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May 2022 | MCI (P) 056/03/2022

Tuas Power-ST Engineering Consortium and PUB open Singapore's fifth desalination plant

PLUS

ENVIRONMENT & WATER ENGINEERING: Singapore's overall waste generation and recycling rates increased in 2021
STANDARDS DEVELOPMENT: Upcoming Launch of Railway Safety Management and Safety Performance Standards
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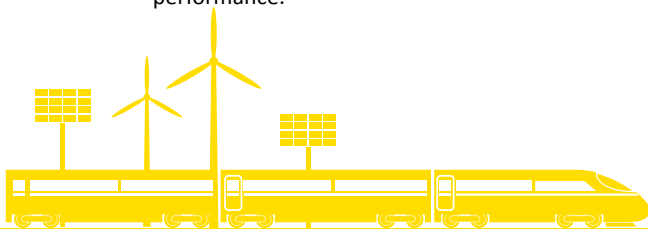
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Design & layout by **2EZ Asia Pte Ltd**

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Cover image by
PUB, Singapore's National Water Agency

Published by
The Institution of Engineers, Singapore
70 Bukit Tinggi Road, Singapore 289758
Tel: 6469 5000 | Fax: 6467 1108

Printed in Singapore

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PUB seeks proposals to boost data capabilities for developing coastal protection strategies

PUB, Singapore's National Water Agency, has launched a Request-for-Proposal (RFP) to seek innovative proposals on the use of emerging technologies, such as machine learning, radar and satellite imagery, as well as crowdsourced data, for the collection and analysis of coastal and inland datasets that will support PUB in the formulation of coastal protection measures.

Funding for the RFP will come from the SGD 51 million allocated to PUB by the National Research Foundation in September 2021, under the Competitive Funding for Water Research (CWR) programme. It is part of the Research Innovation and Enterprise (RIE) 2025 Plan.

Since assuming the role of the nation's coastal protection agency in April 2020, PUB has been making steady progress in charting strategies to safeguard coastal areas against rising sea levels and

extreme rainfall, which are the effects of climate change. Following the commencement of site-specific studies for Singapore's City-East Coast in May 2021 as well as a portion of the north-west coast in April 2022, studies at Jurong Island and the remaining stretch of the north-west coast will start later this year.

PUB is also developing the Coastal-Inland Flood Model – an advanced computational hydrodynamics model that can assess the twin effects of coastal and inland flood risks. The RFP is part of PUB's longer-term research plans to better understand the effects of waves, currents and ship wakes, in order to strengthen the development of coastal protection solutions and ensure they are effective, multi-functional, adaptive and sustainable.

FOCUS AREAS OF RFP

PUB is seeking proposals in the following areas:

Focus area 1: Establish proof-of-concept for the feasibility of real-time, remote, and low-maintenance sensors, such as radar and satellite-based sensors, for PUB's long-term monitoring of Singapore's waves and currents.

Focus area 2: Develop an automated framework to quantify ship wake contribution in Singapore's nearshore wave field, including a machine learning methodology to process vessel transiting information and nearshore wave data.

Focus area 3: Establish proof-of-concept for the feasibility of using opportunistic CCTV footages, data from Unmanned Aerial Vehicles (UAVs) with remote sensors and citizen-sourced smartphone images to provide automated and reliable estimates of the areal extent and depth of inland and coastal flooding.

The deadline for submission of proposals is 15 July 2022.

Funding to drive new initiatives in water technologies and resource circularity

The Government has allocated SGD 220 million under the Research, Innovation and Enterprise 2025 (RIE2025) Urban Solutions & Sustainability (USS) domain to drive new initiatives in water technologies and resource circularity. This draws from the National Research Fund, under the five-year RIE2025 tranche.

Closing the Resource Loop Funding Initiative

Of this, the National Environment Agency (NEA) will administer a new SGD 80 million Closing the Resource Loop (CTRL) Funding Initiative that supports the Green Plan and the Zero Waste Masterplan. The funding will support research and development (R&D) on sustainable resource recovery solutions for key waste streams such as e-waste,

plastics and food, and finding uses for treated waste residues.

The new CTRL Funding Initiative will build upon the R&D work carried out under the earlier Waste-to-Energy (WtE) programme and the Closing the Waste Loop (CTWL) Funding Initiative. The CTRL Funding Initiative will support the implementation of waste-related initiatives under the Green Plan through capabilities arising from the R&D, with greater efforts on technology translation and test-bedding efforts.

Centres of Excellence Programme for Water Technology R&D

Another SGD 87 million has been allocated to support R&D efforts in three water technology focus areas – Desalination and Water Reuse,

Used Water Treatment, and Waste Reduction and Resource Recovery. The funding will go towards supporting the Nanyang Environment and Water Research Institute (NEWRI) and Separation Technologies Applied Research and Translation (START), under the Centre of Excellence (CoE) Programme.

New Desalination Integrated Validation Plant to be commissioned

PUB will require START to build on its existing achievements and deepen its expertise in separation technologies for desalination through the design and operation of a Desalination Integrated Validation Plant (IVP). If successful, the IVP will help to reduce the system-level energy consumption of desalination to <2 kWh/m³.

Coastal protection studies at Jurong Island and north-west coast to commence this year

As the National Coastal Protection Agency, PUB has been making steady progress in charting coastal protection strategies to combat rising sea levels. The increase is projected to be more than 1 m by 2100, due to climate change.

Following the commencement of the site-specific study for City-East Coast in 2021, studies at Jurong Island and the north-west coast will commence this year.

Singapore's coastline is highly varied and stretches over 300 km. Coastal protection solutions will have to be developed, based on the profiles of different segments of the coastline. Studies for the respective segments are conducted in phases, based on factors such as anticipated flood impact, criticality of assets within each segment and opportunities to dovetail with future development plans. This will also allow Singapore the flexibility to adapt its plans and be able to incorporate the latest developments in climate science.

New studies

JTC will lead the study for Jurong Island, while PUB will oversee the studies at the northwestern coast, starting with a 24 km stretch from the Tuas Checkpoint to Lim Chu Kang jetty. This section consists mainly of dams and dykes that make up four coastal reservoirs (Murai, Poyan, Sarimbun and Tengeh), which are important fresh water supply sources and will need to be protected from seawater intrusion. The study will look at ways to ensure the integrity of the reservoirs' structures and further reinforce them against sea level rise. There are also some areas along this coastline that contain mangrove habitats – PUB will work with other government agencies such as National Parks Board (NParks) to explore the potential of implementing hybrid solutions that combine existing natural

elements with hard engineering measures.

The second section of the north-west coastline to be studied covers a 15 km stretch that includes Sungei Kadut and Lim Chu Kang, which will house the future Sungei Kadut Eco-District and Lim Chu Kang high-tech agri-food cluster. Key landmarks within this area to be studied, that require protection, are the Woodlands Checkpoint, Kranji Reservoir and Sungei Buloh Wetland Reserve, as well as several nature parks including Kranji Coastal Nature Park and the upcoming Lim Chu Kang Nature Park and Mandai Mangrove and Mudflat Nature Park. This will be a great opportunity for PUB – working with other government agencies and stakeholders – to reshape the coastline by creating new recreational spaces while conserving these nature landmarks, and to dovetail coastal protection measures with the upcoming developments. All three studies are expected to conclude by 2030.

To assess the twin threats of inland and coastal flood risks holistically, PUB is currently developing an advanced computational hydrodynamics model, known as the Coastal-Inland Flood Model. Both the model and the City-East Coast study are underway and will be completed by 2025.

Said Ms Hazel Khoo, Director of PUB's Coastal Protection Department, "As we embark on the next phase of our coastal protection work with the new studies, we will take a collaborative approach and look forward to hearing from the public and relevant stakeholders on solutions that would ensure our coastal spaces remain vibrant and liveable, while effectively protected against rising sea levels".

Expansion of expert panel

In 2020, PUB established a Coastal

Protection Expert Panel comprising international experts to serve as an independent advisory body and to assist PUB stay abreast of the latest international best practices and planning considerations. Professor Yong Kwet Yew, Professor of Civil and Environmental Engineering at the National University of Singapore, and formerly Chairman of the Land Transport Authority's International Panel of Advisors, has been appointed as the new Chairman of the panel. He takes over from Professor Chan Eng Soon who has stepped down as Chair to focus on his work at the Technology Centre for Offshore and Marine, Singapore (TCOMS).

The panel has also been boosted by the addition of Dr Jane McKee Smith, Emeritus Senior Scientist with the US Army Engineer Research and Development Center and an expert in coastal and hydraulic processes. Other panel members are Emeritus Professor Robert A Dalrymple, Department of Civil Engineering, Johns Hopkins University, USA and Professor of Engineering, Northwestern University, USA; Emeritus Professor Marcel Stive, Faculty of Civil Engineering and Geosciences, Delft University of Technology, Netherlands; Professor Robert Nicholls, Director, Tyndall Centre for Climate Change Research, University of East Anglia, UK; and Professor David Balmforth, Visiting Professor, Water and Environmental Engineering, Imperial College London, UK.

On coastal protection work, Professor Yong said, "Being able to tap on some of the best minds available in the fields of coastal engineering and climate change adaptation will be invaluable to help PUB with its coastal protection work. I look forward to working closely with my fellow esteemed panel members, building on the earlier good work under Professor Chan".

Bentley Systems announces acquisition of ADINA

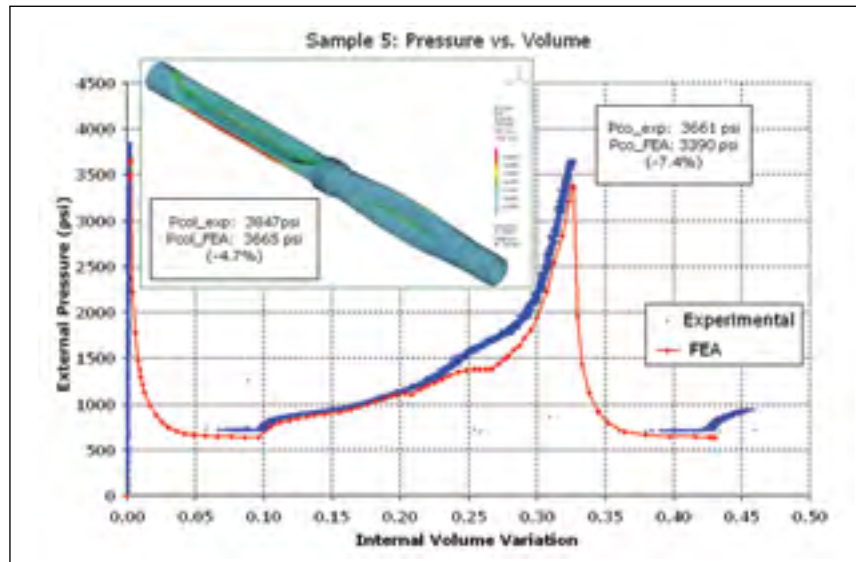
Bentley Systems Incorporated, a leading infrastructure engineering software company, recently announced that it has acquired Watertown, Massachusetts-based ADINA R & D Inc, a leading developer of Finite Element Analysis software applications, used in a comprehensively diverse range of engineering fields.

ADINA was founded in 1986 by Dr Klaus-Jürgen Bathe, Professor of Mechanical Engineering at the Massachusetts Institute of Technology and a world-renowned leader in the field of Finite Element Analysis and its applications.

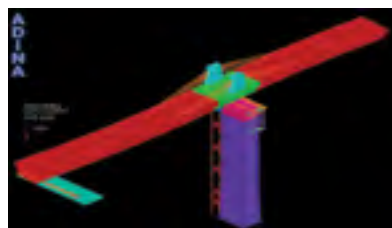
Civil, structural, and mechanical engineers choose ADINA software for its authoritative veracity, including in the analysis of buildings, bridges, stadiums, pressure vessels, dams and tunnels. By virtue of the ADINA System's integral robustness across disciplines, materials, and simulation domains, engineers use it to perform comprehensive safety and performance studies where reliability and resilience are of critical importance.

With infrastructure digital twins, users can simulate the complete behaviour of structures to create confidence in designs that are much safer and more cost-effective than those merely analysed to meet prescribed code standards. Of particular importance for infrastructure resilience, ADINA will also be applied within digital twins of existing infrastructure assets, now made practical by the Bentley iTwin platform, to simulate their responses and vulnerabilities to extreme stresses – caused, for instance, by seismic, wind, flood, pressure, thermal, collision or blast forces.

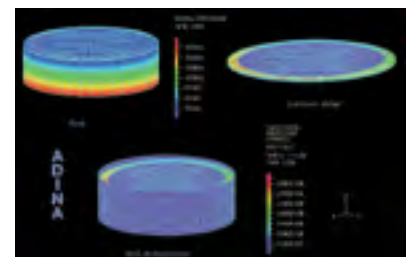
The ADINA System's non-linear simulation capabilities will, in turn, become directly accessible, through convenient technical and commercial integration, to users of Bentley Systems' modelling and simulation software portfolio for infrastructure



Collapse analysis of a pressurised pipe can be performed with ADINA software.



The frictional sliding of a prestressed concrete bridge girder can be studied with ADINA technology.



Sloshing of an oil tank with the base subjected to horizontal ground motion, can be analysed with ADINA software.

engineering. As the ADINA System's non-linear extensions are introduced to complement these existing physical simulation applications – currently spanning STAAD, RAM, SACS, MOSES, AutoPIPE, PLAXIS, LEAP, RM, LARS, SPIDA, and PLS – the scope of mainstream simulation underlying the engineering of infrastructure resilience will be valuably enhanced. ADINA's advantages also include advanced dynamics, 3D solid FEM, buckling, substructuring, and advanced meshing for critical joints and sections.

“Incorporating ADINA and its creators is very exciting for all of our engineering simulation teams, as it will also be for existing and new users. Dr Bathe literally wrote the book on advancing finite element simulations, and the ADINA System

provides the reference for benchmarking all other disparate analysis approaches. We will now be able to extend nonlinear realism across all of our infrastructure digital twin simulation offerings”, said Mr Raoul Karp, Vice President, Engineering Simulation, at Bentley Systems.

Founder of ADINA, Dr K J Bathe, who will remain as a technical advisor, said, “My colleagues and I are proud to be joining Bentley Systems' broad and deep simulation team. Our aim in the development of ADINA has always been to provide a most reliable and efficient analysis tool to scientists and engineers, and it is wonderful that with Bentley, ADINA will now be used and further developed”.

Gradual rebound expected for Singapore's construction sector

Turner & Townsend's latest Singapore Market Intelligence Report – April 2022 retains a cautiously optimistic outlook, in line with the outlook for Singapore's wider economy, which grew by 7.6% in 2021. Construction activity is now approaching pre-pandemic levels, having seen a 2.9% year-on-year growth in the fourth quarter of 2021.

The sector's performance is expected to remain just below pre-pandemic levels for a large part of 2022.

The sector's recovery, however, may be dragged down by a clutch of stiff challenges, chief among which is the continued shortage of labour. The Government's worker retention scheme between September 2021 and February 2022 mitigated only partially the project delays and soaring labour costs. Replenishing migrant labour on-site further and the easing of border controls will require time and careful calibration for everyone's safety, while the costs of bringing in new migrant workers, in compliance with COVID-19 safety

precautions, remain high.

