

# HYDROCARBON PROCESSING®

HP

Construction

R. Karp, Vice President of Design Engineering Analysis, Bentley Systems

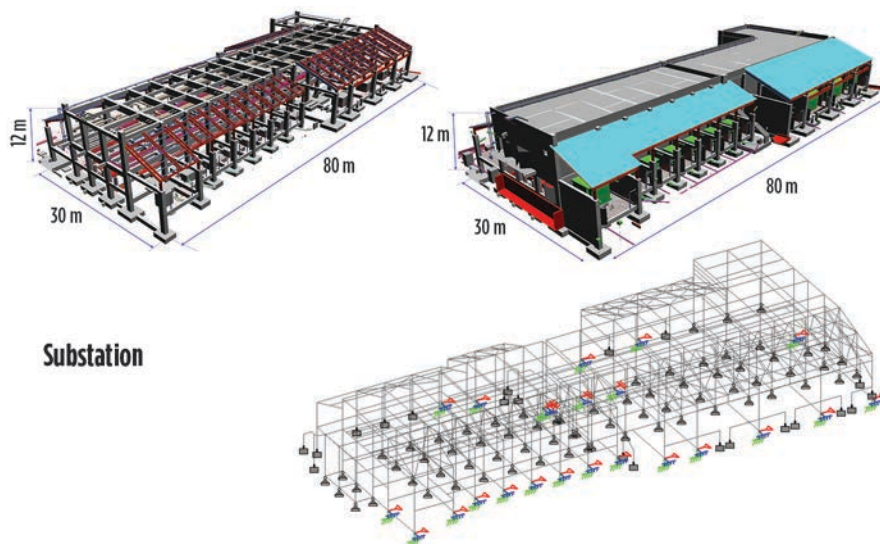
## Malaysian firm integrates engineering and analysis processes to deliver large projects on schedule

Toyo Engineering (Toyo) was awarded a contract to deliver a large-scale steam cracker complex in Malaysia. The plant is an integrated refinery and petrochemicals project that is the largest liquid-based greenfield downstream facility in Malaysia. The petrochemical complex is capable of producing ethylene used to manufacture polymers that are found in many industrial and consumer markets.

The company was responsible for the detailed engineering, procurement of equipment and materials, construction and commissioning of the facility on a turnkey basis. The scope of the project was large, with a plant capacity of 1,300 kilotons/yr requiring approximately 5,000 drawings. The concrete volume on this project was 180,000 m<sup>3</sup>, and the overall structural steel volume was 25,000 metric MMt.

Designing the complex required detailed engineering across multiple disciplines that were globally dispersed, and numerous challenges had to be overcome to ensure a successful project. The detailed engineering for this project was carried out simultaneously by five engineering offices in India, Indonesia, Malaysia, Thailand and Japan. The project team needed to complete the conceptual and detail design within a tight timeline of 18 mos. The project team realized that it must optimize its engineering analysis and ensure design accuracy, all while meeting quality requirements in compliance with strict local and European design codes. To meet these demands, the project team pioneered new methods to integrate the engineering of concrete structures with structural steel design and other disciplines (FIG. 1).

**Integrated technology streamlines workflows.** Given the sheer size of the project, the ethylene plant required complex engineering analysis for various structural elements, ranging from pipe racks and buildings to equipment and



**FIG. 1.** Toyo pioneered new methods to integrate and optimize its engineering analysis and ensure design accuracy, all while meeting quality requirements in compliance with strict local and European design codes.

associated infrastructure facilities. Different design disciplines required collaboration in real time across multiple locations in a coordinated environment to ensure standardization in the quality and formats of the deliverables. The seamless integration of structural analysis and design applications enabled the multi-discipline project team to simultaneously share synchronized model data and update designs and drawings in one integrated set of applications. Through iterative, multi-discipline design checks among the team, team members enhanced design productivity and streamlined workflows to reduce duplication of effort and eliminate errors.

The use of integrated structural design applications accelerated the entire workflow by 30% while ensuring standardization of processes and uniformity of deliverables across multiple locations. The innovative solution enhanced the consistency and quality of the designs, drawings and reports. Iterative and complex design

checks were possible with a single run. The delivery of drawings was synchronized, which resulted in a 30% reduction in resource hours. The integrated workflow also facilitated design optioneering for optimal selection of construction materials and enabled parallel work onsite to shorten construction time by 10%.

