

# **CIB INTERNATIONAL CONFERENCE ON SMART BUILT ENVIRONMENT**

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International Conference on Smart Built Environment**

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## Editorial

### Mohammed Dulaimi and Taha Elhag

For decades the construction industry has experienced significant pressures and challenges. This is due, in part, to its unique contributions and influence on the rest of economy and society. Many of the national reports that have examined the state of the construction industry raised concerns of the gap that have persistently existed between the expectations of the construction industry key stakeholders and the performance of the industry.

The digital revolution that is driving many economies across the globe towards industry 4 and industry 5 models and shaping corporate strategies in many sectors of the economy. This transformation of economy is creating a challenging environment that requires an accelerated pace of innovation to enable the construction industry to meet the expectation of its stakeholders. The dominant role of digital and advanced technologies could drive and motivate effort to create partnerships and alliances to exploit more challenging open innovation projects. Innovations in such projects do not only cross corporate boundaries but also traditional boundaries that have separated the different sectors of the economy. A recent example is of a major car manufacturer who opted to select a supplier from outside the automobile sector to be able to tap into technical solutions needed to improve their product, but the required knowledge and capabilities were beyond its traditional supply chain.

The pressure on the construction industry to deliver smart working, leisure and living environments would require the creation of supply chains beyond the industry's traditional supply chain and recruitment of skills beyond what existing disciplines and professions can offer. This would create opportunities for the emergence of new roles and disciplines as well create new relationships and organisational structures.

The work of the CIB Task Group 96 emphasises how to accelerate the implementation and adoption of innovation frameworks and systems in the construction sector. The ultimate goal to achieve better delivery of construction projects, healthier construction organisations, enhanced satisfaction of stakeholders and much improved industry. TG96 also aims at mapping the association between innovation theories and good practices in delivering accelerated innovation across various industries; and addressing best practice case studies.

The conference paper publications embrace various themes such as: (a) integration of data and information; (b) business models for smart BE; (c) automation and robotics; (d) the impact on culture of smart BE; (e) digitalisation of the construction sector; (f) intelligent building and infrastructure; (g) digital engineering and BIM implementation; (h) internet of things (IoT); (i) real-time monitoring and control; (j) sustainability and the environment (k) design for smart BE; (l) economics and management of smart BE, (m) accelerating innovation process (n) performance measurement; (o) agile and lean thinking; (p) resilience engineering; (q) policies and regulations.

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## Accelerated Innovation Process

# An Investigation of the Influence of Public Clients on Contractors' Behaviour towards the Modern Methods of Construction\_68

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### Abstract

Recently, the Modern Methods of Construction (MMC) are gaining ground due to the support of both the private and governmental sectors. However, the scale of the uptake among more traditional contractors is still weak. On the other hand, public clients have a track record in motivating the traditional sector to adopt innovation towards meeting their specific needs. This paper aims to investigate the gaps within the public sector and their ability to accelerate innovation. The study will review existing literature relevant to understand the required relation and influence. The central hypothesis of this research is that public client's engagement in procuring MMC projects would trigger and accelerate traditional contractors' organizational transformation to adopt such methods. Hence, this study aims to understand the complex dynamics of the involvement of public clients on possibly motivating traditional contractors towards offering innovative solutions. The findings of this research would support the effective intervention for more effective diffusion of MMC and add to the knowledge of facilitating a greater adoption of innovation within the UK public bodies. The main objectives of this research are to a) Understand the relation between public clients and contractors, b) Examine the influence exerted by public clients on contractors' behaviour, and c) Investigate the ability of public procurement frameworks to act as integrators towards increasing the adoption of innovation. The findings highlight a gap within existing literature represented by the limited studies addressing contractors' behaviour in the public client context, particularly in MMC, and more understanding of public clients' decision-making processes are needed to enable researchers and practitioners to have better understanding on contracts' behaviour towards the adoption of innovation's body of research.

### Keywords

Modern Methods of Construction; Accelerating Innovation; Public Clients; Adoption of Innovation; Public Procurement Frameworks

## Construction and its Delivery of Social Capital: An Investigation of the Impact on Culture, Heritage and Wellbeing of Minority Ethnic Communities in Malaysia\_38

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### **Abstract**

Sustainable construction offers modernisation to the community aimed at improving the standard of living with access to basic necessities such as water, electricity, transportation and comfortable housing and internet, which is crucial for the 21st century. Construction becomes the platform to meet the production and consumption needs of the population and narrows the equity gap by creating economic fairness to people. This initial cross-disciplinary study explores the interpretation of the impact of construction on minority communities in two different socio-economic settings. This study seeks to explore the inter-relationship of production and consumption needs as the economic capital investment to the ethnic minority community by examining the social capital impact including culture and heritage. The main questions to ask in this study are how civil modernisation can have a different social capital impact on the community and how do we create the right balance of the three bottom lines of unified entities: environment, economy and society? Interview data derived from the analysis of the two ethnic minorities: Morten Village community and indigenous community called Orang Asli. Both communities are unique and facing threats of urbanisation on their culture, wellbeing and heritage but the effect of modernisation is remarkably different to both communities. This initial interdisciplinary research proposes a bespoke approach in creating a balance of sustainable urbanisation needed to avoid a further loss of intrinsic value and the creation of social disparity.

### **Keywords**

Construction, culture, resilient socio-economy

## Communication Challenges in Building Energy Efficiency Retrofits: Croatia Case\_3

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### **Abstract**

As climate change has become a growing concern, sustainable development has become increasingly important. Emissions reduction is a key step for more efficient energy use. The European Parliament implemented the Energy Efficiency Directive (2012/27/EU), which establishes a set of binding measures to help the EU reach its 20% energy efficiency target by 2020. The building sector is the largest energy consumer in the EU; the new policies implement rules on the energy performance of buildings. In the last few years, the residential building sector in Croatia has received financial support for multi-dwelling building energy efficiency retrofits. However, some of these projects encountered difficulties due to information asymmetry between the key participants. This study addresses the problem from the perspective of the principal-agent theory, which is concerned with information asymmetry and its repercussions. A social network analysis is conducted to reflect the operation and management details of Croatian multi-dwelling buildings. The key stakeholders of energy efficiency retrofits are mapped, along with the contractual and communication ties between them. The analysis stresses the importance of the key relationship between owner representatives and property managers. Trust between them encourages communication and cooperation during project development. This study demonstrates that close cooperation between all stakeholders is essential for satisfactory project completion.

### **Keywords**

Communication, Croatia, Energy efficiency retrofits, Multi-dwelling buildings, Principal-agent theory, Social network analysis

# **BIM-based LCA Integration by Evaluating the Environmental Impacts of Whole Building at the Early Design Stage\_75**

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## **Abstract**

Recently, environmental Life Cycle Assessment (LCA) has become an impartible part of many building projects. There is greater need to integrate LCA tools with the building design workflow. There are several LCA tools, where some of them use an internal database and some are open-source platforms that better enable the use of wide-array of database sources as their life cycle inventory. The former tools have limitations in their database coverage while the latter mostly use the datasets that are not specified for construction projects. This study aims to support the design of resource- and energy-efficient buildings using an integrated LCA methodology in the early design stage. The research aims to integrate LCA capabilities directly into a Building Information Model (BIM) and increase the environmental relevance and scientific robustness of LCA indicators. The plugin, which is developed in the BIM tool is represented to use Ecoinvent to build a complete process of a construction projects to be imported in OpenLCA. The results show much efficiency in using the developed plugin to assist users to find the correct materials from database within the seconds as well as a clear framework that helps to map all the processes of LCA without faults or forgotten processes.

