Civil Engineering in the 21st Century. Words – Menelik Eshetu.

Civil engineering is one of the oldest engineering disciplines that came after Military engineering. Throughout history, it was crucial for the advancement of physics and mathematics. Its sub-disciplines which include structural, materials science, soil, hydrology, environment etc. have impacted society by solving problems and helping other fields to gain momentum and create many of the innovations we see today.

In recent years, the civil engineering world has continued to inspire new technologies. From using computer programs to minimise tedious work to GPS and satellites for gathering large quantities of information on construction sites. The innovations in current times are helping civil engineers take things to another level; they are enabling the use of drones, 3D printing, cloud collaboration, Virtual Reality (VR), robots and many more.

The following analysis describes how certain innovations are being integrated with civil engineering and how using them can make civil engineers' jobs much easier.

Drones

The utilisation of unmanned aerial vehicles (UAVs), otherwise known as drones, has grown rapidly over recent years. Previously, ordinarily used in the military, the benefits of using drones have becoming significantly clear to other sectors. Industries including agriculture, exploration of resources, surveying, and mining have realised the benefits of surveying and inspecting via drones/UAVs. The filming, advertising, and sporting industries are also a beneficiary of this innovation. It is also worth mentioning that search and rescue operations are usually aided with drones too.

Obviously, civil engineering is another industry to notice the huge potential in using drones in construction. With construction companies realising that drones can assist with activities such as site inspection, planning and health and safety - using drones has become inevitable on construction sites.

Drones can be used to quickly and efficiently survey sites and build maps; this service drastically reduces the need for human resources, heavy machinery and expensive surveying equipment enabling a more efficient allocation of personnel. It means projects are completed in less time, with less money and with more accurate results.

They can also be used to show clients progress of a project and keep the project both on track and in budget.

Drones are able to survey large areas and point out potential hazardous situations, high risk areas and increase safety where different projects are taking place. Unstable structures can be inspected without placing workers at risk. This has immense value for locations that are hard to reach such as tall buildings, on or under bridges and along busy highways.

Drones can monitor construction sites, especially large sites or those spread out over several locations, often more quickly and efficiently than on-the-ground construction workers. Drones can be equipped with infrared cameras, radar and other technology that enhances their surveillance capabilities which allows them access and to determine the integrity of structures; Identify problems before they develop through the use of maintenance assessments; Facilitate communication and surveillance which means information can be shared with personnel on site, in headquarters and with clients; And Increase the scope and frequency of inspections. Drones are being developed that incorporate X-ray technology and could create high-res 3D maps. This technology will be used to create accurate models of unknown areas behind walls or for structural monitoring of dangerous buildings, bridges, structures.

Not only tracking of construction progress is possible with drones but also tracking workers, equipment, and material on a site without disrupting ongoing activities. Drones are a cost-effective and efficient way to perform site inspections.

Drones in civil engineering can add value to every phase of a project. Starting from the surveying phase, it goes along to the design phase, the construction phase and all the way to the completion of a project. The ability for project stakeholders to have accurate, real-time project data throughout all phases means that collaboration is more efficient, which helps identify and mitigate obstacles as they arise, saving time and money.

Drones operator can work from a considerable distance and do not need to worry about natural or artificial barriers to the line of sight. And the information gathered from drones can serve for various purposes. They can be transmitted, shared and printed. Software can turn them into topographical maps, heat-maps and more.

There is another huge plus for using drones - battery-operated drones produce no toxic fumes. This makes them environmentally friendly machineries on construction sites.

Considering as to the variety of ways that drones can be used to help keep workers safe, they could soon be as common on construction sites as excavators and trucks. As drone technology continues to advance, their usage in the construction industry is only expected to increase, especially if they can continue to improve worker safety, overall efficiency and reduce costs for contractors. The drone will soon dominate a lot of construction engineering projects because of its practicality and affordability.

