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THE SINGAPORE ENGINEER

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Smart Technology with Drones and
Artificial Intelligence for Building
Facade Inspection



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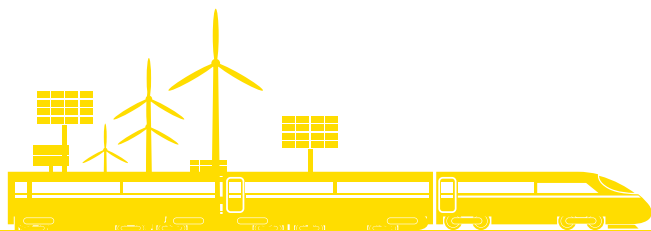
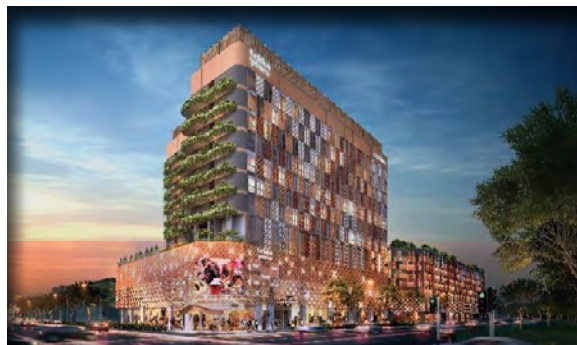
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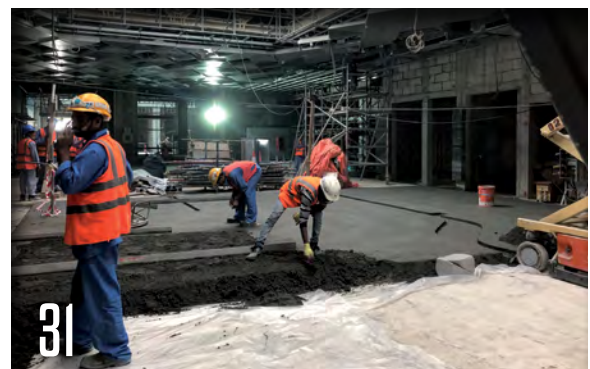
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WORKPLACE INJURIES IN THE FIRST HALF

OF 2021 COMPARABLE TO PRE-COVID LEVELS

The workplace injuries rate, in Singapore, in the first half (1H) of 2021, was comparable to pre-COVID levels (193 injuries per 100,000 workers in 1H 2021 versus 205 injuries per 100,000 workers in 2H 2019). The workplace fatality rate in 1H 2021 has also remained similar to pre-COVID levels (0.7 fatalities in 1H 2021 versus 0.6 fatalities per 100,000 in 2H 2019).

As a result of the gradual resumption of workplace activities since the second quarter of 2020, the number of workplace injuries and fatalities in 1H 2021 has increased slightly when compared with 2H 2020. The number of injuries in 1H 2021 was 6,411 (from 6,293 in 2H 2020), while fatalities were 23 (from 13 in 2H 2020). The six-month workplace fatality rate increased to 0.7 per 100,000 workers in 1H 2021 from 0.4 per 100,000 workers in 2H 2020.

Despite the fluctuations, significant progress has been made pre-COVID to bring down workplace injuries. Everyone has a part to play to meet the goal of reducing Singapore's annual workplace fatality rate to below 1.0 per 100,000 workers by 2028. This outcome has been consistently achieved by only four Organisation for Economic Co-operation and Development (OECD) countries.

The average workplace fatality rate per 100,000 workers, from 2016-2018, for the four OECD countries, was 0.56 for Netherlands, 0.82 for United Kingdom, 0.88 for Germany and 0.89 for Sweden. Singapore's average workplace fatality rate, from 2018 to 2020, was 1.1.

FATALITIES

Top causes continue to be Vehicular Incidents and Falls from Height

Vehicular Incidents and Falls from Height continue to be a key concern, with six and four fatalities, respectively, in 1H 2021. Of the six vehicle-related fatalities, four were work-related traffic accidents (WRTAs) involving delivery or dispatch riders. Of these, three were due to the negligence of other road users.

MAJOR AND MINOR INJURIES

Slips, Trips and Falls remain the leading cause of non-fatal injuries

Slips, Trips and Falls (STFs) remain the top cause of injuries. The number of STF-related major injuries increased slightly to 113 in 1H 2021, from 103 in 2H 2020. On the other hand, STF-related minor injuries fell from 1,846 in 2H 2020 to 1,753 in 1H 2021.

Machinery-related incidents were another common cause of injuries, accounting for 33 major injuries in 1H 2021, up from 30 in 2H 2020, and 968 minor injuries in 1H 2021, up from 912 minor injuries in 2H 2020.

INJURIES BY INDUSTRY

Construction, Transportation & Storage, and Manufacturing continue to be top contributors

The Ministry of Manpower (MOM) is paying close attention to the Manufacturing Industry which saw a six-month workplace fatality rate of 1.0 per 100,000 workers, or four fatalities, in 1H 2021, compared to 0.8, or three fatalities, in 2H 2020. It also had the highest number of non-fatal injuries, with 80 major injuries and 1,364 minor injuries in 1H 2021.

Construction and Transportation & Storage accounted for the highest number of fatalities, with seven fatalities each in 1H 2021. Collectively, they accounted for over 60% of all fatalities in 1H 2021.

The six-month workplace fatality rate for the Construction industry increased to 1.7 per 100,000 workers in 1H 2021, from 1.2 in 2H 2020. In the Transportation & Storage industry, the six-month workplace fatality rate increased to 2.8 per 100,000 workers in 1H 2021, from zero in 2H 2020.

DANGEROUS OCCURRENCES

Collapse/Failure of structures and equipment continued to be the main cause of Dangerous Occurrences

The number of dangerous occurrences (DOs) increased from six in 2H 2020 to seven in 1H 2021 as business activities continue to ramp up. Six of the occurrences were due to collapse or failures of structures and equipment, while one was due to a fire and explosion incident at Tuas which resulted in three fatalities and seven injuries.

DOs are defined as incidents with a high potential for multiple fatalities.

OCCUPATIONAL DISEASES

Work-related musculoskeletal disorders continued to be the leading cause of Occupational Diseases

The Occupational Diseases (ODs) incidence rate grew to 12.1 cases per 100,000 workers in 1H 2021, from 9.9 in 2H 2020. This increase was largely due to work-related COVID-19 cases, and delayed medical assessment due to COVID-19 disruptions. Work-related musculoskeletal disorders and noise-induced deafness remained the leading cause of ODs, jointly accounting for 68% of the total number of ODs in 1H 2021.

WORKING TOWARDS SAFER WORKPLACES FOR ALL

The spate of fatal accidents in 1H 2021 is a cause for concern. MOM urges companies to prioritise workplace safety and health, even as they manage manpower constraints and project schedules.

To reinforce this, the Workplace Safety and Health (WSH)

Council partnered industry associations and unions to conduct Safety Time-Out exercises in March 2021 and June 2021. Employers were strongly encouraged to review control measures and workers were strongly encouraged to follow safe work procedures. The WSH Council has also worked with training providers to provide online courses to workers so that WSH training is not disrupted.

Ensuring companies implement adequate safety measures through increase in enforcement operations

Following the spate of fatal accidents in 1H 2021, MOM has also stepped-up enforcement operations.

This includes operations which focused on:

- Combustible dust at workplaces, following the Tuas explosion incident. More than 500 companies were inspected, with three found to have inadequate control measures in place and issued with Stop-Work Orders.
- High-risk sectors such as manufacturing and construction, with a focus on machinery safety, involving over 500 inspections from May to July 2021. 70% of these resulted in contraventions being uncovered. Top contraventions included poorly maintained machinery/equipment, inadequate guarding of machinery, ineffective barricades/guard-rails and unsafe stacking of materials.

Enhancing vehicular safety for riders

To address the rising number of WRTAs, a Food and Courier Delivery Workgroup has been formed, comprising tripartite partners including the WSH Council, the National Delivery Champions Association and companies such as GrabFood

and Singpost. The workgroup will discuss progressive practices that employers and intermediaries can adopt, such as safety training for new riders.

MOM has also started to identify emerging rider safety technology solutions such as collision alert systems and rider behaviour monitoring systems. These will be test-bedded with logistics and food delivery companies. An enforcement operation on vehicular safety was scheduled to be conducted from October to November 2021, targeting Transportation & Storage, Construction, and Manufacturing, where workplace traffic hazards are common.

Maintaining focus on Slips, Trips and Falls

The WSH Council launched the Slips, Trips and Falls campaign in June to educate employers and workers on the prevention of STF injuries. To complement this, MOM will continue to identify and promote technology solutions, such as slip meters, use of AI wearables and vision analytics, to detect and reduce STF accidents.

The Commissioner for Workplace Safety and Health and Divisional Director of MOM's Occupational Safety and Health Division, Mr Silas Sng, said, "The spate of fatal accidents this year, including February's explosion in Tuas that resulted in multiple casualties, serves as a reminder of the catastrophic consequences when safety practices are ignored or compromised. As companies continue to navigate the challenging operating environment in the midst of this pandemic, I urge all companies to review their risk assessments and control measures, to protect the safety and health of their workers".

US-ASEAN Business Council and NEA sign MoU to deepen collaboration

The US-ASEAN Business Council (US-ABC) and Singapore's National Environment Agency (NEA) signed a Memorandum of Understanding (MoU) on 20 October 2021 to deepen collaboration on sustainability initiatives. More than 30 executives from over 20 different major US companies witnessed the virtual signing ceremony, which started with remarks from Ms Grace Fu, Minister for Sustainability and the Environment, Republic of Singapore; as well as Mr Craig Smith, Chairman of the US-ABC Board and Group President, International Division for Marriott International.

The MoU was signed by Ambassador Ted Osius, President & CEO, US-ABC and Mr Luke Goh, CEO, NEA. They discussed the contents of the MoU, including regional sustainability challenges, and ways in which the US private sector and the Singaporean government could work more closely together to build a more sustainable future. The US-ABC and NEA also affirmed their shared commitment to work together in the areas of waste resource management, recycling initiatives, addressing marine litter through the management of land-based sources of pollution,

carbon credits, and building a circular economy based on sustainable supply chains.

The MoU will be managed through US-ABC's Sustainability Committee which was officially launched in 2020 to establish new partnerships and facilitate private sector sustainability engagements and initiatives in ASEAN.



At the MoU signing event are, clockwise from top-left, Mr Luke Goh, CEO, NEA; Ambassador Michael Michalak, Senior Vice President, US-ABC; Ms Grace Fu, Minister for Sustainability and the Environment; and Ambassador Ted Osius, President & CEO, US-ABC. Image: National Environment Agency.

PUB AWARDS CONTRACT TO INSTALL WORLD'S LARGEST

CERAMIC MEMBRANE BIOREACTOR FACILITY

PUB, Singapore's National Water Agency, has appointed Koh Brothers Building & Civil Engineering Contractor (Pte) Ltd to install the mechanical, electrical, instrumentation, controls and automation (MEICA) equipment for the first of Tuas Water Reclamation Plant's (WRP) two Industrial Liquids Modules (ILMs), which will treat industrial used water.

The contract, valued at SGD 200.7 million, includes the installation of process equipment and a ceramic membrane bioreactor (MBR) system. When completed, Singapore's Tuas WRP will house the world's largest ceramic MBR facility, with a treatment capacity of 75,000 m³ daily.

There will be two ILMs at Tuas WRP with a combined daily treatment capacity of 150,000 m³. The contract for installing ILM2 has yet to be tendered.

To assess the feasibility of deploying ceramic MBR technology, PUB operated a demonstration plant with a daily treatment capacity of 4,550 m³ at Jurong WRP, since 2014. The system proved to be resilient against chemical damage and was able to treat high-strength industrial used water effectively to produce high quality, treated effluent. In addition, ceramic membranes are projected to have a longer lifespan (10-15 years) as compared to polymeric membranes (5-7 years).

Koh Brothers' bid for the ILM1 contract was one of nine offers that PUB received from an open tender exercise in March 2021. Works were scheduled to commence in November 2021 and ILM1 will be commissioned by 2025.

Said Mr Yong Wei Hin, Director, Deep Tunnel Sewerage System Phase 2 (DTSS2), PUB, "The deployment of ceramic MBR technology is significant in finally closing our water loop as we are now able to reclaim the industrial used water stream for reuse. This will ensure a more resilient and sustainable water supply for Singapore. When completed in 2025, Tuas WRP will have the largest ceramic MBR system to treat industrial used water".

This is the ninth major Tuas WRP construction contract awarded by PUB. Previous contracts include those for site development works, construction of the plant's influent pumping stations, biosolids treatment facility, civil structures for both the Domestic and Industrial Liquids Modules, product water pumping facilities, as well as its monitoring and control system.

Tuas WRP is a key component of PUB's DTSS2 project and will be equipped to receive both industrial and domestic used water streams from two separate deep tunnels, for treatment. The plant, with an initial treatment

capacity of 800,000 m³ per day, will be co-located with the National Environment Agency's (NEA) Integrated Waste Management Facility (IWMF) to collectively form Tuas Nexus which integrates solid waste and used water treatment processes to harness various synergies that will improve overall plant performance and optimise land use.

DTSS2 is a SGD 6.5 billion infrastructure project that will enhance Singapore's water sustainability by boosting PUB's capability to reclaim and recycle water in an end-less cycle. Upon completion in 2025, it will convey used water via deep tunnels from the western part of Singapore to Tuas WRP for treatment. DTSS Phase 1, which covers eastern Singapore and channels used water to Changi WRP, was completed in 2008.

IWA and VWSA join forces

The International Water Association (IWA) and the Vietnam Water Supply and Sewage Association (VWSA) have joined forces to advance the future of water professionals in Vietnam and to exchange knowledge and technological insights internationally. This partnership also sees VWSA as the hosting organisation for IWA's Governing Member in Vietnam.

Governing Members are at the heart of IWA's efforts to progress its vision of a water-wise world. They represent IWA at national and regional levels, and convene people locally to share best practices and explore opportunities for innovative water solutions.

IWA and VWSA will be working together to strengthen synergies, tackling the specific needs of Vietnam and Southeast Asia, as well as nurturing the professional development of water professionals in the country for a better water future. Through this partnership, Vietnam's water professionals and their skills will be enhanced thanks to the connection with IWA's extensive global network and rich professional development programme. Within IWA, Vietnamese water professionals will be able to connect with global peers, showcase their expertise, and develop leadership skills. IWA's professional development and leadership programme includes events and access to industry publications and young water professionals as well as specialist groups covering the full water cycle.

LENDLEASE AND STORA ENSO

LAUNCH GLOBAL SUSTAINABLE TIMBER PARTNERSHIP

A major new partnership has been launched recently, between international real estate group, Lendlease, and one of the world's leading suppliers of sustainable timber, Stora Enso, to promote the use of environment-friendly timber products worldwide.

