ASSESSMENT OF INFORMATION AND COMMUNICATION TECHNOLOGY (ICT) AND ITS VITAL ROLES IN CIVIL ENGINEERING: THE INNOVATIVE ADVANCEMENT IN THE 21ST CENTURY

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ABSTRACT

This paper carefully assesses the impact of ICT on civil engineering. Information and communication technology is playing a vital role in virtually every field of human operation, such as the education sector, medical field, banking sector, agricultural sector, field of engineering, and more. Information and communication technology has substantially eased operations in several fields and helped to save resources like labor, cost, and time. It has also helped to drastically increase the speed at which work is done. It also reviewed the impact of information and communication technology in civil engineering practice and examined operations such as the construction industry, road transportation industry, engineering education, structural engineering, energy efficient buildings, building preservation, and engineering design. Information and communication technology is seen to be very relevant for sustainability in civil engineering practices across literature. It was on this basis that the paper concluded that researchers are developing visual simulations of the construction process each day, which is regarded as a significant step forward for the perfection of design. It challenges the existing methods of evaluation that are often more laborious and time-consuming. The success stories of utilizing ICTs in developed countries have drawn the attention of researchers in developing countries like Nepal regarding the beneficial effects of using ICTs in construction processes. The uses of technology in construction require complex and expensive solutions. Although its initial cost is more significant, the use of ICT is found to have long-term benefits in the construction process. One of the recommendations was that it is important to note that in order to ensure that civil engineers become ICT literate and well acquainted with ICT aided services in civil engineering, higher education institutions should integrate vital ICT topics in the courses in the civil engineering program as this will help prepare them and as well equip them for the task of modern civil engineering.

KEYWORDS: ICT, Civil Engineering, Innovative Advancement and 21st Century

Introduction

Almost every aspect of human activity, including the fields of education, medicine, banking, agriculture, engineering, and more, is impacted by information and communication technology. Information and communication technology has made a significant difference in how many industries operate and has helped to conserve resources including labor, money, and time. Also, it has significantly accelerated the pace of work. The building industry has undergone an industrial revolution worldwide thanks to information technology (Ramli and Mesir, 2014). It has resulted in general improvements in the cost, timeliness, quality, and customer satisfaction of construction processes. ICT can now be included into various stages and procedures of a construction project. The pre-design, design, development, operation, and maintenance phases of building are all represented by the construction processes in this context. The collaboration between the customer, contractor, and engineer is improved by the use of ICT. Information technology has brought an industrial revolution to the construction process throughout the world. It has resulted in general improvements in the cost, timeliness, quality, and customer satisfaction of construction processes. ICT can now be included into various stages and procedures of a construction project. The predesign, design, development, operation, and maintenance phases of building are all represented by the construction processes in this context. The customer, contractor, and engineer can work together more effectively by using ICT for coordination and other processes (Ahmad, 2014).

Statement of problem

Implementing ICT is more difficult than it should be due to a number of persistent issues, including insufficient awareness of IT and its advantages, price increases for IT equipment as a result of government regulation, and new technology that necessitates learning new skill sets. Collaboration is necessary for the timely, cost-efficient, and successful execution of a construction project. Collaboration relies heavily on ICT efficiency throughout the project life cycle. A project involves a large number of individuals. It becomes harder to plan and manage this communication process as the population grows. All project information is gathered into a single database and distributed to the appropriate parties using a sophisticated project information management and sharing system, fostering greater collaboration.

Concept of ICT

Information and Communication Technology' (ICT) first appeared in the mid-1980s and was defined as "all kinds of electronic systems used for broadcasting telecommunications and mediating communications", with examples including personal computers, video games, cell phones, the internet, electronic payment systems, computer software, etc. ICT is made up of computer and communication technology. Computer technology is the tool for storing and processing information in digital form, while communication technology helps us transfer and disseminate digital information. Information and communication technology (ICT) may be defined as the convergence of electronics, computing, and telecommunications. It has unleashed a tidal wave of technological innovation in the collecting, storing, processing, transmission, and presentation of information that has not only transformed the information technology sector itself into a highly dynamic and expanding field of work that not only opened up

new markets and brought in new investment, income, and jobs but also gave other industries faster and more effective ways to adapt to changes in demand patterns and shifts in global comparative advantage through more effective manufacturing techniques and new and improved products and services (Sage, 2012). Today, almost every industry is included in the concept of information and communication technology (ICT), which has grown significantly. Every industry that conducts everyday business relies on information and communication technology professionals, including manufacturers, merchants, banks, and publishers, as well as research organizations, medical facilities, law enforcement agencies, public utilities, and libraries. ICT is consistently defined as the following by dictionaries: running a computer network; making original web pages; making digital videos; consulting on computer system design; selling goods online; creating 3-D artwork; running a company's database; writing software; offering technical support; managing projects and budgets; and writing technical documentation. Information and communication technologies are combined to produce ICT.

