SMART CONSTRUCTION: THE NEXT PARADIGM FOR MALAYSIA CONSTRUCTION INDUSTRY

By CIDB Malaysia, 25th AsiaConstruct Conference (ACC)

1.0 Executive Summary

Malaysia's economic development has been significantly influenced by the construction industry, which has long been a critical generator of employment and an enabler of national growth. Its contributions are not limited to the tangible delivery of infrastructure; they also influence urbanisation, industrial expansion, and social well-being. However, in recent years, the sector has encountered increasing pressures that are felt throughout the broader Asian region. These pressures include an aging workforce, a reliance on migrant labour, and productivity that continues to lag behind other industries. Simultaneously, the global urgency of climate change and the pursuit of sustainable development objectives are altering expectations regarding the planning, delivery, and management of infrastructure. It becomes increasingly apparent that the status quo in the construction industry is no longer viable as a result of these challenges.

In this context, Smart Construction has emerged as both a necessity and an opportunity. Smart Construction, which is characterized by the integration of digital technologies, industrialised building methods, and sustainable practices, provides Malaysia with a means to address structural weaknesses and unlock new opportunities for green development. Malaysia's national strategy for transformation is comprised of a triad; industrialisation through the Industrialised Building System (IBS), digitalisation through Building Information Modelling (BIM), and a steadfast dedication to decarbonisation.

BIM is now required for all public projects exceeding RM10 million, as per the government's Treasury Circular PK 1.15, which was implemented on 1st July 2025. This represents a significant stride toward the integration of digital standards into project delivery. Similarly, the implementation of IBS Score thresholds has expedited the utilisation of prefabrication and modularization, thereby improved quality and safety while simultaneously decreased dependence on low-skilled labour sources. These measures are consistent with Malaysia's overarching objectives, as outlined in its Nationally Determined Contribution (NDC), which include a reduction in carbon intensity of 45 % by 2030 and the long-term goal of attaining net-zero emissions by 2050.

The urgency and potential of this transition are both emphasized by the economic outlook. Malaysia's construction sector produced RM158.8 billion in output in 2024, and projections indicate that it will expand by an additional 12 % in 2025, primarily due to private-sector investment and large-scale public infrastructure. According to long-term projections, the industry is expected to achieve a value of nearly USD 60 billion by 2030, which equates to a compound annual growth rate of over 8 %. Embedding Smart Construction practices today will guarantee that the sector's expansion is not only quantitative but also qualitative, thereby driving higher productivity, lower carbon emissions, and greater resilience across the asset lifecycle, as it expands in size and significance. This momentum creates a strategic window for reform.

However, the transition is not without its obstacles. Small and medium enterprises (SMEs), which frequently lack the resources to implement advanced technologies, continue to dominate Malaysia's construction ecosystem, which is highly fragmented. Capacity is still being restricted by skills constraints in digital site supervision, lifecycle asset management, and BIM management. Although progressive, policies are subject to inconsistent enforcement across states and agencies, which poses a risk of diminishing their efficacy. The sector faces the possibility of being growth-rich but innovation-poor if these issues are not addressed with the utmost care.

Malaysia's country paper for the 25th AsiaConstruct Conference (ACC) is presented in this context. This paper investigates the urgent challenges, strategic responses, and forward-thinking opportunities for Malaysia's constructed environment, as outlined in the theme "Promoting Smart Construction for Sustainable Development." It contends that Smart Construction should not be perceived as a mere technological upgrade, but rather as a comprehensive strategy that encompasses policy, industry practice, and human capital development. This will guarantee that Malaysia's construction sector develops as a genuine catalyst for sustainable national growth and regional collaboration.

2.0 Current Policies on Technology and Sustainability in Malaysia's Construction Industry

The Malaysian building industry is struggling to manage rapid urbanization, global ecological goals, and national economic goals. The industry contributes 3.5 to 4 % of Malaysia's Gross Domestic Product (GDP) and employs about 1.2 million people, causing environmental stress and expansion (DOSM, 2023). Nearly 25 % of national carbon emissions come from construction activities (MGTC, 2022). Malaysia has adopted several laws, regulations, and strategic frameworks to promote sustainable practices and technological integration. These policies are influenced by national development agendas like the Twelfth Malaysia Plan (2021–2025) and international obligations like the Paris Agreement and SDGs.

Malaysia has gradually changed its sustainable construction policies over the previous two decades. In the early 2000s, Malaysian Standards (MS) 1525: 2019 – Energy Efficiency and Use of Renewable Energy for Non-Residential Buildings (2001, amended 2019) and the

Energy Efficiency Guidelines (2001) laid the groundwork for energy-efficient building design. Next was the National Green Technology Policy (2009), the first attempt to mainstream green techniques across industries.

Later, the Construction Industry Transformation Programme (CITP 2016–2020) was launched to prioritise productivity and sustainability in structural reforms. The initiatives was expanded by the launched of The Construction 4.0 Strategic Plan (2021–2025) and Green Technology Master Plan (GTMP 2021–2030) to further promote digitalisation and green development as Malaysia's construction policy pillars. Below are the categorisation of government initiatives by segments:

2.1 National Sustainability Frameworks

2.1.1 Green Technology Master Plan (GTMP 2021–2030)

The Green Technology Master Plan (GTMP 2021–2030) presents sector-specific action plans for transitioning to a low-carbon economy, emphasizing energy, manufacturing, transport, and buildings. The focus in construction is on renewable energy integration, sustainable materials, and energy-efficient design. By 2030, the plan aims to create 200,000 green jobs, establishing construction as a key component of Malaysia’s green economy (MGTC, 2021).

2.1.2 Circular Economy and Resource Efficiency

The Sustainable and Circular Economy Roadmap (2023–2040) incorporates sustainability into material flows, promoting recycled aggregates, industrial by-products (e.g., fly ash, slag), and modular construction methods to minimize waste. The National Solid Waste Management Policy (2018) mandates a minimum 40% diversion of construction and demolition waste from landfills by 2025.