The local industry's dependence on imports, the sharp rise in oil prices and global supply chain challenges, will continue to push up the cost of construction materials, as well as costs associated with transport and machinery operations.

The continued escalation of tender pricing, in the construction sector, is anticipated to average between 5% and 8% in 2022, with higher percentages expected for some other sectors.



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SIWW and CESG 2022 successfully enabled partnerships for climate action

Wide-ranging strategic partnerships, initiatives and MoUs were announced at the Singapore International Water Week (SIWW) and CleanEnviro Summit Singapore (CESG) 2022. The two events were organised by PUB, Singapore's National Water Agency, and the National Environment Agency (NEA), respectively.

These announcements are expected to contribute significantly to the region's climate resilience, underscoring the strategic role key platforms play in facilitating industry collaboration to address the challenges of climate change.

Held from 17 to 21 April 2022, at the Sands Expo and Convention Centre, Marina Bay Sands, Singapore, the co-located events hosted over 15,000 physical attendees, comprising leaders in government, industry, and academia, from around the world, who came together to advance international collaboration to accelerate climate action.

Against the backdrop of the 2021 United Nations Climate Change Conference (COP26) and recent Intergovernmental Panel on Climate Change (IPCC) report urging immediate action to tackle climate change, the programmes at SIWW and CESG were designed to spur synergistic exchange and the co-creation of mitigation and adaptation solutions.

To this end, SIWW and CESG 2022 paved the way for a wide range of key initiatives and public-private partnerships that would strengthen climate resilience in Singapore and beyond, push new sustainability frontiers, and open the doors to potential environmental business opportunities. These include the following:

- Official Opening of the Jurong Island Desalination Plant, which marked another important milestone in Singapore's journey towards water sustainability and the enhancement of water security.
- Establishment of the RSK Centre of Excellence for Sustainability which will consolidate the services of 130 environment businesses under RSK, to provide practical solutions for industry and businesses, meeting the growing demand for sustainability services in the region.
- Unveiling of Hyperscale, Asia's inaugural waste-tech accelerator programme for startups, by Start-upX, in partnership with NEA and Enterprise Singapore, which aims to spur sustainable innovation in the areas of plastics, electronics and mixed waste, and help waste-tech ventures scale their innovations globally.
- Commissioning of a coastal protection study and a Request-for-Proposal (RFP) for innovative coastal protection strategies by PUB.
- Signing of a MoU between Enterprise Singapore and Manila Water, as well as between PUB and Rwanda Water & Sanitation Corporation, to promote exchange of best practices, testbedding and deployment of technologies to enhance water resilience.
- Signing of MoUs between Singapore Water Association (SWA) and public and private organisations to foster partnerships and deepen knowledge exchange. They include British Water, International Water Association (IWA) and International Water Hub (IWH).
- Announcement of supply deals for the upcoming Tuas Water Reclamation Plant (TWRP), between Koh Brothers and Meiden and between Koh Brothers and Xylem, to provide cutting-edge ceramic membrane bioreactor (MBR) technology and biological aeration diffuser systems, respectively, for the world's largest MBR plant, when it is completed in 2026. The deals are part of the SGD 200.7 million contract awarded by PUB for the TWRP, announced previously.
- Announcement of the supply agreement between six building owners in Tampines Town Centre and SP Group, for the installation and operation of district cooling technology. The first such sustainable solution to be implemented in a brownfield development in Singapore, the technology will help the town centre reduce its carbon emissions by 1,359 tonnes annually and save more than 2,800,000 kWh of energy annually.
- Signing of MoUs between ZWEEC Analytics, IONI Water and partners from China and India, totalling about SGD 75 million, to provide access to safe drinking water in the region, and water ecological environment monitoring in Yangtze River Basin.
- Discussions of business opportunities worth approximately SGD 45 billion in the areas of waste management, cleaning robotics, and climate risk mitigation.



Ms Grace Fu, Minister for Sustainability and the Environment, Singapore delivered the keynote address at the Opening Ceremony of SIWW and CESG 2022. Image: SIWW and CESG 2022.

The Environment & Water Leaders Forum (EWLF), a combined SIWW-CESG high-level forum, shone the spotlight on how cities and organisations can transform sustainability challenges into opportunities, while working towards a climate-resilient future. Speakers included Her Excellency Mariam bint Mohammed Almheiri, Minister of Climate Change and Environment, Ministry of Climate Change and Environment, UAE; Ms Michèle Blom, Vice Minister for Water Manage-



At the Environment & Water Leaders Forum are, from left to right, Ambassador Ong Keng Yong, Executive Deputy Chairman, S Rajaratnam School of International Studies; Dr Andrew Benedek, Chairman and CEO, Anaergia; Ms Michèle Blom, Vice Minister for Water Management, Ministry of Infrastructure and Water Management, Netherlands; Mr Patrick Blethon, CEO, Saur Group; Ms Dechen Tsering, Regional Director, Asia and the Pacific Office, United Nations Environment Programme; and Dr Axel Schweitzer, Chief Executive Officer, ALBA Group plc & Co KG. Image: SIWW and CESG 2022.

ment, Ministry of Infrastructure and Water Management, Netherlands; Ms Els van Doesburg, Vice Mayor, City of Antwerp, Belgium; Mr Patrick Blethon, CEO, Saur Group; Dr Andrew Benedek, Chairman and CEO, Anaergia; Mr Axel Schweitzer, CEO, ALBA Group plc & Co KG; Ms Dechen Tsering, Regional Director and Representative for Asia and the Pacific, United Nations Environment Programme; and His Excellency Li Guoying, Minister of Water Resources, Ministry of Water Resources, People's Republic of China.

The overarching message from leaders who spoke during the week is clear – that urgent action is required to mitigate and adapt to climate change. Platforms like SIWW and CESG remain integral in bringing the industry together to drive the sharing of expertise and accelerate action against climate change.

“We don’t have decades for something that is put into a legally binding instrument to roll down to society. These amazing innovations, these amazing technologies, this amazing finance – it’s not happening fast enough and we don’t have enough time”, said Ms Dechen Tsering, Regional Director and Representative for Asia and the Pacific, United Nations Environment Programme.

“I couldn’t imagine such a meeting 15 years ago, talking about water and environment. This is a big change we are seeing today in the world, and especially the past five years; everyone is talking and acting. The world is changing”, said



Researchers from SUTD showcasing robotic solutions at the NEA Innovation Pavilion. Image: CESG 2022.

Mr Patrick Blethon, CEO, Saur Group.

The Water Expo and Environment Expo featured more than 300 local and international exhibitors, showcasing the latest innovations in water and environmental management, with digital solutions emerging as powerful levers for change. About 30% of the exhibitors at the Environment Expo featured digital solutions, with robotics solutions commonplace. The Water Expo also featured a dedicated Digital Pavilion for the first time. In addition, the Imagine H2O and Ripple2Wave Pavilions also provided opportunities for some 27 water start-ups to connect with investors, partners and buyers to advance commercialisation of exciting and new water technologies.

“SIWW 2022 is proud to have returned as Asia’s first large-scale water show since the pandemic, bringing together the world’s brightest minds to conduct meaningful conversations and developments to galvanise the international water community into accelerating

climate mitigation and adaptation efforts. The active participation of international businesses at the Water Expo further underscores the importance of SIWW as a platform for the co-creation of innovative and scalable solutions for urban water challenges”, said Mr Ryan Yuen, Managing Director of Singapore International Water Week.

“Ahead of the 27th United Nations Climate Change conference or more commonly referred to as COP27, CESG 2022 has provided opportunities for public and private sector leaders to come together and address climate risks and urban waste issues. The past few days have shown that we have the collective technologies and solutions needed to build a more climate-resilient future. It is now time for participants to act on the insights they have gained from attending this event”, said Mr Dalson Chung, Managing Director of CleanEnviro Summit Singapore.

The next editions of SIWW and CESG will be held from 16 to 20 June 2024.

Tuas Power-ST Engineering Consortium and PUB open Singapore's fifth desalination plant

With its ability to produce up to 137,000 m³ of potable water, the plant will strengthen Singapore's water security.

The consortium of Tuas Power and ST Engineering, along with PUB, Singapore's National Water Agency, have officially opened Singapore's fifth desalination plant, located on Jurong Island.

Jurong Island Desalination Plant (JIDP) has a daily capacity of up to 137,000 m³ (about 30 million gallons) of water – the equivalent of 55 Olympic-sized swimming pools.

Deputy Prime Minister and Coordinating Minister for Economic Policies, Mr Heng Swee Keat was the Guest of Honour at the ceremony, held at the start of the Singapore International Water Week 2022. Also present were Minister for Sustainability and the Environment, Ms Grace Fu; PUB Chief Executive, Mr Ng Joo Hee; Tuas Power President & CEO, Mr Jiang Hanbin; and ST Engineering's President for Marine, Mr Ng Sing Chan.

Constructed under the Design, Build, Own and Operate (DBOO) model, JIDP will be operated by TP-STM Water Resources Pte Ltd – the Joint Venture company formed by the Tuas Power-ST Engineering consortium – for a 25-year period.

Spanning over 3.7 hectares, which is about the size of five football fields, JIDP receives seawater from Tuas Power's Tembusu Multi-Utilities Complex (TMUC), for processing into potable water.

JIDP's co-location with TMUC allows it to derive synergies in resources, such as sharing of seawater intake and outfall structures, as well as energy from in-plant generation facilities. Due to the co-location, the plant is about 5% more energy-efficient compared to conventional desalination plants, which translates to annual energy savings sufficient to power nearly 1,000 HDB households.

Building a full-fledged desalination plant on existing infrastructure called for innovative engineering solutions, from creating modular systems in different areas of the desalination process to the pre-fabrication of equipment such as the reverse osmosis units. The plant is also highly automated – a three-man team can run the entire plant's operations from its control room. In addition, JIDP incorporates the latest proven water treatment equipment and membrane technologies, such as dissolved air flotation, ultra-filtration, and reverse osmosis.

"Although seawater desalination is the most expensive way to produce water, due to the energy required, it is nevertheless an essential source of drinking water for Singapore. Desalination is immune to the vagaries of weather and is always available, rain or not. The efficiencies that come from constructing JIDP, our fifth and newest desalination plant, next to Tuas Power's existing TMUC, make the energy-take for desalination that much more palatable. JIDP further diversifies our water production portfolio and its coming into operation enhances

Singapore's water security", said Mr Ng Joo Hee, Chief Executive of PUB.

"Leveraging on TMUC's existing infrastructure for seawater intake, the synergies between JIDP and TMUC have enabled operations to save approximately 5,000 Megawatt hours per year. That is almost 1,000 HDB households' energy consumption annually, making JIDP one of the more energy-efficient desalination plants in Singapore", shared Mr Jiang Hanbin, President and Chief Executive Officer of Tuas Power.

"The design and construction of the JIDP has provided ST Engineering the opportunity to leverage our expertise in large-scale engineering projects in the marine sector to deliver complex environmental engineering solutions. The result is an energy-efficient, technologically advanced, less labour-intensive and weather-resilient water source that meets Singapore's water needs", said Mr Ng Sing Chan, President, Marine, ST Engineering.

Desalinated water is one of Singapore's Four National Taps, and a weather-resilient source that contributes to the nation's long-



Aerial night-view of the Jurong Island Desalination Plant. Image: PUB, Singapore's National Water Agency.

term water supply sustainability. The other four desalination plants in Singapore are the SingSpring (2005), Tuas South (2013), Tuas (2018) and Marina East (2020) plants.

PUB

PUB is a statutory board under the Ministry of Sustainability and the Environment (MSE). It is the national water agency which manages Singapore's water supply, water catchment, and used water, in an integrated way. From April 2020, PUB also took on the responsibility of protecting Singapore's coastline from sea-level rise as the national coastal protection agency.

PUB has ensured a diversified and sustainable supply of water for Singapore, with the Four National Taps (local catchment water, imported water, NEWater, desalinated water). PUB

leads and coordinates whole-of-government efforts to protect Singapore from the threat of rising seas and the holistic management of inland and coastal flood risks.

Tuas Power

Tuas Power is a key provider of energy solutions and multi-utilities in Singapore. The company is a member of China Huaneng Group, one of the largest and most forward-looking power producers in China and the world.

Tuas Power has a licensed capacity of 2,670 MW, and is a leading power generation company in Singapore. It has five combined cycle plants and a steam plant in its power station in the Tuas industrial region, and develops efficient and environmentally responsible energy solutions through its retail arm.

Tuas Power also supplies utilities such as steam, high-grade industrial water and demineralised water, and provides waste water treatment services, in Tembusu, Jurong Island.

ST Engineering

ST Engineering is a global technology, defence and engineering group, with a diverse portfolio of businesses across the aerospace, smart city, defence and public security segments. The group harnesses technology and innovation, to solve real-world problems, enabling a more secure and sustainable world.

Headquartered in Alexandria, Virginia, since 2001, ST Engineering's US operations span over 50 cities in 23 states, employing 7,000 people and providing innovative products and solutions to commercial and government customers across diverse market segments.

Explosive growth in demand for unconventional water resources

Demand for water reuse and desalination technologies is growing at an accelerating rate as cities around the world come to terms with the vulnerability of their water supply.

According to figures announced in Rome, in October 2021 at the International Desalination Association's International Water Reuse and Recycling Conference, the total contracted capacity for unconventional water production facilities was estimated to reach 321 million m³/d by the end of 2021. That is more than twice the volume of water discharged to the sea by the river Nile every day.

Of the two technologies, water reuse is growing faster. Orders for new water reuse plants were estimated to top 20.9 million m³/d of capacity in 2021, compared with 15.6 million m³/d of capacity in 2020 and 11.8 million m³/d of capacity in 2019. Orders for new seawater and brackish water desalination plants were estimated to reach 5.1 million m³/d – an 8% increase on the previous year. 2021 was expected

to be the fourth year in a row in which the rate of growth of the unconventional water resources market had increased.

The data is provided by GWI DesalData.

The key markets for water reuse have been Asia and the Middle East, where urban populations have been growing fast in areas with limited water resources. Droughts in the southwestern United States and Latin America's Parana river basin during 2021 are likely to lead to accelerated investment in water recycling in those regions in 2022 and beyond. Although agriculture remains the largest sector of the market for water reuse, high grade water use using triple barrier protection for potable applications has been growing fast.

In the past, the desalination market has been held back by concerns about its energy consumption, but in recent years, the emergence of low-cost solar power has dramatically cut the cost of desalinated water.

Records for the lowest cost of desalinated water started to fall in 2018 when the USD 0.50/m³ barrier was broken by a project in Saudi Arabia. And Dubai's largest desalination plant which is under construction is expected to lower the water tariff even further.

Mr Christopher Gasson, Publisher of GWI DesalData, commented, "Water reuse has seen incredible growth over the past five years, but this may be just the beginning of something even bigger. Once politicians understand that indirect potable reuse is the safest, lowest cost and most environmentally friendly source of additional water, it could become the norm all over the world as it is in Singapore today".

"Looking at the pipeline for the desalination projects, 2022 could well be the best year ever. Beyond that, the challenge for the industry will be to replicate the low costs and small carbon footprints achieved in the GCC region, in the rest of the world", he added.

