CONSTRUCTION MATERIALS DIGITAL ROADMAP

Malaysia Productivity Corporation

DIGITAL ROADMAP FOR CONSTRUCTION MATERIALS

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ABBREVIATION

AI	Artificial Intelligence
BIM	Building Information Modelling
CDE	Common Data Environment
CIDB	Construction Industry Development Board
COBEPN	Construction & Built Environment Productivity Nexus
FM	Facilities Management
GDP	Growth Domestic Product
IBS	Industrialised Building System
IoT	Internet of Thing
MPC	Malaysia Productivity Corporation
NCP2030	National Construction Plan
PWD	Public Works Department
RFID	Radio-Frequency Identification
RICS	Royal Institution of Chartered Surveyor
SMEs	small and medium-sized businesses

FOREWORD

YB Dato' Seri Mohamed Azmin Ali
Senior Minister,
Ministry of International Trade and Industry (MITI)

"Digitalisation drives productivity. It enhances connectivity and transactions among businesses, peers, and customers beyond geographical borders. The development of the Construction Material Digital Roadmap by Construction & Built Environment Productivity Nexus (COBEPN) is an apt move to modernize the tourism industry and propel it to the high-yield market segments.

Digitalization beyond borders enables the tourism industry players to reach bigger and broader audiences to promote and market tourism products and services. There is an urgent need to innovate and update Malaysia's construction to match the changing consumer expectations. Health, safety, and security become significant novel elements in the construction business. Technology and digitalization can facilitate the growth of tourism in the new era.

Congratulations to Malaysia Productivity Corporation (MPC) and CPN for publishing this document. I hope to see similar references tackling the diverse aspects of the construction industry"

FOREWORD

YB Dato' Sri Mustapa bin Mohamed
Minister in the Prime Minister's Department (Economy)

"During the duration of the Twelfth Malaysia Plan, the priority is on rebuilding the economy and repositioning Malaysia on a stronger foundation for sustainability and resilience. The pandemic in the past two years severely affected Malaysia's construction industry. 2022 began with a positive note as SOPs were relaxed and Malaysia entered the endemic phase. The stakeholders in the industry have the monumental task of reinvigorating Malaysia's construction industry and bringing its productivity to positive growth.

At the core of rebuilding Malaysia's construction industry is the adoption of digital technology. The Strategic Plan under Construction 4.0 implementation will be fueled by four enablers, namely; people integrated technologies, economy, and governance. The four enablers must work in synchronicity in developing a future-ready workforce from the grassroots and give rise to home-grown technologies. Most importantly, the existing legal framework surrounding construction must be strengthened and reviewed to encourage the adoption of new emerging technologies.

I urge the industry players to leverage the guidance in this digital roadmap to transform the construction business. Restoring the dynamism of Malaysia's businesses requires the digitalization of the economy. As one of the main contributors to the country's economy, the construction industry is no exception".

FOREWORD

YB Dato' Sri Haji Fadillah bin Haji Yusof
Senior Minister of Infrastructure, Ministry of Works

"Construction Material Digital Roadmap is a roadmap for the Malaysian Construction Industry to embrace the Fourth Industrial Revolution (IR 4.0) in ways that would transform its productivity and competitiveness.

Through the Strategic Plan, we envision being the leading country in the implementation of IR 4.0 for the Construction industry in the Southeast Asia Region. This can be achieved by transforming the Malaysian construction industry towards embracing smart construction.

Construction Material Digital Roadmap transformation will certainly not happen overnight. The industry players must convince and the necessary investments must be made by both the private and the public sectors toward technology adoption. As a nation, we must strive to be at the forefront of technological advancement or we risk being left behind.

I urge all construction industry stakeholders to play an active role and collaborate with the industry players towards ensuring the achievement of all Construction 4.0 objectives and goals, thus creating a tremendous positive impact on the construction industry in Malaysia".

OVERVIEW OF THE CONSTRUCTION INDUSTRY IN MALAYSIA

The construction industry is a cross-industry industry that includes manufacturing and service sectors. The construction industry is an economic engine for both industrialized and emerging countries. As it develops solutions to global social, energy, and environmental concerns, construction promotes job development and increased productivity.

In the September 2021 Future of Construction report, Oxford Economics indicated that construction spending accounted for 13% of global Growth Domestic Product (GDP) in 2020 and they expect that share to exceed 13.5% in 2030. The construction sector in Malaysia employs 1.2 million people, which is 9.5% of the total workforce. It has a multiplier effect of 2.03 and contributes 4.6% directly to the national economy thanks to its connections to over 120 different industries, 90% of which are small and medium-sized businesses (SMEs). Due to the Covid-19 pandemic and enforced movement control orders, the GDP of the Malaysian construction industry fell by 19.4% in 2020.

Unfortunately, unlike other industries that had radically adopted new technologies, the construction industry has not yet had to face digitization to any significant extent during the pandemic. The construction industry has an average productivity rate that is lower than most other sectors. This is due to limited adoption of new technologies or best practices and continued reliance on low-income foreign workers. This leads us to believe that improving workforce quality, technology adoption, and business processes in construction can increase productivity rates. Governments and stakeholders worldwide have recognized that change is needed now more than ever, especially during this pandemic, which has revealed the many areas that require our attention. The World Economic Forum has launched an initiative called Future of Construction that encourages all stakeholders to work together and find innovative solutions for higher productivity, greater sustainability, and improved affordability, resulting in better construction quality at lower costs.

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CONSTRUCTION MATERIALS IN THE MALAYSIAN CONSTRUCTION INDUSTRY

Basically, in Malaysia, three (3) main components of construction materials are wood, steel, and concrete. Malaysia has become the main supplier throughout the world for these types of materials.

2.1 Wood

Humans have used wood to build shelters and structures for thousands of years. Despite decades of scientific advances and the development of various plastics, wood remains a popular building material. The attractiveness of wood stems from its low cost. It is also lightweight and easy to work with. It acts as an insulator, letting warm air in and cold air out. Wood, on the other hand, has some disadvantages. Because wood isn't always perfect for supporting a lot of the weight of building materials, it's not the best choice for multi-story buildings. And unlike certain synthetic materials, wood only lasts a few hundred years before it rots. It is also susceptible to fire and moisture damage and prey for destructive termites.

2.2 Steel

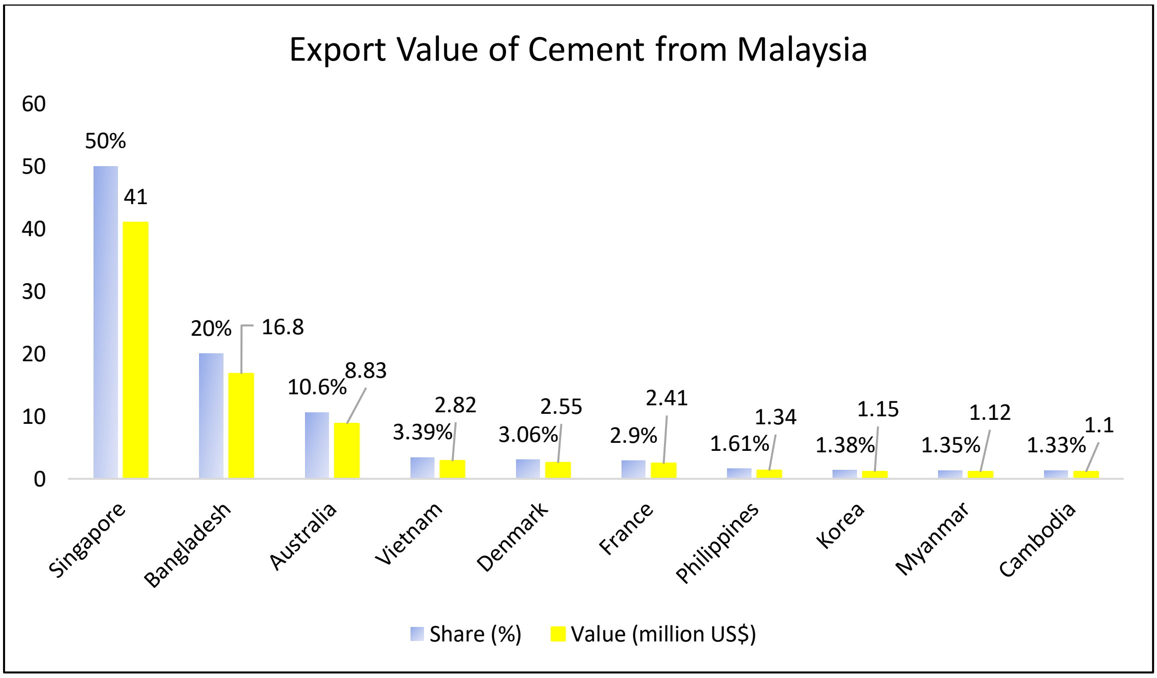
Pound for pound, steel is the strongest building material there is. Steel is always the material of choice because it's tough without being overly heavy. This makes it an excellent choice for multi-story buildings and manufacturing and industrial companies. Unlike wood, steel tolerates moisture and is resistant to termites and fire. It will also survive much longer than wood. Unlike masonry, steel can accommodate large, open designs while maintaining the integrity of the structure. It's also pliable, allowing architects to experiment with more unorthodox building shapes.

2.3 Concrete

Concrete consists of cement, aggregates such as sand or stones, and water. This material is formed into shapes that dry and harden to build everything from walls to sidewalk pillars. Concrete is also both durable and strong, making it an excellent choice for the foundations of your construction. It withstands the weight of the topmost building as well as the damp soil that covers it.

On the other hand, concrete requires different assembly skills than wood or metal. To ensure your structure is built appropriately and will stand the test of time, you should deal with a reputable and professional concrete team. The value of exports of commodity group 2523 Portland cement, alumina cement, metallurgical cement, persulphate cement, and similar hydraulic cement, whether or not colored or in the form of clinker from Malaysia totaled US$83 million in 2020.

Top export destinations of "Portland cement, aluminous cement, slag cement, persulphate cement, and similar hydraulic cement, whether or not colored or in the form of clinkers" from Malaysia in 2020 (Figure 1).



