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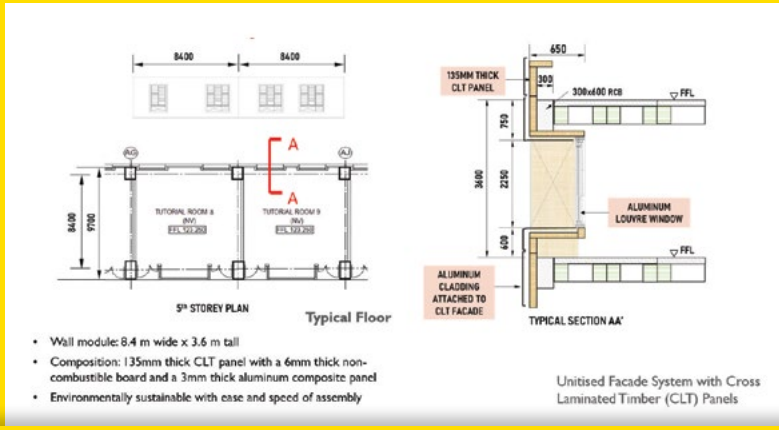
First high-rise building project in Singapore to integrate Mass Engineered Timber with concrete

- Consists of Glued Laminated Timber (Glulam) beams and concrete slab prefabricated off-site. It behaves like a composite slab.
- Panel size: 2.6 m wide x 7.06 m long
- Each Panel: 4 nos. of glulam beams with 80mm thick concrete slab

CREE Panel – Design Basis



- Wall module: 8.4 m wide x 3.6 m tall
- Composition: 135mm thick CLT panel with a 6mm thick non-combustible board and a 3mm thick aluminum composite panel
- Environmentally sustainable with ease and speed of assembly

Unitised Facade System with Cross Laminated Timber (CLT) Panels

PLUS

BUILT ENVIRONMENT TRANSFORMATION: Projects honoured for commitment towards attaining high standards
WORKPLACE SAFETY & HEALTH: Protecting workers' safety and wellbeing with collaborative robots
CONCRETE TECHNOLOGY: The cement industry – the challenges of the future

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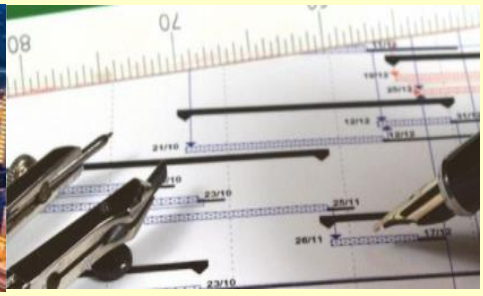

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Built Environment Industry Transformation Map to facilitate integration and collaboration

Jointly organised by BCA and its strategic partner, RX Singapore, the International Built Environment Week 2022 (IBEW 2022), comprising the IBEW Conference and BEX Asia, the premier trade exhibition for the sustainable built environment, was held as an in-person event, from 5 to 9 September 2022, at Sands Expo and Convention Centre, Marina Bay Sands, Singapore. The event, which was supported by 12 Trade Associations and Chambers (TACs), addressed the theme 'Accelerating Transformation, Growing Together'.

Mr Desmond Lee, Minister for National Development and Minister-in-charge of Social Services Integration, was the Guest-of-Honour at the Opening Ceremony of the event.

In a speech made on the occasion, Mr Lee said that the refreshed Built Environment Industry Transformation Map (BE ITM) will help stakeholders within the sector collaborate more effectively across the value chain.

The Construction ITM and Real Estate (Facilities Management) ITM, previously launched as two separate ITMs, in 2017 and 2018, respectively, have been amalgamated into one Built Environment ITM, to transform the Built Environment (BE) sector through the three key stages of a building's life cycle – from planning and design, to construction, and to operations and maintenance.

"Building on the progress of the ongoing transformation, the Built Environment ITM is a timely refresh, as it recognises the need for greater collaboration amongst BE stakeholders as well as the shifts that have been made in technological advancements, sustainability efforts and longer-term structural trends", said Mr Liam Wee Sin, Future Economy Council (FEC) Urban Systems (US) Cluster Co-Chair.

Mr Desmond Lee, Minister for National Development and Minister-in-charge of Social Services Integration, delivers his speech at the opening of International Built Environment Week 2022.

"In formulating the Built Environment ITM, we have engaged more than 2,500 partners from the industry firms, Trade Associations and Chambers (TACs), government agencies, unions, Institutes of Higher Learning (IHLs) and students, to gather inputs on the proposed new strategies and initiatives. Going forward, it is vital that firms and individuals continue to upskill themselves, as we push ahead in our transformation efforts", said Mr Tan Kiat How, Senior Minister of State, Ministry of National Development and Ministry of Communications and Information, and FEC US Cluster Co-Chair.

Integrated Planning and Design to foster greater collaboration

One of the key transformation areas is Integrated Planning and Design (IPD), where stronger collaboration across the building life cycle can optimise resources. This will build on the existing efforts for Integrated Digital Delivery (IDD) which allows project stakeholders to collaborate with one another through digital platforms. Design considerations for the building's entire life cycle, including Facilities Management (FM), are factored in at the design stage, enabled by digitalisation, Common Data Environment (CDE) standards and progressive procurement.

Under the refreshed BE ITM, the Building and Construction Authority (BCA) expects to increase the IDD adoption rate for new developments, from 34% today to 70%, by Gross Floor Area (GFA), by 2025.

The BE ITM also encourages the industry to move towards collaborative contracting where contracting parties, including the builder and facilities management firm, work together towards shared project goals at the start of the project. Seven Government Procuring Agencies have identified nine upcoming projects to pilot collaborative contracting. Contract Management consultants such as Turner & Townsend, WT Partnership, AECOM and Threesixty are also supporting this effort, by providing advisory services to private sector clients.

Advanced Manufacturing and Assembly to increase the use of automation

The second key transformation area is Advanced Manufacturing and Assembly (AMA), to enhance the

efficiency of the supply chain and construction process, by mainstreaming Design for Manufacturing and Assembly (DfMA). This has helped firms reduce their reliance on foreign manpower and raise productivity. Moving forward, BCA aims to increase the DfMA adoption rate by GFA, from 44% today to 70%, by 2025.

Under AMA, more off-site production will be done in a factory environment with greater adoption of automation. By improving the quality of work and working environments, including at the construction site, the industry hopes to attract and retain talent in the sector. The shift from a project-based building approach to a modular, product-based one, also enables industry firms to reap greater economies of scale.

At the same time, BCA is also working with stakeholders to establish new Integrated Construction Parks (ICPs) across Singapore. In ICPs, construction facilities such as aggregate terminals, aggregate storage yards, Ready-Mix Concrete (RMC) batching plants and precast plants will be co-located for greater synergy across the entire supply chain. The first ICP in Jurong Port will progressively begin its operations later this year.

Sustainable Urban Systems to accelerate decarbonisation efforts

The third key transformation area, Sustainable Urban Systems (SUS), will facilitate the ramping up of decarbonisation efforts in the industry for a more sustainable and liveable Built Environment. SUS aims to achieve low emissions buildings and districts, with efficient building management enabled by Integrated, Aggregated and Smart FM.

Under SUS, BCA will continue with existing efforts to meet the '80-80-80 in 2030' targets set under the latest edition of the Singapore Green Building Masterplan. BCA will also aim for a more ambitious target of 80% of public buildings adopting Smart FM by 2030, and set a new target for 40% of private buildings by GFA to adopt Smart FM by 2030. Announced earlier this year, the SGD 30 million Integrated Facilities Management (IFM) and Aggregated Facilities Management (AFM) Grant for firms which wish to adopt IFM/AFM was opened for applications, from 6 September 2022.

Since 2021, the Ministry of National Development (MND) and BCA have engaged more than 2500 partners and individuals from industry, TACs, IHLs/students, unions and government agencies (via large scale meetings, focus group discussions and one-to-one sessions) to gather feedback, hear out industry challenges and work together to co-develop the BE ITM.

Greater industry leadership in transformation

As the industry embarks on the Built Environment ITM, there is also a need to adopt a more ambitious approach in transforming the value chain, as a whole, and push for best-in-class outcomes in projects. Developers and sector leaders are beginning to recognise the pivotal role they play in transforming the industry, by running and developing a capable supply chain. To this end, BCA has been developing the Growth and Transformation Scheme (GTS) to pilot this value chain approach. A set of outcomes for the GTS has been developed with inputs from the industry, over the past year, to support these strategic alliances.

Lastly, in recognition of projects that have embodied the transformation goals of the ITM, the newly launched Built Environment Transformation Award honours firms and industry practitioners who have honed their capabilities to deliver projects that exemplify productivity, digitalisation and sustainability.

BCA will continue to engage the industry to accelerate transformation efforts and gather feedback on the new initiatives under the Built Environment ITM. Those who have embarked on transformation efforts have seen the immense downstream benefits that they can derive. The aim is to work with large firms and SMEs towards creating an advanced and integrated Built Environment sector.

PUB projects bag triple gold at the 2022 IWA Project Innovation Awards

National Water Agency, PUB's upgraded Choa Chu Kang Waterworks (CCKWW), that houses the world's largest ceramic membrane system, has won a Gold award in the 'Market-changing Water Technology & Infrastructure' category at the International Water Association's (IWA) 2022 IWA Project Innovation Awards.

PUB's Changi Water Reclamation Plant (CWRP) Digital Twin project and the Keppel Marina East Desalination Plant (KMEDP) were also conferred Gold awards in the 'Performance Improvement and Operational Solutions' and 'Exceptional Project Execution and Delivery' categories, respectively. KMEDP also clinched the top award – the IWA Grand Innovation Award – presented to the most outstanding example of innovation in the water sector. KMEDP won the award for its unconventional, dual-mode, water treatment plant.

The biennial IWA Project Innovation Awards is a distinguished international industry platform that celebrates and recognises leadership and innovation in sustainable water management. There are six categories, with three finalists each, and the awards were presented at the 2022 IWA World Congress & Exhibition held in Copenhagen, Denmark on 13 September.

Ceramic membrane technology

CCKWW is one of Singapore's oldest water treatment plants, built in two phases, in 1975 and 1981. It underwent a three-year upgrade in 2016, to enhance the robustness of its water treatment processes by deploying cutting-edge ceramic membrane technology. The large-scale deployment of the ceramic membrane technology at CCKWW was the result of years of research and rigorous testing.

Today, CCKWW houses a large scale, 40 million gallons per day (mgd) ceramic membrane system,

With PUB's awards at the IWA World Congress & Exhibition are, from left, Dr Pang Chee Meng, Chief Engineering and Technology Officer; Chew Chee Keong, Director, Water Supply (Plants) Department; and Bernard Koh, Assistant Chief Executive of PUB.

with ozone-biological activated carbon (Ozone-BAC) filters added to strengthen the disinfection and treatment process. With this system in place, the plant can carry out advanced treatment of raw water in a more efficient manner, while occupying a smaller footprint. It also allows PUB to cope with the impact of an increasingly urbanised catchment and the effects of climate change on raw water quality.

Ceramic membranes are also more cost-efficient, with a longer lifespan of 20 years, as compared to polymeric membranes which are usually replaced about once every five years. Water loss is reduced significantly from 5% to 1%, with the use of ceramic membranes.

Singapore's first dual-mode desalination plant

Opened in February 2021, KMEDP is Singapore's fourth desalination plant, and also the first large-scale, dual-mode desalination plant. It can produce up to 30 million gallons of fresh drinking water per day, by treating either seawater or freshwater, depending on the prevailing weather conditions, thus strengthening Singapore's water supply resilience.

The entire water treatment facility and pumping station are located underground, freeing up the space above, for social recreation. There is nearly 20,000 m² of open, green rooftop space for community activity and recreation, seamlessly integrated with the surrounding greenery. KMEDP is operated by Marina East Water Pte Ltd, a wholly owned subsidiary of Keppel Infrastructure, under the Design, Build, Own and Operate (DBOO) arrangement with PUB.

Digital twin platform to improve plant operations

In 2019, PUB and Jacobs Engineering Group jointly developed a digital twin for CWRP as a dynamic simulation model, with predictive capabilities to analyse the impact of operational changes on plant performance, without affecting actual plant operations. The digital twin replicates the plant's processes, retrieves real-time data for processing, analyses the information and feeds it into the digital twin to simulate real operations of the entire plant. By doing so, it can alert operators to irregularities in plant performance and enhance the operational resilience resilience at CWRP. It can also be used for operator training, and scenario planning, to safely evaluate operating strategies before implementing them.

Enabling structural engineers and designers to transfer data easily

Hilti North America, a global leader providing innovative tools, technology, software, and services to the commercial construction industry has integrated its PROFIS Engineering Suite with Bentley Systems' RAM Structural System, a structural design software for buildings.

PROFIS Engineering Suite, a user-friendly, cloud-based application helps handle the calculations and analysis of the different elements of a steel-to-concrete connection, including base plate and anchors, with easier iteration and thorough documentation. Now, PROFIS Engineering and RAM Structural System will be able to work together to streamline the workflow and help simplify the base plate anchor design process.

Users can leverage the integration of RAM Structural System with the design power of PROFIS Engineering to easily import, design, and export anchor and base plate designs, while ensuring accuracy and maximum productivity. PROFIS Engineering can receive all the information needed for baseplate and connection design, with a few short clicks.

"Our customers have requested integrations between their structural analysis software and PROFIS Engineering to increase user productivity while ensuring accuracy of their design", said David Crawford, Director of Technical Marketing and Application Solutions at Hilti North America.

"At Bentley, we are always looking for ways to increase our users' engineering productivity and accuracy", said Josh Taylor, Senior Director of Structural Product Management at Bentley Systems.

Aurecon to expand footprint in Asia with key appointment

Dr Olivier Petit

International design, engineering and advisory company, Aurecon, has appointed Dr Olivier Petit as its new Managing Director, Growth and Strategy, Asia, effective 12 August 2022. Dr Petit will be based in Hong Kong and will report directly to Mr Stephane Asselin, Chief Executive, Asia, at Aurecon.

Dr Petit brings over 20 years of international experience in Mergers and Acquisitions (M&As), business integration, growth strategy development and implementation, as well as operations and management. Having worked in Asia and the Middle East for the majority of his career, his intimate understanding of local, regional and global markets will be instrumental in driving Aurecon's growth in Asia.

He will be responsible for advancing Aurecon's strategic agenda and spearheading new initiatives and areas of business growth. This includes expanding into new countries, markets and business lines, as well as identifying and structuring opportunities for strategic partnerships and M&As.

Before joining Aurecon, Dr Petit was the Strategic Initiative Director, Asia Pacific, at Egis. During his tenure, he led Egis' M&A strategy to grow the company's footprint and operations across the Asia Pacific. He also expanded Egis' regional business in the Middle East and helped to shape many iconic projects there.

Dr Petit was the Lead Master Urban Planner and Acting Project Director for Qatar's Economic Zone 3 – about 4,000 ha combining residential areas, a port and industrial zones; and managed the Green Riyadh project – a 10 million tree planting and irrigation network with a budget reaching US$ 10 billion over 10 years, in Riyadh, Saudi Arabia. In the early stages of his career, he held several leadership positions at Saman Corporation in South Korea and Algeria, as well as at Danu Architects & Engineers.

Dr Petit holds a Doctor of Philosophy (PhD) in Urban Planning and Architecture from the University of Paris 8, France; and Masters' degrees in Urban Planning, from the University of Bordeaux, France and in Political Science, from the University of Bordeaux 1, France. A native French speaker, he is also fluent in English and proficient in German and Korean.

Aurecon strengthens underground engineering expertise in Singapore

Mr Marcus Tong

Aurecon has appointed Mr Marcus Tong as its new Technical Director, Geotechnical, for Singapore.