Launched in Milan, Italy, where Lendlease has AUD 7.9 billion in urbanisation projects underway, the new partnership will focus on three key areas – R&D into sustainable timber products including cross laminated timber (CLT), new ways these products can be used in construction, and their accessibility in the global market.

As part of the launch, Lendlease also announced the establishment of a dedicated studio in Milan to facilitate the creation of new sustainable timber products and increased use of sustainable timber across its AUD

52 billion portfolio of European development projects. Named Podium MX, the new Milan studio will be based at Lendlease's AUD 3.6 billion Milan Innovation District (MIND), the former 2015 World Expo site, and will complement a similar facility established in Silicon Valley, USA, earlier.

In addition, Stora Enso's product catalogue will be fully digitised through Lendlease's end-to-end digital platform, Podium, making it easier for Lendlease to design and build with sustainable timber in the future.

The recent announcement further cements the already strong relationship between Lendlease and Stora Enso. In the past decade, the two companies have worked together to deliver eight sustainable timber buildings in cities including London, Sydney and Brisbane.

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NEW REGULATIONS FOR PERIODIC INSPECTION OF BUILDING

FAÇADES TO START FROM 1 JANUARY 2022

The new Periodic Façade Inspection (PFI) regime will take effect from 1 January 2022. It is aimed at helping building owners detect and address façade deterioration in a timely manner.

Responsible parties, such as building owners, Town Councils and management corporations, have a duty to ensure that building exteriors are properly maintained. Under the new PFI regime, façade inspections will need to be conducted every seven years for buildings that are more than 13 m tall, once they are over 20 years old. Landed houses and temporary buildings are exempted from these requirements. Responsible parties must appoint a Competent Person (i.e. Professional Engineer or Registered Architect with a Certificate in Façade Inspection), who can be assisted by a Façade Inspector (FI), to conduct the façade inspections. The Competent Person will need to propose appropriate rectification works if deterioration is detected. Responsible parties must ensure that these works are carried out within a period specified by the Building and Construction Authority (BCA).

BCA has conducted two rounds of public consultations and more than 20 engagement sessions with building owners, Town Councils, management corporations and industry professionals, to gather feedback on the new requirements. Overall, the industry is supportive of the new PFI regime.

BCA has also received feedback from responsible parties and will implement initiatives to help them adapt to the new PFI regime. For example, BCA will issue advisories to responsible parties at least one year before their buildings are due for inspection. This will provide responsible parties with ample time to plan for the inspections. Responsible parties may consider scheduling their Repair and Redecoration (R&R) works or external building maintenance works to coincide with the PFI, which may allow for cost savings.

BCA has also issued a set of PFI guidelines as reference for Competent Persons and Façade Inspectors carrying out façade inspections. A copy of the PFI guidelines can be found at <https://go.gov.sg/pfi-guidelines>.

Leveraging technology to conduct PFIs

As part of the ongoing transformation efforts for the Built Environment sector, BCA has been encouraging the use of available technologies to increase productivity and efficiency. When conducting façade inspections, Unmanned Aircraft Systems (UAS), also known as drones, can be used to assist the Competent Person in performing the visual inspection. The usage of drones makes façade inspections safer, more efficient and less labour-intensive.

Together with industry stakeholders, BCA has developed the world's first Technical Reference on using drones to conduct building façade inspections under the Singapore



Demonstration of a drone inspecting a building façade. Image: BCA.

Standardisation Programme administered by Enterprise Singapore. The Technical Reference, titled TR78:2020, provides a set of specifications and good practices when using drones to conduct building façade inspections, such as giving at least three days of notice, with details of the inspection, to building occupants; how images or video recordings taken during façade inspections using drones should be handled; as well as the implementation of systems and processes to prevent any unauthorised usage of images and footages captured.

Responsible parties and drone service providers should put in place systems and processes to safeguard data privacy. For example, images of residents captured during façade inspection should undergo anonymisation through masking, using a masking software or by other methods to render them unidentifiable.

Raising capabilities of personnel conducting PFIs

About 30,000 buildings will be required to undergo façade inspection within the first seven-year inspection cycle. To ensure that there are sufficient skilled persons to conduct façade inspections, BCA has worked with the industry to develop and implement a mandatory training course for the 'Certificate in Façade Inspection'. The course equips participants with the essential knowledge and skills required to conduct façade inspections. The course is offered by BCA Academy and IES Academy.

As of September 2021, there are 149 Competent Persons and 140 registered Façade Inspectors. The complete list of Competent Persons & Façade Inspectors can be downloaded from the BCA website: <https://go.gov.sg/bca-periodicfacadeinspection>

The related PFI regulations can be downloaded at <https://sso.agc.gov.sg>:

- Building Control (Periodic Inspection of Buildings and Building Façades) Regulations 2021.
- Building Control (Meaning of Exterior Features) Regulations 2021.

SMART TECHNOLOGY WITH DRONES AND ARTIFICIAL INTELLIGENCE FOR BUILDING FACADE INSPECTION

by Prof David Chua, Prof Lawrence Wong, Prof Justin Yeoh, Prof William Lee, Prof Marcelo Ang, Prof Michael Chew, Lin Yuehan, Janine Wong, Alvin Teo, Liew Jia Min and Ding Man, National University of Singapore; Prof Lawrence Wong and Edwin Loh, WingSpec; and David Ng, Victor Ong and Lee Long Guang, One Smart Engineering Pte Ltd

With the new Periodic Façade Inspection (PFI) regime scheduled to take effect from 1 January 2022, advanced engineering concepts are being deployed, that will help building owners obtain fast and accurate results.

Singapore has a densely populated high-rise cityscape with ageing building stock, with the facades of buildings subjected to weather elements and deterioration over time. There is potential risk to passers-by, should components from the facade of a building fall to the ground, as they can cause major and even fatal injuries. Therefore, it is necessary to carry out early detection of such possible building facade deterioration and to carry out rectification to prevent façade components from falling and injuring people.

Under the Building Maintenance and Strata Management Act (BMSMA), responsible parties have a duty to ensure that building exteriors are properly maintained. Going forward, BCA has introduced a new Periodic Façade Inspection (PFI) regime to facilitate the early detection of facade deterioration and allow defects to be rectified in a timely manner. This will help to reduce the likelihood of facade failures, as our building stock ages. The requirements above are now consolidated into the Building Control Act. Façade inspections will need to be conducted every seven years for buildings that are more than 13 m tall once they are over 20 years old. Responsible parties must appoint a Competent Person (CP), i.e. a Professional Engineer (PE) or Registered Architect, who can be assisted by a Façade Inspector (FI), to conduct the facade inspection.

Application of drones and AI for facade inspection

One Smart Engineering Pte Ltd together with WingSpec, a new start up from NUS, can provide the professional services of the CP and FI to carry out the PFI with smart technology. Drone and Artificial Intelligence (AI) technologies will be deployed to carry out the PFI in a more efficient and practical way to improve the productivity and enhance safety of the CP and FI.

Figure 1 shows a drone in operation during an inspection of the facade of a Housing & Development Board (HDB) apartment block that is more than 20 years old.

The procedure of building facade inspection includes 100% visual inspection of the building, followed by 10% physical hands-on inspection of a few selected portions



Figure 1: Drone performing building facade inspection.

on the facade. A drone is used to carry out close to 100% visual inspection with systematic flight path planning to capture photos, and AI will be used to analyse these photos to identify any pre-classified defects. This can save a lot of time and avoid potential human errors in carrying out the 100% visual inspection manually. The application of AI is a process that is programmed to carry out the duties intended for the purpose. Figures 2 and 3 show the process of carrying out the inspection by a drone followed by the analytical procedures followed, with the help of AI to identify defects, and the generation of a report for the PE/CP.

The drones used are DJI Phantom 4 RTK and DJI Matri-ce210 RTK with additional mounts for advanced distance sensors. The key innovations in this autonomous drone are:

- Combined GPS and RTK GNSS for geo-referencing that is used for UAV navigation.

- Optimised Path Planning for semi-autonomous flights.

The convolutional neural network is applied to the image pixels for defect detection, and defect feature extraction. The ZenMuse X7 optical camera and ZenMUSE XT2 IR and optical camera are used for capturing photos with high accuracy and overlaps. The key innovations for defect management and computer vision are:

- A robust Machine Learning Algorithm for Multiple Defects Detection.
- Photogrammetry for inferring defect and facade features (semantic segmentation).
- Severity Assessment.

In the system integration, the key innovations are:

- Workflow Analysis and Optimisation.
- Streamlined User interface.
- Mixed annotation and tracking.

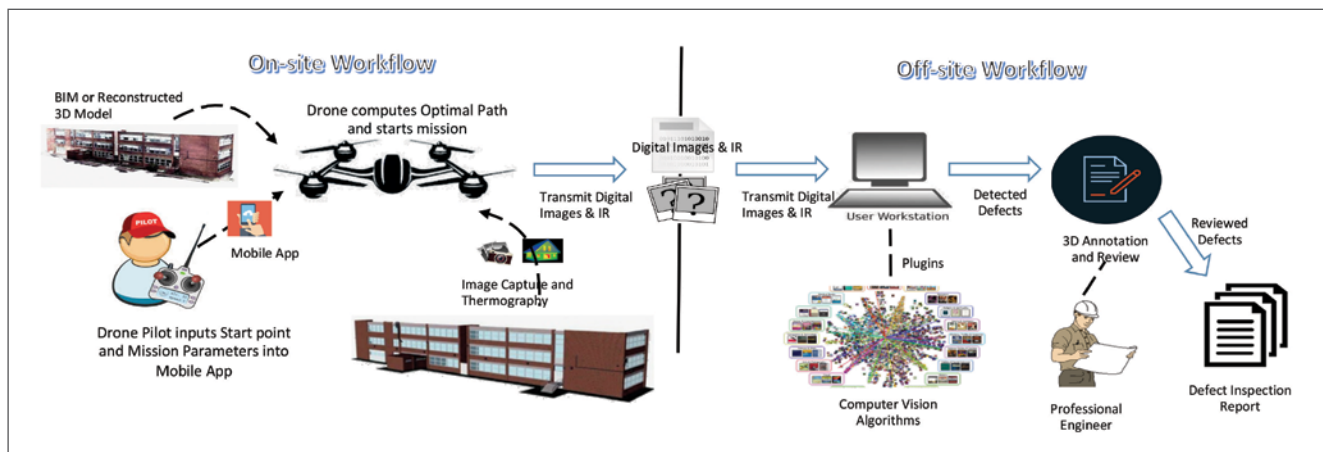


Figure 2: Procedure and workflow for the application of drones in carrying out building facade inspections.

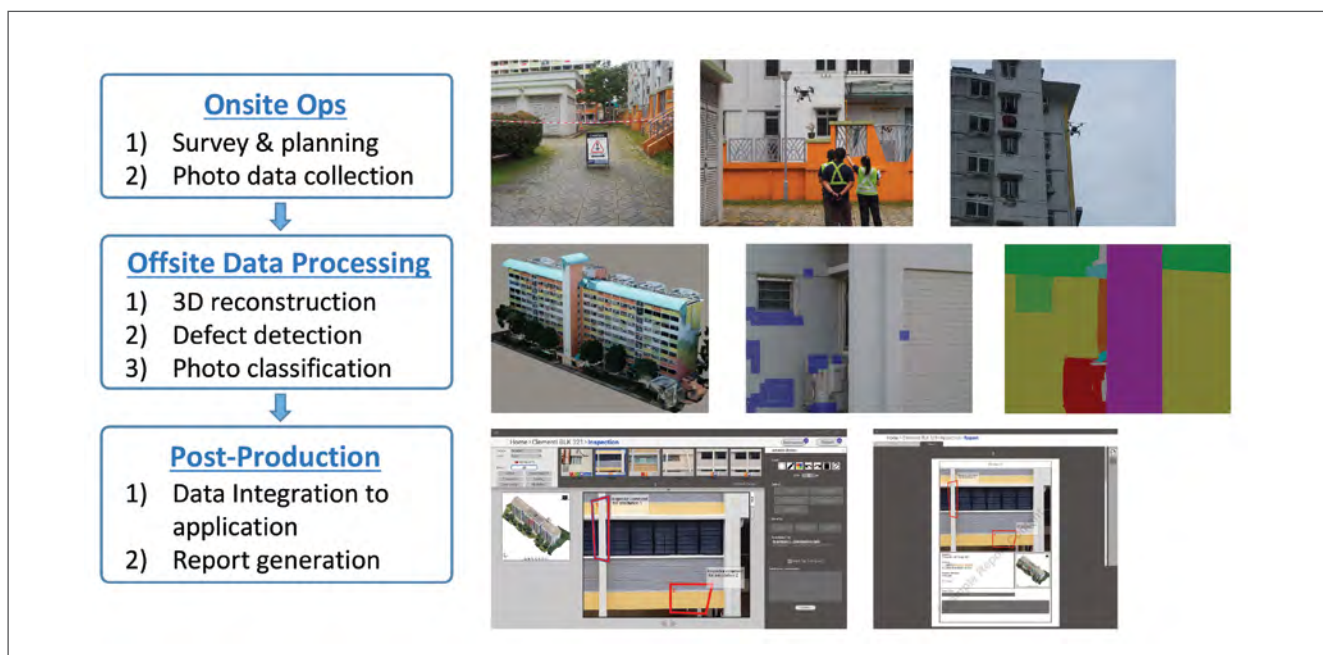


Figure 3: Samples of photos taken by a drone during building facade inspection and results from the data processing and post-production stages.

The technologies deployed are:

- 3D Reconstruction and Geo-tagging.
- Cloud computing and storage.
- Web and Mobile apps.

Figure 4 shows a reconstructed 3D model of a building inspected by a drone.

The main advantages of the application of drones and AI for building facade inspection are:

- Fast turnaround with timely results: This will almost completely eliminate the need for physical access or work at height for the general inspector.
- Professionally trained flight pilot and equipment with the latest technologies: The drone flight team is trained and experienced to deal with any challenging flight environment to ensure safe operation, and the drone fleet is equipped with the latest technology to ensure maximum safety during flight.
- Auto-generation of results and report compilation according to BCA requirements: Understanding the

needs of the PE/CP, inspection reports are auto-generated and are compliant with BCA's PFI requirements.

- Future-ready data management system and apps: The data management platform helps clients to archive any photos taken during flight inspection in a single system with AI-integrated functionality.
- Value for money and provision of value-added services: The drone- and AI-based building façade inspection platform can provide an effective and efficient all-in-one service.

This work was supported by Singapore's Building and Construction Authority (BCA) and the Housing & Development Board (HDB). This research was funded by the National Research Foundation (NRF) [NRF-2018NRF-CG0002-004] and Enterprise Singapore (ESG) [181229HT].