Source: Trend Economy (2020)

Figure 1: Export Value of Cement from Malaysia

Evolving the technology in construction materials, CIDB has introduce the Industrialised Building System (IBS) construction method as part of the objectives to (Figure 2):

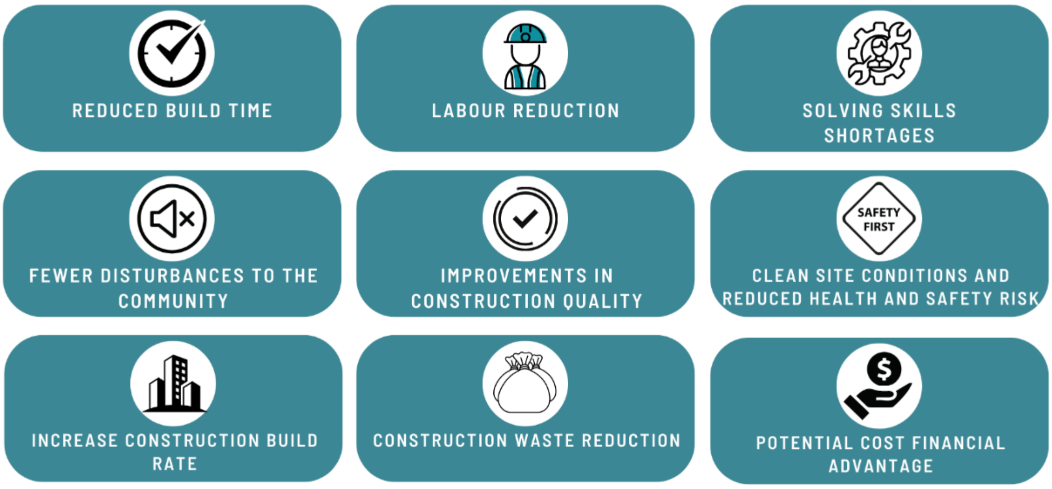


Figure 2: Advantages of IBS

IBS is the term coined by the industry and government in Malaysia to represent the adoption of construction industrialization and the use of prefabricated components in building construction. Six (6) types of IBS have been identified by CIDB to increase the adoption of technology in construction materials as in Table 1.

Table 1: Types of IBS System

System	Component	Description
Pre-cast Concrete 	Column Beam Wall Slab	The common IBS used includes precast concrete elements, lightweight precast concrete, and permanent concrete formwork.
Formwork	Column Beam Wall Slab	The common IBS used includes precast concrete elements, lightweight precast concrete, and permanent concrete formwork.

System	Component	Description
		
Steel Framing 	Column Beam Roof truss	Commonly used with precast concrete slabs, the steel framing system has always been a popular choice and is using extensive track construction of skyscrapers. The recent development of this IBS includes the usage of light steel trusses consistent-efficient efficient cold-formed formed channel and steel portal frame system. These are the alternatives to the heavier traditional hot rolled section.
Prefabricated Timber Framing 	Column Beam Roof truss	This system consists of timber building frames and timber roof trusses. Timber building frame system also has their market and demand, offering attractive designs from simple dwelling units to buildings that required high aesthetical values such as resorts and chalets.
Block Work	Column Beam Wall	The construction method of using traditional bricks has been revolutionized by the developments of interlocking concrete masonry units and lightweight concrete blocks. The tedious and time-

System	Component	Description
		consuming traditional bricklaying tasks are vastly simplified by the usage of these practical solutions.
Innovative 	Wall	To classify new systems introduced in the Malaysian construction industry that do not belong to the IBS in the CIDB's IBS classifications (2003), CIDB introduced innovation classified the new and innovative systems the in IBS approach.

Source: CIDB (2003)

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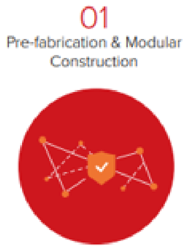
TRENDS IMPACTING CONSTRUCTION INDUSTRY

The World Economic Forum has outlined ten (10) disruptive technologies related to the construction sector. With the introduction of these technologies, the sector can be transformed into a more competitive, modern industry.

3.1 Prefabrication and Modular Construction



Prefabrication means the manufacture of components outside the construction site and assembly on site. In principle, these ready-made elements can be adapted to specific projects. Modular building specifically describes cases of prefabrication where the elements are standardized modules.

Prefabrication and modular construction are particularly relevant when:

- The building consists of several similar units (e.g. office space) and/or has a complex construction that is difficult to create on site (e.g. special facade elements or steel frames).
- Remote or in a densely populated urban area.
- There is access to an efficient external production facility.
- The construction site planning is complex, e.g. many stakeholders, limited space or time the construction site has a short construction season, e.g. due to the climate or on very expensive land.

Benefits and challenges

- Faster construction
- Higher predictability of costs
- Less dependency on weather and site conditions (resulting in higher worker productivity)
- Reduced material waste and CO_2 emissions during transport
- Increased safety for workers
- Construction options can be restricted to a certain extent by using standardized modules
- Overengineering, e.g. Wall thickness as multiple modules are assembled Limited ability to change structure through future renovations

3.2 Advanced Building Materials

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Advanced Building Materials

Advanced building materials offer opportunities to change the way buildings are constructed and upgraded. It offers added value in terms of increasing performance and functionality. New materials can also help meet new durability challenges in a changing climate and meet CO_2 reduction targets.

Advanced building materials can be categorized into two (2) categories which are:

1. Intelligent building materials
2. Interactive building materials

Intelligent building materials – materials that can sense and respond to temperature, action, stimuli, etc. on their own. They react according to the built-in program or the commands preset on the chip.

Interactive building materials - this type of building materials evolves to facilitate human beings and has the nature of establishing a meaningful relationship with the human environment. It requires command or outside force to perform its function.

Top New Sustainable Building Materials as highlighted by Smith (2020) are:

1. Prefabricated Laminated Timber
2. Self-Healing Concrete
3. 3D Graphene
4. Transparent Aluminum
5. Bioreactors
6. Invisible Solar Cells
7. Synthetic Spider Silk
8. Aluminum Foam
9. Nanocrystal
10. Translucent Wood
11. Illuminating Concrete
12. Wool Brick
13. Hydro Ceramic
14. Biochar

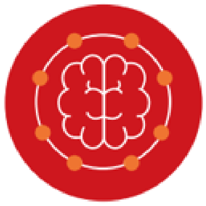
3.3 3D Printing & Additive Manufacturing

Additive manufacturing, often known as 3D printing, is a type of digital manufacturing technique that creates physical objects from a geometric model by adding materials. The field of 3D printing is growing rapidly. 3D printing has become common practice around the world in recent years. Mass customization and the manufacture of open-source designs are becoming more common uses of 3D printing in agriculture, healthcare, automotive and locomotive industries. Starting from a CAD model, 3D printing technology can build up a three-dimensional object layer by layer. This paper provides an overview of the different types of 3D printing techniques, their classification, the materials used and their applications in different sectors.

3.4 Autonomous Construction

Machine that can work independently to perform construction tasks. Most autonomous machines use sensors and artificial intelligence to navigate their environment and complete tasks

This makes them ideal for use in dangerous or hard-to-reach places. For example, many construction jobs, such as constructing underground utilities, can be performed more safely and efficiently using this equipment. Thanks to automation, crews can now dig trenches and lay pipes without a human being in the area. This is just one of many ways autonomous construction machines are transforming the industry.



The possible applications for autonomous construction machines are almost endless. Here are some of the most notable examples:

- Bridge and road construction
- Building Construction
- Tower construction
- Shipbuilding
- Mining
- Railroad maintenance and construction

Some of the benefits of adopting autonomous construction are:

- A higher rate of productivity
- Reduced completion times
- Reduced costs
- Improved safety
- Keep up with industry competition

3.5 Augmented Reality Virtualisation

Augmented Reality is the mixture of real and virtualized information by a computer that combines the three spatial dimensions to create a graphic and digital model that complements the information present in the real world.

As mentioned by iGreet (2018), there are five (5) types of Augmented Reality which are:

Projection based AR	Recognition based AR	Location based AR	Outlining AR	Superimposition based AR
• AR projects digital images on physical objects in the physical space.	• QR code, or scan an image and it comes to live (just like in iGreet cards) you are actually using a recognition based AR.	• Location based AR is taking advantage of the smart devices' location detection features	• outlining AR uses object recognition to work, and might look a bit like a projection based AR.	• Superimposition based AR also uses object recognition in order to replace an entire object or a part of it with an augmented view.

3.6 Big Data

Big data in construction is simply the vast amounts of engineering and financial data, graphics, Enterprise Resource Planning systems (ERPs), etc. that are too large for mainstream software tools to store, organize, and process.

With access to big data, an organization can gain insights and improve productivity and customer experience, as well as reduce the cost of doing business. Proper analysis of big data can help to develop different classification systems and predict the patterns and trends, followed by interpretation of the results.

3.7 Wireless monitoring & Connected Equipment

Just like new standards and regulations, the introduction of new technologies in the construction industry is a slow process. In fact, one of the main reasons adopting new standards and regulations can be such a challenge is the failure of the industry to keep up with technology. Construction decision makers are reluctant to move away from traditional design, construction and testing methods. In a world where everything is becoming more and more networked and new systems are being developed for all areas of life, the use of intelligent technologies in construction is essential. In particular, the use of sensors and devices to monitor and evaluate structural and material properties of concrete is essential.

Source: Pepin (2018)

These wireless sensors make it easy for general contractors (GCs) and engineers to capture critical data. Traditionally, these sensors are connected via a complicated system of cables and data loggers. In recent years, advances have facilitated the development of wireless sensors, eliminating the need for data loggers and exposed wires through the use of smartphone technology.

Access to real-time concrete temperature and maturity information has helped contractors shave days, weeks, and even months off project schedules, saving thousands of dollars in operational and lab testing costs.

3.8 Cloud & Real Time Collaboration

Real-time collaboration simply means that people work together at the same time, even if they are in different locations. And the online collaboration tools available are as diverse as the types of collaboration they enable. For example desktop sharing. If you use a feature that lets you share your device screen with others, everyone can see exactly the same thing, so everyone can collaborate in the same context at the same time. Document sharing is another collaboration tool that gives multiple people access to the same text, spreadsheet, or presentation so they can add, edit, or comment on a single live file together.

Types of real-time collaboration

The possible types of real-time collaboration are as diverse as the apps that enable them. Here is a list of some of the most common types of real-time collaboration:

- Document sharing and editing
- Video conferencing
- Desktop sharing
- Online whiteboards
- Instant messaging (real-time text) and chat rooms (or threads)

3.9 3D Scanning Photogrammetry

3D laser scanner uses lasers to scan an object's geometry and obtain its 3D data. Once all points are collected, a dense point cloud is generated that can be used to create a 3D model. Most 3D scanners on the market are capable of scanning objects that are in the range of 1m in size, while it is difficult for these 3D scanners to scan large-scale objects such as wind turbines, airplanes and buildings. This is where photogrammetry comes into play.

Source: Cousins (2018)

Capturing 3D as a point cloud is only half the battle when it comes to scan-to-BIM, and project teams have several methods at their disposal to export and query the images in software. Certain project review software is capable of importing point clouds of actual construction and overlaying a common coordinate system to perform clash detection against the design to highlight problems. The federated BIM model, which typically includes the architecture, structure and MEP, can be regularly updated to match the point cloud.

3.10 Building Information Modeling (BIM)

Building information modeling is a complex process that involves interacting with information from different phases of construction, collaborating, and overall managing a project. The typical output of BIM is an information model of a building that contains detailed information about how it was built, the history of decisions made at which stages, and other important information. A common misconception about the definition of BIM in construction is that it is just an extension of traditional 3D modeling software, but so much more.

