Gammon

Hong Kong Concrete Institute
香 港 混 凝 土 學 會

Smart and Digital Technology in Concrete

Gammon Construction Ltd.

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9 December 2021

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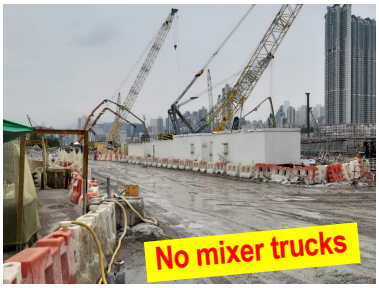
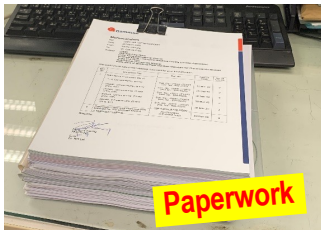
Challenges Faced by Most Construction Projects





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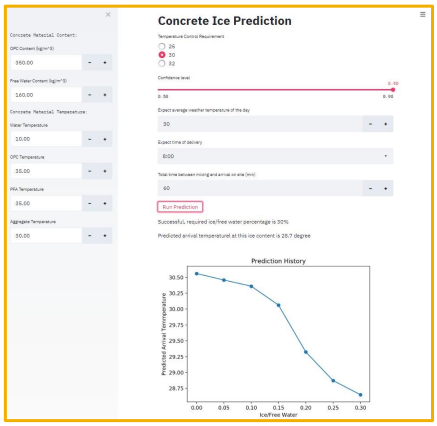
How Smart and Digital Technology Can Help?

Sustainable

Digital

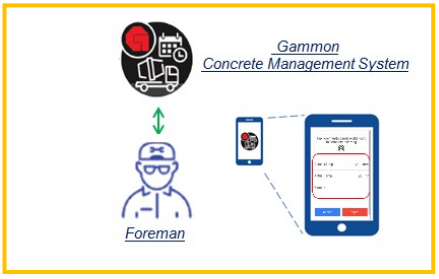
Paperless

Automated
(RPA)



IoT Enabled Concrete Quality Assurance

Maturity Sensor



CMS and Order Optimization by AI

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Enhancement for Production of Temperature Controlled Concrete

Concrete Temperature Prediction & Ice Optimization

CHALLENGE faced by CONCRETE PLANT:
Ice content input is BY OPERATORS' EXPERIENCE.

Temperature-controlled concrete

Cement hydration is an exothermic reaction that gives concrete its strength. Therefore, maintaining concrete at an appropriate temperature is crucial part of concrete quality control.

>60% of concrete poured from July to September are temperature-controlled.

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Methodology

Predict

- Input:
  - Various features (including ice content)
- Output:
  - Arrival Temperature

Evaluate

- Evaluate and determine best model that gives best accuracy
- Determine target arrival temperature for each temp. control requirement based on accuracy

Back-Calculate

- Input:
  - Target arrival temperature
  - Various features (excluding ice content)
- Output:
  - Required ice content

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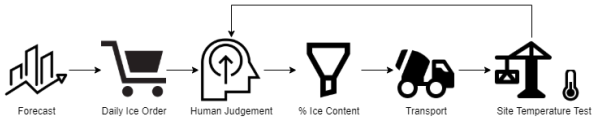
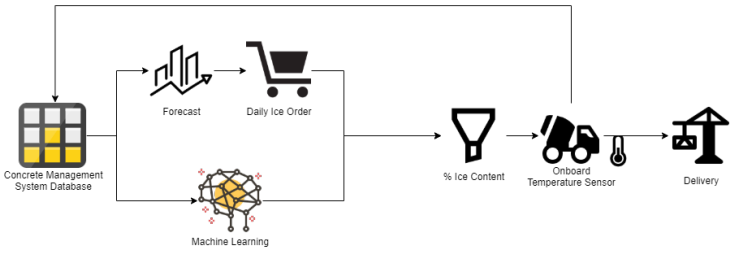
Algorithm



Existing procedure that controls the ice content relies on human judgement and the first truck is often a bit of a blind guess.
This results in **excess ice consumption**.



