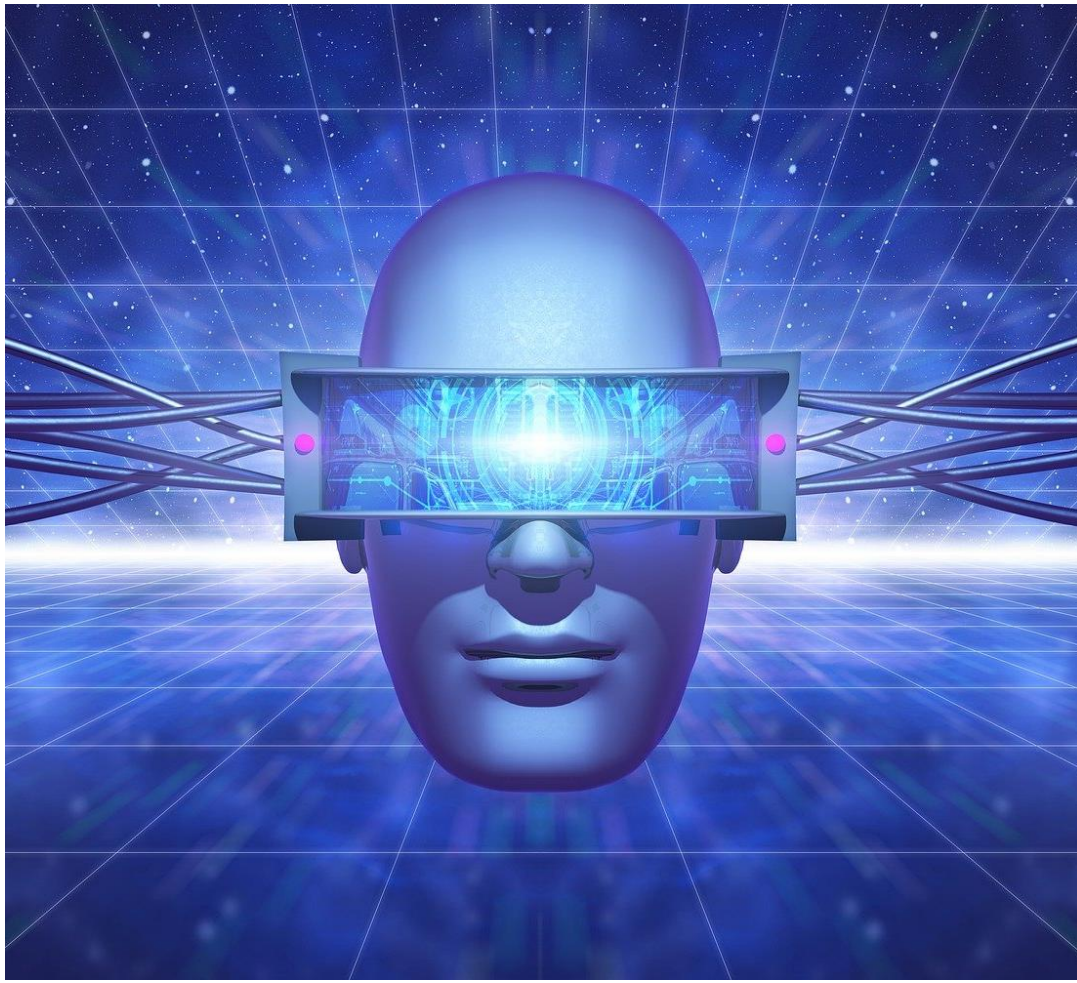
- Autonomous machines, Drones, Robots, IoT sensors and extended reality can be used to improve productivity and quality of buildings.
- New jobs are being created in these areas, and young people could be encouraged into construction with the aid of IT and AI systems.



Machine Learning

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No 3D printer, drone, or robotic arm will be of much use without quality software.
For robots to successfully work on the construction site, they need good intelligence, of the artificial kind.
With AI constructor bots will know where they and each other are at all times.

They'll also learn as they go.

Construction firms are now using data to make better decisions, increase productivity, improve jobsite safety, and reduce risks.

