Guest editorial: Resilience and responsiveness of the AEC sector

The Architectural, Engineering and Construction (AEC) sector is known to be one of the most vulnerable in the advanced and emerging economies. As project commissioning is closely linked to the performance of the financial sector and developments are largely dependent on environmental conditions and other related factors, the AEC sector performance is usually affected by the interplay of the performance of those other sectors.

However, evidence continue to suggest that stakeholder management (SM), technological innovation, sustainable construction and various other interventions are mitigating against the effects of these influencing factors. Various contributors have therefore demonstrated through different approaches and scenarios that the AEC sector continues to show resilience and responsiveness to these externalities. This Special Edition is a compendium of 14 contributions to these efforts. They collectively highlight various dimensions of the resilient and responsive nature of the AEC sector from a global perspective.

In their paper on SM in the alleviation of legal and regulatory disputes in public–private partnership (PPP) projects in South Africa, Khotso Dithebe *et al.* introduced the use of critical success factors (CSFs) of SM as a possible solution to reduce disputes experienced because of legal and regulatory issues in PPP projects. They submitted that among the 19 CSFs identified, 5 factors were highlighted that could contribute to the alleviation of disputes between stakeholders in PPP projects. These are adequate project planning and control; effective leadership; appropriate strategies for the management of stakeholders; confirmation of clear goals and objectives of the project; and effective communication.

Uzor Onyia *et al.* in their own submission evaluated the CSFs to remote development of construction management skills and competencies (CMSC) in Nigeria. As CMSC have been shown to be of greatest importance for the industry to succeed and thrive, some factors are critical to CSMC development. Hence, following the restrictions occasioned by the outbreak of COVID-19 pandemic, their study reviewed and examined these factors to understand their level of influence in the remote development of CMSC adopted by the industry within and post the disruptions induced by the pandemic. They therefore identified CSFs and categorised them into organisational factors and individual factors. Organisational factors included leadership, engineering project networks and eLearning, measurement and review system, strategy and resources, organisational culture, tradition and structure, whereas individual factors included (in the order of influence) – willingness to learn, promotion and career development, obtaining certified qualification and obtaining respect of peers.

Like the challenges of CMSC, SM also continue to place a demand on the industry. Ayman Mashali *et al.* in their paper that focussed on the CSFs for overcoming SM challenges in mega construction projects (MCPs) identified the key factors contributing to improving SM performance in MCPs; none of these is uncommon, but here they come together in a more integrative way. Their study makes a significant contribution through identifying the CSFs that lead to develop efficient SM in MCPs. These results demonstrate a potential to enhance the application of SM practices in construction megaprojects (CMPs) and allow project key stakeholders to place emphasis on tackling the crucial challenges identified in this research.

Furthermore, Martin Evans and Peter Farrell proposed a strategic framework for managing the challenges of integrating lean construction (LC) and integrated project delivery (IPD) on CMPs, towards global integrated delivery (GID) transformative initiatives

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in multinational organisations. In their paper, they argue that the built environment continues to encounter substantial risks and challenges in its evolution towards sustainable development. International businesses and multinational engineering organisations face global connectivity challenges between business units, especially during the outbreak of the novel coronavirus pandemic (COVID-19), which has profoundly disrupted the construction industry throughout the world. That raises the need to manage global connectivity as a main strategic goal of multinational AEC organisations. Their study developed a strategic framework for managing challenges of integrating LC and IPD on CMPs towards GID transformative initiatives in multinational AEC organisations.

As the sector continues to embrace and adopt building information modelling (BIM), Ana Karina Silverio *et al.* in their paper "Status of BIM implementation in the Dominican Republic (DR) construction industry – an empirical study" demonstrated that the increased use and proven benefits of BIM worldwide suggest that its implementation could be of great help in diminishing inefficient traditional practices in the DR construction industry. In the paper, they critically appraised and documented the status of the implementation of BIM in the DR to raise awareness and understand how BIM can be successfully implemented in the country. Their results confirmed that the DR is a BIM infant country with low levels of BIM implementation. They therefore suggested drivers that will aid the implementation of BIM to include BIM benefits, competitive advantage and pressure from external partners. Similarly, Sukhtaj Singh *et al.* in their paper on the key enablers, techniques and benefits of managing stakeholders within BIM supported projects, pointed out that project managers still face challenges with managing stakeholders and that the introduction of BIM had further increased those challenges. Hence, their paper sought to identify the key techniques, enablers and benefits of managing stakeholders within BIM-implemented projects. They identified two key techniques and two enablers required to manage stakeholders within BIM-implemented projects. They also identified nine benefits of managing stakeholders which they further split into interim and eventual benefits.

In Nigeria, on the contrary, James Toyin and Modupe Mewomo investigated the barriers to the application of BIM. They noted that recent studies revealed a low level of BIM implementation in the context of the Nigerian construction sector in comparison with the rapidly increasing rate of adoption among construction professionals across the world. Moreover, previous studies had established that BIM application comes with its share of various barriers. Therefore, they carried out an on-site survey on barriers to the application of BIM on construction sites in the Nigerian construction industry. Twenty-seven barriers were found to be peculiar to the Nigerian construction industry. However, the "lack of familiarity with BIM capacity, habitual resistance to change from the traditional style of design and build, and poor awareness of BIM benefit" were identified as the three most critical barriers hindering BIM application on construction sites in the Nigerian construction industry.