Applying machine learning techniques on concrete management system (CMS) data, we make use of the data collected by temperature sensors installed on concrete trucks to provide suggestions on the **optimal amount of ice to be used**.

% Ice Input

Temperature sensor on concrete trucks

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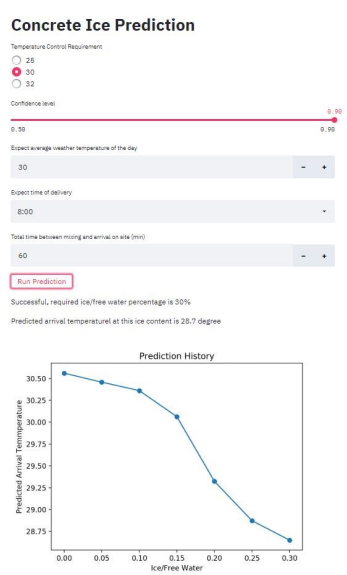
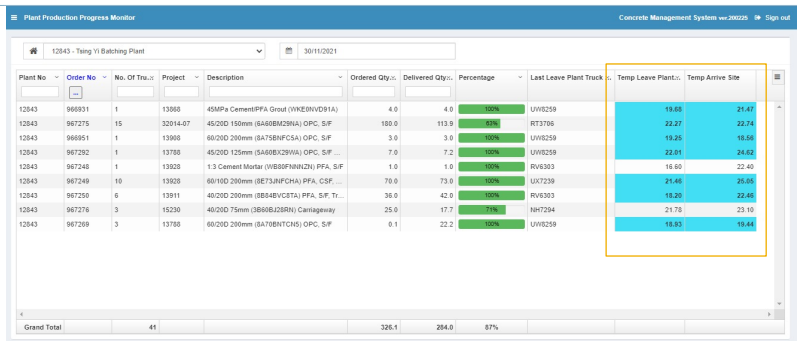
Screenshots and Achieved Benefits



Mobile-friendly user interface for easy access of optimization result.



Concrete Management System to monitor on-site concrete temperature.

Benefits:

- Less waste : Save ~25 kg Ice / m^3 TC concrete
- Minimize non-conformance in concrete temperature
- Minimize temperature checking for every truck of concrete
- Increase Clients' Trust

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In-situ Concrete Strength Monitoring Using Maturity Sensors

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Quality Control of In-situ Concrete

CHALLENGE faced by most construction projects:
In-situ concrete strength is UNKNOWN

For each truck load of concrete, 150mm concrete cubes were tested for compressive strength two at 7 days and two at 28 days.

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Concrete Maturity Sensors

A Solution of Concrete Real Time Monitoring After Placement

Concrete Placement & Site Inspection

Test Method: ASTM C 1074

Remote Concrete Strength Monitoring

Timeline of Concrete Quality Control On site

Compressive Strength on 7D- and 28D Age

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Concrete Maturity Sensors: How does it work?

Source: ***Converge – Calibration report (AMC Project 50/20D) Rev 01 – 08/11/19***

Theoretical basis

The strength development of concrete is driven by cement hydration.

This is an exothermic reaction, so it releases heat.

There is a direct link between the temperature of concrete over time and it's strength development.

Maturity Sensors, i.e. Converge, follows the ASTM-C1074 standard to apply the maturity method as it is the most detailed.

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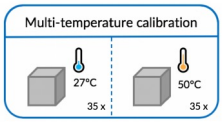
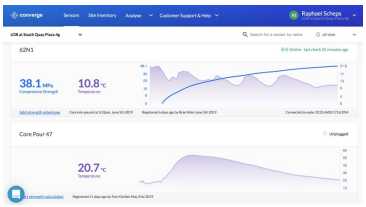
Maturity Sensors for Real-time Monitor In-situu Concrete Strength



Develop correlation between Maturity Index and concrete strength

Install sensor before concreting



In-situ concrete strength is estimated base on maturity reading from sensor

Benefits:

1. Providing accurate real-time in-situ strength information
2. Provide opportunity to reduce construction cycle time with real time concrete strength, hence improve overall construction programme
3. Environmental benefits associated with elimination of test cube transport and disposal.

