

PAPER • OPEN ACCESS

## Construction Digitalisation Tools In South African Construction Industry: An Added Advantage

To cite this article: O T Tanga *et al* 2021 *IOP Conf. Ser.: Mater. Sci. Eng.* **1107** 012230

View the [article online](#) for updates and enhancements.



**The Electrochemical Society**  
Advancing solid state & electrochemical science & technology

The ECS is seeking candidates to serve as the  
**Founding Editor-in-Chief (EIC) of ECS Sensors Plus,**  
a journal in the process of being launched in 2021

The goal of ECS Sensors Plus, as a one-stop shop journal for sensors, is to advance the fundamental science and understanding of sensors and detection technologies for efficient monitoring and control of industrial processes and the environment, and improving quality of life and human health.

*Nomination submission begins: May 18, 2021*



Nominate now!

# Construction Digitalisation Tools In South African Construction Industry: An Added Advantage

O T Tanga<sup>1</sup>, C O Aigbavboa<sup>1</sup>, O I Akinradewo<sup>1</sup>, D W Thwala<sup>1,2</sup> and M Onyia<sup>3</sup>

<sup>1</sup>cidb Centre of Excellence & Sustainable Human Settlement and Construction Research Centre, Faculty of Engineering and the Built Environment, University of Johannesburg

<sup>2</sup>SARChI in Sustainable Construction Management and Leadership in the Built Environment, Faculty of Engineering and Built Environment, University of Johannesburg, South Africa.

<sup>3</sup>Department of Civil Engineering, University of Nigeria Nsukka, Nigeria

\*e-mail: [opeakinradewo@gmail.com](mailto:opeakinradewo@gmail.com)

**Abstract.** The execution of the building project requires the assembling and accumulation of works at a large scale for it to become a reality. This involves the exchange of a large amount of data from one party to another. The development of information and communication technology (ICT) has therefore enhanced an active and proficient way of exchanging data among professionals. This research work set out to assess the benefits of using ICT tools by construction organisations in South Africa. A quantitative research technique was used through a well-structured questionnaire to collect data from construction professionals. They include construction project managers, civil engineers, quantity surveyors, construction managers, industrial, mechanical and electrical engineers. Standard deviation (SD) and mean item score (MIS) were used to analyse the retrieved data. The findings indicated that the most eminent benefits of ICT tools to construction organisations are effective communication management, competitive advantage and time-saving. This study recommended that construction organisations should provide lessons on different ICT tools uses to address each problem that will rise during the construction cycle and reap the full benefit of ICT such as improved productivity, increased speed, and diversification.

**Keywords:** Construction Industry, Communication, Information and Communication Technology, South Africa

## 1. Introduction

The construction industry requires a large number of participants to meet and work together as one body. This involves the exchange of a large amount of data from one party to another [1]. The bodies and participants in the construction industry are tenderers, contract managers, quantity surveyors, project managers, architects, engineers, town planners, land surveyors among others [2]. The execution of the building project requires the assembling and accumulation of works at a large scale for it to become a reality. Thus, construction requires a lot of tasks and works and therefore a good use of ICT tools is essential for the project to become fruitful in any construction organisation. Dawood [1] asserted that the project data communication among the professional team, suppliers, and



subcontractors has anciently been based principally on paper documents such as specifications, engineering and architectural drawings, schedule of materials and bills of quantities. Sheglabo [3] corroborated this by opining that this paperwork involves repetition, incessant change of information when translating and recording the data from one medium to another which might give room for loss of data.

The development of information communication technology (ICT) has therefore enabled communication between different members of the industry and enhanced an active and proficient way of exchanging data [4]. ICT is used in many building sectors to form a strong working bond and collaboration between parties and organisations. ICT is used in the organisation for training sessions of workers and learning platforms, the share of experience and exchange of data and coordination [5]. Furthermore, ICT contributes to the success of organisations' activities such as time and cost savings through enhanced coordination. This is because ICT provides quicker access to significant information, enhanced data storage, monitoring and safety, and enhanced client relationships through enhanced customer feedback and communication systems [6]. Therefore, ICT tools play a big role in the building industry that appears to be wide-ranging and can enhance the sector's competitiveness for small businesses. However, despite their prospective contribution, technological growth in the construction sector has fallen behind as compared to many other sectors, with the consequent use of ageing techniques. This research work set out to assess the benefits of using ICT tools by construction organisations in South Africa.

