



## Project Summary

### Project:

Apollo Tyres Limited

### Organization:

Aswathanarayana and Eswara

### Project Objective:

- Design a new plant approximately 60 kilometers from Chennai on a 126-acre plot. The project has a built area of 167,226 square meters across nearly 30 buildings, including a complex structure measuring 160 meters wide by 77 meters long by 30 meters high.
- Net sales for 2009-2010 were Rs.22 billion, and its total investment in this expansion project is about Rs.2000 Crores or U.S. \$4.7 billion. Its investment in the Banbury building alone is about 60 Crores or U.S. \$13.5 million.

### Software Used:

STAAD.Pro®, STAAD®.foundation, RAM® Concept

## Fast Facts

- Firm saved 50 to 60 percent in foundation design time and achieved savings in materials of 12 to 15 percent using STAAD.foundation software
- With the help of STAAD.foundation, Aswathanarayana and Eswara was able to efficiently design 120 supports with more than 50 load combinations assigned to each support
- Integrated design flow between STAAD.Pro and STAAD.foundation helped engineers sort through a huge amount of foundation data
- Time savings of approximately 80 hours per month over a six-month period
- The firm used STAAD.Pro to analyze the massive models the project required, and used the advance solver to shorten analysis time on the model and other similarly sized

# Apollo Tyres Limited

## STAAD.foundation Provides Comprehensive Foundation Design

### Accommodating Heavy Loads Proved Challenging

Apollo Tyres Limited, India's largest automotive tire manufacturer, is building a new plant on a 126-acre plot, approximately 60 kilometers from Chennai. The entire project has a built area of 167,226 square meters and includes 30 buildings. Among them is the Banbury building, a complex structure measuring 160 meters wide by 77 meters long by 30 meters high. The consulting and engineering firm of Aswathanarayana and Eswara was awarded the structural work for the Banbury and faced some difficult challenges in its design, including the need to accommodate very heavy loads at substantial heights. The firm successfully addressed these challenges and accrued significant material, cost, and time savings – including 50 to 60 percent reductions in foundation design time – with the help of Bentley software.

Apollo Tyres manufactures a broad range of automotive tires for ultra- and high-speed passenger car, truck and bus, farm, off-road, industrial and specialty applications such as mining, retreaded tires, and retreading material. These are produced in Apollo's eight manufacturing locations in India, Netherlands, and Southern Africa. The company's net sales for 2009-2010 were Rs.22 billion, and its total investment in this expansion project is about Rs.2000 Crores or U.S. \$4.7 billion. Its investment in the Banbury building alone is about 60 Crores or \$13.5 million.

Aswathanarayana and Eswara used STAAD.Pro, STAAD.foundation, and RAM Concept for the Banbury's structural design. STAAD.Pro is the world's leading structural analysis and design software. STAAD.foundation is a comprehensive foundation design program enabling structural engineers to model complex or simple foundations. It designs common foundations (such as isolated, combined, strip, pile caps, and mat foundations), plant specific vessel foundations and tower foundation. RAM Concept provides finite element-based analysis to facilitate the design of reinforced and post-tensioned concrete slabs and mats.

### Real-World Challenges

The Banbury is a largely concrete and steel composite structure with areas composed completely of concrete. It is used to mix ingredients, including silica, carbon, and rubber, in the right proportion in preparation for further processing.

"To ensure the mixture is blended in a particular way, which is driven by high process requirements, the building had to be tall," said H.E. Sriprakash Shastry, a partner at Aswathanarayana and Eswara. "Several of the ingredients in the process need to be stored at a great height and are then fed into a mixer at a certain pressure. Large steel bins are used to store materials like carbon and silica at different heights, and this contributes to the heavy loads on some of the upper floors."

Because the structure is a mixture of concrete and steel, designers worked to ensure the two materials act together under various load conditions, such as wind and seismic load. The Banbury building alone required 16 types of footing and 120 footings in total. The building has several heavily loaded floors with a maximum floor load of 3.5 tonnes per square meter.



*Mat foundation ready for formwork to be removed*

### Merging the Structural Model with the Foundation Model

The foundation design required 120 support positions and more than 50 load combinations. This task typically involves the selection of critical load cases and identification of suitable footing types, depending on various site conditions. Because the structure was so large, it even needed a combination of flexible and rigid foundations.