All images by
One Smart Engineering Pte Ltd / WingSpec



Figure 4: Reconstructed 3D model of a building inspected by a drone.

MANAGING CYBER RISKS

AND ENSURING RESILIENCE

Mr Raymond Ung, Assistant Director, Cyber Security Agency of Singapore, summarises his educational and career achievements, and points to the benefits of the CEng qualification, in this interview with 'The Singapore Engineer'.



Mr Raymond Ung

The Singapore Engineer (TSE): Could you provide a few highlights of your education and career to-date, including the awards and commendations received?

Raymond Ung (RU): I graduated from Nanyang Technological University (NTU) as an Electrical Engineer, majoring in Industrial Automation, with an upper 2nd class honours degree. In the first half of my career to-date, I have been working as an engineer, rotating between the private and public sectors.

In 2013, I was awarded a sponsorship by PUB, Singapore's National Water Agency, to further my studies. This enabled me to study for a MSc degree in System Design and Management, at the National University of Singapore (NUS), which I completed in 2015.

The courses of study broadened my thinking and cybersecurity was one of the key focus areas I pursued. I joined an automation company as a Technical Manager and here I was able to rapidly acquire further competencies in technology and cybersecurity, through handling a wider range of realistic cases.

In 2018, I got the opportunity to join the Cyber Security Agency of Singapore (CSA) as a Senior Cybersecurity Consultant and I am currently leading a team of consultants as an Assistant Director at CSA.

Apart from acquiring multiple, professional certifications, as an individual, I have also been part of award-winning teams such as the following:

- The CSA - OT Cybersecurity Masterplan team which was awarded the Recognition of Excellence Award by OpenGov.
- The Red Team (Kopitiam) which was recognised as the Top Red Team at the global Critical Infrastructure Security Showdown (CISS) 2020, organised by SUTD.

TSE: What is the most meaningful career achievement for you so far, and why?

RU: There are two achievements that I would like to mention and both are related to safeguarding our nation's resilience:

- Designing and building a Critical Information Infrastructure (CII) to ensure a continuous supply of water for the nation.

- Developing the Operational Technology (OT) Cybersecurity Masterplan to enhance the security and resilience of Singapore's Critical Information Infrastructure (CII) sectors in delivering essential services. The masterplan serves to improve cross-sector responses to mitigate cyber threats in the OT environment and to strengthen partnerships with industry and stakeholders.

The OT Cybersecurity Masterplan outlines key initiatives covering the areas of People, Processes and Technology, to uplift the cybersecurity postures of our CII owners and organisations that operate OT systems. I was the Lead for Key Thrust 1 & 2.

Key thrusts in the OT Cybersecurity Masterplan include:

1. Providing OT cybersecurity training to develop human capabilities.
2. Facilitating the sharing of information through an OT Cybersecurity Information Sharing and Analysis Centre (OT-ISAC).
3. Strengthening OT owners' policies and processes through the issuance of an OT Cybersecurity Code of Practice (CCoP).
4. Adopting technologies for cyber resilience through Public-Private Partnerships.

In addition, the masterplan encourages OT equipment manufacturers and service providers to implement cybersecurity in the developmental phase, so that products and systems are in-built with strong cybersecurity measures.

The OT Cybersecurity Masterplan will serve as a strategic blueprint to guide Singapore's efforts to foster a resilient and secure cyber environment for our OT CII, while taking a balanced approach between security requirements, rapid digitalisation and ease of conducting business-as-usual activities.

TSE: Could you briefly describe the scope of your current duties?

RU: I am from the Critical Information Infrastructure (CII) Division where we work to strengthen the cybersecurity of the critical sectors in the Government, Transport, Services and Utilities clusters. I am currently the Team Lead of the Utilities Cluster. The key focus here is to partner regulators and CII owners to strengthen the cyber resilience of the nation's CII against cyber threats and to ensure the continuity of essential services.

Towards this end, my work will be focused on enhancing the protection, detection, response and recovery capabilities of CII and I am involved in directing, and administration of, the cybersecurity governance and legislative framework; engaging stakeholders on cyber risk management efforts; and supervising the implementation of security measures.

As a Team Lead of the Cluster Team, I also guide the officers in my team and assist the Head of the Division in day-to-day operations. In addition, I also have frequent interactions with senior leaders in the cybersecurity space.

TSE: What motivated you to become a Chartered Engineer?

RU: I wanted to validate my experiences and competencies in Systems Engineering and the CEng qualification has enabled me to achieve this.

TSE: How do you think becoming a Chartered Engineer has assisted you in the progression of your career so far?

RU: It has resulted in a differentiation in my professional standing, in my area of focus and expertise.

TSE: How do you think becoming a Chartered Engineer will assist you in the future?

RU: By becoming a Chartered Engineer, I will have more perspectives, instead of being limited by a narrow mindset, thereby enabling me to level up, as the landscape of technologies and cybersecurity is constantly and quickly evolving.

TSE: What advice would you give engineers who aspire to obtain the CEng certification?

RU: As engineers, we should strive to succeed and not be afraid of failure in the course of our work. In the event that we need to compromise on certain elements in a design, it should never be on something that may have a catastrophic impact on the business mission (e.g on the safety and security of lives), and it should be collectively agreed to, by all the stakeholders.

TSE: If there was one engineer (living or dead) you could meet, who would it be and why?

RU: I think it would be the engineers from the Honda HRC MotoGP team, such as Jun Miyazaki. Since I was young, I have been a fan of racing bikes and I have been riding superbikes in my younger days. I repaired the bikes myself, with the knowledge in electronics and electrical engineering I gained from school.

I had once been inspired to be an engineer who would design seamless and powerful gearboxes for racing bikes, but I think language and cost were barriers, at that time.

TSE: Any other information that you would like to provide?

RU: We should not constrain ourselves with a narrow, 'checklist compliance' mindset, but rather, by incorporating a risk-based approach in our work, we can see a better picture and resources can be better prioritised.

We should also challenge ourselves by asking questions such as the 5 Ws (Who, Why, What, When and Where) and the 1 H (How), in order to optimise the outcome of the design or engineering process.

Further, to incorporate cybersecurity into engineering perspectives, due to the evolving threat landscape, we should also embrace the changes and upskill ourselves accordingly. We can take reference from the Operational Technology Cybersecurity Competency Framework (OTCCF) which provides guidance on the competencies that professionals should equip themselves with, in performing their jobs in the engineering industries.

CSA launches Operational Technology Cybersecurity Competency Framework

The Cyber Security Agency of Singapore (CSA) has launched the Operational Technology Cybersecurity Competency Framework (OTCCF) which will provide the foundation to attract and develop talent for the emerging OT cybersecurity sector in Singapore.

The OTCCF – jointly developed by CSA and Mercer Singapore, and supported by SkillsFuture Singapore (SSG) and Infocomm Development Authority (IMDA) – maps out the various OT cybersecurity job roles and the corresponding technical skills and core competencies needed. It also captures the possible career pathways showing the options for vertical and lateral progression. The OTCCF aims to guide key stakeholders in the following ways:

- OT and IT system owners can refer to the OT cybersecurity capabilities required to attract the right people, train them adequately, and map out their career pathways.
- Training providers can refer to the technical competencies required by different job roles and be guided to develop best-in-class courses and certifications that cater to local training needs.
- OT professionals or potential jobseekers can identify skillsets for cross- and up-skilling for a meaningful career in the OT cybersecurity domain. The career pathways could apply to job roles inclusive of vertical and lateral advancement opportunities.

Additionally, CSA Academy has begun engaging stakeholders from the Institutions of Higher Learning and selected CII owners to garner their feedback for an upcoming OT Train-The-Trainer (OT TTT) programme.

More information on the OTCCF may be obtained from www.csa.gov.sg/otccf.

THREE PROFESSIONAL ENGINEERS

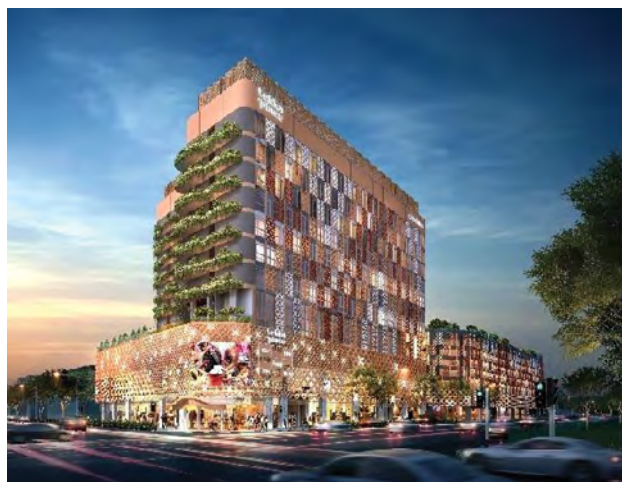
CONFERRED BCA DESIGN AND ENGINEERING SAFETY AWARD 2021

The Building and Construction Authority (BCA) has awarded three Professional Engineers with the BCA Design and Engineering Safety 'Excellence' Awards this year. The Award recognises Professional Engineers and their teams for their innovative designs and engineering solutions for some of Singapore's most challenging projects.

The Professional Engineers (PEs) who won the BCA Design and Engineering Safety Award 2021 are Er. Aaron Foong from KTP Consultants Pte Ltd (a member of the Surbana Jurong Group), for Tekka Place; Er. Loh Kar Kheng, CPG Consultants Pte Ltd, for State Courts; and Er. Joanne Ee, formerly from CPG Consultants Pte Ltd, and currently with BCA, for Eunoia Junior College.

Winner of BCA Design Engineering and Safety Award 2021 (Commercial Category) Excellence

Tekka Place



Tekka Place

Tekka Place is an integrated hospitality and retail redevelopment being built on the site of the former The Verge mall at 2 Serangoon Road. The project comprises a new 10-storey Main Block with link bridges across Clive Street connecting to the seven-storey existing Annex Block which now has a new rooftop deck. The Main Block is a new reinforced concrete mid-rise structure founded on bored pile foundation with the new perimeter superstructure columns supported by the repurposed existing diaphragm wall which was also effectively reused for earth retention in the basement. The Annex Block underwent thoughtful addition and alteration works to maintain most of its existing reinforced and prestressed concrete structures in a sustainable manner.

Challenges

- To achieve sustainable development of the Main Block into a new mixed-use commercial hotel and retail area, by overcoming the constraints from the existing building with two basements seated on soft soil geology located within the LTA Railway Protection Zone and hemmed in by conserved shophouses.
- Making a conscious decision to sustainably retain the existing Annex Block structures, by upgrading the spatial quality with double volume spaces on the lowest floor for commercial activities and increasing the load-carrying capacity at the roof level supported by the existing, critical prestressed transfer structures at the lower levels.

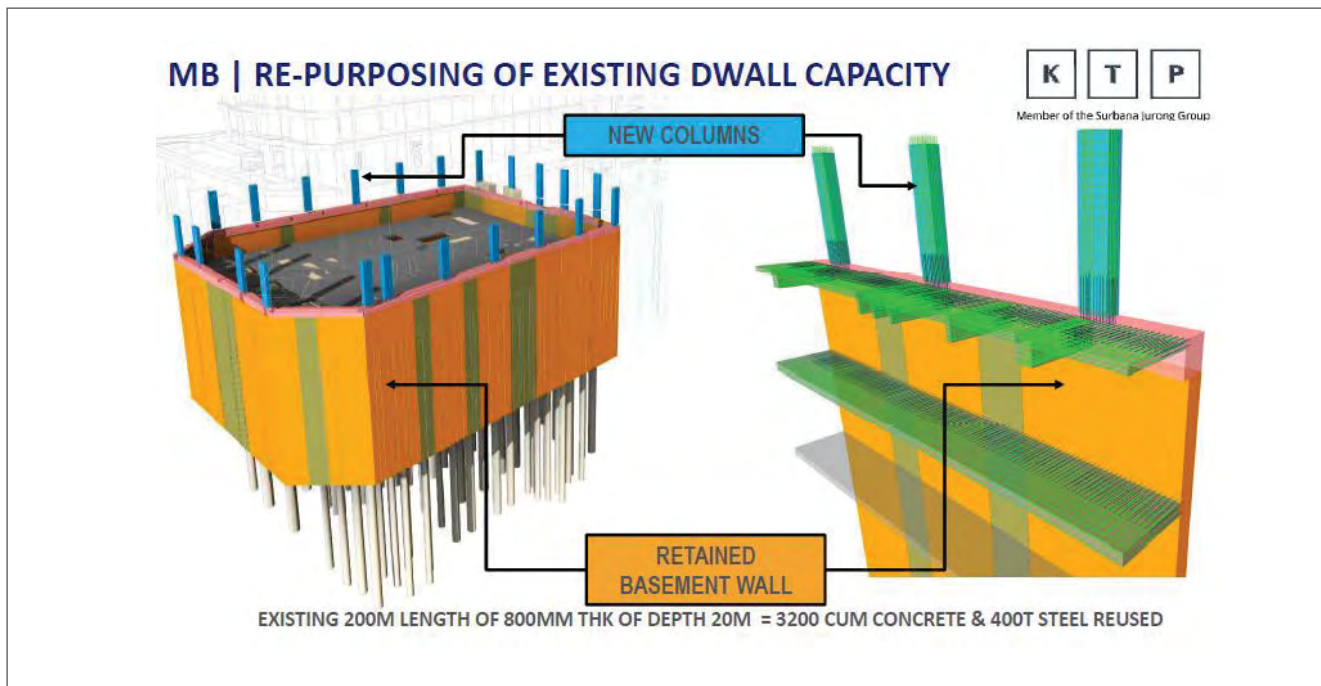
Solutions and Features

- Rigorous engineering analysis with carefully considered loading scenarios and innovative re-designing of the as-built structural capacities, to drive an overall sustainable approach in the re-development.
- On the new Main Block, the engineering-driven solution by informed repurposing of the existing basement diaphragm wall and capping beam structures achieved a sustainable design of the new sub-structure works with flexibility to support new load intensities from the perimeter columns of the new superstructures.
- On the retained Annex Block, in enabling the increased loadings from an entirely new rooftop deck, an innovative engineering solution achieved by stitching of existing prestressed structures has avoided the need to disrupt and reconstruct the existing system of prestressed transfer beam, transfer column and foundation.

Building sustainably through innovation

Fourth time award winner, Er. Aaron Foong, from KTP Consultants Pte Ltd (a member of Surbana Jurong), has won the award, this time, for overcoming challenges of a delicate building project – the redevelopment of Tekka Place, an existing building with two basements seated on soft marine clay located within the LTA Railway Protection Zone and hemmed in by conserved shophouses.

