Technology-Driven Approach to Enhancing Workplace Safety and Health

Present By

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高技工程私营有限公司

Welltech Construction Pte Ltd

Company Introduction

高技工程私营有限公司
Welltech Construction Pte Ltd

Founded in 1987, Welltech Construction Pte Ltd is one of the most established construction companies in Singapore. We have a paid-up capital of S$35 million and our portfolio ranges from Government Institutional to Housing Projects.

We have accomplished large varieties of distinguished projects over the past three decades and is recognized and ranked as Grade A1 Builder for General Building Works by the Singapore's Building & Construction Authority.

We are ISO 9001:2015, ISO 14001:2015, ISO 45001:2018 certified, BCA Green and Gracious accredited and have achieved and received awards for recognition and honoring of our quality and safety performance.

Company Introduction

Mission 

To create value through converging resources.

Vision 

To be a top-notched integrated building group in the region leveraging on operational excellence, and to provide high value-added services for our customers.

Core Value 

Achieve win-win situation with good faith
Pursue excellence through innovation

SMART DIGITAL CONTROL FOR PPVC INSTALLATION

About PPVC (Prefabricated Prefinished Volumetric Construction)

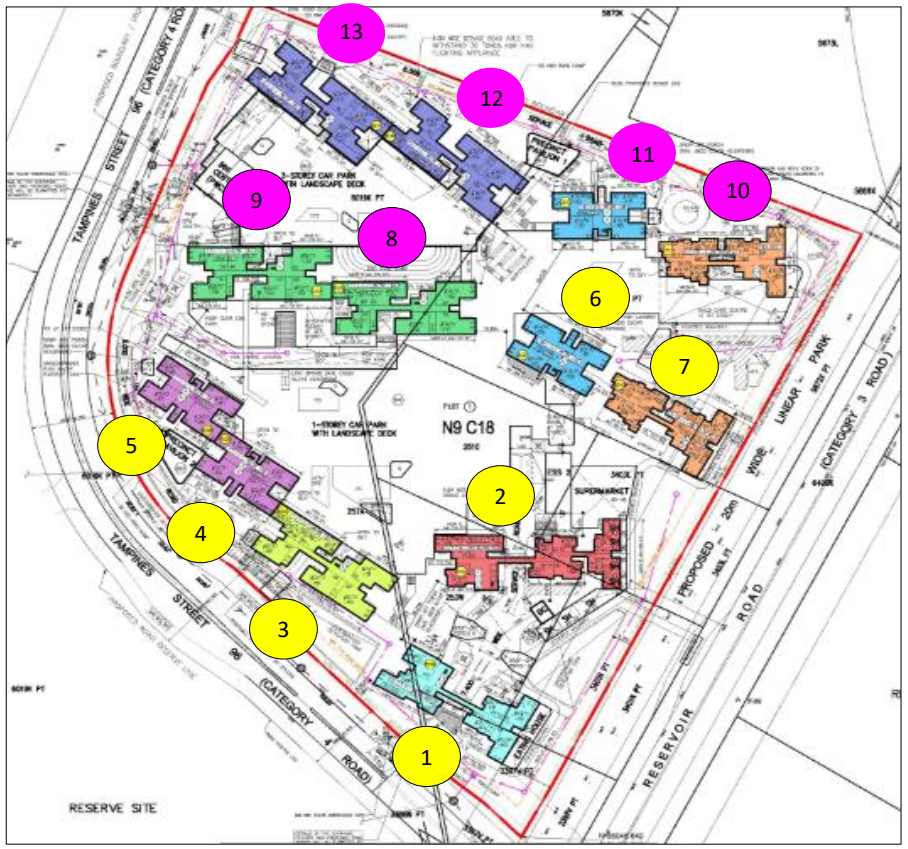
- PPVC is one of the construction technologies that support the Design for Manufacturing and Assembly (DfMA) concept.

- PPVC improves productivity and quality and **it provides a better and safer construction environment on-site**, as the bulk of the construction activities and manpower are moved off-site, thus minimizing dust and noise pollution.

PPVC Project Case Study – HDB TAMPINES N9 C18

Proposed Public Housing Development Comprising of 7 Blocks of 17-Storey, 2 Blocks of 16-Storey, 2 Blocks of 14/17-Storey, 2 Blocks of 13/16-Storey Residential Building (Total 1086 Units), 1 Block of 3-Storey Multi-Storey Carpark with Roof Garden, 1 Block of 1-Storey Carpark with Landscape Deck, Commercial, Social Community Facilities, ESS, Bin Centre, and Precinct Pavilion at Tampines Street 96

Project PPVC Information



Total Modules 6,379

Modules Types 47 (Incl Handed)

Numbers of module for HDB Tampines N9 C18

Phase	Block	Unit Type										Total
		2R1	2R1X	2R2	2R2x	3R1	3R1x	4R1	4R1x	5R1	5R1x	
Phase 1	954D	0	0	15	15	16	0	28	28	0	0	102
	954C	15	0	0	30	15	15	27	27	0	0	129
	953C	0	0	0	0	0	0	0	47	31	15	93
	953B	0	0	0	0	0	0	15	16	16	15	62
	953A	0	0	0	0	0	0	15	16	16	15	62
	952C	0	0	0	0	0	0	14	14	14	13	55
	954B	14	0	14	14	14	14	10	10	0	0	90
	Total Unit	**29**	**0**	**29**	**59**	**45**	**29**	**109**	**158**	**77**	**58**	**593**
	Module/Floor	3	3	4	4	5	5	6	6	7	7	
	PPVC Mould Qty (set)	1	0	1	1	1	1	1	1	1	1	9
	Total Module	**87**	**0**	**116**	**236**	**225**	**145**	**654**	**948**	**539**	**406**	**3356**
	Nos PPVC Casting / 2 sty	5	5	3.75	3.75	3	3	2.5	2.5	2.14	2.14	

Phase	Block	Unit Type										Total
		2R1	2R1X	2R2	2R2x	3R1	3R1x	4R1	4R1x	5R1	5R1x	
Phase 2	952B	0	0	0	0	0	0	0	43	28	13	84
	952A	0	0	0	0	0	0	0	43	28	13	84
	954A	14	0	15	14	15	15	10	10	0	0	93
	951C	0	0	0	0	0	0	14	15	15	14	58
	951B	0	0	0	0	0	0	45	0	13	29	87
	951A	0	0	0	0	0	0	45	0	13	29	87
	Total Unit	**14**	**0**	**15**	**14**	**15**	**15**	**114**	**111**	**97**	**98**	**493**
	Module/Floor	3	3	4	4	5	5	6	6	7	7	
	PPVC Mould Qty (set)	1	0	1	1	1	1	1	1	1	1	9
	Total Module	**42**	**0**	**60**	**56**	**75**	**75**	**684**	**666**	**679**	**686**	**3023**

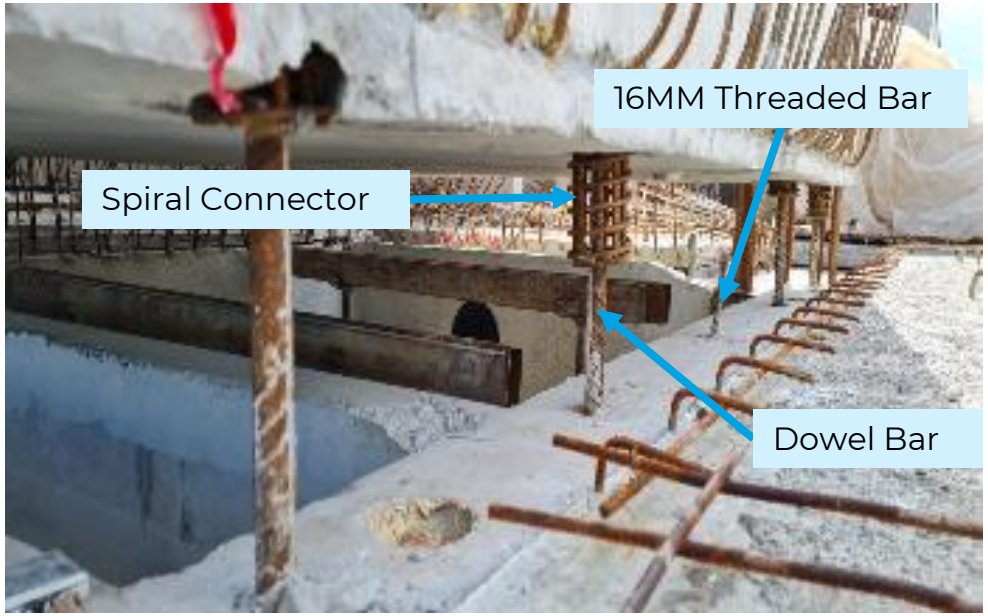
Quick Facts about PPVC (RC)

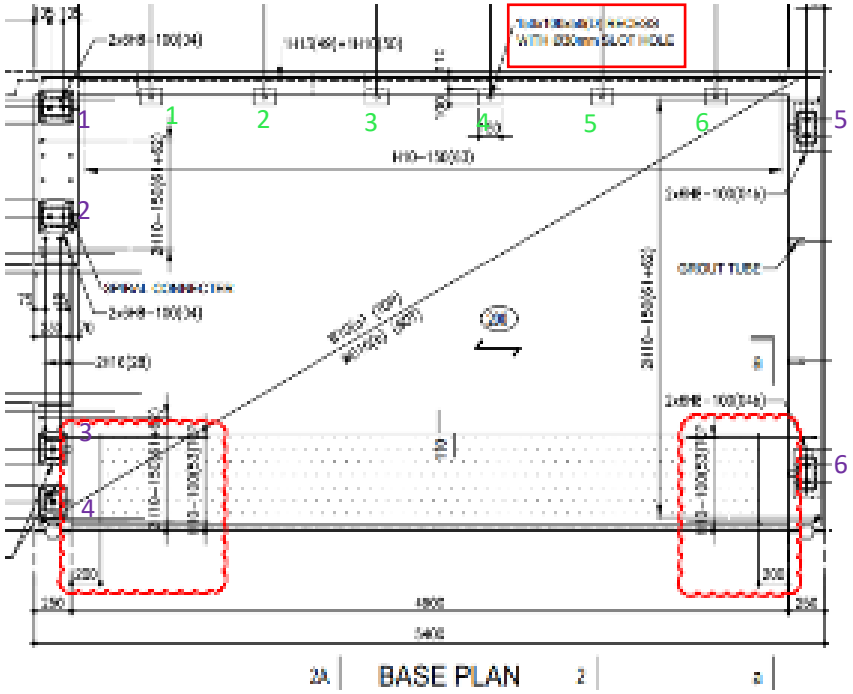
- As PPVC is ‘prefinished’, the installation has to be precise, with very little tolerance in alignment and level.
- The size of each PPVC is limited by the ability to transport via public roads, bigger dwelling areas like the living room and dining room are made up of multiple PPVCs. Hence, many of the PPVC modules will only have 2 or 3 sides with walls. As a result, the Centre of Gravity (CG) of these modules are way off-centre.
- In short, they are bulky and heavy, and mostly off-centre in CG.

Quick Facts about PPVC (RC)

Importance of Balancing PPVC Before Hoisting to Construction Level

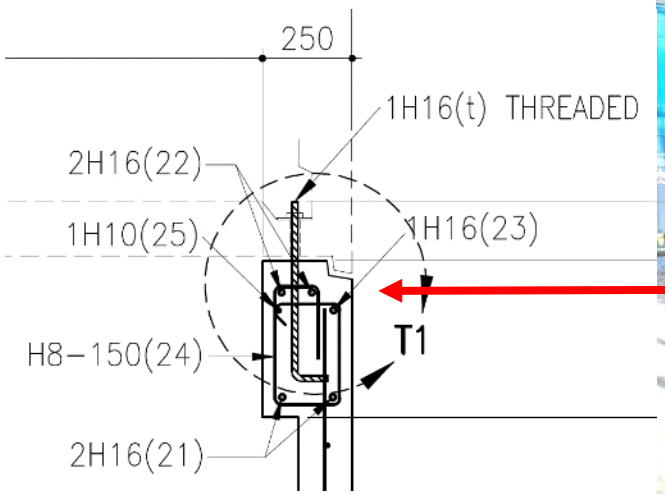
PPVC installation with limitation controls on **6 nos** spiral connectors with dowel bars and **6 nos** 20mm threaded bars of modules into 30mm slot holes on the slab at the same time.



