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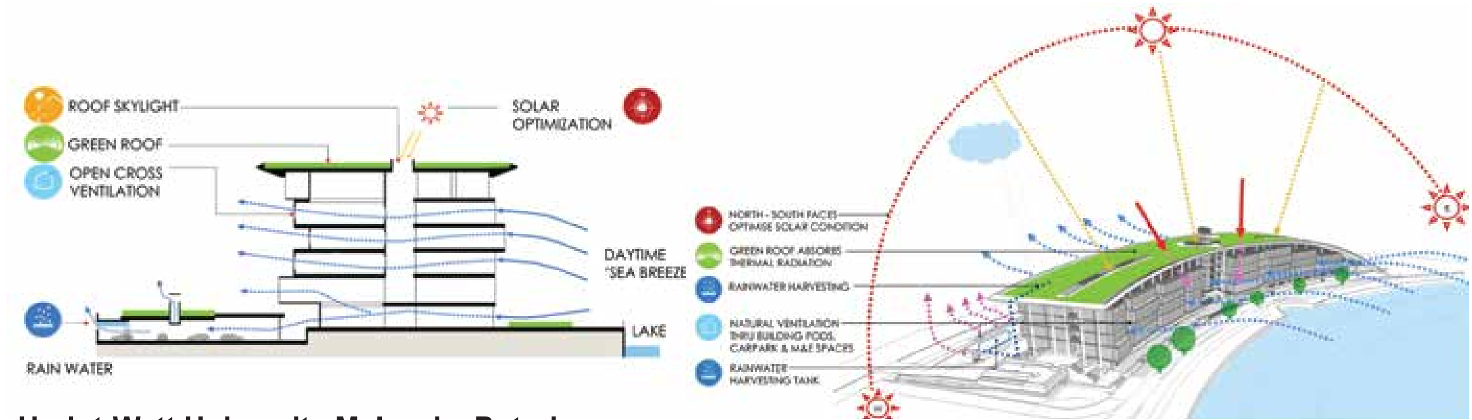

Heriot-Watt University Malaysia, Putrajaya

Innovation & Sustainability In An Urban Engineering Ecosystem

The Construction Sector

Sydney Metro, Australia

DECEMBER 2020 THE MONTHLY BULLETIN OF THE INSTITUTION OF ENGINEERS, MALAYSIA

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ERRATA

The Front Cover design of *JURUTERA*, November 2020, themed "Advancement of Malaysia's Petrochemicals Industry" should read "Advancement of Malaysia's Petrochemical Industry"

The error is regretted.

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COVER NOTE

INNOVATION & SUSTAINABILITY IN AN URBAN ENGINEERING ECOSYSTEM THE CONSTRUCTION SECTOR

by Ir. Phillip TP Wong
Chairman, Urban Engineering Development Special Interest Group (UEDSIG)

The Innovation and Sustainability's motto adopted by UEDSIG is a self-imposed initiative. The basis in adoption is to enlighten the roles of innovation and sustainability prevalent within the ambit of United Nations' Sustainable Development Goals (SDGs). The SDGs are pursuant to United Nations' member states resolution to adopt seventeen (17) global goals for sustainable development in 2015, an agreed noble aspiration to be achieved by the year 2030, as part of a United Nations' Resolution of the 2030 Agenda.

As for Malaysia, sustainable innovations have been at full throttle under the stewardship of YAB Tun Dr. Mahathir Mohamad. Nevertheless, sustainable development has been Malaysia's priority since the 1970s. The emphases have been to include in the eradication of poverty, improving citizens' well-being, provision of an ease of access to education and care for the environment.

The prevailing global challenges in climate change, population increase, concomitant urbanisation, dwelling shortages, new demands for progressive working environments as well as to include environmental, occupational safety and health have resulted in new demands by the global community.

The above state of affairs represents risks if they are suppressed or ignored. However, on the contrary, enormous opportunities can be attained if establishments embrace innovation and sustainability. A point in consideration is the prevailing sustainable innovations in the construction sector, among others, solutions are developed by means of digital applications incorporating more transparent, efficient and intelligent information dissemination for prompt and correct decision-making.

It is therefore evident that both innovation and sustainability are paramount for companies and respective entities (eg: government, non-government organisations, associations, etc) to remain agile in gratifying profits/outcomes and not become obsolete by lacking in them. ■

EDITOR'S NOTE

OVERCOMING THE CHALLENGES OF 2020

by Ir. Dr Bhuvendhraa Rudrusamy
Principle Bulletin Editor

Finally, we are in the month of December, the end of 2020 and it's time for me to review the bucket list of the year past. Although some of the items on the list have yet to be accomplished, I am glad that I have endeavoured and achieved my personal goals despite the challenges of the COVID-19 pandemic. I shall now start to prepare my next bucket list.

Likewise, I am thrilled that the Editorial Board has successfully published 12 issues of *JURUTERA* for 2020 despite the dynamics in its production. I will also advance kudos to the champions of *JURUTERA* 2021 issues. The Editorial Board is committed to keeping *JURUTERA* at the highest publication standard so that our enthusiastic bulletin readers can just sit back and enjoy the magazine.

I'd like to end the year with a classic, yet meaningful quote: "May your heart and home be filled with all the joys the season brings". The Editorial Board wishes everyone a Merry Christmas and a Happy New Year 2021. ■

An Innovation & Sustainability Discourse with An Industry Leader

The Sustainable Development Goals set by the United Nations are a blueprint to achieve a better and more sustainable future for all. These Goals seek to resolve the global challenges we face, including those related to poverty, inequality, climate change and environmental degradation. The 17 Goals are all interconnected, covering a broad range of topics including the future viability of businesses.

The Doka Group (Doka) is an organisation with more than 150 years of tradition and experience. In being an esteemed organisation, it attaches great importance to ensure innovations and sustainability in its products and solutions for society, the environment and people.

(1) INNOVATION & SUSTAINABILITY IN CONSTRUCTION

Doka in Malaysia (Doka Malaysia) Managing Director Craig Cerff, enlightens that as an organisation with its core activities within the construction sector, the company strives to produce high quality products with long product lifecycles to ensure their sustainability. Its organisation focuses on sustainable innovations through the facilitation of innovative products and services in order to maintain itself in the forefront whilst operating on a sound basis.

In addition, he says that the utilisation of high quality durable products, such as plastic coated plywood, is able to increase the lifespan of the products immensely while reducing timber requirements, as well as cut down on waste disposal often associated with 'conventional' temporary works systems.

"In ensuring high utilisation and reuse of temporary works, we are able to recycle our products across many projects, thus in effect able to reduce the demand for environmental raw materials," says Cerff.

"The focus is always to have as little footprint on the environment as possible," he adds. "To fulfil this goal, we employ stringent engineering techniques and value added systems such as Building Information Modelling (BIM) to ensure optimum temporary works design is provided."

Craig Cerff, Managing Director of Doka Malaysia speaks about how his organisation pegs itself as a leader in innovation and sustainability in its industry's various areas of specialisation.

Left to Right:
Mr. Craig Cerff (Managing Director of Doka Malaysia)
Ir. Phillip Wong (Chairman, Urban Engineering Development Special Interest Group) and
Ir. Prof. Dr Leong Wai Yie (Chairman, Standing Committee On Information and Publications)

Cerff also says that with the amount of material minimised, logistics can be drastically reduced by streamlining the amount of lifting, movement and transport required for a specific construction work.

Consequently, the organisation is constantly innovating and has invested substantially in digitalisation and developing virtual reality, site monitoring systems digitalising workflows (Contakt), mobile alignment monitoring system (Xact) and real-time mobile concrete strength monitoring (Concremote) in order to further enhance and facilitate its innovative products and services via digital technology.

(2) INNOVATION & SUSTAINABILITY WITHIN THE ORGANISATION

According to Cerff, Doka began to formally set out and establish its management systems as early as 1992 incorporating all aspects of corporate governance, resource allocation, product and service provision as well as control and alteration. The Quality, Environment and Social aspects, inclusive in the provision of workplace's safety and health and products' safety, are integral to effect innovation and sustainability within the organisation itself.

At the onset, goal-setting and planning process commence at top management level all the way down to individual employees, incorporating responsible and sustainable practices which are carefully monitored and further reinforced by a graduated reporting system. Comprehensive metrics regarding sustainability, environmental protection, quality and safety as well as obstructive findings are an integral part of his organisation's review.

"In addition, the incorporation of knowledge pertaining to current state of market demand, the organisation effects continuous monitoring of the global market inclusive of the technology environment," he adds.

Cerff says that the organisation also carries out pioneering research and development work in cooperation with universities, technical universities, and research institutes on open innovation processes. This exchange is sustainable in several ways, mainly because it can support institutions of higher learning and hence young talents.

(3) TOWARDS INNOVATION & SUSTAINABILITY IN AN URBAN ENGINEERING ECOSYSTEM

(I) Innovation

With regards to **innovation**, Cerff says that their organisation contributes meaningfully towards an improved urban engineering ecosystem through four salient features as listed below:

(i) Software and Sensors for Construction Processes

He says that to ensure the most productive takt (product assembly duration that is needed to match the demand) planning, team allocation and materials disposition during planning and construction, as well as in the derivation of optimum solutions for construction sites (that can be made available to everyone in the company during the construction) on similar projects, his organisation makes use of a sensor-supported software solution called Contakt, that provides direct support during execution on the construction site.

"With Contakt, foremen and site managers could plan, allocate and compare personnel at the takt level, and draw valuable conclusions from them. It sources for actual data to be recorded by means of sensors attached to the formworks and construction workers. With this, the teams benefit from automatic progress reports and early detection of deviations, among other things," Cerff explains.

(ii) Real-time Monitoring for Construction Progress

Real-time monitoring for construction progress is facilitated by means of an unique digital measurement and decision system, which determines the concrete strength on site in real-time via several new features

Burj Khalifa in Dubai

in software and hardware. "This innovative service (Concremote) is already an indispensable partner on numerous construction sites for the organisation," says Cerff.

Among the highlights adopted alongside with the Concremote app are FORECAST and SCENARIO. "FORECAST predicts the strength development of concrete, which supports short-term planning of personnel, equipment and upcoming work steps. In respect to SCENARIO, different concrete mixtures can be compared enabling the more accurate purchase of concrete mixture(s), preventing any shortcomings or wastage," as he deliberates further.

(iii) Automated Formwork Planning

In addition to the solutions for the construction site described so far, Cerff says that digitisation of planning adopting Building Information Modelling also plays an important role at the organisation. "Customers can benefit from up-to-date building information that are available at any time and simulations that can be run to measure construction progress, cost and safety. The collaborative methodology for this automated exchange of data and information across the trades is now regarded as the standard of the future," says Cerff. Significant time savings and greater planning reliability are the main advantages of the said methodology.

(iv) Integrated Digital Formwork Planning

Considerable added value in the continuous 3D planning for construction companies also come in the form of 3D visualisations on a larger scale, as well as 4D simulations, explains Cerff. "This will enable companies to monitor the flow of formwork material inclusive utilisation of formwork for time-critical operations such as during the implementation part. In addition, the 3D planning data can be used directly for the construction site with the Augmented Reality-Virtual Reality (AR-VR) app," he adds.

(II) Sustainability

"As part of its holistic approach to **sustainability**, the organisation addresses the issue of environmental compatibility and resource efficiency thoroughly and systematically right from the start," says Cerff. In particular, the following issues are given in-depth consideration: durability, ease of cleaning, optimised product transport volume, eco-friendly (multi-trip) packaging, re-utilisation, recycling and final disposal after the end of the products' service life, compliance with environmental legislation, degree of danger from substances used in production, resource-conserving materials usage, environmental-friendly procurement and resource-conserving manufacturing process.

"When developing products, great emphasis is placed early in the innovation process, in choosing resource-conserving raw materials, ecological and economical manufacturing processes and on achieving a long lifecycle. At the same time, it is vital to steer away from problem substances and residual materials left over at the end of the production process (in avoiding wastes and scraps, etc.)," he says.

Cerff additionally says that sustainability has many dimensions, which includes:

(i) Products' Quality

"High products' quality and maximum protection against materials' wear means long lifespan and safety," says Cerff. He adds that beyond that, each new product generation must be compatible with the one already in existence. This compatibility is a criterion for a long-product life cycle, making sure an extended product cycle is resource-sparing in every way and contributes positively towards efficiency.