But even though drones have huge positive impacts, a few years ago there were some obstacles and hesitancy in using them on construction sites. And it was largely because the quality of drones available at the time were not adequate - high quality drones were expensive and required significant training. Today, drone technology has advanced far beyond and has overcome the hesitancy and is seen as a major tool in the engineer's toolbox.

There are also some fightbacks from the surveyors' community that drones can capture much of the exterior of a building and dodge the need for skilled surveyors and their laser scanning equipment. However, drones are there to complement surveyors on their existing skillset by offering new insights. Furthermore, even maps and models created with drone data will require official signoffs from licensed surveyors. Therefore, drone and surveyors should work hand in hand together to gain the great advantages of drones for surveying.

Basestone

BaseStone is a UK based cloud collaboration tool that is use by civil engineers. Built for construction teams to access, gather and communicate information, Basestone is available online and over the phone which allows real time and remote sharing of data on construction projects. Throughout the project, BaseStone digitizes and streamlines processes for better project delivery; it makes review processes much faster and helps construction teams have improved collaborations.

Basestone is a cloud-based construction management application suitable for different purposes. It offers on-site data capture, accounting, project management and a mobile app for iOS devices which can be handy especially on construction sites.

It also has an offline mode; if an internet connection is not available; data is backed up and saved so it can be exported and downloaded when a connection is available.

Problems or concerns can also be linked to locations on drawings with Basestone. These issues then can be reviewed by other team members and comments or solutions can be communicated back without the need for the team members to meet.

BaseStone can generate schedules, problem reports, and streamline site-based tasks and workflows. BaseStone ensures that general contractors, construction managers, project managers, superintendents, subcontractors, architects, engineers and owners have the right information in their hands at the right time. This advantage gives visibility over issues as they are raised and resolves them faster - reducing the risk of delays and unproductivity.

BaseStone provides construction professionals, project managers, and other stakeholders with a centralised hub where they can securely store and access information like project documents, files, and much more.

3D Printing

3D printing (formally known as Additive Manufacturing (AM)) is a manufacturing process that builds layers to create a three-dimensional solid object from a digital model. It is particularly useful for prototyping and for the manufacturing of geometrically complex components. 3D printing is increasingly being used in different areas. In medical, 3D printing is now utilised to create high quality bones for the purposes of transplants. 3D printing is also valuable in creating human tissues such as artificial blood vessels that can be used in coronary bypass surgery. Dentists are using 3D printing to create a plaster model of the mouth or to replace patient's teeth. Architectural modellings are one of the major areas that are using 3D printing for developing prototypes to facilitate the communication between architect and client. In aerospace and automotive field industry - 3D printing has numerous contributions too.

In the construction industry, 3D printing can be used to create components or to print entire buildings. Construction is well-matched to 3D printing as much of the information necessary to create structures exists from the design process. Recently, the development of Building Information Modelling (BIM) in particular may facilitate greater use of 3D printing.

3D printing may allow faster and more accurate constructions of complex structures as well as minimising labor costs and waste. It might also enable construction to be undertaken in harsh or dangerous environments not suitable for a human workforce such as on the moon or Mars.

The potential of this innovative building technique resides in the freedom to create any geometrical forms without the usual constraints. Rebuilding whole cities after a natural disaster, giving shelter to homeless people, and building more sustainable habitats are only few problems that 3D printing can assist with.

3D Printing in the construction industry means greatly reduced production time. That is because the machines themselves are extremely fast, some of them are capable of manufacturing 600 to 800-square-foot (55 to 75-square-meter) homes in just 24 hours.

Also, 3D printers do not use additional tooling. They have the construction programmed and they just produce it, there is no need for additional support, different materials, and other aspects that traditional methods require. The main advantage of using 3D printing in the construction industry is cost reduction from material waste. That's because a 3D printer uses exactly the amount of material they need. Not only that, but they are also capable of using recycled materials which also benefits the environment.

As mentioned above, using 3D printing allows for less material usage and involves fewer people to work on constructions. 3D printing is also a much faster technology. Those factors drastically reduce the costs of building structures. 3D printers also reduce supply costs and their working hours of the printers are more adjustable - good news for clients and construction contractors.