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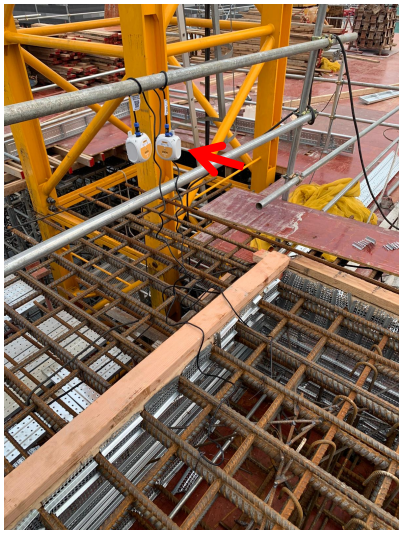
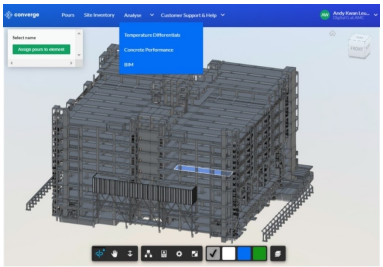
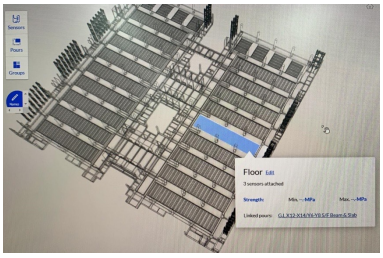
Application: Advanced Manufacturing Centre in Tseung Kwan O

Gammon applied Converge sensors to monitor early age concrete strength instead of testing 7-day cubes at Advanced Manufacturing Centre in Tseung Kwan O.







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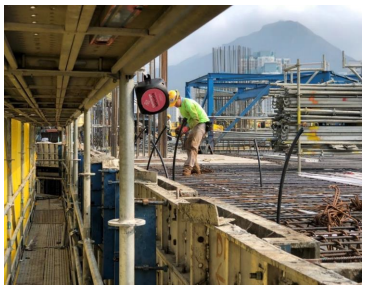
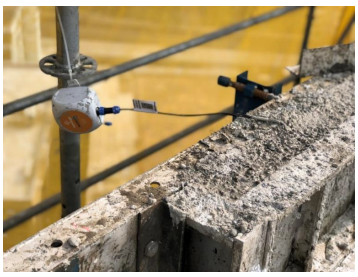
Application: The Quayside in Kowloon East

Gammon applied Converge Sensors to reduce cycle time from pour to strike for Quayside.





- Installed 12 sensors on each floor: 2 sensors per slab
- Shortened the overall programme by 25 days (avg. 22 hours per pour).

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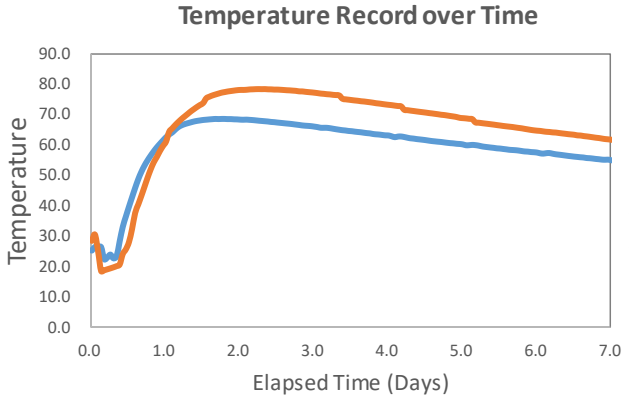
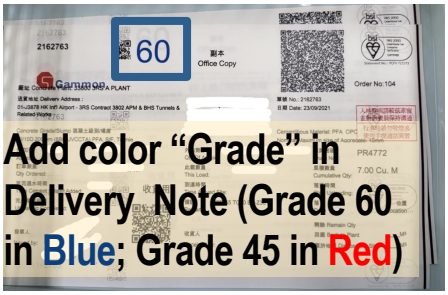
What's Next?

