

A case study on statue of unity: Engineering practices and challenges

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Abstract

The Statue of Unity, the Tallest Statue in the world, is a tribute to Sardar Vallabhbhai Patel's life, a role model of unity and statesmanship in India. The Statue is built in honour of Sardar Vallabhbhai Patel is dedicated to the nation. The Statue of Unity is a colossal statue of Indian statesman and independence activist Sardar Vallabhbhai Patel (1875-1950) who was the first home minister of India and the chief adherent of Mahatma Gandhi during the non-violent Indian Independence movement. Environmental law refers to rules and regulations governing human conduct likely to affect the environment. It reflects the legislative measures, and the administrative and judicial structures to protect the environment. The project includes a canopied bridge to the island, a visitor's centre, a hotel with a conference centre, a transit centre, and a 3.5 km road from the nearby town of Kevadia. This project was launched in 2010 as a public-private partnership model and was completed in 2019. This paper presents the Engineering practices and Challenges faced in building the statue.

Keywords: Statue of Unity; Larsen and Toubro; Radio Frequency Identification Technology; Environmental Law; Public-Private Partnership.

1. Introduction

Standing at 182 meters tall landmark statue dedicated to the visionary leader, which is twice the height of the Statue of Liberty, the Statue of Unity in Gujarat rises on India's western shore as the pride of the nation built on a budget of Rs. 2,989 Crore. Constructed by Larsen and Toubro (L&T), the Statue of Unity is located on Sadhu Hill on the banks of the Narmada in Gujarat.

Table 1 Key Features of the Statue

Project cost	Rs. 2,989 crore
Project duration	33 months
Project management effort	1058 (person-month)
Employment generated	Nearly 8000+ employed for four years
Amount of concrete used	180,000 cum
Amount of reinforced steel used	18,500 tonnes
Amount of bronze used	1700 tonnes + 1850 tonnes for cladding

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The statue towers over another engineering marvel, the Sardar Sarovar Dam, and has already become a draw for tourists from across the country. The project was the winner of PMI India's Project of the Year in the large category in 2019. The statue of unity is not only it is now a pride of the nation, but it has also now become a source of employment and income generation for the local community through the boost the Statue has provided in the region. Construction of a statute of this magnitude was one of India's unique projects in recent times. The project is grand in terms of the size of the Statue and the challenges it posed for the engineers, government, local community, and the environment.



Figure 1 Statue of Unity, the Tallest Statue in the world – Sardar Vallabhbhai Patel

2. Unique challenges

When L&T took over the project, the team knew one of the biggest challenges would be to bring out the finer details – the facial expressions, folds in the garment, orientation, and posture. But these were important facets for the sake of authenticity and accuracy. It meant a fusion of art and engineering on an unprecedented scale. It required engagement with non-conventional agencies, like sculptors and historians, and going through huge archives of Patel's photographs before zeroing in on the look. The final posture of the statue, in which one leg is ahead of the other mimicking a walking stance, also creates significant challenge. It meant that the statue couldn't have one strong, wide base, which is the norm in tall statues for protection against wind speed. After several rounds of discussions, the design engineers opted for two giant columns to pass through both the legs of the statue to make it stable, without compromising on the aesthetic aspect.



Figure 2 Construction Phase of the Statue

Since it was a highly publicized project of national significance, the teams had to work closely with the government authorities on design approvals. Verification of design documents resulted in an increase in approval time from the

contractual 21 days to 45 days. This adversely affected the project schedule and required the engineering contractor to deploy additional resources to mitigate the delays. L&T also battled high attrition of workers at the beginning of the project. This was due to the remote location of the project site in a tribal area.

Some of the key engineering challenges L&T faced were:

- Working within the river bed on a hilltop
- Environmental clearance to protect the aquatic and wildlife population in the area
- The statue's stance and orientation
- Building a high speed lift and emergency stairs inside the legs of the statue
- Maintaining the strength and stability without compromising on the aesthetics.

3. Design and Technology inside the Project

Design innovation, advanced technology, and lateral thinking were applied at every stage as the prestigious project but there was a no chance for any errors or delays. The statue required 6,500 bronze panels of different sizes, shapes, and textures to be assembled. Bronze of minimum thickness was used in the panels to keep the total weight in check. Using the Radio Frequency Identification (RFID) technology, the team tagged each bronze panel with details such as casting date, inspection status, and its location, and fed that data into a master database. This will enable engineers to easily retrieve data on each panel at any time with the help of an RFID detector gun and an android phone.

Two 200-tonne tuned mass dampers, which are devices used to reduce the impact of vibrations during an earthquake, were installed. That makes the statue earthquake resistant.

L&T has used special concrete to strengthen the core of the statue comprising the two legs. Indigenous technology was used to generate self-compacting cold concrete which measured less than 15 degree Celsius. This was accomplished using chilled water and ice flakes. This concrete was then poured at a high speed, which was faster than that used during the construction of the BurjKhalifa in Dubai.

Some of the best practices applied were:

- Building Information Modelling to prepare 4D reports for creative monitoring /approvals.
- CCTV cameras, drones, and time-lapse photography for overall view of the project site.
- Mobile android application like L&T's Pro-Cube for progress monitoring
Digital software for project documentation.
- WhatsApp for daily progress monitoring and follow-ups with the site team.
- Barcoding of drawings that allows users to see 3D images of the drawings on their mobile phones.

3.1. Wind and Earthquake

Natural factors such as earthquakes and wind posed stiff challenges in the construction of the statue of unity. Since the statue of unity was located right in the middle of the river Narmada, it was exposed to the tunnel effect of winds blowing down the river. After analysing the wind pattern data over the years, researchers identified that the wind speeds of 130 kilometres per hour (roughly translated into 39 meters per second) could topple the statue in a worst-case scenario. To address this, issue the Statue of Unity has been engineered to withstand the wind speeds of around 180 kilometres per hour. The challenge in the construction of unity was not just about the wind blowing against the statue but also about the succession effect created at the back of the statue. This aspect was also considered in the structural design of the statue of unity.

The Statue of Unity could easily survive an earthquake measuring around 6.5 on the Richter scale within a radius of 12 kilometres and at a depth of 10 kilometres.

3.2. Risk Management

The engineering and construction team, along with the architects, the sculptor, and a reputable global consultant have completed the project in record time. The commitment to the scale, speed, and quality of their engineering has yielded a desirable outcome, which is not only structurally superior but aesthetically appealing as well. Since it was a highly publicized project of national significance, the teams had to work closely with the government authorities on design

approvals. Verification of design documents resulted in an increase in approval time from the contractual 21 days to 45 days. This adversely affected the project schedule and required the engineering contractor to deploy additional resources to mitigate the delays. L&T also battled high attrition of workers at the beginning of the project. This was due to the remote location of the project site in a tribal area that lacks good infrastructure and amenities.

4. Conclusion

The Statue of Unity is a true feat of engineering. It honours the engineering prowess of India. The architects, engineers, and skilled workers who built this massive work of art with intricate designs have garnered a great deal of praise. We are honoured to have the world's highest statue in our nation.

The Statue of Unity is a representation of strength and unity. It captures the robust and powerful nature of Sardar Patel's actual personality. The public and those in positions of authority have both endorsed and praised PM Modi's idea. According to PM Modi, the people of our nation can draw inspiration from this statue.

Compliance with ethical standards

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Disclosure of conflict of interest

The author has no clash of interest with any person in connection with the research topic, results and research tools with other authors.

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