With limited land area, Singapore's underground space is a valuable resource and holds immense potential to further optimise land use and provide capacity for future needs.

The appointment of Mr Tong is in line with the Aurecon's Asia growth strategy and positions the company well, in its efforts to pursue opportunities in the infrastructure space.

Based in Singapore, he will report directly to Mr Keith Leung, Director, Major Projects and Pursuits, Asia, who is currently leading Aurecon's Transport, Land and Water operations in Singapore.

A highly regarded civil engineer, Mr Tong has over 20 years of experience in large-scale underground-related works, in Singapore and overseas. He has been extensively involved in numerous major infrastructure projects including Singapore's Cross Island Line, Thomson-East Coast Line, Downtown Line, Circle Line, Kallang-Paya Lebar Expressway, Changi Airport Inter-Terminals and Intra-Terminals (Megaspine) Tunnels, PUB Deep Tunnel Sewerage System Phase 2 Tunnels and Sewer Projects, JTC Bulim Phase 1 Dedicated Logistics Network Tunnel, Singapore Power Cable Tunnels, Klang Valley MRT Line 1 and 2 in Malaysia, Shatin-Central Link Diamond Hill Station in Hong Kong, as well as the Delhi Metro and Kolkata Metro projects in India.

He also brings to Aurecon a distinctive skillset, given his specialist experience in tunnel segmental lining design and mined tunnel design, especially in soft ground and under both normal and seismic conditions. He will be responsible for enhancing the firm's underground engineering capabilities, delivering innovative solutions for major and complex projects, and for new business growth.

Prior to joining Aurecon, Mr Tong was Director (Underground Development) at Surbana Jurong Consultants Pte Ltd, and also served in a leadership role at Amberg & TTI Engineering Pte Ltd.

Mr Tong holds a Bachelor of Engineering (Civil) (First Class Honours) degree, with a minor in Business from the Nanyang Technological University, Singapore, and a Master of Science (Civil Engineering) degree from the National University of Singapore, where he was the top graduate of his cohort in geotechnical modules. Mr Tong is a registered Professional Engineer in both Civil and Geotechnical Engineering in Singapore.

The meeting point for the world's construction industry

Organised by Messe München, bauma 2022, the World's Leading Trade Fair for Construction Machinery, Building Material Machines, Mining Machines, Construction Vehicles and Construction Equipment, will be held from 24 to 30 October 2022, at the exhibition grounds in Munich, Germany.

This year, in addition to the exhibitors and their exhibits, the event will offer a comprehensive supporting programme, as in previous editions.

bauma FORUM

This year, the bauma FORUM, with lectures, presentations and panel discussions, will held, from 24 to 28 October, at a new, central location in the bauma Innovation Hall LABO. The Innovation Hall is located in the Internationales Congress Center München (ICM). The forum will focus on a different key topic of bauma each day. These range from 'Construction methods and materials of tomorrow' to 'Mining – sustainable, efficient and reliable' and to 'The road to zero emissions'.

On 24 October, the winners in the five categories of the bauma Innovation Award 2022 will also be presented at the forum. With this prize, the VDMA (Mechanical Engineering Industry Association), Messe München and the top associations of the German construction industry will honour research and development teams from companies and universities that are bringing practical leading technology for the construction, building materials and mining industry to market readiness. The prize winners have an equal focus on resources, the environment and people.

Science Hub and Start-up Area

The Science Hub is located right next to the forum. In this area, 10 universities and scientific institutes will provide information on the latest status of their research. Another segment at the Innovation Hall is the revitalised Start-up Area, where promising young companies can present themselves to a specialist audience.

At bauma 2022, the VR experience will switch focus to the digitisation of construction sites.

An initiative of the VDMA and Messe München, THINK BIG! is primarily aimed at students.

MiC 4.0 stand demonstrates new data interfaces

In order to develop a uniform, cross-manufacturer and machinery-independent communications form for the entire construction process, the VDMA and the Main Association of the German Construction Industry founded the 'Machines in Construction 4.0' (MiC 4.0) working group at bauma 2019. One of the previous results is the MiC 4.0 Bus which is an open, cross-manufacturer data interface between construction machinery and accessory equipment.

At the MiC 4.0 stand in the LAB0 Innovation Hall, visitors can see a demonstration of the new interface in action.

Visitors to the Virtual Reality (VR) experience can immerse themselves in the construction sites of today and of tomorrow, and experience the interactions between people and machines, for themselves, in the digital space. The bauma VR experience will once again be part of the LAB0 Innovation Hall this year.

Career prospects for young people

'THINK BIG!' – an initiative of the VDMA and Messe München – is primarily aimed at students. In the ICM, companies will present 'Technology up close' with a large workshop show, hands-on activities, games and information about a future career in the industry.

First high-rise building project in Singapore to integrate Mass Engineered Timber with concrete

The Eunoia Junior College project was recognised at the BCA Design Engineering and Safety Award 2021 and recently won the inaugural BCA Built Environment Transformation Award, for the innovative and sustainable solutions deployed.

An exterior view of Eunoia Junior College.

The Eunoia Junior College (EJC) project exemplifies integration and intensification in the creation of an environment that meets the learning as well as recreational needs of the students.

EJC comprises a 10- and 12-storey building, with a five-storey high, elevated running track and field, located next to Kallang River.

Overlooking Bishan-Ang Mo Kio Park and located within close proximity to both Bishan and Ang Mo Kio estates, the 51,000 m² EJC takes on the enhanced role of an educational institute that plugs itself into the community.

The architectural and engineering design, as well as the construction of the project presented novel challenges.

Firstly, the site area of 4 hectares is about a third of the conventional site area for junior colleges. Secondly, an elevated running track and field had to be designed and constructed over the future Cross Island Line Rail tunnels, and overhanging the Kallang River, with three mega tree columns sitting in the river.

The interior of a classroom. Using Mass Engineered Timber improved buildability and contributes to environmental sustainability.

RECOGNITION FOR ENGINEERING AND SAFETY EXCELLENCE

For her innovative solutions adopted in the construction of EJC, Er. Joanne Ee, formerly from CPG Consultants Pte Ltd and currently with BCA, was selected as one of three winners of the BCA Design Engineering and Safety 'Excellence' Awards 2021, with recognition received under the Institutional and Industrial Category. EJC is the first project to integrate Mass Engineered Timber (MET) with concrete, for a high-rise building in Singapore. The project implemented the use of a prefabricated hybrid timber-concrete slab system (CREE) for slab construction and a unitised façade system with internal Cross Laminated Timber (CLT) panels for external walls. As CLT panels have a lower carbon footprint compared to steel or concrete, the project's environment-friendliness was enhanced.

In addition, with 70% of the project being prefabricated prior to installation, productivity was increased by 55%, reducing the overall construction period. By relying on prefabrication, with work done off-site, there was also a reduction in disamenities, in the form of reduced disturbance to the project's surroundings including the nearby Bishan-Ang Mo Kio Park. The prefabricated components were installed on-site with simple connections and were lightweight, environmentally sustainable and met all requirements for strength, fire-resistance, waterproofing and durability.

HIGHLIGHTS OF THE ENGINEERING DESIGN AND CONSTRUCTION

Prefabricated hybrid timber-concrete slab system

CREE is a hybrid timber-concrete slab system, consisting of Glued Laminated Timber (commonly known as Glulam) beams and concrete slab, which are prefabricated off-site. The prefabricated panels for the EJC project measured 2.6 m (width) by 7.06 m (length), to suit the site conditions. It comprised four 240 mm by 320 mm Glulam beams with an 80 mm thick reinforced concrete slab. There

Prefabricated hybrid timber-concrete slab system (CREE).

were eight pre-cut grooves on each Glulam beam to allow bonding between the Glulam beams and the concrete slab, so that the system behaves as a composite slab.

The Glulam was made of spruce and manufactured in Germany, with a service class of SC2 and a strength class of GL24. The building structure was designed according to British Standards / European Norms BS EN 1995-1-1 & 1995-1-2 and National Annex.

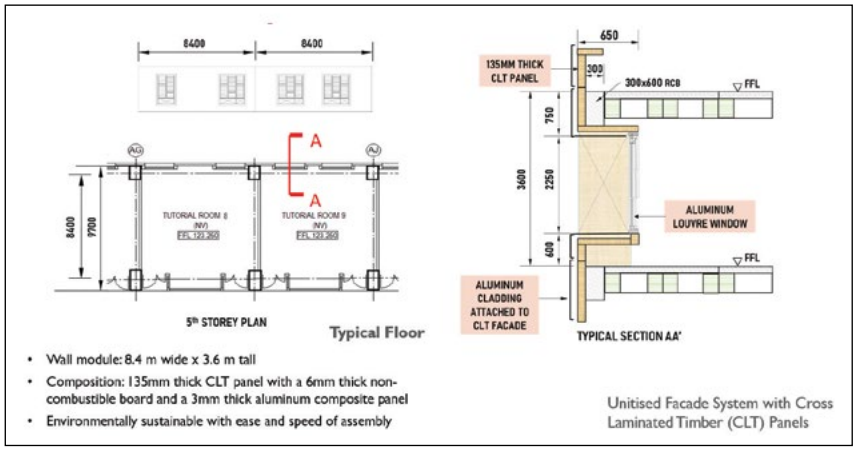
The design approach sought to consider the timber-concrete composite concept, where the formulation of the EI (Engineering Intent) was carried out under BS EN 1995 Annex B. The hybrid slab was designed, following the required partial factors, as specified in SS EN 1991 for Ultimate Limit State (ULS), Fire Limit State (FLS) and Serviceability Limit State (SLS). Both short-term and long-term effects were evaluated, based on the linear stress-strain behaviour, and the peak stresses for the concrete and timber were designed as per the respective Eurocodes. At the groove location, the mechanical joint was designed, based on specialist literature by Professor Schonborn, on the four possible failure modes. SLS checks, which consider the composite stiffness for deflection and vibration control, were designed, based on specialist literature by Patricia Hamm.

To confirm the design assumptions, parameters used and the predicted behaviour, the composite slab was sent for laboratory testing. The slab panel was subjected to uniform load bending tests, with the results used to verify the performance, such as the strength, timber-concrete composite action and the effectiveness of the groove connection. The test specimen was subjected to three cycles of loading and unloading, with the loading, in the last cycle, of up to 2.5 times the service superimposed design load.

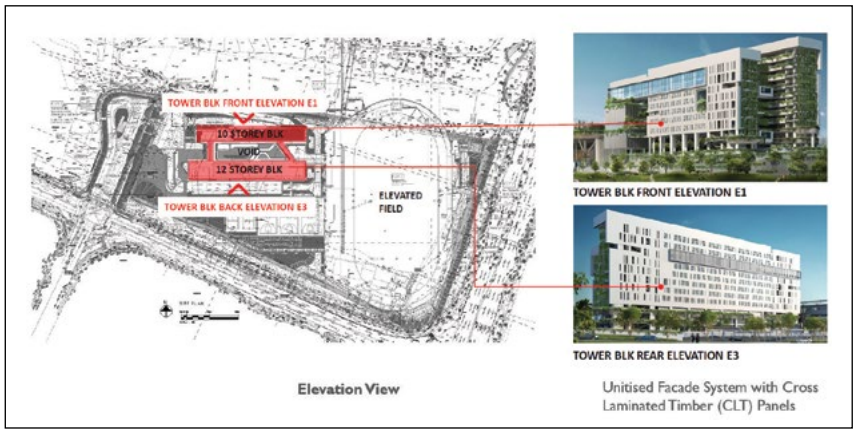
After the last cycle, hairline cracks were observed on the grooves, but with no sign of failure due to debonding from the mechanical joint. A comparison of deflection in the three cycles indicated that the variation between theoretical values and measured values was approximately 19%. The test confirmed the design assumption for the composite behaviour of the panel.

Unitised facade system with internal Cross Laminated Timber panels for external walls

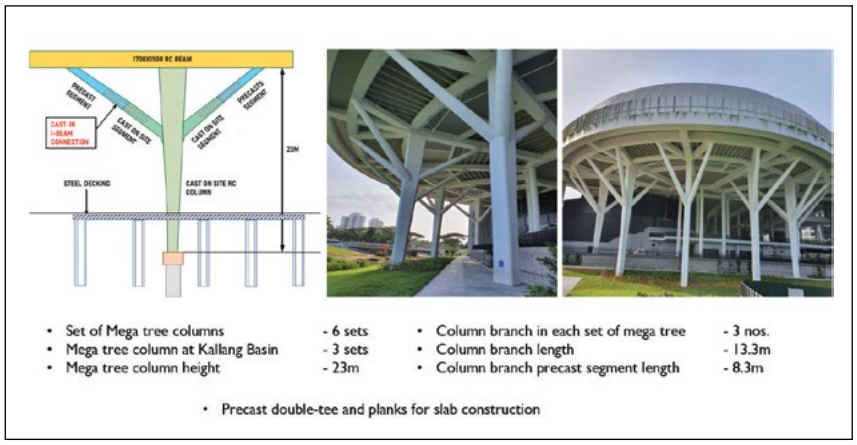
A unitised facade system was used on the external-facing elevation of the teaching blocks. The prefabricated wall panel came in a module, measuring 8.4 m (width) by 3.6 m (height). The exterior face of the wall panel consisted of a 135 mm thick Cross Laminated Timber (CLT) panel, with a 6 mm thick non-combustible board and a 3 mm thick aluminum composite panel anchored onto the structural frame of the building. The CLT panel was made of prefabricated elements on which fire-retardant coating and waterproofing membrane were pre-assembled. This solution met the need for environmental sustainability, as well as ease and speed of assembly,



Unitised façade system with CLT panels (plan).



Unitised Façade System with CLT panels (elevation).



The completed mega tree columns.

which allowed works to take place internally, without the need for external scaffolding.

The details dealt with the connection to the supporting structure frame and met the specific performance requirements, in terms of fire, waterproofing for protection against external elements, and durability. In particular, for durability, dynamic thermo-hygrometric analysis was carried out using the software, WuFi, which has the capability to highlight the behaviour of the CLT panel even under extreme, equatorial climatic conditions, to confirm that the CLT panel would not present any issues, in the long run.

Additional sprinklers were installed on the external classroom windows, to further strengthen fire safety. Fibreboard, 12 mm thick, with fire seals, were also installed on all joints between the floors, to prevent fire from spreading vertically.

CPG Consultants also worked with the contractor to conduct training sessions with the maintenance team, on proper repair and maintenance management, which included the provision of a set of specifications and instructional kits on maintaining the unitised facade system, to ensure long-term sustainability.

Precast branch columns with cast-in I-beam for mega tree columns

There are six sets of mega tree columns, with three sets in the Kallang River. The mega tree columns are 23 m tall and extends below the underside of the elevated deck. They are tapered, from 1.3 m square, at the base, to 1.3 m wide by 2.7 m deep, at the crown. Each column holds three column branches, each of which is 13.3 m in length.

Each column branch is divided into two segments – the precast segment, 8.3 m long, and the cast on-site segment, 5 m long. A cast-in I-beam joins the two segments with a bolted connection. After the I-beams were bolted together, the joint was cast for completion. A metal mould was used for producing the joint. The mould can be reused after each cast, to reduce wastage on formwork.

The completion of a set of mega tree columns was followed by the construction of the reinforced concrete beams and installation of the precast slab for the deck.

Digitalisation

In line with the Building and Construction Authority's (BCA) initiatives to promote digital transformation, CPG Consultants adopted BIM from the start of the project. The team used Autodesk Revit, for modelling, and Navisworks, for clash detection. The adoption of BIM helped the team to better understand the building, as it offered a realistic visualisation and better coordination among the multidisciplinary experts, such as the Architects, C&S Engineers, and MEP Engineers.

The elevated running track and field.