To build sustainably, Er. Foong re-engineered the existing basement diaphragm wall to have a dual function of supporting both the construction works of new substructures (below ground) and the increased



Re-purposing of existing basement diaphragm wall capacity.
Image: KTP Consultants Pte Ltd.

loading from new superstructures (above ground) in the new Main Block. With this innovative re-engineering approach, there was no need to build new conventional periphery basement earth retaining walls and the accompanying foundation piles, saving 3,400 m³ of concrete and 400 tonnes of reinforcement steel. This savings was substantial – it is the same as the amount of concrete and steel that is used for all the concrete structures supporting the entire 320-room Citadines Rochor serviced residences, occupying the upper floors of the Main Block. Beyond savings in cost and reducing the carbon footprint, this innovative structural engineering design enabled the construction period of the project to be reduced by six months without compromising safety standards, in turn, reducing disamenities to surrounding residents and traffic flow along Sungei Road and Serangoon Road.

PROJECT CREDITS

Qualified Person

Er. Aaron Foong Kit Kuen

C&S Consultant

KTP Consultants Pte Ltd

Builder

Lum Chang Building Contractors Pte Ltd

Developer

Corwin Holding Pte Ltd

Architectural Consultant

ONG & ONG Pte Ltd

Winner of BCA Design Engineering and Safety Award 2021 (Institutional and Industrial Category) Excellence

State Courts



State Courts

The new 35-storey State Courts Towers comprises two towers, the Court Tower and a very slender Office Tower. At 178 m high, it is the tallest government building in Singapore to-date. The Court Tower has an open frame building facade, with courtrooms stacked on one another, resulting in aesthetically pleasing, slender Court Tower Columns, consisting of long-span floor slabs/beams and column sizes befitting the facade.



Link bridge erection. Image: Er. Loh Kar Kheng.

Challenges

- As the site is in close proximity to a conserved building, an underground MRT station and a building which is gazetted as a National Monument, the construction of a deep basement (consisting of three basements) required intricate planning and execution.
- To counter the wind tunnelling effect that the narrow open space between the two towers would create on the link bridges, as the interaction between the towers and bridges may affect the building's deflection as well as human comfort.

Solutions and Features

- Circulation spaces linking the two towers are utilised structurally with 39 link bridges linking the two towers together, with the Court Tower providing lateral stability to the Office Tower.
- Link bridges were prefabricated and delivered to site as single units, before being hoisted and placed in position on temporary supporting corbels, after which final connections are made safely.
- Steel-Concrete composite columns with twin H-sections orientated along the weaker axis were used for the slender Court Tower columns. Grade 460 steel was used for columns and was cast with high-strength, self-compacting concrete.
- A deep deck system (CAP Deck) which can span longer, was used for the floor system, supported by composite beams, resulting in material/cost savings and reduced construction time.
- A robust earth retaining structure comprising diaphragm walls and a semi-top-down construction method was adopted for the basement construction, to minimise wall deflection, ground movement and water drawdown. This resulted in safe construction of the three levels of basement, with minimal impact to the neighbouring buildings which are susceptible to soil movement.

Turning a challenge into a solution

Er. Loh Kar Kheng, CPG Consultants Pte Ltd, received the award for his engineering solutions in the construction of the iconic State Courts. Due to the narrow open space between the Court Tower and Office Tower, a wind tunnel study was conducted to understand the effect wind would have on the towers and link bridges of the project, which would affect the building's deflection as well as human comfort.

To overcome the challenge of constructing the slender

Office Tower, 39 link bridges were planned to span the circulation space linking the Office Tower to the stockier Court Tower. These link bridges, in turn, provided lateral stability to the Office Tower. Each link bridge was also prefabricated and delivered to site as one unit before being hoisted and placed in position on temporary supporting corbels, after which final connections were made safely. This allowed the project to be constructed within a constrained space, reducing disamenities and minimising the need for working at height, thereby improving the safety for those on site.

PROJECT CREDITS

Qualified Person

Er. Loh Kar Kheng

C&S Consultant

CPG Consultants Pte Ltd

Builder

Samsung C&T Corporation

Developer

State Courts of Singapore

Architect

CPG Consultants Pte Ltd

Architectural Design Consultant

Serie + Multiply Consultants Pte Ltd

Winner of BCA Design Engineering and Safety Award 2021 (Institutional and Industrial Category) Excellence

Eunoia Junior College



Eunoia Junior College



Prefabrication of Hybrid Timber-Concrete Slab System (CREE). Image: Er. Joanne Ee.

Eunoia Junior College is a 10- and 12-storey building, with a five-storey high, elevated running track and field, located next to Kallang River.

Challenges

- A smaller site at four hectares, which is about a third of the conventional site area for junior colleges.
- To design and construct an elevated running track and field over the future Cross Island Line Rail tunnels and overhanging the Kallang River with three mega tree columns sitting in the river.

Solutions and Features

- Innovative Hybrid Timber-Concrete Slab System, CREE, and unitised façade system with internal Cross Laminated Timber, adopting extensive off-site fabrication for the superstructure of the teaching blocks. The prefabricated components were erected on site with simple connections. These systems are extremely lightweight, highly buildable and productive. They are environmentally sustainable and meet the specific requirements relating to strength, fire-resistance, waterproofing and durability.
- Design transfer piled raft system with tensioned piles located at the zones available for piling, to support the elevated running track and field. The piles were designed to accommodate future tunnelling and address any volume-lost effect.
- Long span (up to 36 m) precast, half-shell, post-tensioned beams were adopted, to give more column-free space required below the running track and field.
- Adopted precast with cast-in I-beam for bolted connection for the 13.3 m branch columns to the mega tree columns supporting the sports running track and field.
- Extensive use of precast, such as double-tee slabs and planks at the elevated field deck and beam, slab, column, and wall system for teaching blocks.

Using prefabrication in an inventive way

Er. Joanne Ee, formerly from CPG Consultants Pte Ltd and currently with BCA, was recognised for her innovative engineering solutions in the construction of Eunoia Junior College (EJC). EJC is the first project in Singapore 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 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.

PROJECT CREDITS

Qualified Person

Er. Ee Hwee San Joanne

C&S Consultant

CPG Consultants Pte Ltd

Builder

Kimly Construction Pte Ltd

Developer

Ministry of Education

Architectural Consultant

CPG Consultants Pte Ltd

RECOGNITION FOR WORKPLACE SAFETY & HEALTH

AND ENVIRONMENTAL EXCELLENCE

Two new award categories this year recognise environmental sustainability solutions and safety practices in building 'Active Mobility' infrastructure.

A total of 69 contractors, operators, organisations and individuals have been recognised by the Land Transport Authority (LTA) for their outstanding workplace safety, health and environment management practices in 2020 at the 23rd LTA Annual Safety, Health and Environmental Award Convention (ASAC 2021), held recently.

The theme for this year's convention – 'Adapting to New Norms and Continual Training for a Safer and More Productive Workforce' – reflects the challenges of navigating COVID-19 in the past year. It acknowledges the efforts and achievements of companies in adapting and ensuring business continuity during the pandemic, in a safe and environmentally-conscious manner.

Championing innovative solutions to promote environmental sustainability

In addition to building a safe and healthy workplace, ensuring environmental sustainability has become increasingly important. A new award category – Environmental Sustainability Innovation Award – was introduced this year to recognise contractors for their innovative practices at worksites to improve environmental protection and sustainability, as well as to enhance the living environment of stakeholders near LTA construction sites.

Shincon Industrial Pte Ltd and Penta Ocean Construction Co Ltd - Bachy Soletanche Singapore Pte Ltd Joint Venture won the inaugural award for adopting innovative and environmentally-sustainable solutions for their projects.

Shincon Industrial Pte Ltd used portable protective flooring to build a temporary footpath when contracted by LTA to carry out infrastructure enhancements under the Seletar flyover. This solution is lighter compared to a conventional concrete footpath and can be reused at other construction sites. The material used also minimises damage to the turf as it is designed with airholes to allow ventilation and sunlight to pass through for grass beneath to grow.

Penta Ocean Construction Co Ltd - Bachy Soletanche Singapore Pte Ltd Joint Venture was recognised for implementing a new type of retractable noise barrier (Silent Up) for the construction of the North-South Corridor between Suffolk Walk and Novena Drive. Made of a lightweight plastic material, this noise barrier can be easily deployed at locations with space constraints, without the use of machinery. It is an efficient solution that helps to address the perennial challenge of construction in dense and built-up environments.

In support of the Singapore Green Plan 2030, LTA is also spearheading efforts to minimise the carbon footprint in its construction projects. This includes keeping track of and analysing construction materials used, in order to identify major sources of carbon emission; using sustainable materials to replace conventional cement; and reducing construction waste.

Recognising workplace safety practices across more construction projects

The second new award category – the Construction Safety Award (Active Mobility) – aims to recognise the efforts by contractors who have contributed significantly towards promoting safe work practices when building and implementing Active Mobility infrastructure such as cycling paths.

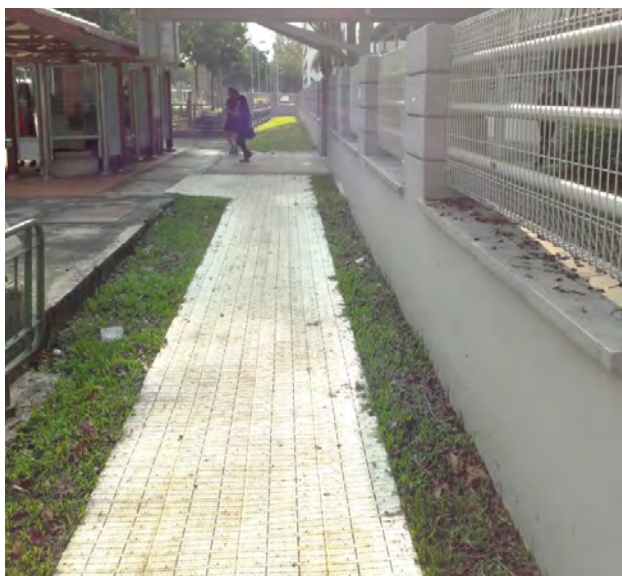
Eng Xian Construction Pte Ltd won the inaugural Construction Safety Award (Active Mobility) under a contract to build public bicycle parking spaces island-wide. The company was lauded for its exemplary work in ensuring that all its worksites are accident-free.

In tandem with promoting safe and environmentally sustainable work practices among its contractors, LTA is also embarking on the use of technology to enhance construction safety. For example, video analytics with closed circuit television cameras is used to complement and automate LTA's site supervision for the construction of Cross Island Line Phase 1. This will aid the remote monitoring of high-risk work areas and prevent unauthorised entry into construction sites or restricted zones.

Besides Shincon Industrial Pte Ltd, Penta Ocean Construction Co Ltd - Bachy Soletanche Singapore Pte Ltd Joint Venture and Eng Xian Construction Pte Ltd, 66 other organisations also received accolades across the 22 award categories, ranging from Construction Safety Excellence to Public Transport Safety.

ASAC

ASAC (Annual Safety, Health and Environmental Award Convention) was inaugurated in 1999 to recognise contractors who have been proactive and successful in promoting Workplace Safety and Health management practices at their worksites, ensuring high health, safety and welfare standards of workers, and giving due consideration to protecting the public and the environment.



Portable protective flooring installed by Shincon Industrial Pte Ltd.



Silent Up noise barrier installed by Penta Ocean Construction Co Ltd - Bachy Soletanche Singapore Pte Ltd Joint Venture.

WINNERS AT THE 23RD ASAC

CONSTRUCTION SAFETY ACHIEVEMENT AWARD

Category A (civil contracts ≥ \$50 million)

Contract 882 – China State Construction Engineering Corporation Limited Singapore Branch - Nishimatsu Construction Co Ltd Joint Venture

CONSTRUCTION SAFETY EXCELLENCE AWARD

Category A (civil contracts ≥ \$50 million)

Contract T305 – Shanghai Tunnel Engineering Co (Singapore) Pte Ltd
Contract 821A – Woh Hup (Private) Limited
Contract 882 – China State Construction Engineering Corporation Limited Singapore Branch - Nishimatsu Construction Co Ltd Joint Venture

CONSTRUCTION SAFETY MERIT AWARD

Category A (civil contracts ≥ \$50 million)

Contract T306 – Woh Hup (Private) Limited
Contract T307 – Samsung C&T Corporation
Contract 885 – China Railway Tunnel Group Co Ltd (Singapore Branch)
Contract RC118 – Hwa Seng Builder Pte Ltd

Category B (civil contracts ≥ \$20 million < \$50 million)

Contract DE135 – Jin Choon Civil Engineering Pte Ltd

Category C (E&M contracts ≥ \$20 million)

Contract T250 – CTCI Singapore Pte Ltd
Contract R153 – Meiden Singapore Pte Ltd

Category D (civil and E&M contracts < \$20 million)

Contract T3102 – Cast Laboratories Pte Ltd
Contract T255 – Hollysys (Asia Pacific) Pte Ltd
Contract ER381 – Megastone Holdings Pte Ltd

CONSTRUCTION ENVIRONMENTAL MERIT AWARD

Category A (civil contracts ≥ \$50 million)

Contract T309 – John Holland Pte Ltd - Zhen Hua (Singapore) Engineering Pte Ltd Joint Venture
Contract N109 – Hwa Seng Builder Pte Ltd - Chye Joo Construction Pte Ltd - Ho Lee Construction Pte Ltd Joint Venture
Contract RC118 – Hwa Seng Builder Pte Ltd

Category B (civil contracts ≥ \$20 million < \$50 million)

Contract ER489 – Megastone Holdings Pte Ltd

PROJECT SAFETY COMMENDATION AWARD

Thomson-East Coast Line (Civil Team 5) Project Safety & Environmental Committee
Rail Expansion (Civil Team 1) Circle Line 6 Project Safety & Environmental Committee

ACCIDENT-FREE RECOGNITION AWARD

For Category 1 (civil contracts ≥ \$120 million) and has achieved above 1.2 million accident-free man-hours worked

Contract T312 – KTC Civil Engineering & Construction Pte Ltd
Contract 821A – Woh Hup (Private) Limited
Contract 882 – China State Construction Engineering Corporation Limited Singapore Branch - Nishimatsu Construction Co Ltd Joint Venture
Contract N106 – Samsung C&T Corporation

For Category 2 (civil contracts < \$120 million) and has achieved above 300,000 accident-free man-hours worked

Contract RC118 – Hwa Seng Builder Pte Ltd
Contract 715 – China State Construction Engineering Corporation Limited Singapore Branch

For Category 3 (E&M contracts) and has achieved above 300,000 accident-free man-hours worked

Contract T252 – Alstom Transport (S) Pte Ltd

Contract T273C – Shinryo Corporation
Contract R153 – Meiden Singapore Pte Ltd
Contract R153A – Meiden Singapore Pte Ltd

