



## Project Summary

**Organization:**  
IQA Solutions

**Solution:**  
Process Manufacturing

**Location:**  
Wilmington, California

**Project Objective:**

- Design foundation for four vertical vessels ranging from 2-4 feet in diameter and up to 24 feet high
- Design foundation for two skids supporting flare and electric boxes
- Fit vessels and skids into constrained space within existing oil refinery

**Products used:**  
STAAD.foundation

## Fast Facts

- Project manager required preliminary estimate of mat foundation size early in project
- STAAD.foundation modeled 20 load cases for accurate analysis of mat load distribution
- Finite Element Analysis in STAAD.foundation sized foundation to fit, with final footings being very close to initial estimates

## ROI

- Confidence in initial design estimate resulted in a more competitive bid for company
- STAAD.foundation reduced design time by 50 percent compared to manual methods
- Foundation sized to fit reduced material and construction costs
- Accurate design reduced rework, construction delays and facility downtime

# IQA Optimizes Foundation for Four Pressure Vessels in Confined Space Using Bentley's STAAD.foundation®

The Software Reduced Design Time by 50 Percent Without Sacrificing Refinery Project Quality

## Constraints Demand Advanced Technology

Based in Long Beach, Calif., IQA Solutions (IQA) is a multidiscipline engineering firm that provides engineering and technical services for the oil and gas industry. The firm has used STAAD.foundation for foundation analysis and design work on more than 50 projects since adopting the software as a stand-alone solution about three years ago. Its benefits were clearly demonstrated on a recent project for a Los Angeles-based oil production facility, where four vertical

All four vessels were closely spaced, and because of the existing structures around them, it was not possible to have separate footings for each. The only option was to analyze and design a mat foundation using finite element analysis. Because of space constraints, the project manager needed a preliminary estimate of the size of the foundation. This estimate had to be as close as possible to the final size.

In the past, IQA had performed foundation designs using Microsoft Excel spreadsheets and manual calculations. Calculating a reasonable mat foundation size without computer-aided analysis is a very cumbersome task and would have taken days. IQA now applies advanced methodologies and technologies for tasks such as this and they are proving to be successful in reducing the cost of large capital and retrofit projects. Among these technologies are a variety of Bentley software, such as STAAD.foundation, STAAD.Pro®, and the AutoPLANT® family of products. The integration of data among these products and IQA's 3D laser scanning software has provided the company a cost-effective design and analysis solution.

*Its benefits were clearly demonstrated on a recent project for a Los Angeles-based oil production facility, where four vertical vessels had to be installed in a tightly constrained space.*

vessels had to be installed in a tightly constrained space. IQA was able to design the right size mat foundation ahead of schedule, saving the client construction time and materials.

The 450-by-240 foot facility contained existing structures in the area designated for the pressure vessels, which were an addition to a current construction project. The vessels ranged from 2-4 feet in diameter and were up to 24 feet high. IQA was retained to design the foundation for the vessels, as well as for two skids supporting flare

and electric boxes. Time was of the essence since the client was losing production time while waiting for the vessels to be constructed.



A view of the vertical foundation vessel designed with STAAD.foundation.

## Rapid Modeling in STAAD.foundation

IQA was able to create the mat foundation model in STAAD.foundation very quickly, according to IQA structural engineer Rahi Movassagh. STAAD.foundation is a comprehensive foundation design program that offers the ability to model complex or simple footings such as isolated footings, combined footings, strip footings, pile caps, and mat foundations. The software

offers various modeling options such as drawing a mat using a polyline, rectangle, circle, etc. The user also has the option to generate mat boundaries based on corner coordinates.

*“With rough economic times, our company needs to be more efficient and competitive. With the help of STAAD.foundation, we are able to save 50 percent in design time, without sacrificing quality, on almost all of our projects.”*

*— Rahi Movassagh,  
Structural Engineer,  
IQA Solutions*

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Unlike an Excel spreadsheet, where the user has to assume vessel loads are point loads, STAAD.foundation allows the user to model a circular load on the mat for better load distribution. IQA found the analysis results with circular loading to be very close to actual mat behavior. Using STAAD.foundation's state-of-the-art physical modeling system, IQA generated the entire mat mesh in just a few seconds.

Generating load combinations and analyzing the foundation for all load cases also had been extremely difficult in Excel. IQA's designers had to enlist the aid of Visual Basic programming to analyze and design for multiple load cases. Now, STAAD.foundation generates multiple load cases based on the user's choice of load combinations. There are six built-in load combination tables in STAAD.foundation, and the user can also define custom load combination tables. IQA analyzed more than 20 load cases for the mat foundation at the refinery in a short amount of time.

### Reporting and Change Management

Using a manual (strip design) method for mat foundation analysis, results are approximate. In most cases, manual methods result in a conservative design—one that takes more space than necessary. At the oil production facility, conservative results would not have been helpful because space constraints dictated a compact design.

To achieve the optimum solution for the mat foundation, IQA used STAAD.foundation to perform finite element analysis (FEA), said Movassagh. Results from the FEA of thousands of plates were converted to the global (mat) axis from the local (plate) axis. With the help of moment envelope generation, designers were able to specify the direction of reinforcement. Once analysis was performed STAAD.foundation automatically generated the mat reinforcement zone, which was editable.

STAAD.foundation generated calculation sheets for the mat foundation, along with code references. The calculation sheets met industry standards for reporting, and IQA used the direct print out of calculation sheets as part of the final calculation report for the foundation design.

Changes in loads or geometry constraints can have a huge impact on foundation design. During the days of manual design using Excel, incorporating the changes was a lengthy and laborious process. STAAD.foundation accommodated changes very quickly, as both geometry and loadings could be easily changed.

### Design Time Reduced by 50 Percent

Working under rushed conditions, Movassagh gave the client a shorter than normal timeframe for delivering the preliminary estimate and final foundation design. As it turned out, the initial estimates were very close to final footing sizes. Because Movassagh was confident about the initial foundation sizes, IQA's bid was more competitive. Producing the final design using STAAD.foundation took less than 50 percent of the time it would have taken using manual methods. IQA also saved considerable material using STAAD.foundation, because the mat was right-sized rather than a conservative size.



*This image captures the 4-foot diameter vessel after installation.*



*A construction crew places the vertical vessel foundation design using Bentley software.*



*A rendering of a vertical vessel with foundation designed in a confined space.*

Using STAAD.foundation has enabled IQA to be more efficient and competitive on all its projects. The software cuts design time in half without sacrificing quality. The firm is also able to give quick and precise initial estimates that are very close to final footing sizes, which helps IQA bid with minimal contingency on foundation design and material cost.

### Benefits of 3D Integration

In general, Bentley's integrated solutions have enabled IQA to import 3D models from various applications (piping, structures, equipment) and view the models as an integrated whole. Data sharing among designers has improved, and revisions are made more quickly. As a result, rework has been reduced.

*“With rough economic times, our company needs to be more efficient and competitive. With the help of STAAD.foundation, we are able to save 50 percent in design time, without sacrificing quality, on almost all of our projects,”* Movassagh said. In addition, Bentley solutions are easy to administer. *“It is a significantly less complicated system in comparison with other products. AutoPLANT and STAAD products can be managed effectively by engineers without a system administrator.”*