Singapore's overall waste generation and recycling rates increased in 2021

This followed a pickup in economic activity after the slowdown in 2020 due to COVID-19.

The National Environment Agency's (NEA) latest waste and recycling statistics revealed that in 2021, about 6.94 million tonnes of solid waste were generated, which was about 18% more than the 5.88 million tonnes generated in 2020. Waste generation is the sum of total waste disposed of and total waste recycled.

Waste generated by the non-domestic and domestic sectors both saw increases – from 4.12 million tonnes and 1.77 million tonnes, respectively, in 2020, to 5.12 million tonnes and 1.82 million tonnes, respectively, in 2021. Non-domestic waste is waste collected from industries and commercial premises. Domestic waste is waste collected from households and trade premises (e.g. shophouses, educational institutions, petrol stations, hawker centres and places of worship).

Of the waste generated in 2021, 3.83 million tonnes were recycled. Overall, the recycling rate increased from 52% in 2020 to 55% in 2021. The recycling rate is derived from the amount of waste recycled divided by the total amount of waste recycled and waste disposed of.

The recycling rate of the non-domestic sector increased from 68% in 2020 to 70% in 2021, while that of the domestic sector remained unchanged at 13% in 2021.

Key highlights and observations

Economic activity picked up in 2021, resulting in more waste generated and recycled in 2021.

- 2020 was an anomalous year with lower waste generation and recycling rates, due to the impact of COVID-19, particularly during the Circuit Breaker period (April to May 2020) when activities were curtailed. The pick-up in economic activity, and resumption of business and social activi-

ties in 2021 led to a 10% increase in waste disposal and 26% more waste recycled.

- Compared to the period before COVID-19 pandemic, 2021 saw 5% less waste generated, and 5% more waste disposed of as waste recycled declined by 11%.
- Due to lower construction activity and export market demands for recyclables in 2021, the amount of waste recycled is lower than the pre-COVID-19 levels, especially for waste streams such as construction and demolition, wood and non-ferrous metal. The overall recycling rate improved from 52% in 2020 to 55% in 2021. The recycling rates of most waste streams, including those for plastic and food waste, were higher than in 2019. However, the recycling rate of paper/cardboard, which is also a major waste stream, was lower than the 2019 level.
- With waste generation growing as economic activities ramp up, there will be greater urgency to shift from a linear to a circular economy which is a key part of the Zero Waste Masterplan and the Singapore Green Plan. It will take a whole-of-nation effort to achieve the vision of a Zero Waste Nation. NEA will continue to encourage businesses and consumers to be more sustainable.

Improvements in plastics, horticultural and wood waste recycling rates

- The recycling rate of plastics waste increased from 4% in 2020 to 6% in 2021. There was a 60% increase in the amount of plastics waste recycled, with more processed locally and exported. More needs to be done to improve the recycling rate of plastics waste as it remains low despite the increase.

- The recycling rate of horticultural and wood waste increased from 80% and 64% in 2020 to 83% and 76%, respectively, in 2021. Waste generators sent more of such waste to biomass and composting facilities for recycling instead of sending them to Waste-to-Energy plants.
- The recycling rate of paper/cardboard edged up marginally from 38% in 2020 to 39% in 2021. It remains below 2019's 44% as less paper/cardboard recyclables were exported than in 2019 while there was an increase in the disposal of paper/cardboard waste.

Increase in household recycling

- More waste was being disposed of by the domestic sector as the work-from-home trend continued into 2021. This was matched by a corresponding increase in the amount of recyclables collected under the National Recycling Programme (NRP), by 14%, contributing to 40% of the increase in the amount of waste recycled by the domestic sector. Overall, the domestic recycling rate remained unchanged at 13% in 2021.
- Through outreach programmes, such as the Recycle Right campaign, NEA will continue to encourage households to recycle more and recycle right. To cultivate good recycling practices, educational and user-friendly content has been developed to guide the public on items that can and cannot be recycled.

Encouraging sustainability practices in businesses and consumers

- While the recycling rates of most waste streams in 2021 were higher than the pre-COVID-19 levels of 2019, there remains room for improvement as Singapore works

towards realising the vision of being a Zero Waste Nation.

- Apart from implementing a disposable carrier bag charge at supermarkets, from mid-2023, NEA is also working to introduce a Beverage Container Return Scheme to support plastics recycling and cultivate recycling habits among consumers.
- To encourage sustainable packaging waste management practices and support companies in fulfilling the Mandatory Packaging Reporting (MPR) requirement, NEA is partnering the Singapore Manufacturing Federation in the Packaging Partnership Programme (PPP) to build capability. Through webinars and resources, the PPP facilitates the exchange of sustainable packaging best practices and trends, to support

the reduction of packaging, which includes the use of paper/cardboard in e-commerce.

- NEA engages the premise operators of various types regularly to encourage the adoption of circular economy practices. NEA has published 3R guidebooks, which can be downloaded from NEA's website. These include guidebooks for food waste minimisation and segregation for recycling, and sustainable packaging practices.
- Through the Say YES to Waste Less and Recycle Right campaigns, NEA encourages the public to make environment-friendly choices in their daily lives and encourage families and friends to do the same.

With waste generation growing as economic activities ramp up, there

will be greater urgency to shift from a linear to a circular economy. The national goals are to achieve a 70% overall recycling rate by 2030 and to reduce the amount of waste sent to Semakau Landfill by 20% per capita per day by 2026 and 30% per capita per day by 2030. This will help to extend the lifespan of the remaining landfill which will be filled up by 2035, at the current rates of waste disposal.

It will take a whole-of-nation effort to achieve Singapore's vision of a Zero Waste Nation. Towards achieving this objective, NEA will continue to initiate various campaigns and engagements as well as encourage greater waste reduction efforts. This is a long-term process that requires everyone – from the people, private and public sector – to work together.

Waste Type	Total Waste Generated	Total Waste Recycled	Recycling Rate	Total Waste Disposed of
	('000 tonnes)	('000 tonnes)		('000 tonnes)
Ferrous metal	1,312	1,306	99%	6
Paper/Cardboard	1,136	437	39%	699
C&D	1,013	1,011	99%	2
Plastics	982	58	6%	924
Food	817	154	19%	663
Horticultural	332	277	83%	55
Wood	310	234	76%	76
Ash & sludge	249	22	9%	227
Textile/Leather	189	7	4%	182
Used slag	182	181	99%	1
Non-ferrous metal	88	87	98%	1
Glass	74	9	13%	65
Scrap tyres	27	26	95%	1
Others (stones, ceramics, etc.)	233	18	8%	214
Total	6,944	3,826	55%	3,118

Waste Statistics and Overall Recycling Rate 2021

RSK Group launches a centre for sustainability excellence in Singapore

The facility will provide practical solutions for industries and governments.

RSK Group, a global leader in the delivery of sustainable solutions, announced the official launch of the RSK Centre for Sustainability Excellence in Singapore, at Singapore International Water Week 2022.

The centre will support the delivery of the Singapore Green Plan 2030, profiling Singapore as a global force in the sustainability arena, while supporting businesses across the Asia-Pacific region in readdressing the balance of people, profit and planet.

The launch was officiated by Ms Grace Fu, Minister for Sustainability and the Environment, Singapore; Dr Amy Khor, Senior Minister of State, Ministry for Sustainability and the Environment, Singapore; and Mr Desmond Tan, Minister of State, Ministry of Home Affairs & Ministry for Sustainability and the Environment, Singapore.

The RSK Centre for Sustainability Excellence is built around four core themes covering fundamental aspects of sustainable development, as set out in the United Nations Sustainable Development Goals. The centre will also house the RSK Research Institute for Climate Strategy.

Climate and sustainability strategy

With a focus on decarbonisation, the centre will offer consulting services and strategic advice on climate strategy and disclosures, particularly on Task Force on Climate-related Financial Disclosures (TCFD) and Taskforce on Nature-related Financial Disclosures (TNFD) reporting, green funding availability and carbon offset markets. Experts will also provide the measurement of natural capital, carbon accounting, water and biodiversity audits, and management plans.



At the official launch of the RSK Centre for Sustainability Excellence are, from left to right, Mr Robert Charnock, Director, RSK Research Institute on Climate Strategy and RSK Centre for Sustainability Excellence (CfSE); Her Excellency Kara Owen, British High Commissioner to Singapore; Dr Amy Khor, Senior Minister of State, Ministry for Sustainability and the Environment, Singapore; Mr Alan Ryder, CEO, RSK Group; Ms Grace Fu, Minister for Sustainability and the Environment, Singapore; Ms Lucy Thomas, RSK Group Chief Scientist and Managing Director of the RSK Centre for Sustainability Excellence; Mr Desmond Tan, Minister of State, Ministry of Home Affairs & Ministry for Sustainability and the Environment, Singapore; and Mr William Yong, Managing Director, Binnies Singapore. Image: SIWW and CESG 2022.

Renewable energy

The centre will offer services to support the development of renewable technologies, including solar, wind and tidal energy technologies, and will follow projects through their life cycle, with construction, operation and maintenance services. For example, through 'Ocean 30', a joint-venture between RSK and Nova Innovation, the centre will design, install, operate and maintain tidal and floating solar projects. RSK's experience in global renewable projects, along with its expertise in marine biodiversity conservation and enhancement, will be vital to renewables projects across the Asia-Pacific region.

Digital water

To provide sustainable and robust water, wastewater and flood resilience solutions, the RSK Centre for Sustainability Excellence will provide infrastructure design, using smart technology such as artificial intelligence to expedite the design process and reduce operating costs at water and wastewater treatment plants. An Innovation Factory will develop ideas,

provide proofs of concept and conduct pilot tests on intelligent water and environmental solutions.

Sustainable agriculture

To improve resilience throughout the food and drink supply chain, the centre will provide insight into agricultural supply chain vulnerability and adaptation, and renewable smart energy systems for crop production, lighting and cooling.

RSK RESEARCH INSTITUTE FOR CLIMATE STRATEGY

An education hub, the RSK Research Institute for Climate Strategy will bridge the gap between academic insights on climate strategy and the challenges faced by practitioners and policymakers. Researchers will provide timely insights into pressing issues, such as corporate climate scenario analysis; zero-carbon transition plans; and measurement, reporting and verification (MRV). Collaborations with leading universities in the world will drive the research institute's agenda and will impact across the areas of business, policy and education.

Consortium develops Autonomous Environmental Service Vehicle

Deployment of the technology will result in an innovative and transformed environmental services industry.

An Autonomous Environmental Service Vehicle has been jointly developed by Nanyang Technological University, Singapore (NTU Singapore); Enway Pte Ltd; SembWaste Pte Ltd; and Wong Fong Engineering Pte Ltd. Their efforts are supported by the National Environment Agency (NEA) and National Robotics Programme (NRP).

Principal Investigator, Professor Wang Danwei, from the School of Electrical and Electronic Engineering, NTU, leads the AESV project which includes the development of novel technologies for off-site operations and robot cybersecurity solutions for the project.

Enway is a developer of autonomous software for heavy duty vehicles, focusing initially on the cleaning industry, with its Blitz class autonomous industrial sweeper launched in September 2019. The company combines knowhow in engineering, robotics, machine learning, computer vision and artificial intelligence, with operational expertise that is unique in the professional cleaning industry. As Co-Principal Investigator, Enway is developing the AESV's navigation system and autonomous road sweeping functionality.

SembWaste is the waste management and recycling arm of Sembcorp Industries, a focused energy and urban development company offering sustainable solutions. A leading environmental services company, SembWaste provides waste management, public cleaning and recycling services, and is the operational partner for the public trials of the AESV.

Wong Fong is a trusted provider of land transportation engineering solutions and systems. For this project, the company developed and manufactured the AESV's field infrastructure including the docking



The AESV developed by the NTU-Enway-Sembcorp-Wong Fong Consortium.

station and waste compactor for autonomous dumping.

Features of the AESV

The AESV incorporates the following features, to make street sweeping sustainable and efficient:

- Zero carbon emission, less noise: The AESV is fully electric and has lower ambient noise output compared to conventional sweepers.
- Improves productivity: (i) Operations can be shifted to late nights/early mornings, avoiding rush hours and optimising road usage and (ii) The system allows for dynamic route planning and remote operation to ensure the AESV can handle all situations it encounters.
- Enable job re-design: Deployment of the AESV will enable job re-design, to address manpower shortage in the cleaning industry and attract young talents to join.
- Precise cleaning: The ability to autonomously sweep along the kerb facilitates effective cleaning of heavy debris areas.
- Safety: The AESV is cybersecure, to guard against malicious attacks on its sensors and actuation systems.

- Tested on the NTU Smart Campus: A living testbed for innovative digital and tech-enabled solutions, the NTU Smart Campus is home to the Centre of Excellence for Testing & Research of Autonomous Vehicles – NTU (CETRAN), where public road trials for the AESV are conducted in small-scale testbed environments.

Specifications of the AESV

- 8 hours sweeping range and 2.5 hour charge time.
- Equipped with 3D LiDAR sensors and cameras for localisation, kerb following and traffic navigation.
- Sweeping speed of up to 12 km/hr.
- Vacuum-based debris collection system.
- Autonomous docking and hopper emptying.
- Remote monitoring and control. A high-fidelity teleoperation system has been developed by NTU, that enables drivers to operate the AESV and other heavy-duty vehicles remotely (from an off-site location) in a simple and realistic manner.
- Cybersecurity functions.

New technology for desalination and water reuse launched in the Asia Pacific region

‘The Barrel’, as it is called, utilises reverse osmosis.

Veolia Water Technologies, a subsidiary of Veolia Group, and a leading specialist in water treatment, recently announced the Asia Pacific launch of ‘The Barrel’ which incorporates integrated plug-and-play reverse osmosis (RO) technology. The Barrel was showcased at CleanEnviro Summit Singapore 2022 and the OzWater 2022 trade exhibition in Brisbane, Australia.

With increasing demand for fresh water and rising concerns over its scarcity in the region, the Barrel is expected to meet the challenges and expectations of the desalination market while producing fresh water complying with all water quality standards. It is also suitable for wastewater reuse and low pressure RO applications. The Barrel is expected to empower users with an economically viable and sustainable source of fresh water.

It was selected as a key technology for the first experiment in Europe, which involves wastewater treatment for the supply of drinking water, through the Jourdain programme, in France’s Vendee region. The technology has also been in use at the Oman Sur desalination plant since 2019.

The Barrel

The Barrel is a multi RO element vessel that is designed to be a plug-and-play system. The carbon steel pressure vessel is manufactured and tested off-site, and is delivered as a single unit, so installation on-site can be fast-tracked and project schedules shortened.

In addition, the modular design of the Barrel makes it scalable, offering varying capacities from 400 m³/day to 50,000 m³/day per unit. It can also be used in place of existing RO membranes and nanofiltration skids, as a more economically viable, sustainable, and innovative alternative.

Compact and suitable for outdoor installation, the Barrel offers a footprint reduction of up to 25% and does not require a controlled environment. The sustainable solution also provides a reduction in electrical consumption in the range of 0.05 kWh/m³ of fresh water produced.

Beyond sustainability, the design of the Barrel also significantly reduces the number of high-pressure piping connections down to just two - the seawater inlet and the brine outlet. This design feature makes it safer for operators and minimises risks on-site during the maintenance and operation phases. Corrosion is less likely to occur as seawater leakage sources, such as those found on the multiple high-pressure connections of traditional RO skids, are reduced.