(ii) Business Models

Renting instead of buying is a sustainable model to save resources such as energy and raw materials.

"In addition, pre-assembly service is available for customers to realise time and costs savings, such as in assembly efforts and pertaining to complex work processes. Here formwork units are tailor-made for the long-term by combining existing systems with customised solutions," he explains.

"Also, with reconditioning service it extends the lifespan, provides safety and saves time and money by delivering perfectly functioning materials," says Cerff.

(iii) Logistics

Logistics is an important factor for ideal construction site implementation. Effective logistics ensures high availability as well as flexibility and fast delivery to construction sites. Furthermore, short delivery paths can reduce CO_2 emissions in the long term," explains Cerff.

(iv) Training and Professional Development

Cerff says that well trained employees are not only smart, but they are also highly motivated and solution-oriented workers. "This is important as construction projects are becoming more complex and efficiency driven," he says, adding that this is the reason the organisation makes significant investments in ongoing employee training. It therefore benefits from above-average loyalty to the company in the long run.

(v) Construction Site Safety

Cerff says that user safety is another top priority towards sustainability in its global organisation. An initiative in the establishment of Doka Safety is aimed at developing heightened awareness of safety-related issues as part of comprehensive safety training sessions at customer sites.

"After all, safety motivates construction site workers to perform at maximum levels and reduces risks," he says.

(4) TECHNOLOGICAL SOLUTION INCORPORATED IN PROJECTS

Efficient formwork systems, which require correct and reliable formwork planning and optimal cycle planning, have significant outcome(s) on the success of a shell construction project, says Cerff. "The BIM software can be used to simulate situations and determine the optimal construction sequence before the project even begins," he says. He adds that the BIM model for the shell can provide a detailed representation of the formwork. "In this aspect, Doka's global BIM competence centre is able to effect works in planning, visualisation and simulation," says Cerff.

PNB 118 Building

PNB 118 and Its Surrounding Development

"The organisation also works closely with Autodesk to create BIM-compatible building models," says Cerff, adding that their in-house software, DokaCAD for Revit, provides productive formwork planning and comprehensive designs to clients in BIM.

Among other things, this formwork planning software enables rapid 3D formwork planning for all project types, increases productivity using positioning guides and supports BIM collaboration. It also provides access to more than 40,000 tried and tested model solutions enabling fast and efficient planning.

"Using formwork automation saves time compared to manually positioning components. This provides technically correct solutions every time and can be used to establish cycles that optimise safety, time and costs," says Cerff.

(5) CREATING ADDED VALUE WITH BIM

According to Cerff, in BIM methodology, the entire building is digitally modelled from beginning to end before construction starts. "Errors and problems are spotted in the digital twin and eliminated before they can disrupt progress on the construction site. Also, the project rigorously follows the principle of building the structure virtually first and afterwards in reality," he adds.

He said that 3D visualisation can also be enhanced with 4D simulation when time is added as the fourth dimension. "Not only the structure is simulated but also the entire sequence of events along the timeline, including start and finish dates and the timing of the individual phases of the building are incorporated. The contractor can look at the stage of construction reached by any given milestone and monitor how progress on a structure stays in synchronisation with the original schedule. The information is unified and transparent, everyone involved is always on the same page," says Cerff.

As an added value, Cerff says that a remote instructor can be appointed to facilitate efficient two-way exchange between customers and its experts, who can operate hands-free via a head-mounted tablet adopting Augmented Reality – Virtual Reality (AR-VR) technology.

(6) BIM & VIRTUAL DESIGN AND CONSTRUCTION (VDC) TOOLS

As mentioned by Cerff, all project information, from planning through construction to the completion and maintenance of a structure, can be coordinated with BIM. "The digital data for the entire life cycle are administered at a single central location," he says, adding that the approach is holistic, supporting efficient interaction and an automated, transparent exchange of data involving all the partners in constructing a building – eg: architects, contractors, planners, formwork specialists and others. "Anywhere, at any time, stakeholders can access the latest data and coordinate the project much more smoothly than it is possible in the ordinary construction process," Cerff adds.

As such, he says that BIM has become an increasingly important tool in the construction industry, providing high-performing design and 3D formwork visualisation at early stages of projects. "Optimising construction processes, boosting productivity on site and effecting respective design solutions become so much easier with automation that Doka engineers would not wish to return to the pre-BIM days," he exclaims.

"The key factors in adopting BIM are to deliver highly achievable solutions involving complex structures, the requirement for fast and accurate solutions inclusive of time and effort optimisation, that enables to foresee conflicts before they happen and make perfect presentations," adds Cerff.

In addition, in the provision of right solutions to clients, it would require a great extent of detailing and drawings to be delivered to the construction site. With BIM, the time taken to produce the drawings is decreased dramatically, at times, to the extent in being a one-click job. Any revision is also easier since all the drawings are linked together - a modification in one drawing automatically updates all the views, elevations and assemblies of the affected formwork immediately.

(7) SAFETY, HEALTH AND WELFARE FIRST

"When we talk about sustainability, it also includes safety," says Cerff. "In incorporating safety and health aspects in our products, we included the development of ever-better work and protection platforms simply because any accident that happens on site consumes so much of our resources."

Therefore, quality and safety are a key focus throughout the entire lifespan of our products and services. A great emphasis is also placed on ergonomic design, to make the products safe and convenient to work with.

He says that right from the first product's performance specification, ergonomic design and safety are incorporated as vital requirements that must be fulfilled when products are identified for development, manufactured, transported, stored and reconditioned.

"During the development phase,

The Exchange 106

a product is regularly evaluated as an integral part of the innovation process to ensure it meets the safety and health requirements, proactively eliminating safety and health risks," says Cerff.

In line with regulatory requirements, the respective standards and rules are referred and taken into consideration, eg: in regard to dimensions, functions, weight and ergonomic design. Significant efforts are made to obtain approvals and certifications, etc both at the national and international level, according to Cerff.

"Customers and other interested parties are well informed on respective products and how to use them correctly. All necessary documentations such as 'User Information' booklets and 'Operating Instruction' manuals are facilitated to customers. In addition, special training courses and comprehensive advisory and planning services, such as professional on-site support by experienced In-house Formwork Instructors, all in all, in order to ensure everyday safe work practices utilising our products on site," explains Cerff.

(8) FACTORS IN THE DEVELOPMENT OF SUSTAINABLE PRODUCTS AND SOLUTIONS

Cerff says that several factors determine the sustainability of his organisation's products and solutions in order to ensure high quality, long life and safety of products. They are as follows:

(i) Quality

"The focus on quality includes in the provision of appropriate resources in good time; innovative and customer-oriented understanding of products and services as well as effective and efficient supervision coupled with continuous improvement," says Cerff. Integrated into this process are the topics of quality and environment as well as guidelines regarding work safety, health and sustainable behaviour.

(ii) Durability

The durability of products is dependent on the quality of the materials used and the care with which they have been manufactured. But not only that, the most hard-wearing of products will be of no use if it is not compatible with the next product generation or with products from the same family of products. "Products which can be passed down from generation to generation because it is always designed to match and are compatible with the other pieces and compatibility in the form of a modular system represents the basic requirement for an optimised product cycle," says Cerff.

(iii) Concrete

"Concrete is a strong alkaline material. The product surface which encounters concrete must therefore demonstrate sufficient alkaline resistance. So must girders, pillars and elements which come into contact with fresh concrete," says Cerff. In addition, he explains that concrete also bonds readily, so for cleaning purposes, both metal scrapers and blades and high-pressure cleaners can be used. "In addition, only an appropriate protective layer in the form of a resistant coating on respective products will guarantee durability without sacrificing the quality demanded by the clients and architects," he adds.

(iv) Wood

"Wood is a natural material and it behaves like one too. When it encounters moisture, for example, it changes its form – it warps. This, however, is not acceptable when building with concrete," says Cerff. He adds that crosswise multiple gluing and the removal of faults followed by the gluing of finger joints make a natural raw material more robust for long-term use. To counteract the natural wear and tear of the wood at the ends and along the edges, these are strengthened with plastic caps which significantly increase the durability.

(v) Steel

Cerff says that steel as a material diverts major forces and is thus an essential component for system formwork construction, but it needs to be protected. "Hot-dip galvanising, powder coating and electroplating extend the useful life of the products," he says.

(vi) Safety On the Construction Site

According to Cerff, the safety of construction workers at the site is reason enough to incorporate the safety's element under sustainability. "Moreover, inadequate safety leads to longer construction times and could thus become a real efficiency problem resulting in higher cost(s). This is particularly so, if insufficient attention is paid to it," he says.

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Through the development of numerous safe products, the Doka Group actively works to counter prevailing and any anticipated safety issues. Craig says that in order to increase safety awareness, numerous safety training sessions are held in the corporate headquarters, at the premises of the construction company as well as directly at the building site.

(9) DOKA'S SALIENT PROJECTS INCORPORATING SUSTAINABLE INNOVATIVE PRODUCTS

"Internationally, Doka's achievements include facilitating its formwork solution in the construction of the world's tallest building being the 830 metre-high Burj Khalifa in Dubai," adds Cerff. The 160-storey building is an inspiration from an Arabian desert flower.

"On the other side of the globe, Doka is involved in the supply of its innovative products and services to Lotte World Tower in South Korea. Standing at 555 metres, the multi-purpose high-rise has a diagrid lantern-shaped roof structure and is currently the tallest building in South Korea," says Cerff.

Moving forward, Cerff says that the outlook for the construction industry in Kuala Lumpur and all around the country is incredible. "Malaysia is not afraid to think with ambition in the construction of high-rise buildings and elevated highways in which it is a fantastic example of what can be done in a progressive country," he says.

Cerff says that Doka as one of the movers in high-rise construction technology, its achievements include the PNB 118 building – a diamond-shaped skyscraper that symbolises the diversity of the Malaysian people. "At 644 metres, PNB 118 will be the tallest building in Malaysia and Southeast Asia when fully completed in 2024," explains Cerff.

Besides PNB 118, he says that Doka also involves in projects to include The Exchange 106, Landlease @ TRX, UOB Tower 2, The Park 2 Pavilion Bukit Jalil, Petronas Tower 3, Eaton Residences, several MRT Line 2 stations and the Setiawangsa-Pantai Expressway (SPE). ■

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Doka in Malaysia is a 100% subsidiary of the Doka Group. Doka Group is a world leader in the development, manufacturing and distribution of formwork technology for use in all fields of the construction sector. The organisation is part of the more than 150 years Umdasch Group AG based in Amstetten, Austria. The consolidated revenues of the Umdasch Group AG amounted to 1.517 billion euros in 2019.

Doka Malaysia's Managing Director

Biodata of Craig Cerff

Craig Cerff holds a bachelor's degree as well as a master's degree in Wood Science from the University of Stellenbosch, South Africa. In addition, he obtained an MBA from the Edinburgh Business School in 2000. In 2018, he joined Doka East Asia & Pacific as Head of Sales. Six months later he took over the Managing Director position at Doka Malaysia. During his previous role, Craig was responsible for sales across nine local branches and four overseas branches (Namibia, Mozambique, Tanzania and Nigeria).

Discourse Convener

Biodata of Ir. Phillip Wong

Ir. Phillip Wong is involved in advisory engagements which include various aspects of land and infrastructural development, sustainable innovative project proponents' initiatives, review and evaluation, project management, project restructuring and rehabilitation. His other engagements included the National Asset Management Company's (Danaharta) Special Administration assignments pertaining to major distressed companies. In addition, among others, he managed a team in respect to the financial and project monitoring of several companies within a major industrial and property conglomerate. He was also involved in corporate recovery and insolvency assignments.