## **Keywords**

Life Cycle Assessment (LCA), Building Information Modelling (BIM), Environmental impacts, Embodied Carbon, Building Performance.

## Using Artificial Intelligence to Automate the Quantity Take-off Process\_46

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### **Abstract**

Quantity take-off is the process of obtaining quantity measurements from construction plans and providing a list of materials needed to complete a project. Despite the recent and wide use of BIM tools, most construction plans and documents are still 2D drawings on electronic files or sheets of paper. Consequently, estimators and contractors need to measure items and then perform calculations from 2D drawings. This is why the quantity take-off is the most time-consuming activity in creating the cost estimate and prone to error (like many other manual activities). It is fair to say that almost all new construction drawings are available (or created) as digital files and PDF is the most common file format for sharing the project plans and documents. A review of commercially available take-off software for construction reveals that we are now able to accurately measure the quantities from digital files and even send them to spreadsheet programs, such as Microsoft Excel. These new software tools can greatly speed up the take-off process and increase efficiencies. But they still need someone with a thorough understanding of architectural and construction terminologies and symbols to assign the measured quantities to the right cost items. Intelligent document processing is the next generation of automation and measuring quantities from a variety of PDF documents. In this study, we use Artificial Intelligence technologies such as natural language processing (NLP) and machine learning (ML) to identify and extract relevant quantities from a set of 2D construction drawings.

### **Keywords**

Quantity Take-off, Cost Estimate, Artificial Intelligence

# Paradigm Shift of Claims Management to Digital Space\_50

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## **Abstract**

Claims in the construction industry are considered unavoidable and can have severe consequences if not managed properly. Claims management has taken prominence in recent years due to the large number of disputes occurring. Inefficiency and lack of competency of both the process and personnel make claims management a cumbersome affair to both the claimants and respondents. This paper aims to review the transformation of the claims management process from being a manual process to a semi-automated one, and how the advanced information and communication technology (ICT) available can be leveraged to further enhance the management of claims, as well as to address the aforementioned issues. The paper begins by discussing the claims management process in brief and illustrates the need to have a system aided by ICT for reducing manual effort and thereby improving the efficiency and the accuracy of the processes involved. The paper then reviews the existing claims management systems available, the impact of IR4.0 and emerging technologies on claims management practice, before discussing the need for a fully integrated cloud-based claims management system capable of bringing about the aforementioned needs and desired benefits.

## **Keywords**

BIM, Claims Management Systems, Cloud computing in construction, Construction claims.

## Net-Positive Water Systems for Schools in Drought-Stricken Areas\_16

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### **Abstract**

In many areas of the world, climate change is leading to higher temperatures and water scarcity. At the same time, rapid urbanisation is increasing the demand for existing water resources. As a result, in many drought-stricken areas, water costs have rapidly increased and supplies are becoming more unreliable. Schools in drought-stricken areas are particularly vulnerable. Limited resources mean that schools struggle to pay additional costs for water. Health risks also mean that schools have to close when there is no water. Closing schools significantly affects the quality of education as teaching is disrupted and learning time is lost. It is, therefore, important to find alternative affordable and reliable water solutions for schools in drought-stricken areas. Rainwater harvesting offers a potential solution but there is limited research and guidance on how these systems work at schools. This paper addresses this gap by investigating whether a rainwater harvesting system can be developed that would enable schools to become more resilient to water scarcity and outages. Modelling carried out indicates that a rainwater harvesting system has the potential of generating sufficient water to exceed the water needs of the school and therefore enables it to be water net positive. The study shows that the business case for rainwater harvesting appears weak where there is a reliable local municipal water supply. However, this changes when schools are faced with punitive drought tariffs and increasing water outages which force closures.

### **Keywords**

Schools, rainwater harvesting, net-positive water systems

## Developing an Early Prediction Model of Bankruptcy in the UAE Construction Industry\_53

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### **Abstract**

The aim of this research is to develop an early prediction model of bankruptcy providing the UAE construction companies with practices to avoid the threat of insolvency and its related consequences on individuals and the economy. The methodology used to achieve the aim of the research is by collecting data from literature review contributing to develop a survey and semi-structured interview questions. The focus of the research methodology is to identify the reasons for bankruptcy, understand organizational strategies during financial crises and pandemics, rating the challenges facing the developed model, and evaluating the developed model of bankruptcy. The outcome from the survey and interviews is that the main reasons for organisations bankruptcy are due to cash flow management, payment delays, and false cost reporting which is justifying the data in the literature review. Moreover, there is no prime reason for bankruptcy as much as it is a series of poor decisions. Another finding is that the level of knowledge and awareness about bankruptcy has increased especially during the current pandemic contemporary with the evaluation of the developed prediction model that is designed specifically for the UAE construction industry. The evaluation of the developed model by participants is good for being accurate, suitable, efficient, and realistic. This research provides a framework for the companies to predict the future risk of insolvency. Moreover, assisting the researcher to investigate and improve the developed model which is lacking transparency and published data on selecting the most important criteria and variables for the model.

### **Keywords**

bankruptcy prediction model, construction industry, UAE.

## Accelerating Building Decarbonization: Houseowner's Adoption Behaviours Analysis towards Residential Photovoltaic (RPV) Systems in Singapore\_12

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### Abstract

Residential photovoltaic (RPV) systems are one type of building-integrated photovoltaics (BIPV) specialized for residential buildings, demonstrating a significant positive impact on reducing carbon emissions. The Singapore government targets to install at least two gigawatts of solar energy by 2030, but the development of RPV is slow. RPV adoption analysis is critical for RPV development as it helps understand the market and identify the driving factors. However, the existing study ignored the non-linear relationships due to the limitations of conventional data analysis approaches. On the other hand, Artificial Neural Networks (ANNs) are robust in dealing with non-linear relationships, but they lack interpretation capability, making ANNs unsuitable for adoption analysis. This study proposed a hybrid-ANN by integrating the behavior theory and the network weight-based method, aiming to find the key drivers of RPV adoption in Singapore by considering non-linear relationships in raw data. The proposed model was trained and tested by a survey study of RPV adoption in Singapore. The results show that the hybrid-ANN outperformed existing models in predicting and explaining adoption behaviors. Furthermore, this study reveals that consumers' pro-environmental, economic attitudes and social obligation are driving factors in determining consumers' intention to adopt RPV. The study contributes the methodology in RPV adoption analysis by developing a novel way to construct the behavioral theory hybrid-ANN, which can be extended to analyse the adoption of other Renewable Energy Technologies (RETs) across the globe.

### Keywords

Adoption behaviors; Artificial Neural Networks (ANNs); Residential Photovoltaic (RPV)

# Logistics Strategy, Structure, and Performance: A Typology of Logistics Configurations in Construction\_32

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## **Abstract**

Building contractors need to understand their operational context to manage logistics efficiently and effectively. However, we know little about the choices regarding organization of logistics in building contractors and its relationship to performance. Thus, the purpose of this paper is to develop a typology of ideal logistics configurations and to discuss the strengths and weaknesses of the fit as profile deviation perspective for logistics configuration studies in construction. The typology is based on a critical review of stand-alone contingency studies within the logistics and construction management research domains. Two logistics configurations positioned at the extremes of a spectrum are identified. The first is the product-process oriented configuration resembling to the way industrialized housebuilders organize and manage logistics. The second is the project-oriented configuration, which resemble to how logistics is managed when operations are characterized by a high degree of on-site construction and project-specific engineering designs. The product-process oriented configuration typically generates low total costs of material supply and short and reliable lead times, while the project-oriented configuration has a flexible material supply process to support the high degree of variability in on-site operations and in the supply chain. Thus, these two configurations will perform better within different performance categories (project lead time, cost, and flexibility). Furthermore, the fit as profile deviation perspective is a promising approach to empirically assess the two configurations. For managerial practice, the typology can guide building contractors and consultants in evaluating existing logistics configurations and how to maintain ideal configurations when new logistics roles emerge.