## **2. Literature review**

The introduction of ICT to the building sector has been very beneficial to the professionals and other parties involved [7]. This is because ICT tools have been highly automated [8,9]. Zachiang [10] submitted that archive and information management is still done traditionally although ICT is a profitable tool to accelerate work. The fundamental advantages accomplished by the utilisation of ICT is the expansion of work done, financial control, better exchange of information, less complex and quicker access to information and decreasing number of mistakes while identifying unrecognised issues in various activities [10]. Oladapo [8] and Oyewole [9] put forward that the ICT advantages to the building sector are to give the ideal opportunity for information handling and reduce the time for data exchange. Also, ICT improves productive decision-making exchange and coordination among different parties involved to upgrade construction profitability [11]. Highlighted advantages of ICT tools in the construction industry are explained as follows.

### *2.1. Collaboration improvement*

ICT tools are highly used to improve collaboration between professionals and the parties involved in the project. According to Villagarcia [12] and Ahuja [13], the exchange of information between organisations inside and outside the firm needs specialised techniques like electronic information exchange (EDI) to expand supplier's coordination since they shape the suppliers into a typical method for working. Bell [14] and Zhai [15] opined that electronic information management innovation helps to coordinate, streamline and simplify exchange between organisations, thereby supporting new methods of collaboration in various ways.

### *2.2. Diversification*

Diversification is simply defined as the enlargement of an organisation's products, markets, and services which is used for competition purposes [16]. An organisation's enlargement can be international or geographical diversification to numerous countries or nations. The construction industry uses ICT tools to deal with continuous external factor changes to avoid business disruption by preparing themselves for different environmental changes [17].

### *2.3. Internet as an Exchange Tool*

Using the internet as an exchange tool has a lot of benefits and advantages particularly in the project management fields [13]. Lu [18] discussed some benefits which are: cost-effectiveness, speedy data transfer, and the requirement to transfer a considerable amount of data between offices and sites.

O'Brien [19] and Ahuja [13] stated that the ICT website must give commonly accessible, centralised, solid methods for storing and transmitting project data in principle, improving project exchange and prompting better project activities. The advantages of such web-based tools have been recognised as decreased manual costs distribution, integration of project data, easy controlling of access rights, recording data and documenting, consistent access to extend data, and negligible programming necessity. Furthermore, Ahuja [13] identified additional advantages in relation with project extranets, which are more noteworthy conviction of result as far as time and cost, reduced disputes among parties by reducing the occurrence of mistakes and reduced ineffective efforts in the construction procedures.

#### *2.4. Innovation*

The construction organisation's remodelling or innovation offers opportunities to expand business procedures [20]. ICT usage gives the organisation many opportunities for business conduction and encourages the establishment of new and different opportunities [21,22]. Howell [23] stated that the data industry technology developments will help organisations to create inexpensive and innovations. Ahuja [13] concluded that an organisation's efficiency and innovation is improved by ICT.

#### *2.5. Simplified tasks*

The primary utility of ICT at the tender stage is to distribute and promote tender documents, choose successful competitors and grant contracts. by registering competitors on the web and downloading work bundles electronically, accelerating the documentation distribution and tenderers exchanges, ensuring the system's security by preventing unofficial access, communicating any changes and discrepancies in the document during the tender process and giving a basic environment to assess responses from tenderers [24,25].

#### *2.6. Improved performance*

Design or planning stage incorporates virtual construction and represents the phase before the construction phase where they evaluate the productivity of the project [26]. Hosseini [27] opined that the design phase is considered significant steps that enhance and enable the improvement of construction project performance. ICT software such as Structural Analysis Program2000 (SAP2000), Computer Aided Design (CAD), Extended Three-Dimensional Analysis of Building Systems (ETABS), Building Information Modelling (BIM), and Structural Analysis And Design Pro (STAAD pro) is used to: reduce errors and risk of losing important documents, save time and improve the productivity of work [26].