2.1.3 Green Building Certification and Regulation

The Green Building Index (GBI) is Malaysia’s main rating tool, supported by systems like MyCREST, developed by CIDB and JKR. GBI offers a market-driven certification, whereas MyCREST associates green ratings with carbon performance metrics, aligning more closely with lifecycle carbon accounting. Amendments to the Uniform Building By-Laws (UBBL, 1984, revised 2021) require energy efficiency measures in large developments, rendering compliance with MS 1525 a legal obligation. The Energy Efficiency and Conservation Bill (2023) under review is set to mandate energy audits for buildings surpassing certain consumption thresholds, enhancing regulatory oversight in the built environment.

2.2 Technology Integration and Digitalisation Policies

2.2.1 National IoT Strategic Framework

The National IoT Strategic Framework of Malaysia, initiated in 2014 by MIMOS under the Ministry of Science, Technology and Innovation (MOSTI), aims to establish the nation as a regional hub for Internet of Things (IoT) development. The roadmap comprises three primary initiatives: establishing a strong national IoT ecosystem (“IoT Malaysia”), creating a standardized Open Community Data Framework for secure data exchange, and developing an Open Innovation Framework to enhance collaboration among government, industry, and academia. The pillars are supported by enablers including harmonised standards, structured governance, and pilot projects for testing and scaling IoT applications. The roadmap forecasts the IoT industry will grow from RM9.5 billion in 2020 to RM42.5 billion by 2025, creating over 14,000 jobs and yielding more than 146 patents, thereby establishing IoT as a key driver of innovation and growth.

The framework, initially sector-neutral, has gained significant relevance in the construction industry, particularly under CIDB’s Construction 4.0 Strategic Plan (2021–2025). IoT technologies, including real-time sensors, smart monitoring systems, and connected equipment, are essential for enhancing safety, efficiency, and sustainability in construction projects. IoT integration facilitates predictive maintenance, environmental monitoring, and resource optimization, while enhancing Building Information Modelling (BIM) and digital twin technologies. The policy emphasizes standardization, governance, and open innovation, offering the construction sector a structured foundation for large-scale IoT solution adoption. The National IoT Strategic Framework accelerates Malaysia’s digital economy and supports the transformation of construction into a smarter, more resilient, and sustainable industry aligned with national digitalisation agendas.

2.2.2 Industry4WRD

The Industry4WRD National Policy on Industry 4.0, initiated by the government in October 2018, serves as the nation's primary strategy for adopting the Fourth Industrial Revolution. The policy primarily targets the manufacturing and related services sectors, while also creating an enabling environment and infrastructure that benefits the construction industry, particularly during its transition to Construction 4.0. Industry4WRD aims to establish Malaysia as a regional hub for smart manufacturing, a preferred site for high-technology investment, and a provider of advanced technology solutions. The objectives focus on enhancing labour productivity, increasing innovation capacity, elevating the manufacturing sector's GDP contribution, and generating high-skilled job opportunities to prepare industries for a digital economy.

The policy is implemented via various instruments and strategies. Included are outcome-based incentives, tax allowances, and the Industry4WRD Intervention Fund, which offers matching grants to SMEs for technology adoption. The Readiness Assessment Programme was introduced as a diagnostic tool to assist companies in evaluating their technological gaps and readiness for Industry 4.0 transformation. Industry4WRD emphasizes enhancing digital connectivity among industrial clusters, research institutions, and training centres, ensuring infrastructure and human capital develop alongside technological upgrades. As of 2023, nearly 300 SMEs have received financial support from the Intervention Fund, demonstrating the policy's effectiveness in promoting digital adoption.

2.2.3 Construction 4.0 Strategic Plan (2021–2025)

The Construction 4.0 Plan emphasises the integration of emerging technologies, including Building Information Modelling (BIM), robotics, automation, artificial intelligence (AI), and Internet of Things (IoT) applications, to tackle persistent productivity and safety issues. Among others, the government aims for 80 % of public projects to implement BIM by 2025, standardising digital design and construction methodologies across the sector (CIDB, 2022).

2.2.4 Malaysia Digital Economy Blueprint (MyDIGITAL)

The Malaysia Digital Economy Blueprint (MyDIGITAL) establishes the foundation for the Construction 4.0 Strategic Plan (2021–2025). MyDIGITAL outlines Malaysia's shift to a digital economy by 2030, while Construction 4.0 implements sector-specific strategies to enhance productivity, sustainability, and competitiveness in construction. MyDIGITAL’s initiatives on 5G rollout, broadband expansion (JENDELA), and national cloud services support technologies essential to Construction 4.0, including Building Information Modelling (BIM), digital twins, IoT, and AR/VR applications. The emphasis on digital talent development aligns with CIDB’s upskilling programmes, equipping a workforce to manage smart technologies and decrease dependence on low-skilled labour.

The National Digital Economy and 4IR Council, established under MyDIGITAL, provides oversight on digitalisation and data governance, supporting the secure use of BIM platforms and cloud collaboration in construction. MyDIGITAL aims for a 22.6 % GDP contribution from the digital economy by 2025, aligning with Construction 4.0's goal to enhance the sector's value in national growth and sustainable finance. MyDIGITAL provides the digital infrastructure and governance ecosystem, while Construction 4.0

implements these enablers through the adoption of BIM, IoT, robotics, and AI, aligning the construction sector with Malaysia's digital and sustainability goals.

2.2.5 Malaysia Smart City Framework (MSCF)

The Malaysia Smart City Framework (MSCF) guides local governments in urban transformation development and administration. The MSCF defines inclusive, technology-driven cities through seven core components: Smart Government, Smart Economy, Smart Environment, Smart Living, Smart Mobility, Smart People, and Smart Digital Infrastructure. The framework aligns with Malaysia's Shared Prosperity Vision (SPV) 2030 and the United Nations Sustainable Development Goals (SDG) with 16 overarching policies, 36 strategies, and 112 activities. The policy agenda integrates sustainability, digital innovation, and citizen-centric governance to make Malaysian cities more competitive and liveable.