## **Keywords**

Building Contractors, Configuration Research, Logistics Strategy

# Assessing the Impact of Smart Technologies on Project Management: The Case of Singapore\_59

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## **Abstract**

Integrated, digitalized and automated value chains can be recognized as the fundamental characteristics of the Fourth Industrial Revolution and can overcome many challenges faced by industries. To effectively utilize smart technologies in the construction industry, it is essential to understand how these technologies impact project processes. Hence, this study aims to provide a better understanding of the impact of smart technologies on project management knowledge areas to anticipate the changes in project management processes. This study has the following research objectives: (i) investigate the smart technologies with the greatest impact on project management; (ii) assess the specific project management knowledge areas that will be significantly affected by the technologies; and (iii) statistically analyze if organizations of different sizes perceive the impact on project management knowledge areas differently. To achieve these objectives, a comprehensive literature review and pilot interviews with industry experts were first carried out, followed by a survey and post-interviews. The results indicated that the smart technologies with the greatest impact on project management were autonomous vehicles, robotics, cyber-physical system, Internet-of-Things and big data, which were largely contributed by the changes in how information has been collected, processed and utilized, and the automation of work processes. All project management knowledge areas were also found to be impacted by the smart technologies at varying degrees, with perceived differences among organizations of different sizes in several smart technologies on project management knowledge areas. The findings of this study provide better understanding of how the smart technologies impact project management, serving as starting points to anticipate and make necessary changes to project management processes in order to maximize the potential of smart technologies and ultimately improve the performance of the construction industry.

## **Keywords**

Impact of technologies, Project management knowledge areas, Smart technologies

# Productivity of Robotic Excavators for Caisson Construction\_61

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## Abstract

Caisson foundation, which had been a popular foundation system in Hong Kong in 1970s and 1980s, was hand-dug by caisson workers. The advantages of using this construction method are cost-effectiveness and low mobilisation resources. However, as a result of airborne silica dust, the caisson workers working in the confined space of a hand-dug caisson may be exposed to the risk of getting pneumoconiosis. Thus, this construction method was banned by the Government in 1995. A robotic excavator was hence invented for replacing the caisson workers to deliver the excavation tasks. This new construction method can potentially improve the productivity performance of piling construction, while the workers' health can be guaranteed. Since the existing literatures focusing on benchmarking the productivity performance of using robotic excavators are very limited, this research study benchmarks the productivity of robotic excavator for caisson construction using site experiment data. The productivities of constructing five circular piling shafts using robotic-dug method and bored pile construction method are simulated and compared. The conclusion is drawn by discussing the cost-effectiveness using robotic-dug construction method.

**Keywords:** Caisson Construction, Process Productivity, Robotic Excavator.

# Assessing Implementation of Planning and Scheduling in Construction Projects Across India\_64

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## **Abstract**

The Indian construction industry is estimated to contribute 9% to the country's GDP, and the industry is currently worth approximately US\$ 145 billion. The market has shown excellent growth potential, but the industry is also facing delayed projects. 70% of infrastructure projects in India face time and cost delays which pose a significant risk to the stakeholders. The COVID-19 crisis worsened the situation as 90% of construction projects in India were slowed down due to the lockdown. Over 30% of labours stayed away from construction sites for fear of contracting the virus, leading to unprecedented circumstances. The leading causes of the delays identified in this research are unforeseen circumstances that remain unaccounted for during project planning and scheduling and a lack of clear communication between project stakeholders. This research focused on planning and scheduling challenges in four different construction terrains in India: hilly region, northern plains, coastal and desert region. The construction sites in these regions face distinct challenges like various soil types, variable climatic conditions, and challenging logistics. This paper highlights essential techniques of planning and scheduling, barriers, the importance of proper planning and scheduling and the significance of the role of the PM to improve the delivery of the projects. The research would support the project stakeholders in understanding the importance of applying planning and scheduling techniques in the construction industry of India.

## **Keywords**

Indian construction industry, planning, scheduling.

# Client Involvement and Construction Project Healthy and Safety Performance\_71

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## **Abstract**

Despite significant effort by business associations, researchers, construction clients and contractors to deal with the unsatisfactory health and safety (H&S) performance in the construction industry, the situation has not improved. Lack of effective involvement by clients has contributed to the construction industry's extremely high number of accidents that occur on a daily basis, resulting in medical treatment cases, lost time incidents, fatalities and damage to property. The objective of this study was to investigate client's attitude towards project healthy and safety performance and the extent to which South African construction clients are involved in projects. A questionnaire was designed for respondents to assess the extent to which construction clients were involved in construction project health and safety in projects they had managed and to evaluate the health and safety performance of those projects. Results from data collected across 135 large-size construction projects in South Africa were analysed using descriptive statistics. Results showed that the attitudes of clients and their involvement before and during construction was unsatisfactory. The results of the study confirmed that involvement by clients throughout the phases of the project could lead to improvement in project health and safety. Future studies should be conducted using a larger sample size to improve the application of the model in the construction industry.

## **Keywords**

construction clients, construction health and safety, health and safety performance, project performance

## Assessment of the Variation in the Maintenance of HVAC Component Units and its Energy Consumption Implication\_52

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### Abstract

The proper maintenance of the Heating Ventilation and Air Conditioning (HVAC) system promises various advantages ranging from energy savings, decreasing maintenance costs, prevention of hazardous conditions, increase the service life of HVAC equipment and guarantee thermal comfort for the building's occupants. However, HVAC systems have been multi-component systems, for proper maintenance demands a well-planned and strategic approach of maintenance. To this effect, this paper sought to nature, frequency, and the pattern of maintenance of the components units of the HVAC system and its energy implication using the HVAC installation of Hotel buildings in Owerri. It was pursued through the use of a structured questionnaire administered to 384 respondents comprising of the maintenance officers and facilities managers of the 115 Hotels studied. A total of three hundred and forty-two (342) questionnaires were returned adequately filled. The responses were analyzed using the computer SPSS software version 19. The result revealed among others that: the nature of maintenance is often unplanned with the frequency spanning between 13-18months except at the report of a fault. Also, the most maintained component of the HVAC system is the Air distribution system. This was closely followed by the 'Chillers'; 'Ventilators' 'Piping System'' among others ranked in the order of maintenance preference. Thus, the study recommends among others: Uniformity in the maintenance of all the HVAC component units, the use of an Automatic thermostat as against the common on/off toolbox' in the control of the HVAC system to achieve a definite and lasting control of the energy consumption.