**Automation optimizes accuracy and efficiency.** The project team not only used the structural design and analysis applications to provide a collaborative work environment, but also to automate otherwise manual and time-consuming tasks. The team needed to perform checks related to sizing, design, crack width, stress levels and buoyancy, using more than 700 different load combinations simultaneously to determine the overall behavior in each of these combinations. Using an advanced concrete design application, the project team generated on-demand reports at various levels of detail to efficiently

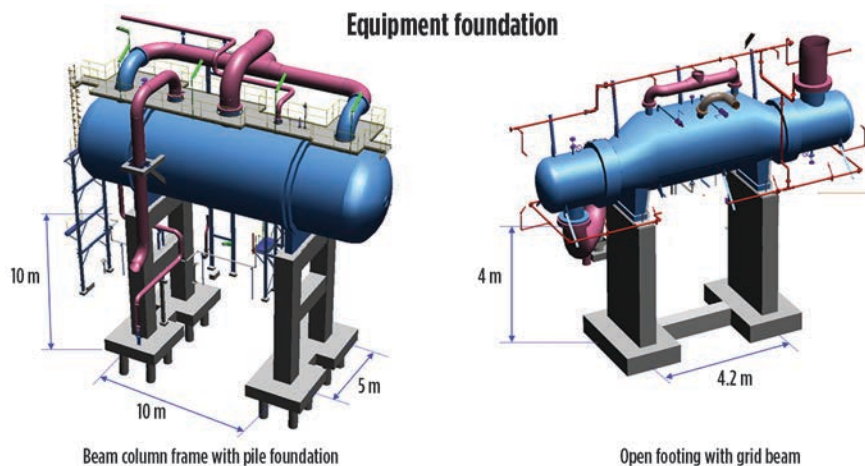
understand the concrete behavior subject to the varying loads. The project team used this cutting-edge technology to quickly define the load combinations, iteratively check the design and automatically adjust the foundation sizing in accordance with each load criteria (FIG. 2).

Like many industrial structures, the ethylene plant contained columns with transverse and longitudinal beams at different levels, requiring engineers to take specific precautions and perform tedious calculations to ensure column design accuracy. These variations were managed automatically in the concrete design application, saving significant time for engineers and minimizing potential error that might result from an otherwise manual calculation. Similarly, the team could perform design checks on the concrete to prescribed crack width limits, while ensuring the highest level of accuracy in the computations.

By designing and detailing the beams for bi-axial and axial force with the advanced concrete design application, the project team introduced top and bottom reinforcement across the length of the beam. The software checked the bi-axial behavior and automatically generated 3D interaction charts for the suggested reinforcement profile. The ability to automate engineering calculations, drawing production and report generation optimized the design accuracy and efficiency that helped the team complete the conceptual design and detailed engineering within 18 mos, and to obtain early approval by the client.

**Setting new country standards for concrete design.** One of the unique challenges was designing the ethylene complex to meet new European standards in combination with local Malaysian codes, the Malaysian Annexure. Given that European standards were new in Malaysia, there was no precedent for applying these codes, which mandated different material safety factors for different types of load combinations. The team was also confronted with the lack of available applications that catered to the Malaysian Annexure.

To overcome these challenges, the project team worked with a software development company to help develop and apply the new European standard codes consistent with local Malaysian regulations. This collaborative effort enabled the



**FIG. 2.** On-demand reports at various levels of detail were generated to efficiently understand the concrete behavior subject to the varying loads, as well as to quickly define the load combinations, iteratively check the design and automatically adjust the foundation sizing in accordance with each load criteria.

engineers to deliver the project within the tight timeframe. Using a built-in application feature for designing foundations within varying safe-bearing capacities enumerated in the European standard codes, the project team accelerated the design and eliminated potential noncompliance. The project team facilitated concrete design in compliance with the European standard codes as per the Malaysian Annexure. Members developed new European standard codes for Malaysia, delivering the first project that applied advanced engineering design codes in the country and setting new country standards for concrete design.

**Moving the industry forward.** Despite the numerous challenges, all project objectives were met. The organization delivered the conceptual and detailed design within the 18-mos timeline, and complied with European codes with Malaysian annexures. By using integrated engineering and analysis procedures, the project team showed how digital technologies can connect different engineering disciplines, revolutionizing how organizations work. Engineering, procurement and construction (EPC) companies should pride themselves on being able to produce projects in the most efficient manner, based on common work standards and a shared commitment to produce projects that meet quality, health, safety, security, environment, schedule and cost targets. This project represented high-quality work and the use of innovative technology.

BIM workflows are becoming ever more prevalent in the processes needed to deliver construction projects, such as in a large-scale ethylene complex, which was the focus of this work. Physical modeling is now a prerequisite to adopting a BIM workflow. To be successful, engineers must have the ability to create detailed concrete column rebar and foundation drawings, generated from their models. Obtaining the structural model from the physical model is key for the efficiency of structural analyses. Engineers now rely on software applications to empower them to produce safe and economical concrete designs. **HP**



**RAOUL KARP** is Vice President of Design Engineering Analysis for Bentley. He is responsible for the strategic direction and management of Bentley's structural, bridge and pipe stress analysis and design products. He previously worked for RAM International, responsible for development and product management, and

joined Bentley as part of an acquisition. Prior to this, Mr. Karp was with Degenkolb Engineers in San Francisco, California, specializing in seismic analysis and design. A native of South Africa, Karp earned his bachelor's degree from Rice University in Houston, Texas, and a master's degree in structural engineering from the University of Texas in Austin. He is a published author and has made several presentations at various conferences, including the World Earthquake Conference, the American Institute of Steel Construction (AISC) and the American Council of Engineering Companies (ACEC).