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Inside Front Cover (IFC)	7,250	6,650	6,350	6,050	5,750
Inside Back Cover (IBC)	6,750	6,250	5,950	5,650	5,350
Page 1	6,650	6,150	5,850	5,550	5,250
Facing Inside Back Cover (FIBC)	6,150	5,850	5,550	5,250	4,950
Facing Cover Note (FCN)	5,850	5,300	5,100	4,900	4,700
Facing Contents Page (FCP)	5,700	5,150	4,950	4,750	4,550
Centre Spread	11,200	9,500	9,000	8,500	8,000
ROP Full Page	4,900	4,500	4,300	4,100	3,900
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FEATURE

CONSTRUCTION 4.0: VIRTUAL DESIGN & CONSTRUCTION

by Ir. Jagjeet S. Sidhu

Since the start of Industry 4.0 (4IR) in 2013, the development of innovative technology, computer coding with visual modelling, cloud computing as well as autonomous and smart devices have grown rapidly. Additionally, the popular use of computing-related terms such as IoT, AI, ML, Big Data Analytics and Blockchain Technology points to an era of evolving smart and virtually connected devices.

Table 1: Acronyms (source: jss.2020)

AEC	Architecture, Engineering & Construction
AI	Artificial Intelligence
AR	Augmented Reality
AUV	Autonomous Underwater Vehicles
BIM	Building Information Modelling
CAD	Computer Aided Design
CAM	Computer Aided Manufacturing
CDE	Common Data Environment
CNC	Computer Numerical Control
DT	Digital Twin
5G	Fifth Generation
4CR	Fourth Construction Revolution
4IR	Fourth Industrial Revolution
IFC	Industry Foundation Classes
IoT	Internet of Things
MEP	Mechanical, Electrical & Plumbing
ML	Machine Learning
MR	Mixed Reality
3D	Three Dimensions (X,Y, Z)
TLS	Terrestrial Laser Scanning
UAS	Unmanned Aerial Systems
UAV	Unmanned Aerial Vehicles
VDC	Virtual Design & Construction
VR	Virtual Reality
XR	Extended Reality

Since 2018, tech giants have strived to develop smart devices using the 5G wireless mobile network technology (≤ 10 Gbits/s), eventually allowing anyone, anywhere and any time, to be virtually connected (Figure 1). Smart technology usage has inevitably penetrated the construction industry, signifying 4CR or Construction 4.0: VDC era, with evolving reliance on CAD/CAM and BIM.

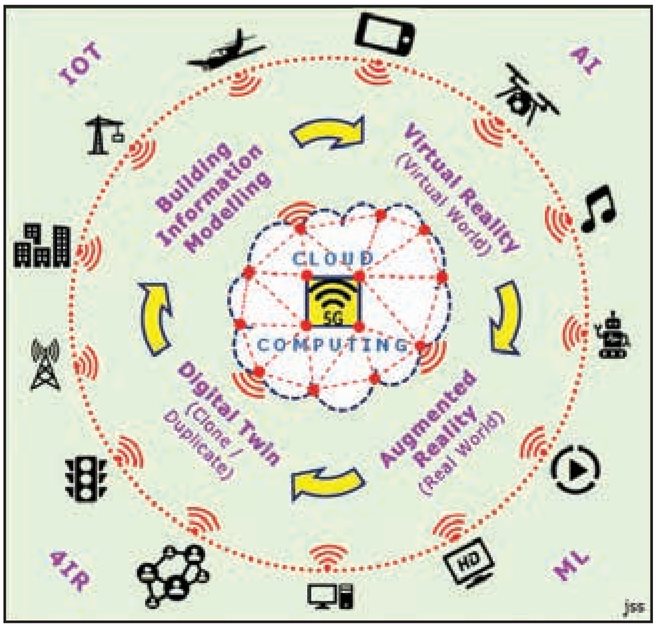

Figure 1: Virtual+Real World IOT (source: jss.2020)

VIRTUAL & REAL BIM MODELS

Tech-reliant BIM (since 1987) is dependent on collaborated CAD/CAM digital data, in a CDE, for project planning, design, modelling, visualisation, estimation, simulation and construction (Figure 2).

Originally, a gaming associated term, VR offers a simulated experience in a virtual-world (artificial/imaginary realm) combined with haptic technology (3D-kinesthetics – visuals, positioning, vibrations, motion, touch, ambience, etc). Correspondingly, AR provides an interactive experience of the real-world (physical/

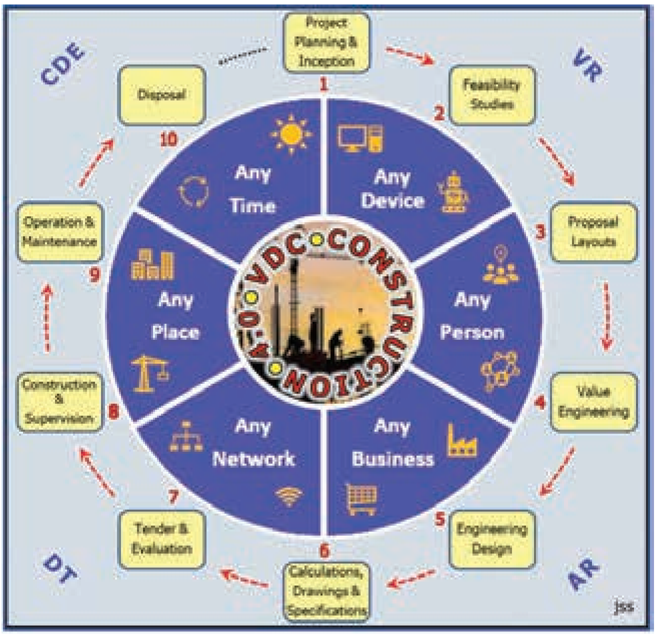

Figure 2: Construction 4.0 - VDC (source: jss.2020)

live realm), via computer generated visuals in design and construction simulation models for infrastructure, building services, energy, utilities, communications, transportation, flood, wind, earthquake, fire, surveillance, etc., which augments greater value. By combining VR and AR models, with interoperable IoT, a DT model is created, acting concurrently (virtual+real), with real-time monitoring and analytics at all times.

Table 2: Key BIM Dimensions @ All Project Stages (source: jss.2020)

No.	Key BIM Dimensions	Reality Modes	Project Stages	Description of BIM Models [Multi-disciplinary CDE, (*.ifc)]
1	2D/3D-BIM	VR (XR)	1-6	Design-Parametric-Models: X, Y & Z parameters in CAD/CAM, calculations, simulations, animations, drawings, specifications & cost estimations.
2	4D-BIM	MR (VR+AR)	7-8	Time-Duration-Models: Resources, planning, scheduling, man-hours, fabrication/ installation monitoring, inspection, etc. (uploaded progressively).
3	5D-BIM	AR (XR)	7-8	Cost-Task-Models: Construction capital, procurement, purchasing, delivery, testing, inspection, fabrication/ installation tasks, equipment, operation, etc.
4	6D-BIM	DT (XR)	9-10	Lifecycle-As-Built-Models: Energy, operation, simulation, maintenance, specifications, replacement, upfront spend-cost decisions.

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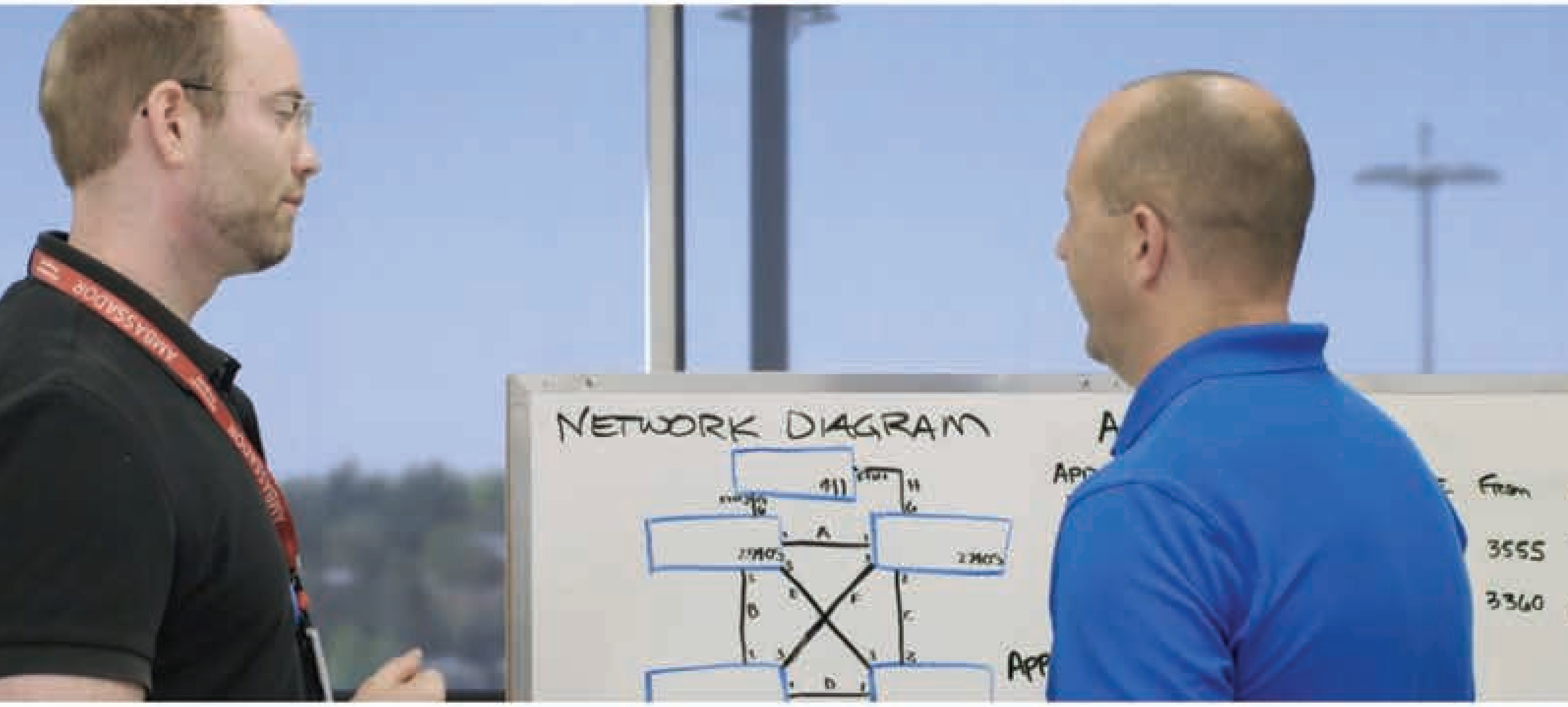

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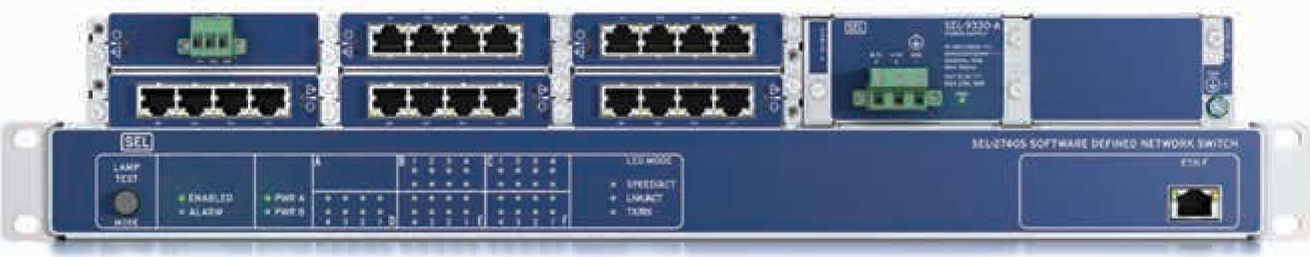

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Participation in any of the BIM realm project stages (Figure 2), commits one to MR (or hybrid-reality [VR+AR]). It requires CDE collaboration which conforms to openBIM (2013) standards (with *.ifc filetype extensions, refer: www.buildingsmart.org), with interoperable software and equipment, within the interlinked key BIM Dimensions (Table 2). XR offers smart interactions within VR, MR, AR and DT environments for real-time cloud based "simulation-learning": Training skills, safety, operators, maintenance, design review, knowledge transfer, commissioning, lifecycles, etc.