The Barrel also has a built-in digitalisation system with smart connectors providing real-time status updates on each membrane’s condition. In fact, their performance

can be monitored automatically and accessed remotely – helping operators to make better decisions on whether to shut down, rotate, or replace membranes.

Veolia Water Technologies

Veolia Water Technologies provides a complete range of services required to design, deliver, maintain, and upgrade water and wastewater treatment facilities and systems, for industrial clients and public authorities.

The company’s extensive portfolio of technologies features everything from online diagnostic solutions to evaporation and crystallisation, energy-producing sludge treatment, desalination, laboratory-grade water, and mobile water services. By optimising both processes and monitoring, Veolia Water Technologies helps clients reduce their water footprint, while generating savings in energy and chemical consumption.



The Barrel is suitable for outdoor installation.

CPG Consultants launches Coastal Protection Strategy Team

Holistic approaches are necessary to combat rising sea levels and heavy rainfall.

CPG Consultants (CPG), a subsidiary of Singapore-based consultancy services, infrastructure, and building management firm, CPG Corporation, has announced that it is forming a core team to devise holistic coastal protection and sustainability strategies for the built environment. As a strategic addition to CPG's multidisciplinary consultancy services, the Coastal Protection Strategy Team (Civil and Structural Engineering Division) will focus on sustainable solutions to strengthen Singapore's resilience against climate change.

"Aligning our strength in engineering adaptive approaches with our sustainability advocacy, we take ownership in driving built environment resilience. With the formation of the Coastal Protection Strategy Team, we sharpen our focus on defining innovative solutions and developing toolkits to weather through rising sea levels and heavy rainfall", said Er. Yeang Hoong Goon, Chief Executive Officer, CPG Consultants.

As a low-lying island city-state, Singapore is particularly vulnerable to climate change. The Centre for Climate Research Singapore has projected that Singapore could experience an increase in daily mean temperature of 1.4° C to 4.6° C towards the end of this century and a mean sea level rise of up to 1 m by 2100. There have been more intense and frequent heavy rainfall events in Singapore, causing major flooding around the island.

As part of the holistic storm water management strategy formulated by PUB, Singapore's National Water Agency, CPG designed and constructed the Stamford Detention Tank (SDT) and Stamford Diversion Canal (SDC). These major drainage projects improve storm water flow and reduce flood risk for the Orchard Road area. During

the four-year construction phase, CPG employed skilled expertise to ensure that these two measures safeguard the Orchard Road area by detaining, delaying and diverting storm runoff before it can do serious harm.

The SDT temporarily stores storm water from Holland Road's drains and pumps the water into drains leading to SDC. This integrated solution helps relieve the drainage of 38,000 m³, or 15 Olympic-sized swimming pools, of storm water during heavy rainfall. The SDT's and SDC's success also provides a benchmark for future industrial, commercial and residential developments to implement similar solutions that will help slow down storm water flow into the public drainage system.

Sustainable strategies are not just for coastal protection. They also help optimise the environment and enhance liveability for communities. Under the Active, Beautiful and Clean Waters Programme, and the Kallang River at Bishan-Ang Mo Kio Park project, CPG upgraded the drainage for a 1.8 km stretch along the Kallang River, for flood control. The river channel itself was designed based on a flood plain concept and linked to a network of drains in the city. In a storm, the adjacent park area doubles up as a conveyance channel, carrying the rainwater downstream gradually, to bring about an 80% increase in drainage capacity. CPG also deployed soil bio-engineering, a technique for bank stabilisation, that incorporates vegetation and engineering structures to increase slope stability. This technique helps prevent soil erosion and gives the area a natural appearance, drawing wildlife to the riverbank and adding to the park's biodiversity.

These ongoing efforts highlight what can be done by an island na-

tion, like Singapore, that is particularly susceptible to rising sea levels and extreme weather conditions.

Further, holistic coastal protection and sustainability strategies are essential in strengthening Singapore's built environment resilience. Last year, PUB announced the commencement of a site-specific study along Singapore's Southeast Coast - a significant step forward in Singapore's long-term coastal protection plans.

Speaking on the background of the study, Lee Adam Harryman, Senior Vice-President of the Civil and Structural Engineering Division and who leads the Coastal Protection Strategy Team, explains that while climate change impacts all on the global scale, it affects different regions differently. More research contextualising Singapore is essential to create adaptation plans applicable to the island nation.

CPG is currently leading the study to develop a climate resilience masterplan and formulate climate change adaptation measures for integrated coastal protection, to keep the population and critical infrastructure safe from flooding.

In addition to the primary objective of flood protection, the Coastal Protection Strategy Team will also work on integrated, multifunctional measures and complement land use visions in these areas. Such integrated measures will create new recreational spaces to enhance the liveability of the areas. Examples of potential measures include sea walls, earthen bunds, empoldering and nature-based enhancements such as mangroves.

CPG is also working on plans to nurture a local talent pool of experienced coastal protection professionals, through the Coastal Protection Strategy Team.

Decision-support platform presented for water and sanitation infrastructure investments

The smart solution will help improve environmental performance.

SUEZ, a major player in environmental services, showcased AssetAdvanced, the company's latest innovative solution, at Singapore International Water Week 2022. By deploying this decision-support platform, water service and sanitation managers are able not only to expand their knowledge of current assets, but also reduce risks and cost overruns from infrastructure failures, as well as make informed decisions on future investments.

AssetAdvanced is compatible with all types of urban services including public lighting, light signalling, urban development, and urban heating and cooling networks.

A key component in the decision-making process, the maintenance and replacement of assets within local communities often represents as much as one third of investments. Expected investments may be reduced by 30%, based on

insights provided by the AssetAdvanced planning solution.

The AssetAdvanced process

- AssetAdvanced collates available asset data from sources such as sensors, inspections, operational data from geographic information system (GIS) etc, into a single analysis, simulation, and visualisation platform.
- Next, AssetAdvanced implements a multi-purpose and multi-criteria solution to develop scenarios reviewing the current and future state of assets which, in turn, identify failure risks, and potential impacts on service.
- Based on data interpretation, AssetAdvanced then recommends inspection and replacement plans that are repurposed to meet the relevant priorities. As such, the solution aims to make assets last longer (networks and plants), in

addition to reducing environmental impact, and ensuring continuity and service quality for users.

“Now more than ever, the deployment of effective asset management is a cornerstone issue for local communities against the background of ageing infrastructure and increased pressure on water resources. To address this challenge, we are pleased to launch our all-new offering – AssetAdvanced. AssetAdvanced is the product of our group's longstanding expertise in water network and plant management, which we have leveraged and integrated with our know-how in data processing and digital solutions. The AssetAdvanced offering will bolster our range of smart solutions designed to improve regional environmental performance”, said Mr Charles Chami, Senior Vice-President, SUEZ Smart & Environmental Solutions Business Line.

SUEZ awarded contract by Sydney Water Corporation to upgrade Prospect Water Filtration Plant

Through collaboration with Sydney Water Corporation (SWC), SUEZ has been operating the Prospect Water Filtration Plant (PWFP).

Operated by SUEZ since 1993, through an extended build-operate-transfer contract that currently runs until 2035, the PWFP is the largest water filtration plant in Australia. It supplies reliable drinking water to 85% of Sydney's population.

In order to maintain the high performance of the PWFP, in light of its criticality to the resi-

dents, SWC awarded a contract to SUEZ in December 2021, to upgrade important aspects of the plant.

The works contracted by SWC include the implementation of a new sodium hypochlorite dosing system, the increase of the usable capacity of the existing Clearwater tanks (CWTs), and the upgrade of the plant control system. SUEZ plans to complete the work by August 2023.

The new contract aims to continually improve the efficiency and effectiveness of the plant in

its infrastructure and operation, and continue to serve the water demands of the communities, while also accommodating the longer-term stresses of population growth and climate change.



The Prospect Water Filtration Plant in Sydney, Australia.



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Upcoming Launch of Railway Safety Management and Safety Performance Standards

‘The Singapore Engineer’ finds out more about two new Technical References (TRs) from Mr Francis Yap and Mr Chow Wai Yein, Co-Convenors of the Working Groups on the two TRs, under the IES-Standards Development Organisation (IES-SDO).



Mr Francis Yap



Mr Chow Wai Yein

The two new TRs are:

- **TR 97: 2021 - Safety management in a rapid transit system**
- **TR 89: 2021 - Safety performance and benchmarking system in a rapid transit system**

The Singapore Engineer (TSE): What is the scope of each of the TRs?

Co-Convenors (CC): TR 97 covers the requirements of safety management in the rapid transit system, spanning leadership and commitment, occupational health and safety policies, organisational roles and responsibilities, hazard identification and assessment of risks, resources, competence, awareness, communications, operations control, management of change, emergency preparedness and response, management review and continual improvement, within the context of the Singapore railway industry.

TR 89 covers the leading and lagging indicators for safety performance, defined across the broad categories of employee safety, contractor safety and passenger safety, in the Singapore railway industry. This reference aids Singapore railway operators to effectively establish common ground for conducting evaluations for international benchmarking.

TSE: What are the challenges faced by the railway industry that led to the creation of the TRs?

CC: Singapore’s railway operators had developed individual safety management systems, using foreign, established railway safety management standards and

authoritative texts, as a guideline. However, using these references may not adequately serve the needs of the local railway ecosystem. To ensure that procedures, processes and systems adopted from these references fit into the context of local needs and regulations, additional validation processes are required. One such initiative is the project safety review (PSR) process which is maintained by the regulator, Land Transport Authority (LTA). The PSR process oversees all safety-related submissions for all rail projects and through all phases, from conceptualisation to operations, to ensure all foreseeable hazards and risks are mitigated, thereby enabling a safe-to-use and safe-to-operate rapid transit system. A safety management system is therefore needed, that demonstrates the ability to meet the certification requirements of the PSR process.

The standardisation of the safety management system aims to develop a more comprehensive and robust system tailored to the local context. The best practices at a national level will enhance the safety performance of the rapid transit system for its workforce and commuters. Accordingly, TR 97 was created.

We also observed that several benchmarking indicators, such as

safety, may not have been clearly defined by international organisations. This limitation encourages collaboration and benchmarking for comparison of performance. Operators in different countries have varying regulations on the constitution of reportable railway accidents and near misses. This invariably changes the way railway companies benchmark against one another, when comparing such statistics globally. Hence, a technical reference can augment the Singapore regulator’s efforts to holistically and proactively identify all potential types of incidents in safety performance management.

Railway industry operators and the regulator holistically agreed on the need to have common safety performance indicators for the rail industry, to allow objective, effective and efficient evaluation of safety performance, across the board. This has led to the creation of TR 89.

TSE: What are the objectives of the TRs?

CC: TR 97 is intended to be used as a technical reference for the railway safety management system. The key objective is to integrate leadership commitment into the safety management of an organisation’s business processes, by leading and promoting a positive safety culture.

For example, parties seeking a 'safe to operate' certification, under the authority's project safety review (PSR) process, will need to submit the details of the safety management system that meets the requirements of the standard. This will eventually lead to the delivery of compliance and competence assurance of safe operation and maintenance within the railway industry.

TR 89 aims to improve environmental health and safety levels at the workplace, across the Singapore rail industry, by owning a clear safety performance standard and striving towards compliance with the standard. The setting of clear performance goals, through established indicators, enables operators to better interpret safety tolerance levels, in the interest of identifying and addressing key areas of concern.

TSE: Which sectors of the industry are the TRs relevant to and who can benefit from them?

CC: With TR 97, rail industry partners can benefit from the standard, through the clarity and transparency of the requirements for safety submissions, allowing them to demonstrate compliance with the requirements. With the current New Rail Financing Framework and associated licensing model, new operators from overseas, may participate in the tenders for new rapid transit system operating licences. This reference aims to support new operators in meeting the operating safety submission requirements, in a manner that is consistent with regulator expectations.

With TR 89, local railway operators can unveil and elevate their level of safety which serves as a core component in bidding for projects internationally.

With both these technical references, the Singapore rail system will be held in high esteem as a professional network – not just the operators, but the industry, as a whole, including the regulator and suppliers, as well. These technical references will also create a conducive environment for the development of skill sets and better collaboration among stakeholders to further improve the capability of the industry. This will bring greater benefits to new operators and eventually to the commuters and railway partners.

The Working Group for TR 89: 2021 and TR: 97:2021 would like to thank former co-convenor, Mr Anson Lim Chwee Kuong, for his contributions to the development of these technical references.

UK takes steps for a cleaner and greener railway

The UK's Rail Safety and Standards Board (RSSB) recently opened a consultation on the Sustainable Rail Strategy (SRS) Prototype, an initial version of the leadership plan that will shape an even cleaner and greener railway.

The SRS will be the first industry-wide approach to sustainability, across environmental and social topics, which has been co-created with industry experts, led by RSSB.

This SRS Prototype sets out clear, strategic sustainability guidance and a framework for alignment across the rail industry, showing where action is required to deliver on policy and meet the expectations of society.

The finalised Sustainable Rail Strategy is expected to be published later in 2022 and will form a key input into the Great British Railways Whole Industry Strategic Plan (WISP).

Webinar on and Launch of Technical References for Safety in a Rapid Transit System

Friday, 17 June 2022 (2 pm - 4 pm)

This webinar will introduce two new Technical References related to safety in a rapid transit system. It aims to promote common understanding and consistency on matters pertaining to safety in the railway industry.

- TR 89: 2021 - Safety performance and benchmarking system in a rapid transit system
- TR 97: 2021 - Safety management in a rapid transit system



To purchase the standards, scan the QR code or visit <https://bit.ly/RailSafetyRTS>.

The webinar is complimentary upon purchasing the standard(s).

Implementing a ‘team concept’ in construction projects

A leading German construction company is reaping the benefits.

The challenge

German company, Ed. Züblin AG (Zublin), is a leader in building construction and civil engineering, with a history that spans more than 120 years.

Zublin is actively involved in all areas of construction, including turn-key construction as well as civil engineering work such as underground, bridge and tunnel construction.

The company’s main market is turn-key construction. However, the conventional contractual forms for turn-key projects often lead to conflict-laden project execution, for the following reasons:

- Inefficient and insufficient planning processes.
- Inconsistent definition of the contractual scope of works.
- Increasing numbers of parties involved.
- Undefined risk handling.
- Budget conflicts.

At the same time, price competition in the construction industry has not brought about the expected good price/value ratio for the parties involved. On the contrary; product quality, confidence in the performance, customer satisfaction, as well as the cost-efficient performance of the companies involved in the contract, have all suffered.

The solution

To tackle the challenges brought by traditional forms to turn-key projects and the competition in the construction market, Zublin has been changing its approach to project initiation.

Over the last few years, the company has been adopting the ‘team concept’ in turn-key projects.

The team concept is based on the

idea that all parties involved should compile the contractual, commercial, and technical aspects of a project, as well as the deadlines and goals, together, and as equal partners. It establishes a binding partnership that generates trust and guarantees continuous optimisation of costs, schedules and quality. Zublin believes that only if all parties involved in a project collaborate in a constructive partnership, in an open and trusting way, will the project goals of high quality, customer satisfaction and efficiency be fully achieved.