#### *2.7. Effective communication management*

The construction phase needs fast access to data exchange continuously [13]. Improving data exchange support for project activities at the construction stage has become a vital problem for the building sector to expand proficiency and efficiency in the construction procedure [28]. Contractors and project managers are responsible for the document exchange management and control between parties involved in the project for the project to be successful and effective [18]. ICT helps the building industry during the construction phase in: improving productivity of work, eradicating the risk of losing valuable documents, by keeping up all present and past versions in only one place, decreasing the risk of rework and mistakes by making sure that everybody in the project group is working with the appropriate documents and drawing. It also helps in providing a communication platform whereby members can perform online communication of data using the web improving group exchange by empowering colleagues to raise and react to inquiries in an organised manner. ICT further helps in keeping up logs of all interchanges for tracking purposes, providing customers and different parties with a perspective on the projects, as some ICT tools have incorporated augmented models to signify the status of a project anytime [29,30].

#### *2.8. Competitive advantage*

ICT utilisation has enabled the improvement of the organisation's competitive position in the construction market [31]. Devaraj [32] and Venkatesh [33] put forward that a competitive advantage can be enhanced by improving work quality and efficiency. Sanchez [34] opined that ICT being an operational supportive tool, can be used as a competitive market drive tool. Competitive advantage is very crucial in the construction industry because it allows the organisation to remain in business.

### *2.9. Trading (e-commerce)*

Buying materials is a complex and lengthy procedure that implies a lot of requirements such as the supplier's quotes evaluation and resource identification and which are typically received in various formats [35]. ICT software benefits the construction industry during the ordering and receiving materials in distributing and handling of documents to different parties involved in the project. This is done by decreasing the regulatory expenses, saving time in obtaining materials via computerised documents exchange and distribution (E-procurement). It can also be done by distributing and handling documents to different parties by decreasing the regulatory expenses and reducing bulky and unnecessary data that lead to errors in the documentation and ensuring easy examination and assessment of offers [36,37].

### **3. Research Methodology**

With regard to this research, quantitative research approach was chosen to assess and evaluate the various benefits of ICT tools in the construction industry. To rank the respondents' knowledge, a well-structured questionnaire was designed as the data collection tool. The questionnaire was designed using information retrieved from reviewed literature. The study location selected for the study was Gauteng province in South Africa. This location was selected due to researcher's proximity and because the research problem to be solved in this study is observed in the location. The target population for the study included civil engineers, quantity surveyors, architects, construction managers, industrial, electrical and mechanical engineers all plying their trade in Gauteng province of South Africa. The total population of the respondents in Gauteng province is 1054. Using Yamane sample size formula and a level of precision of 5%, the sample size of 289 was achieved. A random and convenient sampling method were used to reach out to the population through their professional bodies because it gives a chance to every individual to be selected or included in the sample while working with the available group of respondents. The analysis was established on the eighty-five questionnaires which were completed accordingly. This represents a response rate of 30%. A response rate between 20-30% has been used in previous studies and found suitable statistically for social science research conducted online [38]. Mean item score (MIS) and standard deviation (SD) were used to analyse the data obtained to rank the benefits of ICT tools in the construction industry in South Africa. The output of the analysis is presented in the next section.

### **4. Findings and discussion**

From the analysis of data obtained, all the respondents belong to a professional body and acquired an academic degree certificate with 6 years average experience in the construction industry. The background information of the respondents indicated that they possess adequate professional qualifications as well as good years of experience in the construction industry. This indicates that they are capable of providing answers to the research question.