CHALLENGE faced by most construction projects:
All concrete are same color. Grade strength cannot be identified. Mis-placing may occur.





Concrete mix detection

Concrete Sensor will push an alert to the user when the difference in max temperature between pours is significant.

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Reduction of Paperwork

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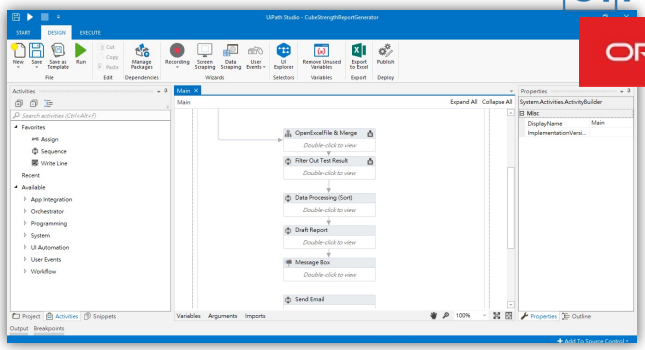
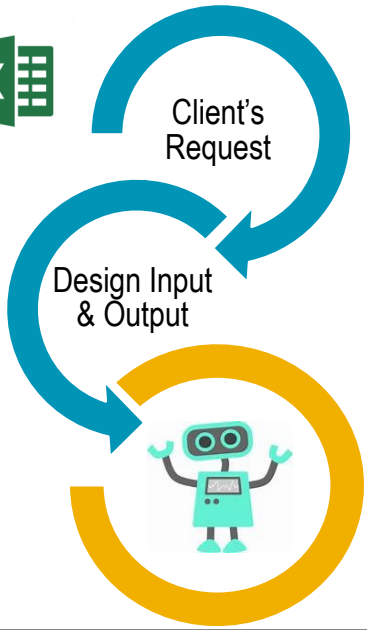
(3) Robotic Process Automation

CHALLENGE faced not only Concrete Batching Plant:
Much paperwork





- To prepare Concrete Mix Submission
- To create new Concrete Item Code, Bill of materials (BOM) and its associated cost in Enterprise Resource Planning (ERP) System
- Time-saving up to 50%; Accuracy is enhanced to 95%.

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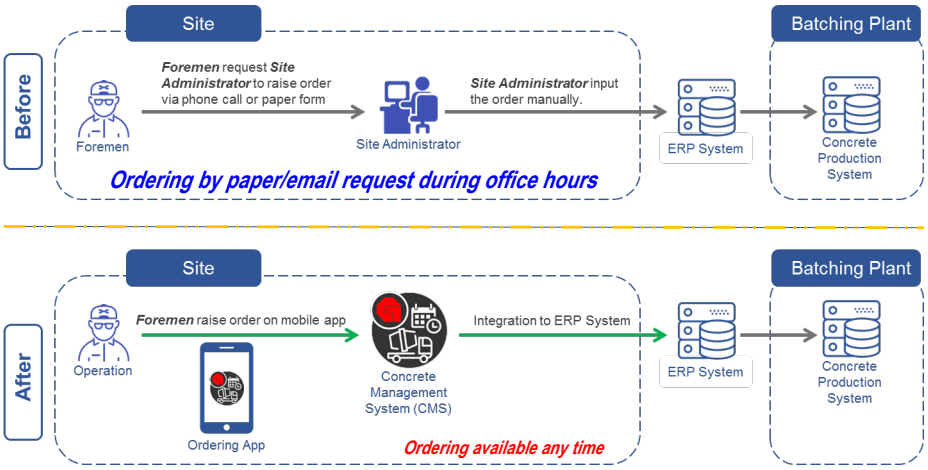
(3) CMS – Concrete Ordering



- ✓ Only approved mixes are available for ordering
- ✓ Clear, yet direct order requisition/transmission
- ✓ Readily available for frontline concrete users