QPS SAFETY AWARD

Contract T3071 – LYL Consultants Pte Ltd
Contract T3131 – Tritech Consultants Pte Ltd
Contract 8851 – Ronnie & Koh Consultants Pte Ltd
Contract N1071 – Worley Pte Ltd
Contract 7151 – RCY Pte Ltd

WSH OFFICER RECOGNITION AWARD

Contract RC118 – Hwa Seng Builder Pte Ltd – Mr Azry Tay

SUBCONTRACTOR'S SAFETY RECOGNITION AWARD

Bok Seng Logistics Private Limited
Dongah Geological Engineering Co Ltd
Doo Ree Engineering & Trading Pte Ltd
Fuchi Pte Ltd
Hsuen Chow Pte Ltd
Top Pave Pte Ltd
TPW Engineering Pte Ltd

CONSTRUCTION SAFETY INNOVATION AWARD

Contract 883 – China State Construction Engineering Corporation Ltd
(Pedal Trolley for Pipe Jacking Works)
Contract ER489 – Megastone Holdings Pte Ltd
(Flexible Easy Safe (FES) Blocks as An ERSS System)

ENVIRONMENTAL SUSTAINABILITY INNOVATION AWARD

Contract DE137 – Shincon Industrial Pte Ltd
(Portable Protective Flooring)
Contract N105 – Penta Ocean Construction Co Ltd -
Bachy Soletanche Singapore Pte Ltd Joint Venture
(Silent Up Noise Barrier)

CONSTRUCTION WORKPLACE HEALTH AWARD

Contract T305 – Shanghai Tunnel Engineering Co
(Singapore) Pte Ltd
Contract T313 – Samsung C&T Corporation

PUBLIC TRANSPORT SAFETY AWARD (BUS OPERATOR)

Excellence Award
PT203 Bukit Merah Bus Package – SBS Transit Ltd

Merit Award
PT212 Jurong West Bus Package – SBS Transit Ltd

PUBLIC TRANSPORT SAFETY AWARD (RAIL OPERATOR)

Excellence Award
North East Line – SBS Transit Ltd

Merit Award
Circle Line – SMRT Trains Ltd

PUBLIC TRANSPORT SAFETY AWARD (POINT-TO-POINT OPERATOR)

Excellence Award
Strides Taxi Pte Ltd

Merit Award
CityCab Pte Ltd
GrabCar Pte Ltd

PUBLIC TRANSPORT SAFETY AWARD (SPECIAL COMMENDATION)

Mohammad Taufik Bin Zawadi
Phoon Soon Tuck @ Dhyan Khorsand, Mohamad Azli Bin
Mohd Azni, Effendi Bin Hashim & Norjan Binte Abdul
Rayman

SAFEST LOGISTICS/TRANSPORT COMPANY AWARD

Certificate of Merit
Yang Kee Logistics Pte Ltd
YCH Global Logistics Pte Ltd

MECHANICAL & ELECTRICAL MAINTENANCE SAFETY AWARD (PUBLIC FACILITIES & SYSTEMS)

Certificate of Excellence
Contract ER439 – Chevalier Singapore Holdings Pte Ltd

Certificate of Merit
Contract TR302C – Fonda Global Engineering Pte Ltd

ROAD TRAFFIC SYSTEM & ROAD TUNNEL OPERATIONS SAFETY AWARD (TUNNEL, ROAD OPERATION & SYSTEMS)

Certificate of Excellence
Contract TR136 – ST Engineering Synthesis Pte Ltd

Certificate of Merit
Contract TR343W – Eng Hup Engineering Pte Ltd

ROAD OPERATIONS INSPECTION & CONSULTANCY SAFETY AWARD

Certificate of Excellence
Contract TR271 – Novaars International Pte Ltd

Certificate of Merit
Contract TR273 – Ang & Ong Consultants Pte Ltd

CIVIL MAINTENANCE SAFETY AWARD (MAINTENANCE/UPGRADING CONTRACT)

Certificate of Excellence
Contract TR305A – Gim Tian Civil Engineering Pte Ltd

Certificate of Merit
Contract TR283 – Gim Tian Civil Engineering Pte Ltd

CONSTRUCTION SAFETY AWARD (ACTIVE MOBILITY)

Certificate of Merit
Eng Xian Construction Pte Ltd

A GAME-CHANGING TECHNOLOGY

FOR LOW CARBON CONCRETE

The use of CO₂ mineralised concrete will help to reduce embodied carbon emissions in the built environment sector.

The built environment sector has a critical role to play in responding to the global climate emergency. According to the World Green Building Council (WorldGBC), buildings are responsible for 39% of global carbon emissions [1], of which 11% is embodied carbon that is emitted during the production of building materials and the construction process. Another 28% of emissions relate to operational carbon emitted from the energy used to operate a building. Half of the entire carbon footprint of new construction between now and 2050 is expected to come from carbon emitted before a newly-completed building is used.

Carbon reduction opportunities in the built environment

In recent years, research and decarbonisation efforts in the built environment sector have focused on improving the operational energy efficiency of buildings. To reduce operational carbon, architects, developers and engineers focus on constructing high-performance, net-zero-energy buildings which emit as little carbon as possible when in use [2]. However, levels of operational carbon will reduce over time, in contrast to embodied carbon which is irreversible once the building is completed. Hence, more attention and effort should be directed towards reducing embodied carbon emissions globally. Ideally, operational and embodied carbon emissions should be reduced in tandem, to address global climate change.

National and international sustainability initiatives, including the Singapore Green Plan 2030, the United Nation's 2030 Sustainable Development Agenda and the Paris Agreement, are in place to address the carbon issue. These initiatives have set ambitious targets for collective action to address climate change. For instance, the Singapore Government is committed to greening 80% of buildings by GFA (Gross Floor Area) under the Green Plan's 'Energy Reset' pillar, by 2030, and having 80% of new buildings by GFA be super low energy buildings, from 2030.

Embodied carbon pledge

In August 2021, over 60 industry players in the Singapore Green Building Council (SGBC) including Pan-United Corporation made their commitment to the Singapore Built Environment Embodied Carbon Pledge. This is to accelerate decarbonisation of the sector by reducing embodied carbon in building projects.

Championing the use of CO₂ mineralised concrete technology in Asia

In 2018, Pan-United partnered with Canada-based

cleantech company, CarbonCure Technologies, to become the first in Asia to use CarbonCure's carbon dioxide (CO₂) mineralised concrete technology to reduce embodied carbon through concrete production. To-date, Pan-United is the only producer of carbon mineralised concrete, graded under the SGBC's new Ready-Mix Concrete, Carbon Capture and Utilisation category.

Carbon mineralisation in concrete effectively reduces the embodied carbon emitted during the construction process. With this Carbon Capture, Utilisation and Storage (CCUS) technology, an average 17 kg of CO₂ can be prevented from entering the atmosphere for every 1 m³ of concrete produced. It is noteworthy that CCUS presents substantial carbon savings yet does not require an overhaul of day-to-day operations. It supplements the batching system of the concrete producer, and can be applied in precast, ready-mix and masonry concrete processes.

Dr Yang En-Hua, Associate Professor & Assistant Chair (Academic), School of Civil & Environmental Engineering at Nanyang Technological University, commented, "Carbon utilisation via CO₂ mineralisation in cement-based materials is a promising approach, offering a sustainable and long-lasting solution for CO₂ sequestration as compared to other carbon utilisation pathways".

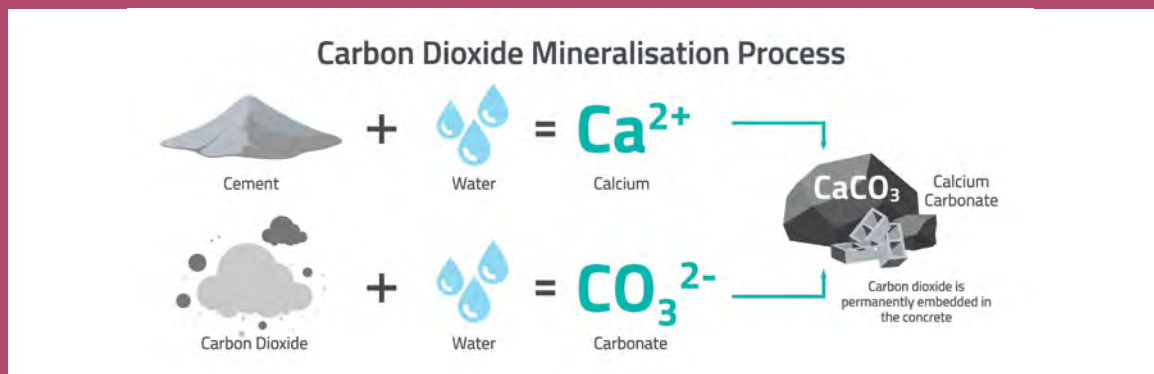
Importantly, the compressive strength of CO₂ mineralised concrete design mixes is enhanced. Projects using this design mix have proven that the same workability and desired strength was achieved using 5% less cement than conventional mix design – with no change to workability, placing or finishing processes.

In addition, CCUS is considered highly cost-effective as existing assets can continue to be used. It is essentially an additive technology and only minimal modifications to the existing process are required, incurring low capital expenditure costs. The material efficiencies, such as the reduction of filler materials, translates to cost savings. Given its ability to reduce carbon emissions, concrete producers and developers could potentially even qualify for certain green building schemes and grants.

Mr Chan Wai Mun, Director of Operations and Sustainability at Pan-United Concrete, noted, "Industry regulators, developers and customers have provided positive feedback that CO₂ mineralised concrete was seamlessly adopted and implemented in their building processes, without any complications. Based on initial projections, if Pan-United's carbon utilisation technology is used to

How CO₂ mineralisation works in concrete

1. The equipment is retrofitted into concrete batching plants.
2. CO₂ is sourced from established gas suppliers that collect, purify and distribute the CO₂.
3. Purified CO₂ gas is delivered in pressurised vessels by commercial gas suppliers.
4. A proprietary delivery system precisely injects the CO₂ into the concrete mix.
5. Batching is controlled by a simple interface integrated with the batching computer.
6. Once injected, the CO₂ undergoes a chemical reaction known as CO₂ mineralisation, where the CO₂ is converted into nano-sized minerals that become permanently embedded within the concrete.



produce all conventional structures in Singapore, up to 280,000 tonnes of CO₂ emissions could be avoided annually, which is equivalent to removing 60,000 cars from the roads”.

In July 2020, Pan-United signed a Memorandum of Understanding with fellow industry leaders Keppel Data Centres, Chevron and Surbana Jurong, with the support of the National Research Foundation, to jointly develop the first end-to-end decarbonisation process in Singapore. This collaboration is aimed at accelerating the development of a highly integrated, clean and energy-efficient Carbon Capture, Utilisation & Storage system that could be used in potential commercial developments in Singapore.

Projects using CO₂ mineralised concrete

Pan-United’s CCUS technology for concrete production has been used in numerous infrastructural, commercial and residential projects in Singapore. These include JTC semiconSpace and the expansion of Linde’s existing gasification complex at Jurong Island.

JTC semiconSpace

JTC semiconSpace is a 32,000 m² semiconductor facility under construction at the Tampines Wafer Fab Park. Developed by JTC, the facility will be built solely with CO₂ mineralised concrete. The first phase of the facility is slated for completion in 2021.

Expansion of Linde’s gasification complex at Jurong Island

As part of a SGD 1.4 billion investment with ExxonMobil at Jurong Island, global gas and engineering company

Linde is expanding its existing gasification complex there. The expanded complex will include four additional gasifiers, a 1,200 metric tonne/day air separation plant, and Linde’s proprietary downstream gas processing units and sulphur recovery plants. So far, Pan-United has supplied more than 13,000 m³ of CO₂ mineralised concrete for the project, which is expected to be completed by 2023.

Achieving a sustainable built environment

Singapore is committed to upholding its sustainable development commitments and achieving its long-term net-zero emissions goal, as soon as possible.

Concrete is inevitably a key building material. It is imperative that all stakeholders are well-informed and kept abreast of the latest advances in concrete technology for both structural and non-structural work. Only then can like-minded industry players collaborate to decarbonise the built environment sector.

As Singapore’s leading producer of low-carbon and green concrete, Pan-United views the expansion of sustainable, viable concrete options as part of its corporate and environmental responsibility to the industry, and to the wider society. As an advocate for environmental sustainability, Pan-United also encourages its peers and customers to embrace and adopt sustainable concrete for the benefit of future generations.

References

- [1] WorldGBC ‘Bringing Embodied Carbon Upfront’
- [2] SPOT – Sustainable Product Database ‘Embodied vs Operational Carbon’



Artist's impression of JTC semiconSpace, a semiconductor facility built with CO₂ mineralised concrete. Image: ID Architects Pte Ltd.



The expansion of Linde's existing gasification complex at Jurong Island is expected to be completed by 2023.

THE SELECTION AND APPLICATION OF

HYDRAULIC VIBRATORY HAMMERS

by Nick Chua, Country Manager (Philippines),
Foundation Associates Engineering Pte Ltd



Mr Nick Chua

The different types of equipment available and their merits are presented.

Introduction

Hydraulic vibratory hammers are used in a wide variety of applications. Apart from their use in driving and extracting elements such as sheet piles and pipes, vibratory hammers are also used for soil densifying or vertical drainage. With currently available technology, it is possible to use vibratory hammers to drive casings for oil & gas pipelines offshore, to a depth of up to 120 m under water.

Principle behind the functioning of a vibratory hammer

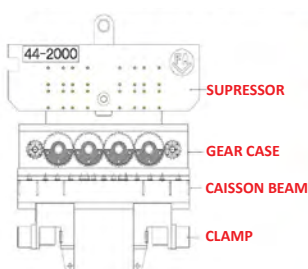
A vibratory hammer drives the object into the soil through the centrifugal force generated by its eccentric

weights, which, in turn, generates vibrations in the adjacent soil particles, that reduce the soil resistance.

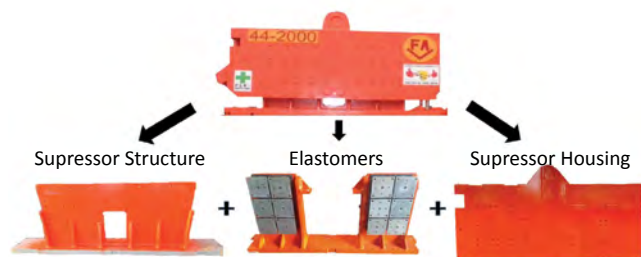
The dynamic weight of a hydraulic impact hammer produces a high pulsating load at a low frequency. With a hydraulic vibratory hammer, the opposite will occur. A relatively low steady load is produced at a high frequency. With the low impact of the hydraulic vibratory hammer, the risk of fractures and cracks is eliminated.