Since the commencement of the construction works, the team worked closely with the contractor and subcontractors. The contractor, Kimly Construction, adopted Virtual Design and Construction (VDC), using Revit for detail coordination; optimised the construction process; and tracked construction progress. This allowed the BIM model to be taken from design into construction layout, directly, and collaboration started in a relatively short time.

The adoption of VDC helped the team to obtain a clearer picture of the project and optimise the construction process involving both prefabricated elements and cast in-situ elements, which greatly enhanced the smooth delivery of the building construction.

High percentage of prefabrication

From the start of the project, the structural design planned on utilising a high percentage of prefabrication to achieve a high speed of construction, a high degree of mechanisation and a minimum of on-site work. To meet CPG's design vision of creating column-free spaces with spans of 12 m, the design adopted a mix of prefabricated and post-tensioned materials.

To achieve a high speed of assembly and reduce wastage, the team adopted prefabricated precast beams, columns and walls, a hybrid timber-concrete slab system for slab construction, and a unitised facade system with internal Cross Laminated Timber (CLT) which formed the external walls for the teaching blocks. This also allowed works to take place internally without external scaffolds.

For the long-span, elevated field, the design adopted precast double-tee slabs/precast planks with precast half-shell post-tensioned beams. The design eliminated the formwork required to support the slabs and reduced a significant amount of falsework for the slabs. In addition, work on the lower floors could proceed, once the slabs covered the area. Propped, precast, half-shell, post-tensioned beams helped to reduce the side and bottom formwork required, thus reducing the time needed for the beam construction.

Combining precast with steel construction, the team devised precast, with cast-in I-beam, branch column segments for constructing mega tree columns. This simplified the construction process and reduced the quantity of falsework and wastage on formwork.

The project achieved 70% of prefabrication, resulting in increased productivity of 55%.

PROJECT CREDITS

Project
Eunoia Junior College

Developer
Ministry of Education

Qualified Person
Er. Ee Hwee San Joanne

C&S Consultants
CPG Consultants Pte Ltd

Builder
Kimly Construction Pte Ltd

Architectural Consultants
CPG Consultants Pte Ltd

M&E Consultants
CPG Consultants Pte Ltd

ESD Consultant
CPG Consultants Pte Ltd

EJC wins BE Transformation Award 2022

Eunoia Junior College (EJC) was one of four winners of the inaugural BCA Built Environment Transformation Award (BE Transformation Award). The award accords recognition to building projects that demonstrate commitment towards transformation.

The objective of the award is to spur firms to attain high standards in sustainability, productivity, digitalisation, and other attributes that support capability building, workforce development, innovation and resilience, as aligned to the Built Environment Industry Transformation Map (ITM).

All images by CPG Consultants Pte Ltd

Projects honoured for commitment towards attaining high standards

Awards were presented under four categories.

The inaugural Built Environment Transformation Award (BE Transformation Award) accords recognition to building projects that demonstrate commitment towards transformation. The objective of the award is to spur firms to attain high standards in sustainability, productivity, digitalisation, and other attributes that support capability building, workforce development, innovation and resilience, as aligned to the Built Environment Industry Transformation Map (BE ITM).

The winners of the inaugural BE Transformation Award are The Tapestry, in the Residential Category, PSA Liveable City, in the Commercial / Mixed Development Category, JTC's 1 & 7 North Coast, in the Industrial Category, and Eunoia Junior College, in the Institutional Category.

The Tapestry

(Winner – Residential)

The Tapestry

Project	The Tapestry
Developer	Bellevue Properties Pte Ltd (CDL)
Builder	Woh Hup (Pte) Ltd
Architect	ADDP Architects LLP
C&S Consultant	P&T Consultants Pte Ltd
M&E Consultant	Belmacs Pte Ltd
ESD Consultant	Building System and Diagnostics Pte Ltd

Project Features

- The project adopted Prefabricated Prefinished Volumetric Construction (PPVC) and, as a result, it was possible to achieve 50% productivity improvement over 2010 levels.
- The project team has also delivered outstanding Quality results, as seen by their Quality Mark (Star) and CONQUAS (Star) achievements.
- The project achieved a Green Mark Platinum rating.

Strong sustained partnerships

- Project owner CDL played a key part in kick starting builder Woh Hup's PPVC journey through this project despite the latter having no track record in the use of PPVC, at the time of the project.
- CDL recognised the challenges for contractors to climb the PPVC value chain and provided strong support to Woh Hup. One of the measures taken included going beyond the conventional construction payment method. CDL worked with Woh Hup to develop an advance payment scheme for off-site PPVC modules and fitting of modules, both of which were very capital-intensive. Both parties then worked closely to coordinate works, especially during the challenging COVID-19 period, to maintain their workforce while building up the team's capabilities.
- CDL recognised Woh Hup's PPVC capabilities through the collaboration on The Tapestry and this has led to more partnerships in PPVC projects including Whistler Grand, Irwell Hill Residences, and Tengah Garden Walk EC, where they employed productive construction methods including Integrated Digital Delivery (IDD), by designing and planning digitally before actual construction. This has helped to reduce cost and abortive works as revisions are clarified at the digital stage.

Good Workforce Development

- Upskilling staff and actively bringing new talent to the industry.

  - Mr Leong Ju Hua, who interned with Woh Hup during his undergraduate days, joined Woh Hup as a site engineer upon graduation. While on board the project, he was given the opportunity to take charge of several blocks. He was instrumental in assisting the Project Manager with many aspects of the site's progress and delivering the project to the client. With proper on-the-job-training, Mr Leong matured and excelled, working his way up to the position of Project Manager by the time the project was completed. He is now working on another PPVC project in Jiak Kim Road / Irwell Bank Road.

  - Mr Kelvin Lee from ADDP Architects was given the opportunity to learn DfMA technologies and IDD implementation throughout the life cycle of this project, together with the project stakeholders. He also submitted his Professional Practice Examination (PPE) case study using The Tapestry, under direct supervision of his senior in the office. He is appreciative of ADDP's support through guidance and advice for his PPE. He was also given the opportunity to lead the project throughout the construction period. He is currently working on another PPVC project by CDL.

- Woh Hup is the recipient of the Best Employer Award in 2020 & 2021 (Kinetic) and 2021 & 2022 (The Straits Times), a recognition of the company's good HR practices.
- Woh Hup is supportive of scholarship programmes to bring local

talent on board the industry. For example, Woh Hup supported 36 students under BCA-Industry Built Environment Undergraduate Scholarship since its formation in 1993, and further supported four students under the BCA-Industry Built Environment ITE/Diploma Scholarship since 2012. In 2017, BCA-Woh Hup iBuildSG Undergraduate Scholarship was established and the company has supported 14 students under this programme.

- As digital tools were used, Woh Hup provided hands-on training for its subcontractors to upskill their BIM capabilities. Levelling up the subcontractors meant that the company would have a steady, competent workforce for future projects, as the industry moves towards digitalisation.

PSA Liveable City

(Winner – Commercial / Mixed Development)

Project	PSA Liveable City
Developer	PSA Corporation Limited
Builder	Lum Chang Building Contractors Pte Ltd
Architect	DCA Architects Pte Ltd
C&S Consultant	RSP Architects Planners and Engineers Pte Ltd
M&E Consultant	Surbana Jurong Consultants Pte Ltd
ESD Consultant	Surbana Jurong Consultants Pte Ltd

Project features

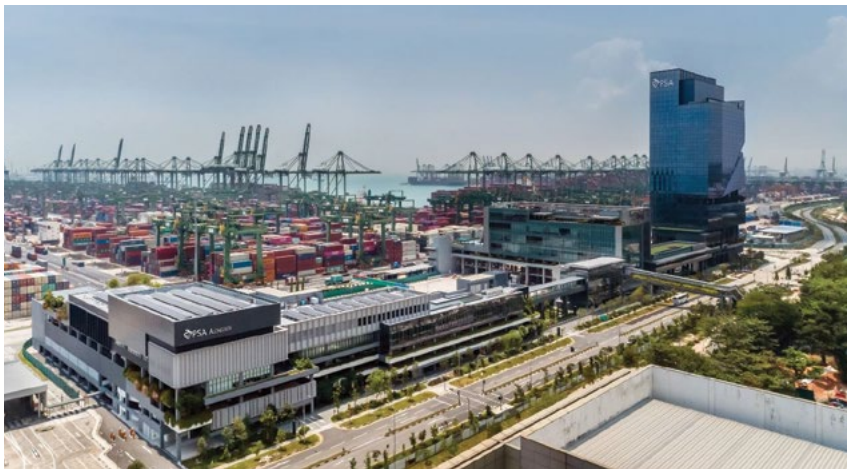
- The project attained the Green Mark Platinum rating and put in place an Integrated Building Management System (iBMS) and Integrated Energy Management System (iEMS) to improve operational efficiency.
- Through the use of iBMS, the team noted a 30% reduction in chiller plant energy consumption and 60.9% reduction in Air Handling Unit energy consumption. There were also productivity improvements of 93.7% and 75% for power and water consumption monitoring, respectively, through digital meter interfacing. Additionally, the team observed a 33.3% manpower productivity improvement for lighting management via a centralised monitoring device at each floor.
- With the iEMS, the team expects a further 3.5% reduction in energy consumption by the chiller plant and 12.5% improvement in manpower productivity.

Extensive use of digitalisation and technology to improve productivity

- Successful use of Common Data Environment (CDE) platforms and structured data standard setup to facilitate data sharing and cross-disciplinary collaboration. With improved coordination between project team members, the team was able to identify issues in the design phase and improve productivity.
- These data-sharing ecosystems create value as multi-disciplinary project team members can easily access project data through their smart devices, allowing the multiple stakeholders to streamline workflow, collaborate on designs in real-time and improve decision-making.
- Utilisation of drones for on-site surveillance, site safety monitoring and real-time façade inspection improved site safety monitoring by 45% and reduced the facade inspection man-hours needed from 60 to 20.

Good Workforce Development

- DCA Architects and builder Lum Chang are committed to upskilling and deepening knowledge of their staff in Industry Transformation and in leadership.
- For example, DCA practices regular check-ins with staff to identify skills gaps, as well as invests in career development programmes to support individual learning paths and promote a culture of lifelong learning, such as acquisition of professional qualifications and accreditation, training programmes, and certification courses. About 40% of architects and 20% of BIM modellers in the firm took on new BIM / REVIT certifications between 2019 to 2021. Additionally, the firm frequently partners BCA on Industry Transformation-related programmes and holds IDD sharing sessions.
- Lum Chang has in place key competency development framework for their engineers, quantity surveyors, and BIM modellers, to help guide and chart out the career progression of staff.
- Lum Chang has participated in the iBuildSG Scholarship and Sponsorship Programmes since 2014, with 24 recipients having benefitted. There are currently 13 CONQUAS specialists, and plans are in place to send 17 more staff to attain the CONQUAS certification. Lum Chang has also identified 21 qualified staff to undergo the Construction Professional Accreditation Scheme (CPAS) to further their progress over time.



PSA Liveable City

- DCA Architects and Lum Chang have been consistent in their talent-attracting efforts. In DCA's case, the company sponsored 14 scholarship recipients since 2013 under the iBuildSG Undergraduate Scholarship and Sponsorship programme. The company also engages in direct mentorship for promising staff to push their careers forward.
- DCA also establishes meaningful partnerships with key stakeholder groups such as youth groups, for engagement sessions. DCA provides sponsorships for various programmes, such the Graduation Prize Sponsorship for Sustainable Urban Design & Engineering with Ngee Ann Polytechnic. It also provides internship opportunities for polytechnic students, to develop the interest of youths in BE areas and careers.
- In addition, the company has internal initiatives to boost staff welfare and morale, including implementing a flexi-hours work schedule, pushing the work-from-home culture for non-operational staff and measuring staff performance by their quality of work and efficiency, rather than the total hours spent at work. This encourages a fair evaluation of performance and is better for employees. Office furniture was upgraded to improve the physical health of staff. Lum Chang also took efforts to ensure wages remain competitive to attract and retain talent.

JTC's Developments in Woodlands North Coast - 1 & 7 North Coast

(Winner – Industrial)

Project	1 & 7 North Coast
Developer	JTC
Builder	Lum Chang Building Contractors Pte Ltd
Architect	Aedas Pte Ltd
C&S Consultant	Arup Singapore Pte Ltd
M&E Consultant	WSP Consultancy Services Pte Ltd
ESD Consultant	Arup Singapore Pte Ltd

Woodlands North Coast (WNC)

- Singapore's new-generation work-live-play-learn mixed-use industrial estate comprising offices, business park, industrial facilities and residences.
- Vibrant ecosystem of global and local SME manufacturers, academia and R&D institutions, where ideas and technology are developed, prototyped, test-bedded and commercialised.
- 1 North Coast is a nine-storey, light industrial building that offers first-of-its-kind flexible space usage, allowing businesses to house non-industrial functions and manufacturing operations under one roof.
- 7 North Coast is an eight-storey building for general manufacturing and generic industrial uses.

Use of digitalisation and technology to improve productivity

- Both buildings adopted extensive use of digitalisation and technology such as IDD and a Common Data Environment (CDE) platform, to improve overall productivity through data sharing and cross-disciplinary collaboration.
- Successful use of CDE platform, FulcrumHQ, and structured data standard setup, to facilitate data sharing and cross-disciplinary collaboration.
- Extensive use of Integrated Digital Delivery (IDD) powered by FulcrumHQ, for process integration from design to asset delivery and management.
- Developed new BIM processes to integrate 3D model and cost-estimating software, CostX, for automated generation of progress payments. The 3D CostX model allows the whole project value chain to be visually verified and the work evaluated, simultaneously, as opposed to verification from hardcopy prints in a traditional submission.
- Implementation of the 5D Progress Claim to achieve an improvement of 34% in resource management.

Design for Maintainability

Through a collaborative design approach, by involving the facilities management practitioners upstream, the team identified potential maintenance issues at the design phase, which could be resolved, thereby ensuring ease of maintenance, after construction. For example, there is an access route for the entire building façade, for ease of maintenance in future. Also, sturdier materials have been used for outdoor furniture.

Strong partnership across the entire value-chain

- The builder co-developed solutions with its value-chain, to incorporate better process integration.

  - For example, the rebar supplier leveraged BIM to generate a bar bending schedule (BBS) which was suitable for immediate use on the company's Computer Numerical Control (CNC) machine. This significantly increased

Woodlands North Coast. Artist's impression. Image: JTC.

the productivity, as time was saved during different stages of planning, ordering, fabricating and claiming.

-Using Tekla software, BBS was generated directly from the BIM and sent directly to the supplier for fabrication. This eliminated redundant processes and increased productivity by 30%.

- Various stakeholders in the value-chain were also trained on the adoption of virtual reality, asset management standards and more.

Eunoia Junior College

(Winner – Institutional)

Innovation and Technology

- One of the first movers to adopt Cross Laminated Timber (CLT), Prefinished Modular Façade (assembly is done on site and larger panels can be hoisted by a Tower Crane, thus overall installation productivity is improved) and CREE Hybrid Slab System (lightweight system with the ability to bear heavier loads, and with a low carbon footprint) which enabled the project to achieve a 44% productivity improvement over 2010 levels.

Project	Eunoia Junior College
Developer	Ministry of Education
Builder	Kimly Construction
Architect	CPG Consultants Pte Ltd
C&S Consultant	CPG Consultants Pte Ltd
M&E Consultant	CPG Consultants Pte Ltd
ESD Consultant	CPG Consultants Pte Ltd

- Eunoia Junior College (EJC) is the first high-rise JC in Singapore. During the time of construction, there was no precedent, in terms of fire safety for such high-rise CLT buildings. The team was able to mitigate potential fire safety issues by seeking the approval from SCDF and other authorities for performance-based design of MET (CREE Slab and CLT façade) and conducting real-life performance testing in Singapore. The new technology and collaboration helped the team to learn and will help in the application of the knowledge in future developments.