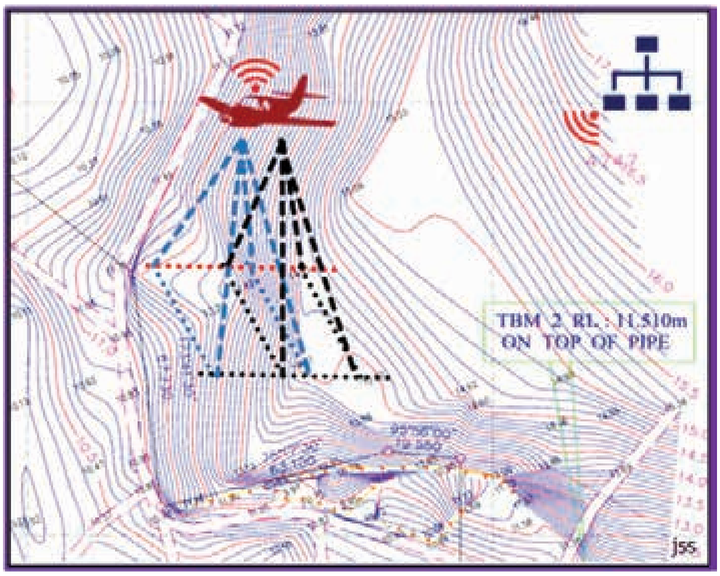

Figure 3: Aero Triangulation (source: jss.2020)

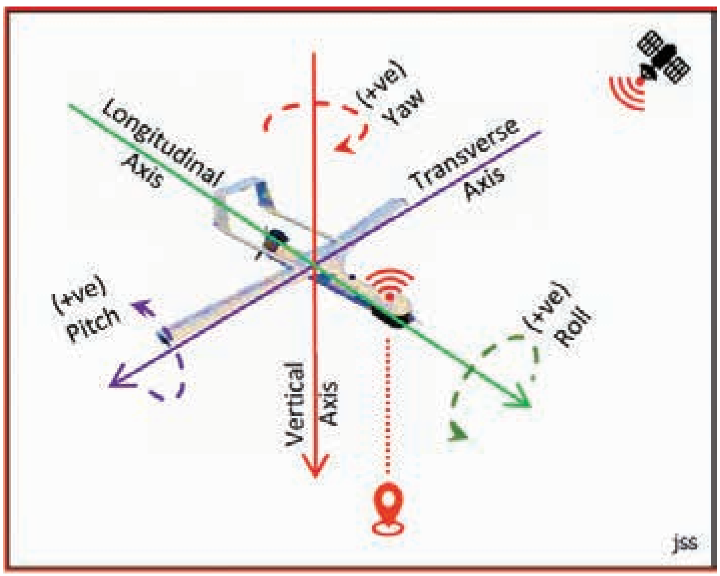

Figure 4: Drone (UAV) (source: jss.2020)

POINT CLOUD DATA

Various disciplines and trades ply all project stages while complying with building codes, standards and safety regulations. Exploring Construction 4.0, step-by-step, as projects begin, topographic or bathymetric survey plans (Figure 3) are initially acquired for preliminary planning and inception. Today, with the widespread use (Figure 4) of UAV, AUV, AI software and smart devices, spatial data harvested from the various smart data systems (Table 3) are quickly, accurately and efficiently synchronised.

Table 3: Key Spatial, Survey, Navigation & Smart Data Systems (source: jss.2020)

No.	Key Spatial, Survey, Navigation & Smart Data Systems	Description
1	**GIS** = Geographic Information System	Big Data Analytics framework (with integrated hardware & software tools) to capture and analyse spatial, geographic and topographic map data (for data management, retrieval, interpolation, manipulation, modelling, visualisation, presentation and decision making in all fields). Real-world usage in environmental, planning, design, construction, transportation, logistics, communications, businesses, management, statistics, etc.
2	**TS** = Total Station	Remote/autonomous recording of field survey raw digital data (combined with GPS), ready for direct data transfer & computer software use: Computerised data collection, electronic distance measuring, electronic angle scanning, digital processing of triangulation, trilateration, traversing, intersection and resection (quick, accurate and reduces manual data recording errors).
3	**Radar** = Radio Detection and Ranging **Lidar** = Light Detection and Ranging (small obj.) **Ladar** = Laser Detection and Ranging (large obj.)	Remote sensing systems with pulsed/radiating electromagnetic waves, lights or lasers to measure range/distance, velocity or angle between sensors and objects in real-time. (Topographic Lidar: Near-infrared laser for land surface) & (Bathymetric Lidar: Water-penetrating green light for sea/river bed surface). UAVs & deep tow multibeam AUVs, robots with AI control systems, used for harvesting 3D data: Mapping, imagery, atmosphere, surveillance, etc.
4	**GNSS** = Global Navigation Satellite System (GPS, Glonass, Galileo, BeiDou, QZSS, IRNSS)	Provides autonomous global geo-spatial positioning (longitude, latitude & altitude) using time signals transmitted from satellites. Used for navigation in (hand-held devices, cars, trucks, aircrafts, ships), surveying, GIS, assets, etc. Often used with GPS augmentation for accuracy. Satellite operators are able to downgrade or block services over any area.
5	**GPS** = Global Positioning System (Navstar-GPS, 1978)	34-Satellite constellation radio navigation system (2020), operated by US Space Force (US Dept. of Defence) which sends real-time exact coordinate location signals to GPS receiver devices which work out X, Y, Z coordinates using trigonometry (30-500cm accuracy, for most civilian GPS receivers).
6	**INS** = Inertial Navigation System	Measures: Rotations ('attitude angles' (yaw, roll & pitch angles)), and Accelerations with respect to the starting point. Consists an Inertial Measurement Unit (IMU) for measuring inertial properties (gyroscopes & accelerometers) and an Advanced Interference Mitigation (AIM) unit for anti-jamming and anti-spoofing. Combined as (GPS+INS) or (GNSS+INS) to provide accurate positioning in engineering, construction, logistics, agriculture, machine control & automation, etc. Operable in environments where visibility of GNSS satellites are obstructed.
7	**Scada** = Supervisory Control and Data Acquisition	Computer controlled systems with AI software for gathering, analysing & monitoring data locally, remotely and in real-time. Used in: water, waste, energy, communication, transportation, infrastructure, construction, industries, etc. Consists of a Programmable Logic Controller (PLC) unit, comprising: CPU, co-processor & I/O module and Proportional Integral Deviating or PID units for recording pressure, temperature, flow, speed, etc.

Similarly, during construction progress monitoring, the use of UAS (Figure 5) helps generate individual 3D-BIM point cloud data (openBIM *.ifc) used in CAD/CAM and modelling software. Together, these point cloud data and camera imagery help generate realistic 3D visuals which can be simultaneously monitored on portable smart devices and computer networks (MR). These digital data systems deliver crucial precisions in computing, design, orientation, visualisation, sensory and human interactions while navigating a VDC environment. Routine tasks are further automated using AI (neural) networks which are designed to solve real-world problems by substituting human intelligence with hardware and software (reverse engineering). In addition, tasks are improved with the use of ML which involves computer software and design that are coded to learn from prior tasks, performances and experiences.

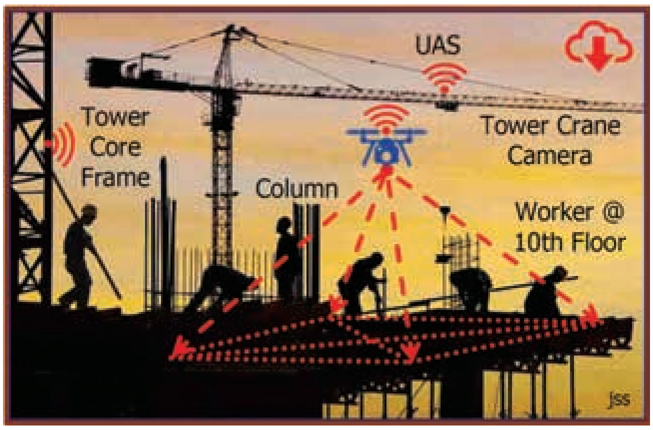

Figure 5: Virtual Remote UAS (source: jss.2020)

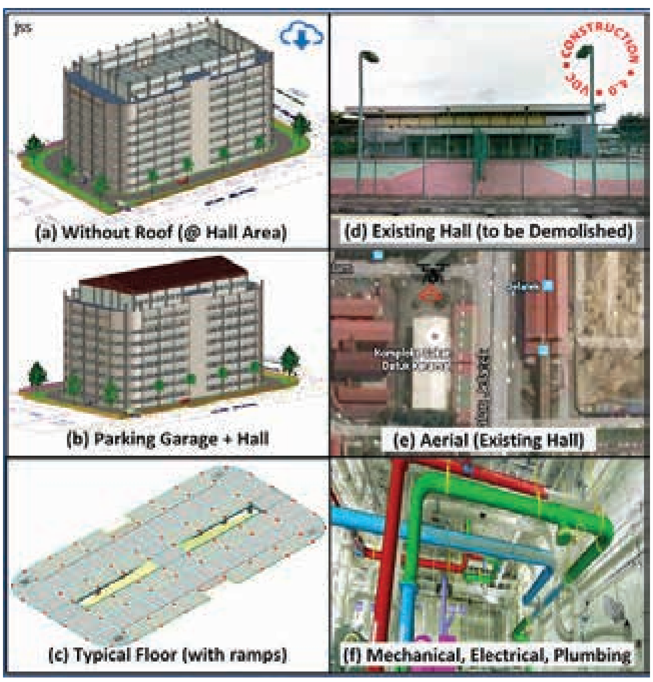

Figure 6: Design Parametric-Models (source: jss.2020)

DESIGN PARAMETRIC-MODELS

Increasingly, AEC firms involved in conceptual planning and design have been adopting software (AI logical algorithms) with variable parameters for the design and optimisation of 3D/4D-BIM layouts (Figure 6). Unlike previously, where separate models had been used for planning, design, structural analysis and detailing, AEC firms now work collaboratively with ONE shared visually-realistic design parametric-model. For example, an architect initially works on a building plan model proposal and defines the overall geometry (position/ sizes: Beams, floors, columns, walls, foundations, etc.), as per architectural design. The engineer then imports the architect's (master) design parametric-model using interoperable structural design software (*.ifc) to predefine structural parametric constraints (dimensions, spacings, deflections, material properties, shrinkage, fixities, loadings, construction sequence, etc.) for preliminary analysis-design optimization. They then collaborate using the design parametric-model during MR sessions to optimise and update the design structurally and architecturally. Complex structural surface geometries, with difficult-to-predict behaviour/deformations, can be accurately and automatically modelled within the structural design parametric-model using mesh-based (2/3/4/6/8/9)-node isoparametric (beam/plate/shell/solid) elements by Finite Element Methods (FEM) or B-splines and Non-Uniform Rational B-splines (NURBS) realistic surfaces by Meshless Methods. For verifications, simplified general models may be used to compare both static and dynamic analyses. Similarly, the design of MEP building services, infrastructure and as-built constructed data are also parametrically (*.ifc) updated in the master model. Eventually, after completion of construction, real-time DT is available for future remote virtual analytics.

ACTIVE COSTING & SCHEDULING

Cost estimation may be complex, however, with active real-time take-off AI software, extraction of collaborated (*.ifc) digital data (CAD, drawings, pdf, images, etc.), significantly reduced computational time, errors and 2D/3D-BIM take-off tasks to merely point, click and define man-hours, material mass/volume, formwork, foundations, beams, floor areas, walls, roofing, tiling, doors, painting areas, insulation, mechanical, electrical, plumbing, etc.

