

CASE STUDY

AI/ML-Driven Cement Strength Prediction and Design Mix Optimization

for a Large Global Cement Manufacturer





Executive Summary

Impact Generated: Over \$13.5 million* in global production cost savings across 50 plants, achieved through strategic clinker factor reduction, energy efficiency improvements, and 88,400 tonnes in CO2 emissions across non-European plants.



**exact point estimation is in progress; this is an approximated value realization*

Client Context

The client, one of the leaders in the cement industry, leverages the Cement Quality Monitoring System (CQMS) that provides forecasts for immediate and long-term cement strength. By identifying key variables, CQMS empowers quality managers and mill operators, enabling informed and timely decision-making in operations. Further, CQMS is powered by AI and machine learning that allows the prediction of cement strength with precision, leading to cost-effective production and substantially reducing CO2 emissions.

Business Challenge



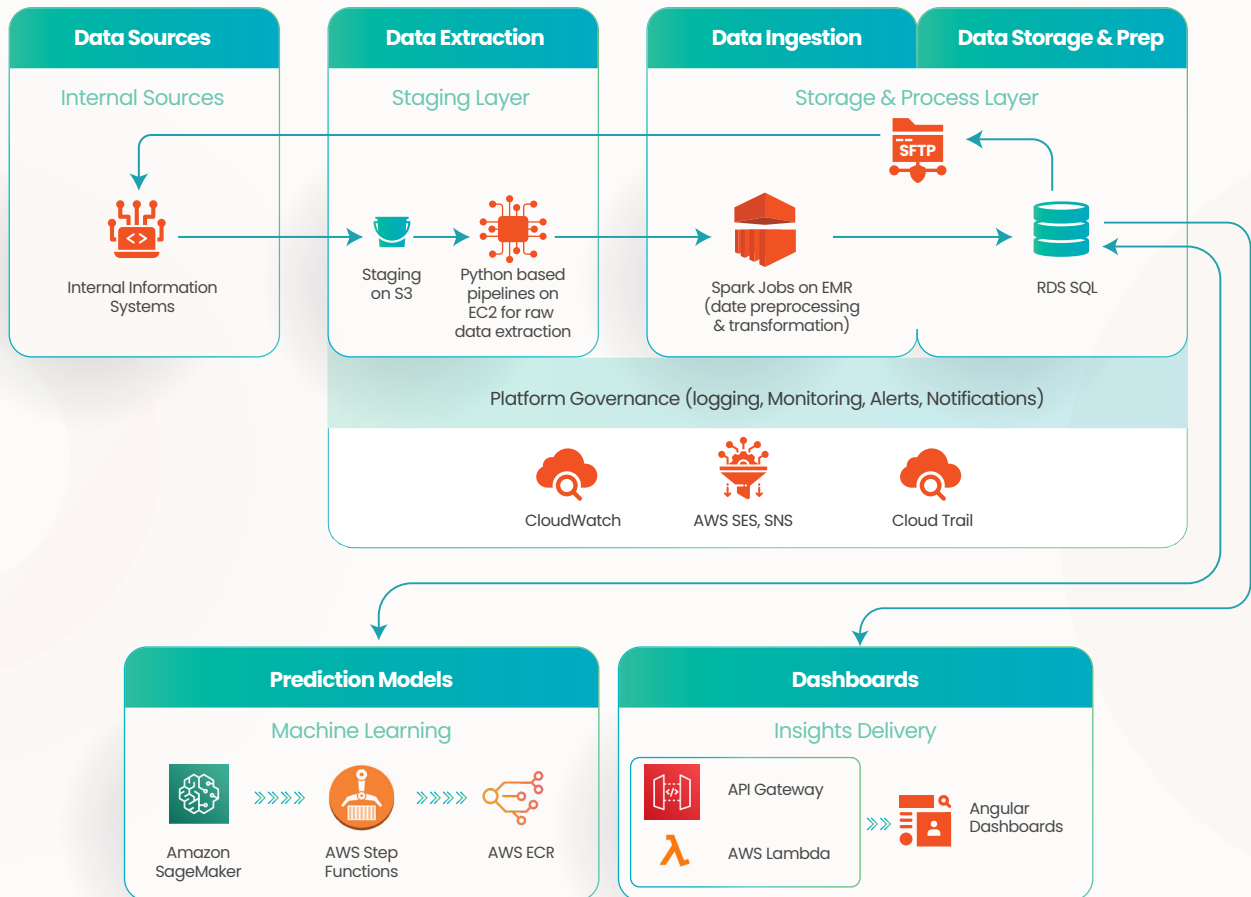
The cement production process presents a formidable challenge, demanding the seamless integration of diverse raw materials and additives through energy-intensive procedures. The overarching goal is to minimize deviations in cement quality while maintaining cost control, encompassing clinker and energy expenses. Furthermore, this challenge extends to reducing CO2 emissions, a crucial aspect of sustainable cement manufacturing.

Tredence Solution Approach

We created a machine learning-based solution on the AWS platform to offer near real-time forecasts for short-term (1d, 2d) and longer-term (7d, 28d) cement strength. These predictions played a pivotal role in stabilizing the quality of cement products, leading to reductions in the clinker factor and grinding fineness. As a result, quality managers and plant operators were empowered to make more well-timed operational decisions.