Malaysia has implemented numerous landmark smart city schemes. MySmart City, Smart Traffic Analytics and Recognition System (STARS), and Smart Parking Blueprint are nationwide programs to provide scalable, technology-driven services. These programs usually involve public, corporate, and academic sectors, demonstrating the government's recognition of multi-stakeholder participation for innovation and resource mobilization. State and municipal governments have MSCF alignment strategies. Malaysia has established smart economic zones like i-City in Shah Alam and the MSC Malaysia Corridor in Cyberjaya and Putrajaya. Smart applications are tested in these zones, which combine high-tech enterprises with ICT-enabled residential and commercial clusters. The MSC Malaysia Corridor is an important part of Malaysia's knowledge-based economy because it attracts technology enterprises with fiscal incentives and digital infrastructure. Developments show the country's desire to become a regional digital urban innovation hub.

Malaysian smart city policy includes regional levels. Malaysia named Kuala Lumpur an ASEAN Smart Cities Network pilot city for cross-border cooperation. The ASCN framework integrates Malaysia's smart city projects into Southeast Asian cities by promoting knowledge sharing, project finance, and standard harmonization. This helps Malaysia evaluate development against Singapore and Jakarta and encourages cooperative innovation.

2.2.6 National Cloud Computing Policy (NCCP)

The 2025 Malaysian National Cloud Computing Policy (NCCP) provides a secure and inclusive framework for public and private cloud use. The framework has five pillars: public sector digitalisation, private sector growth, strong data governance, digital inclusion, and sustainable green cloud infrastructure. A multi-tier data classification scheme keeps sensitive data in Malaysian sovereign cloud settings and less sensitive data on public cloud platforms. In 2024, the government created a National Artificial Intelligence Office to supervise AI policy, ethics, and regulation and a 2030 AI plan. Microsoft's USD 2.2 billion cloud and AI infrastructure program and Google's USD 2 billion data centre and cloud hub in Malaysia reinforce the governance structure, making Malaysia a regional digital leader.

Malaysia's construction policies are increasingly aligned with Environmental, Social, and Governance (ESG) principles, meeting investor expectations and regional trade frameworks like the ASEAN Taxonomy for Sustainable Finance. The Securities Commission’s Sustainable and Responsible Investment (SRI) Roadmap (2019) urges developers and contractors to align projects with ESG benchmarks to obtain green financing instruments, including green sukuk and sustainability-linked loans. The financialization of sustainability positions technology adoption as both a compliance matter and a business strategy.

3.0 Current State, Adoption, and Implementation of Smart Construction in Malaysia

Smart construction in Malaysia is transitioning from aspiration to implementation; however, adoption varies by firm size, region, and technology domain. Recent evidence indicates a rise in the use of digital tools and prefabrication, consistent growth in green certifications, and a gradual, albeit limited, adoption of BIM and cloud-enabled collaboration. Firms across the industry are experimenting with digitalisation. The CIDB update (CR 4.0 Report, 2024) indicates that Malaysian construction firms utilized an average of 6.9 digital technologies per firm, approximately 50 % above the regional average, demonstrating that digital transformation is becoming mainstream. Implementation depth, including integration into workflows, data governance, and lifecycle analytics, varies significantly.

3.1 National uptakes on Green Buildings Rating Tools

The adoption of technology in Malaysia is integral to sustainable development efforts. The construction sector significantly contributes to greenhouse gas emissions and resource consumption, thus being a key focus of Malaysia's commitment to achieve net-zero carbon emissions by 2050 and to reduce carbon intensity by 45 % by 2030 from 2005 levels. Malaysia's path to sustainable construction is significantly influenced by voluntary certification systems.

The Green Building Index (GBI), established in 2009, is the nation's leading benchmark. As of 31 July 2024, 702 projects were certified, increasing to 753 by 30 June 2025. The increase signifies over 316.4 million square feet of gross floor area (GFA) and an estimated annual reduction of 1.829 million tonnes of CO_2, indicating sustained market demand for energy and resource-efficient solutions and measurable environmental outcomes linked to smart design and operation.

GreenRE has emerged as a significant competitor to GBI, especially in the private sector. The uptake is evident among residential and commercial developers pursuing sustainability credentials to meet market demand and international ESG trends. Both frameworks have notably increased awareness of sustainable practices, though their impact is primarily evident in high-value urban development rather than in mass housing or public infrastructure.

Malaysia has introduced the Malaysian Carbon Reduction and Environmental Sustainability Tool (MyCREST), developed by CIDB and the Ministry of Works, to complement voluntary schemes. MyCREST focuses on carbon quantification throughout the building lifecycle, measuring intensity in kg CO_2 equivalent per square metre from design and construction to operation and deconstruction, unlike GBI or GreenRE. The scope includes social and occupant well-being, incorporating a comprehensive view of sustainability that merges environmental and human aspects. MyCREST is increasingly adopted in government buildings, schools, and hospitals, integrating carbon accountability into public infrastructure projects.

Broader industry adoption faces challenges, including limited enforcement mechanisms, inadequate technical training, and low awareness among SMEs. Current capacity-building programs and the expansion of MyCREST training initiatives indicate a gradual shift towards formalizing data-driven carbon and social outcomes in project delivery and facility management.

In addition, regulatory standards enhance sustainability initiatives. The Malaysian Standard MS 1525:2019 establishes minimum energy efficiency requirements for non-residential buildings, addressing essential systems including lighting, HVAC, and renewable energy integration. The National Energy Transition Roadmap (NETR) advances the agenda by promoting renewable energy adoption in buildings, specifically solar photovoltaic readiness in IBS modules for schools, hospitals, and public infrastructure. The policy tools aim to ensure that Malaysia's construction industry adopts modern technologies while embedding energy efficiency and renewable integration at the design stage.