Whenever design changes are made, the corresponding outstanding modifications required are highlighted in coloured layers for all-task action. During construction scheduling, it simplifies subcontractor crew assignments, by highlighting relevant task instructions using MR visuals to be completed sequentially, reducing clashes, rework, high costs, disputes and downtimes. It enables dynamic real-time tracking control (graphs, Gantt charts, etc.) combined with ML (predictive data analytics) for project tracking and cost risks in estimating fluctuating

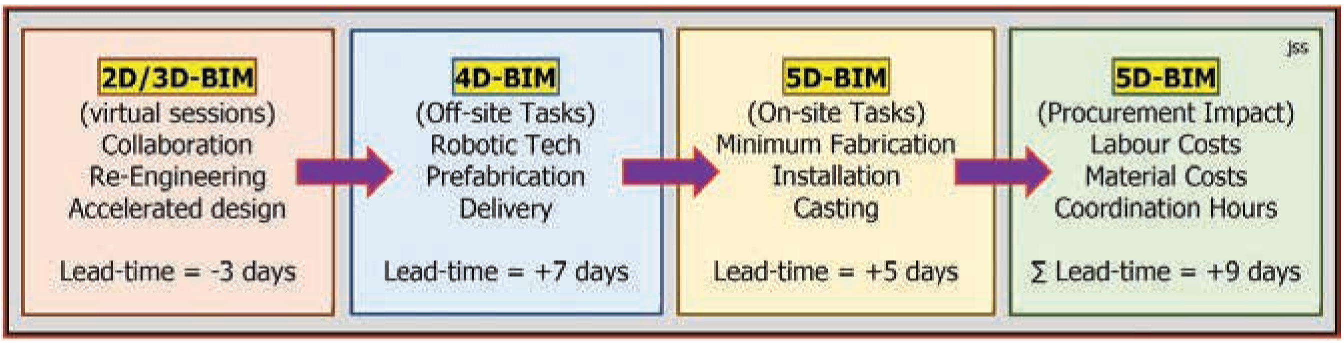

Figure 7: Example Rebar Prefabrication VDC-Workflow (source: jss.2020)

costs and to assign mark-ups. It readily generates work schedules and accurate cost claim reports at unbeatable pricing to win tender bids.

BLOCKCHAIN PROJECT MANAGEMENT

The adoption of Blockchain ConTech (construction-technology) covers start-to-end project management and documentation, with secure big data monitoring analytics while linking all authorised CDE stakeholders in real-time. Blocks of fragmented chronological records (design, specifications, agreements, estimations, key tasks, procurement, purchases, payments, warranties, service cycles, etc.) are securely inter-linked to form a blockchain with a binding audit trail for accountability, with alarm bells. The term data mining (extraction) involves the coding effort required to solve an algorithm (rules/permissions) in order to access/append the previous/next block in the chain. A chain of blocks collectively forms a blockchain ledger or a simple automated book-keeping record which is maintained transparently in secure, encrypted networks and is only accessible to authorised CDE stakeholders. Blockchain records an audit trail for tracking of materials, tasks, testing, inspections, approvals, accounting, etc. and will automatically trigger invoices (with approvals), which link to on-time auto-payments in real-time. In addition, blockchain provides maintenance schedules and asset lifecycle records for future stakeholders.

CONSTRUCTION AUTOMATION

To increase construction lead-times, for example, during typical rebar assembly cycles, detailed designs can be collaboratively re-engineered during MR build sessions to enable off-site prefabrication (Figure 7) with the aid of robotic tech and CNC machining (CAD/CAM). In addition, hand-held battery powered rebar tying tools speed up on-site assembly.

Engineers and contractors are able to increase productivity with the increased use of prefabricated components and modular construction. Routine tiresome tasks, assisted by using battery/fuel powered robotic exoskeleton suits (Figure 8) provide support during extended periods of lifting, climbing, squatting and overhead tasks. Typically, exoskeleton suits do not cause laziness. Instead, they prevent overuse types of injury and fatigue, improves strength, safety and thus, longer working careers.

Figure 8: Robotic Exoskeleton Suits (source: jss.2020)

In order to further reduce intensive tasks, both off-site and on-site 3D printing processes are replacing the delivery of traditional materials for construction such as metal, concrete and plastic. Items such as curtain wall facade components, concrete/steel short span footbridges, etc., are currently 3D printed (additive manufacturing) rapidly with geometrical precision and structural reliability, thus reducing reliance on skilled labour and material wastage.

AS-BUILT DTS

DTs have long been part of manufacturing and aviation fields and are increasingly adopted in the construction industry. With the availability of TLS, radar scanning, digital photogrammetry, AI software etc., as-built infrastructures such as buildings, bridges, roads, railways and utilities, are autonomously surveyed to capture object geometry accurately as 3D-BIM point cloud data (*.ifc) to recreate DT parametric models in real-time (3D-BIM overlaid with 2D image stitching etc.). In addition, by using non-destructive subsurface Ground Penetrating Radar (GPR) equipped with multi-frequency (ω) scanners, GPS and AI software, realistic 3D-visual images of buried utilities and structural assessments such as rebar, cracks, voids and degradation, are accurately reproduced (Table 4).

The integration of BIM and GIS in Construction 4.0 requires CDE collaboration between DT (3D-BIM) parametric-models and GIS (geospatial big data analytics). To sustain interoperability between BIM-GIS, (in 1994) an international consensus standards organisation, Open Geospatial Consortium (www.ogc.org), with its open GIS standards strives for integration of geospatial big data. The world's first DT city, initiated in 2014, totally anew on greenfield (undeveloped), is being constructed at Amaravati, A.P., India, covering 217.2 sq. km., with the entire infrastructure and smart ecosystems digitally connected.

Table 4: GPR-Scanners (source:jss.2020)

No.	*freq.*(ω) [MHz]	Depth [m]	Min.-Size [m]	Typical Objects
1	100	≈30	≈0.500	tunnels
2	500	≈4.5	≈0.006	utilities
3	2000	≈0.6	≈0.0004	cracks

REMOTE VIRTUAL MONITORING

Often, breakdowns in infrastructure (transportation networks, bridges, buildings, utility and energy networks, etc.) are only detected at advanced stages, resulting in service disruptions. Most infrastructure networks practice maintenance based on material age and earlier failure records. However, with real-time on-site/off-site (Figure 9) remote virtual scada/sensors/devices for recording pressure, flows, acoustics, vibrations, inclinations,

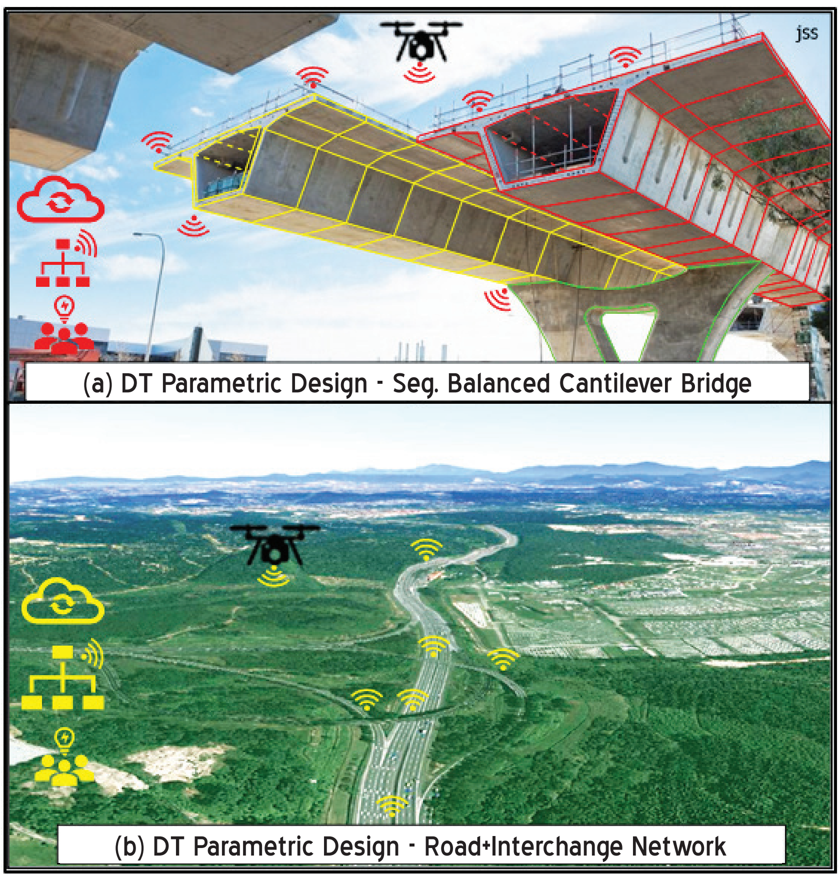

Figure 9: Digital Health Monitoring (source: jss.2020)

deformations, temperatures, simulations, etc., health monitoring and maintenance prioritisation can now be accurately predicted (AI/ML with material degradation data, etc.).

For remote virtual inspection, training, safety and compliance, the International Code Council (ICC) has published a guide titled Recommended Practices for Remote Virtual Inspections (RVI), May 2020.

CONCLUSION

Wireless mobile technology began with 1G in the 1980s and is currently transitioning into the 5G era in the 2020s, advancing at an approximate rate of a decade per generation. Promising a game changing mobile wireless IOT user experience, it is predicted to transform all infrastructure and industries by including AI and ML automation in the near future.

As construction projects become more tech-reliant and complex, AEC firms and stakeholders will require talented specialists with advanced multi-disciplinary mixed-knowledge in coding (Python, C++, script automation), design, construction and contech to collaborate digital data, regardless of project size. AEC firms which have adopted these evolving technologies, will realise improved precision, efficiency, speed, productivity, safety, coordination and profits. However, small-to-medium-sized firms which attempt to implement ad hoc contech will struggle and encounter problems due to high costs, mixed-knowledge know-how and continuing development practices. For additional detailed information, readers are encouraged to explore VDC. ■

NOTE: NO PUBLISHED REFERENCES AVAILABLE

This write-up is based on the latest evolving tech & software (ref: year) researched from the Internet, in addition to the author's Structural FEM education/knowledge/experience. All figures and tables were designed (incl. CAD drwgs.) by the author "jss.2020".

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MALAYSIA'S FIRST LIVING GREEN ROOF CAMPUS, HERIOT-WATT UNIVERSITY MALAYSIA

by Ir. Phillip Wong *Ir. Prof. Dr Leong Wai Yie*

Heriot-Watt University Malaysia (HWUM) building features the largest green roof campus in the country. This green roof acts as a natural shading roof shielding discrete buildings below whilst functions as a mitigating heat island to the surrounding environment. The building is an imposing landmark on the shoreline of Putrajaya's lake, with its beauty-in-simplicity ascending arch appearance.

Figure 1: Malaysia's First Living Green Roof Campus Heriot-Watt University Malaysia @ Putrajaya, Malaysia

This 7,800 square-metre green roof sits atop a state-of-the-art contemporary educational facility located on a 4.8-acre land. The campus is situated in a fantastic green area which is part of the Putrajaya Lake's 'green continuum'.

The green roof is accessible by pedestrians from the base of the building to the top floor at 4-storey high. In addition, it acts as a viewing platform that commands a spectacular view of the Putrajaya's lakeside and its surroundings.

The construction of the iconic HWUM building commenced in May 2012 and delivered to HWUM ready for students' intake in August 2014.

Putrajaya Holdings Sdn Bhd (PjH) is the landowner, project owner and master developer for the HWUM campus. The property is on a 25-year lease to HWUM, offering an exceptional learning environment.

KLCC Projeks Sdn Bhd (KLCCP) was appointed as the Project Management Consultant (PMC) for this flagship campus of the famed Edinburgh's Heriot-Watt University in Malaysia.

(1) SUSTAINABILITY – DESIGN APPROACH

The HWUM building design is a conscious green reference by design. In designing for the future, the architect is cognisant that any adverse deterioration to the prevailing ecosystem would mean significant impact to the natural environment in the coming years.

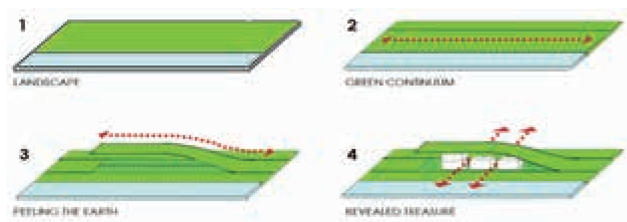

Figure 2: Architect's Design Approach

At the sustainability design stage, it is resolved that the greenfield site should remain predominantly, Green-field. The Architect conceptually decides "to peel the earth up" and over a series of spaces, create an earth berm where the campus settlement could appear as human scale buildings plugged into the earth. An urban forest is to create a buffer for the campus at street level segregating future residences and the campus. At the mid viewing level, a berm park emerges from the ground as a canopy.

With the three key design elements that include "Hidden Treasures", "Connectivity" and "Plug in Spaces", HWUM campus is designed to fulfil the client's requirements and objectives.