The firm used STAAD.Pro to analyze the massive models the project required, and used the advance solver to shorten analysis time on this and other similar-sized models.

*"This one feature saved us hundreds of man hours sorting through massive amounts of foundation data to identify critical loads on the foundation"*

— H.E. Sriprakash Shastry

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The ability to integrate STAAD.foundation and STAAD.Pro enabled the engineers to automatically merge the structural model with the foundation model, to sort through a huge amount of foundation data and identify critical loads on the foundation.

"This one feature saved us hundreds of man hours sorting through massive amounts of foundation data to identify critical loads on the foundation," said Shastry.

STAAD.foundation was also useful in designing the isolated, combined, and mat foundations (using finite element analysis) comprising the foundation system for the entire building. It enabled engineers to create a mat for an entire row of steel columns. Moreover, STAAD.foundation allowed the mats to be flexible foundations resting on the ground. Said Shastry, "Its expertise was clearly visible in the design of the large mat that supports the tower area, which is 30 meters tall."

With the help of the General Arrangement drawing module, footing overlaps were identified and a different type of footing was designed in the same environment using existing controlling parameters. Overall, 16 types of footings were designed, making sure there were no interferences.

Aswathanarayana and Eswara were able to create final design reports by exporting the calculation sheet in a custom Microsoft Word format. The calculation sheet output produces step-by-step calculations with relevant clause numbers and equations. "The calculation sheets in STAAD.foundation are very handy," said Shastry. "The program gives the calculations so precisely with the clause numbers from the code that there is no question regarding accuracy."

With the help of STAAD.foundation, Aswathanarayana and Eswara was able to go through more than 50 load combinations. Without this software, said Shastry, this

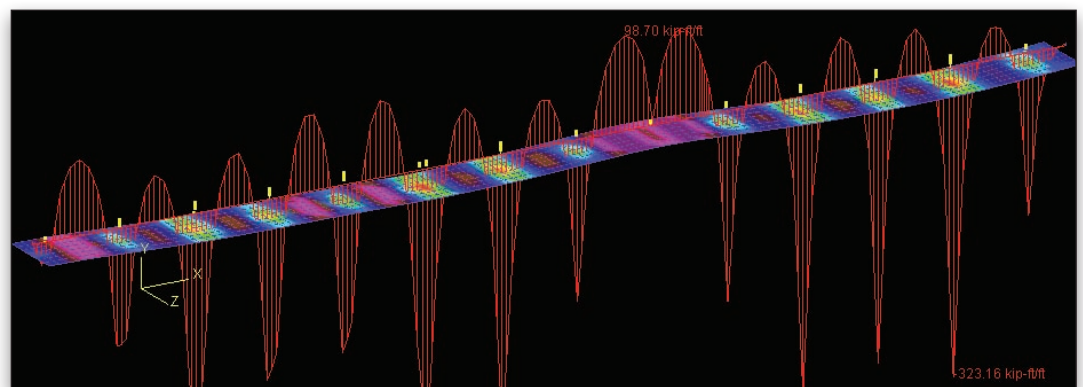


*Six feet deep mat foundation rebar cage ready for concrete pouring*

would have been a "next to impossible" task. "We are also avoiding manual errors by using STAAD.foundation," said Shastry. "STAAD.foundation technical support is very quick and responsive. No matter what, we typically have an answer to a query within 24 hours."

### **Material, Cost, and Time Savings**

"In terms of the entire superstructure," said Shastry, "with the help of Bentley software we added a lot of value and saved close to Rs.1500 (or U.S. \$33) per square meter in member sizing and allocation of rebar." In addition, because of the automatic footing size and reinforcement optimization, Aswathanarayana and Eswara achieved savings in materials of 12-15 percent, plus time savings of approximately 80 hours per month over a six-month period. In general, the firm saved 50 to 60 percent in foundation design time using STAAD.foundation software.



*Moment diagram along length of 16 column mat foundation. Moment diagrams are extremely useful graphical representation to study mat behavior under different loading conditions.*