Sustainability in Malaysia is increasingly linked to financial instruments, beyond standards and certifications. Green sukuk and preferential loan schemes offer developers lower-cost financing contingent upon meeting benchmarks set by GBI, GreenRE, or MyCREST. The connection between sustainability performance and financing incentives is generating market pull factors, prompting developers to exceed minimum compliance and align projects with international ESG standards.

3.2 Adoption rate of Industrialised Building System (IBS)

In order to facilitate industralisation and digitalisation, Malaysia implemented the IBS. Prefabrication and modular construction enhance productivity, safety, and quality while simultaneously decreasing the need for low-skilled manual labour. Governmental and private developers have industrialised construction as a result of the necessity for an IBS Score of 70 or higher for critical projects. Research indicates that IBS can reduce material waste by 20%, thereby enhancing resource efficiency and cost control in a sector that is notorious for waste. In comparison to labour-intensive procedures, the timeframes for the construction of schools and hospitals have been reduced by 40%. These studies demonstrate that IBS is essential for public infrastructure because it enhances project delivery time and resolves environmental issues.

In 2021, Malaysia's construction modernisation was significantly influenced by IBS. According to CIDB data, IBS was implemented in 84 % of government initiatives, with the assistance of structured procurement and policy. A trend toward industrialised and digitally coordinated production is evident in the private sector, where adoption has reached 60 %. The institutionalisation of IBS in national construction processes is suggested by the fact that adoption rates have been increasing since 2020, according to official figures. These figures render IBS indispensable for the sustainability, safety, and productivity of the sector.

The adoption of IBS is occasionally a challenge for small and medium-sized enterprises (SMEs), which comprise the majority of Malaysia's construction sector. The uptake of change is slowed by cultural reluctance to change and high initial expenses for apparatus, software, and training. Traditional on-site solutions are employed by numerous small and medium-sized enterprises (SMEs) due to capital requirements, workforce retraining, and uncertain ROI. The unequal acceptability demonstrates that structural constraints must be surmounted in order for IBS to become an industry standard. The increased adoption of IBS demonstrates that legislative support, procurement mandates, and ongoing capability development can facilitate the deployment of IBS on a large scale. Training and certification programs enhance technical skills for execution, while government-linked programs demonstrate how regulatory requirements can align sector actors with national objectives. IBS is a gateway technology for advanced digital tools such as BIM, digital fabrication, and Construction 4.0 due to its standardized detailing, integrated logistics planning, and supply-chain coordination.

3.3 Deployment uptakes of Building Information Modelling (BIM)

BIM deployment is a clear sign of this transformation. From 17 % in 2016 to 55 % in 2021, BIM awareness and use in Malaysia has steadily increased. This success has been made possible by government policies, CIDB leadership, and the MyBIM Centre's national capacity-building, training, and knowledge dissemination. BIM usage is low compared to worldwide benchmarks despite its widespread recognition. A 2023 peer-reviewed synthesis found that Malaysia has 49% BIM deployment and the UK 69 %. This shows a big gap between Malaysia and early-movers. Previous CIDB reporting and follow-up studies identify public and private BIM adoption as low to unequal. According to the Malaysia BIM Report 2019, 3 % to 4 % of respondents in Johor, Kedah, Perak, Penang, and Borneo adopted BIM. Additionally, over 90 % of respondents said BIM improved quality, cost, and time. This helps explain the gradual rise. Malaysia advanced by mandating BIM for all public sector projects over RM10 million in July 2025. This project aimed to incorporate digital collaboration, conflict detection, cost predictability, and facilities management-ready asset data throughout the lifecycle. This policy reform makes BIM a national project delivery standard, not an optional tool.

In addition to BIM creation, the CIDB National BIM e-Submission (NBeS) launched in 2019 allows project teams to submit and automatically validate BIM models against UBBL and related laws, including fire requirements with Fire and Rescue Department of Malaysia (JBPM), rather than static drawings, digitising building plan approvals. The Auto-Checker gives local governments a visible audit trail, early non-compliance detection, and shorter resubmission cycles. NBeS establishes uniform data for operations, ESG reporting, and future digital twins, which meets national productivity objectives and OSC 3.0 Plus while speeding up permit processing. NBeS makes approvals evidence-driven and model-based, improving accountability, quality, and efficiency in Malaysia's built environment.

3.4 Other emerging technologies

CIDB's Construction 4.0 Strategic Plan (2021–2025) provides a comprehensive framework for the digital transformation of the Malaysian construction sector, identifying twelve essential technologies as central enablers of industrial modernisation. These encompass blockchain technologies, the Internet of Things (IoT), Artificial Intelligence (AI), Augmented Reality (AR), and Virtual Reality (VR), as well as modular and prefabricated construction systems. In addition to serving as a policy statement, the strategic plan has also functioned as a practical guide, influencing the development of a variety of pilot projects, structured training initiatives, and the publication of guidance materials that are designed to increase technical capacity and raise awareness among contractors, consultants, and facility managers.

To date, the most tangible adoption signals have been observed in projects that integrate digital coordination tools, such as BIM with the IBS. This integration enables the precise onsite assembly of standardised components and their off-site fabrication, which is all coordinated through model-based workflows. These synergies serve as a practical demonstration of the feasibility of integrating industralisation and digitalisation, resulting in quantifiable advantages in terms of project delivery timelines, waste reduction, cost management, and efficiency.

Conversely, the utilization of more sophisticated Construction 4.0 applications, including AI-enabled design optimization, blockchain-based procurement and contract administration, and immersive AR/VR systems for virtual inspections and training, is still restricted. Although these technologies are increasingly being discussed in academic and policy contexts, their field deployment remains nascent, largely restricted to experimental pilots or research-led initiatives rather than mainstream industry practice, as per recent systematic reviews of Malaysian construction literature.