- Due to the nature of the running track, which is elevated, the team faced challenges to find the best possible solution to build the track. Part of the foundation, located in the Kallang River, was optimised during the construction stage to minimise impact to the biodiversity and minimise disruption to the surrounding users / community.

Eunoia Junior College

Design for Maintainability

- A collaborative design approach, with involvement of FM practitioners upstream, meant that the team could identify and address potential maintainability issues at the design phase, thereby reducing operational challenges in building maintenance after construction. In addition, abortive works downstream were reduced, leading to better overall project management and a higher quality of the end product. This also means improved maintainability and an overall longer lifespan for the building.

Good Workforce Development

- Both Kimly Construction and CPG Consultants have been actively training staff in the areas of Industry Transformation. CPG has a 1-1 IGNITE Coaching Program, which is a six-month talent development programme to groom their talents. Kimly adopts the BE Sector Competency Framework Development and a structured On-the-Job (OJT) blueprint development.

- Both Kimly and CPG are strong advocates in attracting local talents into the construction industry and have participated in various initiatives.

- Kimly was presented with the SkillsFuture Employer Award in 2021. The company is on the SGUnited Traineeships Programme and participated in Career Conversion Programmes.

- In adopting the CREE technology, the team had to make several trips to Austria to learn about the technology which was new to Singapore at the time. The trips were learning experiences, as the team was able to learn about the best practices in MET design/ construction.

- As a result, in addition to the collective knowledge that Kimly learnt from its partners, it is now capable of embracing integrated planning to offer a holistic, natural and simple construction method to all those who want to break new ground in MET construction.

Bentley Systems announces the finalists in the '2022 Going Digital Awards in Infrastructure'

Winners to be announced at an awards ceremony in November.

Bentley Systems Inc, a leading, international infrastructure engineering software company, recently announced the finalists in the 2022 Going Digital Awards in Infrastructure. The annual awards programme honours the work of Bentley software users in advancing infrastructure design, construction, and operations throughout the world. Eleven independent jury panels selected the 36 finalists from over 300 nominations submitted by more than 180 organisations from 47 countries, encompassing 12 categories.

The winners will be revealed on 15 November, during the 2022 Going Digital Awards in Infrastructure celebrations in London, at the Intercontinental Park Lane, in front of invited press members and industry executives.

Mr Nicholas Cumins, Bentley's Chief Operating Officer, said, "After two years of hosting the event virtually, we are excited to reunite in person with the Going Digital Awards' finalists, to celebrate their accomplishments, along with press members and industry analysts. Bentley executives will share insights about digital advancements in infrastructure along with updates on Bentley applications and technology innovations".

THE FINALISTS

BRIDGES AND TUNNELS

- **Ferrovial Construction and Alamo Nex Construction** – IH35 Nex Central Section, San Antonio, Texas, United States
- **Southwest Municipal Engineering Design & Research Institute of China** – In-depth and Collaborative Application of BIM Technology in the Second Section of Chengdu's East-West City Axis, Chengdu, Sichuan, China
- **Zigong Urban Planning and Design Institute Co Ltd** – Section C and D of the Infrastructure Construction Project of City-industry Integration Belt between Fushun County and Rong County of Zigong, Zigong City, Sichuan, China

CONSTRUCTION

- **Acciona** – Safely Removing Dangerous Level Crossings through Digital Construction, Melbourne, Victoria, Australia
- **China Railway 18th Bureau Group Co Ltd** – Application of BIM Technology to Ultra-deep Water Transmission Tunnel in Pearl River Delta, Foshan, Guangdong, China
- **DPR Construction** – RMR 20 Massachusetts Ave, NW Repositioning, Washington D C, United States

ENTERPRISE ENGINEERING

- **Mott MacDonald** – Smart Object Library for the Environment Agency, United Kingdom
- **National Highways** – Complex Infrastructure Programme – A303 ProjectWise and iTwin Deployment Pilot Project, Salisbury - Stonehenge, Wiltshire, United Kingdom
- **WSB** – Digital As-built Proof of Concept, Elk River, Minnesota, United States

FACILITIES, CAMPUSES, AND CITIES

- **Kaunas University of Technology** – Kaunas Digital Twin, Kaunas, Lithuania
- **Kokusai Kogyo Co Ltd** – Project PLATEAU: Japan's Largest 3D City Model Project, Numazu City/Kaga City, Shizuoka Prefecture/Ishikawa Prefecture, Japan
- **Sydney Airport** – Maps@SYD, Sydney, New South Wales, Australia

GEOPROFESSIONAL

- **GHD** – Cressbrook Dam, Toowoomba, Queensland, Australia
- **Mott MacDonald** – Driving Efficiency and Sustainability in Material Reuse through geoBIM, Birmingham, West Midlands, United Kingdom
- **PT Hutama Karya (Persero)** – Semantok Dam Project, Nganjuk, East Java, Indonesia

GRID

- **Essential Energy** – Essential Energy Intelligent Substation Design, Port Macquarie, Australia
- **POWERCHINA Hubei Electric Engineering Co Ltd** – Full Life-cycle Digital Application in Wuhan Xudong 220 kV Substation Project, Wuhan, Hubei, China
- **State Grid Hengshui Electric Power Supply Company** – Comprehensive Application of BIM Technology for Power Transmission and Transformation Engineering Construction, Hengshui, Hebei, China

PROCESS AND POWER GENERATION

- **OQ Upstream** – OQ Asset Reliability Digitalization with Purpose, Oman
- Sarawak Energy Berhad – Modernizing Bakun Hydroelectric Plant with a Digital Twin, Bintulu, Sarawak, Malaysia
- **Shell Projects and Technology** – Deepwater Project Delivery Digital Platform, Gulf of Mexico, Texas, United States

RAIL AND TRANSIT

- **Arcadis** – Carstairs, Scotland, United Kingdom

- **Metro Manila Subway Project (MMSP) - Phase 1** – Metro Manila Subway Project (MMSP) - Phase 1, Metro Manila, Philippines
- **PT Wijaya Karya (Persero) Tbk** – Integrated High-speed Rail & Station Jakarta – Bandung, Jakarta - Bandung, Indonesia

ROADS AND HIGHWAYS

- **AFRY** – New Test Track for Autonomous and Electrified Vehicles, Södertälje, Stockholm Area, Sweden
- **Beca Ltd** – Takitimu North Link, Tauranga, Western Bay of Plenty, New Zealand
- **Foth Infrastructure & Environment, LLC** – City of Perry Innovates with Foth Creating a Digitally Mapped City Using Digital Twins, Perry, Iowa, United States

STRUCTURAL ENGINEERING

- **Delhi Metro Rail Corporation Limited** – Design & Construction of Tunnel and Underground Station at Krishna Park of Delhi MRTS, New Delhi, India
- **Sinotech Engineering Consultants Ltd** – TPC Changhua Offshore Wind Farm Phase 2 Project, Changhua County, Taiwan
- **WSP** – Unity Place Delivered with Optimized Design by WSP Using Innovations from Bentley, Milton Keynes, Buckinghamshire, United Kingdom

SURVEYING AND MONITORING

- **Aegea** – Brazil's Largest 3D Sanitation Map (Digitalization of Rio de Janeiro), Rio de Janeiro, Brazil
- **HDR** – Murray Dam Condition Assessment, San Diego County, California, United States
- Singapore Land Authority – SG Digital Twin Empowered by Mobile Mapping, Singapore

WATER AND WASTEWATER

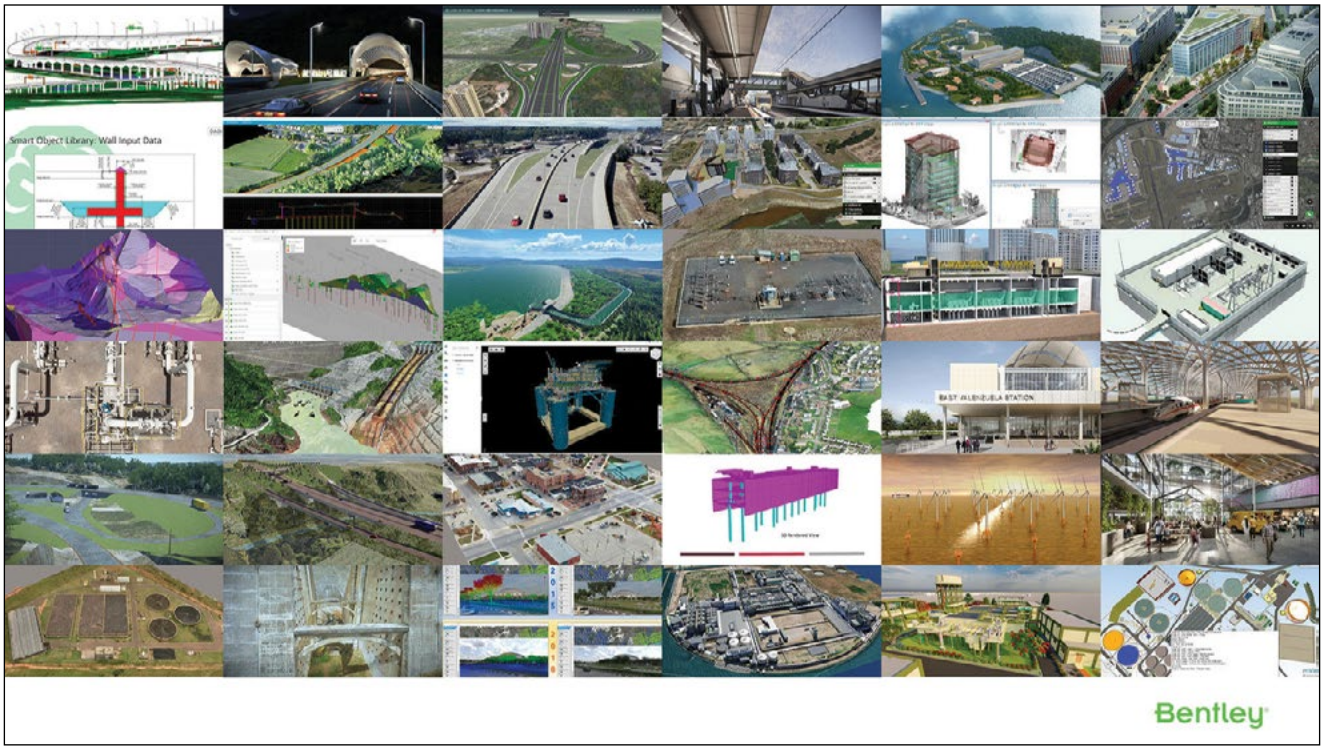
- **Jacobs** – Tuas Water Reclamation Plant (TWRP) for PUB, Singapore's National Water Agency, Singapore
- **L&T Construction** – Utility Development and Management for Nadaprabhu Kempegowda Layout (NPKL), Bangalore, Karnataka, India
- **MWH Treatment, as part of Advance Plus Framework JV with J Murphys & Sons** – Burnley WwTW Capital Investment Project, Burnley, United Kingdom

Bentley Systems

Bentley Systems is an infrastructure engineering software company, providing innovative software to advance the world's infrastructure – sustaining both the global economy and environment.

The company's software solutions are used by professionals, and organisations of every size, for the design, construction, and operations of roads and bridges, rail and transit, water and wastewater, public works and utilities, buildings and campuses, mining, and industrial facilities.

The company's offerings include MicroStation-based applications for modelling and simulation, ProjectWise for project delivery, AssetWise for asset and network performance, Seequent's leading geoprofessional software portfolio, and the iTwin platform for infrastructure digital twins.



Images of the finalists in the 2022 Going Digital Awards in Infrastructure.

Enabling first-ever 3D City Infrastructure Digital Twin Solution for urban India

Several benefits can be expected through various applications.

According to a recent announcement, OpenCities 365, Bentley Systems' infrastructure digital twin solution for cities and campuses, will power the 3D City Digital Twin Solution for Urban India, from Genesys International. This massive mapping and surveying project has begun and will capture most of the urban areas in the country.

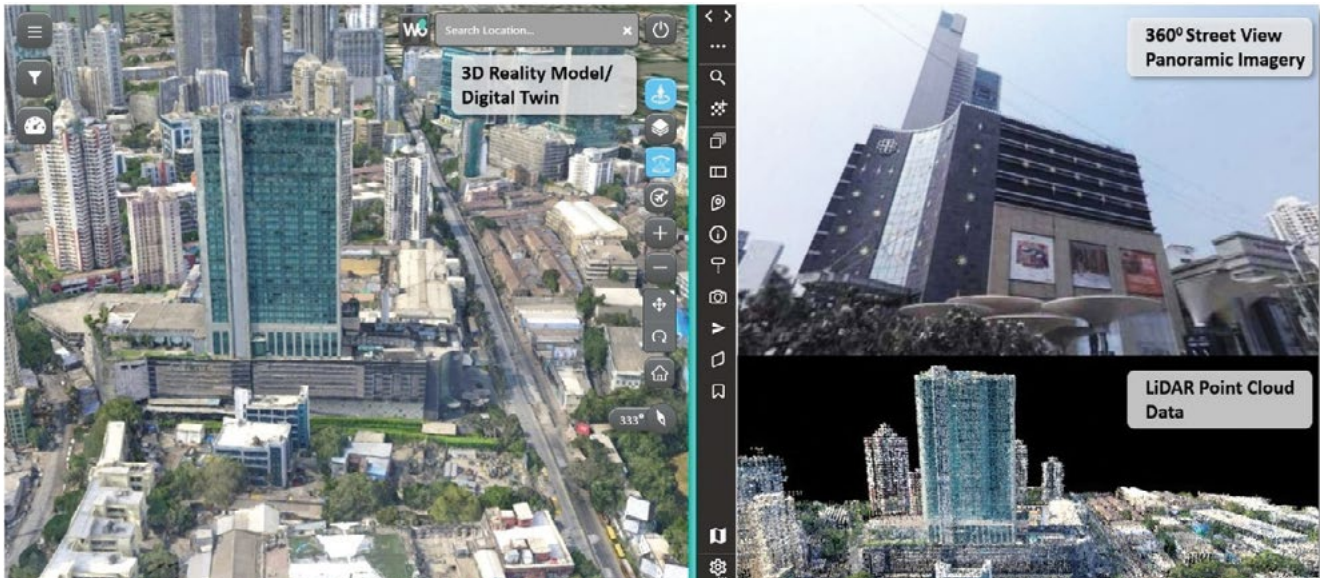
Headquartered in Mumbai, India, Genesys International is a pioneer in advanced mapping and geospatial content services. The company's 3D City Digital Twin Solution for Urban India is said to be the country's first city digital twin project.

Genesys previously partnered with Bentley to successfully pilot an earlier digital twin solution that enabled the smart inventory management of telecom infrastructure, using Bentley's OpenTower iQ software. The robust solution provided operators with accurate and up-to-date information on planning and installing 5G towers, which saved time as well as reduced the cost of conducting labour-intensive tower inspections.

Once a 3D digital twin for each of the cities is ready, engineering and application data layers can be added, based on an end-user's requirements. These 3D city digital twins will enable local governments to improve public services, including urban governance, disaster management, emergency response, and tourism. Additionally, it will help governments deliver more resilient and sustainable environments for their citizens through enhanced urban development; optimised road, rail, utility, and water network upgrades; location-based services; and other smart city initiatives.

On the private corporate front, processes followed in telecommunications and broadband infrastructure, city gas distribution, e-commerce, construction, autonomous navigation, renewable energy and various other verticals will be served and modernised by the 3D digital twins. The openness of Bentley applications provides Genesys further benefit because the software can connect with other asset management systems, such as third-party geospatial information systems, to capture and read that data.

Digital Twin of G South Ward located in Worli, Mumbai, India. Image: Genesys International.



Oyster Maps, Genesys' in-house-developed 3D digital twin platform showcasing multiple datasets in parallel, on a single window. Image: Genesys International.