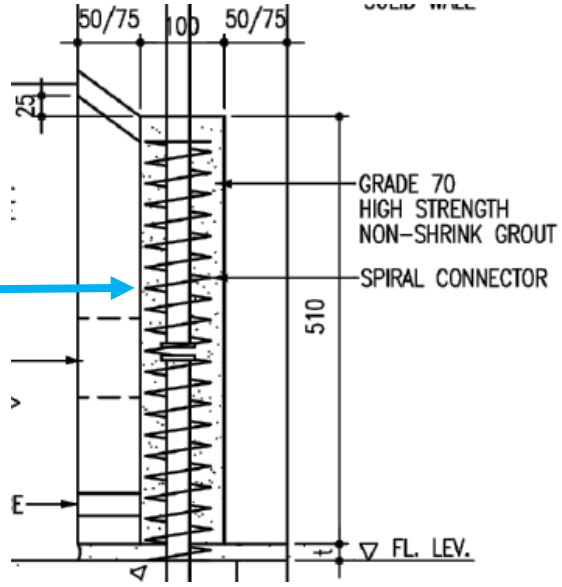


Quick Facts about PPVC (RC)

Importance of Balancing PPVC Before Hoisting to Construction Level



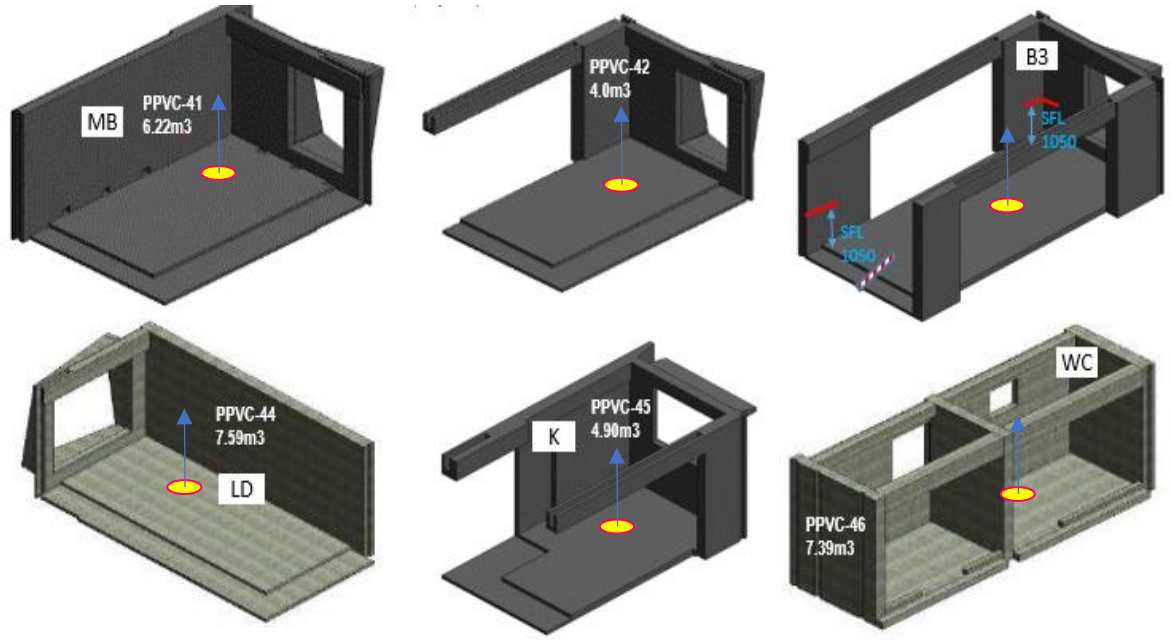
16MM Threaded Bar

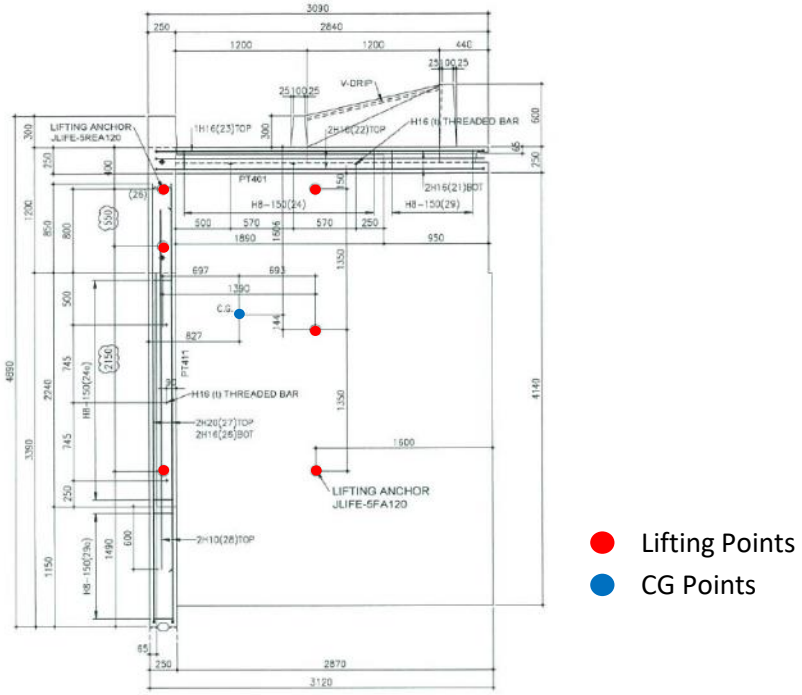


Spiral Connector

Quick Facts about PPVC (RC)

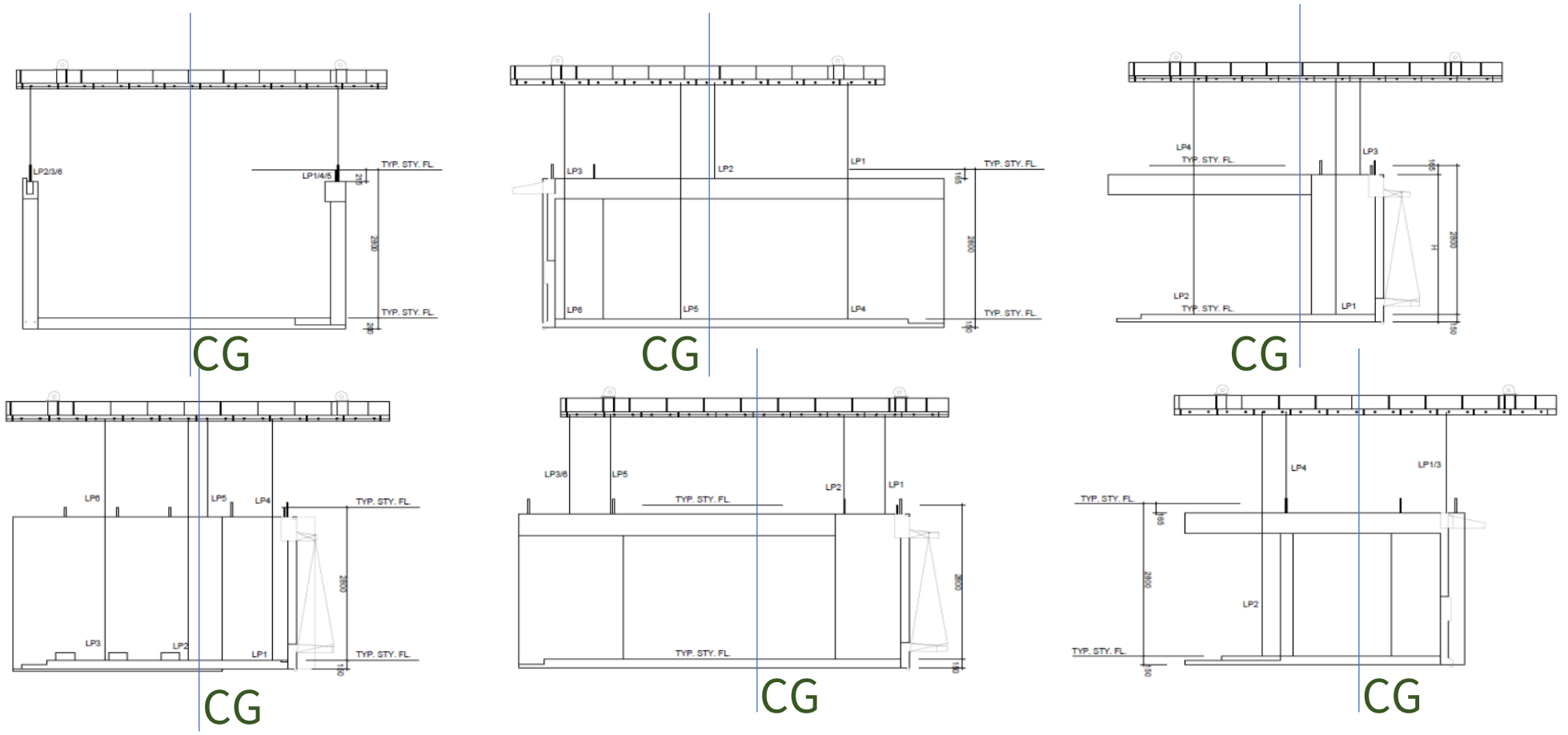
- The centre of gravity of each module can be manually calculated and determined with the formula of **CoG = (ΣD* W) / ΣW**, but should be easily handled with today's BIM software.
- Some lifting points are above the walls and some lifting points are on the slab, positioned to spread the hoisting load evenly and maintain the structural integrity.





Quick Facts about PPVC (RC)

- Due to the design of the modules, the Centre of Gravity varies for each modules.



Ideas Explored That Did Not or Will Not Work Out

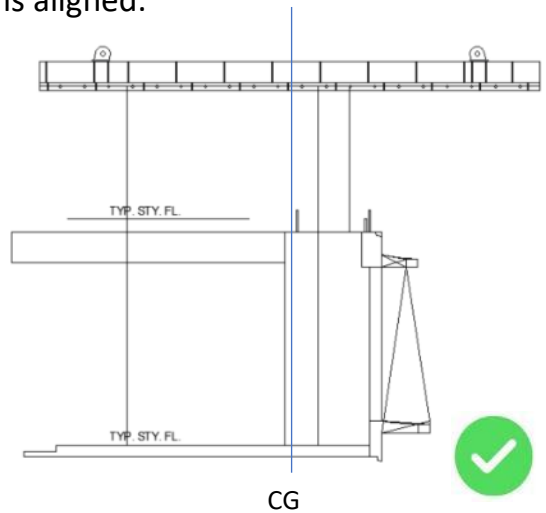
- **Pulley system with a single cable to connect all the lifting points** 
  - The pulley system has equal tension and balances the forces, eliminating the issue of differential loads
  - However, it does not well level up PPVC properly, especially those 2 or 3-sided modules, where the CG is off-centred, especially when the lifting points are some on the top of the walls/beams and some on the slab (floor).
  - The system is heavy or the wired cable too massive for bigger and heavier PPVCs.

- **Auto-leveling Hoisting Rig Utilizing Electronically Controlled Electric Winches** 
  - The project was ditched after the initial studies with engineers and fabricators.
  - Fixed positions of the winches are not ideal
    - Cables angle too much, inducing horizontal compressive forces within the PPVC modules.
    - High variation of lifting forces among the winches requires them to be severely oversized and the rig will be overly heavy, and costly to build.
    - Only suitable for lighter and more regularly shaped 3D precast like PBUs and Household shelters.
  - Cost and ROI issues, etc.