SM in BIM implementation continues to pose challenges to the AEC Sector and hence, Sukhtaj Singh *et al.* in their contribution on the key enablers, techniques and benefits of managing stakeholders within BIM-supported projects provide some insights on how the industry can respond better to the challenge. An exploratory approach was adopted to the study because of the paucity of the variables on the topic. In total, 23 semi-structured interviews were conducted in the UK through purposive and snowball sampling. Two key techniques and two enablers required to manage stakeholders within BIM-implemented projects were identified. Nine benefits of managing stakeholders were identified which split into interim and eventual benefits as presented in their paper.

Also, as the world continues to leverage the developments around Industry 4.0, John Smallwood and Chris Allen examined practitioners' perceptions of the potential impact of Industry 4.0 on construction health and safety (H&S). Historically, a range of H&S challenges continue to be experienced. Their study determined the perceptions of stakeholders and their understanding and appreciation of the H&S challenges and the potential of Industry 4.0 technologies to improve H&S. Their findings indicated that a range of H&S challenges are experienced in construction and that Industry 4.0 technologies can contribute to addressing the H&S challenges.

Adetayo Olugbenga Onososen and Innocent Musonda in their paper presented a research focus for construction robotics and human–robot teams (HRTs) towards resilience in construction based on scientometric review. They submitted that rapid urbanisation and recent shock events have reiterated the need for resilient infrastructure, as seen in the pandemic. Yet, knowledge gaps in construction robotics and HRTs research limit the maximisation of these emerging technologies' potentials. The state of the art of research in this area is reviewed as a precursor to identifying future research directions in HRTs and their ability to aid the resilience and responsiveness of the AEC sector.

Sustainability of materials used in construction has been the subject of research for a long time. Sandeep Singh *et al.* studied and reported on heat resistance and sorptivity of an air-entrained concrete containing mineral admixtures and coal bottom ash (CBA). The purpose of the work was to improve the air entrainment capacity of a concrete by using fine mineral admixtures such as fly ash (FA) and silica fume (SF) as cement substitute, and CBA as fine aggregate substitute. Air entrainment capacity has been studied indirectly as a measure of heat resistance of concrete. They found that a concrete mix containing 20% FA and 10% SF along with 50% CBA could give similar post-heated strength to a normal (without mineral admixtures) AEC. In AECs, where only CBA is present and cement paste is not substituted, both of the pre- and post-heated strengths of concrete reduce. Also, some mixtures containing large amounts of mineral admixtures in concrete with nil CBA show a high reduction in post-heated strength though they show good pre-heated strength. Therefore, mineral admixtures and CBA complement each other in improving the post-heated strength. Air pore structure found from sorptivity test also verifies these results.

Also, Helen Dion *et al.* posited that energy saving is a growing challenge worldwide because of population growth, economic activity and high consumption rates that are unsustainable in the long term. Health-care facilities and hospitals (especially) face the challenge of increases in operational costs. In their submission, they appraised the challenges to adopting energy-saving policies and proposed a roadmap for sustainability and energy efficiency management in hospitals and health-care facilities. They concluded that the best performance is secured by integrating their proposed guidelines with the adoption of ISO 50001 energy management systems to achieve the United Nations' sustainable development goal – SDG 7 "affordable and clean energy"

Hanane Bouhmoud *et al.*, on the contrary, studied the COVID-19 impacts on the AEC industry especially as the unexpected spread of COVID-19 rapidly switched from a health crisis to an economic one in the wider African context. The AEC industry experienced drastic impacts, especially in Africa. Several studies investigated COVID-19 impacts on the AEC industry, but very few were conducted in Africa. This study sought to cover this gap by addressing a detailed overview of negative and positive impacts of COVID-19 on the AEC field – especially in the different African regions. They also highlighted their causes and the measures taken to overcome them. In the five African regions, the AEC industry experienced 22 heavy impacts that were split into 4 categories: financial, managerial/strategic, operational and opportunities. Their paper thoughtfully explained the causes of

COVID-19 impacts and presented the measures undertaken by the African private and public sectors to overcome them.

Hamdan Alzahrani *et al.* in their paper "Evaluating the effects of indoor air quality on teacher performance using artificial neural network" opined that a building's indoor air quality (IAQ) has a direct impact on the health and productivity on its occupants and that understanding the effects of IAQ in educational buildings is essential in both the design and construction phases for decision-makers. Their paper thus outlined the impact air quality has on occupants' performance, especially teachers and students in educational settings. Their research findings indicated an optimal relative humidity with 65%, ranging between 650 and 750 ppm of CO_2, and 0.4 m/s ventilation rate. This ratio was considered optimum for both comfort and performance.

Finally, Modupe Cecilia Mewomo *et al.* in their paper on the synthesis of critical factors influencing indoor environmental quality (IEQ) and their impacts on building occupants' health and productivity discussed that there is a definite shift and change in the human lifestyle across the world. During the COVID-19 pandemic, individuals spent a substantial amount of time indoors. This change in human lifestyle had devastating effects on human health and productivity. As a result, the influence of IEQ on the health and productivity of building users has become a critical field of research. As a result, this study reviewed state-of-the-art literature by establishing a connection between the factors that influence health and productivity in any given indoor environment. The findings from the 90 selected articles revealed four critical factors influencing the quality of the indoor environment were categorised into IAQ, indoor thermal comfort, visual comfort and acoustic comfort. The findings suggested that when developing a system for controlling the quality of the indoor environment, the IAQ, indoor thermal comfort, visual comfort and acoustic comfort should be considered.

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