
Trends in Construction Engineering Technology

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Abstract: *The global construction sector has been experiencing a plethora of technological advancements in recent decades. Automotive technologies offer huge potential to enhance productivity, efficiency, and manufacturing flexibility throughout the construction industry. Some of the innovative technologies include terrestrial and aerial devices, Building Information Modelling (BIM) and structural data collection software, 3D printing, artificial intelligence, etc. This paper briefly discusses some of the advantages of the latest construction technologies and software, such as SAMSTTM, that can be used in the future construction industry. These pioneering construction technologies hold the promise of benefiting the building construction sector and affiliated research institutions in the future by facilitating sustainable, cost-efficient engineering designs that optimize construction workflows, mitigate risks, and enhance the overall value of infrastructure projects.*

Keywords: construction, technology, buildings, ground, infrastructure

INTRODUCTION

To address the present and upcoming demand challenges, the construction sector needs to greatly enhance its productivity. As the global population continues to grow, the increasing necessity for more affordable housing, along with social, transportation, and utility infrastructure, has placed societal pressure on the industry to adopt the latest technologies (Cherian, 2020a). The construction sector in the United Arab Emirates (UAE) and the Kingdom of Saudi Arabia (KSA) is the largest and fastest growing in the Middle East region. The key factors influencing the construction industry are economic, socio-cultural, legal, environmental, technological, etc. Some of the major components of a growing economy include a stabilized economy, lower inflation, logistics costs, and raw material costs. The growing population and entry of younger workers from various countries, including locals, indicate a multinational socio-cultural environment. To encourage the construction sector, legal laws and regulations are simplified to open new businesses even with 100 percent foreign investment. The government is planning to construct smart, sustainable buildings that could promote the reduction of pollution, wastage, and use of resources. The construction industry can attract investors in the future with the use of innovative technologies (Ventures, 2011). This article briefly discusses recent trends in construction technology and structural data acquisition software to improve the on-site construction process of buildings in the construction economy.

Construction Technologies

The construction sector in the Middle East will soon endure a radical change due to the need for sustainability and the quick uptake of digital technology. Businesses in the area are incorporating energy-efficient building techniques, low-carbon design concepts, and more intelligent asset operations into all facets of the project lifecycle. This includes the robotic devices, Building Information Modelling (BIM), 3D- printing, AI-based simulation, etc.

Ground monitoring devices

Robotic devices, both terrestrial and aerial, are being developed to perform tasks ranging from monitoring and measuring to surveying and inspection in less time and with a greater amount of data than traditional methods (Fig.1). The application of these systems brings improvements to the overall productivity of construction projects because the 3D information extracted from the multi-sensor robots can be incorporated into BIM technology and used in different design phases.



Figure 1: Terrestrial and Aerial devices

Foundation and Earth works

These devices (Fig.2) can remove, loosen, and lift soil automatically; in fact, they are sufficiently developed to be considered robots. The advantage brought by this equipment consists also in the possibility of connecting many robots to automate a variety of tasks and optimize times and operations, reducing the total cost of the projects. The category includes robotized conventional machines, such as dumpers and excavators, which have been transformed into robots, by equipping them with multi-sensor systems, and new electric automated vehicles. This technology can reduce carbon dioxide emissions, noise, and wastage of time.



Figure 2: Earth work equipment

Building Information Modelling (BIM)

Building Information Modelling (BIM) is a novel technology, a 3D model and an intelligent structured data-driven concept that aids in developing a virtual model or construction process of a building prior to its actual physical construction to minimize uncertainty, improve safety, identify collisions, and simulate and analyse potential environmental impacts (Azhar, 2011). The traditional building design was reliant on 2D plans, elevations, sections, drawings, and BIM converts this to 3D width, height, depth, etc. (BIM, 2016; Azhar *et al.*, 2008). BIM has the potential to increase efficiency by encouraging the integration of all project stakeholders' roles, as well as business structures and practices, into a collaborative process that allows for waste reduction and efficiency optimization throughout the construction project life cycle. The BIM model is also used for post-construction monitoring and facility management (Azhar *et al.*, 2009). This is still a new technology, and few construction companies have adopted it because of the challenges that it presents during implementation (Azhar *et al.*, 2012). To assess the feasibility of BIM adoption in the Saudi construction industry, an effort was made to identify some barriers and strategies (Table 1).

Table 1: Barriers and strategies for implementing BIM

Sl no.	Barriers	Proposed implementation strategies
1	Most clients do not require BIM for architectural and engineering designs and analysis.	The importance of BIM should be discussed and promoted by organizing workshops and seminars.
2	There are no approved specifications/standards to support the use of BIM.	The use of BIM should be regulated and specified in the project documents. A policy should be introduced to encourage construction organizations and professionals to use BIM for design.
3	Technical engineers do not require BIM to develop a project design model or to extract information.	The proper training of construction staff on how to use BIM is needed and should be encouraged by all construction organizations.
4	BIM software is too expensive and not affordable for all clients.	Development of localized systems with financial subsidy from authorities.
5	BIM development takes longer than other CAD software.	Support from authorities to encourage the adoption of BIM.
6	BIM does not add much value to our organization.	A comprehensive project specification is needed to compel practitioners to use BIM.