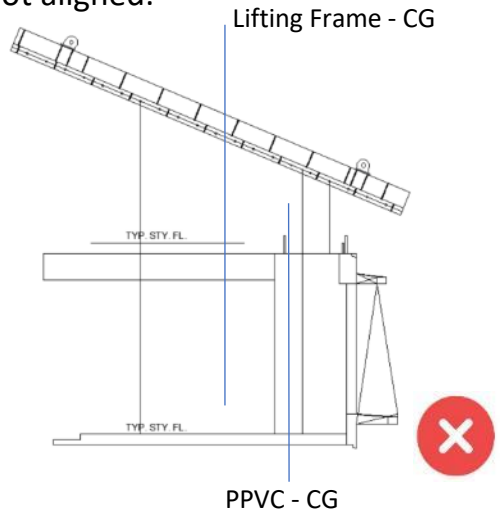
Lifting Frame Design Concept

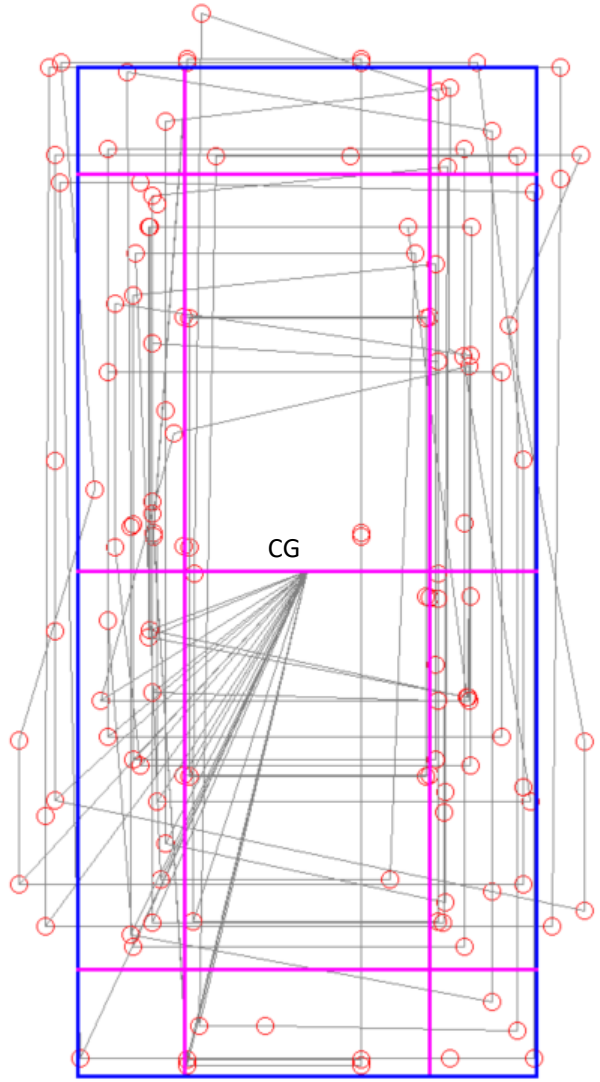
- In order to achieve balance and level, both lifting frame and PPVC CG (Center of Gravity) need to align with each other.
- We superimposed all PPVC modules over their CG with all lifting points.
- A lifting frame was designed with outer and inner frame in order to cover all PPVC modules' lifting points with a lifting clutch angle of not more than 15°
- A direct point-to-point lifting system is implemented.
- Lifting holes are provided at 300mm c/c to both outer and inner frame for lifting cables to hook on.

If CG is aligned:



If CG is not aligned:

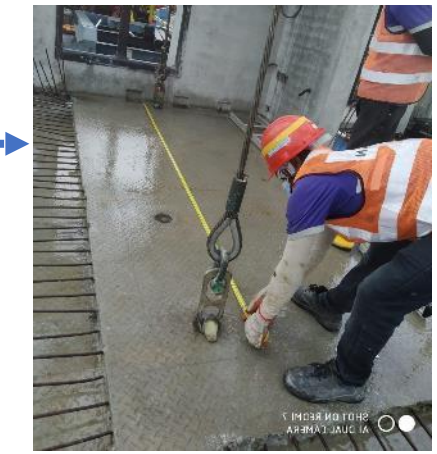




PPVC Lifting Point
Inner Frame
Outer Frame

Problems Faced

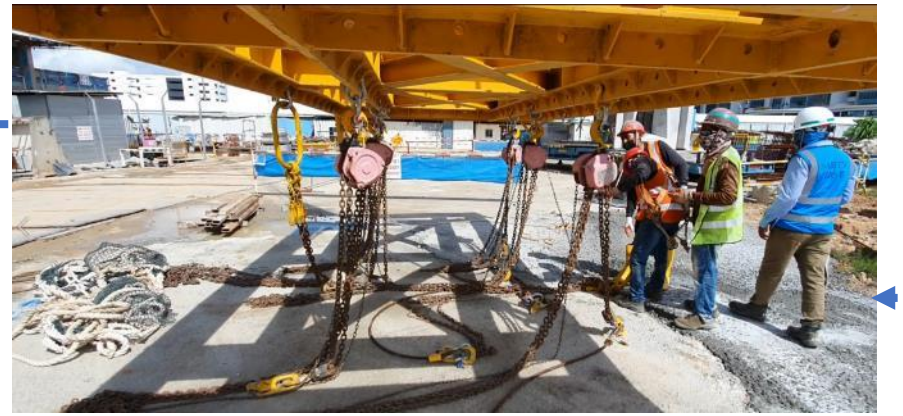
Check corresponding PPVC layout drawing



Measure and roughly estimate the CG point of the module

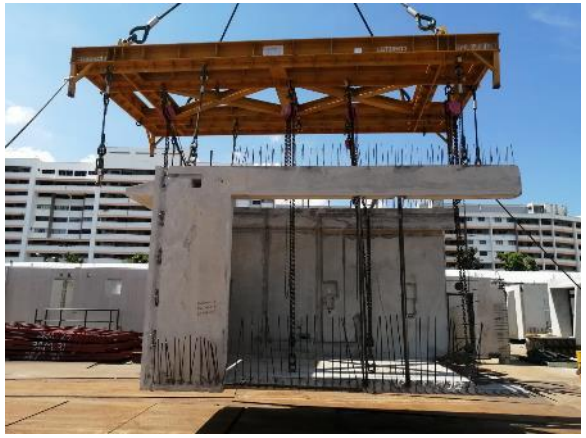
Lifted to check balance of the PPVC

PPVC Slanted



Repeat Steps

Change hooks position and try again



Try until Lifting frame CG point matched with PPVC CG point and achieved balanced

Problems Faced

Chain block hooked at wrong position, as there are no markings in lifting frame.

1

Lifting Team may miss out some lifting points on PPVC modules before hoisting.

2

Lifting Team unsure the lifting chain length required, which caused some lifting chain not tighten properly and other chains took additional load which exceeded SWL.

3

When PPVC module is tilted or slanted during lifting, it causes imbalance exertion of force to the Lifting Gears. Integrity of the Lifting Gear would be compromised, and the lifespan would be reduced.

4

Frequent adjustment of chain block is needed in order to balance PPVC.

5

High risk of falling from height due to high frequency of climbing up and down.

6

Installers may need to adjust the position of spiral connector under PPVC module during PPVC installation at the façade side.

7

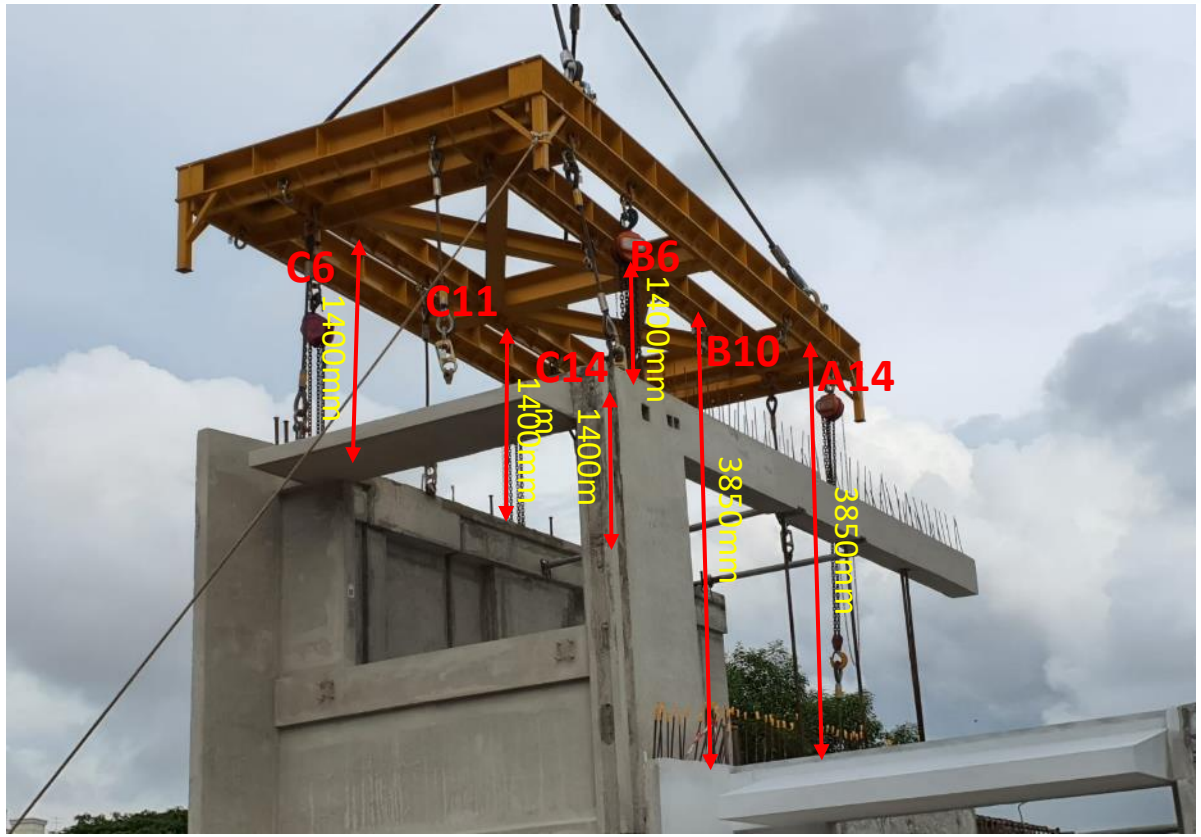
Time consuming to identify the CG point for every PPVC.

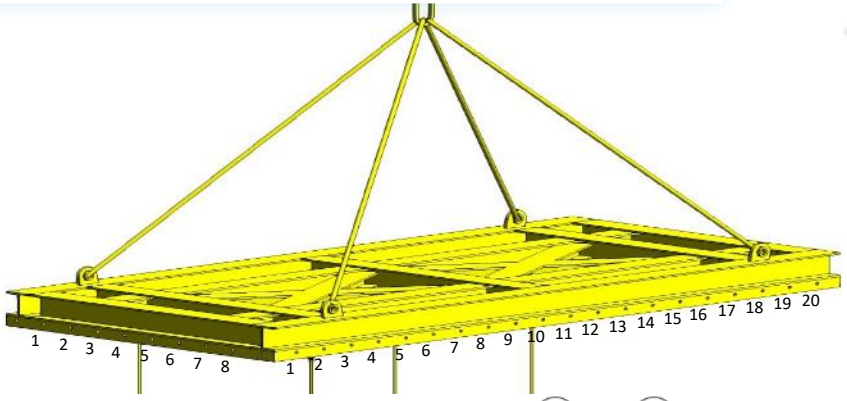
Difficult to align PPVC CG point and lifting frame CG point due to metal deck on top of PPVC is obstructing.