Table 1 revealed the respondents' ranking of the benefits of ICT tools in the construction industry in the Gauteng province of South Africa. It revealed that effective communication management was ranked the leading benefit with a mean score of 4.41 and a standard deviation of 0.71; followed by Competitive advantage and Saves time as the second benefit of ICT tools with a mean score of 4.35 and standard deviation of 0.78 and 0.91 respectively. At the bottom of the ranking, Internet as exchange tool ranked thirteenth with a mean score of 4.00 and standard deviation of 1.01 while Diversification ranked the least at the fourteenth place with a mean score of 3.80 and a standard deviation of 1.00. The standard deviation values indicate the internal consistency among the group of respondents concerning each variable. Values above 1.0 is a reflection of no consistency among the groups while values below 1.0 reflects otherwise.

**Table 1.** Benefits of ICT tools in the construction industry

<b>Benefits of ICT tools</b>	<b>MIS</b>	<b>SD</b>	<b>R</b>
Effective communication management	4.41	0.71	1
Competitive advantage	4.35	0.78	2
Saves time	4.35	0.91	2
Improved productivity	4.32	0.86	4
Improvement in procurement processes	4.29	0.78	5
Innovation	4.24	0.81	6
Simplified tasks	4.20	0.87	7
User satisfaction	4.20	0.81	7
Improved competitive edge	4.14	0.86	9
Better project stakeholder management	4.13	0.83	10
Trading (e- commerce)	4.04	0.85	11
Collaboration improvement	4.01	0.87	12
Internet as an exchange tool	3.98	1.01	13
Diversification	3.80	1.00	14

MIS = Mean Item Score; SD = Standard deviation; R = Rank

The analysis result is an indication that all the perceived benefits from reviewed literature are actual benefits according to respondents as they all have mean item score values above 3.00 which is the average for a 5-point Likert scale. The results from the survey showing that ICT can give competitive advantage in the construction industry supports the study of Sanchez [34] who stated that ICT being an operational supportive tool, can also be used as a competitive market drive tool. Competitive advantage is very crucial in the construction industry because it allows the organisation to remain in business. Through the ICT tools usage, a lot of companies and business can provide effective project results which attract more customers compared to rival markets or organisations. The study also revealed that ICT usage saves time in the construction industry. In the same alignment with literature, Björk [24] and Regan [25] submitted that ICT tools save time by having a database of contractors online who can be sent the contract documents electronically, thereby accelerating the documentation distribution and tenderers exchanges. The benefit reaped from saving time on a construction project according to Regan [25] indicated that the companies gain client's trust, avoid cost overruns, deliver project on time, put less pressure on construction workers, have more time to think about the organisation growth, promote client satisfaction, get more contract opportunities, and also increase the company value. These highlighted benefits bring improved productivity just as the study has indicated. The study further shows that one of the benefits of using ICT in the construction industry is improved communication management. This is in line with the submission as put forward by Samuelson [28] that improving data and exchange support for project activities at the construction stage is very beneficial for the building sector to expand proficiency and efficiency in the construction procedure. This is because ICT tools facilitate group work which promotes productivity and helps to avoid wasting time on site. It also helps in avoiding job rework, improve cost saving, improve quality, avoid dispute among workers, allow fast stakeholders communication and also build trust among stakeholders. This is also in line with the submission of Hosseini [27] who explained that ICT increase productivity because there is a direct relationship between organisation productivity and worker's performance. This implies that when a worker's performance decrease, the productivity also decreases. With the use of ICT tools, managers can track worker's performance on site for better advancement, improvement of work, efficiency and productivity. Findings from the study also revealed that ICT brings about innovation. This is supported by the study of Howell [23] who concluded that data industry technology developments will help organisations to create inexpensive

innovations. ICT tools can help organisations to innovate and expand opportunities by improving construction phases process, enhance competitiveness as well as help organisations to keep in business.