Generally, there was a knowledge gap as well as a lack of BIM awareness among construction industry professionals such as consultants, project managers, engineers, and others. It is acknowledged that the suggested BIM adoption strategies are useful and beneficial for the construction industry's future technological development.

3D- Printing

The technology of 3D printing has the potential to revolutionize material sourcing. Materials for a project can be printed and then transported to the site. By removing unnecessary steps in the middle, materials can be processed faster, and the process is streamlined. Materials can be printed on-site with 3D printing, reducing waste and saving money on transportation and storage. However, one of the current limitations of the widespread adoption of this technology is the high cost of mass production.

Artificial Intelligence

Recently, Artificial Intelligence (AI) has provided benefits to construction projects through increased safety, improving workflows, and getting tasks done faster and better (Fig.3). However, many construction companies still navigate and learn how to best apply this complex technology within their organization. They are finding AI is helpful with scheduling site tasks and material supply to prevent delays, conflicts, and other issues.



Figure 3: AI in construction

Data Collection Applications

Field data collection is made possible by user-friendly apps that allow field engineers to collect data from any device, at any time, and share it with clients in real time without errors. Subsequently, structural health monitoring (SHM) systems, which include data handling and decision-making, must be carefully designed during the planning phase. Rather than focusing solely on sensitivity to idealized defects in simple structures, which often ignores false calls, it would be beneficial for the research community to recognize this and consider practical use examples. Measurements on a real structure are required for performance evaluation, and a methodology has been presented that combines measurements on an undamaged structure with damage signature prediction and logical characterization. It allows for the simulation of multiple damage scenarios without the use of an unrealistic number of test structures, lowering the cost of performance validation significantly (Cherian, 2020b). Fiber optic sensors, wireless monitoring techniques, machine learning, and artificial intelligence will be used as the foundation for future SHM programs and will become an integral part of the Building Information Management System.

The SHMs are generally categorized as permanent or periodical to record and analyse various parameters such as structural behaviour, various loads, deflection, etc, on the structures. The software SAMSTTM (Smart Asset Management System), developed for structural and ground monitoring by our experts at James Fisher Group, United Kingdom (Strainstall), acts as a comprehensive IoT data store for specialized applications in the construction industry. It offers the best way to organize and display structural monitoring data and information in a reliable and convenient manner. It is a web-based system that gives round-the-clock real-time access to data. Maps, blueprints, drawings, sketches, photos, and 2D or 3D graphics are all capable of acting as the foundation for user presentations. This involves an automated network of sensors that track the physical behaviour of the structure and its surrounding ground to ensure safety throughout the full lifecycle of the structures. Data from numerous sensors and sources, using the SAMSTTM platform, are integrated and reported in a simple actionable format, allowing users to make fast, data-informed decisions on the structural health of their assets (Fig.4).