### Keywords

Component Unit Maintenance, Energy Implication, Maintenance of HVAC

# Terrestrial Laser Scanner Analytical Modelling towards Effective Scan Area Planning for Damage Detection on Structural Members\_62

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## **Abstract**

Non-contact measurement technology such as Terrestrial Laser Scanning (TLS) can detect damages on the surface profile of structural members such as bridge components quickly and reliably compared to traditional diagnostic methods. However, the accuracy of the point clouds collected using the TLS depends on various factors such as atmospheric conditions, scanning surface properties, scanner angular resolution, and its location. Among all the influencing factors, the location of the scanner from the target surface is the only operator-controlled factor. Further, it has a significant influence on the interpoint spacing of point clouds, which affects the accuracy. Therefore, an appropriate selection of scanner location beforehand helps to accurately collect the point cloud data. In this research, a set of mathematical equations are proposed using trigonometric relationships to understand the variation of interpoint spacing when the scanner location varies on structural components. The calculated interpoint spacing values using the proposed equations are validated through a known field scan experimental result. A set of interaction graphs are obtained using the proposed equations, and its analytical calculations on various scanning locations are helpful in deciding TLS coverage areas while measuring the damages on structural components with differing accuracy. Further, the study demonstrated the procedure to obtain the customizable scanning accuracy by fixing the various TLS data acquisition parameters.

## **Keywords**

Inter point spacing, Structural inspection, Terrestrial laser scanning

# Management of Recovered Wastewater for Passive Irrigation of Buildings Green Landscaped Areas: Blue/Green Roof Subterranean Water Management System\_77

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## **Abstract**

Countries in the Middle East region, including United Arab Emirates (UAE) are amongst the most water-scarce countries facing water management challenges due to rapid population growth and urbanization, and Dubai is a strong example. Currently, the resident population of the emirate is 3.42 million, expected to increase to 5.8 million by 2040. Dubai has an average water consumption in excess of 550 liters of water per person. The primary source of freshwater is desalinated seawater from the Arabian Gulf as it accounts for 89.9% of the city's water supply needs. Dubai 2040 Urban Master Plan for sustainable development promises the best environment and infrastructure required to enhance the community's happiness and wellbeing through adopting greener areas. Life within the surrounding environment counts on the water as a vital natural resource, and smart management of water is integral to the success of the future master plan. Recovered water usage from condensate, greywater, Treated Sewage Effluent (TSE), and rainwater to reduce the requirement on potable water supply is essential, in addition to the energy required to treat and distribute potable water. Irrigation water systems implemented throughout the region are predominantly overground drip-feed, sprinkler, and manual handheld hose systems. This paper investigates delivering recovered wastewater to a shallow subterranean storage system, where water is then transferred on-demand to the growing medium by passive capillary action. Passive Irrigation is a method of growing plants and grasses using inert porous medium to transport water and oxygen to the root zone by capillary action.

## **Keywords**

Water scarcity, Water management, Passive Irrigation

# Studying Buildings Outlines to Assess and Predict Energy Performance in Buildings: A Probabilistic Approach\_65

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### Abstract

Building performance is commonly calculated during the last phases of design, where most design specifications get fixed and are unlikely to be majorly modified based on design programs. Predictive models could play a significant role in informing architects and designers of the impact of their design decisions on energy consumption in buildings during early design stages. A building outline is a significant predictor of the final energy consumption and is conceptually determined by architects in the early design phases. This paper evaluates the impact of a building's outline on energy consumption using synthetic data to achieve appropriate predictive models in estimating a building's energy consumption. Four office outlines are selected in this study, including square, T-, U-, and L-shapes. Besides the shape parameter, other building features commonly used in literature (i.e., Window to Wall Ratio (WWR), external wall material properties, glazing U-value, windows' shading-depth, and building orientation) are utilized in generating data distribution with a probabilistic approach. The results show that buildings with square shapes, in general, are more energy-efficient compared to buildings with T-, U-, and L-shapes of the same volume. Also, T-, U-, and L-shape samples show very similar behavior in terms of energy consumption. Principal Component Analysis (PCA) is applied to assess the variables' correlations on data distribution; the results show that wall material specifications explain about 40% of data variation. Finally, we applied polynomial regression models with different degrees of complexity to predict the synthesized building models' energy consumptions based on their outlines. The results show that degree 2 polynomial models, fitting the data over 98% R squared (coefficient of determination), could be used to predict new samples with high accuracy.

### Keywords

Building Energy Performance, Building Outline, Machine Learning, Uncertainty.

## Investigating the Drivers & Challenges of Implementing Immersive Sensory Technology within Construction Site Safety\_8

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### **Abstract**

The use of immersive sensory technology for safety management is generally shown positively in academic literature. Many researchers have demonstrated applications of this technology for improving safety training in a risk-free environment. Despite the reported benefits and a global pandemic forcing the digital agenda, the uptake of this technology for this purpose remains slow. This study aims to investigate current drivers and challenges of implementing this technology for safety from an industry-based perspective. To achieve this, qualitative data was collected through 4 online focus groups involving 21 industry professionals working within the field. The findings identified that even amongst these experts, the technology was rarely implemented on projects specifically for safety. Despite this lack of adoption, participants agreed that if implemented correctly this technology has the potential to enhance site safety processes such as inductions, toolbox talks and general safety training. The commitment to safety and legislative requirements were identified as key drivers, whilst deep rooted challenges surrounding client demand, costs and leadership dominated the discussion. The onsite practicalities, personal comfort and lack of digital skills were also identified as concerns if this technology was to be adopted more mainstream in safety training. Further recommendations are made to develop understanding of these specific challenges, including investigating the industry need and availability of specific skills in immersive safety applications. In addition, it is recommended that further empirical evidence including the impact of this technology when implemented for safety on projects is provided in literature.

### **Keywords**

construction, immersive technology, safety.

# Barriers to Effective Digital Leadership Enactment in the Construction Industry\_26

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## **Abstract**

This study considers the role of leaders in driving digital transformation in their organisations. Considering that the construction industry is slow at adopting digital technology, the aim of the study was to explore the factors that inhibit leaders from driving digital transformation in their organisations. Data was collected through a qualitative questionnaire survey. Participants were asked to describe barriers to effective digital leadership in their organisations. The issues that hinder effective digital leadership were grouped under five themes: leadership characteristics, management and organisational issues, resource constraints, technological issues, and risk perceptions. The study shed light on the barriers to digital leadership enactment in the construction industry, an issue that has received limited attention in the existing literature. The findings are useful to business leaders, researchers, trainers and educators to develop measures to encourage leaders in the industry to be at the forefront of digital transformation in their organisations.

## **Keywords**

leadership; digital leadership; digital transformation; digital innovation

# Towards a Hybrid Approach to BIM Implementation – A Critical Discourse\_49

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## **Abstract**

BIM adoption in many countries involves different approaches including the use of government mandates. The UK's 2016 BIM mandate for public projects to be delivered at BIM Level 2 maturity, is an example. However, BIM mandates do not apply to private sector projects which leave questions about the inclusivity of its adoption and the susceptibility of SMEs to being digitally disenfranchised. Developing countries yet to adopt BIM are at the risk of out-rightly imitating the mandate-driven policies of countries like the UK, without considering alternative options that might better suit their socio-economic realities. This research investigates the use of alternative strategies (nudge theory) for promoting BIM adoption for inclusivity of smaller organisations, the private sector or developing countries. By drawing on two interrelated yet independent theories of loss aversion theory and nudge theory, this study examines the current mandate-driven policies and provides a critical discourse around ways that these two theories can be combined to form a new kind of construct on the way BIM implementation is (or can be) understood. The result from the critical analysis suggests that a hybrid of mandate and nudge can be effective in promoting BIM and none of these approaches is self-sustaining given their challenges. This finding opens a new vista for applying behavioural policies based on nudge theory and its potentials for promoting BIM implementation in the construction sector.