Benefits of adopting Virtual Design and Construction

Projects can be successfully delivered using cloud-based solutions.

The construction industry has faced disruptions during the COVID-19 lockdowns and continues to face a shortage of labour. To help overcome this, DPR Construction, a general contractor and construction manager is leveraging Virtual Design and Construction (VDC) methods to navigate workflow constraints resulting from disruptions.

VDC, by nature, is extremely compatible with a remote working environment. DPR's teams are virtually building projects using cloud-based solutions like BIM Track and Autodesk BIM 360, in conjunction with web platforms like StructionSite to seamlessly collaborate, share ideas and create content to navigate constraints posed by the disruptions.

VDC services like design coordination are enabled by a data-rich Building Information Model (BIM) and applied design integration processes, which DPR uses to identify and resolve issues before construction begins. In early design phases, better collaboration and information enables project teams to make more informed decisions about design intent and constructability. When issues are addressed at this stage of the project, it leads to better predictability, productivity and quality.

Many assume that design coordination happens by default on projects set up for a high level of collaboration using Integrated Project Delivery or design-build. While it happens more often on these types of projects, silos can still exist in execution. Additionally, throughout the industry, budgets for design integration and preconstruction services are traditionally on the lighter side. At the same time, the construction budgets can be inflated with contingency budgets, mainly due to unforeseen issues that can actually be resolved during the preconstruction phase, without the added cost impact, delays or rework during operations.

Through applications of VDC and clash detection, DPR has identified over thousands of issues, ranging from existing conditions, to design specifications, to maintenance access, to constructability and to traditional trade coordination issues. Using the BIM Track platform, DPR can analyse issues by location, system priority, impact and other sets of criteria, to calculate the priority in which design issues should be addressed and resolved. Assigning and tracking issue accountability for all project team members translates to more agile issue resolution. It also helps to promote 'right behaviours' through the ability to track progress and overall project team performance using data points, such as average time to resolve issues and issue accountability.

With this information, along with historical data about the company's core markets, DPR can inform owners and designers of typical design challenges and equip them with the added knowledge to make better and more informed decisions.

VDC applications

On a recent life sciences project in the US, DPR converted an existing 261,000 ft² office into a multipurpose facility including labs, clean rooms and clinical spaces, over the span of 15 months. The project stipulated liquidated damages which made coordination even more critical to ensuring successful delivery. During the coordination process, more than 2,000 issues were identified and resolved by the project team, resulting in only 150 RFIs (Requests For Information) and no impacts to schedule.

After completing the coordination, DPR reviewed six major roadblocks and assessed the averted impact to the project. The results were dramatic. If not for VDC coordination and early trade engagement, the project would have hit a 14-week delay. When comparing associated costs for the six roadblocks to the cost for coordination services, DPR found a 200% ROI. The benefits of model-based coordination have been fully embraced by the team as a best practice, moving forward.

DPR finds that while more preconstruction budget is needed to properly apply VDC services in the preconstruction phase, rework during physical construction is significantly reduced and project teams can easily recoup the upfront investment. In most cases, the project realises ROIs that generate more than tangible cost savings, as well as qualitative value due to timely coordination efforts.

Likewise, in an ongoing design-to-build project in Singapore, the DPR team is seeing the advantages of using VDC:

- The project's design was completed in VDC, prior to creation of drawings. By doing so, DPR could share information with trade partners more quickly – weeks earlier, as compared to the traditional way of preparing 2D drawings.
- During the tender stage, VDC aided the procurement team in determining the accuracy of trade partner quantity take-offs and assumptions. Normally, it is a challenge to quantify mechanical, electrical and plumbing (MEP) services based on 2D drawings, since these do not show routing and vertical movement of services across floors. If DPR saw major variances, these were highlighted to the trade partner, resulting in lower tender returns.

The installation of rebar cages. Projects can be delivered faster and safer, through the application of prefabrication and VDC, and the utilisation of design resources and strategic partnerships.

- The project had a low floor-to-floor height, with more than nine layers of services that had to be routed within a technical floor. Without VDC, DPR would have needed to factor in tolerance for site installation and not have been able to easily coordinate within the tight ceiling space.
- On a weekly basis, the DPR team uses a LiDAR (Light Detection and Ranging) scanner to capture any services that may not have been installed in the right location. Any deviations are quickly rectified, if needed. If not, the design is quickly amended in the BIM model to notify subsequent installations. This process alone saved the project hundreds of thousands of dollars in possible late rework.

"There is an objective and quantifiable return on investment by using VDC. By making slight adjustments to how the project teams, including owners, designers, contractor and trade partners integrate early, it is possible to influence and mitigate the impact of design changes, later down the road, during construction", said Mr Richard Kimber, Managing Director for Singapore and Southeast Asia, DPR Construction.

Applying elements of a design-to-build approach to project delivery.

DPR Construction

US-headquartered DPR Construction is a general contractor and construction manager, specialising in technically complex and sustainable projects for the advanced technology, life sciences, healthcare, higher education and commercial markets. Its portfolio of work ranges from large-scale new construction to small tenant improvements and special projects. It has leveraged the use of technologies to deliver more predictable outcomes through application of VDC and prefabrication.

DPR's Asia Pacific operations bring global, technical and construction expertise to the region. In Singapore, DPR Asia Pacific is a BCA-registered contractor.

Ensuring successful outcomes

'The Singapore Engineer' finds out more on the application of VDC, from Mr Richard Kimber, Managing Director for Singapore and Southeast Asia, DPR Construction.

Mr Richard Kimber

The Singapore Engineer (TSE): Could you briefly define Virtual Design and Construction (VDC)?

Richard Kimber (RK): Virtual Design & Construction (VDC) is a process focused on using Building Information Models (BIM) to improve the design coordination and building process, through a visual medium. It integrates project information and presents the information in 3D. However, VDC is more than just having a 3D model, it is about combining people, process and tools, to better execute projects.

TSE: What are some of the main advantages gained through the adoption of VDC?

RK: We have an opportunity to ensure quality, schedule and safety, by identifying and removing unknown constraints that typically result in rework, system underperformance, cost overruns and/or schedule delays. When VDC is executed well, we can improve building performance through optimising design and ensuring field installation quality, and also achieve more predictable cost and schedule outcomes for our clients, because we have a digital twin (prototype) that allows us to solve problems before construction.

TSE: In the context of Singapore, what are the main challenges that are hindering the more widespread adoption of VDC?

Firstly, customers are not as familiar with the advantages of VDC and thus are not willing to pay for VDC. Secondly, there are non-collaborative procurement methods being followed. Thirdly, many see VDC as BIM 4D and 5D or a 3D model with additional information on schedule and cost, and not as a framework that provides clear guidelines for the management of multi-disciplinary models in building projects.

TSE: Could you give us an example of a project in Singapore, where the adoption of VDC has produced significant gains?

RK: We have been involved in a biotech manufacturing facility project which is expected to be completed in December 2022. The facility includes a 280,000 ft², steel framed, three-storey main building.

The integrated design delivery (IDD) process ensured that the complex, multi-trade coordination was done, well in advance, and supported critical fabrication and installation milestones. The field installation was therefore productive and efficient. All trade models were completed to Level of Design (LOD) 400 and our onsite VDC team ensured that the field installation was completed as per the coordinated model, by using LiDAR and model comparisons. This has resulted in minimal field discrepancies, thus ensuring that we can achieve our key project schedule milestones.

TSE: Were there interoperability issues among the different software systems used by the different stakeholders?

RK: The team at our biotech manufacturing facility found success in a cloud-hosted solution, BIM 360 Design Collaboration, which supports model hosting, real-time collaboration and agile issue resolution. The interoperability issues of the past are less common now, since platforms like Autodesk Navisworks supports multiple file formats and we can convert files into IFC standard or Revit for easier file federation in BIM 360.

TSE: How would you summarise the application and value of VDC?

RK: Virtual Design & Construction is a 'team sport'. In order to realise the true benefits of VDC, a culture of collaboration and increased trust is needed, from everyone on the project, and support is needed from the client. The timely onboarding of key subcontractors is critical, so that project stakeholders can provide timely input.

This means that we need to onboard certain design-assist partners much earlier in the design process, and establish clear roles and responsibilities, define a design packaging and BIM execution plan, and a VDC execution framework that explains how everyone can contribute to the team. It may sound like more work, but it actually saves work in the field and delivers measurably more value for all project stakeholders.

Design economics of multi-purpose solar highways

by Bob L Y Cheung, Bob Cheung Offshore Consultants

The possibility of creating large sized solar farms above the road network is discussed.

INTRODUCTION

Singapore is a small, well-developed, garden-city-state, located near the equator, with mild and sunny weather, and has one of the highest population densities in the world. Out of the three most common renewable energy sources (solar, wind and wave), solar energy is the only viable option for green energy generation in Singapore. However, being a small country, with 720 km² of land area, it is not possible to find enough space to generate sufficient quantities of green energy to assist energy transition in all sectors, by 2050. Hence, the government initiated a 'four switches' strategy to tackle the energy transition issues [1, 2].

One of the switch targets is to produce 2 GWp (2000 MWp) of solar energy by 2030. In fact, this target represents a small percentage of the energy needed in Singapore. To achieve the goal, the government is building many mini solar farms on roof-tops, and floating solar farms on reservoirs. The first 'large' floating solar farm went into operation last year.

However, to reach the 2 GWp target is not a simple task, due to lack of land space. For example, the floating solar farm on Tengeh reservoir produces only 60 MWp, based on a floating area of 45 football fields, covering almost one-third of the small reservoir, and each HDB block's mini roof-top solar farm usually generates energy in KW rather than MW. It is still a long way to the 2 GWp target.

This leads to one interesting question. Can we overcome the land shortage problem and develop large sized solar farms in Singapore, in a short time-frame? One possible answer is to use the available air space to create 'land space' to build solar farms. It may not be the cheapest solution but it can be done. The idea of creating new space for solar farms is similar to the one proposed by the author in an article published in the May 2020 issue of 'The Singapore Engineer' [3].

The purpose of the current article is to propose a simple lightweight structural system on land, to create a large land space for the development of solar energy. In fact, we plan to make use of the unused air space to build solar farms. We believe that the proposed scheme is buildable in a few years, using a smaller construction workforce, and the project cost is 'reasonable'. As reported by Energy Market Authority (EMA), Singapore reached the 2020 target of producing 350 MWp of solar energy after 10 years [2]. With the additional contribution from the proposed solar highways (solar farm network), the 2030 target can be reached and exceeded far sooner.

LAND SPACE CREATION

Being a small country, land usage is a major issue in Singapore. It is highly unlikely that the government can afford to allocate a large plot of land to build a large solar farm on a long-term basis. For short-term needs, it is not economical to build, dismantle, relocate and re-build a large solar farm in different locations, every few years. However, there are two possible options worthy of careful consideration (using reservoirs and using the existing road network), that may provide the land space needed for the solar farm network. In the case of reservoirs, the government is building small floating solar farms on several reservoirs.

Alternatively, we can build above-water, multi-span, lightweight solar bridge-farms in shallow water depth reservoirs, assuming there is no water seepage after construction. In fact, almost all the reservoirs are in shallow water, that is, their depth is less than 50 ft. The bridge concept is, therefore, another way to use the air space above reservoirs. The above-water option may attract fewer objections.

Presently, we are using unused ground-space under viaducts and MRT stations to build shops, food courts and small parks. The Jurong East MRT Station can be considered as a good example.

We can similarly use the existing road network to create large solar farms. The solar highways concept offers a simple and speedy solution. There are no reasons, other than high costs, for not using the unused air space above existing roads and motorways to build an overhead highway system of sizeable solar farms. According to the Land Transport Authority (LTA), Singapore has used 12% of the total land area for land transportation [4, 5]. This means that Singapore has used up approximately 930,000,000 ft² of land for railways, roads and motorways. It also means that we have lots of unused air space above existing roads and railways, without infringing on land used by others.

Suppose we use 40% of this unused air space to create a large land space, equivalent to almost 5391 football fields. Using the Tengeh solar farm as a reference, this unused air space can produce (5391/45) x 60 = 7,188 MWp = 7.2 GWp of solar energy, which is about 3.6 times

higher than the 2 GWp target. This amount of energy can be further increased by introducing a simple and reliable solar tracking system which can work better on dry land. In addition, if we were to add on some of the unused air-space provided by the covered walkways and above-ground MRT lines, we may be able to reach 7.5 GWp before 2030.

In our opinion, building an elevated solar highway system is not difficult, but the design process is a lot more lengthy and tedious, since existing roads, flyovers, walkways and MRT lines all have different layouts and different design load limits. The design will produce many thousands of Approved-for-Construction (AFC) drawings. To avoid cost overrun and re-work, project control is extremely critical. We will discuss how the solar highways project should be designed and executed in the following sections:

Design objectives and project requirements

- Design a structural system on land that will create a large land space, to build a large solar farm network. The design code is based on the 'Manual of Steel Construction', published by American Institute of Steel Construction Inc.
- The design / construction must not interfere with the daily traffic, at all, ideally, or should cause minimal interference.
- To reduce fabrication schedules, the structural design must facilitate easy fabrication. All work should be done in the yards. Site work should be avoided.
- To speed up construction, the design must be based on site assembly work and a low amount of site construction work.
- All structural components must enable easy road transportation from yards to sites.
- The design must facilitate installation using small-sized, lorry-mounted cranes, available in Singapore.
- The solar highway system (solar farm network) must be easy to operate and maintain. Substations and converter stations can be built on the ground. There should be no exposed cables on the roads.
- The design must enable easy decommissioning. Also, it must be easy to modify or re-locate the solar highways, if required.
- The clear height of the solar highways should be the same as that for existing overhead bridges.
- Trees may be cut and re-planted as required but existing structures should not be modified, if possible.

Figure 1: Conceptual solar highway.

Figure 2: Flyover solar highway.

Discussion of the structural concept and execution

A simple structural system is proposed, as shown in Figure 1 and Figure 2. No further discussion is needed for such a simple structural scheme. MRT lines will be considered as a single lane highway. We will discuss how best to design, fabricate, install, operate, maintain and decommission the system to cut costs, based on years of practice in the offshore oil & gas industry. For ease of control and co-ordination, we will assume that only one turnkey contractor is running the project.

After the job is awarded, the selected EPCI (Engineering, Procurement, Construction and Installation) contractor will design a structure which must be acceptable to all parties. The design should aim for a fit-for-purpose assembly method, using simple details rather than complicated fabrication details which will need lots of man-hours. After completion, we will have a network of overhead highways sitting on tubular legs, forming a solar farm network. Part of the highway areas can be allocated for vegetable farming and for recreational pedestrian walkways. The project activities are summarised below:

- Conduct Front-End Engineering Design (FEED) studies and impact studies, as well as cost and risk analyses.
- Prepare project specifications and contract documents.
- Call for tender and award the EPCI contract(s).
- Finalise the project execution plan in great detail.
- Procure materials, solar panels and solar tracking system(s).
- Fabricate the structures at local yards.
- Remove obstructing trees.
- Prepare support foundations.
- Install all the columns and bracings.
- Lift and install all cross beams.
- Lift and install all longitudinal beams.
- Install all secondary steel structures and gratings.
- Install solar panels, solar tracking system and other details.
- Install farm and walkway details, including all the safety measures, as required by law.

This multi-purpose structure will serve three functions (solar energy generation, food production and recreation). If we are willing to accept the idea of elevated solar highways for solar farms, we may consider building above-water solar bridge-farms in all the reservoirs. Construction, operation, maintenance and decommissioning are all not difficult. There will be fewer concerns about water quality in the next 50 years, if everything is above water.

Cost-cutting suggestions

The following cost-cutting ideas may be helpful. They come from lessons learnt from post-completion analyses of past EPCI projects.