Based on the team concept, Zublin has developed guidelines for project initiation and execution. The company has created common project standards which include structured processes and cross-group standards and tools.

Zublin is using iTWO technology as the backbone for core processes, which enables BIM models management, and forms the basis for quotation, awarding and billing of subcontractor works, as well as estimation and construction management within the group.

iTWO technology is an integrated solution for collaboration among all stakeholders and project lifecycle management. iTWO is the core solution of RIB Software’s MTWO construction cloud.

Within the scope of the team concept, Zublin works with specialised tools, following clear guidelines on how to handle all the important aspects of construction projects successfully. The company has a clear idea, when approaching a project, on how it will carry out the tasks and the tools it will use.



Zublin has deployed iTWO as the backbone for core processes.



By adopting iTWO, Zublin is able to perform several tasks accurately.

Cost management

In cost management, Zublin has defined its goal clearly, with regard to its workers and customers. The goal is cost certainty and risk minimisation. The company achieves its goals through transparent depiction of construction costs, continuous planned/actual comparisons, effective control mechanisms and regular extrapolation of costs with the support of iTWO.

Procurement management

In procurement management, Zublin aims to promise customers the best and most economical supplier or subcontractor, at the right time. The company has used iTWO procurement modules for the procurement processes, plus its in-house procurement solution developed through cross-regional and regional market exploration, team-oriented networking for procurement processes, early awarding of contracts and adoption of a fair code of ethics to achieve it.

BIM

With regard to BIM, Zublin's goal is model-based confirmation of buildability and optimised management of construction processes. With iTWO, the company is able to do model-based visualisation, model-based quantity takeoff and estimation, and model-based collaboration. With BIM models exported from Revit to iTWO, Zublin can use formulas created on the platform to carry out automatic quantity takeoff and estimation. This results in the following benefits:

- The 3D-Objects are linked in iTWO with the formulas, so that one can see which object belongs to which quantity or set of costs.
- The bill of quantities can be automatically generated.
- One can easily make comparisons between different constructions and related prices.

The adidas World of Sports Arena building

One of Zublin's flagship projects implemented using the BIM method is the adidas World of Sports Arena building located within the adidas World of Sports campus in Herzogenaurach, in Germany. Opened in



The adidas World of Sports Arena building is reminiscent of a football stadium.



iTWO was used in the cost estimation for the complete shell construction in the World of Sports Arena building project. The steel work consisting of 9,500 tons of steel was completely modelled and estimated in iTWO.

2019, the building houses more than 2,000 employees over an area of 52,000 m². Inside the building, the sporting goods manufacturer has implemented a new, flexible workplace concept that combines the advantages of open, communicative areas with private areas for meetings.

The adidas World of Sports campus accommodates several modern buildings, rich greenery, sports grounds and a lake.

Long-term partnership for improved results

Zublin started to use iTWO 5D technologies since 2009, and sees RIB as a long-term partner and iTWO as the core of its 'process interfusion'. Within the Zublin Group, more than 6,000 users are using iTWO technologies in hundreds of projects. For their internal processes, with iTWO technology, they have high control of the software they use, the methods they apply and the tenets they want to implement. This means they can create lean structures with integrated processes, and consistent data management. In turn, this leads to significant

improvement of their processes.

MTWO construction cloud

RIB Software's MTWO construction cloud is an integrated 5D BIM enterprise cloud platform for contractors, asset owners and developers to accelerate their digital transformation journey. It helps AEC companies move away from digitalisation with the 'tool thinking mindset' into a 'platform thinking' one. It enables all teams on construction projects to perform their day-to-day work and collaborate throughout the project lifecycle, on the same platform.

RIB Software is headquartered in Stuttgart, Germany.

RIB Software has partnered SoftwareONE to help construction businesses adopt MTWO construction cloud as part of their digital transformation journey, so that they can better manage risks, avoid rework and reduce waste.

Headquartered in Switzerland, SoftwareONE is a leading global provider of end-to-end software and cloud technology solutions.

Design economics of infield bridges for offshore wind farms

by Bob L Y Cheung, Bob Cheung Offshore Consultants

The article will put forward suggestions for cost-effective outcomes.

INTRODUCTION

At the Glasgow 2021 UN Climate Change Conference (COP26), hosted by the UK and co-chaired by International Energy Agency (IEA), IEA reported that, as of 2021, 44 countries and the EU have pledged to achieve the net-zero target by 2050. However, it also pointed out that, even with all the pledges fully delivered, the global net-zero initiatives may not meet the 2050 target for various reasons [1].

Among major developing countries, China has pledged to reach net-zero by 2060, and India has set the target at 2070. Due to huge financial costs and the associated industrial transformation required, these two large economies may find it difficult to reach the desired targets.

Nowadays, every offshore wind farm (OWF) project is a multi-billion-dollar venture, and few countries and mega-companies in the world can afford the high development costs [2]. Recent power shortages around the world showed that fossil fuels may continue to play a major role in many countries after 2050, if the energy transition movement is not quickened. The real problem is not technical, instead, it is the lack of international financial support for many energy transition projects around the world. To assist developing countries in energy transition, many rich nations have pledged billions of dollars every year to help, but it is still a plan with little action.

The best way to accelerate the transition is to make it much more affordable for participants in the developing world. The objective of the three articles on design economics (inclusive of this article), published in 'The Singapore Engineer', is to propose an alterna-

tive approach to develop offshore wind farms, as a small part of the global net-zero action plans, using old and/or makeshift equipment and avoiding subsea activities as much as possible. In essence, the developing world should not follow the European development method which involves the use of new-build jack-up turbine installation vessels and new-build cable-lay vessels. The method is too costly for developing countries.

The alternative approach is economical and may also create many new business opportunities and a lot of new jobs in many developing countries. In our view, offshore wind energy is not the most cost-effective solution for energy transition and is likely to be overshadowed by wave energy, when the application of wave energy technology has reached the production stage. Ideally, the best transition solution is to have an integrated offshore energy farm (OEF) which is capable of producing energy from all three sources – wind, wave and solar. This could be the truly economical and achievable target in the future.

We published an article on Multi-Purpose Offshore Wind Farms [3] in the March 2021 Issue of 'The Singapore Engineer', where we proposed to bridge-link all the pile-supported wind turbines in a farm. The intention is to run cheaper surface array cables on the bridge decks instead of burying expensive subsea array cables below the seafloor. The proposal can reduce project cost from operation, maintenance and decommissioning. To partially offset the high cost of building the infield bridges, the bridge decks can be turned into a solar farm to generate income. As a

bonus, the bridge-support structures can provide lots of locations to attach wave energy converters in the future.

We published another article, this time, on Trimaran Wind Turbine Installation cum Decommissioning Vessels [4], in the September 2021 Issue of 'The Singapore Engineer'. The article deals with the replacement of jack-up wind turbine installation vessels with used and cheap barges. The makeshift trimaran vessel can also be used for turbine decommissioning.

The author also suggested that the single, large diameter wind turbine tower, usually weighing more than 800 tons for bigger turbines, should be replaced by a lighter and stronger tubular space truss. Under extreme weather conditions, a truss tower offers better 'overload performance' than a single, vertical tubular cantilever. Large tubular turbine towers do get damaged in extreme storm conditions [5].

However, the proposed multi-purpose offshore wind farm raises one important question. How expensive is the infield bridge system? This article will address the design aspects of the issue. We will discuss how best to design, fabricate and install the bridge-support structures and the infield bridges. Due to a lack of reliable data, the total financial cost cannot be properly discussed in this article because it is inter-related to the costs relating to the three renewable sources of energy.

DISCUSSION OF PROJECT EXECUTION STRATEGY AND HIGH COST AREAS

In engineering design, the designed product should reflect how the job is bid and executed. In the design

example [3], [4], wind turbine spacing is set at 3850 ft. This separation will be sub-divided into six segments of about 600 ft each. For a wind farm with 100 turbines, there will be a few hundred infield bridges and a few hundred internal bridge-support structures. To execute this huge construction project, we have to invite many qualified fabricators to bid for the jobs. A bridge length of 600 ft is chosen to suit many yards in the region. By having a large pool of bidders, the offered prices should be competitive.

However, bidders submitting alternative proposals should also be allowed. In engineering, there are many ways to do the same job, and some bidders may offer cheaper alternatives. The work scope calls for complete fabrication of all the structures in the yards prior to loadout. Transportation, installation and commissioning will be under separate contracts. Installing a 600 ft long bridge is still within the capability of many qualified installation contractors, without the need to build new vessels and/or special handling equipment. All installation bidders will be requested to bid on a lump-sum basis.

They have to factor in all the risks in their proposals. In times of arbitration, it is better to have a lump-sum contract. The selected project derrick barges should each have a lift capacity greater than 2000 tons. This bidding strategy is both realistic and cost-effective but requires a large project management team (PMT) to coordinate the activities of all the suppliers, contractors and inspectors, from a few countries. The PMT cost could be in the range of millions of dollars.

It is obvious that the infield bridges and the internal bridge-support structures will be a major cost component of a wind farm project. To reduce project cost, three high-cost impact areas must be studied.

Wind farm site selection and field layout for the multi-purpose wind farm

There are many important factors related to site selection and field

layout, but we will consider only OWF infield bridges installation-related issues. In shallow water offshore construction, derrick barge relocation is time-consuming and non-productive. In a typical oil field development project, platforms are usually not far apart. Hence, barge relocation is not a big issue, requiring just extra hours of barge time. For a long duration wind farm installation project, as in our example, the accumulated barge relocation time for all the wind turbines could be more than 100 days.

For the multi-purpose offshore wind farm, the total relocation time is much longer. The unproductive cost is huge and must be reduced. In offshore pipe-lay operations, to achieve high lay-rates, the lay-barge must move forward on an almost continuous basis, in order to match the speed of welding of the pipe-joints. A higher lay-rate implies higher profit. For the multi-purpose OWF project, the installation speed is a major cost component.

One should make sure that the layout of all the turbine structures is installation-friendly, and the selected site should not create major problems for pile driving. The field layout is site-specific and it is not possible to cover this topic at length. As a comparison, the time needed to relocate a jack-up installation vessel is much longer, as there are many safety procedures to go through before the jack-up rig can be set up onsite. The use of jack-up vessels is excluded in these articles on multi-purpose wind farms.

Bridge-support structures

In the oil & gas industry, a traditional bridge-support structure is usually a tripod or a simple four-pile jacket. In the example of the wind farm, this traditional design is still applicable. But the design concept must be modified to cut cost.

Long span bridges

A 600 ft long infield bridge is considered a long span bridge. There are many outstanding long span bridges in the world, and the common features are their low weight and the fact that they are usually

site-assembled. Site-assembly is not cost-effective and is impractical for building infield bridges. To house a few thousand workers offshore, for years, to carry out site construction, is not a feasible solution. Offshore hourly labour rates are much higher than onshore rates. Therefore, the contracts call for all bridges to be fabricated in the yards prior to loadout.

A robust design is needed to enable transportation and installation to be done without many temporary bracing supports. It is a time-consuming operation to remove tie-down braces and restore the bridge to the original condition, as is usually dictated by the owners. Maintenance, repair and decommissioning activities must be made easy and without relying on expensive jack-up vessels. These requirements call for a different thinking in the design.

DESIGN OF BRIDGE-SUPPORT STRUCTURES

Design considerations

The simplest structure is a portal frame (sway frame) which does not require frequent underwater inspections. Basically, a portal frame has four piles supporting a deck. The deck serves as an intermediate landing platform for the infield bridges. However, a portal frame is not buildable offshore, and there are major installation and decommissioning problems with regard to the structure.

Pile driving is a routine offshore operation, but keeping all four piles in the correct positions and orientations, after driving, is problematic, especially if the piles are set 40 ft to 70 ft apart. To pre-install the piles using a subsea template will change the whole installation concept and possibly double the cost due to doubling of derrick-barge-days in the project.

To build the whole portal frame onshore and install it in one piece is a difficult operation, without lots of bracing members. The leg length is 170 ft, and it will be difficult to stab the pile into the leg for driving using a small derrick barge.

In addition, this option cannot provide the required flexibility to deal with different site conditions and installation errors. A transition piece is a must. A piling frame is a better choice to assist pile driving and deck mating operations, and the piling frame will remain as part of the permanent structure. A feasible design leads to a modified portal-frame/jacket structure which can provide a stable platform for pile driving. The traditional pile-in-leg concept is better than the skirt pile, because it is a simple design with a direct load-path.

In past piling projects, a piling frame was used to drive over 1000 external tubular piles in less than four months. To speed up the project schedule, both steam and vibratory hammers were deployed, depending on the soil conditions (Figures 1, 2 and 3). All installation activities were discussed and accepted by the owner and the certification authority, beforehand. A similar approach should be followed to ensure the project is fully covered. Based on past experience, assuming no pile-splicing, all four piles can be batch-driven and the deck can be set in less than 48 hours. However, a simple transition-piece design is required to correct all the installation errors and out-of-level issues.

Fabrication, loadout and transportation

In the proposed design (Figure 4), the portal-jacket has few members and few tube-to-tube connections, so fabrication can be done in seven to eight weeks. For the deck, it is a simple design. Since the bridge reactions go almost directly into the deck legs and the piles, all deck beams and braces should be small sized, and the fabrication should be simple. The tubulars are thin-walled, even at the joint-cans, which make welding easy and without special procedures. All large diameter tubulars can be rolled in Singapore or in nearby yards in Asia. The standard fabrication time should be about 10 hours per ton.

Loadout can be done using multi-wheel transporters or dollies, which are standard equipment in many lo-



Figure 1: Piling frame.



Figure 2: Steam hammer.



Figure 3: Vibratory hammer.

cal yards. Skid-loadout needs more preparation work and costs more.

For transportation, a few upended portal-jackets and decks can be placed on a material barge and the piles can be transported on a separate material barge in a three- or four-tier tie-down arrangement, similar to the transportation of line pipes. However, the jackets must be checked for hook clearance using the project derrick barges.

Installation and decommissioning

The proposed bridge-support deck is 60 ft x 90 ft, and the Top of Jacket (TOJ) is 40 ft x 70 ft (Figure 4). Qualified installation contractors should

already have many standard installation procedures in-house, and further explanation is not needed. However, these documents must be approved by the client and the certification authority beforehand.

For decommissioning, we can cut-off all the grouted legs at mudline, then lift up the structure in one piece. The pile cutting tool is readily available in the market.

DESIGN OF INFIELD BRIDGES

Design considerations

In the oil & gas industry, an infield bridge between two platforms is usually about 100 ft to 200 ft long.