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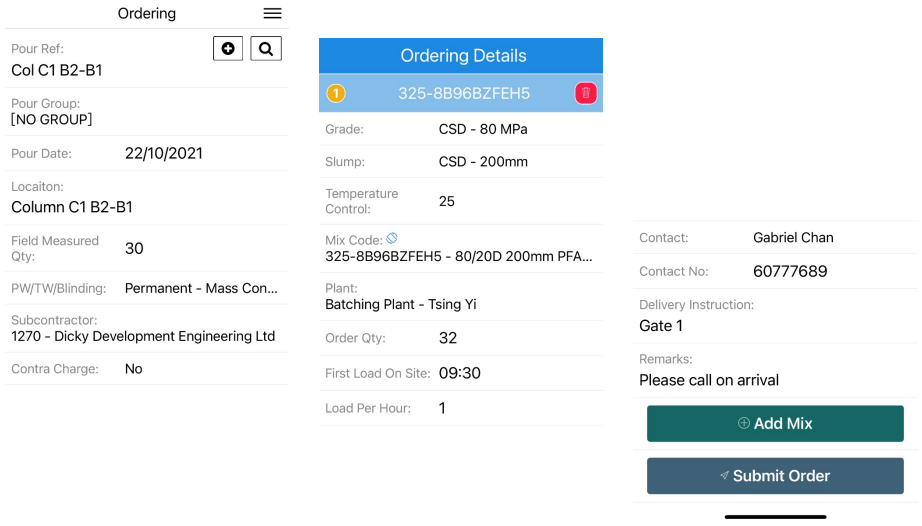
Screenshot of Concrete Ordering App



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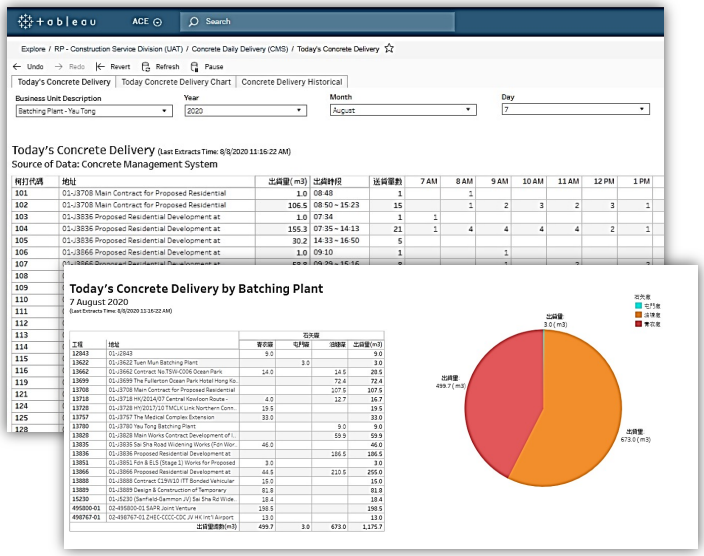
Enhancement of Concrete Delivery and Resources Planning

Dashboard for Logistic Management

CHALLENGE faced by most construction projects:
Worried on No trucks on site



Dashboard

Key members access to the concrete delivery performance report of all concrete orders whenever they need to make informed delivery arrangement.

With this new report, the limited resources can be better utilized.