Two further tendencies are also further emphasised by emerging empirical evidence. Initially, cloud-based collaboration platforms are commencing to be implemented, particularly in projects that necessitate real-time coordination among geographically dispersed teams. However, the utilisation of these systems is still restricted, as numerous organizations continue to rely on isolated communication and document-sharing systems. Secondly, there is a positive correlation between the performance of projects and the implementation of automation technologies, such as robotic monitoring, sensor-integrated equipment, and automated safety systems. Numerous studies have demonstrated that automation is associated with improved operational outcomes, such as increased site safety, better schedule adherence, reduced rework, and better overall quality control. These findings suggest that industry stakeholders are gradually acknowledging digital investment as a driver of measurable operational and financial performance, rather than solely as an innovation label.

The trajectory of Construction 4.0 adoption in Malaysia demonstrates a dual-speed dynamic when considered in its entirety. Supported by policy frameworks and institutional capacity-building, foundational technologies, including cloud-based collaboration tools, BIM, and IBS, are acquiring traction. In the interim, sophisticated applications, including AI, blockchain, and large-scale AR/VR deployment, are frequently relegated to conceptual discussions or isolated trials, and they continue to be peripheral.

The primary obstacle in the future is the transformation of these pilot initiatives into scalable and replicable practices, which will be further bolstered by robust policy incentives, procurement mechanisms, and sustained industry-wide training. Malaysia’s current state of technology adoption reflects commendable progress in BIM and IBS uptake, moderate experimentation with IoT and AI, and limited engagement with more advanced technologies like robotics and 3D printing.

These tools collectively establish a multilayered ecosystem that connects digitalisation and decarbonisation, thereby enabling Smart Construction to serve as both a productivity driver and a catalyst for green development. Nevertheless, obstacles persist. Adoption is inconsistent among small and medium-sized enterprises (SMEs), enforcement is inconsistent across states and agencies, and digital and sustainable practices are still primarily found in high-value urban projects, rather than mass-market or rural developments.

In order to fully realise the potential of Smart Construction, Malaysia must increase the scale of skills development, strengthen the enforcement of standards, extend access to green financing, and integrate lifecycle thinking into all levels of the industry. This comprehensive strategy is indispensable for guaranteeing that Malaysia's construction sector is not only modernized but also in accordance with the nation's overarching dedication to inclusive and sustainable development.

4.0 Issues & Challenges

Malaysia's construction sector is facing mounting pressure to modernize through smart construction and digitalisation, in accordance with the Construction 4.0 Strategic Plan (2021–2025) and national digitalisation frameworks like Industry4WRD and MyDIGITAL. In order to enhance productivity, cost efficiency, and sustainability, smart construction incorporates cutting-edge technologies including BIM, IBS, IoT, and AI. Nevertheless, adoption rates continue to be restricted and fragmented, despite the existence of robust policy drivers. The adoption of smart construction in Malaysia is impeded by a variety of structural, institutional, financial, and socio-cultural barriers, as identified in the existing literature.

4.1 Industry Structure and Fragmentation

Malaysia has established a definitive digitalisation strategy for the built environment. The Construction 4.0 Strategic Plan (2021–2025) outlines twelve enabling technologies, including BIM, the IoT, robotics, IBS, Modular construction, and digital twins. This initiative is supported by the National Construction Policy (NCP) 2030, which emphasises the digitalisation of the construction sector, alongside broader economic enablers such as Industry4WRD and MyDIGITAL.

Adoption is inconsistent; government-led and large-scale projects progress, whereas SMEs and private initiatives fall behind, despite the impending construction rebound in 2024 increasing the demand for productivity and quality improvements. Market structure serves as the primary constraint where as in 2022, SMEs constituted approximately 82 % of registered contractors, predominantly in G1–G3 categories, while G7 represented around 7 %. These entities exhibit limited capital, short-term perspectives, and significant reliance on subcontracting. The outcome is a dual-speed ecosystem in which large projects can require model-based deliverables, while numerous small and medium enterprises face challenges in investing in BIM tools, drones,scanners, Common Data Environments (CDEs), and site connectivity.

4.2 Human Capital and Skills Gaps

Malaysia's smart construction push is constrained by capability gaps across the value chain. At project and client leadership level, literacy in digital procurement, outcome based contracting, and information requirements is limited, notably the ability to specify, audit, and accept BIM and CDE deliverables under PK 1.15, leading to weak tenders and inconsistent acceptance tests. Information management lacks BIM or Information Managers, CDE administrators, model coordinators, and 5D planners; clash KPIs, submission grade data dictionaries, and structured BIM to Computer-Aided Facility Management (CAFM) handover are immature.

Design and engineering show uneven competence in model based coordination, 4D/5D, open standards, and performance simulation for energy, daylight, and embodied carbon. Site execution suffers from shortages of digital site supervisors, reality capture technicians, and robotic layout operators, alongside low data literacy for tablet and CDE use. Offsite manufacturing lacks Design for Manufacture and Assembly (DfMA) technicians and digital traceability; commercial and controls lack 5D or model based quantity surveyors and cost engineers; operations and FM have thin BIM to CAFM integration, IoT analytics, and cybersecurity despite PK 1.15's lifecycle intent. These disparities continue to exist as a result of institutional and structural factors. The majority of the market is dominated by smaller contractors in which 81.1 % are G1 to G3, while only 8.9 % are G6 to G7. This constrains capital for software, devices, and training, and results in a dual-speed diffusion of digital methods.

The National Technical and Vocational Education and Training (TVET) Policy 2030 and other technical and vocational education and training reforms have enhanced coordination; however, the emphasis remains on supply-side provision rather than demand-led, stackable micro credentials that correspond to task roles such as CDE administrator, BIM coordinator, and digital site supervisor. There is still a broader skills disparity, as curricula frequently prioritize craft competence over the cognitive, digital, and entrepreneurial capabilities that firms need to manage data, models, and automated workflows. Incentives are further complicated by workforce composition: a significant proportion of lower-skilled positions are filled by foreign labor, which can discourage firm-level investment in continuous upskilling unless procurement and contract conditions explicitly mandate digital deliverables and audited performance evidence.