With artificial intelligence and machine learning systems, firms can turn the mountains of data they have collected over the years on projects to predict future outcomes on projects and gain a **competitive advantage when estimating and bidding for construction projects.**

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Artificial Intelligence

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1. Autonomous Machines on the Construction Site

- Perhaps the most common example of automation in construction is the use of autonomous machines.
- These are essentially **self-driving machines that can be used to transport materials across the work site and to haul heavy items without posing a risk to workers.**
- For example, machines can be fitted with robotic technology solutions and sensors that enable forklifts, diggers, trucks, and other similar equipment to operate without a driver in the cabin.
- With GPS capabilities construction site workers can remotely operate machinery and enjoy more efficient processes such as laying kerb stones.
- Consider day to day automated machines such as: lawnmovers and vacuum cleaners and of course automated self drive cars. All these use sensors and software to control.

Robotics Rawpixel.com

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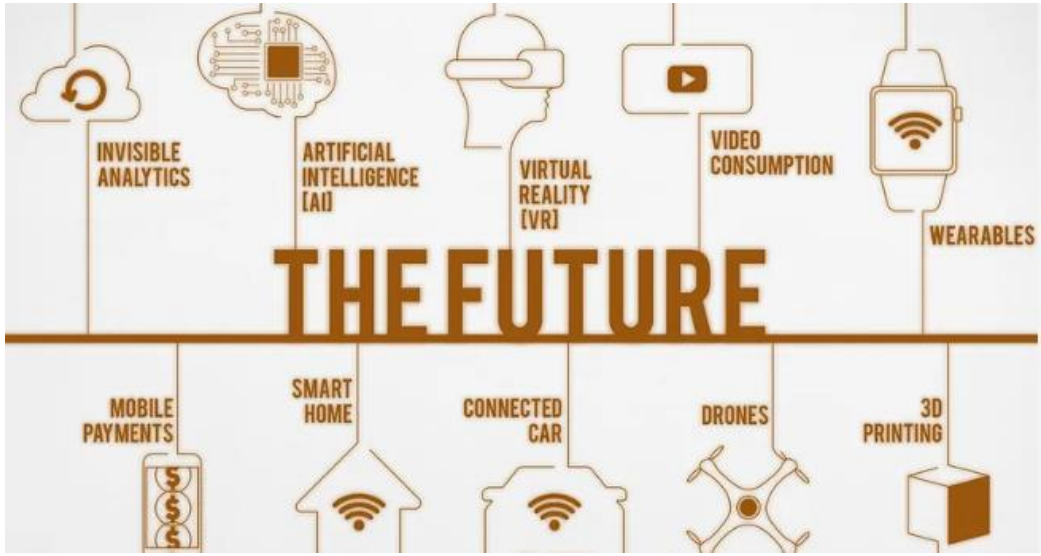
2. IoT Sensors to Collect and Process Data

1. Sensors are key for automation.
2. These devices take real-time readings of location, temperature, pressure and other conditions.
3. Sensors allow construction companies to automate many different machines and robots according to their preferences.
4. Sensors can transmit signals to machines to trigger a specific action. For example, automation is typically achieved in welding and fabrication machines through the use of sensors.
5. These sensors collect important environmental data that can be used to trigger a relevant action in the welding machine.



The Future Connected Drones Technology Concept. Rawpixel.com

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3. Drones

Drones are being used on site in a number of ways:

1. Conduct daily site inspections and **identify potential hazards** each day.
2. **Monitor the safety of workers** throughout the day
3. **Take photos of the progress of work** to create as-built models of sites to keep everyone informed of developments.
4. Conduct **pre-project inspections** and other important site monitoring activities.

Autonomous drones and rovers are equipped with high-definition cameras with LiDAR to **photograph and scan the construction site each day** with pinpoint accuracy. Artificial Intelligence, AI then uses those scans to compare against the BIM models, 3D drawings, construction schedule, and estimates to inspect the quality of the work performed and to determine how much progress has been made each day

Drones can also be used for pre investigation of a site, to determine where services are, topography and levels of the land and if there will be any transport issues