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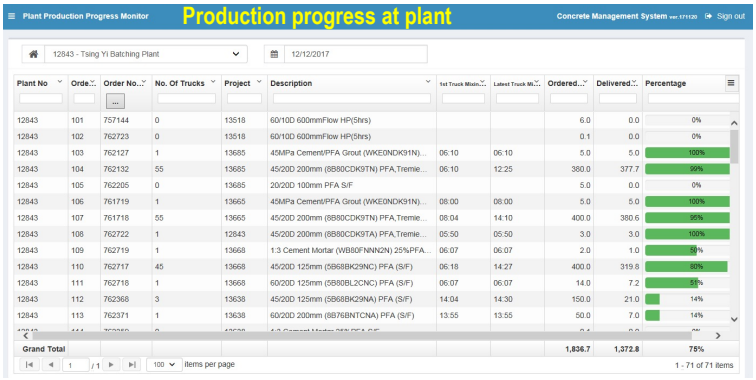
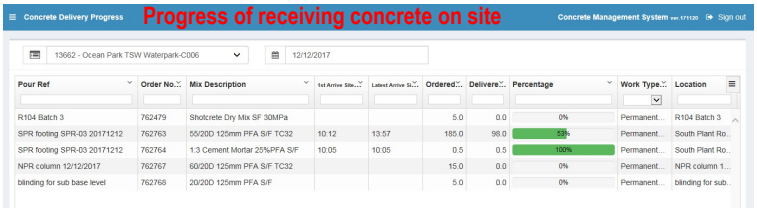
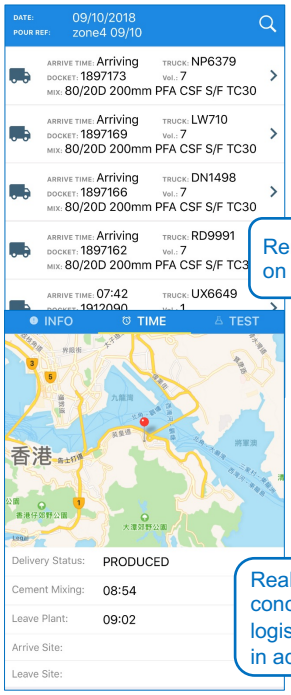
Concrete Supply Tracking







Remote monitoring on delivery status

Real-time Truck Tracking

Real-time tracking on concrete truck for site logistics arrangement in advanced

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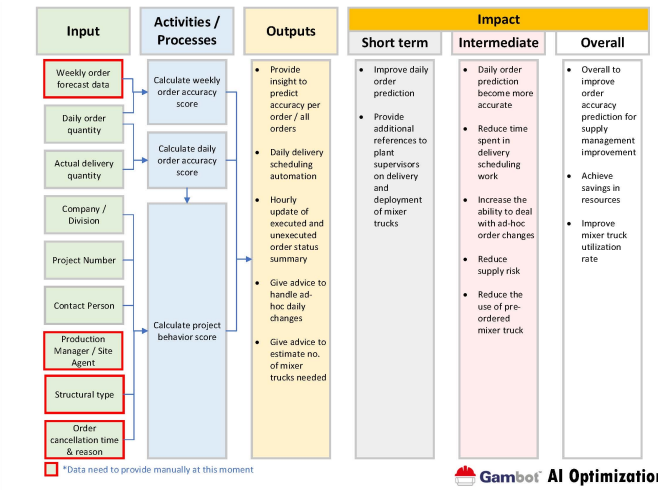
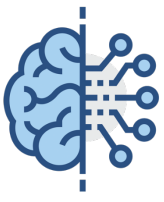
Logic Model of Concrete Order Optimization by Machine Learning





Machine Learning

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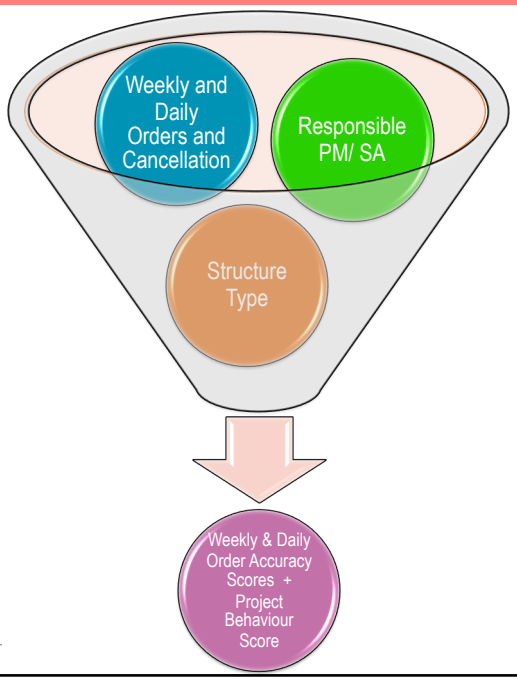
Factors considered in AI Model



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Output of AI Model

- Provide insight to predict order accuracy
- Daily delivery scheduling automation
- Hourly update of executed and unexecuted order status summary
- Advice to handle ad-hoc daily changes
- Advice to estimate no. of mixer trucks needed