- **Changes monitoring.** Better monitoring of the different parts of the project in general, the possibility to undo everything if the last change shows an error, which saves a lot of time for the designers compared to the previous iterations.

- **Clash detection.** The whole process is automated, so you can detect possible collisions between different BIM objects from the start, saving time and money throughout the project lifecycle.

- **Improved scheduling/sequencing.** BIM can indeed save a lot of money, but it also works as a time-saving tool. By eliminating various setbacks from the construction process, making changes easy, and documenting all at once, companies can save a great deal of time that they would otherwise spend on unnecessary changes and subtleties.

- **More time-effective projects.** Due to the numerous benefits of BIM, companies can improve their overall project schedules by reducing or eliminating errors, adjustments, repetitions, etc.

- **Lowered risks and expenses.** There are many ways that BIM can reduce both the risks and costs of a project, e.g. B. Better coordination with contractors, improved accuracy of models in general, a single document database, easy coordination and collaboration, and much more.

- **Accurate cost assessments**. This is the direct representative of the 5D layer of BIM that introduces the cost dimension into the equation, resulting in an automated, real-time cost assessment of your projects. It can be used to show the estimated cost of the entire project or the impact a specific item may have on its price. This allows architects to implement a variety of different ways to reduce construction costs, including:

- Streamlining the overall construction process with fewer billable hours for the customer;
- Purchase of materials at the lowest possible market price;
- Reducing the number of costly repairs and project delays by dramatically reducing the number of human errors;
- Selection of less expensive material types;
- Decide between building on-site and prefabrication, which is cheaper and more effective overall.

- **Improvements in teamwork and communication in general**. This is possible via several different technologies. Cloud accessibility, better project framework distribution, and seamless interfaces to different project fields. With all project information stored in a single place accessible to all different parties, miscommunication is as close to zero as possible. For example, contractors don't have to figure out how to resolve a conflict on an actual building because everything can be modulated and resolved in advance.

- **Productivity improvements.** Various BIM tools can generate diagrams and production processes and significantly increase overall labor productivity by leveraging technologies such as pre-construction and modular development. For example, BIM software gives architects more freedom in designing complex architectural parts and offers various tolerance-related calculations. In addition, better productivity means shorter lifecycles, resulting in lower costs and shorter payback periods.

- **Better build quality.** While the most obvious benefits of BIM tend to focus on areas such as construction and design, it's safe to say that clients should also notice consistently better build quality. The main reason for this would be the improved accuracy of both the models and the calculations, resulting in a higher quality structure. In addition, BIM allows for more aesthetically pleasing structures, as architects can fully mimic what the project would look like in reality, right down to emulating artificial and natural light.

- **Planning stage with project visualization.** The ability to see the entire project model before the construction process begins reduces the risk of making time-consuming and expensive changes to fix a specific oversight or simple error.

- **Development sites are more secure.** BIM can automatically identify problem zones and potential logistical disasters in advance, saving both time and money for the organization and creating a safer place for team members. With BIM, it is extremely easy to pass on-site assessments and comply with all safety regulations.

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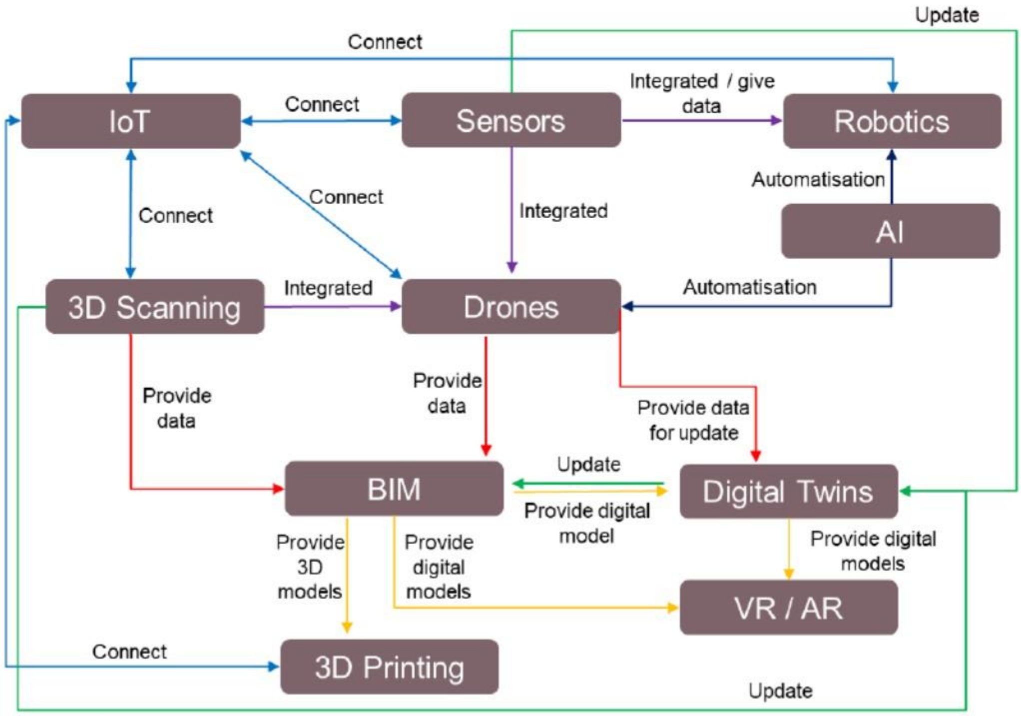
STATE OF PLAY OF DIGITALISATION IN THE CONSTRUCTION SECTOR

Of all the major contributor industries, construction has been the slowest to absorb the untamable technological tornado that first erupted around 1985 with 3D modeling. With the advent of more tools and software to get work done efficiently, it has picked up speed and it is now clear to everyone that it is not going to slow down. While the other industries have undergone a complete systemic overhaul through their total submission, the construction industry, relentlessly clinging to traditional techniques, has yet to bow to it.



Source: European Construction Sector Observatory (2021)

Figure 3: Application of Digitalisation in Industry

4.1 Digital Maturity Globally

A study by BCG, authored by Burfeind et al., (2015) identified three levels of digital maturity for retailers in the US construction industry. As mentioned, the three phases are breaking ground, building the foundation, and climbing the heights. The details of the stages are shown in Figure 4.

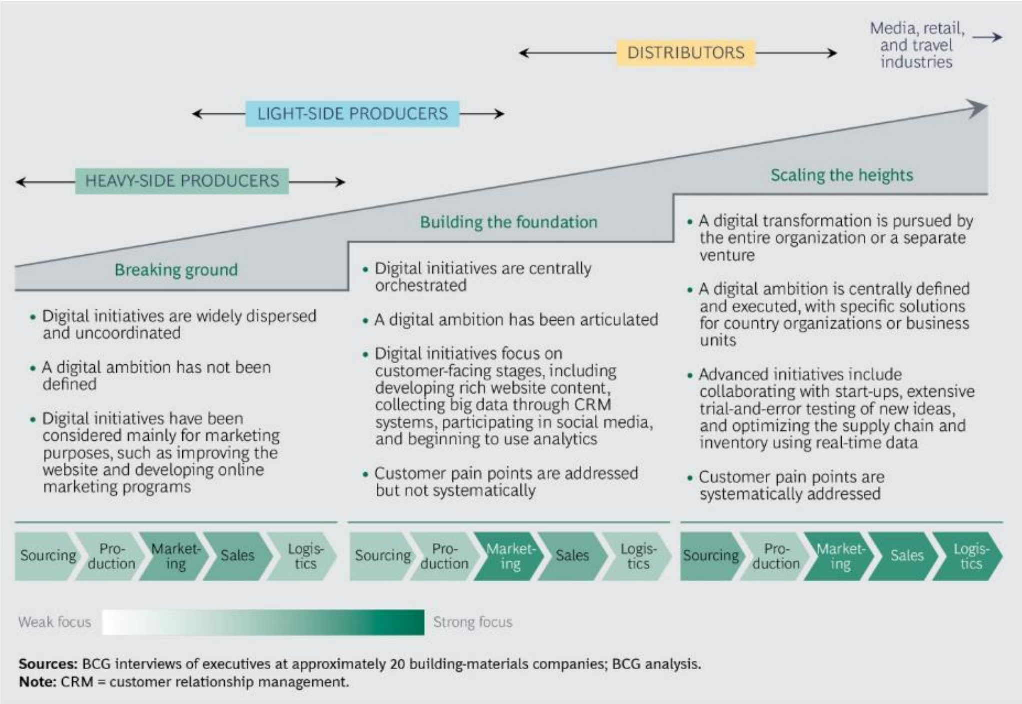


Figure 4: Digital Maturity of Distributors

i. Breaking Ground

Organizations in the earliest stages of transformation have few uncoordinated digital initiatives and have not defined an enterprise-wide ambition for digital adoption. The main focus of these companies was on digital implementations in marketing, such as B. integrating basic e-commerce functions into their website, providing intranet communication tools, and developing online marketing programs. These companies have not explored what pain points along the customer journey could be addressed through digital initiatives.

ii. Building the Foundation

In the next phase, companies have formulated a digital ambition and started to centrally coordinate digital initiatives. They have gone beyond executing basic digital initiatives in marketing and have addressed the pain points for all steps of the customer journey. These efforts include developing comprehensive website content, collecting and structuring big data by implementing advanced customer relationship management systems and participating in social media. These companies have also taken the first steps to apply analytics to big data.

iii. **Scaling the Heights**

When building materials companies reach the advanced stage, digital ambition is built into the company's DNA. In some cases, a separate company was set up to perform the digital transformation and systematically address pain points along the customer journey. Although digital ambition is defined and implemented centrally, specific programs are tailored to the councountry’sanizations or business units. Advanced initiatives typically involve collaborating with startups, extensive trial and error testing of new ideas related to apps and mobile devices, and optimizing supply chain and inventory through the use of real-time data. However, these companies typically still have opportunities to make more extensive use of big data and advanced analytics.

So far, retailers are the only building materials players who have reached the third level of digital maturity. They have been motivated to aggressively pursue a digital transformation because they see that a strong e-commerce offering is essential to maintaining customer loyalty and increasing revenue. The digital transformation of distributors has taken place quickly. Fletcher Building, for example, recently launched an independent digital innovation lab just a few years after its first digital initiative. The first companies to use e-commerce to sell and distribute building materials have demonstrated the potential for revenue growth.

4.2 Adoption of Digital Transformation in the Malaysian Construction Industry

The adoption of IoT in the Malaysian construction industry is improving day by day as technology changes very rapidly. Currently, the establishment of 5G technology has become a key issue around the world, and the new generation is aware of the existence of this improvement. The construction industry has also been exposed to the latest construction technologies as the Internet of Things (IoT) is one of the core components of construction 4.0. In general, the adoption of IoT in the context of the Malaysian construction industry is improving but is still slow compared to other Asian countries such as Singapore, China, Japan, South Korea, and, Hong Kong (Ansaruddin Agus, Hamzah & Khoiry, 2019). However, with the encouragement of the Malaysian government and the support of the Department of Public Works (PWD) and the Construction Industry Development Board (CIDB), the adoption of the IoT will have a bright future as the private and public sectors are aware of the benefits of taking it on of the IoT.