A vibratory hammer is used to drive sheet piles, pipes or other elements into the soil by vertical vibrations. The adjacent soil particles are initiated into motion and thus the soil is 'loosened'. The dynamic weight of the hammer will drive the steel casings / sheet piles etc into the soil. Extraction is done using a crane.

Main Components of Vibratory Hammer



Suppressor Unit



How does it work?



- The hydraulic motor will rotate the eccentric weights in the gear case.
- The rotation of the eccentric weights creates the vibrations
- The main power source to the vibratory hammer hydraulic system comes from the Hydraulic Powerpack.

Components of a hydraulic vibratory hammer and how it works.

Criteria for selecting a hydraulic vibratory hammer

The selection of a hydraulic vibratory hammer, to use on a particular job site, depends on the following:

- Project details: whether the project is a building, refinery, infrastructure, railway or another type of project.
- Types of objects to be installed: steel casing, sheet pile, pipe pile etc.
- Material of construction of the objects to be installed: steel, concrete, wood etc.
- Dimensions and weight of the object to be driven.
- Soil condition below ground, with SPT values, preferably, if the soil investigation report is available.
- Type and capacity of the lifting equipment available.

Characteristics of the different types of hydraulic vibratory hammers

There are several types of hydraulic vibratory hammers, including the following:

- Normal frequency crane suspended hydraulic vibratory hammer.
- High frequency crane suspended hydraulic vibratory hammer.
- Resonance Free (RF) crane suspended hydraulic vibratory hammer.
- Excavator mounted hydraulic vibratory hammer.
- Knuckle grip excavator mounted hydraulic vibratory hammer.

Normal frequency vibratory hammers have a constant eccentric moment. When passing the critical frequency area, during start-up and stop, the constant amplitude will cause disturbing negative vibrations in the boom of the crane and in the soil – not just at the spot, but within a considerable perimeter. However, the normal frequency vibratory hammer producing 1600 vibrations per minute (VPM) to 1900 VPM is being used, as the difference in cost between a Resonance Free vibratory hammer and a normal frequency vibratory hammer is quite significant.

High frequency hydraulic vibratory hammers have been designed to avoid the resonance which may damage nearby buildings or structures. The pile is driven into the ground under its own pressure or weight from the vibratory hammer. The vibration allows for easy extraction of the pile when the vibratory hammer is pulled. High frequency vibratory hammers generate vibrations from 2000 VPM to 2,300 VPM. Compared to a normal frequency vibratory hammer, a high frequency vibratory hammer produces less vibrations in the surroundings. Tests have demonstrated that the level of vibrations produced by a high frequency vibratory hammer – measured at distance of 2 m from the driving element – equals the level of vibrations produced by a normal frequency hammer at a distance of 16 m.

Therefore, when driving in urban areas, it is best to use a high frequency vibratory hammer, to minimise the disturbance to the surrounding area.

Resonance Free (RF) hydraulic vibratory hammers eliminate the start-up and shut-down vibrations by utilising a mechanism which enables control over the vibrations. The vibrations of the RF hydraulic vibratory hammers can be switched on and off easily. When the vibrator is starting up, the effect of the eccentric moment is switched off and no vibrations are generated. Once the vibrator has reached its operating frequency, the effect of the eccentric moment is switched on and vibration immediately commences at this frequency. Similarly, during shutdown, the effect of the eccentric moment



A 5-ton series normal frequency crane suspended hydraulic vibratory hammer.



An 8-ton series high frequency crane-suspended hydraulic vibratory hammer at work.

is switched off before the vibrator slows down. This avoids transmitting resonance vibrations to the crane jib and the surrounding environment. In addition, the amplitude can be adjusted to reach the maximum permitted level in sensitive areas. Therefore, RF hydraulic vibratory hammers produce significantly less stress to the carrier's boom.

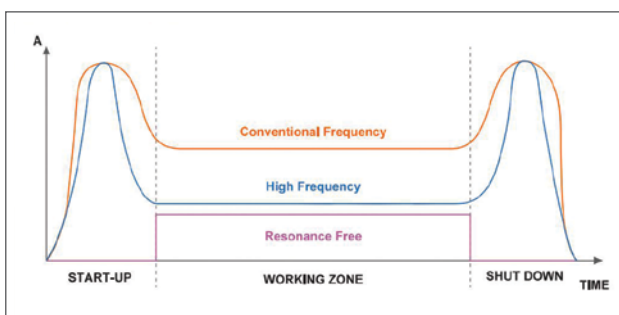
- The high frequency of the RF hydraulic vibratory hammer produces less ground vibrations.
- There are no harmful low frequency vibrations during starting and stopping.
- Operators using RF hydraulic vibratory hammers can work much closer to buildings, utility lines and other vulnerable spaces, compared to operators using conventional vibratory hammers.
- The driving speed of RF hydraulic vibratory hammers can be adjusted.

Hydraulic vibratory hammers installed on excavators are widely used to drive and extract piles. Vibratory hammers are easily attached to excavators by connection brackets. These excavator mounted vibratory hammers draw their hydraulic power from the excavators and are easy to operate. The excavator mounted vibratory hammers do not require any modifications on the excavators themselves.

There are several advantages of excavator-mounted vibratory hammers. Their small size contributes to improving workability in confined spaces. Their innovative design and simple operation make their handling easy for the operator. They can be used for different applications such as drainage maintenance and work on marshlands. With user-friendly and mobile functions, excavator mounted hydraulic vibratory hammers can give optimum performance under demanding site conditions.



Resonance Free (RF) hydraulic vibratory hammer with hydraulic powerpack.



Comparison between normal frequency, high frequency and resonance free vibratory hammers, during start-up, operation and shutdown.

Excavator mounted vibratory hammers can work on construction sites that are in close proximity to residential areas and in confined spaces, with minimum disturbance to the surrounding environment. In addition, the parts are carefully selected to ensure their reliability and optimum performance.



An excavator mounted vibratory hammer driving a sheet pile into a targeted area.



An excavator mounted vibratory hammer, with extended boom, driving a sheetpile as part of a flood control project in Philippines.

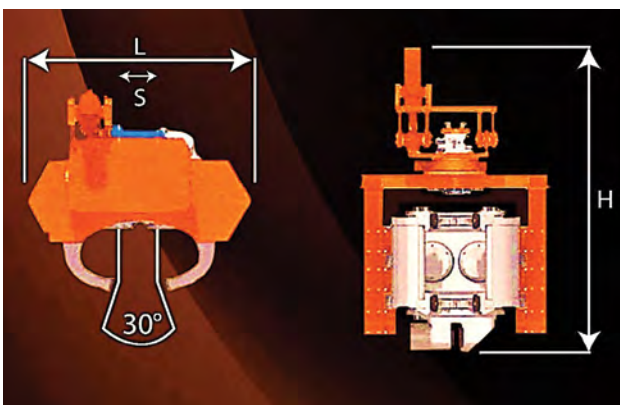
Knuckle grip vibratory hammers can handle, pitch and drive sheet and tube piles. They are capable of accomplishing the whole pile driving process without any need for manual handling of the piles or assisting machinery.

Advantages of knuckle grip vibratory hammers include the following:

- Fully hydraulic, flexible control.
- 360° rotation, $\pm 30^\circ$ tilt, easy pile pick up.
- There is no lifting height limit for the excavator boom and there is no need to extend the boom, to drive long piles.
- Core components are reliable brands, ensuring reliable performance
- The cooling systems ensure there are no high temperature issues.
- The hammers can be used to drive a wide range of piles, including sheet piles, H-piles, tubular steel piles, timber piles etc.



The knuckle grip vibratory hammer.



Dimensions of a typical knuckle grip vibratory hammer. Length (L) = 1,380 mm. Arm Stroke (S) = 250 mm. Height (H) = 2,200 mm.

Bentley Systems announces Seequent's acquisition of Imago

Bentley Systems Incorporated, the infrastructure engineering software company, recently announced that its Seequent business unit has acquired Imago Inc, a developer of cloud-based software for the capture and management of geoscientific imagery.

The acquisition will expand Seequent's technology solutions portfolio while boosting cloud capabilities to help geoscientists and engineers solve earth, environment, and energy challenges.

Imago's cloud-based platform enables the capture, cataloguing, and review of drilling core and chip images from any source, to support every aspect of the geological process from exploration to grade control. Continued development of Imago's machine learning will lead to a step function in the interpretation of geological data.

Mining companies around the world apply Imago's solution in conjunction with geology data management and modelling tools to enable teams to make more confident, profitable decisions using instantly available, high-quality images. Seequent already integrates its Leapfrog, Oasis montaj, Target, and Minalytx MX Deposit with Imago's solution, making it easy for geologists, engineers, and other stakeholders to extract knowledge and learn from geoscientific imagery.

The goal is to unlock significant potential for mining and other industries, transforming image data into meaningful insights for geological activities.

Seequent, founded and headquartered in Christchurch, New Zealand, serves geologists, hydrogeologists, geophysicists, geotechnical engineers, and civil engineers in over 100 countries, and the world's top mining companies. Its established presence in mineral-intensive geographies such as South America and southern Africa is expected to accelerate Bentley's overall opportunities in these regions with significant infrastructure requirements. In turn, Bentley's established presence in China, and its mainstay reach across civil engineering sectors, is expected to accelerate Seequent's expansion in new markets.

Seequent's products include Leapfrog, its leading product for 3D geological modelling and visualisation, Geosoft for 3D earth modelling and geoscience data management, and GeoStudio for geotechnical slope stability and deformation modelling. Bentley's complementary geotechnical engineering software portfolio, including PLAXIS, gINT, and OpenGround, will be integrated in due course to support open digital workflows from borehole and drillhole data to geological models and geotechnical analysis applications.

CONSTRUCTION OF THE NEW HEADQUARTERS OF HEIDELBERGCEMENT

Innovative formwork solutions were used to produce the high quality concrete elements in this building.



An exterior view of the building. The 11.75 m high facade supports were realised with PERI timber girder formwork.

The new building

HeidelbergCement has demonstrated what is possible with concrete, in an impressive way. The results of using the highest quality architectural concrete, class SB 4, and the finest white concrete, are visible in the many architectural highlights of the building. Twisted tree-like supports, creatively patterned façade, prefabricated concrete elements and sharp-edged beams in a radial pattern, make the new headquarters based in Heidelberg, Germany, particularly eye-catching. A total of 31,500 m³ of concrete was used for the construction of the building which consists of three interconnected parts of different heights. The building was opened in June 2020.

Successful cooperation in planning and execution

The architectural firm AS+P Albert Speer + Partner based in Frankfurt am Main, Germany, was responsible for the project, as general planner, and carried out the design in cooperation with W+ Architektur- und Ingenieurge-



The results of using high quality architectural concrete, class SB 4, and fine white concrete are visible in the many architectural highlights.

sellschaft mbH, with the latter providing the consulting office for the client's project manager. The complex construction work was carried out by the building contractor, Diring & Scheidel.



The three groups of tree-like supports tower over three storeys in the foyer.



The formwork for the tree supports fitted into the already erected PERI UP Shoring without any problems. Image: PERI AG.

PERI and the building materials manufacturer HeidelbergCement combined their architectural concrete expertise for the execution of this project. In doing so, existing limits were extended, and the wide range of possibilities offered by concrete and the PERI product range were exploited. The architectural highlights of the project were successfully realised using special PERI formwork elements.

The view from outside

The bright, curved facade of the new headquarters impresses with its delicate filigree – despite the use of concrete. The 11.75 m high facade supports, in class SB 4 architectural concrete in white concrete, are particularly striking. In order to construct the facade columns and their particularly smooth concrete surfaces to the highest quality, PERI timber girder formwork with multi-layer panels coated with melamine resin was used.

Individual planning and implementation of the tree-like supports

The focal point of the approximately 11 m high foyer of the HeidelbergCement headquarters is formed by two groups of tree-like supports which, from a structural point of view, serve as the root of the building. Each of these tree-like supports, in class SB 4 architectural concrete, consists of three square cross-sections inclined towards each other, crossing approximately in the lower third. In compliance with the architectural concrete quality required, only one panel joint is visible over the entire column height of around 11 m. An additional requirement was that no fastening screws, clamping holes and formlining joints should be visible.



The feature wall consists of several prefabricated concrete elements. These were subsequently mounted to the in-situ concrete wall.

Due to the high architectural concrete requirements, the statically required fresh concrete pressure of 200 kN/m² and the tough space limitations in the foyer, special formwork made of wood was not an option for implementing the tree-like supports. PERI therefore developed a complex 3D special formwork made of steel elements with an overall height of 150 mm. The basis for the three-dimensional design, which was carried out completely via the CAD systems PERI CAD and RHINO, was a 3D model of the tree-like supports, in which the later element separation points were already taken into account.

Sophisticated honeycomb structure

The supporting structure of the prepared special column formwork was a sophisticated honeycomb structure consisting of 63 CNC laser-cut individual parts. The individual parts were assembled as a plug-in system to avoid time-consuming welding. Each individual component had to be newly constructed and statically dimensioned. A total of around 12.7 t of steel was used to produce this formwork. Steel formlining, 5-mm-thick, was then attached to the supporting structure to withstand the high level of fresh concrete pressure. At the point where the arms of the three tree-like supports cross, additional external ring constructions were attached to specifically counteract deformation of the steel.

Concrete pouring from below

In addition to the requirements for the colour and structure of the architectural concrete surface, another special feature was the pouring of the concrete. Unlike in most cases, the concrete was not poured from above but from below. A concrete distribution system transported a total of 30 m³ of concrete simultaneously into three column sections and pressed the concrete upwards up to 11 m via three pump hoses in the formwork.

Real-time determination of concrete pressure

Additional sensors of the PERI InSite Construction (ISC) Pressure Monitoring Set integrated into the formwork made it possible to measure the fresh concrete pressure in real-time during the concreting process and to monitor it via the ISC Web Application on the mobile phone. The determined characteristic data for the formwork pressure provided a precise picture of the concreting process for the tree supports.



For the dome ceiling, PERI developed a formwork solution made with 82 factory pre-assembled, 3D-designed architectural concrete timber formers that were delivered pre-assembled to the construction site.

Use of special formwork for the feature wall

The walls of the foyer also stand out due to their architectural design. The so-called feature wall is characterised by its recessed, radial pattern. It consists of several prefabricated concrete elements that were retrofitted to the in-situ concrete wall. In addition to the architectural concrete quality of SB 4 standard and the white concrete used, an additional requirement was that no visible fastening points or tension holes should negatively impact the appearance. Furthermore, there are no visible vertical joints and a maximum of two visible horizontal joints at the height of the galleries. The butt joints were concealed by an overcut. In order to be able to realise the 8 cm thick prefabricated concrete elements (4 cm in the recesses), project-specific PERI special formwork was used.