More to Explore and Adopt

More to Explore and Adopt

Use of WaveScan Technology (Microwave Radar) for Non-Destructive Structural Inspection
Detection of Voids and Rebars inside Concrete

Alternative to Ground Penetrating Radar (GPR) Technology

WaveScan Technologies

(Electromagnetics based sensor solutions for safer, resilient, and sustainable cities)

- Frequency: 1-5 GHz (Shorter wavelength)
- Step size: 40MHz

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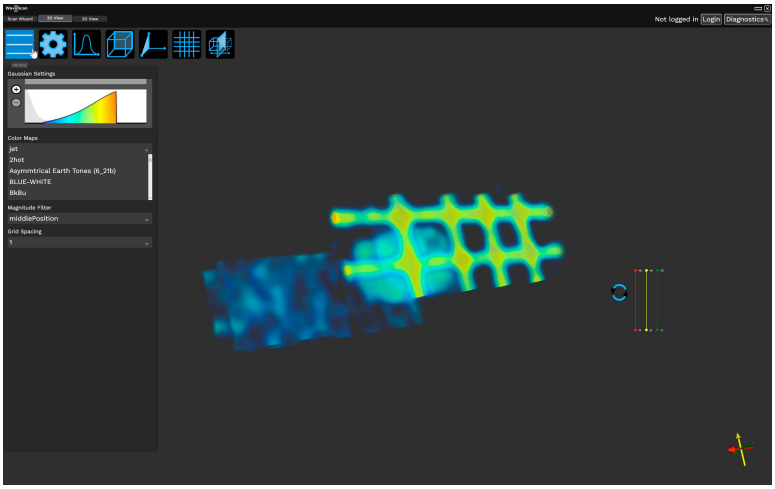
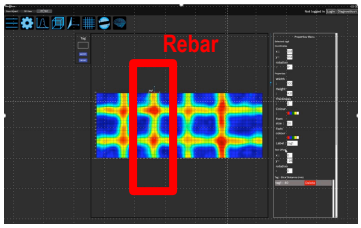
More to Explore and Adopt - Point of care (PoC) test



Software for visualization (WaveScan)

WaveScan can accumulate training data by distributing their software and gathering information about anomaly.



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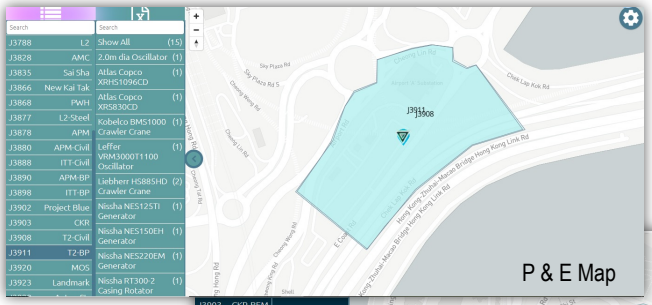
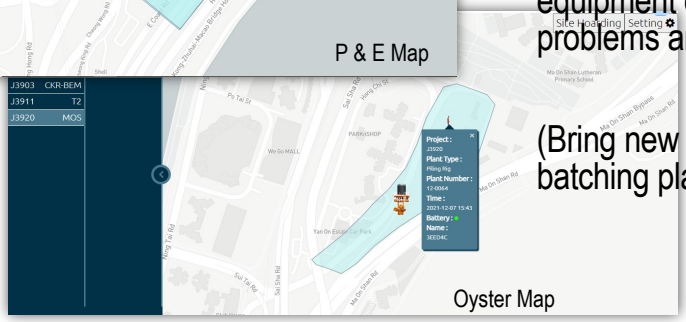
More to Explore and Adopt

Sensors Installed to Critical Plant and Equipment at Concrete Batching Plant
Instantaneous Problem Reporting to Minimize Down Time





ENVISAGE DIGITAL

Digital Project Management

Plant Equipment Management

Manage and maintain all plant and equipment on a site to prevent problems arising

(Bring new idea to our concrete batching plant)

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