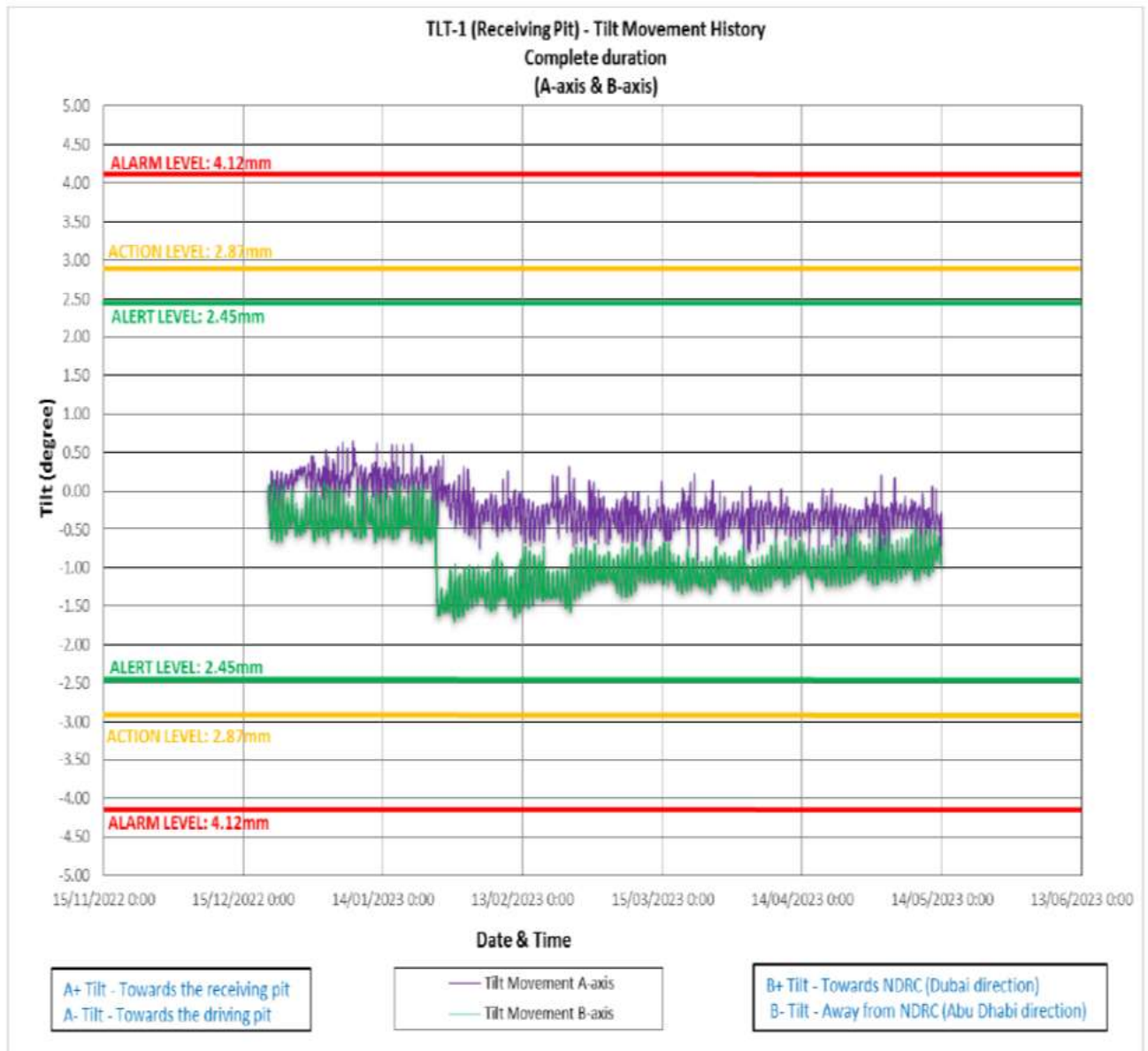


Figure 4: Sample result from SAMS software

Some of the common risks associated with structures are earthquakes, precipitation, landslides, material failure over time, unexpected loads, overturning, tremors, fires, etc. The SHM system should be able to deliver, on demand, consistent information relating to the safety and integrity of the structures. Based on the experience gained from various construction projects in the Middle East region, some of the features of long-term and periodic monitoring are listed in Table 2.

Table 2: Features of monitoring methods

Features	Long-term	Periodic
Sensors	Unlimited	Limited
Control of Data	Complex	Simple
Unexpected events	Logged	Not logged
Damage detection	Online	Offline
Alarms	Real-time	Deferred
Installation and set-up costs	Medium to High	Low
Functioning costs	Medium to High	Low
Suitability for towers	High	Low
Codes	Available	Available

The long-term monitoring is generally permanently installed and sustains operation of the structure from the initial construction stage to the end of the tower construction or can be extended as per the project requirements. In this method, continuous real-time data of static/dynamic responses, environmental parameters, and load characteristics are used to check the construction process and quality control. Moreover, unexpected events like tremors, shocks, and storms can be detected and evaluated instantaneously. The drawback of permanent monitoring systems is that they are not cost-effective and need to be designed appropriately to produce meaningful data, a large amount of data management, and permanent storage. Periodic monitoring is executed by installing required sensors on the structure and collecting data for a short period during the construction stage or afterward to understand the overall health condition of the structure. The advantages of this method are cost-effective and simple. But the limitations are a smaller number of sensors, accidental events that cannot be recorded, and, hence, a lack of knowledge of the proper damage detection.

The continuous health condition monitoring of high-rise structures during and post construction is essential and advantageous to assess the settlement and load sharing between the different foundation/structural elements. Implementing a permanent monitoring program will help to understand the deviation from the design expectations and can be used as a prototype for future similar high-rise building projects.

COST REDUCTION APPROACHES

- Efficient time management - The contractor would be able to effectively design and plan how to best utilize resources and could better develop and control the whole process.
- Adequate supervision - This will help Clients to manage their construction projects accordingly and eventually reduce the possibility of errors during the construction phase.
- High-rise building projects – An experienced and qualified workforce with quality work can reduce the cost and delay.

- Innovative technologies - Advanced technological involvement can provide cost-effective solutions to unexpected construction problems.

Infrastructures in many regions of the world are nearing their intended design life. This could result in a dangerous and risky situation around the world. In the construction world, the methods used to rejuvenate these aging assets present both an opportunity and a challenge. Some issues and future suggestions for the construction industry are listed in Table 3.

Table 3: Issues and suggestions for future construction

Sl. no.	Issues	Suggestions
1	Aging of infrastructures	Acceleration of new constructions
2	International work forces	Global sharing of projects
3	Meeting the energy demands	Alternate energy sources
4	Sustainable design and construction	Sustainable infrastructure
5	Material and technology advancement	Alternate material and integration of advanced field technologies

CONCLUSION

A brief discussion on some of the construction technologies in this article gives new insights on using on-site building construction to solve the problems. Unquestionably, making the right investments in the innovative construction technologies is a wise business decision that may assist in modernizing present procedures in a way that is both economical and sustainable. More research and training on construction technologies are needed before they are implemented on-site to ensure that the right information is available at the right time, which invariably leads to better project outcomes. In the future, a significant portion of construction projects will be built utilizing modular, customizable sections and components developed in off-site factories using standardized techniques.

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