4.3 Procurement Practices and Policy–Practice Gaps

Procurement inertia remains the binding constraint. Lowest-price tendering crowds out lifecycle value and information deliverables, dulling incentives to produce robust BEPs, run a true CDE, or hand over ISO 19650/COBie-aligned asset data. JKR reports public-sector exemplars in which 455 BIM projects (2021–2024) and an expectation of 90 % BIM use for projects more than RM10 million but signals have not fully reached private or sub-national pipelines.

IBS policy has tightened, culminating in 2024 circulars that require a minimum IBS Score of 70 for large private projects (≥RM50 million and ≥50,000 m² GFA), alongside earlier public-works mandates (≥RM10 million). Yet enforcement and monitoring vary across authorities and project categories, yielding uneven adoption, particularly in local-authority submissions and private works. Research echoes this, despite strong digitalisation policies, "lowest cost wins" still dominates; even where BIM clauses exist, more than 60 % of contractors revert to 2D (Mohd Rahim et al., 2021) due to weak enforcement and limited client oversight as an enduring policy–practice gap (Olatunji, 2014).

4.4 Technological Infrastructure and Interoperability Challenges

Technological readiness is another area of concern. Malaysia's 5G deployment reached 82.4 % of populated areas in 2023 (MCMC, 2023), yet site-level connectivity issues persist, particularly in semi-urban and rural regions where many projects are located. This undermines the reliability of cloud-based BIM platforms, IoT dashboards, and drone-enabled site monitoring. Furthermore, interoperability challenges remain unresolved, as different stakeholders often use incompatible file formats, naming conventions, and workflows. CIDB's BIM Report 2022 highlights recurring disputes over "single sources of truth" in project data due to the absence of ISO 19650-aligned CDEs. These challenges align with findings from Eadie et al. (2017), who argue that interoperability remains one of the most significant technical barriers to BIM globally.

4.5 Financial Constraints and Perceived ROI

High upfront investment costs are a recurring theme in Malaysian studies. Upfront costs for software licences, scanning/drones, CDE subscriptions, devices, and training loom large for SMEs. Nurulhuda et al. (2020) reported that 67 % of SMEs perceived BIM adoption as financially unfeasible without subsidies or government support. While international studies have demonstrated cost savings from BIM through reduced rework, improved clash detection, and shorter project timelines (Bryde et al., 2013), Malaysian contractors remain sceptical about these returns, particularly in short-duration projects with tight budgets. The literature suggests that the absence of clear ROI metrics and lifecycle-based cost–benefit analyses contribute to this hesitation (Kamaruzzaman et al., 2021). In Malaysia's SME-heavy context, however, short project durations and thin margins make it difficult to internalise longer-tail gains without contractual incentives. This financial barrier is particularly acute in SMEs, reinforcing the structural fragmentation of the industry.

4.6 IBS Design for Manufacture and Assembly (DfMA) uptake: measurable progress, uneven integration

Empirically, the adoption of IBS has increased: for public projects totaling RM10 million or more, the adoption rate increased from approximately 69 % in 2016 to 86 % in 2019. Similarly, the adoption rate for private projects totaling RM50 million or more increased from approximately 14 % in 2016 to approximately 40 % in 2019. Subsequently, the utilisation rate in 2021 was reported to be approximately 84 % in government programs and approximately 60 % in private projects.

However, the complete productivity dividend of IBS is contingent upon digital coordination, which includes Design for Manufacture and Assembly (DfMA) with shop-ready models, logistical support, tolerances, and traceability. IBS devolves to component substitution rather than process industralisation, which blunts performance benefits, when BIM-to-factory workflows and site logistics planning are weak. If digital submittals and factory-to-site data are consistently enforced, the IBS Score 70 requirement can be catalytically strengthened.

4.6 Sustainability Integration and Green Retrofitting

Although Malaysia introduced the numerous Green Rating Tools such as MyCREST rating tool since 2009 to promote carbon-conscious construction, integration with smart construction technologies has been limited. IoT-enabled monitoring and BIM-based energy simulations are not widely linked to sustainability certification processes, resulting in manual and post-hoc reporting (Chong et al., 2022). This weakens the ability of smart construction to support Malaysia's international commitments, such as the 45 % reduction in carbon intensity by 2030 (NDC, 2021). Scholars argue that sustainability frameworks must be embedded into digital workflows at the design stage to achieve meaningful outcomes (Darko et al., 2020), yet this linkage remains underdeveloped in Malaysia.

4.7 Cultural Resistance and Change Management

Finally, cultural resistance is an often overlooked but significant barrier. Salleh et al. (2021) found that 54 % of practitioners cited resistance to change as a challenge, particularly in SMEs where management tends to be risk-averse. Contractors accustomed to traditional workflows often perceive digital tools as disruptive or unnecessarily complex. This aligns with studies in other developing contexts, where “pilot projects” frequently fail to scale into sustained adoption due to organisational inertia (Succar & Kassem, 2015). In Malaysia, this resistance manifests as reluctance to invest in training, reluctance to enforce digital deliverables, and dependence on traditional workflows even when technology is available.

The literature on smart construction adoption in Malaysia highlights a convergence of structural, human, institutional, technological, financial, and cultural barriers. While Malaysia has established comprehensive strategic frameworks, including CIDB’s *Construction 4.0 Strategic Plan*, actual adoption is hindered by industry fragmentation, limited human capital, entrenched procurement practices, weak technological infrastructure, high upfront costs, poor sustainability integration, and cultural resistance. These findings underscore the need for systemic interventions that extend beyond technology deployment to address procurement reforms, financial incentives, workforce development, and organisational change management. Without addressing these interconnected challenges, Malaysia risks limiting the transformative potential of smart construction to isolated pilot projects rather than industry-wide transformation.