The other key benefit of using 3D printing in the construction industry is all the innovative solutions it brings. 3D printing allows for mass customisation and complex shapes that cannot be produced in other ways. 3D printers can be designed to use solar, wind, or hydro powers providing green construction projects. They also enable regions that don't yet have access to electricity to print environmentally friendly structures with local resources. Since 3D printing now allows structures to be created more quickly, it is ideal to combat the housing crisis.

However, unlike 3D printing applications in other areas, structures in the civil engineering world are at a much larger scale. They are subjected to complex forces throughout their lifetime which includes different types of loadings, gravity, wind, seismic, etc. Therefore, it is challenging to develop suitable printers and materials. Yet the integration of 3D printing with civil engineering looks promising.

Virtual Reality (VR) and Augmented Reality (AR)

Before seeing how VR and AR are changing the civil engineering world, it is essential to know the difference between them. Augmented reality (AR) adds digital elements to a live view often by using the camera on a smartphone. Examples of augmented reality experiences include Snapchat lenses and the game Pokémon Go. But Virtual reality (VR) implies a complete immersion experience that shuts out the physical world. Using VR devices such as HTC Vive, Oculus Rift or Google Cardboard, users can be transported into a few real-world and imagined environments. While VR is more immersive, AR provides further freedom for the users.

One of the biggest impacts **AR** has had on the architectural and construction industries is the ability to more realistically visualise a project. It blends the user's real-world environment with virtual renderings to be viewed on a screen. A lot of people have trouble visualising an end product from a set of 2D drawings, while a 3D model can help people see the product itself. AR, ontheotherhand,projectsvirtualimagesintotheuser'slineofsight,and has the potential to be used on-site as a tool for creating the structure exactly as a design intended. This could greatly speed up construction projects and minimise the number of errors made during building processes.

Augmented reality data can be fed to the virtual reality model in real-time so that inventory is tracked and updated on the model. The reverse is also possible, where the virtual model feeds data to the smart device to provide reference information directly to contractors.

VR is proving to be an effective planning and visualizing tool. By providing an immersive virtual environment, engineers and architects can get a better sense for a building before it is physically constructed which enables them to make more informed and accurate design decisions. Using a combination of Building Information Modeling (BIM) technology and immersive VR headsets - architects, project managers, engineers, and others involved in the project can identify design flaws and plans before building activities takes place. The more

information that can be input into the virtual reality model in terms of not only architectural features, but also structural, mechanical, plumbing, lighting, etc., the more informed the interaction can be between the project team and client.

By being able to perform risk assessment in buildings during the design stages such as fire safety, it could end up being a vital component of virtual reality simulation. A great deal could be learned from how people evacuate spaces in simulated emergency situations. Even after a building has been completed, the potential to simulate evacuations in emergency situations could be a major benefit of this **VR** technology.

Virtual reality can allow construction teams to get involved in the design phases of a project. Contractors can supplement new perspectives on designs and reduce any issues that may occur. Not only will the construction team be able to provide a new perspective early – but potential savings can be significant because coordination issues are resolved early on.

Before construction even begins, virtual reality models offer contractors or construction managers an opportunity to plan for every stage of construction. This saves time and makes the whole process more efficient. In addition, construction scenarios can be explored well before the beginning of work. Equipment logistics and material needs can be pre-identified too.

For VR and AR to become integral parts of the design and construction of buildings, the technology needs to seamlessly integrate with the software most used by design professions, namely CAD and BIM. As the level of demand and complexity in modern building continues to increase; embracing AR and VR, along with other innovative technologies will be key. We need to start taking better advantage of the new, impactful tools and resources at our disposal. Today, construction is up against increased regulatory complexities, a growing demand for building efficiency and diminished environmental impact, therefore, adapting and integrating new innovations like the above to enhance the way we design and operate in the civil engineering industry will be rewarding and essential.