## **Keywords**

BIM implementation, BIM mandate, BIM policies, Loss Aversion theory, Nudge theory.

# **BIM in Facilities Management. Has COVID-19 Widened the Gap between Academia and Practice? A Case Study from Dubai\_60**

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## **Abstract**

BIM has attracted the attention of researchers over the past 2 decades. More recently, BIM in FM has started to get the attention of academics. However, the adoption of BIM in FM is still a puzzle, particularly in developing countries. This study aims to investigate the gap between research and practice, and the subsequent impact of the COVID 19 pandemic using Dubai as a case study. The study used a mixed-methods approach with a survey of the challenges rolled out to a random sample of 300 practitioners building on a set of challenges identified from the literature. The statistical analysis applied to the data gathered from 143 responses indicated the significant lack of awareness among practitioners. This was confirmed during the 10 interviews conducted with practitioners. The factor analysis identified two principal components for the challenges; the technical side and the resistance to change. The findings of the interviews indicated that many universities do not offer BIM training not to mention BIM for FM at the undergraduate level. The required initial investment in IT infrastructure and capacity building was another major challenge. The study found that Covid-9 has hit the sector hard thus holding any initiative that required investments. It was concluded that the education sector both universities and further education should introduce BIM practical training as a core component at undergraduate level courses. This will facilitate the adoption of BIM in FM saving the industry time and cost and should enhance the employability of graduates.

## **Keywords**

BIM, Challenges, COVID 19, Education, FM

## Research on the Adaptability Design of Smart House Based on Residential Demand\_31

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### **Abstract**

With the development of Internet of Things technology and the wide application of multimedia information technology and intelligent control mechanisms, great changes have taken place in people's living environment and lifestyle. In the prevention of COVID-19, higher requirements are put forward for current living quality. The application of smart home systems can help to upgrade the quality of the living environment into the intelligent era, but its intelligence is mostly reflected in the addition of unilateral multi-functions and the centralized control of the system. There is a lack of system analysis and design of residential intelligence that meets the actual needs of the users. Qualitative investigation and correlation analysis are used in this paper. Firstly, Taking the residential needs based on temporal and spatial behavior as the starting point, the functions and performance of smart home system products in the market are classified and summarized. Secondly, a correlation system is further established among residential behavior, residential needs and smart home systems. Finally, the paper takes the project of "24 · 35 housing home" in the 2021 International Solar Decathlon Competition as an example, and proposes adaptive design strategies for smart houses from three aspects: structural form, flexible space design and smart home scene setting. Based on the development of the Internet of Things and the background of new residential demand, this paper provides reference basis and optimized direction for the construction of smart homes and improvement of living quality.

### **Keywords**

Living demand, Smart house, Adaptive design

# Optimal Collaborative Energy Model among Vehicle-to-Home (V2H) and Solar Systems\_47

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## Abstract

Replacing traditional car engines with electric vehicles (EVs) has been suggested as an effective strategy to address climate change. The EV boom will also increase electricity demand especially if EV charging times coincide with peak-electricity demand. Most EV drivers are charging their vehicles at home, and some are doing it using solar-generated power. At the same time, the number of smart homes that can potentially coordinate the generation, consumption, and storage of energy across the available resources is steadily increasing. Because EVs spend more than 90 percent of their use time off the road and parked, their batteries could be used to store and distribute solar-generated electricity. With the aid of vehicle-to-home (V2H) systems, we can communicate with the smart home to store and discharge electricity generated from renewable energy sources. The use of EVs as electricity storage needs to be properly managed to not only avoid the negative impacts of EV charging on the power distribution network but also to help strengthen the grid and reduce operating costs. Among available renewable energy systems, rooftop solar represents a significant source of power generation in smart homes. This study investigates energy models to optimize energy flow among smart homes equipped with rooftop solar and EVs.

## Keywords

Vehicle-to-Home, Solar Systems, Electric Vehicle, Smart Buildings

# Smart Cities in Developing Countries with an Emphasis on GCC Countries, and its Impact on Expatriates amidst the COVID-19 Pandemic – A Systematic Literature Review\_67

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### **Abstract**

Considering the growing concern for sustainability within the development of smart cities and the pressing need for a holistic approach to new urban developments, this study presents a systematic literature review covering the past 50 years on “Smart cities within the Gulf Cooperation Council Countries (GCC)”. All relevant journal articles were analysed. Primarily, the aim was to understand the mushrooming smart cities developments within the GCC countries. The main constructs were identified from the wider literature on smart cities: challenges and drivers. These were then explored in the context of the development of smart cities within the GCC countries, and the subsequent themes and factors were mapped. Furthermore, these factors were evaluated in the context of the sizable expatriate population residing within the GCC countries and the impact of COVID-19 on them. The analysis of the articles revealed specific gaps in the literature, on smart cities within the GCC countries with respect to the expatriate population as well as the impact of COVID-19. The main findings indicated the need for further empirical studies about developing and implementing smart cities initiatives across the region, holistically, while considering the impact of COVID-19 on the expatriate population within the GCC amid this transformation.

### **Keywords**

COVID-19, Expatriates, GCC, Smart cities.

# Creating Smart Cities: Case Study of Energy Hub for Effective Energy Management\_70

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## Abstract

One of the most critical challenges facing humanity in the twenty-first century is scarcity of energy. These challenges appear in many different fields, including energy supply, exchange, and consumption. Scarcity of energy is due to population expansion, growing worldwide demand for energy, natural resource shortages, and environmental concerns. Furthermore, scarcity of energy requires the growth of renewable energies as well as energy efficiency, it is considered as a top priority for all governments and organizations to resolve. Energy efficiency of buildings is an important concept when discussed in the context of smart cities. Buildings are the largest energy consumers since building sector being responsible of 40% of energy consumption. Recent developments in machine learning within big data environment have created opportunities for more effective management of energy use in buildings. Managing buildings energy consumption effectively through real time measuring process enables the economy to move away from a linear model of consumption to a circular model. this will solve the problem of late notification of energy saving measures failure and allow for quick rectification bring the energy management system back to high performance. The size of the energy hub is unlimited, it can be a single home energy system or a city-wide energy system. This paper will present a case study on developing smart energy hub called Hub grade 4 that relies on connected products and artificial intelligence. Hub grade 4 is the name of Enova by Veolia smart energy hub, Enova is MENA regional leader in integrated energy and multi-technical services delivering performance-based energy and facilities management solutions. Hub grade 4 provides an innovative approach to the successful implementation of energy efficiency improvement using artificial intelligence and real time data. the case study will explore how energy management can utilize real-time data to efficient use of resources of residential, commercial, and industrial clients. This paper concluded and highlighted lessons learned from the successful implementation of innovative energy management, which relied on a dedicated organization, effective adoption of digital technologies, and embracing new business models, resulting in power savings of 254 million kw and water savings of around 3 million cubic meters, as well as financial savings of around 138 million AED in 5 years since hub grade 4 started operations its first energy saving contract in 2017

## Keywords

Energy hub, Smart cities, Sustainability, Energy management

## A Review on Embodied Carbon Reduction Strategies of Iron and Steel Building Products\_6

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### **Abstract**

Whilst the operational carbon emission of building continues to attract significant attention, the embodied carbon emission of building materials receives increasing attention in both industrial and academic fields. Iron and steel are very popular building materials in modern construction and they are among the most carbon-intensive building materials. In recent years, numbers of studies have been conducted to disclose the embodied carbon emission of iron and steel building products and explore the possible carbon reduction strategies. This study aims for discovering the status quo and features of the available carbon reduction strategies of iron and steel building products through a review on existing literatures. Numbers of reduction strategies have been identified through a broad review of research articles and subsequently been systematically analyzed. Results of this study reveal that alternative fuel & renewable energy, alternative ironmaking processes, alternative reducing agents, carbon capture and storage, waste gas recovering, are key measures to achieve low-embodied-carbon iron and steel building products. In many cases, the carbon reduction strategies work cooperatively to achieve maximum performance. Alarmingly, the impacts of policy drivers, and management measures such as a thorough life cycle analysis of manufacturing process and use of local raw materials have been overlooked in most researches. The challenges and barriers of implementing the reduction strategies have also been discussed in this research.