Furthermore, the use of IoT devices has also been adopted in tertiary levels educational institutions such as universities, colleges,s, and vocational schools to demonstrate and educate students studying construction and engineering that they are BIM enabled and IoT competent as they will lead the industry in the future. Based on the previous discussion on IoT adoption, the Malaysian construction industry has already implemented IoT for site monitoring, machine control, construction safety, fleet management, and project management. These IoT adoption areas are important to ensure that all data from construction, whether off-site or on-site, is accurate and sufficient to develop good project progress. The adoption of IoT devices is significant as it will make it easier for people to get accurate information, save time and money, and reduce potential risks efficiently and effectively. However, Malaysia still has limitations in deploying or using the latest IoT technology devices due to their cost as well as the limited number of experts able to install and operate the devices. Overall, IoT adoption in Malaysia is aligned with the latest global technology, but continuous improvements are needed to ensure Malaysia's construction industry can compete globally.

Malaysia is expected to meet its GDP growth rate of 5.1% projected in the 11th Malaysian Plan (2016-2020). Digital transformation and the advent of the Internet of Things (IoT) will be key to unlocking future growth potential (Ho, 2019). Figure 5 shows the current state of digital transformation in the Malaysian construction industry.

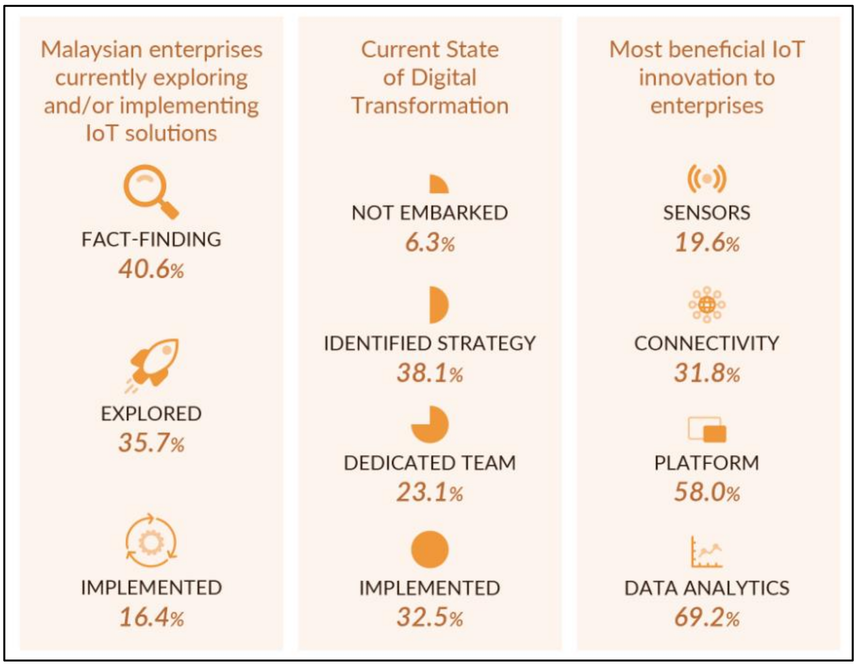
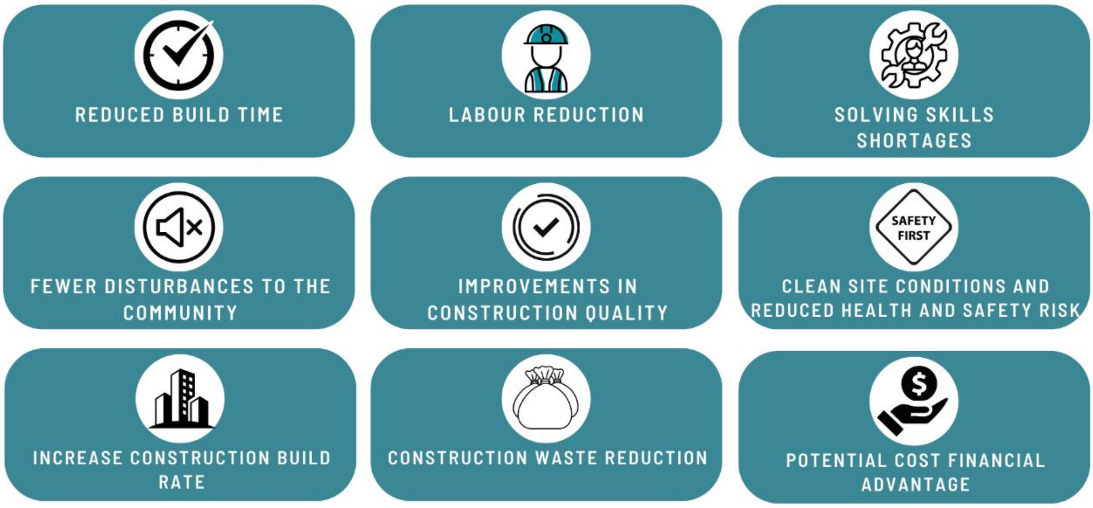


Figure 5: Current State of Malaysian Digital Transformation

According to Asia IoT Business Platform's Enterprise IoT Report 2018/2019, 9 out of 10 companies in Malaysia have set their digital strategies for the next few years, but 40% are still in the exploratory phase.

From the launch of the National Fiberisation and Connectivity Plan (NFCP) to the establishment of the Digital Free Trade Zone and the recent Industry4WRD policy, Malaysian government agencies and businesses are embracing digitalization to address issues across sectors.

The sixth annual Asia IoT Business Platform will address five important opportunities for technology adoption, as recommended by a panel of industry experts across Malaysia's digitalization ecosystems.



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DRIVERS AND CHALLENGES OF DIGITALISATION IN THE CONSTRUCTION SECTOR

5.1 Drivers towards Digitalisation

The prominent niches being conquered by digital technology are collaboration and information management. The advent of new technologies is redefining engineering practices and the way we behave in difficult situations. Whether it's BIM, virtual reality, drones, 3D mapping, 3D printing, or mobile technology, understanding how it all could come together to make a job easier is essential for companies to thrive, compete, and survive in the industry. Customer expectations have also increased significantly as they have faced rapid changes in other industries. From the possession of smartphones to smart televisions to the desire for your smart infrastructure, the requirements are increasing and becoming more and more complex. Falling costs and increasing efficiency of hardware (sensors) and software are other temptations sure digitization into industry ry. The industry is also witnessing the influx of tech-savvy engineers who have a propensity to embrace digitization in their communities. The demand for the rebuildings could also be met by introducing digital tools. Above all, there is a need to compete with and conquer the massive infrastructure projects that require digital literacy from you. Sonia (2022) in her writing has identified five (5) benefits adopting digitalization.

i. Improved Productivity

With real-time data collected by 3D laser scanners and sensors, construction professionals can now easily track quantity and quality with the help of 3D laser scanning companies and tools. Bringing the design into an immersive environment will give project managers and teams a better understanding of the design.

It will help the team save time before going back to the design plan and then back to the site. Plus, digital designs can be shared and accessed between team members at any time, so everyone can stay on track without physical collaboration and translation loss.

i. High Accuracy

The use of new technologies helped collect precise data that can be implemented in any building and construction project. Using laser scanners and software to create the 3D point cloud and BIM has made the work of infrastructure professionals much easier and much more accurate. Replacing manual paper drawings and spreadsheets with digitization made work faster and easier. In addition, digitization has pushed building and construction professionals to identify issues and potential issues to avoid delays and cost increases due to fixes.

ii. Improved Clarity

Digital technologies have improved communication regardless of location and time zone. Explaining and sharing ideas between employees is no longer that difficult, and this has proven very useful in today's COVID19 pandemic

Stakeholders can collaborate in real-time to discuss project progress. With centralized communication, anyone can access the main design plan and the rest of the project-related information at any time. For example, 3D BIM models allow you to coordinate the design and construction of a building due to easy access to data. Optimize and manage your construction project to enable optimal performance and virtual reality experiences. And that is just one aspect of digitization for construction.

Modern technology made it easier for everyone involved to share their knowledge and expertise without having to travel to and from offices and construction sites. Not only is this a great way to save time, but it also ensures projects are completed on time while maintaining build quality for clients and users.

iii. Enhanced Work Safety

In addition to the quality of buildings and infrastructure, the safety of workers should have the highest priority. Worker safety has been an important issue to address given the range of hazards that can threaten their health and safety. It’s one of the most dangerous jobs in Britain.

Integrating new technology into construction can help contractors or project owners improve safety and the work environment for the benefit of all. The integration of intelligent machines will eliminate the risky jobs that can endanger workers' lives. In addition, AI, known as artificial intelligence, can provide project leaders with an overview of potential hazards and risks at work that can be acted upon immediately. Create a harmonious balance between technology and workers by using the beneficial elements of machines. When key security concerns are addressed upfront, everyone can focus more on project completion and other opportunities that require quick action.

iv. Maintenance and Sustainability

Today, owners and facility managers can easily track all infrastructure assets and other data that can be used for operations and maintenance. The power of artificial intelligence can help predict potential problems, which is an advantage for predictive maintenance. From the composition of the material, weather conditions that can have adverse effects on the building, environmental conditions, and more, they are vital to sustainability and property management. With so many benefits, incorporating construction trends and technology will make building completion easier and construction projects faster, cheaper and safer.

5.2 Challenges towards Digitalisation

The main reason for the reluctance is believed to be the extreme sophistication and intricacy of the construction projects, which there are fears could be jeopardized by taking on anything new. The other reason is the lack of big enough players that can set an industry standard. The industry has always focused on continuous improvement processes, which they now need to change and stop seeing digital tools as impractical. Nowadays, the industry must embrace and accept digitalization with open arms as it impacts the growth and development of the economy tremendously.

Due to a few causes, construction industry participants are still hesitant to utilize the IoT to manage their projects, which contributes to the low acceptance rate of new technology. The main difficulty is brought on by the dearth of professionals who are skilled in using this equipment effectively. This is because in order to bto, a person must have thorough training and strong knowledge of the instrument.

Additionally, the company will incur additional costs to teach its staff on how to utilize these devices. The high cost of purchasing the devices and performing routine maintenance will make it difficult for construction industry participants to use IoT. The primary method for establishing a link between the IoT device and the system for data transfer into the information will be an internet connection. The device's interoperability will be disrupted and the operator won't be able to receive the information if the internet connection is poor or non-existent. Because of this, the construction site needs to have a strong internet connection for the device to perform effectively and to employ the best technology possible to assure accurate information and interoperability. Due to their limited exposure to the global construction industry and technology, small and medium-sized businesses in particular face difficulties adopting the Internet of Things (IoT).