Artificial Intelligence

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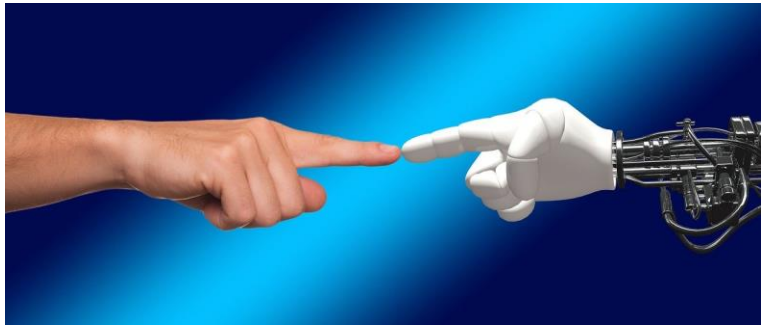
4. Robots

Current robots are good at doing simple, repetitive tasks – such as bricklaying, rebar tying concrete works or demolition.

- Once set up, these robots can work faster and continuously without stopping.
- In both these examples, humans are still needed to perform some of the work.
- Both still require workers to set up the robots and get them started.
- For the **bricklaying robot**, a mason is needed to oversee the work, ensure bricks are correctly placed and clean up the mortar after they've been set.
- The **rebar tying robot** still needs humans to correctly place and space the rebar before it gets set in motion.
- **Concrete works robot** are being used to mix concrete, lay the cement, polish floors, and remove surface water.
- **Demolition robots** are being used to bring down walls and to dismantle concrete slabs.

- Instead of replacing workers, most construction robots are there to aid and augment a worker's performance, enabling them to be more productive

Image: NCCR Digital Fabrication



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Extended Reality

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5. Virtual Reality (VR)

- **VR allows for construction companies to plan for a project even before they lay down a single brick.**
- Virtual reality simulates a realistic environment that allows workers to interact with a particular structure using a series of 3D scanned images. Workers can interact with a computer-generated simulation 3D image (both auditory and visually) using special electronic equipment, such as a helmet with a screen inside or gloves fitted with sensors.
- **VR paired with BIM will lead to better collaboration and communication.** Most virtual reality applications are using BIM models as the basis to create virtual environments.
- No matter how accurate drawings or concept renderings are, there's no better way of seeing how a project will turn out than an accurate, detailed virtual render viewed with virtual reality technology.

For example, workers can virtually crawl through pipes in the building to determine if they have enough room for repair and maintenance.

Example of VR Source: Duurzaam Gebouwd

Extended Reality

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6. Augmented Reality (AR)

- AR is the incorporation of a computer-generated image on a person's view of the real world. It provides a view of both what the world and work actually looks like and what it could look like.
- With AR, a project manager or contractor could walk through a construction site and easily view an overlay of a BIM model on top of as-built construction and compare the two.
- At the same time, they could be accessing checklists completing a daily report using a heads-up display.
- The project manager could instantly take photos or record the augmented reality walkthrough and send it back to the design team for clarification as issues arise.

- The most popular augmented reality wearable in construction is the Microsoft HoloLens, but there are a growing number of companies developing their own wearables.

Example of Microsoft HoloLens (www.microsoft.com/en-gb/hololens

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Training

- The worker can use VR in training simulation to get more skilled in a certain task or when a project task is complex or time sensitive. Workers need extra training for using VR effectively.
- Safety training and equipment operator training are two areas where Virtual Reality (VR) could have a strong impact on the construction industry. With VR, workers could get exposure to situations such as confined spaces or working at height in a safe, controlled manner.
- Augmented Reality (AR) is another technology that can greatly improve safety on the construction site. Whether it's allowing for a more detailed safety plan to be developed or providing training on heavy equipment using actual equipment on real sites with augmented hazards, there are a number of ways that AR can be deployed on the jobsite.

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Other advances on site technologies