5.0 Smart Construction as a Strategic Response to Sustainable Development in Malaysia

Malaysia's construction sector is situated at the intersection of two national imperatives; the acceleration of productivity and the successful implementation of thorough decarbonisation in the built environment. The policy scaffolding for this twin transition is already in place, including the Malaysia Digital Economy Blueprint (MyDIGITAL) and Industry4WRD, which expand digital capacity, the Construction 4.0 Strategic Plan (2021–2025) in which IR4.0 technologies are mainstreamed across the project lifecycle, and the National Energy Policy 2022–2040 with the National Energy Transition Roadmap (NETR), which integrates efficiency and renewable energy into long-term planning. When considered in conjunction, these instruments establish "smart construction" as the standard delivery paradigm for national development, rather than as a boutique add-on.

In economic terms, the opportunity cost of business-as-usual is visible in the scale and momentum of current activity. Official data show the value of construction work done reached roughly RM158.8 billion in 2024, up 20.2 % year-on-year, underscoring the macro leverage of even marginal productivity and energy-efficiency gains at project level. When a sector of this size digitises its coordination, industrialises its methods, and codes carbon performance into delivery, the aggregate effects cascade into national competitiveness.

Smart construction in Malaysia should be interpreted as a disciplined delivery system that transforms reliable data and industrialized methods into measurable sustainability and productivity outcomes throughout the entire asset lifecycle, rather than as a collection of new devices. In this context, the national ecosystem is already equipped with the majority of the components for instance; the Ministry of Finance to direct procurement and fiscal levers, CIDB Malaysia to standardize methods and evidence and to expedite industrialized building solutions, SEDA Malaysia to unlock energy transition incentives and net-energy metering. The strategic objective is to connect these components in a manner that ensures that information, money, and responsibilities are in accordance with outcomes such as Building Energy Intensity (BEI), embodied carbon, Indoor Environmental Quality (IEQ), cost-in-use, and social value. Subsequently, these outcomes must be rendered operationally visible and contractually binding. These are the nine game changer for promoting the smart construction widely across the counrty:

5.1 Make BIM-to-Twin the default delivery spine

The BIM to Twin agenda should be treated primarily as an exercise in information governance. Each public project should designate a Senior Responsible Owner for Information on the client side, accountable for approving the BEP and the Asset or Exchange Information Requirements (EIR) before design commences, and for certifying at completion that handover has occurred as a data product. A single CDE configured to ISO 19650 principles should serve as the authoritative record of truth; information produced outside this environment shall have no contractual standing.

A national data dictionary, curated by a central coordinating agency such as CIDB, should map building systems, meters, and sensors to fields for BEI, water, IEQ, and embodied carbon, with strict alignment to MyCREST or GBI credits and to attributes specified in MS 1525.

Digital twins should be treated not as optional visualisations but as regulated operational assets. They should be registered, secured, and audited, with BEI, IEQ, and maintenance KPIs streamed to an owner’s portfolio dashboard. When data governance is specified at this level of precision, disputes are reduced, organisational learning accelerates, and asset performance becomes transparently inspectable.

5.2 Industrialise delivery with IBS / DfMA

Industrialisation through IBS and DfMA is a governance task that shapes the market. The Government should designate platform owners to maintain standardised pattern books for repeatable public building types such as schools, clinics, and housing, with explicit interface rules, tolerances, service zones, and quality verification protocols. A common IBS Information Centre should serve as steward of these open platform rules so that multiple manufacturers can compete on a shared technical backbone. Planning consent and tender awards should be contingent on demonstrable compliance; without an approved pattern there is no approval, and without a declared pathway to the required IBS Score there is no award.

Factory audits, conformance testing, and the publication of serial defect watch lists and cleared supplier lists should be centrally managed to raise minimum standards of quality and safety. Portfolio procurement should aggregate demand to reduce the risk of factory capital expenditure and to create predictable throughput with lower carbon intensity.

5.3 Energy and carbon as hard metrics, not aspirations

Energy and carbon should be treated as hard performance metrics with enforceable decision gates across the asset lifecycle. At the design stage, digital compliance with MS 1525 embedded in the model must be a mandatory precondition for tender issuance. At commissioning and early operation, release of the final account should be contingent on verified BEI and functional end use submetering, with analytics activated and fault detection demonstrably operational. Portfolio owners should set typology specific BEI targets, publish quarterly performance league tables, and require directed improvement plans for persistent under performance, with escalation to contractual remedies where necessary.

Measures under the NETR, which include submetering, photovoltaic readiness and Net Energy Metering participation, peak shaving, energy storage, and heat recovery, should be standard contractual clauses, with design allowances and grid interaction logic documented in the CDE to enable financing, delivery, and verification without reinvention.

5.4 Finance must reward verified performance

Financing the transition requires rigorous assurance and enforceable covenants rather than slogans. SRI and green sukuk, together with sustainability linked instruments, should embed model based baselines such as predicted BEI and embodied carbon estimates, and should link coupon step ups or step downs to audited operational outcomes at 12, 24, and 36 months.

Capital Markets Malaysia templates and independent reviewers provide the second line of defence; the first line is the owner’s digital twin supported by submetering evidence, and the third line is periodic external assurance commissioned by the issuer. Treasury rules should allow agencies to ring fence a portion of verified savings from BEI improvements for debt service, thereby closing the loop between performance and affordability and making retrofit pipelines bankable at scale.

5.5 Procurement must buy outcomes rather than inputs

Procurement should be governed to secure outcomes rather than inputs. Prequalification should screen for digital maturity, including BIM capability, secure CDE operations, and information security, as well as readiness for IBS such as factory capacity and platform conformance. Tender documents should specify outcome KPIs, including BEI at year one and year three, ceilings for embodied carbon per functional unit, minimum adoption levels for IBS and DfMA, and limits on defects and rework, all linked to payment mechanisms and structured pain and gain sharing.

Whole life value should replace lowest price as the organising principle, with lifecycle cost, maintainability, carbon performance, and social value as the core evaluation criteria. Contract management should move from manual files to analytics, with performance monitored through the CDE and the digital twin; early warnings should trigger collaborative interventions, and under delivery should carry financial consequences that are predictable, proportionate, and enforceable.