On the other side, they are hesitant to adopt because new technology is always changing, necessitating updates and adjustments that would waste their time and result in more expenses each time the IoT devices were modified. Due to this, even if they are aware of the benefits of IoT in saving them time, money, and improving project performance, the majority of construction players are at ease maintaining their traditional methods.

Another difficulty arises when the government and organisations cannot promote IoT adoption among the building industry's players. The requirements for deploying IoT on construction sites must be regulated by the government to increase IoT adoption in the construction industry. This can be achieved by requiring them to operate their project using techniques such as building information modelling cloud computing, big data, sensors, and remote operation.

How to shift unproductive sites that are currently too difficult to build on into productive uses is a significant challenge facing the building industry. The necessity to utilize the limited amount of land at their disposal more efficiently as societies urbanize is urgent. Sites that were previously awkward or even impossible to build on quickly become desirable places as more and more land is developed.

The construction sector is primed for change. Large projects across all asset classes often finish 20% later than expected and cost up to 80% more than expected. Since the 1990s, construction productivity has decreased in several areas, and contractor financial returns are frequently low and unstable.

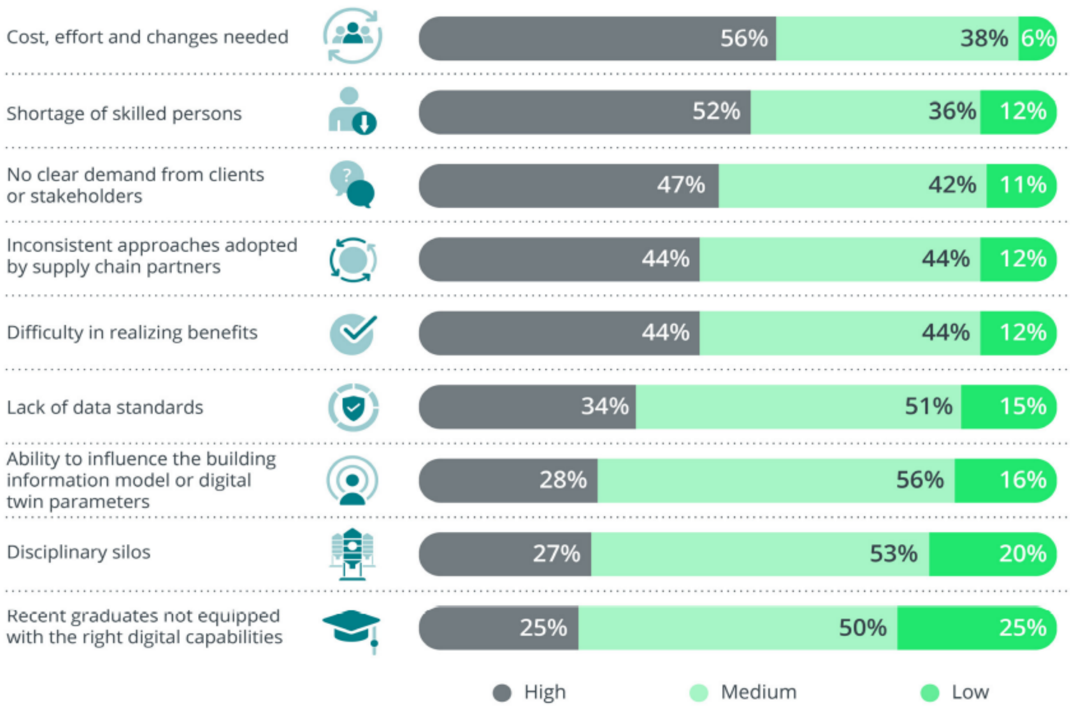
Even though the construction industry has been sluggish to accept new processes and technologies, there is still a problem when it comes to mending the fundamentals. For instance, project planning is frequently done on paper and is not coordinated between the office and the field. Contracts lack incentives for innovation and risk sharing, performance management is subpar, and supply-chain procedures are still crude. Even while new digital technologies require upfront investment and have tremendous long-term benefits, the industry has not yet accepted them. Less than 1% of revenues are spent on R&D in the construction sector, compared to 3.5 to 4.5 percent in the car and aerospace sectors. This is also true for IT expenditures, which represent less than 1% of construction revenue even though a number of fresh software programmes created for the sector.

The slow rate of digitization is a result of technical issues unique to the building industry. It is a difficult effort to roll out solutions across construction sites for various sectors that are spread out geographically—for example, compare an oil pipeline with an airport. And developing new capabilities at scale is a challenge given the various levels of complexity of smaller construction companies that frequently serve as subcontractors.

But nothing of this is going to become any simpler. Projects are getting bigger and more complicated. Traditional methods must adapt to meet the increased need for ecologically responsible construction. And the need for supervisory personnel and specialized labor will only worsen. These are complex concerns that call for fresh approaches to thinking and doing. Because many people think each project is unique, new ideas cannot be scaled out, and embracing new technologies is impracticable, the sector has historically tended to concentrate on making incremental improvements.

By 2030, the world's infrastructure spending would need to reach $57 trillion, according to the McKinsey Global Institute. Players in the construction sector have a strong motivation to find ways to enhance productivity and project delivery using new technologies and better procedures.

A report done by the Royal Institution of Chartered Surveyors (RICS) undergone ego survey on the global response on the blockers that hinder digitalization of the design and construction processes and practices (Figure 6).



Source: RICS (2022)

Figure 6: Blockers in Digitalisation

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DIGITALISATION

POLICIES AND INITIATIVES

6.1 Construction Strategy Plan 4.0

The Construction Strategy Plan 4.0's implementation will be guided by the four strategic axes listed below:

a) Building Capacity
b) Research, Innovation, Commercialisation, and Entrepreneurship
c) Smart Integrated Technology, Innovation & Infrastructure
d) Enhanced Business Environment

These will provide the ecology needed to support the required adjustments. The Plan also outlines 12 new technologies that will transform the building industry, including Building Information Modelling (BIM)

a) Pre-fabrication and Modular Construction
b) Autonomous Construction
c) Augmented Reality & Virtualisation e. Cloud and Realtime Collaboration
d) 3D Scanning and Photogrammetry g. Big Data & Predictive Analysis
e) Internet of Things
f) 3D Printing and Additive Manufacturing
g) Advanced building materials k. Blockchain
h) Artificial Intelligence

6.2 National Construction Policy 2030

One of the primary endeavors of the government to transition the whole construction sector into the digital era is the National Construction Policy (NCP) 2030. To achieve equitable and sustainable national development by 2030, the policy acts as a book detailing the growth of the construction industry and a crucial resource and guide for both the public and private construction sectors.

This will be furthered by the National Construction Policy 2030, which will concentrate on several crucial sectors to advance the construction industry. NCP 2030, with the theme "Digitizing the Construction Sector," will concentrate on accelerating the application of technology throughout all work processes before, during, and after construction.

The Shared Prosperity Vision 2030 (WKB 2030), which envisions a developed and sustainable country with an equitable and inclusive economic distribution, serves as the foundation for the NCP 2030. In summary, the three (3) key goals of WKB 2030 are to reduce inequality, reform the economy at all levels of society, and strengthen the country.

The NCP2030 will act as a stimulus for infrastructure growth by efforts to restructure the economy and alleviate income and wealth inequality. The empowerment of Bumiputera entrepreneurs and Small and Medium Enterprises (SMEs) in order to put toel with other importana t sector players is one of the efforts that has been highlighted in this policy. Figure 7 shows the aims of NCP2030 which involved four (4) of the main objectives.

Figure 7: Objectives of NCP 2030

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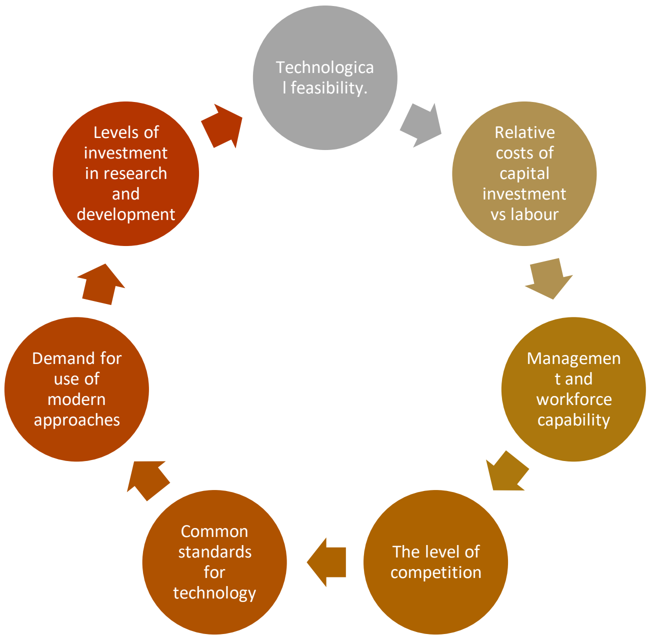
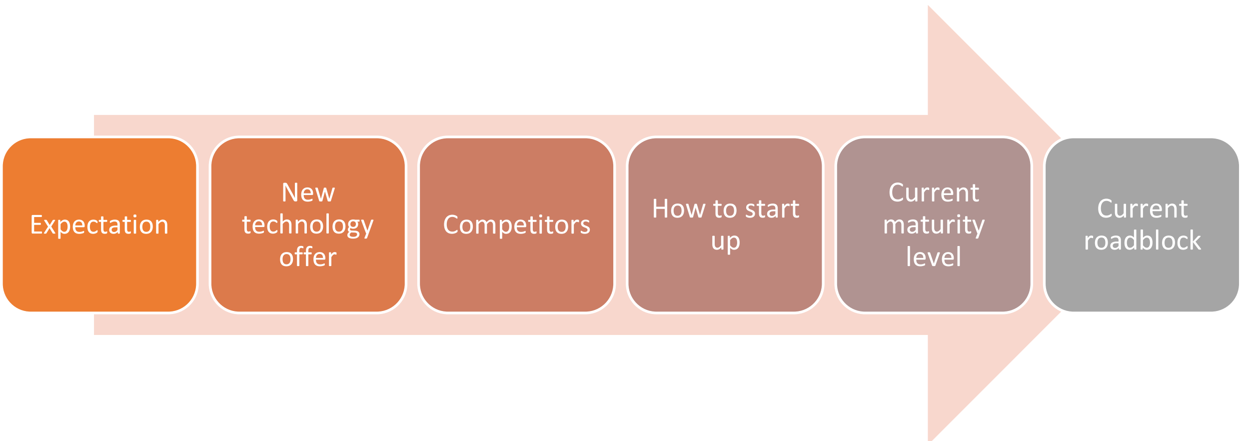
CONSTRUCTION GO DIGITAL

In order for the industry to embark into a new phase which digitalization, few things we need to considered, does construction industry have this access? According to Radley (2019), seven (7) factors should be considered before adopting digitalization.