"The design philosophy is developed and described into the scheme where the scheme 'peels' open from the ground to reveal 'Hidden Treasures' in the form of knowledge spaces. The peeling over of the earth is a gestural feature reinforcing the concept of the Green" – Ar. Serina Hijjas – Director, HIJJAS Architects + Planners.

The HWUM campus is a state-of-the-art teaching and learning environment, reflecting its status as a leading provider of high-quality, professionally oriented education, knowledge transfer and research. The campus is architecturally designed in conjunction with educational design specialists, in which it has been developed with the current generation of students in mind, to create a dynamic, exciting place that maximises the potential of its various green endeavours for study and student life.

HWUM is built as a first campus in Putrajaya that incorporates various sustainability design features to include low window to wall ratio to ward off heat from its surroundings. The overall building lays bare to open air ventilation where students will have good fresh air circulation both in and out of the respective classrooms.

In addition, the HWUM building is supported with high performance air conditioning system, flexible lighting controls and auto sensor control lightings, extensive green roof, low volatile organic compound (VOC) paints for interior surfaces, rainwater harvesting system as well as low flow water efficient fittings.

(2) SUSTAINABILITY – PASSIVE (ENVIRONMENTAL) DESIGN'S COMPONENTS

Sustainability Is Best Incorporated In Synchronisation with Prevailing + Compelling Passive (Environmental) Design's Components

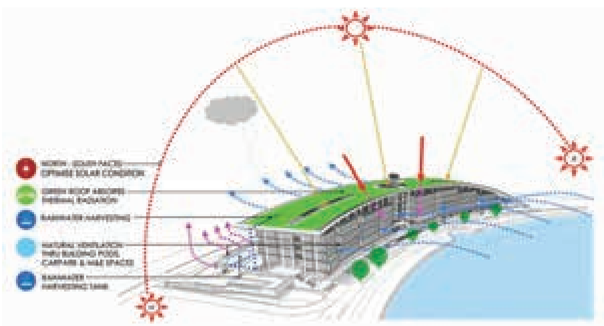

Figure 3: Sustainability Developed In Synchronisation with Prevailing + Compelling Passive (Environmental) Design's Components

(i) North-South Building Orientation Coupled with the Main Glazing and Openings

The building orientation is set in the best passive tropical orientation with the long waterfront facade facing North-South, hence, minimising solar impact whilst optimising diffused daylighting.

(ii) Cross Ventilation of the Entire Building Is Developed Through A Series of Discrete Buildings

As part of the HWUM building incorporation of environmental design, the entire building is built with several discrete buildings separated with vertical gaps between them, resembling 'fingers', to promote natural ventilation. These allow frequent breezes from the lake to cross ventilate the building. In addition, the designed gap between the building and roof is closed to compel air movement through the building. A sub-basement car park relies on pure natural ventilation. The HWUM building is rated 'Certified' under the Malaysian Green Building Index (GBI).

Hybrid cooling is implemented to optimise on the operating times of the HWUM building with a combination of variable refrigerant volume (VRV) for classrooms, chilled water adopting local district cooling for administration and natural ventilation for all circulation and breakout spaces.

With prevailing passive energy, HWUM building energy intensity of 103.5 kWh/m^2/year is about 50% lower than any other typical tertiary institution's building energy intensity.

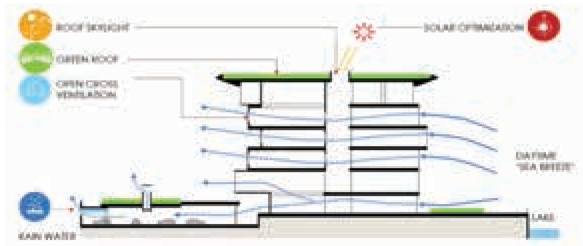

Figure 4: Solar Optimisation, Cross Ventilation, Indirect Daylighting & Natural Ventilation, Double Roof cum Green Lawned Roof and Rainwater Harvesting

(iii) Indirect Daylighting & Natural Ventilation to Circulation Spaces of the HWUM Building

The HWUM building design captures the natural cross ventilation from the lake through the building at the circulation spines. In managing the 45-degree wind & rain penetration into the building during construction, perforated screens are introduced to control the penetration of rain deep into the building whilst maintaining the visibility and air movement into spaces within the HWUM building.

(iv) Green Lawned Roof for Heat Reduction In An Urban Heat Island

The iconic green roof is the first of its kind in Malaysia. There is a 30-degree curvature on the green roof from the ground to the fourth (4th) floor's roof. This green roof acts as an observation deck, accessible by a glass elevator. The 300 metres long and 30 metres wide green roof requires a combination of various types of soil, grass, waterproofing, and irrigation system to avoid erosion.

The design also incorporates many naturally ventilated spaces below the curved roof in particular, the incorporation of unobstructed columns in the middle of the 5-storey structure, which reduce thermal transmittance.

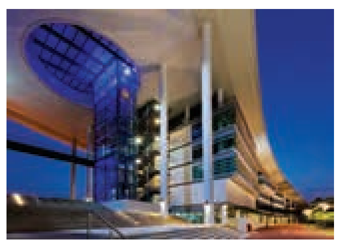

Figure 5: The Unobstructed Columns In the Middle of the 5-Storey Structure

In addition, arising from the pedagogy of emerging learning environments, more versatile uses of spaces are facilitated, where aside from designated lecture halls, regular classrooms can be converted into function rooms for workshops, group discussions and meetings.

(v) Harvesting of Rainwater

Rainwater harvesting is incorporated in the building's design to enable the supply of rainwater for irrigation of surrounding landscapes.

(3) APPLICATION OF INNOVATIVE & SUSTAINABILITY MEASURES (WHERE EXPLICITLY NOTED) IN SOME OF THE CONSTRUCTION CHALLENGES

Innovative and sustainability measures were continuously developed (where applicable) in the construction of the HWUM campus, as challenges prevailed which included:

(i) Tight Construction Timeline

The construction duration was with tight timeline, at 24 months. The HWUM campus was required for handover latest by 5 August 2014. Any delay was detrimental as the registration of students will commence in September 2014. In the event HWUM campus was not timely delivered say, in respect to PjH's delivery failure, the latter would had to facilitate an interim tertiary education facility for the use of HWUM.

Figure 6: Vertical Control: Curvatures Ranging from 1 – 30 Degrees whilst Horizontal Control: To Adhere to the Curvature cum Alignment of the Lake's Waterfront Promenade

(ii) Building Geometry's Uniqueness

Arising from the curvature of the building, setting out of the site was compounded by the challenges in the vertical control that involved curvatures ranging from 1 - 30 degrees whilst the horizontal control was to adhere to the curvature cum alignment of the lake's waterfront promenade. In order to attain precise positioning, more points were facilitated, whilst great care was vital as small errors were likely to prevail as more points were introduced.

(iii) Construction Methodology

The project team developed its own innovative construction methodology in the simultaneous construction from both ends of the HWUM building instead of the conventional sequencing to roof coordinates. In respect to the innovative construction, respective building coordinates were progressively precision monitored in order to attain the desired design curves' intent.

In addition, the project team advised its contractor for the latter to thoroughly monitor its construction sequence as well as to increase respective workforces for timely concurrent works' execution in order to attain meaningful water-tightness construction for the HWUM building. The state of good water-tightness for the HWUM building was vital in order to proceed with interior fittings as bounded by the Contract.

(iv) Teamwork and Collaboration

Teamwork amongst stakeholders, in particular those that entailed the project team, consultants and contractor were of paramount importance for the success of the project. Numerous workshops were carried out and these contributed to the successful HWUM campus delivery.

At times, the KLCCP's project team participated in direct engagements with the subcontractors and skilled workers in order to appreciate challenging situations such that appropriate sustainable innovative solution(s) could be identified/developed in assisting the contractor towards meaningful construction completion of the HWUM campus.

Figure 7: Preparation for Water Proofing and Soil Laying

(v) Soil Erosion

The respective soils' self-weights, retained water loading together with the tropical torrential downpours were the main challenges that could erode soils particularly, during occurrence of surface runoff on the green lawned roof.

It was essential for the roof to be equipped with appropriate planting media. Many laboratory tests were conducted to determine what the most appropriate media mix percentages (50% Enviro-Mix : 50% Normal Top). During construction stage, the soil mixture was mixed at site's premise before being poured at the rooftop. The quality of mixture control was important to avoid unnecessary erosion.

Figure 8: Drainage Cell

The project team innovatively developed a special mixture of light weight soil to encourage percolation and minimise the detrimental effects of surface runoff. Intelligent drainage system included adopting drainage cell – versiDrain 25p to improve water discharge capacity. Stepped ridged structure roof was introduced to mitigate soil erosion from the roof.

Locally sourced materials with high recycled content were adopted to reduce carbon footprints and environmental impacts in respect to the HWUM campus's development.

(vi) Irrigation System and Maintenance Safety

In the original design, an irrigation system was not included in the Contract. The original scope of the Contract only specified manual irrigation.

An innovative irrigation system was vital for a sustainable green roof as revealed in respective studies. If water was inadequately irrigated to areas of a green roof (particularly, greens on a steep slope), patches of yellow and green turfs will prevail along roof spreads (symptom of dryness)

In respect to manual irrigation, workers will frequently tread on the lawned areas. This could result in undesirable soils' compactions over time.

It was also deliberated that at areas in which the roof's slopes were the steepest, the safety of workers involved in manual irrigation was of concern.

In addition, with manual irrigation, the effectiveness of manual water spray in respect to soils' water absorption including grass roots attaining adequate water was also of concerned consideration for the project team.

The above respective issues did not augur well when in particular, the design intent was to minimise maintenance activities involving humans treading on the grass areas. Eventually, the concern that any particular grass areas may not be well irrigated during regular grass watering was resolved in the introduction of a sustainable innovative irrigation system monitored by building automation system.

(vii) Avert Lake Pollution

During construction, one of the main challenges for a development situated at the lakefront was lake pollution. An earth drain and silt fence were innovatively implemented where water from the earth drain(s) would be channeled into silt trap(s).

Thus respective waters would be filtered in silt trap(s) before they entered the lake. Weekly and monthly monitorings were part of the environmental plan that was established for the HWUM campus.

(4) INNOVATIVE & SUSTAINABILITY OUTCOMES OF THE HWUM CAMPUS

The project was delivered on time and below its budgeted amount. This was made possible through the various innovations instituted, value engineering conducted and more importantly, the effective communication and collaboration involving all stakeholders.

HWUM has been in operation for more than 5 years and has met the set objectives pertaining to green design's parameters. Savings in terms of electricity, water and waste are 50% reduction at all all levels.

Savings on electricity are attained by means in the adoption of T5 lightings, motion sensors for all corridors, individual rooms, meeting rooms, toilets and classrooms as well as in the implementation of hybrid cooling strategy. Electrical and cooling loads are monitored through the Energy Management System (EMS). Current Building Energy Intensity is 103.5 kWh/m^2/year.

It is noted that 55% water is saved with the installation of water efficient fittings. In addition, approximately 16,400 litres of water per day or 5.9 million litres per year of water is harvested for irrigation purposes. Any excess stormwater is filtered prior to its return to the lake as Class 11, completing this green loop.

Waste recycling is a high priority in Putrajaya Green City. The opportunity for wastes to be reduced is aplenty as Putrajaya itself is rigorously executing the 3Rs (Reduce-Reuse-Recycle) operation. Accordingly, it is heartening to note that the 3Rs practice has been implemented for the entire development of the HWUM campus since the construction stage.

"Heriot-Watt University Malaysia's campus is an innovative and eco-friendly campus that fits into Putrajaya's master plan. Putrajaya aspires to maintain a green acreage above the mandatory 30%. Currently, 38% of its land remains green. In addition, the development of the HWUM campus sets high benchmark standard for future development of educational institutions." – Dato' Hashimah Hj Hashim, Chief Executive Officer of PjH.

(5) THE SELECTION OF A PROJECT MANAGEMENT CONSULTANT

In an inherently fast-paced development required in the development of an esteemed campus to cater for an institution of higher learning, the selection of a financially sound with proven track record Project Management Consultant (PMC) was paramount. In this respect, KLCC Projeks Sdn Bhd (KLCCP) was secured by PjH being the master developer for the HWUM campus.