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Wearables

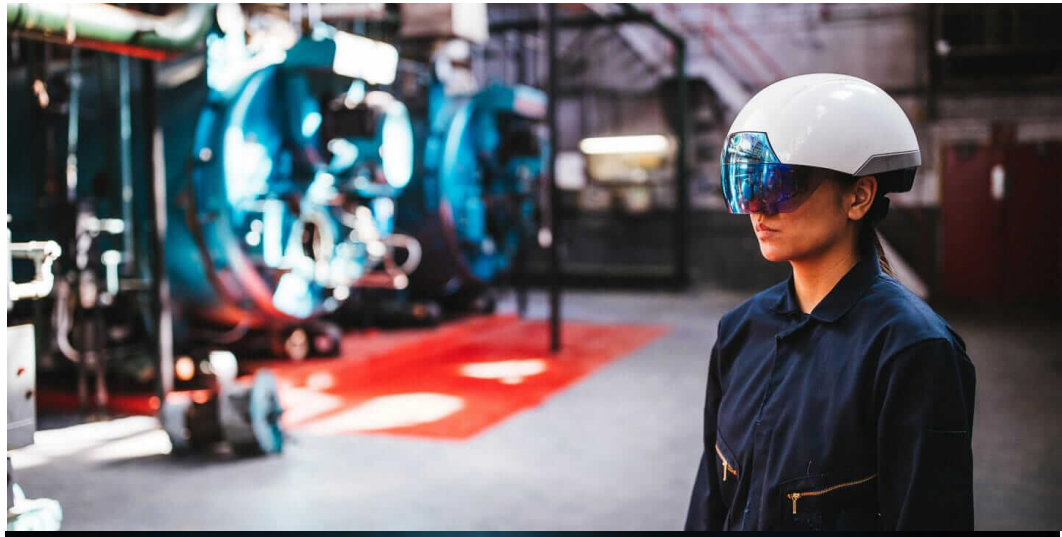
Wearables are something every project manager should be looking at. From smart helmets and smart glasses to smart vests with GPS and bionic suits that enable super-strength.

Tool Tracking Devices

Trackers consist of a small attachment that can be glued, screwed or strapped to your tools, which allows you to locate your tools using an app on your smartphone.

New Materials

Some examples include self-healing concrete that uses bacteria to mend its own cracks, super strong, ultralight nanomaterials, a top mix permeable cement alternative and the super-transparent insulating material aerogel.



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Discussion

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Discussions

- Discussions on relevance to site works
- How these can be used to improve productivity and quality

  - Digital on site – Lean Construction and Green Deal
  - Digital tools - IoT, Mobile Solutions and BIM
  - Artificial Intelligence – Drones and Robots
  - Extended Reality (VR and AR)

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Automation

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- Changes in the construction industry has led to workers needing to learn to work side by side with machines.
- Benefits include more efficient on-site construction, allows project teams to eliminate mistakes and better coordination of the workforce.

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Automation

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3 primary opportunities for **automation** in construction:

1. **Digitization** - and the subsequent automation of design, planning, and management procedures, For example, building information modelling—which essentially brings together the designers, coordinators and general contractors to identify clashes before they move to the site—makes the planning process more efficient.
2. **Physical tasks** – automation of what are considered traditional physical tasks on-site—for instance, robots laying bricks and machines paving roads.
3. **Production** - comes from the automation of modular construction produced in factories, including 3-D printing of components such as facades and window details to reduce thermal bridging.

In a nutshell, it makes the on-site execution more efficient, allows project teams to eliminate mistakes and better coordinate the workforce.

What impact will automation have on work for builders?

1. A substantial shift to modular construction off-site could have a significant impact on the construction workforce, but the transition will take decades. **Producing individual components, or modules, in factories lends itself to much more machine use than what can be done on-site.**
2. This means **workers will need to learn to work side by side with machines.** For example, even the average construction worker will be expected to use a tablet to access building plans or operate a drone in place of doing a physical site walkthrough.
3. Automating more of the construction process could also help **deliver infrastructure and buildings faster** — without needing to reduce headcount. In the long term, automation is likely to increase productivity

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2. Off site technologies

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Offsite and modular construction

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- Offsite and modular construction fundamentally changes the approach to the design and build.
- It refers to construction carried out in a workshop/factory specifically designed, with individual modules or components of the building assembled in the factory and then transported to the site. It can be used for both new build and retrofitting.
- Minor finishing works are completed on site such as joints between each modular section.
- Offsite and Modular Construction delivers low-carbon prefabricated buildings and can reduce the embodied energy of a building by up to 30%, as well as provide accurate quality detailing.