In summary, firstly we need to identify what is the expectation of the client and the industry. Next, we need to search the new technology offer and competition digital roadmap the digitalization would help in guiding the start-up process. Current maturity level should be analysed the adopters and not to be missing is to identify the current roadblock.



A construction system, according to Gassel (2005), is a technical installation that brings building components together to form a building. An installation is made up of various pieces of machinery, computers, communication tools, and individuals working alone or in groups. The four categories of construction systems are traditional, mechanized, mechatronics, and automated. Who will be handling the physical and planning chores will determine which category the systems are placed in (Table 2).

Table 2: Types of Construction Systems

Type of Construction System	Physical Tasks	Control Tasks in Execution	Control Task in Management
Traditional	1. People 2. Equipment	People	People
Mechanized	Equipment	People	People
Mechtronised	Equipment	1. Computers 2. Telecommunication devices	People
Automated	Equipment	1. Computers 2. Telecommunication devices	1. Computers 2. Telecommunication devices

Source: Gassel (2005)

7.1 Level of Maturity in Technology Access

It was necessary to switch from the traditional labor-intensive methods to a more industrialized one because of the development of new construction materials, the emergence of an industrial sector specifically for the production of construction machinery and equipment, and the rising demand for buildings. These factors formed the basis for the development of more efficient construction technologies.

Prefabrication, which is based on the manufacturing of building components off-site or close to the site, is one type of industrialized construction. Prefabrication is currently a viable option for all structural materials, and it has been successfully used to create multi-story industrial structures and dwellings, also known as portal homes, mobile homes, manufactured homes, system buildings, etc.

As a result, the level of industrialization should serve as a gauge for assessing the adoption of industrialization in the building industry. The classification also illustrates how far industrialization adoption has advanced. Richard (2005) asserts that the five (5) levels of industrialization can be distinguished, primarily by extrapolating from developments in related sectors like manufacturing and the auto industry.

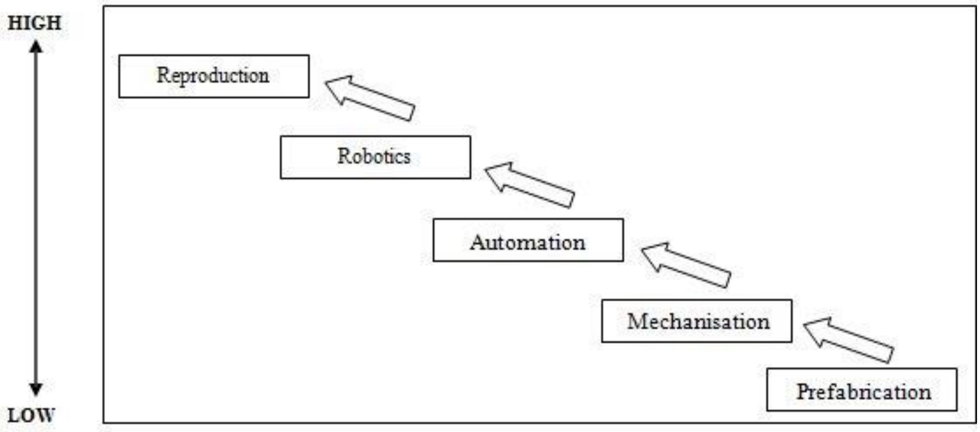


Figure 8: Level of Industrialisation

a) **Prefabrication**

A manufacturing process where diverse materials are connected to make a part of the final installation usually takes place at a specialist facility.

b) **Mechanisation**

Any machinery used to reduce the workload of the laborer is considered mechanized It refers to either the state of having a highly technical implementation or the act of putting advanced technology—typically electronic hardware—to control equipment into use.

c) **Automation**

A situation where a tool (machine) entirely substitutes a worker; is known as automation replacing workers with machines.

d) **Robotics**

Robotics is the ability of a single piece of machinery with multi-axis flexibility to carry out a variety of activities on its own. This makes the idea of mass customization possible.

e) **Reproduction**

Reproduction means that creative process development and research are capable of making the production process simpler.

The traditional building techniques are still in use for the first four (4) degrees. While the next three (3) degrees (mechanization, automation, and robotics) strive to replace labor with machinery, prefabrication focuses more on the location of production. To fulfil the primary goal of IBS, which is the reduction of foreign llabor more development is required for the industry to go from prefabrication to thaigher degree of industrialization. Additionally, the use of greater industrialization modes will boost productivity, efficiency, and safety as all jobs are carried out by machines, equipment, and robots.

Australian Digital Maturity

This approach (Figure 9) states that in the early phases of digital maturity, construction organizations may leverage fundamental technologies like internet connectivity, a website, and email to improve communication with stakeholders. In the middle stages of digital maturity, organizations may adopt a more strategic, integrated approach to leveraging digital technologies, such as the use of cutting-edge tools like cloud computing, social networking, e-commerce, and big data analytics to enhance their operations.

When an organization reaches an advanced stage of digital maturity, it may start mixing digital technologies in novel and transformational ways rather than just digitizing business procedures. Reaching digital maturity is a dynamic and ever-evolving process that necessitates ongoing research into novel uses of technology to boost productivity and keep their competitive edge.

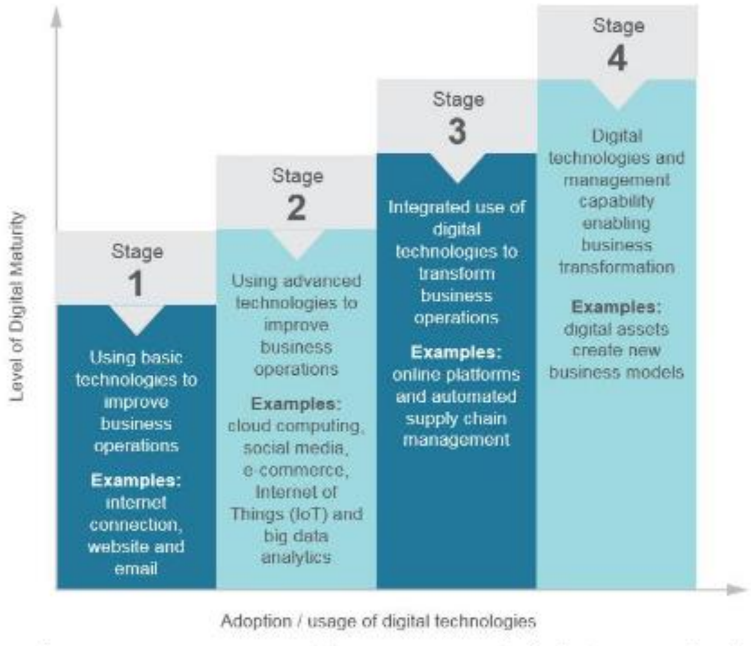


Figure 9: Proposed four stages of digital maturity in Australian industries (Chief Economist 2017)

2022

DIGITAL ROADMAP

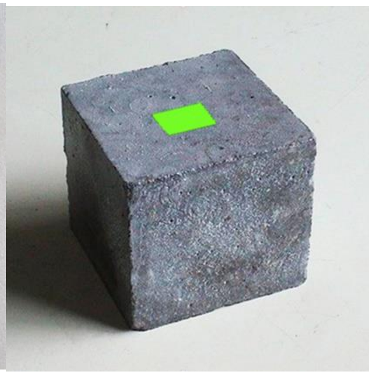
8.1 RFID

Radio-frequency identification (RFID) is a well-liked type of near-field communication technology. This is widely utilized to gather exact data about a product, place, time, and transaction in the logistics, retail, and manufacturing industries. RFID has been utilized in construction since the 1990s to track supplies and machinery and create automated time sheets. The cost of RFID hardware, such as scanners, receivers, and tags, is declining, and new uses are opening up. In the near future, tags will be able to contain details about requirements, dates, flaws, suppliers and the makers of original equipment, maintenance logs, operational conditions, and other applications.

We have seen a rise in market demand in recent years for the use of RFID technology in the concrete industry. RFID is a beneficial application since it can demonstrably speed up the fabrication and building of concrete structures.

The premade concrete material has RFID tags installed, allowing mobile RFID scanners to track it. The best way to connect RFID tags is in the manufacturing after curing. The control is used twice: once before shipment and once on location following transport and mounting. There is no longer a need for time-consuming paperwork or issues with difficult-to-read barcodes because all the relevant parties may consult the data in one single system.

RFID tags also provide the option to store more data on the quality of the concrete components. The Real Moment Location System (RTLS) can be used to get the material's location at any time. The just-in-time approach can be used thanks to precise stock and volume data.

The use of RFID technology in sectors like manufacturing, retail, distribution, and others has increased significantly. However, the UK's construction industry has expressed interest in how various applications, such as tags, might be implemented into boilers and doors. Most housing associations and facilities management (FM) can also use these applications for asset management systems. Previous research into the use of RFID in quality control, logistics tracking, system or component build, waste reduction, and asset management have been done in the UK construction industry. As RFID technology becomes more affordable, it should present construction with fresh chances to enhance asset upkeep. It may offer the possibility for financial and operational savings by:

- Improvements in productivity,
- the availability of "real-time" data capture,
- job tracking,
- better quality control,
- better stock control,
- less paperwork,
- fewer incidents of sending incorrect products to the job site, better customer information,
- web-enabled customer information systems increased health and safety;

In addition to reducing labor and material costs and advancing project schedules, RFID systems have the potential to increase construction productivity, quality, safety, and economy. the management and tracking of specially tagged materials throughout the supply chain and on the construction, site using RFID in the construction sector. The following are instances of RFID uses in materials management:

- Inventory tracking: RFID technology makes it possible to track and inventory unique materials automatically, in real time, and without error at every stage of the supply chain, from manufacturing to installation. A pipe spool, for instance, can be automatically identified when it is delivered and received, which reduces the likelihood of error in present human identification processes. It can also be updated and promptly downloaded electronically into materials management systems without manual data entry.

- Simplified materials tracking and expediting: an RFID-enabled process can deliver material status information sooner than the current manual processes, give field planners trustworthy advance information, and be able to optimize planning on schedule crucial tasks or quickly find available work for crafts that may be temporarily underutilized.

- Accurate material status and inventories: Provide accurate shipping, receiving, and inventory information to prevent missing, misplaced, or delayed products that could disrupt schedules. This circumstance is easily supported, for instance, by utilizing a hand-held reader to validate ownership of items that may have been relocated or placed in the wrong spot within a yard. The prospect of using RFID technology in the construction industry has been the subject of numerous research initiatives over the past few years. These consist of:

    - The use of RFID technology to track material usage planning in a water supply project that has poor material management because of its complicated operational environment;
    - The development of a tool tracking and inventory system that can store operation and maintenance information, as well as the use of RFID for tool tracking on construction sites;
    - creation of an automated model using RFID technology for materials management and control;
    - A model for tracking the percentage of construction projects that are finished through the use of RFID and wireless technology;

    - Using RFID technology to automate the present tracking process would help solve several issues with the current techniques for tracking pipe spools. Tracking the delivery and receipt of manufactured pipe spools in industrial projects;
    - Using RFID to track precast concrete components and their historical data from fabrication to completion;
    - The creation of a prototype system for the spatial tracking and identification of structural steel elements on the job site.