### **Keywords**

Carbon emission reduction strategies, embodied carbon of building, iron and steel building products

# Carbon Reduction during Building Construction Projects – Trend Mapping from Construction Journals\_9

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## **Abstract**

In recent times, there has been an increasing attention on embodied carbon reduction of building construction projects. However, most of this attention have been concentrated on carbon emission related to materials used for building construction while construction activity related carbon emission seems to have been largely ignored. Hence, this paper examines this claim by analysing literatures in construction management journals published between year 2000 and 2021. The authors performed the analysis by examining the annual publication of research related to carbon reduction during the construction phase of building projects, geographical spread and/or institution of authors who have contributed to these studies, and key research themes covered. The systemic review of literature conducted shows that there seems to be very little research published relating to carbon reduction during building construction projects. Also, the findings suggest that carbon reduction during building construction project related research have only just been in mainstream publication in the last five years with this research largely domiciled in China, US, Australia, and Hong Kong. Furthermore, it was discovered that most of the existing research related to the focus of this paper was done in the context of life cycle analysis or assessment. Research gaps were highlighted, and future research path is proposed. It is likely that the findings of this study may arouse researchers with interest in construction carbon reduction and industry stakeholders alike.

## **Keywords**

Carbon Reduction, Construction Carbon, Construction Journals, Building Construction Projects

# Urban Sustainability Transformation through Building Adaptive Pathways\_15

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## **Abstract**

It is becoming apparent that inappropriate infrastructure is one of the main reasons that climate change targets are not being achieved. The structure of existing infrastructure and systems perpetuate unsustainable working and living patterns and it is difficult for people to avoid environmental impacts such as carbon emissions, even if there is a will to do so. Methodologies are therefore needed to understand how existing infrastructure and built environments can be transformed to enable low carbon lifestyles. A potential methodology for achieving this is called Building Adaptive Pathways. The study presents the methodology and illustrates how this can be applied through a case study urban site in Pretoria, South Africa. Findings generated by the application of the methodology, and the methodology itself, are critically reviewed to ascertain the value of the approach. The study concludes that the methodology presents a valuable alternative approach for addressing urban sustainability transformation and makes recommendations for its further development.

## **Keywords**

Sustainability, urban, transformation, Building Adaptive Pathways.

# Integrating Users Satisfaction to Support Decisions in Sustainable Developments\_39

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## **Abstract**

With the growing concerns on the environment and the rapid consumption of scarce re-sources, the green building movement and sustainability initiatives started to rapidly grow and stress the importance of sustainable developments and the related benefits under sustainability three dimensions (3D): social, economic, and environmental. Studies showed that current sustainability initiatives and rating systems could not successfully capture the claimed 3-dimensional benefits of sustainability. Most of the sustainability assessment systems and frameworks assign significant weight to environmental credits with an insufficient concentration on social and economic dimensions. Environmental consultants are inclined to follow the client aspirations without balancing user needs and satisfaction to achieve the highest 3D benefits. The study survey showed that lack of knowledge on the impact of green buildings solutions on business value and the lack of public awareness on sustainable developments are two main obstacles towards capturing 3D benefits in the UAE market. The aim of the study is to optimise the sustainability value by integrating the user preferences and levels of satisfaction as a leading role-player in balance with the extent of the scoring points. A survey was conducted to scale the users' satisfaction on several environmental, social and physical factors, wellbeing provisions selected from LEED and WELL building standards. LEED framework was chosen as a foundation of the study. Hence, the results were transformed to user preferences weight and associated with LEED credit options and UNSDG's to support practitioners in the UAE on accreditation decisions towards better sustainability benefits.

**Keywords** Sustainability social pillar, UN Sustainable Development Goals (UNSDGs), Users satisfaction.

# Towards Automation of Sustainable Green Building Materials in India\_58

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## **Abstract**

The AEC (Architecture Engineering and Construction) industry has had a reputation for being a major contributor to negative effects on the environment. Hence, the need for development of sustainable buildings is increasing. Sustainability in the construction industry has the utmost potential to effect change in current construction practices. In this paper, two stage assessment of material is conducted in one stage IGBC green materials rating system is developed in BIM for the ease in process and in second stage an analytical tool to assess the eco-efficiency of building facade materials is developed (ECO-DEA Green rating system-EDGRS). This two-stage process assesses sustainable criteria and optimization of material selection aspects and process automation of material selection through BIM approach in both stages respectively. The ECO-DEA tool evaluates the eco- efficiency of façade material by using data envelopment analysis (DEA), a linear programming-based mathematical approach. Life-cycle assessment (LCA) and life-cycle cost (LCC) is used to rank material alternatives. It provides a holistic approach combining two pillars of sustainability, economy and ecology which gives complete information to the decision makers. It is followed by quantitative cradle-to-gate approaches, since they cover multiple environmental criteria. Most of the important decisions regarding green building construction are taken before the construction process starts. The created framework is an expandable automation assessment of sustainable criteria and green building rating system in India. It offers a vital guidance to the decision makers to evaluate alternative construction material selection.

## **Keywords**

Building Information Modelling (BIM), Green BIM, Sustainability.

## Computational Infrastructure Design to Support Applications in Intelligent Building Environments – Case Study Focused on Intelligent Laboratories\_17

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### Abstract

The Internet of Things (IoT) has provided a significant increase in the number of devices connected to the Internet, which need to be managed by a computing infrastructure. Usually, these computational infrastructures are designed for large-scale applications, which often involve proprietary solutions and high acquisition and maintenance costs. Based on the bibliographic study, we defined what is IoT applications of a small, medium, and large scale, then we propose an architecture for small and medium scale applications. Our main contributions with this work are found in the mapping of the information flow of these architectures, proposal of a PaaS for managing the medium-sized architecture, providing an extensible architecture according to the addition of smaller architectures, it also shows an approach aimed at complexity of the solution from the bottom up, that is, from simpler applications to more complex applications. A case study carried out at University of São Paulo's LaSDPC using open-source technologies covered a small environment (laboratory) and a medium environment (building). Finally, it is concluded that the advantage of this approach is a centralized service platform, in which new services can be integrated.

### Keywords

Architectures; Internet of Things (IoT); Platform-as-a-Service

# Live VR: Realtime Virtual Reality is Architecture Practice on Air\_78

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## **Abstract**

This paper poses the question of what is to gain in architecture, urban design, landscape and interiors with the advent of real-time rendering and live streaming of designs in Virtual Reality. Technological innovation from video gaming is rapidly filtering into external domains such as design consulting and research. This paper discusses emerging opportunities, in particular, streaming software tools and VR technologies. The paper looks at applications in practice and also applied research within environmental psychology such as new ways to predict user experience, user feedback, behaviour and stakeholder engagement. Four worked scenarios illustrate the use and opportunities. The closing section provides a summary of reviewed methods, tools and technologies, applications for professional practice and people-environment research.