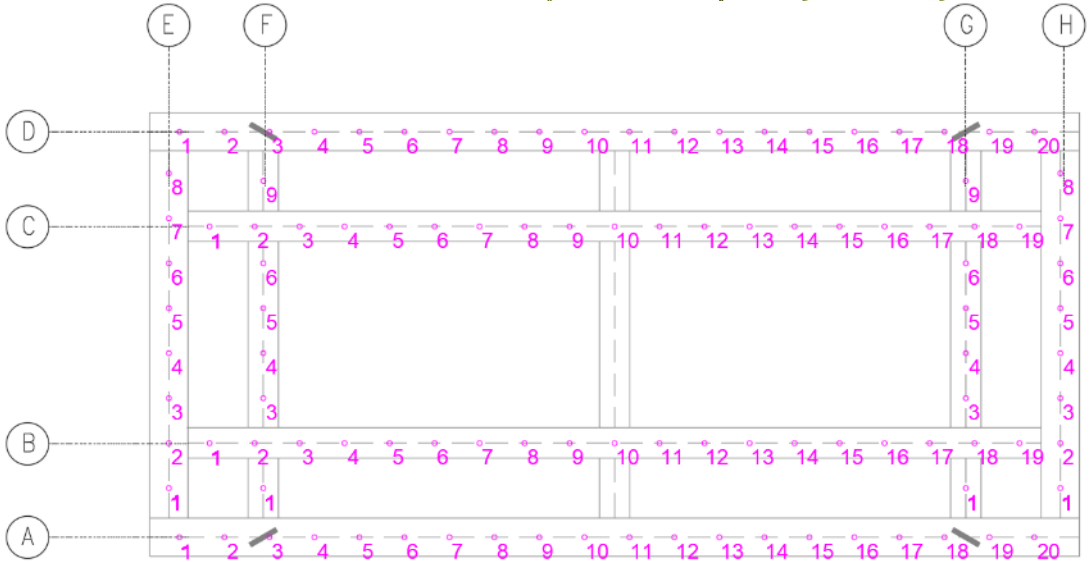
8

Refinements to the Solution

- Professional Engineer calculated and concluded the location of CG point, then determined Chain block length and where the chain blocks to be placed for each module types.
- Marked and Numbered all lifting holes (110 nos holes) at the lifting frame

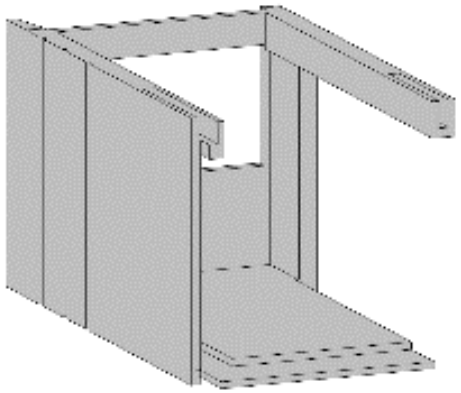


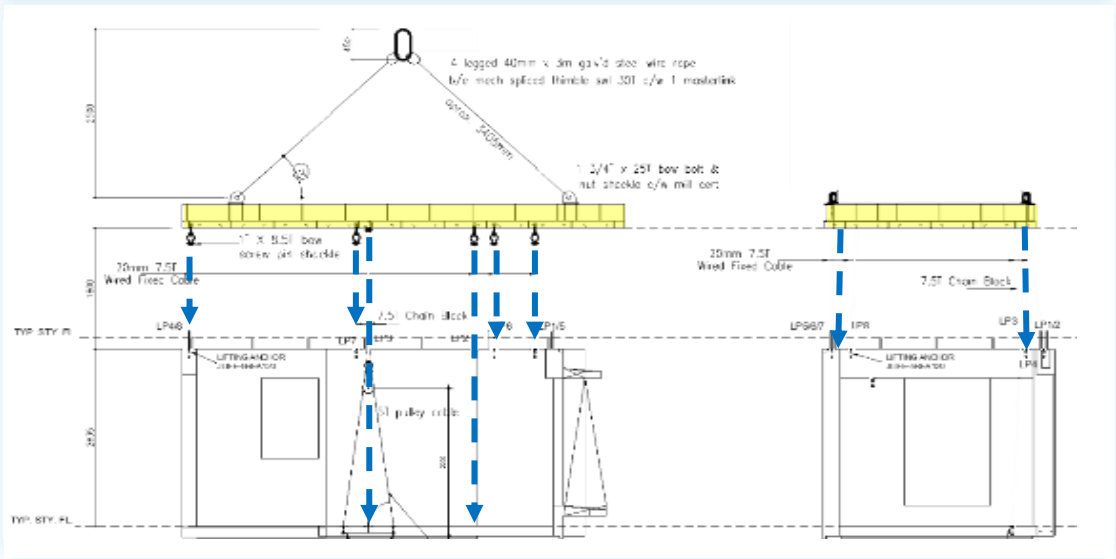


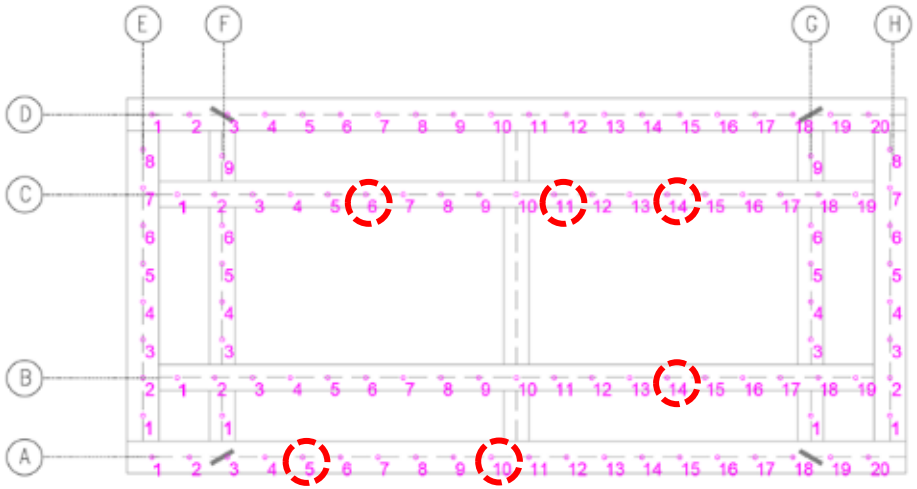


Refinements to the Solution

- Drawings are created with the following details to show the length required for each chain block at each lifting position to ensure balance and level.



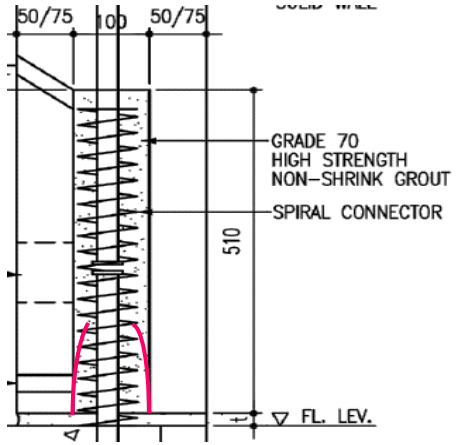




PPVC – 45		
A5 - 3850	C6 - 1400	A10 - 3850
C11 - 1400	B14 - 3850	C14 - 1400

Refinements to the Solution

- Additional spring secured bars of spiral connector welded before PPVC installation to fix springs in accurate position.



Enhancement with Technology

Use Design for Manufacturing and Assembly (DfMA) and Integrated Digital Delivery (IDD) in Building Construction

DfMA

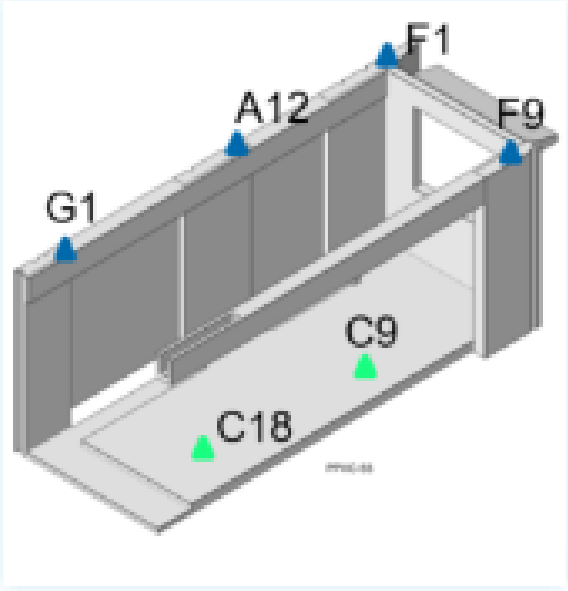
PPVC

\+

IDD
Smart Application

=

Smart Digital Control For PPVC Installation



Enhancement with Technology

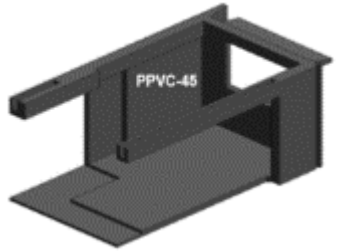
Go to scan QR code

01

QR code available at every module

02

Verify the actual module with 3D Photo in Novade

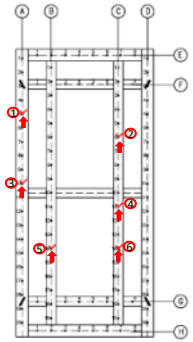


03

Get the lifting data from Smart Application

04

Get correct hook's position from Smart Application



05

Conduct lifting based on selected lifting hook and chain length

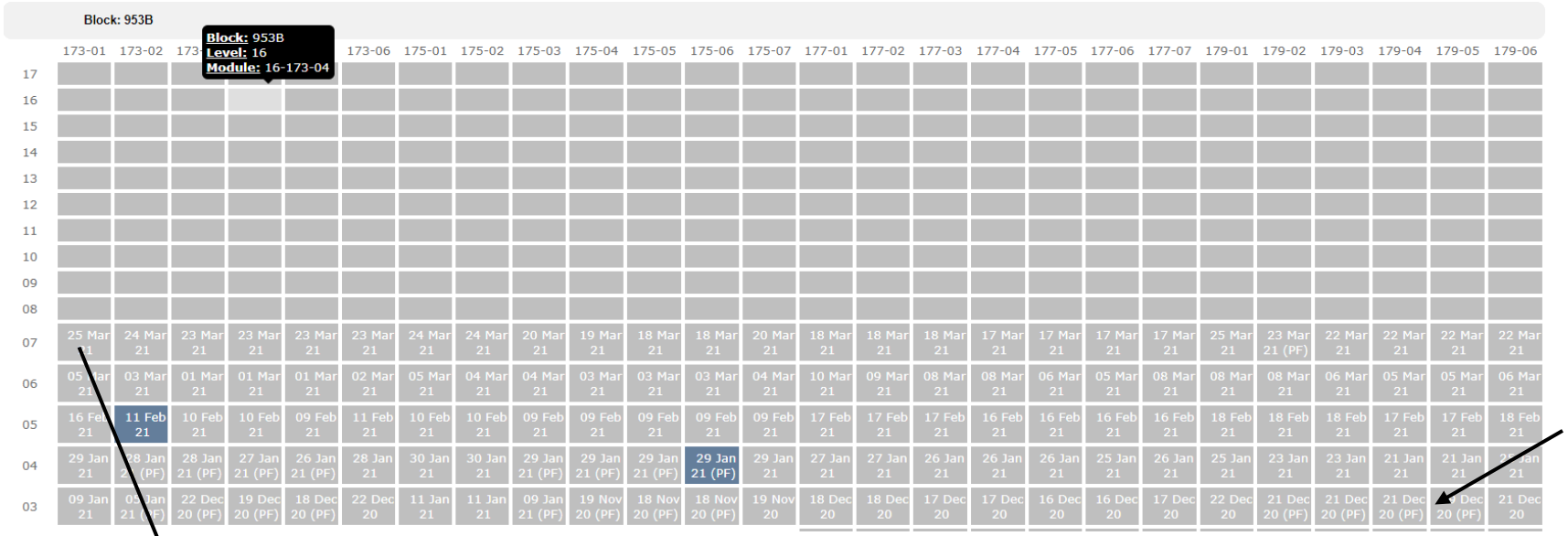
06

Enhancement with Technology

Video Process of Smart Digital Control for PPVC Installation

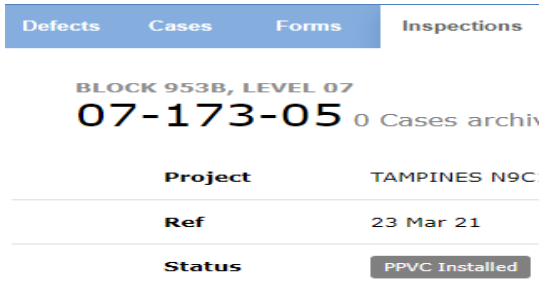
Enhancement with Technology

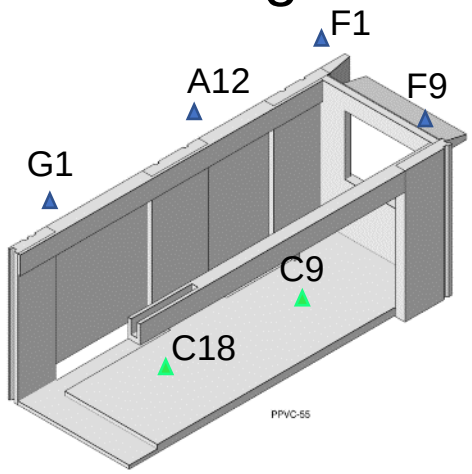
Installation information for each modules sent to database for record and analysis

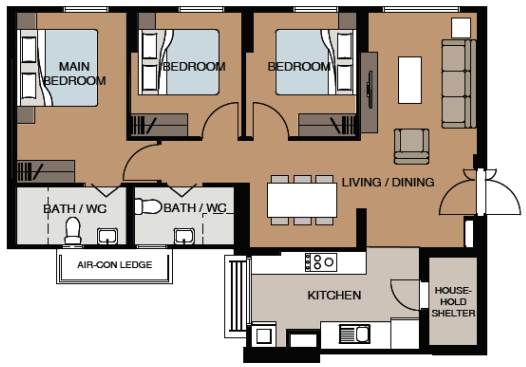


Data-platform facilitate PPVC installation record and progress checking.