8.2 Common Data Environment (CDE)

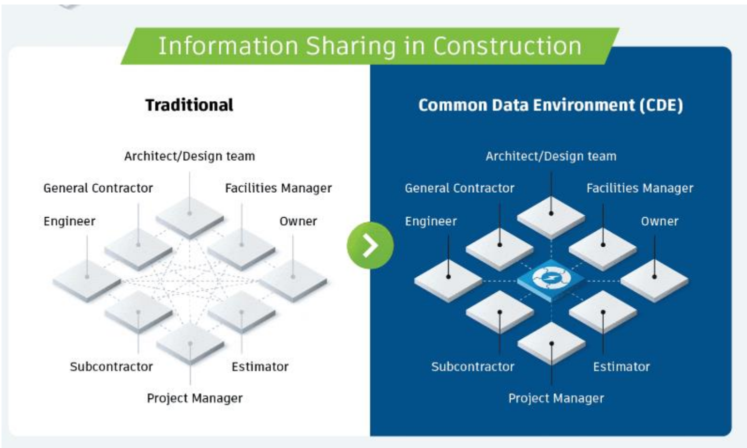
> "The Common Data Environment (CDE), is single source of information used to collect, manage and disseminate documentation, the graphical model and non-graphical data for the whole project team"
>
> - **Designing Buildings Wiki**

The benefits of a CDE in the construction industry are:

i. Reduces the time spent searching, sharing and coordinating information.

ii. Improves build quality with greater accuracy.
iii. Improves collaboration and efficiency with one system.
iv. Creates a single source of truth to improve decision making

The comparison of information sharing in construction in tradthe itional way and with CDE is illustrated in Figure 6.



8.3 3D Printing

3D printing technology has had a revolutionary impact on companies around the world. It enables companies to quickly develop models and prototypes, allowing them to test and optimize new products faster. It also makes it easy and affordable to manufacture parts and components that keep important machines working as intended, such as B. medical ttestsand diagnostic equipment.

Industrial 3D printing is a manufacturing-driven process that produces physical materials and objects from a digital plan or design. It uses large machines into which an engineer inputs floor plans and building designs. Concrete and other building materials are then fed into the machine. An extendable arm or nozzle then applies the mix of build materials in thin layers, controlled by software. The entire building or structure is then produced (or printed) layer by layer according to the engineer's specifications. Although methods vary, many 3D printing techniques require very little additional assembly by workers.

The Benefits of 3D Printing:

- 3D printing ensures building materials are used with accuracy; There is no waste as the printer can manage building materials exactly according to the blueprint.

- Both because there is so little wasted material and because fewer human workers are needed to assemble the structure, 3D printed buildings can be very inexpensive.
- Some builders have been able to build homes for around $4,000, suggesting potential low-cost housing options. Less material waste and shorter construction times also mean that 3D printed buildings have a lower environmental impact than traditionally built buildings.

8.4 Mobile and Real-Time Information

Through the use of cellular and GPS technologies, manufacturers can give their customers access to information about products and services anywhere and anytime. Leading companies have already launched apps that address the specific needs of builders. For example, W.W. Graingers' KeepStock Secure app helps customers replenish product stocks when they are on a construction site and don't have access to a desktop computer. The app allows customers to order items by scanning barcodes on labels and has an automatic reorder feature. Companies have also rolled out apps that allow customers to track orders and deliveries using GPS-based updates.

The deployment of cellular and GPS technologies will be particularly important in emerging markets, where mobile devices are the primary way businesses and consumers access the Internet. PPC, a leading supplier of cement in southern Africa, has launched an app that offers a product catalog, a store locator, a tool to determine the quantity and cost of products needed, and promotion updates.

Examples from other industries point to the disruptive potential of mobile technologies. Consider how Uber has disrupted the New York City cab industry. Uber is estimated to have taken about 2 million trips from traditional medallion cabs in the city's CBD in the last two years. And the total number of journeys made with the medallion taxis fell by 10 percent in the first half of 2015 compared to the same period last year. Not surprisingly, the value of a taxi medal license has plummeted, from $1.3 million in 2013 to less than $900,000 in 2015.

8.5 BIM in the Cloud

The Building Information Modeling (BIM) platform enables architects and contractors to create digital representations of the physical aspects of construction projects. These representations facilitate collaboration and decision-making among stakeholders, including project owners, government agencies, and subcontractors. Cloud-based BIM enables real-time access to these models by organizations anywhere in the world and from various devices, including mobile devices. By facilitating real-time interactions between multiple parties, using BIM in the cloud speeds up the planning and execution of project work and helps ensure the right materials are sourced. Adoption is expected to increase as these platforms become easier to use. BIM has already become the standard for some government projects in Denmark, Finland, Norway, South Korea, and the UK, with strong growth in healthcare, infrastructure,e and large sports arena projects. For building material manufacturers, the adoption of BIM increases sales opportunities as the use of cloud-based platforms makes it even easier for customers to order products directly from them.

8.6 Concrete Management System

This application is designed to plan, monitor and control pouring operations and related activities on site. The application uses live feeds from RF, GPS systems from the mixing plants, transit mixers, and boom placers to provide accurate and real-time data needed to monitor project progress. Figure 10 shows the real-time dashboard of the concrete management system portal. Through this data, the efficiency of concrete dosing, transport,t and concreting is available on an hourly basis.

Source: Kalirajan Sivagnana & Mohan Babu (2019)

Figure 10: Dashboard of Concrete Management

8.7 QR Code

With the increasing volume and complexity of jobs in the infrastructure industry, we see a critical need for e-management of fabricated steel assets as these assets play an important role in enabling any construction project. This application uses QR code technology integrated with a mobile application and web portal to track the usage and movement of manufactured support structures across project sites. This breaks through the conventional, manual way of inventory management processes and brings transparency to the material availability at all locations with one click. This revolutionizes decision-making for competitive bidding, improves site planning, and improves reusability, reducing the likelihood of rebuilds. Figure 11 illustrates the tracking of structural assets initiated at various locations.

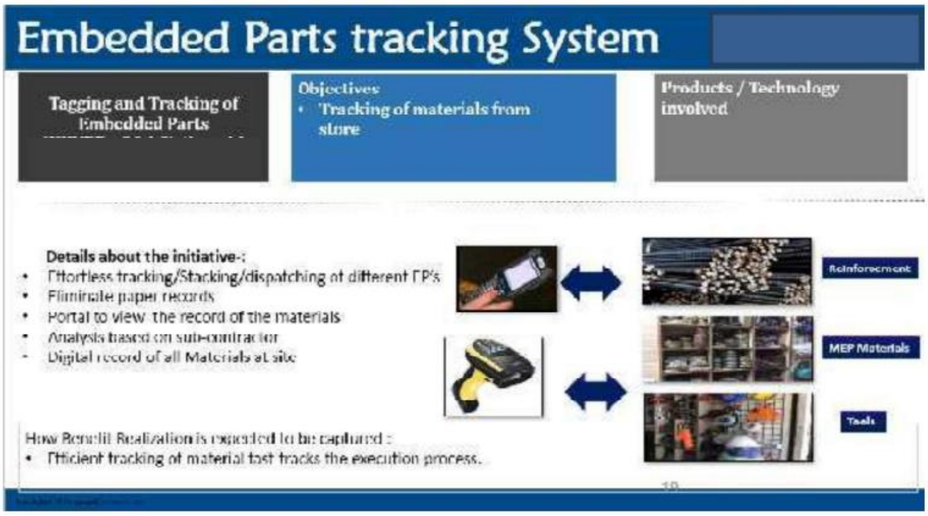


Figure 11: Embedded parts tracking initiated in project sites

8.8 Internet of Things (IoT)

To monitor plant and machinery assets, an IoT, Big Data Analytic Hub was developed that can analyze every connected P&M item and employee at a site to provide nearly hourly insights into asset utilization and productivity. This provides insight into how the motor graders or pavers are being used over a 24-hour cycle, how much of their movement is productive and otherwise what the top performing machines are and how two machines in the same category compare. Such information allows us to take timely constructive actions that will help us save significant operating costs. Transportation Infrastructure also implemented an analytics engine that processes an impressive 3.2GB of data per day to identify patterns and generate actionable intelligence.

Through a progress tracking application, the site manager can plan and track daily progress at remote sites with just a few taps on his mobile screen. A supply chain solution was also deployed to track different types of materials (aggregates, formwork, tools, and equipment, etc.) at sites and avoid potential waste. These solutions are often embedded in voice bots to make them more convenient for users. There is an AI-powered chatbot that gives road engineers on-site quick answers to their questions about Indian Road Congress policies and regulations. Figure 12 shows vehicle tracking implemented at project sites.

In addition to the possibilities of the Internet of Things, digitization could enable construction companies to collect data. Then, advanced analytics can help improve efficiency, schedules, and risk management.

Figure 12: Vehicle Tracking and Productivity monitoring

Project sites generate vast amounts of data, but little of it is captured, let alone measured and processed. The sensors of the Internet of Things and wireless technologies that make it possible to make devices and assets intelligent by connecting them could change that. On a construction site, the Internet of Things would allow construction machinery, equipment, materials, structures and even, formwork to reach a central IT platform to capture critical performance parameters. Sensors, near-field communication devices, and other technologies can help monitor productivity and reliability. Potential applications include device monitoring and repair, inventory management, quality assessment, energy efficiency, and security.

8.9 Robotics

Construction projects are inherently unstructured and often unpredictable; They can also be placed in difficult terrain and environments. For these reasons, the use of robots has so far been limited. However, robots are now being used selectively for repetitive and predictable activities such as tiling, masonry work, welding and coil making, demolition, and concrete recycling. Robot welding is performed for the manufacture of precise equipment, repetitive/continuous work and work with ergonomic challenges.

Summary of Digital Roadmap

Summary of Digital Roadmap based on the stage, type of digitalization, and period of implementation is summarized in Table 3.

Table 3: Summary of Digital Roadmap

STAGE	TYPES OF DIGITALISATION		ROADMAP PERIOD (CURRENT - BEYOND 2023)			
			UP TO 2023	2023-2026	2026-2030	BEYOND 2030
1	BASIC	PDF, 3D-CAD Submission				
2	ADVANCED	Cloud-based software, data analytics, BIM, DfMA, ERT, IoT, Blockchain, 3D Printing, robotics, CDE, BIM portal				
3	SMART	ERP system, LiDAR scanning, AR, VR, MR, Intelligent BIM, Collaborative robotics, advanced blockchain, smart contracts-based system				
4	TRANSFORMATIVE	Automated scan to BIM, digital twins, extensive use of robotics and automation, AI integrated tools				

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DIGITAL SKILLS NEEDED

In shaping the direction and future of the construction sector, sector stakeholders along the value chain need to be proactive and ready to face future challenges and problems. This includes strengthening existing workforces through upskilling and reskilling, and attracting new talent to take advantage of the latest business mechanisms. Industry players must be aware of the current scenario influenced by this high-tech world that requires different skills than today. Therefore, the reskilling and upskilling process needs to be implemented immediately to prepare for the future of work.