Concept of Civil Engineering

Civil engineering is a professional engineering discipline that deals with the design, construction, and maintenance of the physical and naturally built environment, including public works such as roads, bridges, canals, dams, airports, sewage systems, pipelines, structural components of buildings, and railways. Civil engineering is traditionally broken into a number of sub-disciplines. It is considered the second-oldest engineering discipline after military engineering, and it is defined to distinguish non-military engineering from military engineering. Civil engineering can take place in the public sector, from municipal public works departments through federal government agencies, and in the private sector, from locally based firms to global Fortune 500 companies (Wikipedia, 2022). Civil engineering is the application of physical and scientific principles for solving the problems of society, and its history is intricately linked to advances in the understanding of physics and mathematics throughout history. Because civil engineering is a broad profession that includes several specialized sub-disciplines, its history is linked to knowledge of structures, materials science, geography, geology, soils, hydrology, environmental science, mechanics, project management, and other fields (Baveystock, 2013). Throughout ancient and medieval history, most architectural design and construction was carried out by artisans, such as stonemasons and carpenters, who rose to the role of master builders. Knowledge was retained in guilds and rarely supplanted by advances. Structures, roads, and infrastructure that existed were repetitive, and increases in scale were incremental. One of the earliest examples of a scientific approach to physical and mathematical problems applicable to civil engineering is the work of Archimedes in the 3rd century BC, including the Archimedes Principle, which underpins our understanding of buoyancy, and practical solutions such as Archimedes' screw. Brahmagupta, an Indian mathematician, used arithmetic in the 7th century AD, based on Hindu-Arabic numerals, for excavation (volume) computations.

Impact of ICT Civil Engineering

Using Drones for Surveying Land: Most people who have flown drones know that they are a great tool for capturing aerial views and conducting drone inspections. But did you also realize that another use of drone technology is land surveying?

Civil and geotechnical engineers have found a new use for drones by using them to survey land. They have found that unmanned aerial vehicles provide a quick and safe way of measuring out large tracts of land for surveying purposes without risking human life by sending people into harm's way or into treacherous terrain. In rock blasting applications, engineers are able to conduct surveying from a distance to avoid exposure to blasting areas. These unmanned flying machines can map the earth's surface with incredible accuracy, so they're being used more and more often in surveying. Drone usage is most prevalent among construction managers, who are able to quickly assess their worksite while avoiding hazards such as heavy machinery or scaffolding that pose safety risks not only for themselves but also for others around them (Damkor, Irinyang, and Haruna, 2015).

In addition, in an effort to find new ways of dredging, civil engineers may have found a solution that could help make the process less labor-intensive. In many industries (such as mining), dredging is often done by hand and can be difficult work for those who are involved in this kind of manual labor on site. However, with the use of drones, there has been significant progress in dredging while also reducing costs significantly when compared to traditional methods, which require more manpower than necessary just to get the job done.

Designing Structures with CAD Software: The tools of today's civil engineers are far more advanced than the tape measures and graph paper they used in years past. The work has also become much less tedious with time, thanks to computer-aided design software. With state-of-the-art CAD software, civil engineers can design structures that are more efficient and cost-effective. Civil engineers can now create and manufacture designs for machine parts, tools, buildings, and other structures with more accuracy thanks to computer-assisted drafting (CAD) programs like Autodesk Inventor Fusion 360. These highly sophisticated tools allow users to plan out their creations and prototypes digitally in a 3D space that gives them complete control over every detail from start to finish, including making changes on the fly as they please without having any fear of destroying materials or wasting time by needing physical prototypes first (Sebastian and Jochen, 2014).

Enabling Remote Sensing Via Cloud Technologies: Remote sensing is one advance that allows for remote monitoring on-site with minimal interference from physical presence. Civil engineers can now monitor construction progress from the comfort of their homes thanks to remote sensing technology. For example, they might use a thermal camera to detect hot spots on underground pipes or send an unmanned aircraft system into the airspace over the site for aerial views and photographs. Civil engineers can use remote sensing to monitor the progress of a construction project without being physically present for any part of it. They'll be able to see what's happening in real-time through live video feeds or take pictures and videos with drones that fly around, taking photos from all angles. But let's not forget, remote sensing would not be possible if it weren't for today's mobile and cloud technology. Cloud technology enables the possibility to

access, modify, and manage data stored on remote servers. Both mobile and cloud technologies allow data sharing in real-time to all participants in any building construction process for improved collaboration and information sharing.