This application was developed and hosted within the Factories of the Future. It utilizes machine learning techniques to predict cement strength by analyzing laboratory results and processes. The outcomes of these predictions were seamlessly integrated into the global FIS (Factory Information System) user interface.

The tool uses AWS EMR to process the samples' data using Spark, which is stored as fact tables in the RDS SQL server after transformation. ML models are developed using SageMaker notebooks and stored as Docker images in ECR, and processing jobs for prediction are triggered using Step Functions. The Model assets, UI application code, and logs generated using Cloud Trail are stored in S3. The frontend application leverages the Lambda function fronted by the API gateway to provide access control.



AI/ML Model Process Flow



Solution Features



Comprehensive KPI Tracking:

Real-time insights by tracking critical KPIs such as CO2 emissions, electricity consumption, and clinker factor reduction to optimize plant performance.



Precision Deviation Monitoring:

Rapid and precise response to deviations between predictions and actual outcomes, ensuring operational efficiency.



Advanced Cement Strength

Forecasting: State-of-the-art prediction capabilities to forecast cement strength accurately, enabling proactive planning.



Influential Ingredient Tracking:

Continuous monitoring and optimization of the factors influencing cement ingredient performance, addressing data and feature drift for consistent quality and efficiency in production processes.

Solution Delivery

Our project's solution delivery mode unfolds through a meticulously orchestrated sequence of key steps, ensuring a comprehensive and effective approach:

1

Lake Formation

We laid the foundation by creating a data lake at the project's inception. This centralized repository is the data collection and analysis bedrock, enabling a holistic view of the cement production process.

2

Global Roll Out

With the data lake in place, we formulated a strategic rollout plan tailored to specific geographies and plants within the organization. This step ensured a customized approach, addressing each plant's unique requirements.

Phase 1

Dispatch Operations

Optimization—Cement Sample

Analysis: We concentrated on enhancing cement distribution efficiency and quality in the initial phase. This involved analyzing cement samples from dispatch operations. We aimed to predict and optimize the strength and quality of the cement during transportation and delivery.

Phase 2

Process Enhancement – Cement Production Sample Analysis:

Moving into Phase 2, we embarked on a more comprehensive journey. Here, we seamlessly integrated cutting-edge AI and ML solutions into the production processes. In this stage, we focused on the analysis of cement production samples. The objective was to predict and fine-tune cement strength and quality during manufacturing.

This staged approach facilitated a gradual adoption and adaptation, minimizing disruptions to ongoing operations. By addressing dispatch and production aspects, we ensured a holistic improvement in cement quality, efficiency, and sustainability throughout the supply chain.

3

Continuous Enhancement and Maintenance of Deployed ML Models (Optimization)

Our commitment to excellence didn't end with implementation. We established a robust framework for continuously improving and maintaining the implemented ML models. This ongoing process guarantees that our solutions remain aligned with evolving production needs and industry best practices, delivering sustained benefits in terms of quality, cost-effectiveness, and CO2 emissions reduction.

AWS Service Suite



EMR (for processing big data using the Spark framework), **RDS** (for storing the sample data as a fact table after transformation), and **AWS SageMaker** (for the development and training of ML models)



Additional Tools: S3, Lambda, API gateway, Step Functions, ECR, SNS, CloudTrail, CloudWatch

Business Impact

For the fiscal year 2021-22, we've ensured a significant business impact (~\$270,000/plant or ~£250,000/plant), with results scaled across 50 plants.



CO2 Emissions Reduction

Successfully reduced CO2 emissions by approximately 3,000 tons and 3,400 tons (ref. for a Non-European plant) (CO2 conversion factor: ~\$90/Ton) amounting to an aggregated \$ ~6.5 MM CO2 cost saving across European region (24 plants) & an additional 88,400 Ton of CO2 saving across non-European region (26 plants).



Clinker Factor Reduction

Achieved a reduction of 1% of clinker factor, amounting to around \$120,000 in cost savings (clinker conversion factor: \$33/Ton; it accounts for the additional electrical energy consumption due to grinding additives).



Variable Cost Reduction

With a reduction of £120,000 per plant in variable costs currently implemented in 50 plants, we are saving £6 MM using CQMS.

These outcomes underscore our commitment to the client's sustainability and operational excellence across the plant network with the mentioned plant.

Bottom Line: Tredence's AI/ML Expertise Drove \$13.5 Million in Savings and Enhanced Sustainability for the Client

With Tredence's invaluable assistance, the client has successfully harnessed AI/ML for cement strength prediction and design mix optimization, leading to exponential benefits. Together, we've unlocked over \$13.5 million in cost savings, orchestrated significant reductions in CO2 emissions (150,000 Tons of CO2 savings across the client network), and improved operational efficiency. This strategic collaboration has strengthened the client's financial standing and propelled it towards its sustainability objectives. Furthermore, Tredence's expertise has equipped the client's business teams with the insights to make data-driven decisions, rendering the organization more agile and responsive.

About Tredence Inc.

Tredence is a global data science solutions provider focused on solving the last mile problem in AI. The 'last mile' is the gap between insight creation and value realization. Tredence is a Great Place to Work-Certified and as a 'Leader' in the Forrester Wave: Customer Analytics Services. Tredence is 2000+ employees strong with offices in San Jose, FosterCity, Chicago, London, Toronto, and Bangalore, with the largest companies in retail, CPG, hi-tech, telecom, healthcare, travel, and industrials as clients.

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