Meanwhile, automation has started to replace traditional building methods, forcing the Malaysian workforce to move towards engineered and internet-based work systems. According to a 2019 Department of Human Resources survey report, 63% of respondents believe that automation will replace their jobs in the next 5-10 years. Meanwhile, a study by Randstad Workmonitor in the second quarter of 2019 found that 89% of employers need to invest in digital skills development.

In this perspective, the government's current priority is to strengthen human capital through reskilling and upskilling to fill the talent gap and meet the growing need for a skilled workforce, especially in the construction sector, where the demand for technology and innovation is high. This is a paradigm shift in the Construction Sector that pays special attention to adapting to innovations of technological applications aligned to the nine (9) pillars of IR 4.0 by MoW (Figure 13).

Figure 13: Pillars of the IR 4.0

2022

GET STARTED

NOW

i. Make digital transformation a C-level priority.

Top management needs to be involved in defining overall digital ambitions and tracking the company's progress towards achieving those goals. The digital program leader should report directly to C-level leaders and meet with them regularly (e.g. every six weeks) to provide updates and discuss developments. Corporate leadership should commit to hiring digital experts and dedicate a portion of corporate budgets specifically to the pursuit of digital innovation. The CEO should approve the digital roadmap that guides the organization's initiatives and regularly communicate about the importance of digital opportunities through tools such as a monthly newsletter and investor presentations. As Clayton M. Christensen noted in The Innovators Dilemma, disruptive change within established business models can only succeed if the CEO is fully committed to it.

ii. Establish an independent digital unit.

To foster the risk-taking and independence of country organizations and business units, manufacturers must establish a center of excellence (COE) to define digital strategy and guide digital transformation. The COE should have own budget and authority to centrally coordinate the digital initiatives pursued at counthe try and business ulevelsevel. The company's top leaders should specifically require all stakeholders in the organization to respect the COE's independence to enable it to fulfill its mandate to advise on digital disruptions, stimulate idea generation and challenge the current way of doing business. Skills in identifying opportunities to collaborate with startups and universities will also be crucial. Some distributors and some light-side producers have established a digital COE, while heavy-side producers have yet to do so. In the industry today, it is more common for companies to adopt a hybrid model that involves weak central coordination of digital initiatives specific to country organizations or business units. In fact, most heavy-side producers have yet to establish centralized coordination of country organizations and business units' digital initiatives.

iii. Become agile to innovate.

Agility is essential for pursuing innovation opportunities. For example, a company may create a separate digital company, or the marketing function or specific business units may partner with startups to pursue their digital goals. The culture must encourage innovation throughout the organization so that it can proactively generate new ideas and respond quickly and effectively to competitive moves. The company should continuously look for innovative opportunities and be open to cooperation with start-ups, universities, and venture capital firms. A start-up called Building Radar, for example, has made it easier for manufacturers to research sales contacts by maintaining a global database of construction projects and the associated contacts. Producers can use the database to identify projects in the markets they serve and then proactively contact the right people at existing or potential customers to discuss sales opportunities. Producers looking outside the four walls of their organization for such innovative players to work with are likely to reap great benefits as the distribution model evolves.

The COE should serve as a central hub for sharing innovative ideas generated across the organization, and the company's top experts should be easily accessible to challenge and prioritize the ideas. The company also needs skills to quickly test ideas using prototypes and gather feedback from all relevant operational units. Several companies have successfully set up a venture capital subsidiary to evaluate an extensive portfolio of digital opportunities.

iv. Implement digital ideas effectively.

To achieve competitive advantages, manufacturers must bring their digital ideas to market effectively. Leading building materials companies have already established practices that can serve as inspiration for other companies looking to up their game in digitally-enabled distribution.

v. Cloud-Based Analytics.

Saint-Gobain, a global building materials manufacturer, ran a pilot program in Denmark to evaluate how cloud-based marketing and analytics resources could be used to tailor promotions to customer needs. These resources have allowed the company to obtain detailed information about the performance of advertising programs and to compare the results with those of similar programs used in the past. The company used the insights to better tailor its offerings to specific customer classifications and expand company-wide knowledge of marketing practices. These efforts have helped online shopping more than double the conversion rate (from 10 percent to 22 percent).

Augmented Reality. To close the gap that often exists between actual products and the photos displayed on screens, leading retailers like Lowes are experimenting with using augmented reality to deliver 3D renderings. The technology enables customers to visualize even complex features of products such as bathroom faucets. The use of augmented reality showrooms promises to increase customer satisfaction and reduce the cost of replacing materials that do not meet customer requirements.

vi. Tracking Technology

Leading heavy-side manufacturers are exploring ways to use tracking technology to gain better insight into when shipments are delivered and respond more quickly to customer demand. Hines, for example, is testing technology that would allow contractors to track their orders in real-time on mobile devices. The tracking system is a single repository for all truck location and product specification information. By reducing the need to respond to customers' requests for information, the program has enabled the company's sales force to spend more time on revenue-generating activities. Cemex uses customer data to forecast the areas where demand is likely to be the highest over a given period. By proactively loading trucks for customers in these areas, the company has reduced its fleet size by 35 percent.

vii. Measure the results.

Tracking the company's progress toward its digital goals is critical to determining ROI and continuously improving initiatives. Best practices include having marketing, sales, and IT stakeholders agree on a holistic set of digital KPIs that tie into broader business goals such as revenue and profit growth. By providing insight into how performance is evolving, these KPIs make it easier to centrally manage and continually refine initiatives that support specific goals, such as B. higher conversion rates. Some distributors have made strides to reach this level of maturity, but heavy and light side players have yet to effectively track the performance of digital initiatives and demonstrate their benefits.

viii. Creating A Digital Roadmap

Taking action to meet these demands requires a clear roadmap that establishes responsibilities, milestones, and timelines for achieving the company's digital strategy goals. Creating a digital roadmap is a multi-step process. The execution plan for tracing the pathways should be set out in a clear roadmap that forms the basis for identifying resource needs (including technology platforms) and building the required external partnerships. The roadmap should also apply the health check results to specify the company's plan to build an organization with world-class digital capabilities. Although building materials manufacturers have been successful in the past by following a conservative strategy that does not follow the latest trends, such an approach could lead to failure shortly. Put simply, sticking to the traditional sales model is no longer an option in the digital economy. Even companies that decide against entering digitally supported direct sales cannot afford to wait and see. Manufacturers must take immediate action to understand the digital trends and opportunities that are reshaping their industry and develop digital strategies and capabilities that will enable them to remain competitive in the rapidly changing marketplace.

ix. Conduct a current adoption

A company should first determine where it stands today. A standardized health check can both assess the maturity of the company's digital capabilities and identify gaps compared to those of the competition. The Company may gather relevant information by surveying and interviewing key stakeholders in marketing, sales, IT, and business intelligence, as well as executives from external partners. The company may find that it needs to improve digital capabilities at every stage of the customer journey, e.g. the ability to identify customer needs at the order stage, set up new features at the checkout step, or make better use of real-time data to help customers manage their inventory. Identify potential digital pathways.

Health check results should be applied to identify potential opportunities or ways to create a digitally enabled customer journey. Opportunities for gaining competitive advantage can be revealed by identifying customer needs, assessing and evaluating internal capabilities, and understanding the best-in-class digital offerings from competitors and, more importantly, companies in other industries. Through surveys, focus groups, and interviews, the organization should gather a fact base that will enable it to evaluate customer segments in terms of their potential value and benefits that could be unlocked through digital pathways. Discussions with external experts can also help to understand which approaches will have the greatest impact on the company.

x. Prioritize and closely evaluate selected pathways.

The company should focus its efforts on a set of prioritized digital paths. Paths should be ranked based on their value creation potential and alignment with other strategic organizational priorities. The organization should conduct an in-depth analysis of the priority paths to determine how they can be applied to design the ideal customer experience. The results of this analysis should enable the organization to select which paths to pursue first, establish a testing approach and timeline, and create a detailed execution plan.

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REFERENCES

Burfeind, A., Rahne, U., Heck, P., & Gross, I. (2015). *Bringing Digital Disruption to Building Materials: Reinventing the Customer Journey*. BCG. https://www.bcg.com/publications/2015/engineered-products-infrastructure-bringing-digital-disruption-building-materials

CIDB. (2003). *Industrialized building systems (IBS) - roadmap 2003-2010*. *72*, 1–24.

Cousins, S. (2018). *How 3D building scanning transforms construction projects*. NAVVIS. https://www.navvis.com/blog/54-how-3d-scanning-is-being-used-to-transform-construction-projects

European Construction Sector Observatory. (2021). Digitalisation in the Construction Sector. In *Europian Construction Sector Observatory* (Issue April). https://ec.europa.eu/docsroom/documents/45547/attachments/1/translations/en/renditions/native

Gassel, F. van. (2005). The development of a concept for a Dutch construction system for high-rise buildings. *22nd International Symposium on Automation and Robotics in Construction, ISARC 2005*, *January 2005*.

Ho, S. Y. (2019). *5 Key Opportunities for Digitalization in Malaysia*. AIBP. https://iotbusiness-platform.com/insights/5-key-opportunities-for-digitalisation-in-malaysia/

Kalirajan Sivagnana, & Mohan Babu. (2019). Digitalization in Construction. *Smart Materials and Techniques for Sustainable Development*, *June*, 16. https://www.researchgate.net/publication/333746431_DIGITALIZATION_IN_CONSTRUCTION

Ocean, J. (2020). *What is BIM in construction management? BIM in construction industry*. Revitzo. https://revizto.com/en/bim-in-construction-management/

Pepin, R. (2018). *Wireless Sensors in Construction*. Construction Canada. https://www.constructioncanada.net/wireless-sensors-in-construction/

Radley, S. (2019). *Digitalisation in construction: The path ahead*. Pbctoday. https://www.pbctoday.co.uk/news/planning-construction-news/digitalisation-in-construction/56536/

Richard, R. B. (2005). Industrialised building systems: Reproduction before automation and robotics. *Automation in Construction*, *14*(4), 442–451. https://doi.org/10.1016/j.autcon.2004.09.009

Smith, C. (2020). *14 new building materials to watch for 2020*. KnowTechie. https://knowtechie.com/14-new-building-materials-to-watch-for-2020/

Sonia. (2022). *Digitalisation in Construction: Why we Need it*. Birmingham Measured Survey. https://birminghammeasuredsurvey.co.uk/why-we-need-digitalisation-in-construction/

Trend Economy. (2020). *Annual International Trade Statistics by Country (HS02)*. Trend Economy. https://trendeconomy.com/data/h2/Malaysia/2523