KLCCP was incorporated in 1992 specifically to undertake the Project Management Consultant's role for the RM 4.5 billion, mammoth development of the Kuala Lumpur City Centre (KLCC). This included the construction of the **world's tallest twin towers, namely the Petronas Twin Towers.**

Pursuant to KLCCP's stellar performance, it was tasked to undertake another behemoth endeavour namely, as the PMC for the **development of Putrajaya.** Putrajaya is a planned city and federal territory of Malaysia, serving as the federal administrative centre of the Malaysian capital, Kuala Lumpur.

Fast forward, with more than 27 years of valuable experience, proven track records, awards' winning projects, KLCCP has carved its name as a premier Project Management Consultant in Malaysia and beyond. ■

REFERENCES

It is hereby acknowledged that all printed materials and references adopted (inclusive of copyrighted materials, references, internet references, digital pictures, illustrations, graphics, etc) are those facilitated by KLCC Projeks Sdn Bhd and its Project Team.

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SURREAL SUPERTREES

Ir. Dr Oh Seong Por

Ir. Dr Oh Seong Por *is the immediate past chairman of IEM Negeri Sembilan Branch.*

Supertrees are 18 man-made tree-like structures standing at 25m to 50m tall at Marina Bay in Singapore. Of these, 12 are at Supertree Grove and there are 3 each at the Golden and Silver Gardens.

The Supertrees support over 158,000 plants, including orchids, tropical flowering climbers, epiphytes and ferns. Each Supertree is made up of 4 major components designed for specific purposes. These are:

1. A reinforced concrete core supporting the supertree
2. A steel frame trunk attached around the core
3. Planting panels to grow the plants and
4. A canopy-shaped inverted umbrella to provide shelter.

The Supertrees were designed by Grant Associates which had incorporated sustainable energy and water technologies into the design to enable plants to grow and flourish. The canopy is embedded with a sophisticated lighting system that creates an exhilarating display of light and sound in the evening, somewhat similar to a scene from the Avatar movie. ■

WEBINAR EVENT - THE GUIDELINES ON OCCUPATIONAL SAFETY AND HEALTH IN CONSTRUCTION INDUSTRY (MANAGEMENT) (OSHCIM)

by Ir. Phillip Wong

An OSHCIM[1] Webinar Training Programme was exclusively organised by the Urban Engineering Development Special Interest Group (UEDSIG) as its inaugural "Webinar Training Programme" on Saturday, 12 September 2020. The total numbers of registered participants for the two (2) sessions were 409 participants.

The OSHCIM Webinar Training Programme was conducted in two (2) sessions with the caption "An Overview + Application of Occupational Safety and Health In Construction Industry Management".

The two (2) sessions of the OSHCIM Webinar Training Programme were made possible with the kind collaboration involving Ir. Omar bin Mat Piah, being the Director General of the Department of Occupational Safety and Health (DOSH) and his team of directors based at headquarters, Putrajaya. In addition, Ir. Omar bin Mat Piah was graceful in presenting a Closing Speech to fellow webinar's participants.

The panel of esteemed DOSH speakers were En. Nazruddin bin Mat Ali - Director of Construction Safety Division, En. Azman bin Hussain - Deputy Director, Statistics Section, Construction Safety Division, Ir. Dr Mohd Fairuz bin Ab Rahman - Deputy Director, Engineering Section, Construction Safety Division, Ir. Mokhtar bin Sabtu - Deputy Director, Enforcement Section, Construction Safety Division and En. Mohamad Syamir bin Senin - Assistant Director, Engineering Section, Construction Safety Division.

Ir. Ong Ching Loon the President of The Institution of Engineers, Malaysia, in his Opening Speech made reference to one of the four (4) strategic goals in his recent Presidential Speech entitled "Augmenting IEM", which was Strategic Goal No. 3 being namely, Increase Member Value and Engagement.

In this regard, IEM requires "to be member-centric, if not all, in a majority of its actions and decisions" As the popular saying goes, "Let each of you look not only to his own interests, but also to the interests of others"

It was upon the above Strategic Goal No. 3's premise, that the OSHCIM Training Programme was structured in two (2) sessions to benefit fellow engineers to include any other colleagues in related sectors of the economy. In addition, the adoption of the Webinar platform will facilitate digital ease of access for all participants nationwide.

Participants of the OSHCIM Webinar Training are enlightened of the immense deliberation that organisations and nations are truly sustainable when a progressive safe system

Ir. Ong Ching Loon
IEM President

Ir. Haji Omar bin Mat Piah
DOSH Director General

Left to Right: Koh Wei Sang and Tay Tee Tiong UEDSIG's Moderators for OSHCIM Webinar Training Programme

Encik Nazruddin bin Mat Ali Director of Construction Safety Division, DOSH

Left to Right: Encik Azman bin Hussain - Deputy Director, Statistics Section and Ir. Dr Mohd Fairuz bin Ab Rahman - Deputy Director, Engineering Section Construction Safety Division, DOSH

of practices is in place to ensure the safety, health and welfare of their workforce. In addition, it is noteworthy to mention that out of the seventeen (17) United Nations' Sustainable Developments Goals (SDGs), a number of the SDGs have direct and indirect relation to worker and labour issues.

These can be identified in SDGs' Goal #8 and Goal #12. Goal #8 relates to Decent Work and Economic Growth whereas Goal #12 relates to Responsible Consumption and Production.

As our nation progresses in sustainable development, it is indeed timely that DOSH has promulgated the Guidelines On OSHCIM. The Guidelines On OSHCIM provides practical guidance to the client(s), designer(s) and contractor(s) on the management of safety, health and welfare when carrying out construction projects.

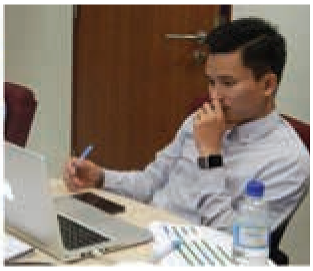
The OSHCIM Guidelines is for individuals with legal duties under the Occupational Safety and Health Act and the Factories and Machinery Act. It is an industry guidance that details what to expect of construction's duty holders (also stakeholders, ie: client(s), designer(s) and contractor(s)) as well as what to expect of other construction's stakeholders (ie: workers, regulatory [enforcement] bodies, local authorities, professional bodies and educational institutions)

The Guidelines On OSHCIM involves the respective duty holders and stakeholders to work together to avert occupational safety and health hazards out of the construction sector's processes and products. In collaborating, they should identify and eliminate or reduce, as far as is reasonably practicable, all foreseeable risks (not limiting to those identified at the design and construction stages) affecting safety and/or health of any person.

The OSHCIM Guidelines entails the risk management process in the form of Hazard Identification, Risk Assessment and Risk Control (uniquely, identified in Malaysia with the acronym, HIRARC)

Accordingly, a Safety and Health File is evolved. This Safety and Health File is required to be regularly updated

Ir. Mokhtar bin Sabtu
Deputy Director
Enforcement Section
Construction Safety Division, DOSH



Encik Mohamad Syamir bin Senin
Assistant Director
Engineering Section
Construction Safety Division, DOSH

and retained for the entire lifetime of say, a building, structure inclusive of any built facility and/or infrastructure facility until demolished.

The Safety and Health File among others, will comprise construction method advisory notes by the designer(s) to the contractor(s) for the building to include for the demolition of the completed structure/facility in the future. ■

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Ir. Phillip Wong *is a practising civil + structural engineer. In addition to his continuing professional development, he undertook postgraduate studies and specialised training in environmental & occupational noise assessment and control pursuant to the New South Wales, State Pollution Control Commission's Competency Registration as well as separately, in the accounting and finance discipline. He has also successfully completed industry-specific Occupational Safety and Health (OSH) regulatory programmes notably, in the safety and health officer's competency examination, chemical health risk assessment, mineral dust monitoring including programmes relating to OSH's practice and development.*

DOMESTIC PLASTICS WASTES & POLLUTION: SEARCHING FOR POSSIBLE SOLUTIONS

by Ir. ChM. Dr Lee Tin Sin

Ir. Dr Bee Soo Tueen

Plastics is generally divided into two major categories: Thermoplastic and thermoset. Polyethylene, polypropylene, polystyrene, poly(vinyl chloride) are examples of thermoplastic. These can withstand heating as well as be melted down to form other plastic items, with limitations on thermal degradation after several times of recycling.

On the other hand, thermoset plastic cannot be recycled as it will undergo serious degradation upon application of thermal effects. Examples are tyres, shoes, crosslinked insulation, mattress foam and etc. Usually, thermoset materials can only be "reused" by adding them to other virgin polymeric materials for cost reduction, with limited improvement of the existing materials.

But although thermoplastic can be recycled, there are several concerns when it comes to recycling, including:

1. Competency on segregation of thermoplastic materials into polypropylene (PP), high density polyethylene (HDPE), low density polyethylene (LDPE), polyethylene terephthalate (PETE), polystyrene (PS), polyvinyl chloride (PVC) and others.

   Usually, manufacturers will imprint labels (see Figure 1) to help consumers to identify and carry out segregation. The segregation is very important because a mixture of different categories of plastics will lead to low quality recycled products as well as difficulty in the processing.

   Issues occur when manufacturers do not label all the different parts of an item. For instance, mineral water bottles are made of PETE but the bottle caps are made of HDPE. So, for recycling purposes, the bottle and cap must first be separated.

   Another serious problem occurs when there are missing labels as this results in the misidentification of the plastics categories which, in turn, makes the recycling almost impossible.

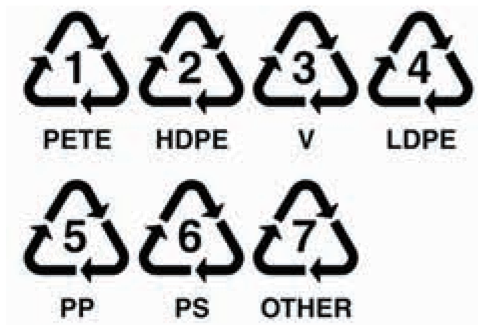


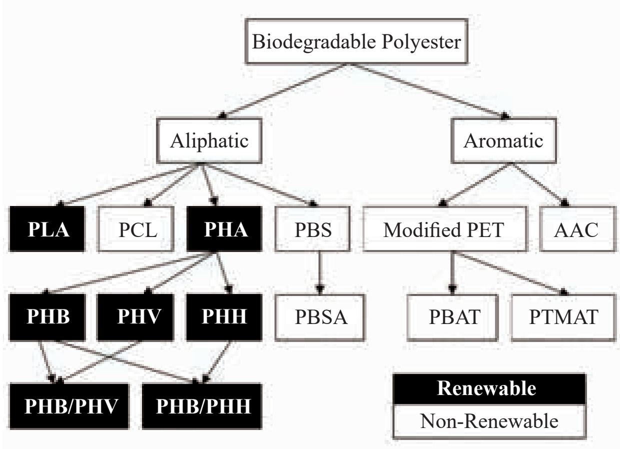
Figure 1: Labelling of plastics categories for recycling

2. Cleaning and hygiene issues: It is commonly perceived that recycling of plastics is merely collecting plastics from the recycling bins without cleaning them. In fact, the cleaning of plastics items for recycling is a very important step. Most recyclers welcome pre-cleaned plastic items, those without oil, grease or leftover food and beverages as this will reduce the cleaning work to be carried out in the factory. Recycling companies also prefer to accept plastic items from known sources as the unknown previous contents in containers can cause an entire batch to be contaminated. For instance, some consumers may have used mineral water bottles (i.e. PETE bottles) to store detergent, while others use them for storing pesticides. Recyclers do not want such plastic items as these can cause health and other concerns.
3. Multilayers packaging, commonly found in perishable food packing, cannot or are difficult to be recycled. Most plastic packaging bags are multilayers. The purpose is to preserve perishable food content. A single

layer plastic film can be easily recycled but multilayer plastics packaging can hardly be recycled.