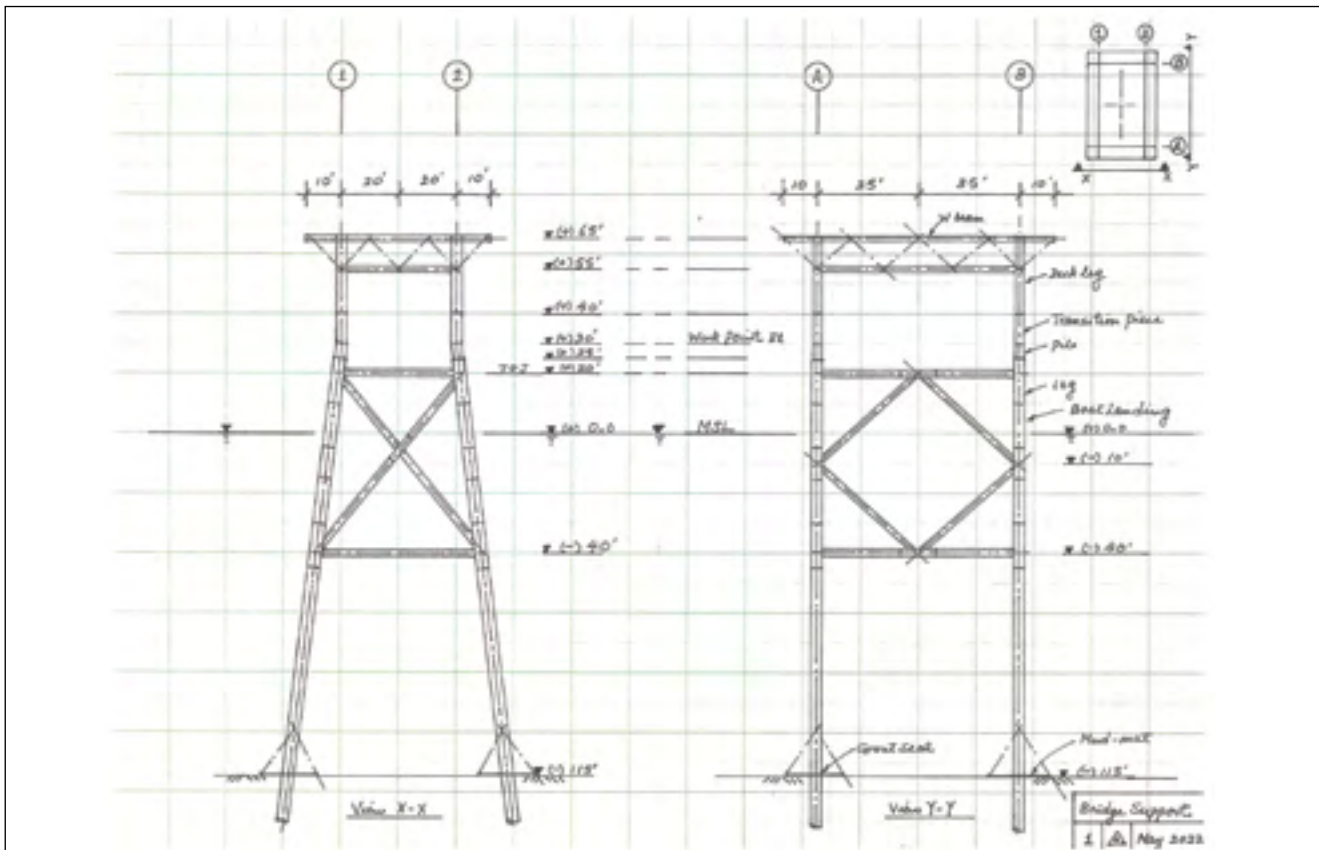


Figure 4: Bridge support structure.

For safety and/or based on other process requirements, in few large oil field developments, the bridge can be as long as 400 ft, if it goes from a production platform to a flare tower jacket or to a living quarters platform or to another process platform. In Southeast Asia, the usual bridge design fulfils the following requirements:

- The bridge is designed for the simply supported condition. The relative displacements, at both ends, can be large, due to independent excursions of the two supporting structures.
- The bridge design is robust, to handle loadout, transportation and lifting forces.
- The bridge design is suitable for single-lift installation using one derrick barge, for economic reasons. If the bridge is too heavy or too long, intermediate bridge support platforms are introduced and the bridge is cut into two pieces.

For a typical offshore installation campaign in Southeast Asia, the

installation contractor will usually mobilise one derrick barge to perform all the lifts and the campaign duration is usually less than 30 days for a multi-platform field. For an offshore wind farm, the whole development can last for a few years, and we have to optimise every operation to cut costs. Therefore, the design requirements for the infield bridges must be expanded to cover more conditions.

- The bridge design must be simple enough to encourage more qualified local fabricators to bid. The intention is to solicit more competitive prices. A complicated design will cost more to fabricate and with no real advantages. Simple, direct load-path design will always be the cheapest.
- The bridge length must be selected to suit many local fabrication yards.
- The bridge rise should be limited to about 100 ft, as large cranes are not common in local yards. Big crane rental is prohibitively

expensive due to difficulties in moving a big crane on the roads. It must be dismantled, reassembled on-site and load-tested before using. For a simple, not-too-heavy lifting job in Singapore, the rental cost could be few hundred thousand dollars. Big crane rental from Europe will cost a lot more.

- The bridge must be almost fully fabricated in the yard prior to load-out. Offshore assembly must be restricted to commissioning items.
- The bridge design must be robust, so temporary bracing structures are seldom needed during loadout, transportation and lifting. However, a large weather window must be maintained.
- The bridge must be designed for easy repair, maintenance and decommissioning, and the deployment of jack-up rigs and heavy-lift vessels should be avoided.

From our previous discussions, the bridge length of 600 ft is selected to suit local conditions, and the lift weight is about 2000 tons.

For offshore installation, we will go for a dual-barge lift, using two small size derrick barges. The day-rate should be less than USD 100,000 per day. A single-barge lift will likely cause overstressing.

For the infield bridge design, the usual concept of a structure that is both light weight and long span is not suitable, as it usually involves site-assembly using special equipment. Hence, both suspension and cable-stayed bridges can be ruled out. The other possible choices could be a truss bridge, a tied-arch bridge or a network arch bridge [6], [7]. They are all self-equilibrated structures and can be fully fabricated at a yard. However, they have shortcomings. Since we imposed a height limit of 100 ft, a 600 ft long uniform depth truss bridge will be heavy and costs more to fabricate.

Alternatively, the tied-arch bridge and the network arch bridge are load-path efficient. But cable hangers will have corrosion problems in an ocean environment and main-

tenance cost will be high. Cable replacement is out of the question. A modified version is a bowstring truss bridge which offers a similar load-path as a tied-arch bridge, but is stiffer. All the web members will be designed for towing and lifting conditions. A better description of the design is a tied-arch bridge supporting six pyramids on deck with an arch chord (Figure 5). A truly bowstring truss has a curved arch which is not beneficial for the project.

Large diameter curved tubulars have to be ordered directly from the mills around the world. Each mill has a different rolling schedule and shipping timetable. Every fabrication yard must take this into careful consideration in the fabrication schedule. In fact, delay is unavoidable in a big project for many unforeseeable reasons, especially since the suppliers are from many countries. It would be better to use locally produced straight chords instead of curved ones. For the bridge design, the primary design

loads consist of dead loads (solar panels, array cables and the weight of steel for main and secondary structures) and a small traffic load (the weight of small inspection vehicles). There is no heavy traffic on the bridge.

Based on the above assumptions, we estimated the lift weight of the bridge to be about 2000 tons, which included a large contingency factor. In the design example, one arch bend is sufficient instead of two inclined arches, but a spread footing is needed at each end to provide more stability (Figure 5). This means that the arch chord should bifurcate near the supports. To prevent lateral buckling of the compression arch chord, if needed, the arch chord walkway can be designed to work as a strong-back structure to provide the required lateral restraint forces.

Fabrication, loadout and transportation

Fabricating a straight chord bowstring truss bridge is not a difficult

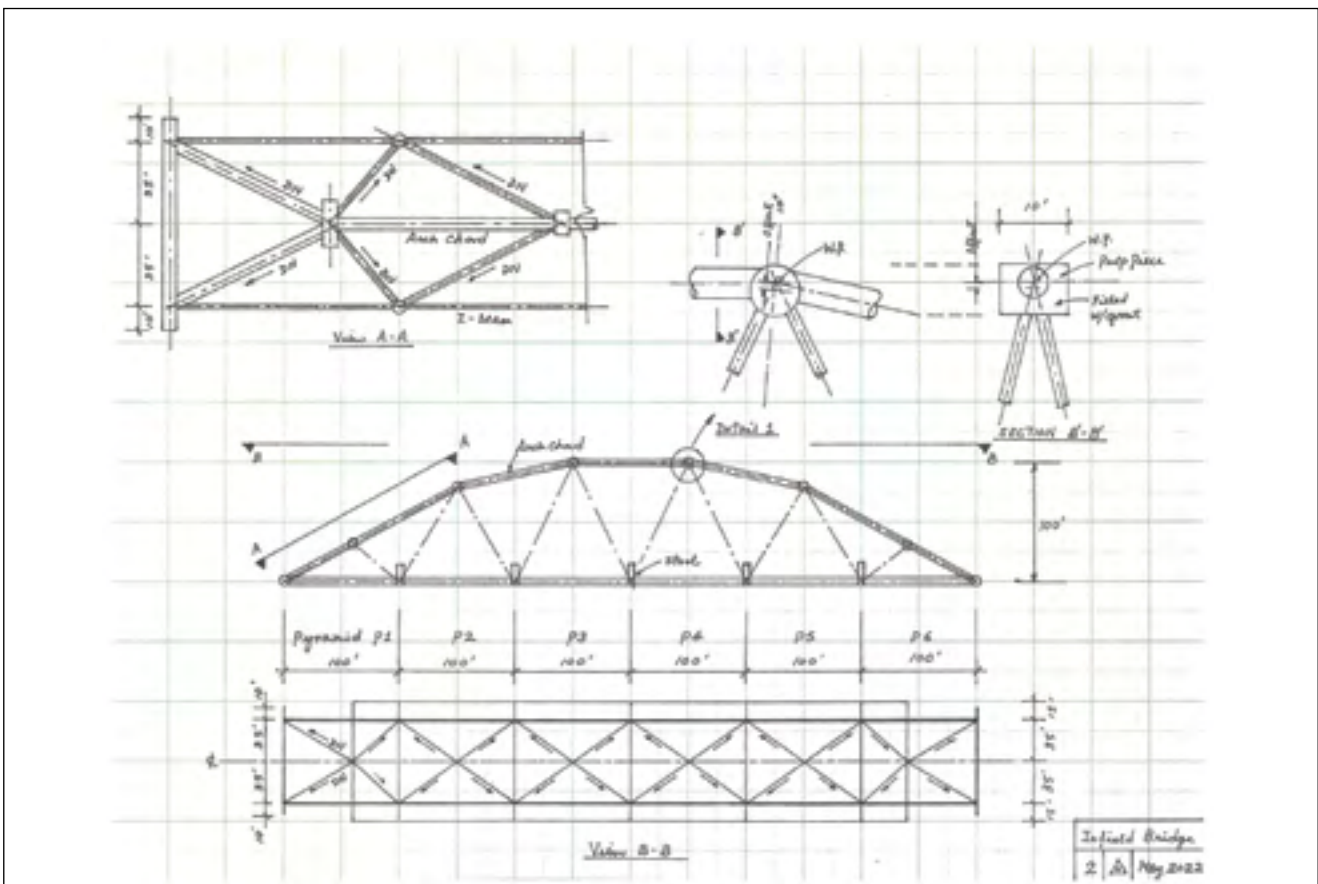


Figure 5: Infield bridge.

task except at the joint intersections. One possible joint detail is shown in Figure 5. In general, the eccentricity moment will have little effect on a fully triangulated offshore structure, if the amount of eccentricity is within the $D/4$ limit. If necessary, we can perform Finite Element Analysis (FEA) to confirm the proposed detail, if it is not covered in the codes. However, FEA should not be over-used as a standard design procedure. Since the bridge height is limited to 100 ft, the whole bend can be fabricated on the ground, then rolled up to the vertical position to mate with the bridge deck and the web members, using yard cranes.

In loadout operation, failures may occur in the bridge structure, the transportation barge, the loadout skidways and the loadout bulkhead. Usually the last three items have been conservatively designed by the barge owner and the yard. The biggest uncertainty is the bridge structure. The most critical

situation is when the bridge goes across the loadout bulkhead onto the barge. The usual overstress is caused by differential settlements of the barge and the bulkhead, due to imposed loads, ballast/de-ballasted water and tidal variation. In the design example, the supports have been arranged to ensure the bridge will always behave in a 'simply-supported condition', so that the support reactions do not vary. This will eliminate all the problems. Otherwise, the loadout process will be more complicated and costly to co-ordinate. Local structural failures have been observed in a few loadout cases before, and on-site repairs and urgent re-certification caused project delays. To reverse the loadout operation is not possible in all cases.

For transportation, the barge-bridge system will experience towing forces such as heave, roll and pitch. Some restraints may be needed. But, this is a project-specific issue and cannot be covered in this article.

Installation and decommissioning

From the load-path consideration, the cheapest way to install an infield bridge is to use two derrick barges, one at each end. The bridge will be lifted in the same way as it will be positioned in the final in-place condition. Therefore, structural strengthening is not necessary during lifting.

A proposed lifting arrangement is shown in Figure 6. Dual-barge lift is not a new concept. In a past project, a 1600 ton production deck, the heaviest deck in Asia at the time, was lift-installed in Indonesia, more than 35 years ago. Since the eight-leg production deck was less than 200 ft long, the two barges were tied together to perform the lift. The dual-barge system was able to inch forward in unison using anchor lines and support from a fleet of anchor handling tugs (AHTs).