*The EPCI approach is more suitable. The four components in large scale construction projects have inter-related costs. In an EPCI project, the design department must design a structure such that it can be constructed and installed by the respective in-house teams, ensuring minimal man-hours and maximum profits. This is the common objective. For safety and insurance reasons, the project owner will appoint an external certification authority to check and approve the design.

Based on past projects, the EPCI approach is cost-effective. It is better than using multiple contractors, where different parties have different objectives, including those relating to profit margins. In some cases, the owner may invite a few EPCI contractors to take part in a design competition, on the basis of which the final job award is made. This approach may be useful in solar projects.

- We should select the sections of roads that will enable cost-effective construction and installation.
- The design should avoid using trusses and built-up members, to reduce fabrication man-hours. It should go for standard beams and columns. A simple, direct load-path design will always lead to economical structures.
- The transverse frame is either a simple portal frame, consisting of a beam and tubular legs, or a simply supported cross beam sitting on free-standing columns.
- In the design, we should pay careful attention to the problem of thermal expansion.
- We can assume that each solar panel has an area of 21.5 ft² and weighs 51 lb, for a loading of 2.37 lb/ft², and a 1 inch grating, for a loading of 5.81 lb/ft²; and cables, with a cable weight of 20 lb/foot run. A standard W36 beam should be adequate to cover all the dead, live and environmental loads, including the self-weight. However, this statement must be checked against the actual loading conditions in a real job.

As per LTA regulations, a 4-lane highway spans less than 50 ft. A standard W36 beam can easily handle this span. All the W-beams can be ordered to length, from the mills, with edges prepared for welding or bolting, if the mill surcharge is reasonable. This will reduce the extra man-hours required for handling, when the shipments reach the yards.

- The W-beams can be replaced by precast concrete beams, if appropriate.
- Direct beam-to-beam connection should be used with caution, as it will increase the fitting-up time. Overlaid details are preferred, as long as the compression flanges are stabilised. This can reduce the number of workers onsite.
- The design should use slotted holes and friction grip bolts, as much as possible, for easy fit-up. Again, this will cut down the man-hours onsite.
- All tubulars should be ordered to length directly from the mills, if the additional cost is justified.
- Foundations can be prepared without greatly affecting the daily traffic. Only a small area will be cordoned off. Piled foundations are not necessary.
- Once the foundation work is over, the contractor can lift and install all the columns after midnight. Working a night shift is more expensive but is worthwhile.
- The design should use cables for sway bracings at places that can be easily reached during regular maintenance and repair.
- For steel structures, the design must incorporate the process of periodic painting. Weathering W-beams may be useful, if the cost is justified.

CONCLUSION

In the article, we have presented a feasible steel solution to develop a large solar farm network, from a purely engineering standpoint, without considering city planning requirements, environmental impact considerations, road safety regulations and other land users in the country. However, this solar highway system can also function as recreation walkways and food production platforms. For the upper bound, we can produce 7.5 GWp of green energy, hopefully before 2030 or 2050. For the lower bound, if we were to use the lane-kilometre roads definition used by LTA and assuming 80% usage, we can still produce 5.6 GWp of green energy, which is still much higher than the 2 GWp target.

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Forecast for the solar highways market

Published by 360 Research Reports, the 117-page '2022-2029 Global Solar Highway Professional Market Research Report' provides data, statistics, trends, and competitive landscape details in this niche sector.

The Solar Highway market has witnessed growth from one million USD to multimillion USD from 2017 to 2022. This market is estimated to reach multimillion USD in 2029.

The report focuses on the solar highway market size, segment size (mainly covering product type, application, and geography), competitor landscape, recent status, and development trends. Furthermore, the report provides detailed cost analysis and supply chain information.

Technological innovation and advancement will further optimise the performance of the product, making it more widely used in downstream applications. Moreover, consumer behaviour analysis and market dynamics (drivers, restraints, opportunities) provides crucial information for knowing the solar highway market.

Moreover, it helps new businesses perform a positive assessment of their business plans because it covers a range of topics market participants must be aware of, to remain competitive.

The report identifies various key players in the market and sheds light on their strategies and collaborations to combat competition. It provides a two-dimensional picture of the market. By knowing the global revenues of manufacturers, the global price of manufacturers, and the production by manufacturers during the forecast period of 2022 to 2029, the reader can identify the footprints of manufacturers in the solar highway industry.

Competition and segmentation analysis

As well as providing an overview of successful marketing strategies, market contributions, and recent developments of leading companies, the report also offers a dashboard overview of leading companies' past and present performance. Several methodologies and analyses are used in the research report to provide in-depth and accurate information about the solar highway market.

The report provides the market growth potential, opportunities, drivers, industry-specific challenges and risks to market share, along with the growth rate of the global solar highway market. The report also covers monetary and exchange fluctuations, import-export trade, and the global market status. The SWOT analysis, compiled by industry experts, Industry Concentration Ratios and the latest developments for the global Solar Highway market share, are covered in a statistical manner, in the form of tables and figures, including graphs and charts for easy understanding.

A thorough evaluation of the restraints included in the report portrays the contrast to drivers and creates room for strategic planning. Factors that overshadow market growth are presented so that they can be understood and used to exploit the opportunities in the growing market. Additionally, insights from market experts have been included.

The report further studies the market development status and future solar highway market trends across the world. Also, it splits the solar highway market segmentation by type and by applications.

On the basis of product type, the report displays the production, revenue, price, market share and growth rate of each type, namely:

- Monocrystalline
- Polycrystalline
- Perovskite/silicon tandem

On the basis of the end users/applications, the report focuses on the status and outlook for major applications/end users, consumption (sales), market share and growth rate for each application, Parking lots, Patios, Sidewalks and Others.

Higher rate of workplace fatalities in first half of 2022

The Ministry of Manpower releases the Workplace Safety and Health Report (January – June 2022).

In the first half of 2022 (1H 2022), there were 28 workplace fatalities, bringing the six-month fatality rate per 100,000 workers to 0.8. This is higher than in 2H 2021 (0.4) and 1H 2021 (0.7). The top causes for fatalities in 1H 2022 were falls from height and vehicular-related incidents, which made up half of the 28 fatalities. The Ministry of Manpower (MOM) is concerned with the high fatality rate. To arrest the spate of fatalities, MOM introduced a series of new and targeted measures, and called for a six-month period of Heightened Safety from 1 September 2022 to 28 February 2023.

The total number of reported workplace injuries (i.e. fatalities, major injuries and minor injuries) in 1H 2022 was 10,429 – 4.5% lower than in 2H 2021 (10,915) and 7.5% lower than in 1H 2021 (11,271). This was driven by a decline in the number of both major and minor injuries. The term 'minor injuries' includes all work injuries resulting in workers being given medical leave or asked to perform light duties.

MAJOR AND MINOR INJURIES

Slips, Trips and Falls remain leading cause

The major injury rate per 100,000 workers for 1H 2022 fell to 8.7, from 8.9 in 2H 2021 and 9.6 in 1H 2021, and is lower, compared to pre-COVID levels. In absolute numbers, there were 297 major injuries in 1H 2022, compared to 294, 316 and 319 in 2H 2021, 1H 2021 and 1H 2019, respectively. However, major injuries are still a concern as they reflect persistent safety lapses at workplaces.

Similarly, there were fewer minor injuries in 1H 2022 (10,104) compared to the minor injuries in 2H 2021 (10,607) and 1H 2021 (10,932). The six-month injury rate

MOM issued Stop-Work Orders (SWO) to worksites in the Construction industry with unsafe conditions and practices that posed imminent danger to the workers. Image (on top): A worker was seen performing work at the edge of the third floor of the structure, without barricades or a fall arrest system. The worker was not wearing a safety harness. Image (below): Open sides, which are edges without barricades, were observed at multiple locations at the site.

per 100,000 workers was 296 in 1H 2022, lower than the 322 in 2H 2021 and 331 in 1H 2021.

Slips, Trips and Falls remained the leading cause for both major and minor injuries, accounting for 95 of the 297 major injuries, and 2,887 of the 10,104 minor injuries.

Prior to January 2021, workplace major and minor injury numbers covered injuries sustained by employees that resulted in four or more days of medical leave, or at least 24 hours of hospitalisation. Following the amendments to the Work Injury Compensation Act (WICA) that took effect from 1 September 2020, employers are now required to report all work injuries resulting in workers being given medical leave or asked to perform light duties.

KEY FOCAL AREAS

Construction industry as the biggest contributor

With 10 fatalities in 1H 2022 and a six-month fatality rate of 2.3 per 100,000 workers, the Construction industry accounted for the highest number of fatalities. It was also the biggest contributor of major injuries, with 84 cases and a six-month major injury rate of 19.1 per 100,000 workers.

MOM has stepped up enforcement efforts in the construction industry. From January 2022 to mid-September 2022, MOM issued 63 Stop-Work Orders (SWO) to worksites in the Construction industry with unsafe conditions and practices that posed imminent danger to the workers.

To further raise safety standards, MOM has also announced the introduction of a new set of harmonised disqualification criteria across public sector construction tenders, from 1 October 2022, in addition to lower thresholds for issuing demerit points to companies found to have breached the Workplace Safety and Health Act.

Worrying rise in vehicular-related fatal accidents

The number of vehicular-related fatal accidents has been rising over the last one and a half years. There were 7 in 1H 2022 (of which 4 were work-related traffic accidents), 5 in 2H 2021, and 6 in 1H 2021. This is a worrying trend. As such, the recent mandatory Safety Time-out from 1 September to 15 September 2022 targeted companies in high-risk industries with higher number of fatalities (Construction, Manufacturing, Marine, Process and Transport & Storage) as well as companies in other industries that use heavy or industrial vehicles. They were required to review their safety procedures, or face debarment from employing new foreign employees for one month if found to be non-compliant.

MOM issued Stop-Work Orders (SWO) to worksites in the Construction industry with unsafe conditions and practices that posed imminent danger to the workers. Image (on top): At another site, toe-boards and guardrails were not provided on the sides of the work platform at a height of more than 2 m, from where workers could fall. Image (below): Workers were found working on work platforms that were not closely boarded and properly secured, which may lead to accidental displacement (i.e. shifting of the platform).

Rise in the number of dangerous occurrences

The number of dangerous occurrences, which are incidents with a high potential for multiple casualties, more than doubled, from 6 in 2H 2021 to 13 in 1H 2022, the highest in the past three years (there were 7 cases in 1H 2021, 6 in 2H 2020, 4 in 1H 2020, 12 in 2H 2019, and 9 in 1H 2019). Nine dangerous occurrences in 1H 2022 were due to collapse or failure of structures and equipment, mostly in the Construction industry.

A SHARED RESPONSIBILITY

MOM calls on all stakeholders, from top management to supervisors, to workers and members of the public, to do their utmost to prevent further deaths and injuries, and build safer workplaces.

Protecting workers' safety and well-being with collaborative robots

Mr James McKew

by James McKew, Regional President APAC, Universal Robots

Their value as an automation option is increasing.

Automation and robotics are often credited for their contribution towards achieving increased productivity and efficiency. Various sectors, especially manufacturing, construction and automotive, have relied heavily on industrial robots to achieve greater production output. Over the last 30 years, the capabilities of these large and bulky machines improved and transformed countless industrial processes. Built for sheer power and speed, the traditional industrial robots, however, presented safety risks to human workers.

In recent years, global economic uncertainties and unprecedented crises have upended many aspects of life, from the way people live and their outlook on work, to the incorporation of new business models. This also means that the factors, that made a manufacturer successful, historically, have changed. The health and safety of employees have taken precedence over productivity and efficiency.

Reducing workplace injuries with cobots

According to the Workplace Safety and Health Report 2021, released by the Ministry of Manpower, there was a total of 12,766 workplace injuries reported in Singapore last year. Compared to the 11,350 workplace injuries reported in 2020, this was an 11% increase in the number of occupational injuries. In 2021, the top contributing sector/industry for major injuries in Singapore was the manufacturing sector, with 141 major injuries. These figures are high and the effects of accidents in workplaces are significant. Hence, manufacturers are radically changing their approach and providing employees with a safe working environment.

The beliefs and factors that supported years of consistent growth may no longer be valid.

This is where collaborative robots, or cobots, come in. Collaborative automation is changing the landscape and empowering employees. Unlike traditional industrial robots that require safety cages to keep employees out of the workspace, cobots are designed to work alongside human workers, without safety cages (upon risk assessment). Cobots have managed to unravel the general misconception that robots are dangerous. Recognised as the perfect man-machine collaboration, cobots are safe enough to function around human workers.

For Koyo Electronics Industries, a manufacturer of electronics equipment, based in Japan, safety is given a high priority on the manufacturing floor. Accordingly,

Human operators working easily and safely alongside cobots.

Japan-based Koyo Electronics Industries made a jig that can be used for any stylus patterns required for inspection, by modifying the combination of the UR cobot's end effector.

the company decided on the deployment of cobots from Universal Robots (UR). The UR cobots feature safety functions such as protective stops. With built-in safety features, cobots can operate safely, without the installation of safety fences. This was a decisive factor in the choice of UR cobots by the Japanese company.

Cobots boost capacity and job satisfaction

While preventing workplace accidents is imperative, nurturing employees' well-being is crucial in creating workplace resilience. Performing monotonous, repetitive tasks, such as heavy-lifting, loading and unloading, can lead to repetitive strain injuries. The deployment of cobots relieves human workers of these monotonous and strenuous tasks, freeing them to work on higher value activities that require the cognitive abilities of human beings.

This was the case for BTC Mold, a Taiwan-based, 'full-process' manufacturer of plastic injection moulds. Initially, large machines were deployed at its production line. However, the manufacturer was faced with ongoing problems such as noise pollution as well as safety issues and space constraints, caused by the traditional automated equipment. Despite adopting automation solutions, ensuring the well-being of employees had become a challenge for BTC Mold.

Before cobots were introduced, the packing of products was done manually. Human workers were required to bend over, when placing the products into boxes, causing joint pains and muscle aches, after a prolonged period of time.

The introduction of UR cobots, by BTC Mold, relieved the workers from repetitive tasks, further reducing the risk of occupational accidents caused by extensive periods of hard labour. Now, 11% of the company's manufacturing processes are supported by UR cobots. The manufacturer has solved work environmental issues and created safe working conditions for employees, with the introduction of cobots.

Manufacturing-related jobs often involve dull, dirty or dangerous tasks, potentially leading to workplace injuries and serious health complications. Such accidents can be significantly reduced. Collaborative automation has become increasingly capable of mitigating safety risks and improving employees' well-being. Gone are the days when monotonous and repetitive tasks are conducted manually by humans.

The use of cobots is an accessible automation option. It is here to stay and offers manufacturers a safe solution.

Why cobots are safe co-workers

Traditional industrial robotics still play an important role in manufacturing, but they are no longer the only option.

In 2008, robot technology changed forever, with the introduction of collaborative robots (cobots). What is a cobot? For Universal Robots (UR), a cobot is a robot with Power and Force Limiting (PFL) safety functions contained within the robot that, 'from the start', have been designed to lessen risks. For example, UR robots have rounded surfaces and are designed without crushing points between moving parts of the robot arm. Cobots are smaller and easier to deploy than the industrial robots previously used, and cobots are specifically designed to be able to work alongside humans, safely.

Risk assessment performance

Performing a risk assessment for the intended use of robots, including cobots, and identifying foreseeable misuses is a global requirement. Risk assessment addresses these varying risks, to reduce the likelihood of workplace injuries.

Advanced technology to reduce safety risks

Technology is readily available to improve robot safety. In the case of PFL cobots, for example, with the PFL safety functions, the speed and motions of the cobots can be limited, and the operation stopped upon detection of contact.

Products certified to safety standards

All reputable robot manufacturers and integrators embrace their responsibility to deliver safe products and solutions, as described in the safety standards. They invest a significant amount of time to ensure their robots meet safety compliance standards (ISO 13849-1 and ISO 10218-1). Although ISO 10218-1:2011 requires only two safety functions (emergency stop and safeguard stop), some manufacturers take safety to the next level.