Information and drawings attached in system for each modules







4-ROOM FLOOR PLAN

Enhancing Productivity with the Technology

Description	Conventional Method	New Improved Method
Methodology	Non Smart Application Used for PPVC Installation	Using of Smart Application for PPVC Installation
Description of Work	1. Identify PPVC module and check drawings. (2 worker. 5 minutes) 2. Measure Center of Gravity (CG) point. (2 workers. 10 minutes) 3. Match PPVC CG point with lifting frame CG point. (2 workers. 15 minutes) 4. Hook chain block to lifting frame. (2 workers. 10 minutes) 5. Adjust chain blocks length to balance PPVC. (2 workers. 20 minutes) 6. Hoisting up and installation. (4 workers. 60 minutes) TOTAL TIME CONSUMED = 120 MINS	1. Scan QR code found in PPVC module and checking of drawings. (1 worker. 1 minute) 2. Install the hook and chain block to lifting frame. (2 workers. 4minutes) 3. Adjust the chain block height according to the length indicated in the drawing. (2 workers. (5 minutes) 4. Hoisting up and installation.(3 workers. 50 minutes) TOTAL TIME CONSUMED = 60 MINS. 

Enhancing WSHE with the Technology

Conventional Method (No Smart Application Used for PPVC Lifting)	**New Improved Method** (Using of Smart Application for PPVC Lifting)
Adjusting of spiral connector and dowel bar due to imbalance PPVC Module while lowering of PPVC module.	Eliminate the need to adjust spiral connector and dowel bar from below module.
Multiple touch point for the hardcopy drawing of PPVC modules.	Elimination of hardcopy drawing thus eliminating multiple touch point
PPVC modules hitting onto other metal platform due to imbalance of PPVC modules.	Able to reduce risk of hitting onto metal platforms as PPVC modules are balanced
Workers falling from height due to high frequency of workers climbing to adjust the hook locations	Able to reduce the frequencies of workers climbing onto the metal platform.
PPVC module crack due to force exertion by improper hooking of Lifting Gears	Able to determine the location of hooking the Lifting Gears to reduce amount of force exerted thus reducing the risk of PPVC module crack.
Imbalance distribution of Safe Working Load for all Lifting Gears that can cause faulty Lifting Gear due to imbalance hoisting of PPVC modules	Able to determine the location of hooking the Lifting Gears thus increasing the lifespan and integrity of Lifting Gears.

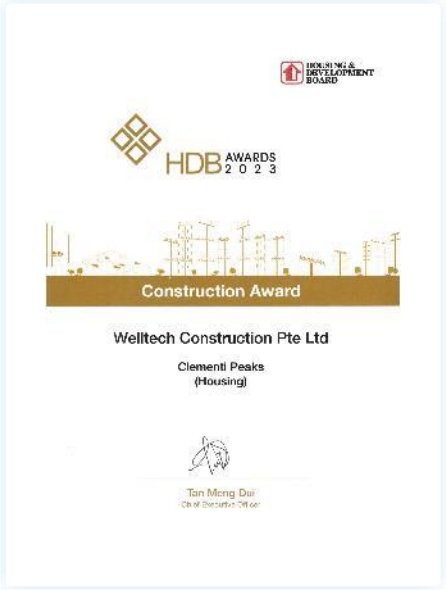
Overall Benefits with the Technology

➢ High Productivity. ➢ 6 modules/block/day installed and 2.5sty /month (RC Cycle) ➢ (vs. 4 modules/block/day and1.5sty /month) ➢ RC cycle: 70-minute cycle per module. ➢ Manpower Saving: 14,990.65 Man-hours ➢ Overall Cost Saving: S$ 1,853,926.00 ➢ Estimated to reduce 2months for overall project duration.	PRODUCTIVITY	70% ↑
➢ Eliminate the need to person standing below module ➢ Reduce risk of falling from height ➢ Reduce risk of LG failure / dislodge ➢ Reduce the imbalance force for the LG ➢ Reduce risk of PPVC module hit another structure. ➢ Increase the lifespan of LG	Safety	60% ↑
➢ Elimination of multiple touch points on hardcopy drawings between supervisors, engineers and lifting team as QR code available for anyone	SMM	100% ↑
➢ Reduce to usage of diesel for crane ➢ Reduce smoke emission for prolonged crane due to frequent adjustment of Lifting Gear ➢ Reduction of paper wastage for printing drawings got lifting team	ECO	70% ↑

ARTIFICIAL INTELLIGENCE FOR VIDEO ANALYTICS (AI/VA) FOR SAFETY NON-COMPLIANCE

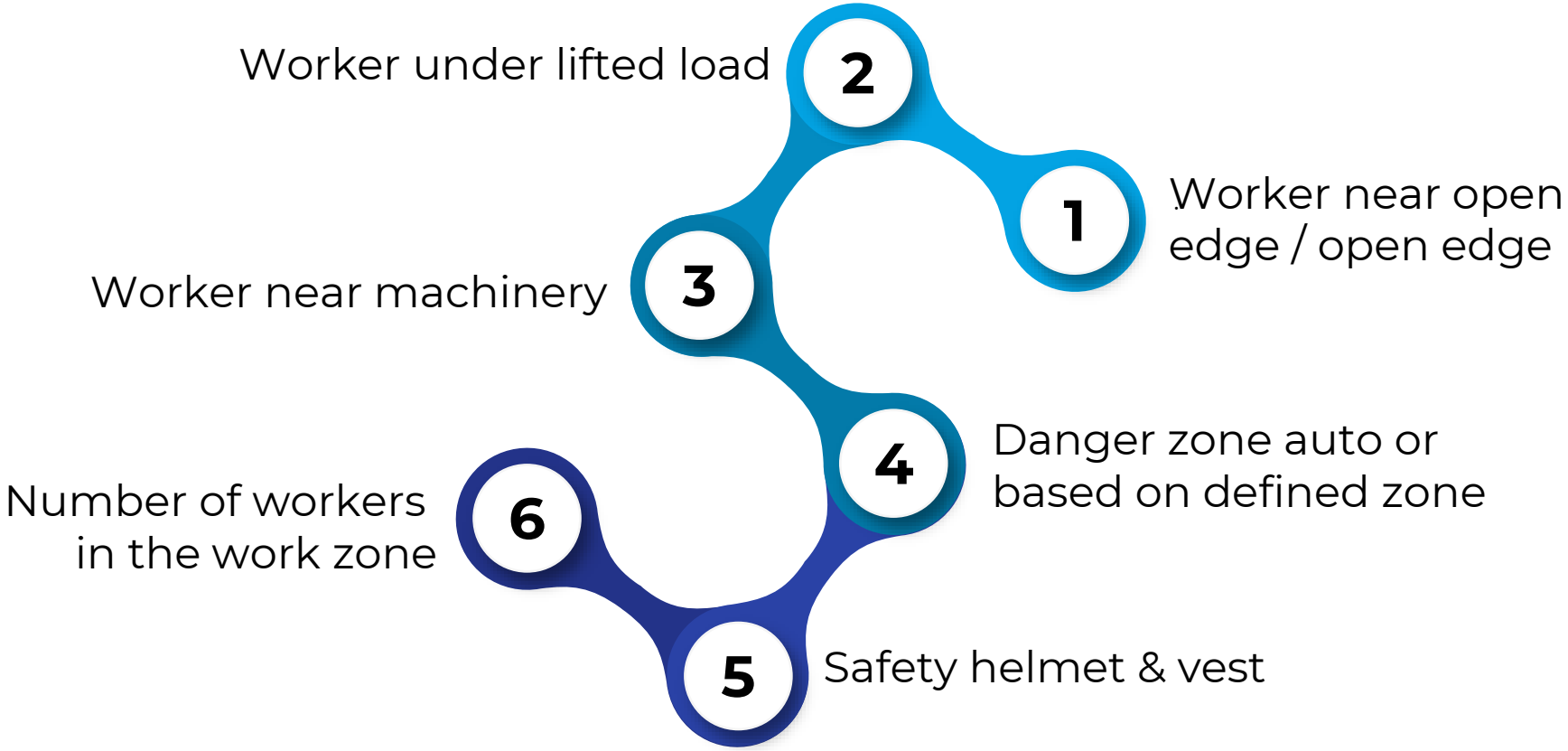
About AI/VA

- AI/VA stands for Artificial Intelligence for Video Analytics.
- Welltech's first encounter with AI/VA system was June 2018 in United Kingdom at RoSPA Safety Expo.
- Welltech's 1st pilot project implementing AI/VA was in HDB Clementi N4 C12.
- AI/VA to assist us to monitor high risk activities and alert the relevant personnel.