For instance, a pudding cup consists of 5 layers, i.e. polyethylene, co-extrudable adhesive resins, ethylene vinyl alcohol, co-extrudable adhesive resins and low density polyethylene (see Figure 2, Massey, 2002). Such multilayer cups require the separation of the different layers as part of the recycling process. However, to do this, advanced machinery is required and small and medium industries cannot afford such technology. So, multilayers plastics packaging are seldom recycled and are, instead, sent to the landfill.

Figure 2: Composition of multilayers film for pudding cup



AAC - Aliphatic-Aromatic Copolyesters
PBAT - Poly(Butylene Adipate/Terephthalate)
PET - Poly(Ethylene Terephthalate)
PBS - Poly(Butylene Succinate)
PBSA - Poly(Butylene Succinate/Adipate)
PCL - PolyCaproLactone
PLA - Poly(Lactic Acid)
PHB - Poly(Hydroxy Butyrate)
PHH - Poly(Hydroxy Hexanoate)
PHV - Poly(Hydroxy Valerate)

Figure 3: Types of biodegradable polymers

IS BIODEGRADABLE POLYMERS THE SOLUTION?

It has been suggested that biodegradable polymers is the solution because of its degradability characteristic and agricultural source. However, there are some factors to be considered.

For a start, biodegradable polymers can be derived from agricultural or petrochemical sources. For instance, polylactic acid (PLA) and polyhydroxybutyrate (PHB) are derived from the fermentation of agricultural produce whereas polycaprolactone (PCL) and poly[butylene succinate] (PBS) come from non-renewable sources. Figure 3 summarises the types of biodegradable polymers and the different sources.

Although biodegradable polymers (e.g. PLA) can be obtained from agricultural sources, we also need to take into account factors such as the use of fertilisers, fuel for harvesters, water for irrigation, pesticides and herbicides; these can be more complicated than biodegradable polymers generated from petrochemical sources. In addition, the growing of crops to produce biodegradable polymers also involves deforestation which subsequently leads to environmental issues as well.

Another factor to be considered is that most biodegradable polymers are not produced in Malaysia but are, instead, imported from other countries. For instance, the factory that produces PLA "Ingeo" is located in Nebraska, USA. The long-distance transportation will incur carbon footprints before delivery to the consumer.

Actually, biodegradable plastics costs several times more than conventional petrochemical polymers. So the case for biodegradable polymers is less convincing when it comes to single-use items such as food containers and utensils. This is also why biodegradable polymers products are limited in the market although it has existed for over 15 years.

EDUCATION THE KEY

Since we cannot avoid the use of plastics in our daily lives, it is more important to reduce plastic wastage. This is where comprehensive education is most important. Consumers need to be educated further on the 3Rs: Reduce, Reuse & Recycle.

They must be well informed on the usage, segregation and recycling of plastics. Armed with this knowledge, consumers, the media and legislators can then pressure manufacturers into producing better quality plastic items with environmental friendly characteristics.

Lastly, the handling of plastic wastes is a long-term effort which requires the co-operation of everyone. Most importantly, let's start practising 3Rs today. ■

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POST COVID-19 INDUSTRY: WHAT FUTURE ENGINEERS CAN EXPECT

by Aisyatul Husna binti Zalizan

On the 4 July 2020, IEM Student Chapter UiTM Shah Alam organised a webinar titled Post Covid-19 Industry: What Should Young & Future Engineers Expect, from 2.00 p.m. to 3.00 p.m. It was held via GoToWebinar.

The speaker was Ir. Prof. Madya Dr Mohamad. The objective was to create awareness among future engineers of the current situation and what would be expected from them. The contents of the talk were:

1. An overview of the global and domestic Covid-19 situation
2. Demand for technology and talent, post Covid-19 and
3. Social hybrid engineers.

Covid 19 has created a new norm in the way we work, which includes working remotely, attending online meetings and flexible working environments as more employers adopt work-from-home programmes. Covid 19 has succeeded in driving a greater digital transformation than many CEOs have been able to achieve in the past. For companies to survive, they need to expedite their digital transformation.

There are several top essential job skills that future engineers will need. The first is technology savviness. Emerging technologies like artificial intelligence (AI), Internet of Things (IoT) and robotics are set for our near-future. Those with digital and social media marketing skills will be an asset to their company. Knowledge in search engine optimisation or building webpages will be very attractive to employers.

As the workplace keeps evolving, adaptability to change is another important job skill which future engineers need to learn. According to employers in the 2018 Cengage/Morning Consult survey, critical thinking skills were identified as the top missing soft skills in graduates. Those who are able to objectively evaluate information and make decisions when faced with a disruptive situation, will have a better chance to impress employers.

Overall, Covid-19 is changing the work landscape around the globe, but it's not all bad. The crisis has exposed emerging areas of opportunity in the technology space. Executives from leading technology organisations and solution providers are weighing it on the job roles and skills that will be needed in the post-pandemic world.

Upskilling is the most important factor in the post-COVID-19 job scene. Having the right skills will make the difference, even in difficult times. Acquiring relevant skills is no longer limited to going back to school to earn a graduate degree. From short-term credential programmes to skill-specific online courses, graduates can choose to enrol in and pick up the skills necessary for success in the rapidly changing workplace. ■

CONGRATULATIONS

*Congratulations to **Y.B. Ir. Haji Shahelmey bin Yahya**, J.P., on his appointment as Minister of Community Development & People's Wellbeing, Sabah.*

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FORTRESS CITY OF NGUYEN DYNASTY

Ir. Dr Oh Seong Por

Ir. Dr Oh Seong Por is the immediate past chairman of IEM Negeri Sembilan Branch.

In Hue City, Central Vietnam, my friends and I visited Hoang Thanh, the Chinese-style Imperial City enclaved within a fortified 2km square fortress which was also known as Hue Citadel. It was constructed by Emperor Gia Long, founder of the Nguyen Dynasty.

After he unified Vietnam with the help of France through the Versailles Treaty in 1787, the Emperor conscripted thousands of citizens to dig a moat and build walls to protect the Imperial City. From here, the Nguyen Dynasty ruled Vietnam from 1802 to 1945 before Vietnam became a republic.

The city's long association with the Chinese, either through battles or alliances, had resulted in some assimilation of Chinese culture during the Nguyen Dynasty. As such the architectural design of the Imperial City was greatly influenced by Chinese elements and was modelled after Beijing's Forbidden City.

The first magnificent structure that caught my attention was the Meridian Gate or Ngo Mon. I was amazed to learn that the gigantic gate had survived devastating attacks by the French (1947) and the Americans (1969), with significant portions still intact. It consists of a tower and a pavilion known as Five Phoenix Pavilion or Lau Ngu Phung. It is in the shape of a 'U', with a base length of 58m and two protruding sides, each 28m in length. The tower is 6m high and has 5 arched gates.

According to the tour guide, the central gate with the largest arch was reserved for use by the Emperor. The two medium-sized gates were used by officials, Mandarin advisors, soldiers, horses and elephants while commoners could only use the two small gates.

Entering the Imperial City, I felt like I was stepping into an ancient Chinese city. Almost all the building structures, pillars, towers, statues, gates, furniture and lanterns were copies of Chinese designs. Even the carved inscriptions on the walls or entrances were in Chinese characters.

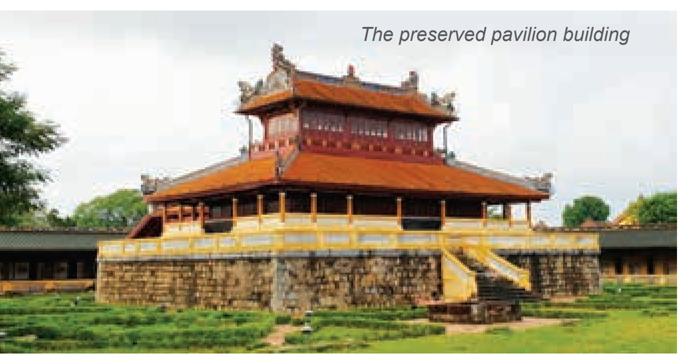
A significant building at the main entrance is the Supreme Harmony Palace or Dien Thai Hoa. This was where the Emperor conducted official duties such as receiving foreign envoys or handing out royal decrees to Court officials. The palace was made of solid wooden trusses supported by large columns which allowed the creation of a spacious hall; the throne was located at one end. It was from here that the Nguyen Dynasty ruled with absolute power for 143 years. Some of the pillars had been reinforced with steel beams though in general, the old structures were well preserved.

Next to the Supreme Harmony Palace is the surviving stone foundation of the once-magnificent Forbidden Purple Palace, home of the Imperial family, including concubines. Nobody was allowed to enter this building except eunuchs. During the Tet Offensive of the Vietnam War in 1968, the palace was completely destroyed. Its crumbled remains are now overgrown with weeds.

There are many different courtyards, segregated by decorative gates and each has its own unique buildings and palaces. One can get disoriented because the buildings are not systematically positioned. The guide cautioned us to stay tight and move together. He said that each emperor, upon his ascension to the throne, would order the construction of new structures for specific purposes within the city. As a result, the inner city was scattered with special purpose structures such as temples, a library, a medical centre and a theatre. It was estimated that about 160 structures were erected but only 10 survived the wars. Part of the rich heritage of the last dynasty was lost along with the destroyed structures. This bears proof to the saying that "the greatest enemy of mankind is man".

When the Vietnamese government later realised the historical significance of the Imperial City, conservation works were started to restore the ancient city and in 1993, the Imperial City of Hue was granted UNESCO World Heritage Site status.

We spent almost a day exploring and admiring the Imperial City. As we were leaving, I remembered a bestselling book I had read, *Built To Last*, written by Jim Collins. I believed Emperor Gia Long and his successors had envisioned the creation of a formidable fortress city for the Nguyen Dynasty and had succeeded in this objective. The Imperial City had survived over 2 centuries of wars and civil unrest and was truly a city built to last.



The preserved pavilion building

Meridian Gate

TEMUDUGA PROFESSIONAL

Tarikh: 10 November 2020

Kepada Semua Ahli,

SENARAI CALON-CALON YANG LAYAK MENDUDUKI TEMUDUGA PROFESIONAL TAHUN 2020

Berikut adalah senarai calon yang layak untuk menduduki Temuduga Profesional bagi tahun 2020.

Mengikut Undang-Undang Kecil IEM, Seksyen 3.8, nama-nama seperti tersenarai berikut diterbitkan sebagai calon-calon yang layak untuk menjadi Ahli Institusi, dengan syarat bahawa mereka lulus Temuduga Profesional tahun 2020.

Sekiranya terdapat Ahli Korporat yang mempunyai bantahan terhadap mana-mana calon yang didapati tidak sesuai untuk menduduki Temuduga Profesional, surat bantahan boleh dikemukakan kepada Setiausaha Kehormat, IEM. Surat bantahan hendaklah dikemukakan sebulan dari tarikh penerbitan dikeluarkan.

Ir. Dr David Chuah Joon Huang
Setiausaha Kehormat, IEM
(Sessi 2020/2021)

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41081	YAP CHUNG LING	BE HONS (KLiUC) (CIVIL, 2009)
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Pengumuman yang ke-145

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Automotif									1	1
Bioperubatan					2				36	38
Kimia			3	2	29				111	145
Awam	2		47	6	102	2		2	138	299
Komunikasi			1		3					4
Komputer				1					9	10
Sistem Komputer									1	1
Elektrikal & Elektronik									18	18
Elektrikal			18	2	54				80	154
Elektronik			5	3	14	2			84	108
Alam Sekitar									1	1
Geoteknik			2							2
Pembuatan				1	3				18	22
Marin					1					1
Bahan					1				2	3
Mekanikal			21	6	64	1		1	211	304
Mekatronik			1		6			1	61	69
Perlombongan					1					1
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Petroleum					1				16	17
Pengeluaran						1				1
Struktur									1	1
Telekomunikasi			1						4	5
Sumber Air	1		1							2
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Lain-lain							1			1
JUMLAH	3		100	21	282	7	1	4	804	1,222

Senarai nama ahli dan kelayakan adalah seperti di bawah. Institusi mengucapkan tahniah kepada ahli yang telah berjaya.

Ir. Mohd Khir bin Muhammad FIEM, PEng

Setiausaha Kehormat, Institusi Jurutera Malaysia, Sesi 2019/2020

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