For example, UR's cobots include 17 configurable safety functions certified by TÜV Nord as PLd Cat 3. This means that UR cobots have configurable limits for stopping time and stopping distance, joint position, pose, tool orientation, safety planes, safety boundaries, safe home (typically used for mobile applications), and forces. There are advanced capabilities for the Tool Centre Point (TCP) and elbow – TCP force limiting and elbow safety (force, speed and boundary restriction).

Societal benefits

Combining the efforts of both humans and robots offers significant opportunities to improve productivity, safety and overall workplace satisfaction.

Building bridges with modular systems

Provision of formwork and scaffolding solutions and the necessary expertise assisted in the construction of the Filstal Bridge in Germany.

The 485 m long Filstal Bridge is part of the new high-speed Wendlingen-Ulm railway line. At a height of 85 m, it is one of the highest railway bridges in Germany, connecting the Boßler Tunnel, in the north, with the Steinbühl Tunnel, in the south. As the tracks run on two separate bridge sections, creating the structure was extremely demanding, in terms of architecture and engineering.

Provision of solutions

The Filstal Bridge brought together all the challenges of bridge construction – high bridge piers that widen in a Y-shape at the crown, a sophisticated construction method with slender superstructures, high architectural concrete requirements, and a narrow time window to meet the completion deadline because of interim adjustments to the structural model of the bridge structure.

PERI, an experienced solution provider for formwork and scaffolding projects was on hand to support the construction consortium partners, Max Bögl and PORR. Particularly when requirements changed during the construction process, the infrastructure specialists always found a solution to meet the completion deadline and, at the same time, achieve a high quality of execution. In all phases, digital 3D planning provided visualisations of the formwork and scaffolding use, thus simplifying communication with the various decision-makers.

Pier construction kit

Three PERI modular systems served as the formwork and scaffolding for the bridge pier construction work. The slender reinforced concrete shafts sprouted upwards, cycle by cycle, with the aid of the rail-guided RCS climbing formwork. In the complicated expansion areas at the pier

The 85 m high and 485 m long Filstal Bridge brings together all the challenges of bridge construction – a sophisticated construction method with slender superstructures and high bridge piers that widen in a Y-shape at the crown, high architectural concrete requirements and a narrow time window to meet the completion deadline.

The slender reinforced concrete shafts sprouted upwards, cycle by cycle, with the aid of the rail-guided RCS climbing formwork.

head, working platforms based on the RCS and SCS climbing systems ensured that the loads could be transferred safely. For this, PERI UP reinforcement scaffolds installed around the perimeter provided a safe working environment.

Y-pier special feature

The way in which the inclined piers between the Y-pier head and the superstructure were created was a special feature of the project. For this purpose, PERI engineers designed a rail-guided finishing carriage, by combining the PERI UP Scaffolding System with VARIOKIT and RCS climbing technology. This allowed the entire scaffolding unit to be moved hydraulically, in 50 cm increments, to the desired position, guided safely via RCS Climbing Rails and Shoes on the inclined pier caps and connected to the structure.

Combination solutions for the superstructure

The two, single-track superstructures running parallel to each other

were constructed as pre-stressed concrete end-to-end girders, using a formwork carriage – first the west bridge, then the east bridge. The cantilevered parapets on the west bridge were constructed in 24 m sections, using a total of four VARIOKIT Cantilevered Parapet Carriages. The VARIOKIT carriages were then fitted with additional PERI UP scaffold suspensions and could then also be used for quality-assuring finishing work. At the same time, the PERI solution could be used as assembly scaffolding for the windbreak wall, by adding additional scaffolding and enclosing it, as required, as wind and weather protection.

In order to speed up the construction process considerably, the working platforms on the eastern superstructure were kept available along the entire length of the bridge so that the parapet could be constructed in sections. The project-specific VARIOKIT solution from the PERI engineers also took the additional assembly and finishing platform applications into consideration here. The metric, basic grid of both modular systems, VARIOKIT and PERI UP, paved the way for an almost limitless number of combinations in all respects, which was hugely beneficial for planning, structural analysis and on-site construction work.

For this, the consortium partners Max Bögl and PORR had a competent subcontractor at their side, in Schäfer Gerüstbau, who had already had positive experiences with both PERI systems while carrying out assembly work on many construction sites. With safe, coordinated work processes, the agreed deadlines could be met without any interruptions that might delay construction. The high level of working safety facilitated both the formwork and scaffold assembly processes as well as subsequent use at great heights and in the area of the motorway crossing at the Drackensteiner Hang on the A8.

The versatility of the PERI UP Scaffolding Kit meant that the suspended scaffolds could be optimally adapted to the geometry of the bridge. Using the new, second generation of PERI UP components also resulted in noticeable weight advantages and increased the load-bearing capacity by, for example, enabling the standards to be double-pinned. In addition, the modular, easy-to-handle system formwork girder could be used to quickly and easily install bridging in 25 cm increments, up to a length of 10 m – without tubes and couplings.

PERI engineers designed a rail-guided finishing carriage, by combining the PERI UP Scaffolding System with VARIOKIT and RCS climbing technology in order to work on the inclined piers.

The cantilevered parapets on the west bridge were constructed in 24 m sections using a total of four VARIOKIT Cantilevered Parapet Carriages.

Tunnel portals

The comprehensive service package provided by PERI comprising engineering services, construction site support, chief erectors and factory pre-assembly, even included the final construction of the tunnel portals as a transition between the bridge and the tunnel. As the tunnel formwork carriage was also based on the VARIOKIT Engineering Construction Kit with rentable system components, it was possible to develop a customised project solution, deliver it to the construction site and assemble it on site, in a short time. Both large-format recesses for sound propagation and sections that had to be formed and concreted, on one side, were taken into account.

All images by PERI SE

The cement industry – the challenges of the future

by Matteo Magistri, R&D Manager, Cement Additives Division, Mapei SpA, Italy

Mr Matteo Magistri

Carbon dioxide emissions can be reduced by using additives and adopting the correct approach to innovation.

Thanks to a unique combination of high mechanical performance, durability, ease of use, wide availability of raw materials, good possibilities for the modification of properties and relatively low cost, concrete is the most common construction material in the world and the second most used, after water.

The active ingredient of concrete is Portland cement, and the active ingredient of Portland cement is Portland clinker which is an artificial blend of calcium silicates and silico-aluminates. The Portland clinker can react with water and, thanks to this hydraulic reaction, hardens and transforms the fluid mix of cement and water into a solid mass, binding together fine and coarse aggregates.

The typical manufacturing process for Portland cement (Figure 1) starts with the extraction of raw materials, mainly limestone (natural calcium carbonate) and clay, that are quarried and properly blended and ground to prepare the so-called raw mix. This is fired in a special kiln, in a high temperature process, where silica and lime (with alumina/iron oxides, added to the raw mix to improve process efficiency), react to form the calcium silicates and aluminates that make up the Portland clinker.

The clinker is then finely ground together with gypsum and secondary mineral additions (such as limestone, fly ash, granulated blast furnace slag and natural or artificial pozzolans) to obtain the well-known grey powder, usually referred to as Portland cement, which is used by millions of construction workers as the hydraulic binder for concrete.

Reducing greenhouse gases

Cement manufacturing is a typical heavy industry process characterised by high energy demand due to both the high temperature required, which is achieved by the combustion of fuels, and the electrical energy required to drive the grinding mills and all the machinery of a modern cement plant. Moreover, during clinker production, limestone is decomposed, releasing carbon dioxide (CO_2) into the atmosphere. The cement industry is reported to be responsible for 5% to 8% of total anthropogenic greenhouse gas emissions, mainly associated with clinker production and grinding.

Table 1 summarises the current available data on CO_2 emissions in cement and concrete production, while Table 2 shows the main strategies that can be implemented for the reduction of emissions. Figure 2 represents a forecast of the global cement production until 2050, at which point it is supposed to reach 5 billion tons.

Keeping this in mind, it appears that the reduction or elimination

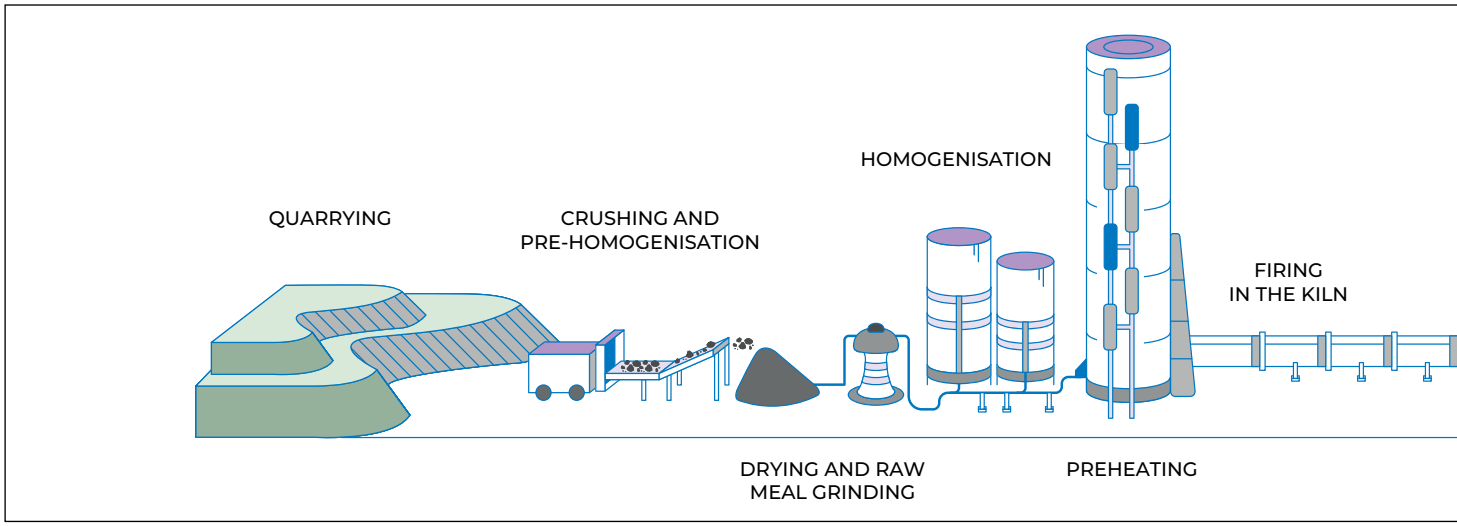


Figure 1: The cement manufacturing process.

of CO_2 emissions is a serious challenge for the cement industry, and the more promising strategy is to reduce the quantity of clinker contained in cement.

Blended cements (cements where clinker is partially substituted with other materials) are not a novelty.

Their production and use have been a common industrial practice for a long time and the use of secondary cementitious materials, such as limestone, fly ash, slag, and natural or artificial pozzolans, is well-known and is described in technical standards. On the other hand, the reduction of the clinker factor that is now required is far beyond what the building industry has been accustomed to.

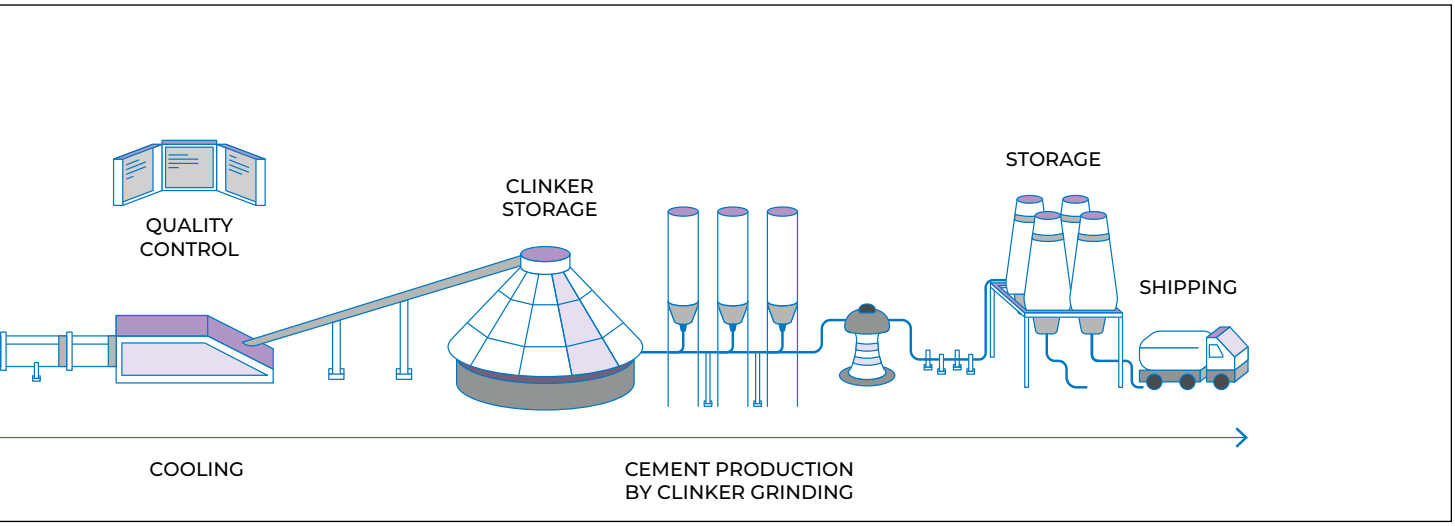
To face this challenge, new technical standards have recently been released (for example, the European Norms EN 197-5 and EN 197-6), describing the production of new cement types (named CEM II/C and CEM VI) with very low clinker content. Moreover, new types of secondary cementitious materials and their combination with traditional ones are being investigated and developed, and in some cases they are already available on the market. A typical example is represented by calcined clays and calcined clays/limestone combination. This will probably have the highest potential for significant clinker reduction.

Direct CO_2 emissions associated with clinker production	0.84 t CO_2/t clinker	Data from 19% of cement plants worldwide
Average clinker factor in cements	0.65	Strong local differences (average Europe: 0.74 – Ireland, Denmark: 0.9 – Germany: 0.71 – Netherlands: 0.46)
Direct CO_2 emissions associated with cement production	0.54 t CO_2/t cement	Considering average clinker factor
Total specific electrical energy consumption for cement production	100-110 kWh/t cement	Corresponding to 50-55 kg CO_2/t cement (considering energy mix with 0.5 kg CO_2/kWh)
Concrete emissions	Non reinforced: 250 kg CO_2eq/m³ Reinforced: 312 kg CO_2eq/m³	Considering typical C30/C37 ready mix concrete

Table 1: Updated data on CO_2 emissions from the cement/concrete industry. Data source: M Schneider, 'The cement industry on the way to a low-carbon future', ICCC2019, Prague.

Improvement in thermal energy efficiency of clinker production	Limited potential: already reached the state-of-the-art
Use of alternative fuels	Average substitution range in Europe: 41% (100% reported in some plants). Good potential, limited to availability of suitable waste
Reduction of clinker factor	Good potential for CO_2 reduction. Related to local and global availability of Secondary Cementitious Materials. Need to improve blended cements performance
Alternative cements: CSA, geopolymers, belite	Potentially high reduction of CO_2, but high raw materials/investment cost and limited applicability
Improve electrical energy efficiency	Limited potential
CCS/U – Carbon Capture and Storage: the process of capturing CO_2 emitted from an industrial plant before it is emitted in the atmosphere and storing or reusing it.	Theoretically, extremely high or complete reduction of CO_2. Presently at pilot plant stage (although long term experience exists in oil sector). First operative industrial CCS forecast for 2024-2030 in Norway

Table 2: Strategies for reduction of CO_2 emissions. Data source: M Schneider, 'The cement industry on the way to a low-carbon future', ICCC2019, Prague.