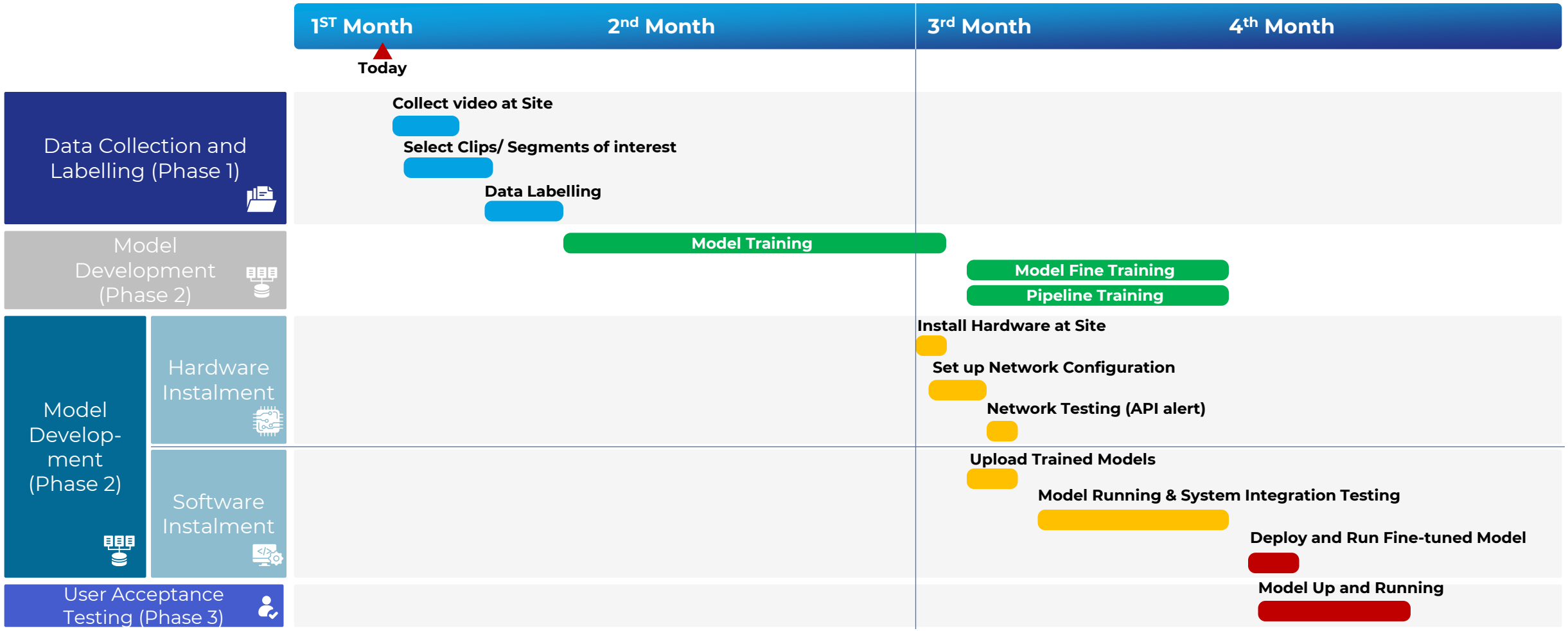


AI Detection

The system can detect these safety non-compliances / occurrences



AI/VA Implementation Schedule



AI Detection – Worker near open edge / open edge

AI Detection – Worker under lifted load

AI Detection – Worker near machinery

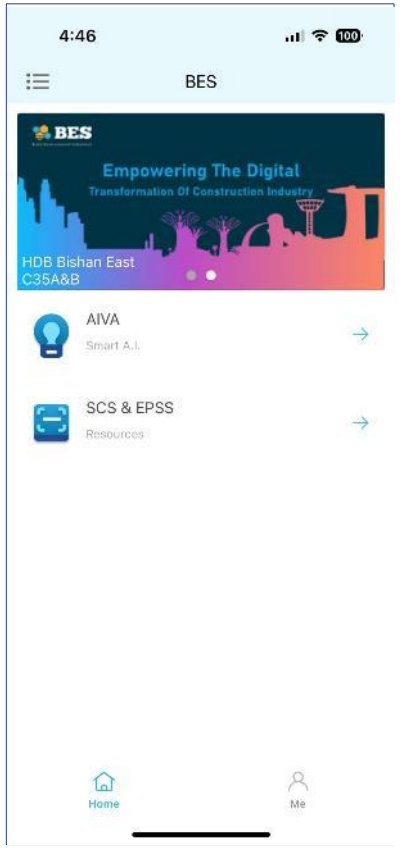
AI Detection – Danger zone or based on defined zone

AI Detection – Safety helmet & vest

AI Detection – Number of workers in the work zone

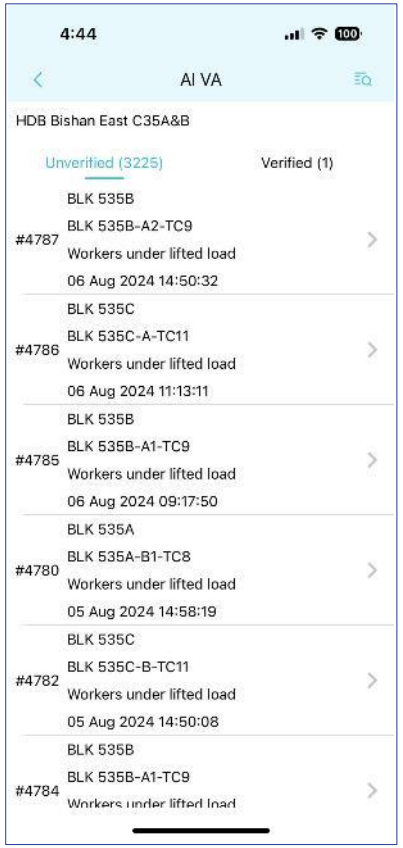
AI/VA using Mobile Phone Application

AI/VA Module
In Mobile App

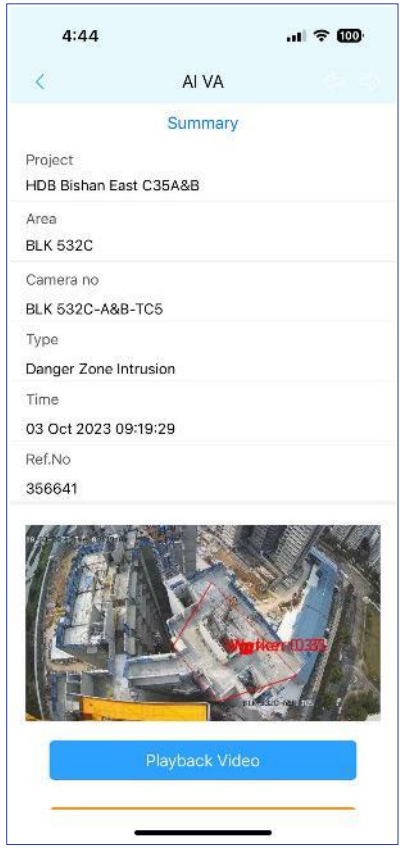


Dashboard
Overall view

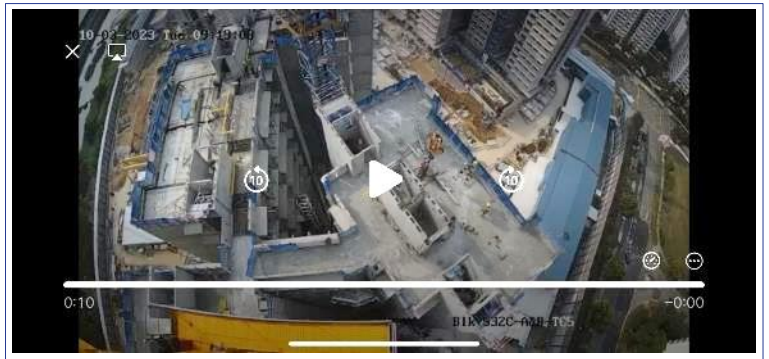
Summary
List of all alerts



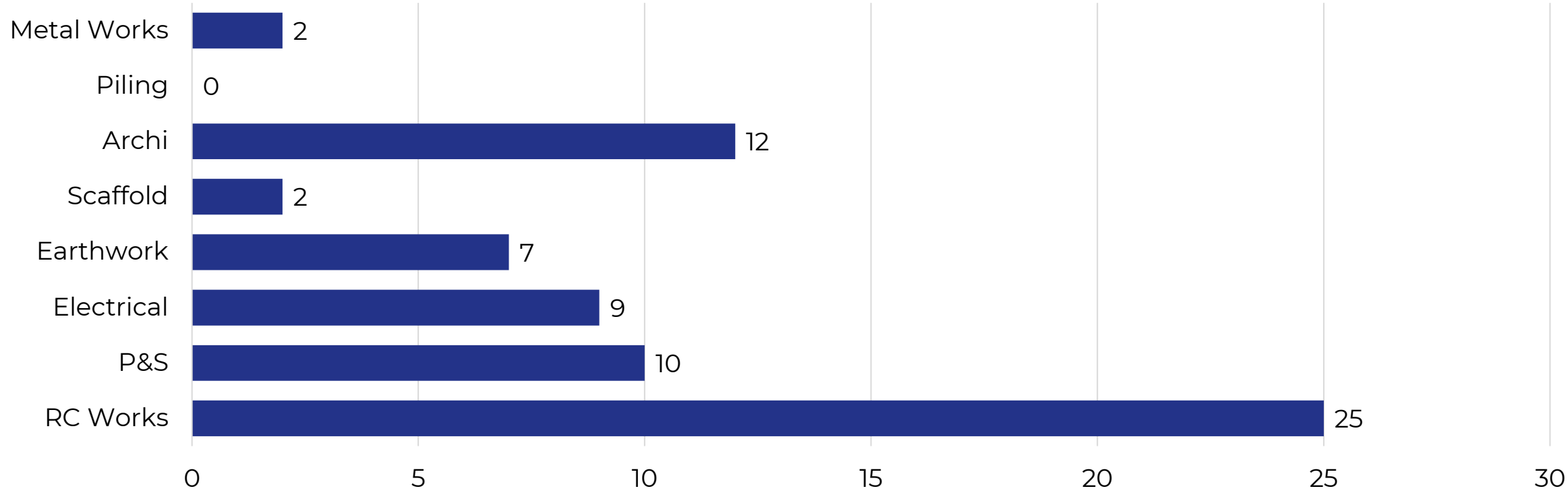
Information
Details of alert



Video
Link to video available



Sample Safety Data Collected by using AI/VA.



Breakdown in total number of the safety non-compliance found based on trades

Benefits of using AI / VA at work

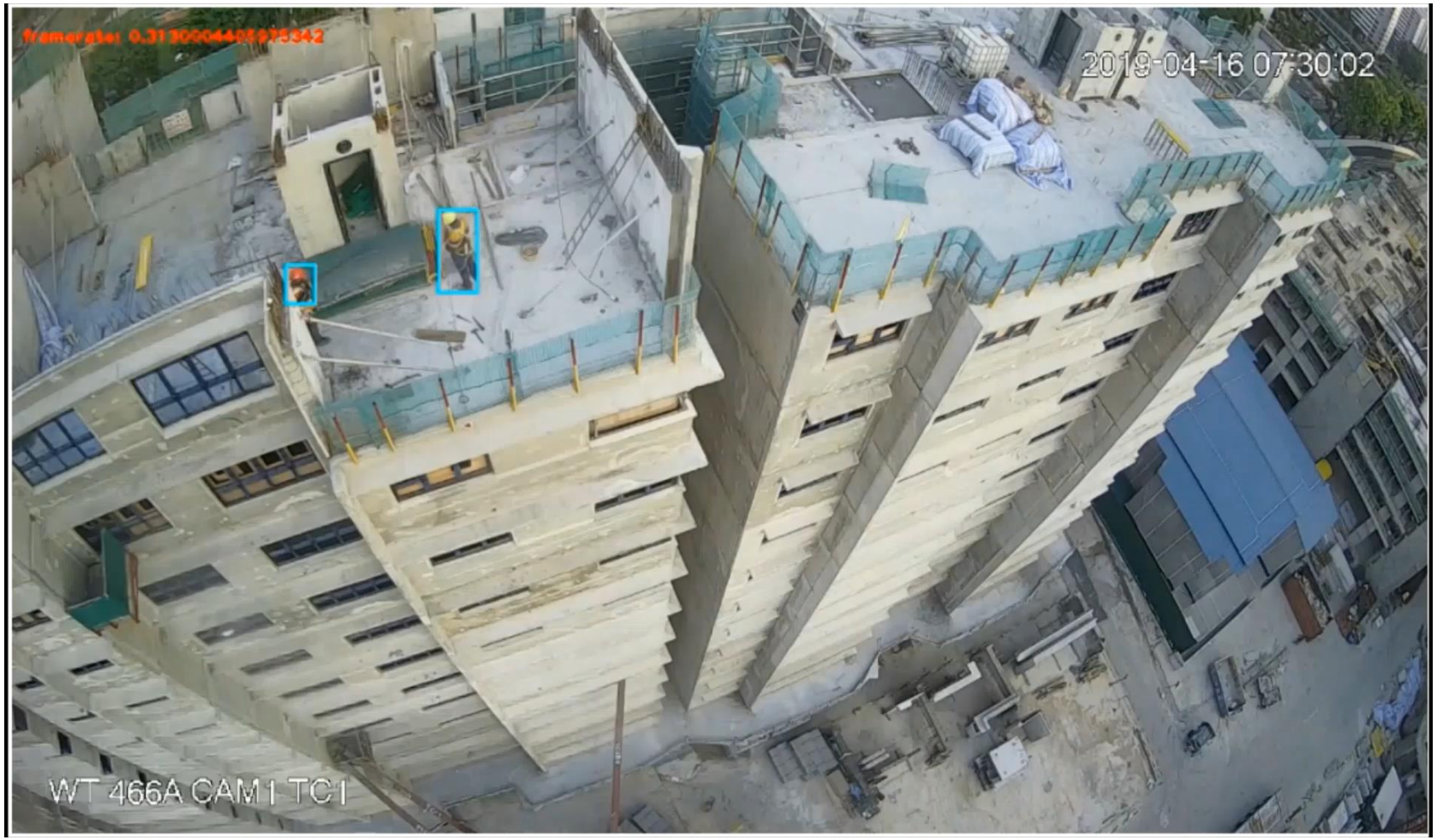
The usage of the system further enhances the safety of the work force working onsite in addition to safety inspections carried out by the site to ensure safe work conditions.