5.6 Human capital and TVET must be re-tooled for Construction 4.0.

Human capital and TVET should be governed through structures that mirror actual work practices. A national "Smart Construction Competence Framework" should define market relevant roles, such as BIM Coordinator and Information Manager, Digital Site Manager, IBS production and assembly technicians, energy analysts, and building analytics engineers, and align curricula, micro credentials, and assessments with verifiable project artefacts, including clash reports, commissioning plans, BEI dashboards, fault lists, and evidence of pattern book conformance. MyDIGITAL can enable modular and stackable credentials, while the government and academia can broker industry placements and recognition of prior learning, and procurement should reward projects that build these capabilities through structured on the job residencies and documented knowledge transfer.

5.7 Assurance must be systematic and proportionate

A three lines of defence model maintains alignment of incentives. Delivery teams are responsible for performance and data quality; independent project controls and energy managers validate metrics within the owner organisation; and external reviewers, such as expert panels, certified verifiers, and cyber and operational technology assessors, conduct periodic checks. Gateway reviews at concept, design freeze, tender, factory readiness, site acceptance, practical completion, and post occupancy should be brief, evidence based, and tied to the release of authority.

Cybersecurity for the CDE and the digital twin should operate under a trust framework that includes data classification, role based access, incident reporting, and recovery drills. Safety and quality passports should accompany each prefabricated unit, thereby closing the loop from factory to site to operations.

5.8 Eliminating fragmented governance

At the portfolio level, governance requires a dedicated institutional anchor and a regular cadence of public reporting. A Built Environment Performance Board, chaired jointly at Ministrial level, related agencies and major asset owners, should set annual targets, approve updates to the pattern book, and publish transparent dashboards on BEI, embodied carbon, adoption of technologies and smart methods, and cost in use.

A small Programme Management Office should enforce common templates, deliver training for Senior Responsible Owners for Information and Information Managers, and maintain a curated library of model clauses, rule sets, and test scripts so that each new project begins from current best practice rather than from first principles. Exemplar projects should be publicly recognised, and their lessons codified into subsequent releases of templates and platform rules.

5.9 Change management then becomes a disciplined cadence

This paper proposes a staged implementation pathway comprising three phases. In the first six month period, standard BEP and EIR templates should be issued alongside a national data dictionary and mandatory security minima for the CDE and the digital twin; typologies should be nominated for the initial pattern books; and outcome based clauses should be embedded in model contracts. By the eighteen month mark, projects should be awarded on the designated platforms, the first BEI league tables should be published, and the initial SRI linked retrofit programmes should commence with live and auditable key performance indicators. By the thirty six month point, a default to platform and default to twin approach should be normalised across core asset classes, with procurement, finance, and accreditation fully aligned.

When governance is specified with this level of clarity, the system learns in public, capital is allocated to interventions that demonstrate effectiveness, and national objectives for sustainability and productivity reinforce one another because rules, roles, data, and funding are consistently aligned.

Considered together, these nine mechanisms constitute a coherent operating model for the sector. The BIM to twin information spine makes performance visible and auditable; industrialised building systems and design for manufacture and assembly make delivery repeatable and precise; energy and carbon metrics keep attention on measurable outcomes; sustainable finance instruments reduce the cost of compliance; outcome based procurement aligns incentives across the value chain; and a modernised TVET system supplies the capabilities needed to sustain the transition. Because each mechanism is anchored in existing Malaysian standards, institutions, and financial instruments, the task is less invention than disciplined integration.

The result is a delivery system for the built environment in which sustainability and productivity are not parallel ambitions but two perspectives on the same objective. Every design choice, factory process, site activity, and operational adjustment is reflected in improved Building Energy Intensity, embodied carbon, cost in use, and occupant well being, and these improvements are intentionally planned, procured, financed, and taught.

6.0 Conclusion

Malaysia's transition to smart construction will succeed only if it is governed as a national mission with clear accountability, enforceable standards, and auditable evidence. The core mechanisms comprise BIM to Twin as the information spine, IBS and DfMA as the production system, energy and carbon as hard metrics, SRI and green sukuk as the financing lever, outcome based procurement as the market signal, and TVET with micro credentials as the skills engine. Together they form a single operating model rather than a set of discrete programmes. When these elements are embedded in law and contract, executed through a secure CDE, and verified by live performance data such as BEI, IEQ, water performance, and embodied carbon, sustainability and productivity become one deliverable viewed from different perspectives.

Governance is the force multiplier. Each public project should appoint a Senior Responsible Owner for Information (SRO-I); approvals should depend on digital compliance with MS 1525 and on IBS platform conformance; release of the final account should be linked to verified BEI and end use submetering; and financing should be tied to outcomes through SRI linked covenants. A small permanent Programme Management Office, supported by a cross ministerial Built Environment Performance Board, can institutionalise this discipline by curating national templates and pattern books, conducting gateway reviews, publishing quarterly league tables on BEI and IBS adoption, and refreshing procurement clauses as the market matures. Consequences, both incentives and remedies, must be predictable. Agencies should ring fence a portion of verified savings to repay upgrades; under performance should trigger directed improvement plans or contractual deductions; exemplary teams should be publicly recognised to set the benchmark.

The payoff is systemic. A governed default to platform and default to twin approach compresses delivery schedules, reduces rework and waste, stabilises quality, and lowers lifecycle costs while de risking the energy transition in operational assets. Capital becomes cheaper because outcomes are measurable; local manufacturers invest because demand is patterned and predictable; facility management and construction talent deepen because credentials are tied to real artefacts and verified performance. By adopting design principles that are outcome first, data verified, platform delivered, and skills driven, Malaysia can move from sporadic pilots to a compounding practice that strengthens fiscal discipline, advances the NETR, and positions the country as a regional reference for productive, low carbon delivery. This is a deliberate choice in governance rather than a wager on technology.

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