Uneven cross vault in SB 4 grey concrete

Another challenge was encountered with the dome ceiling, which consists of an uneven cross vault with a circumferential edge upstand in SB 4 grey concrete. This was expected to be formed at a height of up to 7 m and a slab thickness of 25 cm. The desired result was a joint- and butt-free appearance, without visible fixing points on the formwork facing. The formwork solution that PERI developed for the implementation of the cross vault consisted of a total of 82 3D-designed architectural concrete timber formers. PERI designed and manufactured the timber formers especially for this project and delivered them pre-assembled to the construction site. They were then mounted onto components of the PERI UP scaffold construction kit and were finally sealed. The PERI UP Weather Protection Roof ensured that work could be carried out according to schedule, regardless of the weather conditions.

Diamond-shaped recesses in the casino

The casino on the ground floor of the new headquarters offers HeidelbergCement employees ample seating and a commercial kitchen. As one of the project highlights, this room features a special reinforced concrete ceiling with radial sharp-edged beams. These stand out in SB 4 white concrete from the underlying ceiling in SB 2 grey concrete mainly due to the striking shapes and colours. Here



For the casino slab, PERI special formwork developed especially for the project was used, which was later fitted with a total of 64 different, diamond-shaped box outs, pre-assembled in the factory.

too, no visible fixing points of the formlining or bracing points of the beam formwork are visible.

For the slab, PERI special formwork developed especially for the project was used, which was later fitted with a total of 64 different, diamond-shaped box outs, pre-assembled in the factory. The load was transferred on four diamond-shaped supports with different cross-sections in the facade area. A VT 20 beam structure supplied by the contractor with a squared timber layer was opted for, in the centre of the viewing panels. The pre-assembled viewing panels were fixed to a scaffold, based on components of the PERI UP Scaffolding Kit. For the casino, first, the beams were created by simultaneously forming them from the outside to the inside, with two pumps. Only then, after the beams had hardened, was the ceiling concreted.

Precise PERI support

A total of around 3,000 m² of project-specific architectural concrete girder wall formwork was used during the project, most of which was pre-assembled in the factory and delivered to Heidelberg on schedule. The special challenges for the PERI engineers therefore included the intensive planning, the creation of individual special formwork solutions, as well as the support of the site personnel during the implementation of the complex geometries and shapes, and also the punctual provision of materials and coordination of the delivery dates.

PROJECT CREDITS

General planner

AS+P Albert Speer + Partner

Building contractor

Diringer & Scheidel Bauunternehmung GmbH & Co KG

Project support

PERI Germany

All images by Thilo Ross unless otherwise stated

CHEMICAL SYSTEMS

FOR A METRO RAIL PROJECT IN DUBAI

Materials were supplied for tunnel boring, excavation and underground works, as well as for installing ceramic tiles and engineered stone in the stations.



The new Route 2020 is an extension to the Red Line of the Dubai metro system and runs for 15 km from the city to the Expo 2020 Dubai site. Image © Government of Dubai Media Office. All other images by Mapei.

Expo 2020 Dubai opened on 1 October 2021. The event, which was to have been held in 2020, had to be postponed due to the pandemic. It will now run from 1 October 2021 until 31 March 2022. It is the first world fair to be held in the Middle East/North Africa/South Asia region.

One of the infrastructural developments for Expo 2020 Dubai was the implementation of the 'Route 2020' project. The aim of the project was to extend the Red Line of the Dubai metro railway system, connecting the city to the Expo site. Thanks to an investment of USD 2.9 billion, the new stretch is now 15 km long (11.8 km of elevated railway and the remaining 3.2 km underground) and runs from Jebel Ali Station to the Expo area, near Al Maktoum International Airport. As a result, this new development makes it easier to access the exhibition area and, because it passes through various densely populated areas of the city, it is also a fast, safe method of urban transport for many inhabitants of Dubai.

Four of the seven stations, in total, were opened to the public on 1 January 2021 (Jebel Ali Station, The Gardens, Discovery Gardens and Al Furjan), and Route 2020 became operational a little later, on 1 June, along the section running to the Expo site.



A map of the Dubai metro railway system.

Route 2020 can guarantee the journey of the 35,000 visitors a day expected during the week and 47,000 at weekends during the months of the Expo. The construction work also included the building of three main power supply stations and an additional traction power supply station.



Mapei took part in the excavation work of the Red Line by supplying products for the TBM and underground works.

Mapei's contribution

Mapei was involved in the excavation works of the new metro line, supplying products for underground works to the Expolink consortium, comprising Alstom, Acciona and Gülermak. Mapei provided solutions for building a 2.5 km long, 10 m diameter tunnel which was excavated with a TBM (Tunnel Boring Machine).

The company supplied chemical products used for the TBM excavation works, such as the grout systems for the backfill of the TBM segment (MAPEQUICK CBS SYSTEM 1, MAPEQUICK CBS SYSTEM 2 and MAPEBENT CBS 2), the foaming agent POLYFOAMER FP for the TBM cutter-head, and the sealants MAPEBLOX T and MAPEBLOX H. Besides, LAMPOSILEX and RESFOAM 1 KM were used to stop the water leakage in the tunnel.

Mapei also took part in the construction works for the new Route 2020, by supplying materials for the screeds, to prepare substrates and for the installation of stone inside all the stations along the line. To cope with the constantly increasing passenger levels, the stations have larger access ramps to the platforms, compared with those along the existing stations of the Red Line.

TOPCEM special hydraulic binder was used to create normal setting, controlled shrinkage and rapid drying screeds in all the stations along Route 2020, over a total surface area of 70,000 m².

In four of the stations, slabs of engineered stone were installed using GRANIRAPID adhesive, which allowed the site teams to install the material in difficult climatic conditions – at temperatures of more than 30° C. The stone covering was made up of engineered agglomerate. Following extensive tests in Mapei's R&D laboratories, this adhesive system was selected, to avoid any stains or moisture-related problems in the final surfaces. Besides, fast-track products like TOPCEM and GRANIRAPID helped the application teams meet the tight timeline. The stone was then grouted with KERACOLOR FF cementitious mortar mixed with FUGOLASTIC admixture. The product chosen to seal the expansion joints was MAPESIL LM which helps prevent the formation of marks and stains on the surface of stone.

In the service areas of the stations, ceramic tiles were installed with Keraflex MAXI S1 adhesive before grouting the joints with KeraPOXY. Given the high level of vibration caused by the movements of the trains, Keraflex MAXI S1 was chosen due to its high deformability.

For the four buildings that house the electric controls for the trains, the MAPETHERM SYSTEM, an external thermal insulation system for facades was used, to prevent rooms inside the buildings from heating up excessively, thereby reducing energy consumption, and improving the level of comfort and the sustainability of the



TOPCEM hydraulic binder was used to create the rapid-drying screeds in the stations.



In the stations, the engineered stone flooring was installed with GRANIRAPID before grouting joints with KERACOLOR FF + FUGOLASTIC.

structures. Apart from bonding rockwool insulation panels with MAPETHERM AR2 mortar, the materials chosen for this work were MAPETHERM AR1 adhesive and skimming compound and MAPENET 150 mesh. In all the buildings, the insulated surfaces were then treated with QUARZOLITE BASE COAT coloured acrylic undercoat before applying QUARZOLITE TONACHINO textured coating with 1.5 mm grain size. Using the ColorMap automatic tinting systems which is also available in the UAE, enabled the right shade of grey to be obtained from amongst the more than 1,000 colours of the Mapei Master Collection.

In several areas, ULTRAPLAN ECO 20 levelling compound, which is produced and distributed on the local market by

Application of Mapei products

Products for underground constructions – MAPEQUICK CBS SYSTEM 1, MAPEQUICK CBS SYSTEM 2, MAPEBENT CBS 2, POLYFOAMER FP, MAPEBLOX T, MAPEBLOX H, LAMPOSILEX, RESFOAM 1 KM

Building screeds – TOPCEM

Preparing substrates – PRIMER SN, ULTRAPLAN ECO 20, QUARTZ 1.2 ME, ULTRAPLAN MAXI, ULTRAPLAN FIBER KIT

Installing ceramic tiles and stone materials – GRANIRAPID, KERAFLX MAXI S1

Grouting joints – KERACOLOR FF, FUGOLASTIC, KERAPOXY, ULTRACOLOR PLUS

Sealing expansion joints – Mapesil LM

Installing vinyl floors – ULTRABOND ECO 375

Thermal insulation – MAPETHERM AR1, MAPENET 150

Wall coatings – QUARZOLITE TONACHINO, QUARZOLITE BASE COAT

Other building materials used – MAPEFILL GP ME, PRIMER G, LAMPOSILEX, MAPEFILL SP ME, MAPEGROUT T80, POLYFOND KIT DRAIN, RESFOAM 1 KM FLEX, RESFOAM 1K-M, RESFOAM 1K-M AKS, EPORIP, LAMPOSILEX, MAPEGROUT ME 05, MAPEGROUT ME 06, MAPEGROUT T60 ME, PLANIGROUT 300 ME, PLANITOP 110 ME

Website for further information

www.mapei.com

www.mapei.ae

Mapei Construction Chemicals, was used to level off the substrates, after treating them with PRIMER G.

On raised floors, on the other hand, the system chosen to level any irregularities was made up by PRIMER SN, mixed with QUARTZ 1.2 ME (which is distributed on the UAE market by Mapei Construction Chemicals), and ULTRAPLAN MAXI.

In some areas, vinyl floor coverings were installed with ULTRABOND ECO 375 adhesive.

Various building materials distributed on the local market by Mapei Construction Chemicals, such as MAPEGROUT ME05, MAPEGROUT ME06, MAPEFILL GP-ME and MAPEGROUT T60 ME, were also used in the construction work for the various structures of the Route 2020 project.

This editorial feature is based on an article from Realtà MAPEI INTERNATIONAL Issue 88.

LIEBHERR LTM 1110-5.2 MOBILE CRANE

INCORPORATES THREE NEW FEATURES



The Liebherr LTM 1110-5.2 mobile crane features the latest crane technology.

The Liebherr LTM 1110-5.1 mobile crane has become the LTM 1110 5.2, with three completely new features – the crane control system, the driver's cab and the gearbox.

The 5-axle Liebherr 110 t crane is characterised by a powerful, 60 m telescopic boom and variable axle loads for maximum mobility all over the world. It has now been made simpler, safer and more comfortable.

LICCON3 crane control system

This is now the third generation of the LICCON (Liebherr Computed Control) control system and incorporates time-tested control features, a completely new software package and programming language as well as a faster databus, significantly more storage space and more computing power.

Driver's cab with award-winning design

Liebherr has developed the modern design of the new driver's cab, in collaboration with designer Jürgen R Schmid, Design Tech, Ammerbuch (Germany). It was awarded the American GOOD DESIGN Award 2020 in the 'Transportation' category.

Liebherr first unveiled its new driver's cab at bauma 2019, to obtain feedback from customers at an early stage of the development process. The company is introducing the new cab at the same time as the LICCON3 control system. The modern design of the new cab features premium materials and several improvements

for the crane driver. These include a new multifunction steering wheel, side roller blind on the driver's door, improved instruments and modules, as well as new displays. Options, such as the central locking system with remote key, the cool box and tyre pressure monitoring system, deliver additional comfort.

ZF TraXon DynamicPerform gearbox

The DynamicPerform clutch module delivers almost zero wear, starting and manoeuvring, for the modular ZF TraXon gearbox, and without overheating. The new clutch module transmits the engine power via an oil-cooled plate pack. The friction heat generated when starting is dissipated in the clutch oil and transferred to the vehicle's cooling system via an oil/water heat exchanger. Due to the higher energy and power consumption, together with a calculation model, permanent and almost wear-free manoeuvring is made possible. An implemented clutch protection function also prevents overheating of the clutch and the associated increased wear or destruction of the clutch in extreme load cases. That prevents downtimes and helps to significantly extend the service life of the drivetrain.

Initially, Liebherr plans to install DynamicPerform in its 5-axle mobile cranes on a step-by-step basis. On mobile cranes with six or more axles, Liebherr intends to continue to use the ZF 12-speed TraXon Torque gearbox with starting converter which, in addition to zero wear while manoeuvring, also delivers an increase in torque.

WAVIN LAUNCHES PIPE FITTING

WITH AN ACOUSTIC LEAK ALERT

Wavin, a world-leading solutions provider for the building and infrastructure industry, recently expanded its line-up of innovative pipe and fittings solutions, with the launch of the Wavin Tigris K5/M5. The Wavin Tigris K5/M5 is a new press fitting series with an acoustic leak alert feature that is expected to raise the standards of water management for metal-plastic pipe connections.

Water is one of the most valuable resources across the globe, but its scarcity is particularly acute in Asia Pacific (APAC). Amidst climate change, growing urbanisation and ageing water infrastructure, Asia Pacific's water networks are getting more complex and extensive. When carrying drinking water, the pipe is only as good as the joint. The fittings to secure joints safely, are essential. The Wavin Tigris K5/M5 offers a new approach for governments and organisations looking to secure their water supply by installing these products in buildings.

Advantages of the new fittings

The Wavin Tigris K5/M5 is said to be the world's first series of fittings with the acoustic leak alert feature. In a leakage test executed with air instead of water, the fittings will generate a loud and clear whistling sound (at +/- 80 dBA), when they are not fully pressed, thereby alerting installers of leaks.

According to Wavin, when testing with air instead of water, leak and pressure tests will no longer be a challenge in the pipe installation phase. Testing with air has several advantages such as eliminating the risk of bacterial (Legionella) growth due to water stagnation in the period between testing and final use of the installation. Additionally, it avoids slippery work spaces or water damage and there is no need for using leak sprays. The method is quick, clean and safe as it already works at 0.15 bar, making it also a solution to check prefabricated installations. Ultimately, this approach eliminates dependency on early water supplies at the building site, as a simple air compressor will do the job.

A new generation

The new Tigris K5/M5 is an improvement over the Wavin Tigris K1/M1 fitting. It is characterised by good flow performance, with improved flow area due to the increased inner bores, called OPTIFLOW.

It also features MULTIJAW, which means that the fittings can now also be pressed with the most common pressing profiles such as U and Up, TH, H and B. This enables installers to easily switch to Wavin, without switching tools, and retain their system warranty.

Furthermore, to make the installation as easy and reliable as possible for installers, the fitting also incorporates IN4SURE, 360° pipe visibility to check if the pipe is inserted properly. It also includes EASYFIT which makes it unnecessary to calibrate or chamfer the pipe after cutting.

The Wavin Tigris has two core lines, based on the preferred choice of body material. The Wavin Tigris K5 is a press fitting with bodies made of the high technical performance plastic Polyphenylsulfone (PPSU), while the Wavin Tigris M5 is a metal press fitting with bodies made of UBA-listed, drinking water approved brass materials. The radial press fits, in PPSU or brass, cover a complete range of fittings that fit up to 40 mm multi-layer composite pipes with Tigris K5/M5 and 50 mm to 75 mm pipes with Tigris K1/M1, its predecessor.