Unsafe work environments are swiftly identified and rectified

It further minimizes the risks of unsafe acts by workers as workforce understands that work locations are monitored.

It reduces the number of accidents or incidents occurring onsite by minimizing the chances of the above occurring.

AI/VA in Action



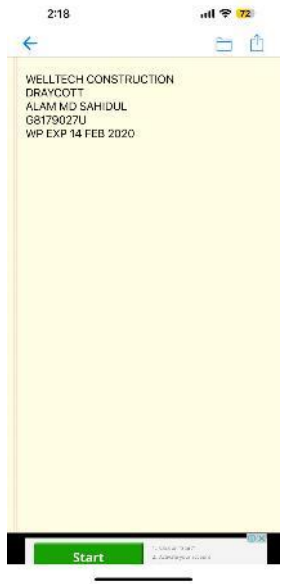
Video of AI/VA in Action

Developments in the Future

- Strengthen and refine the AI/VA detection function, making it more accurate and reliable, reducing false alarms.
- Explore ways to improve detection during the night (low light conditions).
- Further refine alerts into different safety levels or tiers, based on severity and proximity to danger.
- Integrate AI/VA alerts system with on-site IoT warnings (lights + sound). In case of non-compliance, besides sending alerts to the app, also activate on-site IoT warnings: red light flashing + sound during the day; only red light flashing at night.
- Use PTZ cameras for the CCTV. When non-compliance occurs, AI/VA can link to the PTZ camera to zoom in, allowing identification of the workers in violation. This is technically challenging according to vendors.

Sticker on Helmet with QR

PTZ detect non-compliance, zoom in and scan QR

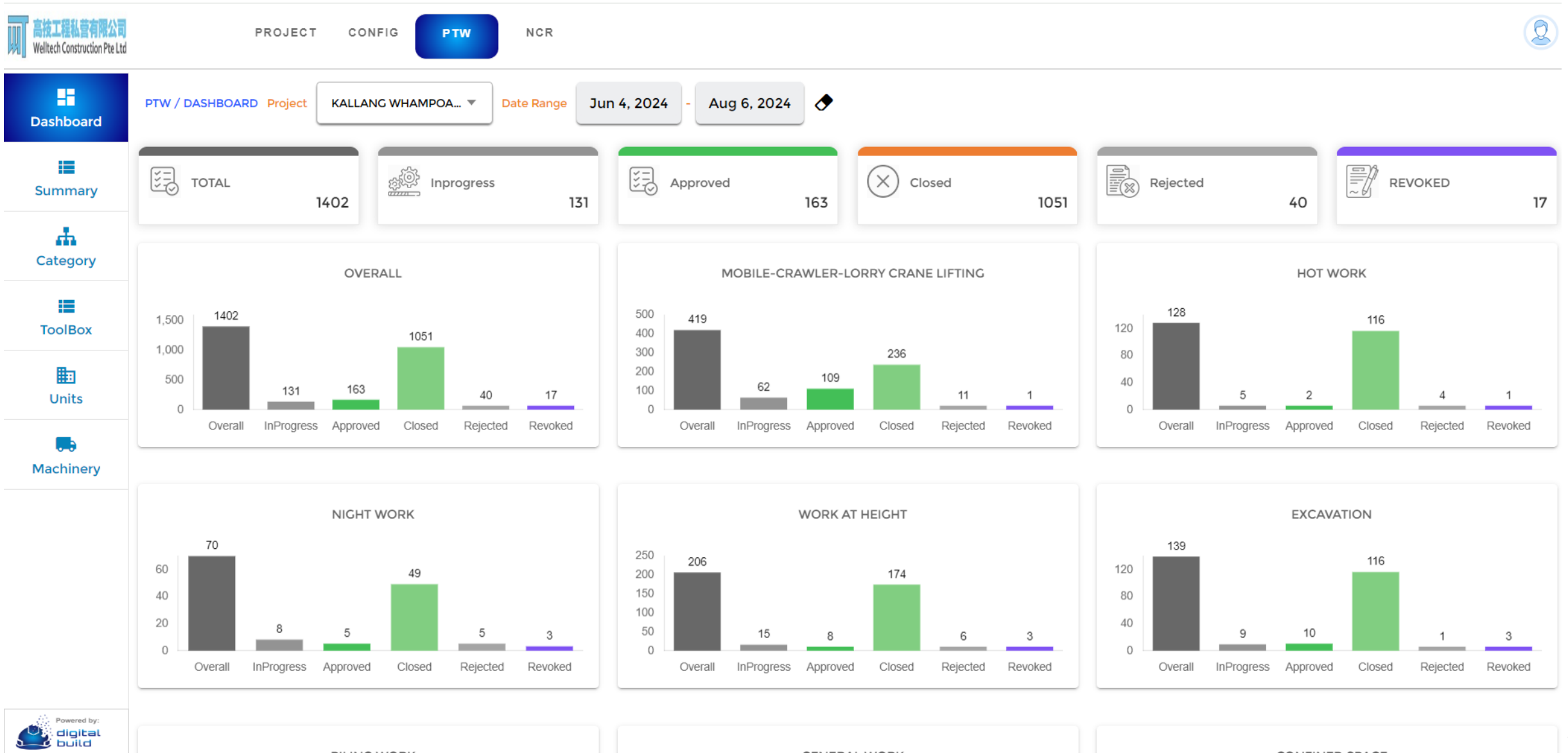


DASHBOARDING & DATA ANALYTICS

About Dashboarding & Data Analytics

- In today's data-driven landscape, dashboarding and data analytics are essential for turning raw data into actionable insights.
- Dashboards provide real-time visual summaries of key metrics, making it easier to track performance and spot trends, uncovering patterns and correlations that inform strategic decisions.
- In the realm of workplace safety and health, dashboarding and data analytics are transforming how we can manage and improve their safety practices.
- Dashboards offer real-time visual insights into key safety metrics, such as incident rates and compliance status, enabling quick identification of trends and potential issues.
- Data analytics enhances this by analyzing patterns and correlations in safety data, allowing for proactive measures and more effective risk management.
- Together, these tools will help Welltech create safer work environments, ensure regulatory compliance, and drive continuous improvements in health and safety outcomes.

Current Dashboards of ePTW Vendors



Integrating Safety Data Using Tableau Dashboard

Safety performances from multiple projects and multiple apps can be integrated into a single dashboard.

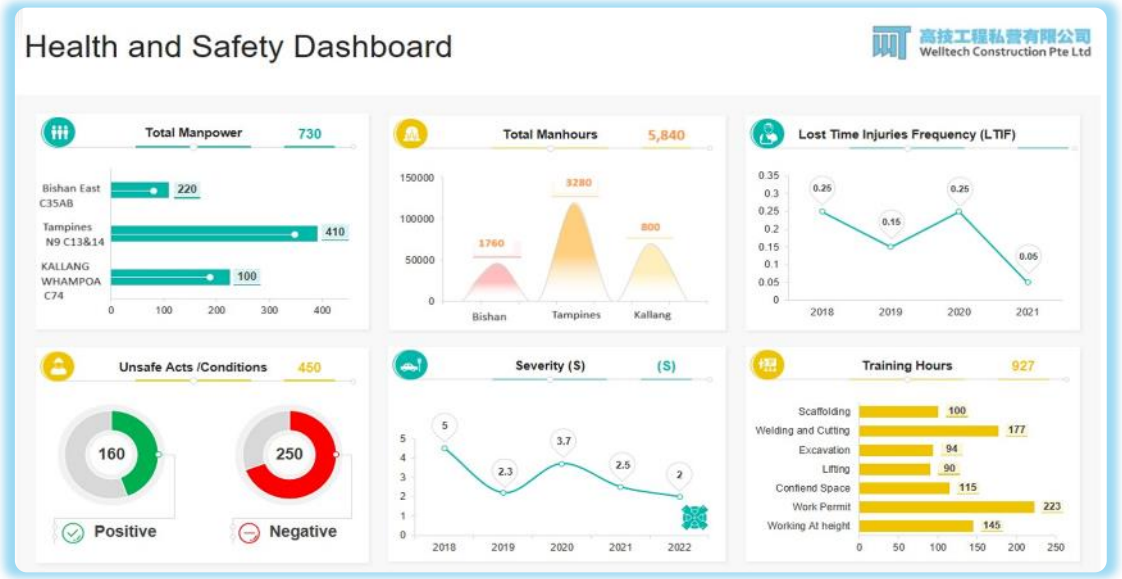
The platform allows us to connect, access, and blend data from multiple sources into a single visualization.

Macro to micro-level details of safety performances can be viewed and analyzed.

A data-driven decision can be made based on the analysis.

digital build

HUBBLE



Novade

BES
Built Environment Solutions

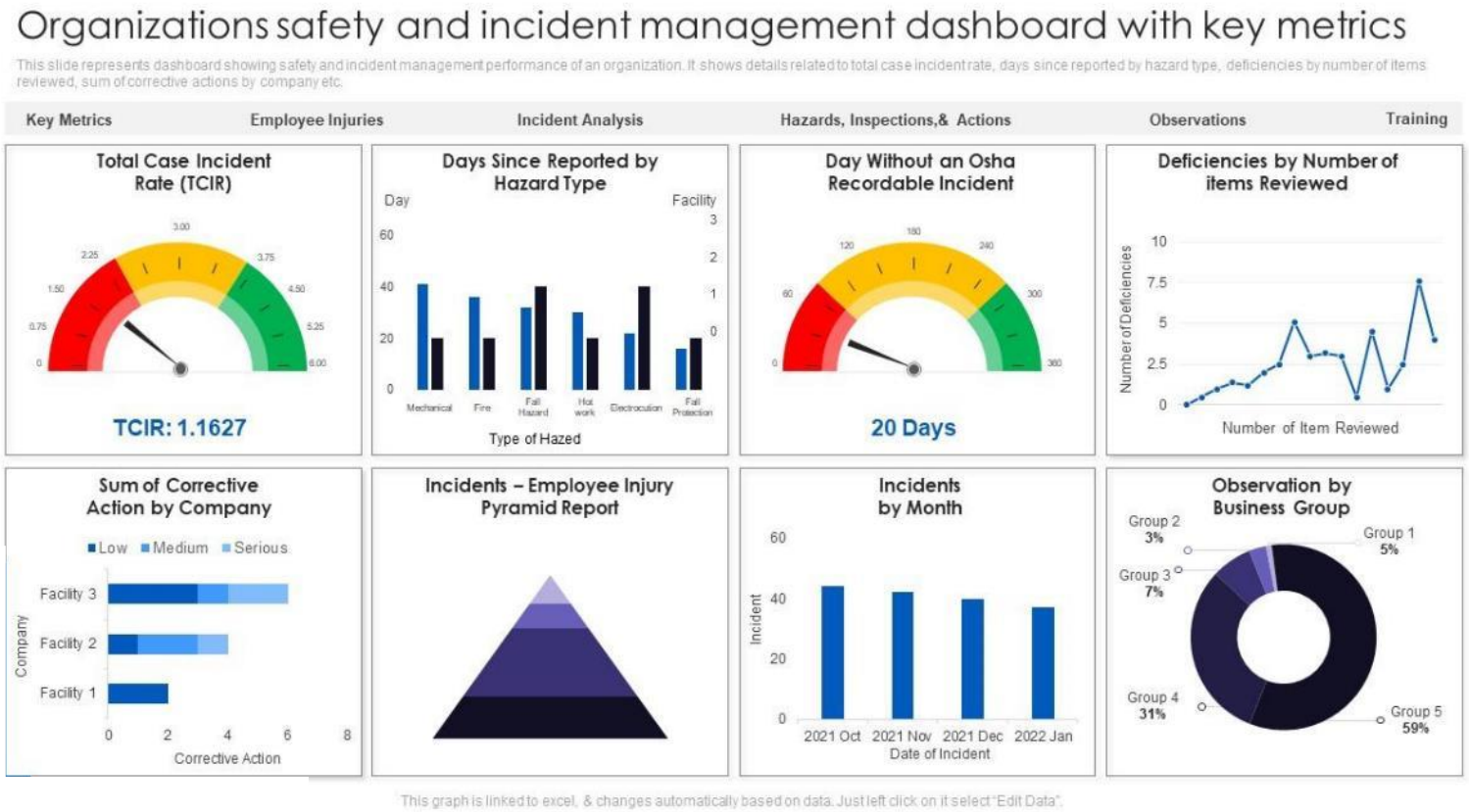
Google Sheets

Evaluated the best data visualization dashboard platform

Figure 1: Magic Quadrant for Analytics and Business Intelligence Platforms

Gartner (June 2024)