**Keywords:** Live Streaming, People-Environment-Design, Virtual Reality

## Critical Success Factors towards Collaborative Road Infrastructure Projects Delivery in Tanzania\_66

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### **Abstract**

Infrastructure projects have been known for their importance to the economic development of a nation both during and after their delivery. However, achievement of infrastructure development goal, is reliant on how well their delivery is managed. Prevailing infrastructure projects delivery process in Tanzania has been experiencing inadequate collaboration among project participants. As a result, delivered infrastructure have been characterized by cost and time overrun, low quality and productivity, safety concerns and conflicts consequences. Establishing collaborative success factors in infrastructure delivery could improve the value of infrastructure facility as well as enhance their contribution towards economic development. The objective of the study was to establish critical success factors towards improved collaborative relationship in the delivery of infrastructure projects. Literature review on generic factors for successful collaboration relationship in project delivery process was conducted to collect secondary data. A structured questionnaire was used to collect primary data in order to establish stakeholders' perception on critical success factors for creating and maintaining collaborative relationships during infrastructure project delivery. Respondents targeted for the study were public clients (local government councils) which were represented country wide by council engineers; and consultants and contractors based in Dar es Salaam. Commitment, effective communication, efficient coordination, prompt problem-solving and mutual trust were regarded to be the most important factors for collaborative relationship in infrastructure delivery project in Tanzania. Further, this study recommends that it is important to device and adhere to proper means of communication, coordination and problem solving in delivering roads infrastructure projects.

### **Keywords**

Critical success factors, Collaboration and Infrastructure Project delivery.

# Smart and Sustainable CAPEX Planning to Develop New Infrastructure. Case Study: Hosting Mega Event - Dubai EXPO 2020\_76

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## **Abstract**

The availability and quality of infrastructure are considered as critical elements and pillars to ensure high standard of living for any city. However, securing budget for investment in new infrastructures or upgrading existing ones is a challenging task for governments, therefore, the competition between cities worldwide to achieve and maintain a distinguished place in quality of living is tough. Nevertheless, infrastructure projects are considered as catalyst for economy as it is linked to different industries and businesses. Hosting global mega event, such as, EXPO, Olympic Games & FIFA World Cup is a national ambition for any city to mark its position on the globe, furthermore, it is an opportunity to attract investment and secure budget in building new infrastructures, buildings and facilities to improve the quality of living. This paper explores the efforts made by Dubai government to deliver Expo 2020 event and the governance model adopted by Dubai emirate for planning and management to assure successful delivery of the event. The research work will shed light on sustainability model implemented by different authorities to deliver the required projects for the event, as well as the long lasting Legacy, in addition, the paper will explore the sustainability concepts to maximise the benefits from investment in infrastructures and buildings and the generation of new development, urban areas and places of interest. The main objective of the research work is to present Dubai model and methods applied to balance different factors to deliver the sustainable event of Expo.

## **Keywords**

Hosting mega event, legacy, sustainability.

## Developing Bluetooth Communication Technologies for Safer Construction Sites: Experiences and Learnings\_25

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### **Abstract**

The construction industry is one of the most dangerous industries when it comes to safety and situations involving collisions between vehicles and workers are often fatal. Site activities are carried out simultaneously by skilled workers and machine operators, which makes communication between these groups crucial. Based on a single case study, the aims of this paper are to investigate: (i) problems related to communication on construction sites and (ii) the usefulness of Bluetooth headset technology to improve communication. In the first research phase, three semi-structured interviews revealed problems related to communication. Respondents identified improvement areas such as sound isolation in vehicles, making it difficult to hear, and problems with using sign language when it is dark or too sunny. Working together with the same person on a regular basis improves communication as well as safety and productivity, and interviewees suggested that inexperienced personnel should be mixed in groups with more experienced personnel, which can help them to avoid injuries and learn safer practices. In the second research phase, Bluetooth headsets were introduced to improve communication between different groups. Data was collected through five rounds of mini questionnaires with construction site personnel. Feedback from each survey was used to improve the usefulness of the Bluetooth headsets. Analysing patterns from respondents' suggestions, showed that they first complained about the fit and comfort of the headsets, followed by noise isolation, frequency and other additional functions of the headsets. The possibility to add warning signals enhance the usefulness of Bluetooth headsets, e.g. by increasing the situational awareness and reducing cognitive load of construction workers, making workers more productive while also helping to avoid injuries.

### **Keywords**

Bluetooth headsets, communication technologies, construction sites, HSE

# Impediments to the Deployment of Drones for Construction Project Delivery in South Africa\_34

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## **Abstract**

As the designs of construction projects become more complex, there is a corresponding increase in the difficulty encountered in project monitoring. Hence, it is advisable to integrate innovative technologies such as the use of drone technology to abate some of the problems encountered in the delivery of construction projects. This paper aims to evaluate the barriers to the usage of drones in construction project delivery in South Africa. Adopting a quantitative method for the study, data was collected with the aid of questionnaire from construction professionals in Gauteng province, South Africa. Findings from the study indicates that most significant factors hindering the deployment of drones in the South African construction industry are lack of training by institutions and lack of investment in new technologies by organisations. Conclusively, the paper recommends measures that would propel the espousal of drone technologies for effective and efficient construction project delivery in the South African Construction industry.

## **Keywords**

Barriers, Construction projects, Drone, Project monitoring, Project delivery.

# Strategies of Urban Resilience Related to the Built Environment: An Overview of the Literature\_14

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### **Abstract**

Urban resilience has been an increasingly discussed topic in the scientific community. The term relates to the city's ability to return or simply not to interrupt its routine in the face of some disturbance. Cities around the world have sought to create and implement strategies to improve their resilience to cope with tensions arising from climate change, as well as issues that are already familiar to them, but which have not been overcome. Thus, studies on resilience run through urban systems and communities, which makes the theme attractive and necessary for the engineering context, since it is indispensable for the construction of a smart and prepared environment to face climate change. This article presents an overview of the current literature on the implementation of urban resilience strategies directly related to the built environment and the construction industry. Bibliographic research uses systematic mapping supported by bibliometric analysis and performs content analysis to identify trends and gaps in knowledge. As a result, several strategies, both governmental and technological, applied in various cities around the world are identified and categorized. In addition, the need for more studies on urban resilience in the built environment was perceived.

### **Keywords**

Built environment, systematic mapping of literature, urban resilience.

# Efficient Utilization of Public-Private Partnerships (PPPs) to Develop Resilient and Sustainable Public Infrastructure\_51

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## **Abstract**

The efficient utilisation of long-term public-private partnerships (PPPs) contractual models for the procurement and operations of public services and infrastructure has been a widely debated topic within the infrastructure industry and the academic research. Whilst the key driver for PPPs remains to be the public deficits facing critical infrastructure requirements crucial for both current public needs and future economic growth, the socioeconomic benefits have been historically marginalised. This paper examines the global and the regional landscape for achieving socioeconomic benefits under PPPs and the associated contribution to the national development agenda in alignment with the global pledge to develop sustainable and resilient infrastructure under the umbrella of Sustainable Development Goals (SDGs). The paper is based on the researcher's master thesis This where the research approach follows Conceptual Framework of an exploratory Study of existing literature and semi-structured interviews followed by case study research. This paper concludes that incentivised output-based performance PPPs can drive the private sector to achieve optimum efficiency through utilising the best of its experience and innovation to maximise efficiency gains incentivised by revenue sharing or rewarding schemes whilst concurrently delivering socioeconomic benefits contributing to the economic growth and quality of life, conditional to identifying the targeted socioeconomic outcomes at the earlier preparation stages and specified within the contractual agreements e.g. reduced service tariff, improved service quality and coverage, service reliability and availability and moreover, employability and income.