Connecting Devices in Cities- Internet of Things (IoT)-Enabled Sensors: In today's industries (oil and gas, manufacturing, food, dairy, etc.), civil engineers are not only responsible for designing and building infrastructure that sustains us but also creating automated systems to help make our lives easier (Mehdi, 2012). This is why the term "Industry 4.0 has been coined: it focuses on improving production efficiency by allowing automated machines to communicate with each other without human intervention using sensor networks connected via the Internet of Things (IoT). The internet of things is one step closer to reality. As more smart devices become interconnected, this opens up a whole new level of innovation that will change everything about how we live and work in our city. Smart factories (aka "factories of the future") can reduce operating costs while generating quality products at a faster rate than traditional methods used before Industry 4.0 was introduced because they use sensors embedded into machinery that collect real-time data through machine learning algorithms, so there's no need for humans to work long hours or shifts over.

But let's go back to IoTs. It's a fact: civil engineers have been hard at work connecting new technologies to our cities by way of connected smart objects, aptly referred to as the "IoT." With the use of PLCs, HMIs, and SCADA, these IoT-enabled sensors can tell engineers things like how much water a pipe is carrying or what the traffic volume looks like on any given day, for example. Building sensors into these structures allows civil engineers to monitor them easier than ever before from anywhere on earth using modern communication technologies such as cellular phones and satellites. One application that can really make a difference for natural disaster relief efforts and disaster restoration, such as earthquakes or floods, would be IoT-enabled sensors with predictive analytics features. Using IoT methods can help save billions of dollars per year lost due to damages caused by natural disasters because it would allow disaster relief crews faster access.

The Use of Building Information Modeling (BMI): Professional civil engineers are in high demand, and the business of building information modeling (BMI) is booming. BMI technology has been around for at least 15 years now, but it's only recently become a household name among civil engineering professionals as they've had to deal with increasingly complex projects that have required more data visualization technologies than previously existed. Interestingly enough, many people who use this type of software don't even realize it was created by civil engineers. Civil and structural engineers are using Building Information Modeling (BMI) and data visualization technologies to create more efficient and sustainable buildings. This is an advanced system that helps keep track of all parts involved in constructing buildings through various means, like cameras installed throughout the site and data gathered from sensors embedded within materials used during each stage. With Building Information

Modeling (BIM) technology dashboards, civil engineers can monitor everything about their project at all times throughout every step of its development process. This technology also allows experts to review project results in real-time, enabling better collaboration. BMI dashboards help building owners, investors, developers, contractors, and regulators stay informed about every detail related to their project, from site analysis data like soil types or geological conditions, for example, right down to individual components that go into constructing the actual structure itself, such as steel rebar size requirements or required spacing between posts on an exterior beam wall system. BMI is the perfect support for clash detection and problem-solving during design, which improves planning and increases efficiency.

The Use of Big Data: Historical big data can pick out patterns and probabilities of risks, increasing safety. Big data from weather, traffic, and the environment can determine the optimal phasing of activities to improve efficiency. Big data is a term used to describe extremely large data sets that can be used to uncover hidden trends, patterns in behavior, and unknown correlations. Civil engineering has been around for a long time, but now they have access to more powerful tools than ever before—in this case, "big data." Civil engineers are always on call during major storms or earthquakes; however, today's civil engineer is much better equipped at assessing their impact thanks to all that information swirling about. Civil engineers use big data to forecast the behavior of natural disasters and assess their environmental impacts. Big data is important for construction technology because it can help uncover hidden trends and patterns in behavior that might not be seen with a small sample size. Bigger samples allow us to make more informed decisions about the way we use our resources, which leads to an increase in productivity within any industry (Aimie, Graham, and Christine, 2015).

The Use and Development of Water Conservation Technology: Civil engineering has developed different and innovative water conservation technologies, from residential and commercial solutions to systems used nationwide. The average American residence consumes more than 300 gallons of water per day, which translates to nearly 110,000 gallons per year (most of it from daily hot showers). When you factor in all of your multi-tenant buildings, that’s a lot of water. Thankfully, engineers and designers have developed many viable tactics and water conservation methods for reducing water consumption and correcting water meter inaccuracies in ways that will have a real impact on your bottom line. Some examples include: shower flow controllers, leak detection systems, toilet leak prevention devices, and water flow management devices. Innovation often comes as small ideas like these form into larger concepts with potentially huge impacts. For example, the elimination of excess is so important in our current drought conditions that the use of these new inventions could be a solution to this problem. Similarly, civil engineers have been working tirelessly for years on developing sustainable and efficient technologies relating to water sustainability, but their work may finally pay off as we face one of the worst droughts in recent memory nationwide, with California being most severely impacted by it all due largely to its

reliance on agriculture, which requires copious amounts of irrigation. This means there's more need than ever before for people to look at ways they can conserve water without cutting into production or lifestyle quality whatsoever if possible, or to wait patiently until things get better again if that's not possible (Yuan and John, 2018).