Gartner

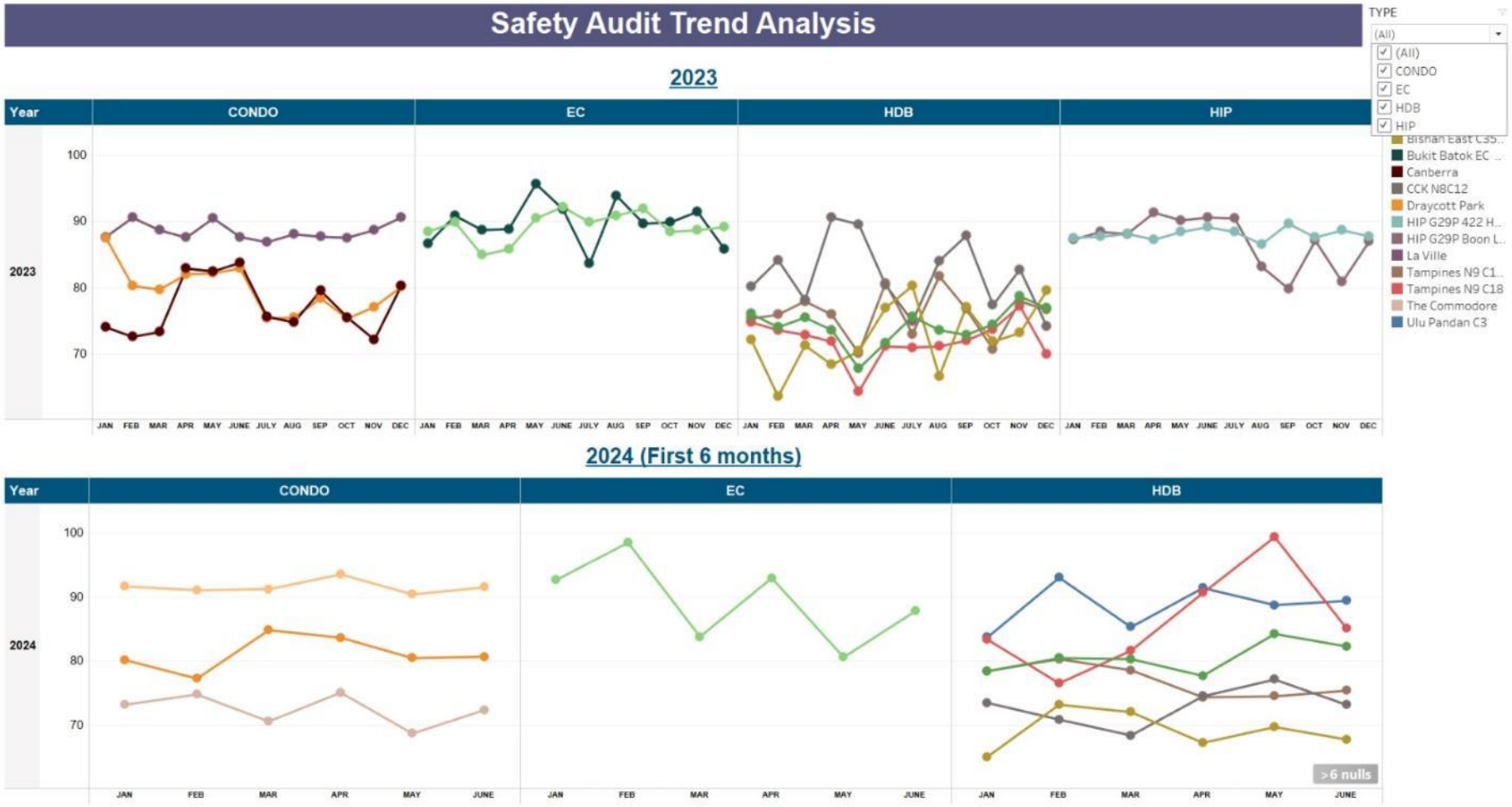


Power BI

+ a b | e a u

Safety Audit Score Trend Analysis

(Using Tableau Platform)



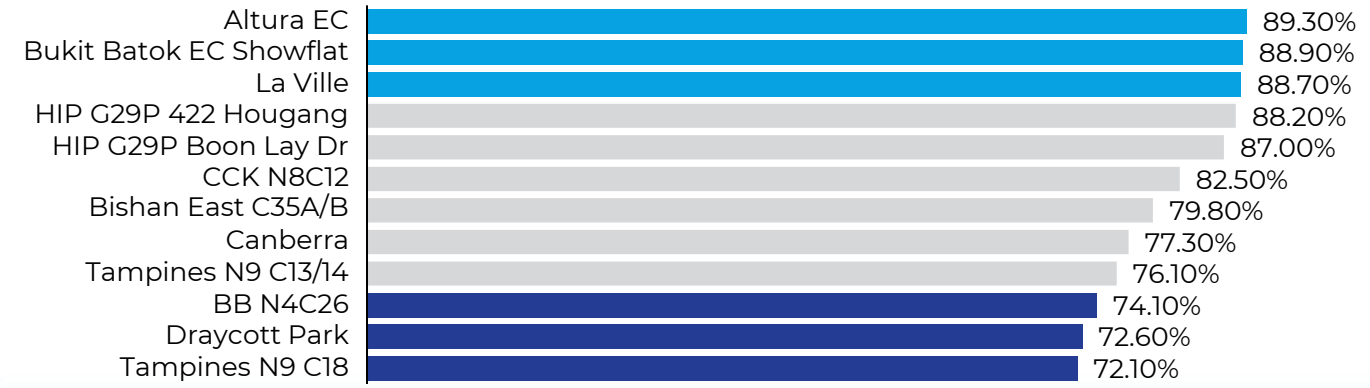
Safety Audit Score Performance Analysis

Safety Audit Score for all Projects

Projects

	2023	2024
Altura EC	89.3	89.8
Arina East Residences	NA	91.8
BB N4C26	74.1	80.2
Bishan East C35A/B	79.8	81.3
Bukit Batok EC Showflat	88.9	NA
Canberra	77.3	NA
CCK N8C12	82.5	72.9
Draycott Park	72.6	69.5
HIP G29P 422 Hougang	88.2	NA
HIP G29P Boon Lay Dr	87.0	NA
La Ville	88.7	NA
Tampines N9 C13/14	76.1	77.3
Tampines N9 C18	72.1	86.3
The Commodore	NA	72.5
Ulu Pandan C3	NA	88.7

TOP THREE & BOTTOM THREE of SAFETY AUDIT SCORE 2023



TOP THREE & BOTTOM THREE of SAFETY AUDIT SCORE 2024

ROBOTICS

About Robotics

- Construction robots offer innovative solutions to enhance productivity and WSHE on-site.
- Robots can handle risky tasks and operate in hazardous environments, reducing the risk of accidents and improving overall workplace safety, health and environment.
- Embracing robotics not only positions Welltech at the forefront of construction technology but also aligns with Singapore's broader goals of digital transformation and smart city development.
- Investing in construction robots is a strategic move towards a more innovative, safe, and efficient construction company.

Current Deployment

- **Indoor Spraying Robot**
  - Equipped with specialised spray painting equipment, the heart of the system is a robotic arm that is articulated and can move in multiple directions to allow the spray head to access various angles and positions, as well as the consistent distance of the spray surfaces from the spray nozzle, for the most accurate possible paint placement.
  - The robot also utilises high-precision laser guiding and positioning, cloud-based/preloaded floor plan mapping, AI and other technologies to manoeuvre efficiently in the designated work area for optimum productivity.

Robot Information

Main Features of Fulltime-BES FT-A011 Spraying Robot

6-axis Robotic Arm

The 6-axis robotic arm has a 1400 mm arm span and 1200 mm effective reach. It can return to its prior position with high precision to eliminate inconsistencies between spraying intervals. It also allows the nozzle to turn sideways to spray the inner faces of wall recesses.

Execution Terminal

The robotic arm's execution terminal enables quick and easy attachment and detachment of the spraying nozzle, minimising maintenance downtime. Additionally, this adaptable design allows for seamless switching to other attachments for skim coating and sanding.

Control System

The core of the control system is a computer that employs high-performance processors and industrial-grade logic controllers, coupled with laser, AI and other technologies, to carry out all the automated spraying and navigating functions accurately and seamlessly.

Remote Control

The spraying robot automated operation is wirelessly managed with a supplied tablet running on Windows platform (Android version to launch in Q1 2024). Parameter settings are entered and dynamic information is viewed on the tablet.

Elevating Mechanism

The elevating mechanism, operates on both the chassis-to-jack and jack-to-arm travel, to achieve a total effective elevation gain of 960mm, enabling the robot to spray at height up to 4.6m.

Material Tank

The material tank has a capacity of 45L and level detection. It is designed for easy access and removal.

Spraying Equipment

Through the utilisation of a high-powered, heavy-duty pump and a proprietary anti-clogging nozzle (patent pending), the robot achieves uninterrupted spraying across extensive areas, with an increased width in each stroke of the robotic arm for outstanding speed and productivity, as well as achieves the ability to handle thicker material like skim coat used in Singapore.

4-wheel Omni-directional Chassis

The industrial-grade AGV chassis safely handles the weight of a fully loaded robot and manoeuvres with forward and backward motion, in-position rotation and side-stepping motion at any angle.

Robot Specifications

Measurements	
Dimensions (L x W x H)	(1130 x 820 x 1720) mm
Height of Robotic Arm Base from Ground Level	1300 mm
Effective Travel of Elevating Mechanism	960 mm
Effective Reach of 6-Axis Robotic Arm	1200 mm
Length of Spraying Nozzle	250 mm
Weight	680 kg (Fully equipped, Dry)

Battery Specifications	
Battery Type	LiFePO4 (Lithium Iron Phosphate)
Battery Capacity	173 Ah
Operating Voltage	48V DC
Charging Voltage	220~240V AC
Charging Current	30 A
Max. Continuous Operating Time With Full Charge	4 hrs

Performance	
Working Height	4.6 m
Material Volume	45L
Max. Spray Distance	1000 mm
Min. Spray Distance	500 mm
Max. Output (Max parameter setting on spray distance and arm speed, using the widest nozzle)	150 m^2/hr
Real-World Spray Output	~ 60% to 70% of calculated output based on the parameter settings

Mobility	
Max. Speed	0.5 m/s
Max. Gradient	10°
Max. Obstacle Clearance Height	30 mm
Max. Ditch Width	50 mm
Min Turning Radius	0mm (in-position 360° rotation possible)
Motions Allowed	Forward, Backward & Sideways at any angle

Enhancing WSHE with Robotics

Safety

- Direct Replacement of Manual Labor – Elimination of All Risks Involved
- Operate up to 4.6m – Work-at-Height Eliminated

Health

- Direct Replacement of Manual Labor – Elimination of Any Medical or Health Issues Arising from the Trade Works

Environmental

- High Precision of the Robot reduces Material Usage
- More powerful, precise and concise spraying causing negligible misting that airborne the material into the air

THANK YOU