The Wavin Tigris K5/M5 is a new press fitting series with an acoustic leak alert feature that is expected to raise the standards of water management for metal-plastic pipe connections.

WES 2021: CONVERSATIONS ABOUT ENGINEERING SUSTAINABILITY IN A POST-PANDEMIC WORLD

The World Engineers Summit (WES) 2021 took place from 10 to 12 November 2021. Held at Resorts World Sentosa, it was a hybrid conference with some 1,000 participants from 20 countries in attendance, both virtually and physically.

Mr Heng Swee Keat, Deputy Prime Minister and Coordinating Minister for Economic Policies, graced the WES 2021 Opening Ceremony as the guest-of-honour, where he spoke about innovation, design for maintainability, and the pressing need to inspire the young and empower women to pursue STEM education and careers.

During the ceremony, IES also pledged its commitment to the Vision Zero Movement, being the first society in Singapore to do so. The Institution will work with the Workplace Safety and Health Council, as well as other industry stakeholders, to inculcate a safety-focused mindset in all engineers, so as to create healthier and safer workplaces.

In line with this year's theme, "Engineering towards a Post-Pandemic Sustainable World", the conference tracks covered the areas of sustainable living, Industry 4.0, AI and digitalisation, urban mobility, engineering education and safety and human factors practice.

The plenary speakers - Ms Susanna Kass, Stanford University Energy Fellow and Chief Sustainability Officer, InfraPrime; Dr Bicky Bhangu, President, South East Asia, Pacific & South Korea, Rolls-Royce Singapore; Associate Professor Ong Soh Khim, NUS Department of Mechanical Engineering; and Professor Paul Teng, Managing Director, NIE International, spoke on topics such as net zero emissions, collaborative innovation, digital twins and AR, and food security, setting the intellectual backdrop for the conversations that happened over the next two days.

Marking the end of the intensive discussions was the WES 2021 Conference Dinner, which happened on 11 November. Mr S Iswaran, Minister for Transport and Minister-in-charge of Trade Relations, was the guest-of-honour.

He spoke about collaborations in building a sustainable public transport system, and the importance of growing and upskilling the workforce. At the event, he also witnessed the unveiling of new enablers for the transport sector.

The first of these was the launch of the Transportation Standards Committee (TPSC), established under the Singapore Standards Council (SSC) and Enterprise Singapore (ESG).

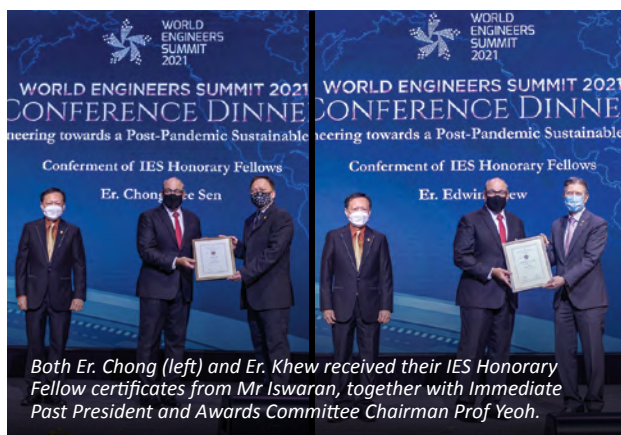


With the support of IES, government agencies and industry players, the TPSC seeks to address emerging challenges in the rapidly evolving transport sector by providing strategic leadership to existing Technical Committees (TCs) on Automotive and Railway Systems and an upcoming TC on Intelligent Transport Systems. The aim is to enhance interoperability in the sector through the development of common national and international standards.

Next, three new Technical References (TR) on Railway Systems were introduced: TR 89, TR 90, and TR 94. The new TRs will provide rail technicians, engineers and stakeholders with industry best practices to enhance reliability, safety and productivity of railway solutions.

In addition, the Transport Resource Manual, a commemorative book put together by industry experts to serve as a rich repository for development of future standards, was unveiled.

IES Emeritus Presidents Er. Chong Kee Sen and Er. Edwin Khew were also conferred the IES Honorary Fellows titles for their exceptional contributions to IES and the engineering community. They received their certificates from Mr Iswaran.



Furthermore, nine outstanding engineering teams received the IES Prestigious Engineering Achievement Award, the nation's top honours for remarkable accomplishments in engineering. The projects have been successfully implemented in various sectors, such as the built environment, defence, aviation, and medicine (see page xx for more details).

Lastly, to support brilliant engineering students in their pursuit of engineering studies, IES presented the IES-

Yayasan MENDAKI scholarship awards to Omer Bin Basil Ali Omer Uqba, a third-year mechanical engineering student from Singapore Polytechnic and Mohammed Abdullah Afrar bin Jainul Akbar, a second-year electrical and electronic engineering student from Nanyang Technological University.

The conference ended on 12 November with virtual visits to Emerson's Digital Plant, Schneider Electric's Singapore Innovation Hub, and the Microsoft Experience Center Asia.

IES Prestigious Engineering Achievement Awards 2021: Recipients and project descriptions

Applied Research and Development Category



Rapid Classification of Soil using Artificial Intelligence

With the use of computer vision and sensors, the artificial intelligence system can classify excavated soil rapidly and accurately, to speed up HDB's staging ground operations. This first-of-its-kind technology is more accurate, advances construction technology and can potentially increase productivity and save cost. A patent has been granted in Singapore and the team is exploring collaboration with industry. This project contributes to HDB's efforts to reuse excavated soil from land-based construction activities to create land in a more cost-effective and environmentally-sustainable manner.



Next Generation of Breakthrough Stent-Graft for Treatment of Aortic Arch Pathologies

NUS and the IHPC have jointly developed a new generation of preferential covered aortic stent-graft to treat aortic arch pathologies. This preferential covered stent-graft is an innovative approach that incorporates several new features to allow better conformability between stent-graft and aortic wall at various curvature. It preserves all supra-aortic branches blood flow and permits stable accurate deployment.



Replication & Repair of Hot Air Thermal Defects on Composite Aero-Structures

The motivation was to develop a high technology readiness level device (TRL-7) to assess in-service thermal damage induced by hot-air on composite aero-structures. Two horizontal and vertical thermal-defect generating machines were designed and fabricated to replicate hot air effects and to generate over 200 composite test samples exposed to various temperatures to simulate composite damage due to hot air in flight. The outcomes of this research project will help the staff in MRO centres as a new method to analyse thermal damage severity and perform efficient composite repair.

Engineering Project Category



Thomson-East Coast Line - TE2 Woodlands Station

The TE2 Woodlands MRT Station is an example of Arup-led total design and engineering that culminated in solutions that addresses the needs of people, places and the planet. While overcoming constraints including a dense site with a 'live' MRT line, Arup also led many innovative designs including a more optimised alignment, maximised space from relocating the substation, reduced excavation works, and helped provide a more integrated intermodal transport network that connects into the wider precinct. The result was a shorter interchange between MRT lines for commuters, reduced land sterilisation, and carbon savings.



Unmanned Mine Countermeasure Capability

The team developed advanced hardware, autonomy, and automatic launch and recovery systems, enabling unmanned assets to take over the mine countermeasure (MCM) role from manned vessels. A new resiliency by design approach and validation framework was also pioneered to ensure reliability and safety of the new unmanned assets. This transformation removes Republic of Singapore Navy crew from danger, reduces cost by half and manpower requirements by 60 per cent, improves response time, and is both sustainable and scalable.



JTC Logistics Hub (JLH) Inland Container Depot (ICD) Building - Innovative SEN Structural system

To address the engineering and construction challenges posed by heavy structural elements due to the average 45 m floor-to-floor height, 16 m – 22.65 m spans and 25 kN/m² live load during construction, the innovative Korean SEN Structural System was implemented at the JLH ICD building. SEN is a hybrid steel-concrete composite system comprising of Formed-Prefabricated Steel Reinforced Concrete columns and Thin Steel-plate Composite beams. This has resulted in improved productivity, enhanced Safety, increased headroom compared to traditional steel truss or concrete precast systems, and faster construction. JTC worked closely with SEN, Meinhardt, and Kimly Construction to adapt the system for this pioneer Singapore project to building requirements and Eurocode standards.



Development of the Responders' Performance Vehicle (RPV)

The RPV is the first known mobile facility in the world leveraging on science and technology to provide on-site treatment to first responders – this engineering feat was achieved through close collaboration with industry partners, the deep involvement of SCDF's Chief Medical Officer, and both NSMen and NSF medical doctors. The Vehicle provides calibrated treatment catered to the requirements of each responder to accelerate recovery in between deployment cycles of prolonged operations, to continually deliver highest levels of operational performance, reduce chances of heat injury, and increase responder safety.

Technology Innovation Category



Deep Learning AI System for Medical Imaging Diagnosis

BioMind uses state-of-the-art deep learning technology to analyse brain imaging scans. It assists doctors in diagnosis and automatically generates report for them to review within seconds. Its mission is to empower physicians with machine intelligence so patients can benefit from fast, accurate and consistent diagnosis.



InfinityGlove – Smart Sensorised Glove for Gaming and Healthcare

The team developed and patented a smart microtubular sensor that uses liquid metal as its sensing element. This sensor can be woven seamlessly into any fabrics or clothing and is imperceptible to the user. By weaving into a fabric glove, the team developed an InfinityGlove which can track finger movements and act as controller for gaming, virtual reality, robotics and healthcare applications.

ER. KENNETH GIN

IES FOUNDING PRESIDENT

Er. Gin Ying Doon Kenneth, PPA(P), PBM, Hon. FIES, our Founding President, passed away peacefully on 15 October 2021. He was 96.

Er. Gin's pioneering work not only laid down the roots for the growth of IES into a stellar institution, but also shaped Singapore's early years of nation-building through his excellence in Civil Engineering.

Realising the need for representation amongst the burgeoning engineering community in Singapore, Er. Gin worked towards setting up a place that engineers could call 'home'. He became the Founding President of IES at its historic inaugural meeting held at the Public Works Department Sports Club in Kallang, on 1 July 1966.

Aided by Er. Gin's steadfast stewardship in its early years and his contributions in the succeeding decades, even after the completion of his term as President, IES has grown from strength to strength, to become the premier engineering institution in Singapore. From a humble set-up of just 166 engineers, IES has today become the heart and voice of close to 7,000 engineering professionals.

Er. Gin's hallmark selflessness and dedication have set high standards for his successors to emulate. As the first President of IES, he tirelessly initiated the setting up of various committees to look into various tasks that would define IES's future roles.

Born in Melbourne, Australia in 1924, Er. Gin graduated with an Honours Degree in Civil Engineering from the University of Melbourne in 1945. He moved to Singapore in 1956 and worked with Hume Industries (F.E.) Ltd as a Project Engineer.

The relocation to Singapore was a difficult decision for Er. Gin, as it meant foregoing a secure job and the prospect of becoming a partner of a large firm of engineering consultants, Scott & Furphy.

But Er. Gin had no regrets as his move to Singapore gave him the unique opportunity to play a leading role in establishing the basic infrastructural systems of a country that was to become a global economic powerhouse and one of the world's most liveable cities.

Er. Gin made significant contributions to Singapore as a Civil Engineer. He was one of the project engineers for the Merdeka Bridge over the Kallang River, measuring 2,000 ft in length and with 80 ft spans. His job related to the manufacturing and erection of the pre-stressed concrete beams for the bridge.

The turning point in Er. Gin's career came when he was appointed the Deputy Director of Public Works, Singapore in 1959 and he was appointed Director of PWD in 1963. This was a period when Singapore was going through an exciting phase of infrastructural development, to support its rapidly growing population and the expanding economy.



During his seven years at PWD, Er. Gin saw the completion of noteworthy engineering projects, including the Paya Lebar Airport terminal, the iconic Market Street multi-storey carpark, Singapore's first pedestrian underpass at Connaught Drive, as well as the initial phases of the Pan Island Expressway and the Mass Rapid Transit system.

He continued to make remarkable contributions to Singapore, over the next few decades, in sectors from public infrastructure to public utilities and building development.

Er. Gin was appointed General Manager of the Public Utilities Board in 1966, handling the development and maintenance of electricity, water and gas, in Singapore, a position he held till 1969. Between 1970 and 1975, he was the Group General Manager of Singapore Land & Investment Company Limited and he later became the General Manager of Sentosa Development Corporation, overseeing the development of Sentosa into a tourist attraction.

Er. Gin set up his own consultancy in 1976 and continued to practice until 2000.

He has received many accolades including the Public Administration Medal (Silver) and the Public Service Medal, and he was elected as Honorary Fellow of IES.

To IES, their Founding President is not just a link to the past but an inspiration for newer generations of members. His values, commitment and courage in steering IES through the unknown, in its early years, will serve as a driving force in advancing IES towards a brilliant future.

Er. Gin was an exemplary role model and his loss is keenly felt. The President, Council and Secretariat are deeply saddened by this news and express their sincere condolences to his family.

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THE HEART & VOICE OF ENGINEERS



IES Membership

1) Professional Development

- Eligible for Chartered Engineers Certification Application (subject to registration criteria and conditions)
- Enjoy preferential rates for IES conferences, seminars and workshops
- Enjoy 10% to 15% discount for IES Academy Courses (T&Cs apply)

2) International Affiliations

- Interaction with overseas engineering institutions in joint programmes

3) Networking

- Exclusive FREE Members' Night (T&Cs apply)
- Enjoy preferential rates for networking activities
- Join our Sports Interest Groups
- Join our Social Events

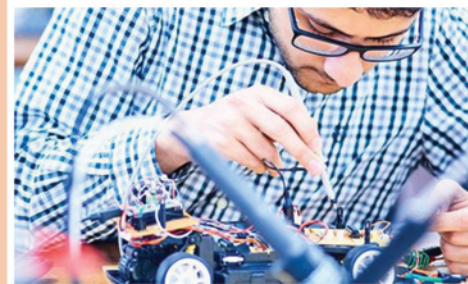


4) Communication

- Enjoy free subscription of IES weekly e-Newsletter
- Free monthly e-zine – The Singapore Engineer
- Free Annual IES Directory containing the business contacts of all members
- Get the latest updates on government regulations and the activities of allied institutions

5) Others

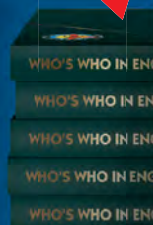
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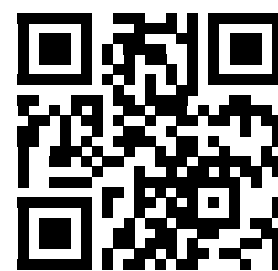


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