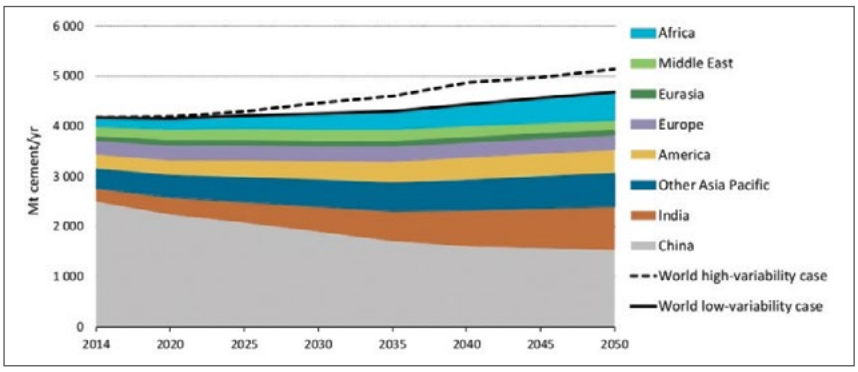


Figure 2: Global cement production forecast. Data source: IEA/CSI Technology Roadmap – Low-Carbon transition in the cement industry.

Low clinker cements, however, present some issues – mainly reduced early strength and increased water demand.

First of all, the reduction in the active ingredient (the clinker) limits the mechanical performance that can be reached. Second, some cementitious materials often absorb a significant amount of water, increasing the initial viscosity of fresh concrete. It is then mandatory to correct the strength and water demand using suitable cement additives – these are chemical products that influence the cement hydration, accelerating the strength increase and improving the viscosity that the cement will have. Moreover, these additives also work as grinding aids, increasing the output of grinding mills in cement plants and reducing the specific energy consumption.

Cement additives can be tailor-made according to the required targets and to the type of cement/clinker, considering its chemistry and mineralogy. They are commonly used as process additives that are usually added to cement during grinding. This usually turns into indirect CO_2 savings that can be more or less evident, depending on the energy mix used to generate electricity. The cement produced, thanks to the improved early hydration and the reduced water demand guaranteed by the presence of additives, can permit a higher extent of clinker substitution, resulting in a reduction of greenhouse gas emissions.

The global cement industry is going to be subjected to a change that has never happened before, but with the correct approach to innovation, there are good possibilities for success.

This editorial feature is based on an article from Realtà MAPEI INTERNATIONAL ISSUE 93. Images by Mapei.

Frequently Asked Questions

Are 'grinding aids' and 'cement additives' the same?

Basically yes, because modern products, available in the market, act as both grinding efficiency improvers and cement performance enhancers.

Why are grinding aids used?

Grinding aids are mainly used to increase the efficacy of the production process. This means it will be possible to produce a higher amount of cement with the same energy consumption, or produce a finer and more reactive cement.

Moreover, modern cement additives also play a role in performance enhancement, from a chemical point of view. During cement hydration (the complex series of chemical reactions that take place when cement is mixed with water, leading to hardening and mechanical strength development), cement additives modify the reactivity and allow the attainment of higher strength, or better control of hardening kinetics, or reduce water demand.

What is the typical dosage of cement additives?

The typical dosage lies in the range between 200 g to 300 g and 2 kg to 3 kg, per ton of cement.

What is their mechanism of action?

Cement grinding (as it happens in many other grinding operations) is a low efficiency process. Only a minor part of the energy used, measured in kilowatt-hours (kWh), goes into increasing the fineness of the cement. A significant part of this energy is wasted in the form of heat. This happens because, as fineness increases, there is an agglomeration of fine particles, that reduces the overall efficiency of the process. Cement additives help to control and reduce this agglomeration. This increases the hourly mill production and the fineness that can be reached, with the same energy consumption.

Are cement additives available in the market?

For more than 20 years, Mapei has been marketing two lines of cement additives – MA.G.A. (Mapei Grinding Aids) and MA.P.E. (Mapei Performance Enhancer).

Can we calculate the reduction in CO_2 emissions, resulting from the use of cement additives?

It is estimated that for each ton of cement produced with the use of cement additives, there is a 20 kg reduction in CO_2 emissions, in comparison with the CO_2 emissions for the same type of cement produced without additives. This calculation considers an average additive dosage of 350 g/t, a 25% mill production increase, and a 2% clinker reduction in the cement composition. It is also based on 0.57 kg CO_2/kWh produced by the energy mix and on 862 kg CO_2 per ton of clinker produced. For a medium sized cement plant, this corresponds to a reduction in the CO_2 produced, in the range of tens of millions of kilograms (kg), every year.

New tower cranes and digital solutions from Liebherr

Liebherr will unveil its first large cranes featuring fibre ropes, and its first hydraulic luffing jib crane, at bauma 2022, the international trade fair for the construction industry, which will be held from 24 to 30 October 2022, in Munich, Germany. Whether they are for large hook heights or for particularly constricted sites, these new cranes enhance Liebherr's reputation as a reliable partner on sites of all types. At the same time, Liebherr is working on new technologies to make crane operations even safer and more economical.

When it launched its pioneering fibre rope over three years ago, Liebherr also unveiled its first fibre cranes in its popular EC-B series. Flat-top cranes featuring a high-tensile fibre rope, which is the result of 10 years of development work by Liebherr and rope manufacturer Teufelberger, are now being used on sites around the world. Now Liebherr is taking the next step – producing cranes with fibre rope for applications defined by particularly challenging hook heights and hoists.

Liebherr's crane for special projects, the 1188 EC-H 40 Fibre, and the luffing jib crane, the 258 HC-L 10/18 Fibre, are cranes with fibre rope. The high-tensile fibre rope for large cranes has a diameter of 25 mm (previous versions measured 20 mm and 22 mm in diameter). The significant weight difference between a 25 mm steel rope and a fibre rope of the same thickness means that the new fibre cranes can be used to build skyscrapers and industrial plants with even greater efficiency. The latest 'Tough Guys' from the EC-B series, the 370 EC-B 16 Fibre and the 520 EC-B 20 Fibre, also feature the 25 mm fibre rope.

Better performance

The lighter fibre rope is particularly noticeable on HC-L cranes, the specialist cranes for large hook heights. This is because every metre of additional hook height means that the benefits of the lower rope weight increase. The use of the fibre rope enables the lifting capacities at the jib head to be increased by up to 20%, compared to the steel rope versions. In addition, the fibre rope delivers a significantly longer service life than a steel rope. As the fibre rope weighs only around one-fifth of a steel rope, it is also easier to handle for erection engineers, when reeving the hoist rope. Furthermore, the fibre rope is easier to maintain as it does not require lubrication. That also means that the downtimes of the crane are reduced.

What is more, safety during crane operations is increased – the various components of the cover wear at different rates, and the crane operator can see at a glance that the rope has to be replaced when the red layer under the cover fabric appears.

Technologies for more safety

The construction site of the future requires not only powerful machines but also smart digital solutions for crane operations. At bauma 2022, Liebherr will provide an insight into new planning and analysis tools, such as 3D models for planning a site in detail.

The 258 HC-L 10/18 Fibre crane from Liebherr features a 25 mm fibre rope.

Junttan to showcase sustainable solutions at bauma 2022

Junttan will be exhibiting at bauma 2022 for the 13th time. This time, the company is showcasing its latest sustainable solutions for piling. At the show, visitors have the possibility to see the world's first electric pile driving rig which was officially launched in 2021 by Junttan and will be on display at an exhibition, for the first time.

At the Junttan exhibition booth, visitors can also see the company's fast and efficient hydraulic impact hammer with a new modular pile sleeve solution. Remote service tools and a new service agreement offering for the whole life cycle of the equipment will also be presented by the company.

Electric pile driving machine

Junttan's fully battery-powered eJunttan, PMx2e, will also be on display at bauma 2022.

The company has combined optimised hydraulics with modern batteries and electric motor technology.

The result is the fully battery-powered electric pile driving rig that is ready to meet the same challenges, at the work site, as its predecessors. Instead of a diesel engine, Junttan is now powering the hydraulic system with a modern electric motor that generates its power from a battery pack at the rear of the rig where the counterweight was located.

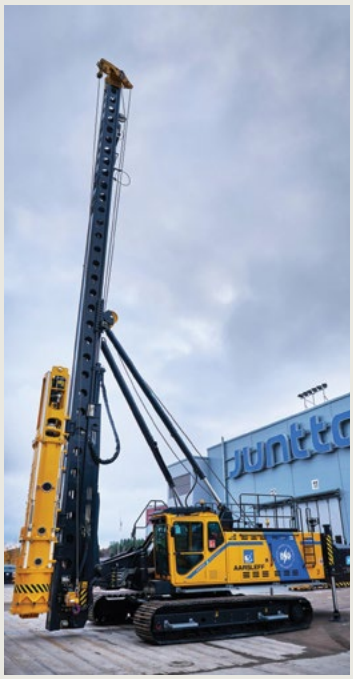
In this way, the company was able to build a solution that is reliable and easy to operate, and is as effective as normal diesel-powered Junttan rigs. The rig is powered by two separate 396 kWh battery packs that can be replaced during the day, if needed. By choosing a detachable two-battery system instead of one larger fixed battery, charging can be done with a normal 63 A mains outlet, and both batteries are ready the next morning.

With the state-of-the-art CCS DC-DC quick charging, the battery packs can be charged with up to 250 kW to enable even more flexibility and extended range for future worksites also, with a single battery pack. The Kempower quick charger will also be on display at Junttan's bauma stand.

HHx160 hydraulic impact hammer with a new modular pile sleeve solution

The company will also present a new modular pile sleeve solution for more efficient and flexible operation, with quick change inserts for different pile sizes.

The Junttan HHx series, the new generation hydraulic hammers for demanding conditions, provides an adjustable stroke, with a blow rate of up to 60 blows to 180 blows per minute. With Junttan intelligent solutions, not only optimised energy and high productivity are gained, but there is also less noise, vibration, and emissions. The new HHx hammer series, combined with intelligent x-series solutions, leads to a high level of piling project productivity, flexibility, reliability, and user-friendliness, as well as easy on-site service. The modular structure allows up-grading or down-grading of the size, by changing ram weight. All housing, caps, and sleeves are interchangeable with all Junttan HHx-models.



The fully battery-powered eJunttan PMx2e electric pile driving rig.

Ammann addresses a changing industry at bauma 2022

Ammann will present a variety of product lines and technologies at bauma 2022.

The company is an industry leader in asphalt-mixing plants, such as the Ammann ABP HRT (High Recycling Technology) plant, and asphalt recycling solutions. Asphalt producers have a variety of choices to ensure there is an option that fits their needs.

The RAH100 recycling system is capable of producing mixes with up to 100% recycled materials. The quality of the recycled mix, which results from a gentle heating process, is high. All Ammann recycling systems are able to produce high-quality mixes with 100% virgin aggregate, if so desired.

The CBT 60 SL Elba concrete mixing plant is designed as a skip plant and can produce up to 60 m³/h of concrete. It is equipped with the proven CEM 1000 S Elba single-shaft mixer and an integrated linear bin for storing up to four aggregate components.

Alternatively, it is possible to use the containerised linear bin CEL 25 where, between two and eight aggregate components can be stored. The storage volume is between 50 m³ and 100 m³.

Ammann's light compaction equipment line up will be well represented at bauma 2022. The company's new 3D Drive Compactor is a finalist for the bauma Innovation Award. It is the first vibratory plate on the market that can go in an arc, circle or turn on the spot. The number of shafts has been doubled, from two to four. The shafts are newly arranged in an X shape. The compactor features an e-drive for sustainability. A low centre of gravity and an electronic control system enable easy operation.

The new Ammann ARX 140 StV/T3 and ARX 160 StV/T3 Articulated Tandem Rollers are characterised by an absence of front and rear crossbeams. A new symmetrical cab that improves safety and productivity is among the key new features. Well-designed and positioned fuel and water tanks add to the impressive appearance and improve access to components. The 360° visibility from the operator station establishes a new market standard.

The spacious cab is also quiet. It is suspended and isolated from external heat, noise and vibration. Those features keep operators comfortable, fresh and focused.

The new Ammann ARS 30 and ARS 50 Soil Compactors utilise innovative engineering and robust power trains to deliver high compaction output. These single-drum machines, with weights of 3 tonnes and 5 tonnes, are the most compact rollers in Ammann's soil compaction product line.

The no-rear-axle concept enables a lower engine location that improves the centre of gravity – which enhances stability, even on slopes. The design also improves visibility and manoeuvrability. Those factors, combined with stability, promote jobsite safety.

An easy-to-reach adjustable operator seat optimises comfort, as does the fully vibration-isolated platform. All control switches are accessible and highly visible – essential for quick operator overview. A robust dashboard is highly durable, particularly important in open-platform models. A multi-functional control display is located on the main dashboard, making it easy for operators to monitor the functioning of the equipment.

The Ammann ABP HRT asphalt-mixing plant.

The CBT 60 SL Elba concrete mixing plant.

SEMINAR FOCUSES ON HOW ENGINEERING CAN CONTRIBUTE TO ATTAINING THE VISION ZERO GOAL

Organised by IES, the Seminar on Design for Safety towards Vision Zero was held on 14 September 2022, at Suntec Singapore.

The seminar was part of OS+H Asia 2022, the 13th Occupational Safety + Health Exhibition for Asia, organised by Messe Dusseldorf.

In his Opening Address at the seminar, Mr Dalson Chung shared on what IES will be doing to drive the Vision Zero Movement in the engineering community, in the coming years. IES was the first professional institution in Singapore to sign the Vision Zero pledge.

Mr Chung shared on the importance of Vision Zero (VZ) and stated that IES is committed to driving greater action towards achieving this objective. He pointed out that IES signed the Vision Zero pledge in November 2021, at the World Engineers Summit 2021.

Mr Chung also provided an overview of IES' five-step action plan to achieve VZ.

In his presentation on 'DfS - the sustainable way to VZ', Mr Chan Yew Kwong, Senior Consultant, Workplace Safety & Health Council (WSHC), shared with the audience on how Design for Safety (DfS), applied with a VZ mindset, can provide a sustainable framework for saving lives and preventing work-related injuries and illnesses.

Er. Lim Peng Hong, Managing Director, PH Consulting Pte Ltd, spoke on 'DfS - Adding Value to Safety', highlighting the importance of Design for Safety workshops which are useful tools in enhancing safety in the built environment.

The presentation 'DfS – Toward VZ Mindset', by Mr Thia Toh Men, OSH Inspectorate, Ministry of Manpower, provided an overview of the WSH Guidelines – Design for Safety version 2022, and shared on DfS solutions.

In the concluding presentation 'Design Safety into Factory Automation Systems', Ms Wan Siew Ping, Technical Consultant, Design Engineering 82 Pte Ltd, discussed the various safety concerns in the manufacturing sector and the different methods used by machinery designers to ensure the protection of everyone.

President of IES, Mr Dalson Chung (3rd from right), flanked by the speakers at the seminar. From extreme right, Er. Lim Peng Hong, Managing Director, PH Consulting Pte Ltd; Mr Chan Yew Kwong, Senior Consultant in the Workplace Safety & Health Council (WSHC); Ms Wan Siew Ping, Technical Consultant, Design Engineering 82 Pte Ltd; and Mr Thia Toh Men, OSH Inspectorate, Ministry of Manpower. On extreme left is Mr Jason Oh, IES Council Member and IES VZ Champion.

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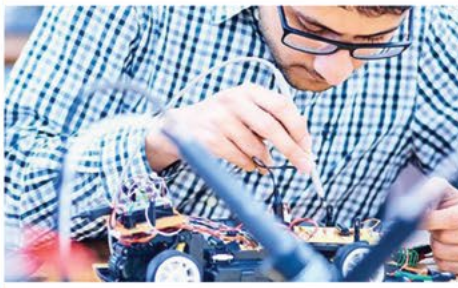

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