In the present situation, the two barges are 470 ft apart and there is not enough space to run all the anchor lines independently within a small separation. Spacer-barges may

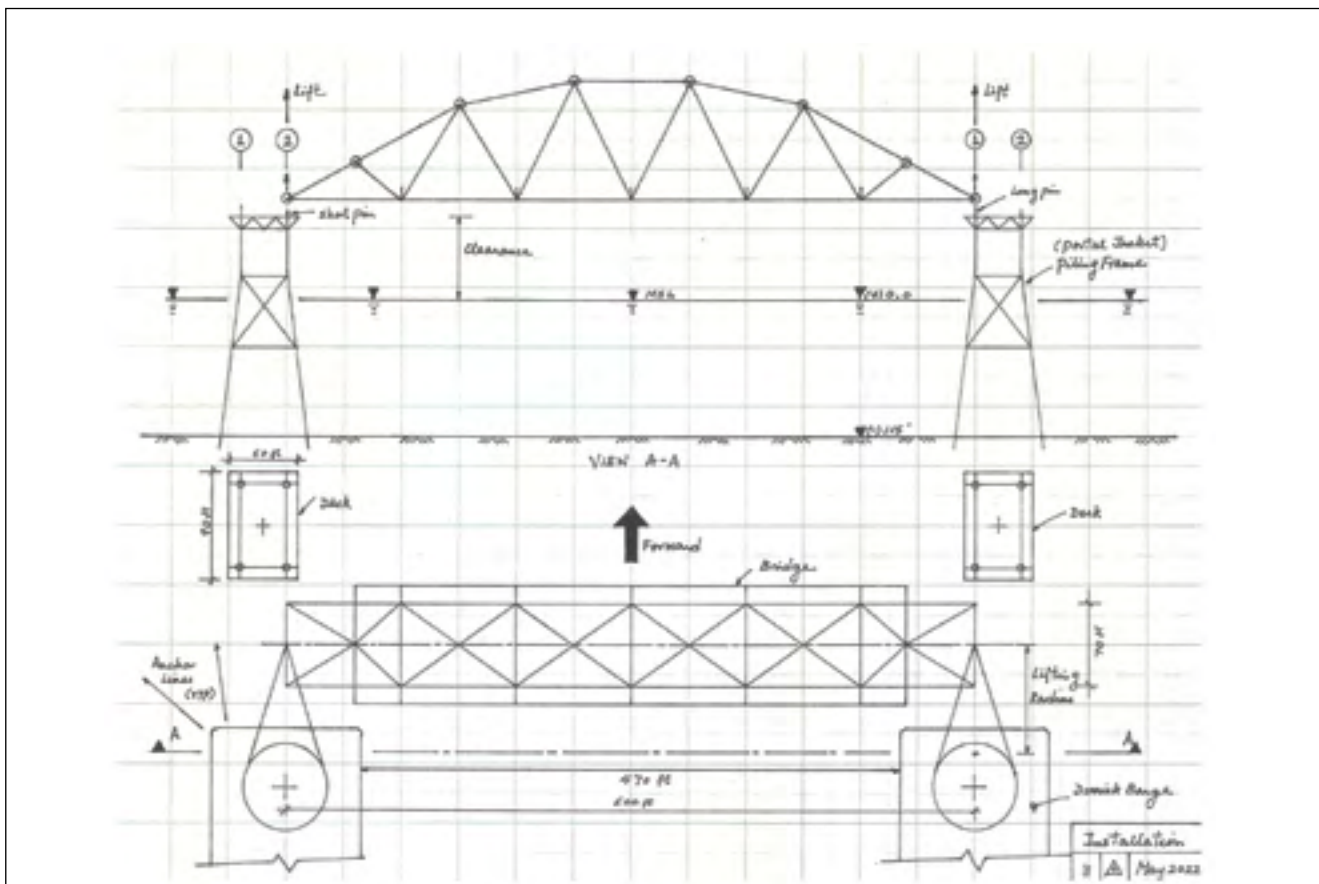


Figure 6: Bridge installation.

be needed to tie them together to form a single unit for lifting. Alternatively, we can lift from other points, but additional strengthening will be needed. However, the final lifting arrangement will usually be decided by the barge superintendent who is the commander for the whole operation. He is always supported by a team of engineers to double-check every step. For a two-point lift, the hook loads will not change. From experience, we believe that this is an economical solution.

CONCLUSION

In the three articles on the design economics of offshore wind farms, the feasibility of the alternative approach is presented with a few design sketches to support the argument. The offshore oil & gas

industry is more than 100 years old and it has accumulated a huge amount of experiences in all areas. It also has a huge inventory of equipment. Huge savings can be realised if one can make use of this asset. Wind energy is free and abundant, and it must be possible to extract it with the least cost.

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Super-sized offshore wind installations could suffer bottlenecks from 2024

Offshore wind turbines are growing in size as technology advances and demand for renewable energy soars, but installing them could be a headache for operators as demand will outpace the supply of capable vessels by 2024, research by Rystad Energy shows. Operators will have to invest in new vessels or upgrade existing ones to install the super-sized turbines that are expected to become the norm by the end of the decade, or the pace of offshore wind installations could slow down.

Wind turbines globally, excluding China, have experienced a growth spurt in recent years, rising from an average of 3 megawatts (MW) in 2010 to 6.5 MW today, with the largest in operation clocking in at 10 MW. Turbines larger than 8 MW accounted for just 3% of global installations between 2010 and 2021, but that percentage is forecast to surge to 53% by 2030.

Accordingly, the demand for offshore wind turbine installation vessels worldwide, excluding China, will increase.

Unable to install new and larger turbines, the first-generation

installation fleet has now transitioned into maintenance and repair services for installed turbines, while operators have upgraded other vessels' cranes in order to remain competitive in the installations market.

In Europe, Asia (excluding China) and the emerging US market, turbine sizes are ramping up towards 2025 and beyond.

Vessel demands

Larger turbine installations require stronger cranes on installation vessels to lift heavier materials higher, and only a handful of purpose-built vessels available worldwide can install 10 MW+ turbines. As a result, many vessels have moved from Europe to China, where lower crane capacity vessels are still in high demand.

Excluding China, demand for 12 MW+ capable installations vessels is set to increase rapidly, taking a larger share of overall demand.

Out of the current fleet of purpose-built vessels, only a handful of units can install 10 MW+ turbines, and none are currently able to install 14 MW+ turbines.

This will change towards 2025, as newbuilds start to be delivered and existing vessels get crane upgrades.

In addition to the purpose-built vessels, some semisubmersible heavy lift vessels are being proposed for turbine installation.

Generally considered too large and inefficient for installing the smaller turbines of the past, these vessels have instead landed work in the offshore wind industry, installing substations and heavy foundations. However, as the size of turbines increases, these units will fit right into the large cranes of heavy lift vessels.

Vessels built early this decade are already becoming outdated as turbines grow, making owners reluctant to commit to expensive newbuilds that could be obsolete before they are profitable.

Rystad Energy

Rystad Energy is an independent energy research and business intelligence company providing data, tools, analytics and consultancy services to the global energy industry.

Restoration work on the Enel head offices in Italy

The intervention involved concrete repair and the application of new coatings for the renovation of the façades.



An exterior view of the head offices of Enel, in Palermo, Italy.

The building housing the offices of Enel (an Italian multinational manufacturer and distributor of electricity and gas), in Palermo, was built in 1963 according to a design by the architect Alberto Samonà in collaboration with his son, Alberto, and Giuseppe Marcialis. It was welcomed by critics as an architectural example of exceptional formality and is one of the most prominent buildings of post-war Palermo.

The volume of the structure is arranged into four buildings of different heights, grouped around a courtyard garden, an element

that acts as mediator between public space and private space, and is open on one side along the main thoroughfare, Via Marchese Di Villabianca. The decision to avoid having a closed-off block is a reminder of Palermo's approach to town planning in the 19th century and results in the provision of two splendid gardens.

Various influences and linguistic overlaps can be found in the four buildings that host the Enel offices. In fact, according to the architectural historian, Manfredo Tafuri, there is a mixture of styles that

draw references from Frank Lloyd Wright to Ludwig Mies van Der Rohe and from Giuseppe Terragni to Le Corbusier.

By assembling the elements over multiple vertical floors, and creating windows with an eccentric axis of rotation, the design creates truly dynamic architecture.

FIGHTING AGAINST DETERIORATION

Before the restoration work was carried out, the structure of the complex was in an advanced state

of deterioration. The unusual design complexity of the forms and elements, and the very thin layer of concrete cover imposed by the refined slenderness of the elements, exacerbated by the inefficiency of the guttering, were the causes behind the deterioration of the façades.

The structure was more badly damaged in the areas in exposed-finish concrete, particularly those more subject to rainwater runoff and leaching, with the travertine stone covering damaged by the leaching effect of rainwater, causing the onset of deterioration of its consistency. After a careful analysis of the structure, the deterioration in the reinforced concrete was traced back to oxidation of the rebar, causing it to increase in volume and detach the concrete cover.

RESTORATION WORK

The aim of the refurbishment and conservative restoration work was to conserve the front of the building and provide effective protection while, at the same time, safeguarding its historic and architectural significance by respecting the original typology, forms and structural characteristics of the elements.

The approach to the project was based on the concept of 'minimum intervention' and on the principle of the 'mechanical, chemical and physical compatibility' of the old materials used for the original structure with the new materials used to integrate the old materials or to carry out repairs.

The most difficult part was choosing which materials to use for the restoration work, to ensure the identity and the memory of the building were respected, and whose symbol, still imprinted on the façade, was represented by the marks left by the wooden formwork originally used to mould the raw concrete.

MAPEI'S CONTRIBUTION

To plan the work and guarantee a high level of durability and, at the same time, overcome the problem of restoring exposed-finish concrete, a well-defined procedure, compliant



The damaged rebar was protected by applying, by brush, two coats of MAPEFER 1K corrosion-inhibiting cementitious mortar.



The deteriorated concrete ledges were repaired with MAPEGROUT 430 preblended, normal-setting, fibre-reinforced, thixotropic cementitious mortar.

with the reference European Standard (EN 1504), had to be followed. With technical support from Mapei, the work cycle was defined, along with the materials required to meet the requirements of the client. After the first series of tests with mortars, the next step was to test the wall coatings and then the complete cycle proposed for the intervention. The entire system respected the original aesthetic characteristics and guaranteed a good level of protection for the concrete.

Restoration of the ledges

Work was carried out on the deteriorated areas in the protruding part of the ledges by reintegrating the gaps and missing parts in each element to restore them to their original shape, consolidating the existing deteriorated parts and, lastly, treating the elements with protection and finishing systems.

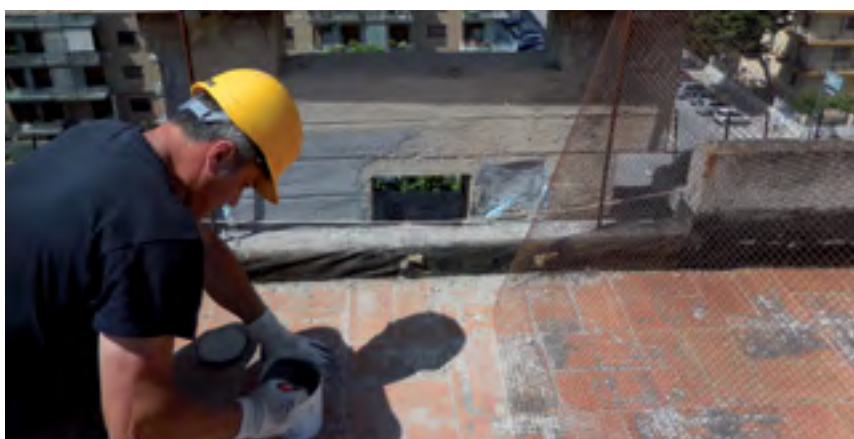
After demolishing all the crumbling and unstable areas, and any parts of the concrete that had become detached, and brushing the rebar by hand and then cleaning all the surfaces, the rebar was passivated by applying, by brush, two coats of MAPEFER 1K one-component, corrosion-inhibiting cementitious mortar. The deteriorated concrete structures were then repaired by applying, with a trowel, MAPEGROUT 430 pre-blended, normal-setting, fibre-reinforced, thixotropic, cementitious mortar.

The surfaces were skimmed with PLANITOP 210 one-component, water-repellent, normal-setting, fine-grained, cementitious skimming mortar.

The product chosen to protect the horizontal surfaces was MAPELASTIC GUARD two-component, flexible, waterproofing cementitious



The concrete surfaces of the ledges were skimmed with PLANITOP 210 water-repellent, normal-setting, fine-grained cementitious mortar.



Also on the balconies, the rebar was treated with MAPEFER 1K and MAPEGROUT 430 was chosen to repair the deteriorated elements.

mortar which forms an effective barrier against the penetration of sodium chloride and calcium and sulphate salts, and against the penetration of carbon dioxide into concrete substrates.

Refurbishing balconies and exposed-finish elements

The balconies, made up of three different elements, were restored by repairing the deteriorated areas, while maintaining the original look and consistency of the architectural features. This part of the work included the repair of the old concrete and rebar, followed by the application of a protective coating and finish. As in the previous case, after brushing the rebar and clean-

ing the surfaces, the rebar was protected with MAPEFER 1K, and MAPEGROUT 430 was chosen to repair the deteriorated elements.

The surfaces were then treated with MALECH acrylic water-based primer, before applying ELASTOCOLOR PAINT, an acrylic resin-based paint in water dispersion.

The same type of work was carried out to restore the structural integrity of exposed-finish, load-bearing elements, such as beams, pillars and partition walls.

Painting the façades

The aim of this part of the work on the façades was to even out and protect all the surfaces, and to

PROJECT DATA

Project

Enel offices, Palermo, Italy

Year of construction

1963

Period of the intervention

2013 to 2015

Client

Enel Servizi srl

Design

3TI Progetti Italia SpA

Technical consultant

Davide Bugliarelli, Tecnotek srl

Main contractor

Sicci Sud

INTERVENTION BY MAPEI

Contribution by Mapei

Supply of products for concrete repair and for the restoration of façades

Mapei distributor

Saces

Application of Mapei products

Concrete repair – MAPEGROUT 430, MAPEFER 1K

Skimming surfaces – PLANITOP 210

Waterproofing – MAPELASTIC GUARD

Painting façades – MALECH, ELASTOCOLOR PAINT

Website for further information

www.mapei.com

www.mapei.it

This editorial feature is based on an article from Realtà MAPEI INTERNATIONAL Issue 91. Images by Mapei.

ensure that the old parts and the rebuilt parts would have the same texture, absorption and colour. The coloured finish of the surfaces was again created by applying MALECH primer followed by ELASTOCOLOR PAINT elastomeric paint.

Complex civil engineering for hydroelectric power plant project

The project will generate electricity that will be supplied to 200,000 households in Töging am Inn, Germany.

This year, the Töging am Inn Canal, partially drained for the last phase of work, will be flooded again. From the dam between Jettenbach and Aschau am Inn, the diverted Alpine river will flow 20 km to the run-of-river Töging power plant, where it will rush a good 31 m into the deep, and the water velocity of 410 m³/sec will be used to produce electricity in the powerhouse, by three machine sets, each consisting of a Kaplan turbine and a generator. The electricity will be enough to supply 200,000 households in the region.

Although it is a spectacular project, nothing will be visible in the lush greenery, except for two elegant concrete apertures marking the inflow and outflow of the new power plant. The future of hydroelectricity in Töging am Inn will be subterranean. This project was the result of nine years of planning and construction. The implementation of the project involved complex civil engineering, including advanced formwork planning.

Benefits of digitalisation

As the solution provider, Doka demonstrated that slopes of almost 30° and slab thicknesses of 4 m can be achieved. The Töging am Inn project involved expanding and modernising an old power plant as well as building a new one. In this project, the geometry of the turbines and inlet slabs was so complicated in several areas that formwork planning would not have been possible without a comprehensive 3D model.

The aim was to understand which negative forms were needed to ensure flawless concreting later on. Accordingly, PORR GmbH & Co KGaA, the construction company, received the freeform formwork to cope with the demanding geometry.



The new Töging power plant is being built right beside the existing historic power plant. Image: Verbund.



Inlet structure: The water of the Inn river is guided from the inlet structure through the pressure pipeline to the turbine. Around 1,400 frames of the Load-bearing tower Staxo 100 were used for the inlet structure. In order to compensate for the longitudinal incline of 26.5°, the shoring system was installed on a special construction of the Large-area formwork Top 50. The top of the inlet structure was formed with pre-assembled and largely reusable Top 50 elements. Image: Doka.

With custom-built modules delivered, already pre-assembled, the construction company could concentrate on reinforcing and concreting. Even six-level structures, such as stair towers, were simple to handle and could be moved easily with one of the five cranes. All this gave the construction crew a feeling of security at work – another

basis for the high level of safety in what is currently Germany's largest hydroelectricity construction site.

Everything was running seamlessly until the COVID-19 pandemic period, when there were scarcely any border crossings or on-site support possible, and almost everything had to be done remotely, via video calls. However, it was still possible to obtain a

good overview, thanks to the use of digital technologies such as BIM, 3D planning, real-time concrete monitoring and video conferencing.