## **Keywords**

*Public Private Partnerships (PPPs), Sustainable Development Goals (SDGs), Sustainable Cities*

# Appraising Institutional Work Involved in Setting up Governance Structures in Megaprojects\_30

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### **Abstract**

'Rules of the game' which articulate technical, contractual and associational decisions, and thereby how projects are organized constitute project governance. Megaprojects, in particular, are active sites of a project governance paradox: One school of literature builds grounds for interpretative flexibility in seamlessly organizing large and complex engineering projects; Another school of literature recognizes the embedded, taken-for-granted rules, norms, and values in which these seemingly unique settings are organized, and advocates that institutional order persists involuntarily and by default in project governance. However, both underlying propositions are increasingly being questioned by various banners such as 'inhabited institutions' and 'institutional work' on the grounds that institutions are instantiated or disrupted as a product of ongoing, situated, and emergent interactions. With a similar realization being trivial in project governance, we attempt to illuminate the modalities of institutional work involved in setting up contingent governance structures in megaprojects. We adopt a multiple case-based, evolutionary method to qualitatively study the development of a vanguard megaproject – the Central Metro, and two trailing megaprojects - South-East Metro and South-West Metro, in India. The contingent governance structures enacted in all the three projects reveal the dynamics behind the enactment of adaptive and institutionalized arrangements prevailing in the respective fields. Consequently, our analysis captures the situated modalities of institutional work exerted in three hybrid organizing zones – environment-related, actor-related and task-related zones, of the megaprojects to sustain or adapt the institutionalized arrangements prevailing in the fields. We infer that institutional work is exerted in these zones by accommodating or aligning with plural logics, mobilizing actors and negotiating role structures, and working boundaries respectively. Further insights from this analysis highlight the transition in institutional work exerted by the promoters as megaprojects move from being vanguards to trailers.

### **Keywords**

Governance, Institutional work, Megaprojects

# Development of Integrated Framework Based on Agile Principles and BIM Functionalities\_69

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## **Abstract**

Building information modelling implementation in construction industry requires changing the process and proper management approach to deliver successful projects in terms of design, construction, operation and manufacturing. This paper discusses alternative management approach to support BIM application in construction projects. Agile project management integrates with BIM in order to develop new two-dimensional framework to lead construction project teams into effective implementation of BIM functionalities and agile principles. The endeavour of integrating BIM and Agile is to deliver value in terms of minimizing wastes and rework, motivating individuals, early project delivery, better communication and collaboration, satisfying customer and effective adaptation of changes. This paper evaluates the associations between 12 agile principles and 13 BIM functionalities; and assesses how agile principles facilitate the implementation of BIM. This paper utilizes questionnaire survey to collect data from professionals in construction and software industries to verify the two-dimensional integrated framework. The main finding of the study include: (a) 75% of respondents agreed that BIM functionality of reusing of data model supports agile principle of customer satisfaction ; (b) 78% of respondents agreed that BIM functionality of construction simulation supports agile principle of welcoming changes; (c) 72% of respondents agreed that BIM functionality of visualization supports agile principle of priority of working product; and (d) 81% of respondents agreed that BIM functionality of automated cost estimation supports agile principle of simplicity.

## **Keywords**

Agile Project Management, Agility Principles, Building Information Modelling

# An Exploration of the Potential for Using Modular Housing Solutions to Address the UK's Housing Shortage\_73

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## **Abstract**

The UK construction industry is affected by a shortage of affordable housing exacerbated by a shortage of skilled labour. This paper explores opportunities to use modular homes to address the UK's housing shortage. In developing this paper, a questionnaire-based survey was undertaken following a literature review. The survey of industry professionals involved 70 structured questionnaires sent online. The study revealed that one of the most pressing issues within the housing industry is the lack of affordable new developments. Again, a lack of investment in apprenticeships has led to skilled trades shortages in the industry. The study found that modular homes would provide would produce homes quicker and cheaper. Other benefits of modular housing are the use of eco-friendlier materials, waste reduction and reduced CO2 emissions from construction processes and from reduced transportation. Reduced maintenance requirements also reduced life-cycle costs however traditional housing was seen as having a longer lifespan. Due to restrictions in place at the time relating to the COVID 19 pandemic, detailed confirmatory interviews could not be conducted. This could have provided some additional insights into the general trends arising from the survey. Further research could investigate the costs associated with contractors establishing their own manufacturing facilities as a means to reducing the time and costs for offsite manufacture of construction components. Future research could also explore the potential of increased integration of Value Engineering and Building Information Modelling (BIM) into modular house building and the evaluate the potential benefits.

## **Keywords**

Modular, Housing, offsite-construction, skills shortage, construction

## Perspective of Public-Private Partnership (PPP) in Various Economies\_63

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### Abstract

With the growth of economies and population worldwide, there is an increased demand for the development in various sectors and the country's sustainable development. For the modern economies, with the objective to minimize the overall costs and to increase efficiency, such huge investments cannot be funded by the government alone but with the involvement of private sector as well. There has been a significant popularity in the construction industry regarding the implementation of Public-Private Partnership (PPP) scheme as it is based on a long-term partnership concession on the basis of mutual appreciations of risks, costs and opportunities. The PPPs with innovative modern technology in different forms are being implemented for infrastructure development in both the developed and developing nations with diverse results. There is a larger and growing number of PPP practitioners within the government and private sector focusing on 'lessons learned' for PPP implementation. Although the PPP model is being implemented over the past three decades, various countries are still working on developing solid PPP policies and legal frameworks to govern such contracts. This paper aims to conduct a review on PPP literature, critiques on the history and modern trends in various economies, covering different regions in Europe, Asia and Middle East.

### Keywords

Public-Private Partnership, PPP, History of PPP, Project Statistics, Challenges for PPP, Success failure criteria

## Challenges to the Adoption of Strategies and Regulations for Energy Efficiency Initiatives in the Retrofitting of Retail Centers\_72

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### Abstract

This study investigates the challenges experienced in the implementation of energy efficiency retrofit initiatives in retail centres in South Africa. The participants of the study were management of 20 retail centres in and around the KwaZulu-Natal province. A close-ended questionnaire was used to determine to examine the challenges associated with implementation. The stratified random sampling was used to determine the sample of the population to be used. Data was analysed using descriptive statistics comprising of frequency distributions providing the mean, median, standard deviations as well as maximum and minimum values for nominal data. The findings of the study indicated that the issues faced by retailers were the high capital costs as well as lack of demand from tenants and customers. Larger retail centres who have overcome these challenges enjoy the many benefits associated with the implementation of retrofit energy efficiency solutions. Further study into the level of benefits received through various implementations of retrofit solutions could provide a detailed mapping of implementation solutions with relation to benefits achieved. Challenges faced by retailers could be extended to challenges faces by building or property owners as well as store managers. Limited reasons were investigated in this study for lack of implementation of energy efficiency strategies. Further study can be done into more reasons for lack of implementation. Many retailers declined to provide information surrounding the cost of strategies implemented and benefits received, more study can be done surrounding the costs of energy implementation.

### Keywords

Energy Efficiency, Retrofit Strategies, Green Buildings, Retail Centres