## 5. Conclusion and recommendation

The study was aimed at assessing the benefits of ICT usage by construction organisations. The study reviewed extant literature to evaluate how ICT is being used in the construction industry. Besides, the literature reveals that the usage of ICT tools has improved the productivity and efficiency of construction work over the years in some building industry sectors by controlling operations such as engineering design, architectural drawing and preparation of bills of quantities among others. The data collected indicated ICT benefits as effective communication management, competitive advantage, time-saving, innovation, among others. This research work, therefore, recommends that construction organisations should provide lessons on different ICT tools use. This will keep professionals up-to-date with innovative technologies that ICT brings. Also, the construction industry will be able to reap the full benefits of ICT such as improved productivity, increased speed, and diversification. Gauteng province of South Africa was the focus of this study which is a limitation to the study. Other provinces can be evaluated in further studies to have a general overview of ICT use in the South African construction industry.

## References

- [1] Dawood, N., (2010). Development of 4D-based performance indicators in construction industry. *Construction and Architectural Management*, 17(2), 210-230.
- [2] Voordijk, H. and Adriaanse, A., (2016). Engaged scholarship in construction management research: the adoption of information and communications technology in construction projects. *Construction management and economics*, 34(7-8), 536-551.
- [3] Sheglabo, J., (2016). An investigation of the factors that impact the intention to adopt and use ICT in the Libyan construction industry (Doctoral dissertation, Murdoch University).
- [4] Ahuja, V., Yang, J., Skitmore, M. and Shankar, R., 2010. An empirical test of causal relationships of factors affecting ICT adoption for building project management: An Indian SME case study. *Construction Innovation*, 10(2), 164-180.
- [5] Hu, Q. & Kapucu, N. (2016). Information Communication Technology Utilization for Effective Emergency Management Networks. *Public Management Review*, 18(3), 323-348.
- [6] Ballan, B., 2011. A value map for communication systems in construction. *Journal of Information Technology in Construction (ITcon)*, 16(44), 745-760.
- [7] Musa, N.A., Oyebisi, T.O. and Babalola, M.O., (2010). A study of the impact of information and communications technology (ICT) on the quality of quantity surveying services in Nigeria. *The Electronic Journal of Information Systems in Developing Countries*, 42(1), 1-9.
- [8] Oladapo A. A. (2006). The impact of ICT on professional practice in the Nigerian construction industry, *The Electronic Journal on Information Systems in Developing Countries*, 24, 1-19.
- [9] Oyewole, E.O. and Dada, J.O., (2019). Training gaps in the adoption of building information modelling by Nigerian construction professionals. *Built Environment Project and Asset Management*.
- [10] Zachiang, J. B., (2017). The impact of ICT in construction industry. Available at: [https://www.academia.edu/29363044/the\\_impact\\_of\\_ict\\_in\\_construction\\_industry](https://www.academia.edu/29363044/the_impact_of_ict_in_construction_industry) [accessed 29 June 2019].
- [11] ITU, (2005). ICT Usage Statistics Available at: <https://www.itu.int/en/ITU-D/Statistics/Pages/stat/default.aspx>[Accessed 29 June 2019].
- [12] Villagarcia, S. and Cardoso, F., (1999). New supply chain network in Brazil's house construction industry. In *Proceedings IGLC 7*, 26-28.
- [13] Ahuja, V., Yang, J. & Shankar, R., 2009. Benefits of collaborative ICT adoption for building project management. *construction innovation*, 9(3), 323-340.
- [14] Bell, C.G., Mudge, J.C. and McNamara, J.E., 2014. *Computer Engineering: A DEC View of Hardware Systems Design*. Digital Press.