Impressive achievement

Compared to the historic power plant, built 100 years ago by up to 7,000 workers on what was then Europe's largest construction site, the new and modern construction architecturally blends modestly into its surroundings. However, its performance, with three vertically anchored turbines, has been enhanced.

All parameters, from the increased flow rate, to the storage level and rise, to the bottleneck capacity and controlled output, are designed to supply an extra 50,000 households with electricity. Bavarian operator Verbund Innkraftwerke has spent a quarter of a billion euros on the project between Jettenbach and Töging.

PROJECT DATA

Project

Töging Power Plant

Location

Töging am Inn, Germany

Client

Verbund Innkraftwerke GmbH

Architect

Format Elf Architekten/Robert Maier Architekten

Construction

PORR GmbH & Co KGaA

Construction period

2019–2021

Doka products in use

Framed formwork Framax Xlife

Load-bearing tower Staxo 100

Top 50 special elements

Moulded timber boxing

Working scaffold Modul

Stair towers

Dokamatic tables

Circular formwork H20

Folding platform KL

Special platforms

Doka services provided

Concremote

Formwork planning



Pressure pipe area: The water plunges down through three pressure pipelines, each with a 10.4 m x 12.75 m cross-section and a gradient of 26.5°. Then the water is directed towards the three Kaplan turbines. Framed formwork Framax Xlife was used to build the steeply inclined walls. Image: Doka.



Powerhouse: The main challenges when constructing the powerhouse with its three truncated cones for the turbines, including spiral covers, were the complexity of the cone geometry and turbine slabs, and the ambitious schedule. On top of that, the activities of the numerous participants had to be coordinated. The comprehensive 3D models were extremely helpful for coordination and approval. Image: Kasjan Choroba.



Outlet structure: The outlet structure guides the water back into the Inn river. In addition to the Framed formwork Framax Xlife and Load-bearing tower Staxo 100, Dokamatic tables were used as slab formwork. Image: Doka.

World first for Liebherr luffing jib cranes

Two new cranes from the company are working on the construction of the Central Boulevard Towers in Singapore.

Two new Liebherr luffing jib cranes are currently raising a 48-storey office building in the centre of Singapore. Internal climbing systems have been a successful part of high-rise building construction for a number of years now. What makes the Singapore project a world first is that the two 710 HC-L cranes are using a 24 HC 1000 tower system to climb up on the inside.

The cranes started work in November 2020. Back then, the cranes belonging to the fleet of the Kim Soon Lee company were assembled freestanding at a tower height of around 40 m. The Central Boulevard Towers are being built right next to the historic Lau Pa Sat building, also known as Telok Ayer Market. One of the two new towers will be approximately 241 m in height. It is for this part of the project that the two 710 HC-Ls, with jib lengths of 40 m and 45 m, are being used.

Fewer climbing stages and less downtime

The two cranes will reach their maximum tower height of 245 m in just 10 climbing stages. This is made possible by a 57 m-high tower.

One climbing stage takes about two hours, so the cranes stand still for as short a time as possible. In addition, there are significantly fewer storeys to reinforce, which also has a positive impact on cost efficiency.

Due to the amount of guying that is legally required, and the resulting significantly increased costs, having the cranes climb completely on the outside of the building was not a viable option. Plus, enough space is not available on site, to use exterior climbing cranes.

Lifts of up to 30 tonnes

The high-performance Liebherr 710 HC-L model was chosen because of the tight conditions on site, and the



Two Liebherr luffing jib cranes are currently working on the construction of one of the two towers in the Central Boulevard Towers project in Singapore.

project's heavy load and handling capacity requirements. The 710 HC-L has a maximum lifting capacity of 64 tonnes and is the largest luffing jib crane Liebherr offers. It can easily lift and precisely position the pre-cast concrete parts, weighing up to 30 tonnes, which are needed for the skyscraper's construction.

When completed, the 48-storey tower will accommodate office and retail space. The Central Boulevard Towers project also includes a second tower, which is 16 storeys

high. One of the highlights is an urban 'sky park' with green spaces. Small recesses are to be incorporated into the greenery as meeting areas, and the park will also include a jogging track for employees.

The two luffing jib cranes will be working on this site, which borders high-traffic roads, for several more months. They will continue climbing skywards section by section, watched over by the city's skyscrapers. When they reach their maximum height, they will tower over the surrounding high-rises.

Volvo Construction Equipment brings its first commercial electric machine to Asia

The zero-emissions, near-silent ECR25 Electric excavator, from Volvo Construction Equipment (Volvo CE), can now be ordered by customers in South Korea. This development is in response to the market's increased focus on more sustainable construction solutions, prompted by stronger emission regulations, government incentives and an urgent desire to build more sustainably.

The 2.5-ton, battery-powered, compact excavator is said to be the first electric machine from a major manufacturer to arrive in the Asian market, with further roll out planned for China, Japan and Singapore, as the demand for electric equipment has been growing across the region.

The Volvo ECR25 Electric excavator is already a success in Europe and North America, since it was unveiled in 2019, thanks to its ability to match power and performance with zero emissions, near-silence and a much more comfortable work environment for operators. Korea was chosen as the first market for Asia, due to its adoption of new technologies and innovative ways of working, as well as its quick response to building an electric charging infrastructure.

"Increasingly, authorities are recognising the need to work more sustainably and embrace new technologies that will allow us to tackle our global climate change crisis with equipment that provides less noise, fewer vibrations and no exhaust fumes. We are proud to be leading the charge by being the first major manufacturer to offer electric solutions to a region that is so significant to the global construction equipment market", said Jaetack Lim, Head of Market Korea at Volvo CE Region Asia.

The introduction to the Asian market represents the next step in Volvo CE's ambition to move its range of compact excavators and wheel loaders to electric, and entirely stop new diesel engine-based development of these models. As such, the market can expect more electric compact equipment to be introduced in the future.

The ECR25 Electric excavator comes with an integrated on-board charger allowing customers to charge from 0% to 80% in under six hours. With an optional fast off-board charger (380V-420V, three phase), it takes just one hour to charge from 0% to 80%. For the most accurate picture, Volvo dealers can determine the expected operating

time and optimum charging solution, based on customers' activities.

The product will be of interest to customers in Asia looking to meet emission regulations while maintaining the same levels of productivity they have come to expect from its diesel counterpart. Numerous applications range from agriculture and landscaping through to utilities and building – with the added benefit that operators can run the machine in noise-sensitive areas and out of standard hours, as well as in low-carbon projects and indoors, without the need for costly fume extraction systems.

Volvo Construction Equipment

Volvo Construction Equipment is a leading international manufacturer of construction equipment. The company, a part of the Volvo Group, offers a wide range of products and services in more than 140 countries, through its global distribution network

The Volvo Group offers transport and infrastructure solutions, including trucks, buses, construction equipment, power solutions for marine and industrial applications, financing, and services that increase customers' uptime and productivity.



The zero-emissions, near-silent ECR25 Electric excavator, from Volvo Construction Equipment, has now entered the Asian market.

Wirtgen introduces the W 120 Fi compact milling machine

Wirtgen presented a quartet of high performance, next generation compact milling machines, including the W 120 Fi, at the World of Asphalt 2022, held from 29 to 31 March 2022, in Nashville, USA.

The front loaders are powered by John Deere engines compliant with EPA Stage 4 / EU Tier 5 Final exhaust gas emission standards. The diesel engine delivers a rated output of 265 kW / 355 hp.

The machines achieve considerably better fuel consumption, emit less CO₂ and are much quieter – even when delivering high productivity and milling to a maximum depth of 330 mm.

New assistance systems

Also onboard are the digital assistance systems, Mill Assist, Wirtgen Performance Tracker (WPT) and the Level Pro Active levelling system. Wirtgen already set new benchmarks for cost-efficient and precise milling with its large milling machines. Now, customers can look forward to the benefits of high milling performance, maximum efficiency, and clear documentation in the compact milling machine class.

In automatic mode, Mill Assist selects the operating strategy with the most favourable balance between milling performance and operating costs. To achieve the ideal balance, the system automatically adapts various parameters and, in addition, also provides recommendations to the operator. This not only increases milling performance, but also reduces diesel fuel, water and pick consumption, and CO₂ emissions.

Mill Assist automatically controls the engine speed and simultaneously enables a wide range of usable milling drum speeds for a wide spectrum of applications. The low speed range enables significant reductions in fuel consumption and minimises pick wear. The upper speed range enables the achieve-

ment of an optimal milling pattern, even in the case of higher area performance rates.

Already proven in the F-series large milling machines, the Level Pro Active levelling system has now been made available for compact class milling machines. Developed by Wirtgen especially for cold milling machines, the levelling system features informative operating panels and is intuitive and easy to use. All connected sensors and measured values are clearly displayed on the operating panel, in order to make the work processes efficient. The system is fully integrated in the control system of the cold milling machine and, as essential machine functions are directly interconnected, it provides a high level of automation. The system also offers many automatic and additional functions that make the operator's job easier, for instance, by enabling automatic lifting for driving over manhole covers.

Rapid redeployment possibilities

With smaller dimensions and optimised machine weight for easy transportation, the compact milling

machines are suitable for a multitude of construction site scenarios. The manoeuvrable cold milling machine is particularly suitable for milling work, where space is limited, for example, in city centres or in parking areas. As a result of their high productivity, they are also suitable for surface layer rehabilitation and complete pavement removal on smaller or medium-sized construction sites. Thanks to the ability to quickly change the FCS milling drums with different pick spacings and working widths, the compact milling machine from Wirtgen can also be rapidly reconfigured on-site, to adapt to changing applications.

Operator's cabin with advanced design

The newly developed operator's cabin of the W 120 Fi is characterised by comfort, ergonomically designed control elements and modern design. An overview of all relevant working areas is provided by the slender waist of the machines and up to five cameras. The new 5-inch control screen in the multi-functional armrest clearly displays all machine-relevant information.



The new Wirtgen compact milling machines can be used in a variety of applications.

New generation of compact wheel loaders from Caterpillar

Building on the success of the Cat M-Series compact wheel loaders, the new next generation Cat 906, 907, and 908 wheel loaders boast a re-engineered operator's station, leveraging exclusive Cat technologies to improve operator experience and provide larger wheel loader model comfort on a smaller platform. Featuring the new Cat C2.8 engine, the upgraded drive and powertrain deliver faster roading speeds and drive train performance. The hydraulics and structures have gone through an overhaul, making these new models an optimal fit for many applications.

Improved operator experience

The new sealed and pressurised cab improves the operator experience, while keeping previous design functional aspects like raised floor pedals and two doors to make cab cleaning easier. Optimum visibility is achieved with larger standard side mirrors, optional parabolic lens electric and heated mirrors, and front and rear camera options. New single-piece front and rear windshields offer 60% better wiper coverage.

Seat-mounted controls improve operating ergonomics of the new loaders. A multifunction joystick controls travel direction and speed, proportional auxiliary flow, differential lock, and constant hydraulic flow without operators removing their hand from the joystick, elevating operating safety. Like larger Cat wheel loaders, companies will be able to choose from a range of seats, including a new premium heated and ventilated seat.

The heart of the new cab design is the next generation control monitor which offers a range of real-time machine operating information. It allows the operator to configure hydrostatic transmission response, auto engine idle shutdown and a utility powertrain mode that provides operators with a more intuitive means of con-

trolling ground and engine speed, which is ideal when working with hydromechanical attachments.

Upgraded powertrain

Specifically designed for Cat products, the new Cat C2.8 engine delivers the same 55.7-kW (74-hp) gross power as the previous engine with 13% more torque, resulting in roading performance and tractive effort improvements. The Cat C2.8 meets EU Stage V and US EPA Tier 4 Final emission standards with alternative emissions packages available. Its shift-on-the-go transmission offers increased roading speeds of 40 km/h (25 mph), and larger fuel tank capacities of 30% for the 906 and 12% for the 907 and 908 deliver extended work cycles.

When working in dusty environments, the new reversing-fan option assists in keeping cooling cores clean for more efficient temperature control. Through an in-cab soft-touch button, the system can be turned off, set to operate in an automatic mode or momentarily activated by the operator. The Automatic mode uses the factory-setting to reverse direction for 10 seconds every 10 minutes. Frequency and duration of automatic reversing can be changed easily by the operator via the new control monitor.

Enhanced hydraulics and structures

To meet demand for increased multifunctionality with lift and tilt,

while powering hydromechanical tools, these next generation wheel loaders feature a new standard pressure-compensated valve, allowing operators to simultaneously control implements and operate hydromechanical attachments seamlessly. Increased working auxiliary pressures make work easier and improve steering to reduce operator fatigue.

Modifications to the optional skid steer coupler improve visibility through the coupler when setting fork tines. In conjunction, realignment of the compact wheel loader fork carriage improves forward visibility. Bucket capacities have been increased across the range, adding to the operating capacity legacy of the Cat machines.

New for this class size, an optional Cat 908 high-lift configuration is available, ideal for customers operating in agricultural as well as industrial and waste markets. When combined with the reversing fan option, the high-lift configuration offers farmers increased operating efficiency and reliability. Available solid tyres and the high lift configuration make the new 908 loader ideal for industrial and waste applications.

Efficient, high-illumination LED lights options are now available for both working/roading and under-hood-service lights, to better illuminate work areas in low-light conditions. Task-focused LED under-hood lighting simplifies servicing in poor ambient light.



The Cat 908 compact wheel loader in a high lift configuration.

TAKING THE FIRST STEP FROM ENGINEER TO ENTREPRENEUR

Continuing the Young Engineers Career webinar series was the ninth session, titled Entrepreneurship in Engineering, which took place on 25 April 2022.

The speaker for the evening webinar was Associate Professor Foo Kim Peng, the director of IES Incubator and Accelerator (IES-INCA) and chairman of the IES Technopreneurship Development Committee. IES-INCA is a strategic initiative by IES to support engineers in technopreneurship and new technology business ventures.

Prof Foo started things off with a case study of RushOwl, a ride-sharing company established in 2018 that offered timely and affordable shuttle rides. Through analysing the company’s mission, vision, unique selling points, and customer and commercialisation strategies, he drew out some insights as to why some engineers made the leap to become entrepreneurs.

He also shared some key characteristics of successful businesses, such as the ability to recognise the potential of an invention, capability in organising capital, talent and other resources to turn it commercially-viable, and being able to understand the business canvass model, customer delivery and product-to-market fit.

Team composition is also crucial – the more versatile it is, the better chance the company has of succeeding, he said.

Bearing in mind that entrepreneurs must “work on their business,

not in it”, one must also consider developing their companies holistically and not just around their own personal ability to get things done, he added.

Prof Foo’s concluding point was that the entrepreneur needed to take note of feedback from all levels, for it is not just good product ideas or the strength of its team that guarantees business sustainability – a keen understanding of company processes and issues will help it stay in business for a long time.

During the Q&A session, Prof Foo was asked whether it was better to be an entrepreneur, engineer

or both. In answer, he felt that it depended on one’s interests, motivations, and core values. An evaluation of the individual’s strengths and weaknesses would help determine a suitable path.

When asked about his biggest success and failure, he shared candidly some nuggets of experience, and encouraged participants to not fear failures, for it was the accumulated experience that enabled him to ultimately succeed.

Jointly organised by the Young Engineers Committee and IES-INCA, the webinar had nearly 250 registrants, with a healthy mix of students and engineering professionals.



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