Benefits include:

- Efficiency and Predictability
- Quality Assurance
- Sustainability
- Streamlined Scheduling

Examples of modular offsite construction projects

Modular Construction

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https://youtu.be/ItCToQSSdhQ

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3D Printing

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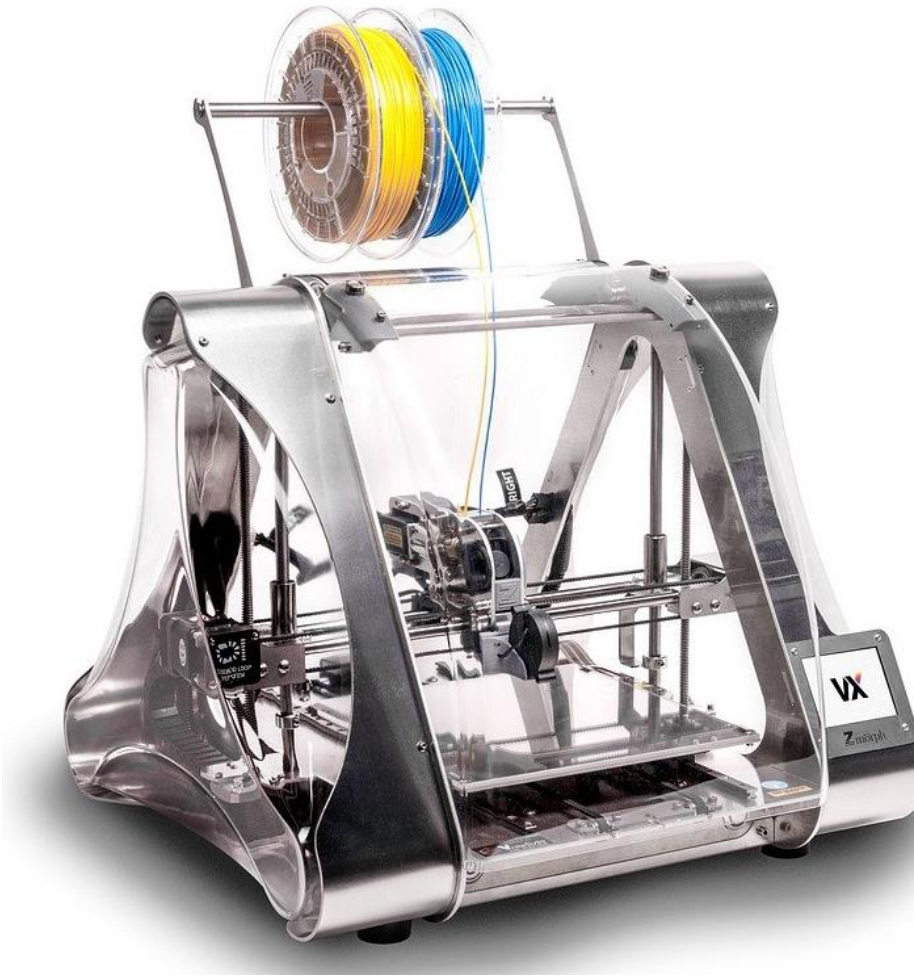
In some cases, walls are built in sections and trucked to a site where they are assembled. Other systems do their printing on site.
Materials used can be recycled products, such as a concrete material made from sand and recycled tiles.

Advantages of 3D printing includes:

1. Reduced injury of workers on site
2. Reduced material costs
3. Faster construction
4. Cheaper to build

3D printers are ideal to create elements of the build such as thermal breaks for windows or even complete windows omitting thermal bridging. Although these need to be installed on site by workers, it is likely to ensure quality improved detailing.



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3D Printing

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https://youtu.be/9FKDAb4R4B4

What is the future in construction?

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- Construction companies are starting to come around to technology adoption. Companies that are researching and using construction technology are reaping the rewards with increased productivity, better collaboration, and completing projects on time and under budget—resulting in higher profit margins.

- **We have got to the point where companies that are not investing in new technologies and solutions are no longer staying competitive, whilst those that are strategically adopting and using technological solutions are moving forward.** Construction companies that continue to refuse to innovate are destined to die.

- To stay ahead, all professionals and workers need to be trained or upskilled in NZEB and Green design, innovative technologies, new installation techniques and digitalisation.

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Discussion

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Discussions

- Discussions to explain relevance to site works
- How these can be used to improve productivity and quality

  - Automation – opportunities, impact for workers
  - Off site construction – modular construction, 3D Printing
  - Future of construction

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Assessment

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