- [15] Zhai, D., Goodrum, P.M., Haas, C.T. and Caldas, C.H., (2009). Relationship between automation and integration of construction information systems and labour productivity. *Journal of Construction Engineering and Management*, 135(8), 746-753.
- [16] Song, H.X. and Wang, F.S., (2011), August. Research on the relationship between corporate governance structure and diversification strategy. In 2011 International Conference on Management and Service Science 1-4. IEEE.
- [17] Li, D., Eden, L., Hitt, M.A. and Ireland, R.D., (2008). Friends, acquaintances, or strangers? Partner selection in R&D alliances. *Academy of management journal*, 51(2), 315-334.
- [18] Lu, Y., Li, Y., Skibniewski, M., Wu, Z., Wang, R. and Le, Y., (2014). Information and communication technology applications in architecture, engineering, and construction organizations: A 15-year review. *Journal of Management in Engineering*, 31(1), p.A4014010.
- [19] O'Brien, W.J., (2000). Implementation issues in project web sites: a practitioner's viewpoint. *Journal of management in engineering*, 16(3), 34-39.
- [20] Volpe, J.M., Cowell, L.G. and Kepler, T.B., (2005). SoDA: implementation of a 3D alignment algorithm for inference of antigen receptor recombinations. *Bioinformatics*, 22(4), 438-444.
- [21] Sharma, R., (2013). An appraisal of internet business models as a research paradigm. In *Innovation in the High-Tech Economy ( 35-51)*. Springer, Berlin, Heidelberg.
- [22] Shin, N., (2009). Information technology and diversification: how their relationship affects firm performance. *International Journal of e-Collaboration (IJEC)*, 5(1), 69-83.
- [23] Howell, R., van Beers, C. and Doorn, N., (2018). Value capture and value creation: The role of information technology in business models for frugal innovations in Africa. *Technological Forecasting and Social Change*, 131, 227-239.
- [24] Björk, B.C., (2002) The impact of electronic document management on construction information management. In *Proceedings of International Council for Research and Innovation in Building and Construction CIB w78 conference (12-14)*.
- [25] Regan, M., Smith, J. and Love, P., (2009). Public-private partnerships: What does the future hold?. In *Proc., RICS Construction and Building Research Conf. (COBRA)*, Royal Institution of Chartered Surveyors, London 462-474.
- [26] Paudyal, G. & Prakriti, K., (2016). Role Of ICT In Construction. NCIT, Balkumari.
- [27] Hosseini, R., Chileshe, N., Zou, J. and Baroudi, B., (2012). Approaches of implementing ICT technologies within the construction industry. In *Australasian Journal of Construction Economics and Building-Conference Series 1(20)*, 1-12.
- [28] Samuelson, O., (2008). The IT-barometer—a decade's development of IT use in the Swedish construction sector. *Journal of Information Systems*.
- [29] Peansupap, V., (2004). An exploratory approach to the diffusion of ICT in a project environment.
- [30] Hosseini, M.R., Chileshe, N., Zuo, J. and Baroudi, B., (2015). Adopting global virtual engineering teams in AEC Projects: A qualitative meta-analysis of innovation diffusion studies. *Construction Innovation*, 15(2), 151-179.
- [31] European Commission, (2006). European economy Available at: [http://ec.europa.eu/economy\\_finance/publications/european\\_economy/2012/index\\_en.htm](http://ec.europa.eu/economy_finance/publications/european_economy/2012/index_en.htm) [Accessed 29 June 2019].
- [32] Devaraj, S. and Kohli, R., (2003). Performance impacts of information technology: Is actual usage the missing link?. *Management Science*, 49(3), 273-289
- [33] Venkatesh, V. and Bala, H., (2008). Technology acceptance model 3 and a research agenda on interventions. *Decision Sciences*, 39(2), 273-315.
- [34] Sanchez, R., Zmijarevi, I., Coste-Delclaux, M., Masiello, E., Santandrea, S., Martinolli, E., Villate, L., Schwartz, N. and Guler, N., (2010). APOLLO2. Nuclear engineering and technology, 42(5), 474-499.
- [35] Sekou, E.A., (2012). Promoting the Use of ICT in the Construction Industry: Assessing the Factors Hindering Usage by Building Contractors in Ghana (Doctoral dissertation).



- [36] Kim, M., Wang, X., Love, P., Li, H. and Kang, S.C., (2013). Virtual reality for the built environment: a critical review of recent advances. *Journal of Information Technology in Construction*, 18, 279-305.
- [37] Woksepp, S. and Olofsson, T., (2006). Using virtual reality in large-scale industry project. *Electronic journal of information technology in construction*, 11, 627-640.
- [38] Knaub Jr, J. R. (2013). Projected Variance for the Model-Based Classical Ratio Estimator: Estimating Sample Size Requirements. *Journal of surveying method*, 2885-2896