Develop 3D Printing Solutions: Civil engineering and 3D printing are two of the most important innovations in construction technology. These techniques have both changed how buildings, bridges, roads, dams, etc., can be constructed with an efficiency never before possible. A well-known example is that today's modern skyscraper could not even exist without it! 3D printing enables civil engineers to prefabricate ready-to-use materials, either offsite or directly on site. Large-scale 3D printing is used today to create houses, bridges, and other structures that would have been difficult or impossible before. Civil engineering has come a long way since the days of clay bricks (Sebastian and Jochen, 2014).

The Use of Digital Marketing: The field of civil engineering and digital marketing is a dynamic, evolving one. The two fields overlap in an interesting way because both deal with the concept that information has value on its own merits. Civil engineers use math to determine how much material it would take to build bridges or design structures, while marketers analyze data about customers' buying habits, such as their age range and income level, to help companies find ways to attract new clients through targeted advertising campaigns. Today, civil engineers have been able to make a successful venture into inbound marketing and SEO (search engine optimization). The economic downturn has had an adverse effect on the civil engineering industry, causing many companies to lower their prices in order to compete for new contracts and jobs. In response, some of these firms have expanded into other areas such as website development, SEO optimization, or strategic inbound marketing campaigns that they may not have traditionally been involved with but that can still provide additional revenue streams (Ede, Oshokoya, Oluwafemi, Oyebisi, and Olofinnade, 2018).

Conclusion

Researchers are developing visual simulations of the construction process each day, which are regarded as a significant step forward for the perfection of design. It challenges the existing methods of evaluation that are often more laborious and time-consuming. The success stories of utilizing ICTs in developed countries have drawn the attention of researchers in developing countries like Nepal regarding the beneficial effects of using ICTs in construction processes. The uses of technology in construction require complex and expensive solutions. Although its initial cost is more significant, the use of ICT is found to have long-term benefits in the construction process. Nepalese contractors can save a considerable amount of Nepalese currency from foreign contractors by using new technology efficiently. Hence, developing countries like ours must realize the need for new technologies of information and communication in civil engineering prospects and break the technical crisis.

Recommendations

1. It is important to note that in order to ensure that civil engineers become ICT literate and well acquainted with ICT aided services in civil engineering, higher education institutions should integrate vital ICT topics in the courses in the civil engineering program as this will help prepare them and equip them for the tasks in modern civil engineering.

2. Civil engineers should have both general and some specialized ICT-related knowledge to be able to specify and participate in the development of new ICT tools and to be proactive in the process of changing work routines and company and project organization.

3. Regular maintenance of the constructed structures should be done using ICT.

REFERENCES

Ahmad, Y. (2014). *STAAD. Pro Version 2013 Training Notes- First Edition.* Faculty of Civil Engineering, UTM, April 2004, pp 1-2

Aimie, R., Graham, D. & Christine, P. (2015) Impact of information and communication technology (ICT) on construction projects. *Org. Technol. Manag. Constr (Electronic Materials*). Pp 1367-1382

Damkor, M., Irinyang, D. & Haruna, M. (2015). The Role of Information Communication Technology in Nigeria Educational System. *International Journal of Research in Humanities and Social Studies* (Electronic Materials) Pp 64-68.

Ede, A., Oshokoya O., Oluwafemi J., Oyebisi S. & Olofinnade O. (2018) Structural analysis of a genetic algorithm optimized steel truss structure according to BS 5950. *International Journal of Civil Engineering and Technology (Electronic Materials)* Pp 358-364

Mehdi, N. (2012) Mobile application prototype for on-site information management in construction industry. *Eng. Constr. Archit. Manag. (Electronic Materials)* Pp 474-494

Ramli, M. & Mesir, B. (2014) Civil Engineering Information System-3rd Edition. *ITUCE FKA,* Pp 75-80

Sage, A. (2012). Information Technology and Civil Engineering in 21st Century. *ASCE Talk.*

Sebastian, S. & Jochen, T. (2014) Mobile 3D mapping for surveying earthwork projects using an unmanned aerial vehicle (UAV) system. *Autom. Constr. (Electronic Materials)* Pp 1-14

Wikipedia (2022). *Civil engineering*. Retrieved from: https://en.wikipedia.org/w/index.php?title=Civil_engineering&oldid=1108124015

Yuan, C. & John, K. (2018) Using mobile computing for construction site information management. *Eng. Constr. Archit. Manag. (Electronic Materials)* Pp 7-20.