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DESIGN AND CHALLENGES IN HIGH-RISE STRUCTURE: OVERVIEW OF STATUE OF UNITY

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Abstract: This paper is aiming to provide through review on today's high-rise sustainability structures with an outlook to future projects. High rise buildings, tall buildings, colossal statues and skyscrapers are a daily discussion of scientific and public discussion, however there is no globally accepted, crystal clear definition connected to any of these terms. A higher demand for high-rise buildings worldwide, relatively recent advances in concrete technology and developments in construction methods has led to an increasing number of reinforced concrete super tall and mega tall high-rise buildings being constructed. Special attention is required when making use of concrete in these buildings. Stringent performance requirements, careful design of mixes required and numerous construction considerations that must be taken account of. In an effort to better understand the use of concrete in high-rise buildings. A case study provides in order to highlight of 'Statue of Unity' design and sustainability. Rough quantitative results of life cycle energy analysis and life cost analysis.

Keywords: High-Rise Building, Tall Building, Colossal Statue, Skyscrapers, Design Life, Analysis

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INTRODUCTION

The statue of unity is a tribute to the man who united India, Sardar Patel. The one who won over British leaders in the satyagrah of the kheda and bardoli, Sardar Vallabhbhai Patel was the Bismarck of the modern India, who led the welfare of the farmers. He is renowned as the architect of the independent India, as he united all diverse 562 princely states to built one great republic of India. It is located on the river island facing the sardar sarovar dam on the river



Narmada in kevadiya colony, 100 kilometres (62mi) southeast of the city of Vadodra.

(<https://en.wikipedia.org>)

Figure 1 Location of Statue of Unity

(www.mapsofindia.com)

According to senior Sardar sarovar Narmada nigma limited (SSNL) official, the Gujarat Government initially hired an American consultant who commissioned sculptor Joseph Menna to create the statue of unity's first digital proof-of-the-concept model. However, once they realised that Menna's model was an adaptation of Ram Sutra's statue of Patel at Ahmedabad airport, the government directed L&T to avail the services of Sutra himself. There it was designed by Indian sculptor Ram V. Sutra who graduated from the Prestigious J.J School of Art in Bombay. He is recipient of Padma Bhushan in 2016 and Padma Shri 1999 for his contribution in the field of art. (<http://www.quroa.com>).

Before foundation the geotechnical techniques applied, the stone is removed in the levelling process is used as a backfill where the hillock edges need to be built up edges of the hillock supporting the podium. Hillock has several fracture phases that have been detected which remediation, via epoxy or grout injections and grouted anchor rods by borwells to check strata. Hillock base is levelled for the foundation mat. The foundation mat sits on strong rock is not required but the rock anchors to take the localized tension are required. For the average bearing strength of the rock was about 2500 KN/m² which is more sufficient to support the statue and the associated lateral force and the gravitational force. (<http://global.ctbuh.org>)

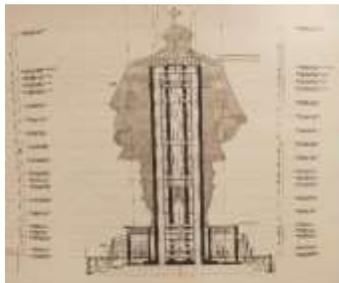


Figure 2 Geological Site (indianexpress.com)

The lidar survey is done for the site selection. Lidar is a surveying method that measure distance to a target by illuminating the target with pulsed laser light and measuring the reflected pulses with the sensor. The lidar is used to scan buildings, rock formations, etc., to produce a 3-D model. The laser beam is used to measure the distance to the first object path.

The project comprise the 182 meters tall statue of shri sardar vallabhbhai Patel a 3.5 kilometres highway connecting sadhu island to kevadiya, a hotel , a convention centre , a memorial garden and a visitor centre. The statue contains a viewing gallery at the 153- meters elevations, which can accommodate up to 200 visitors at time and offer expansive view of the dam and the surrounding environment. (<http://deshgujarat.com>)

Figure 3 Plan of Statue of Unity (www.quora.com)



OBJECTIVES

The statue of unity, apart from being a symbol of nation pride, and the integration is also a tribute to India's engineering skills and project management abilities. Local tribal belonging near there who are opposed land acquisition for development of tourism infrastructure around the statue. They offered cash and land compensation, and have been provides jobs.

MATERIALS AND METHODS

A. Material

For the construction of the statue 210,000cum (7400000 cu ft.) cement concrete is used and 6500 tonnes of structural steel is used and 18500tonnes of reinforcement steel and for the

outer façade 1700 tonnes bronze plates and 1850 tonnes for bronze cladding. (<https://www.Intecc.com>)

The ordinary Portland cement is used of the 53grade, the concrete grade is M65 with the strength of the 65KN/m². The concrete is supplied by two site batching plant of 56 cum per hour capacity cement is of uptratech brand. The structural steel is supplied by the Tata steel and SAIL. The entire steel work of supply and installation was sub contracted to M/s eversendai (Malesian Company). The rebar are supplied locally by the Loha Campaign where the iron tools are collected from the farmers across India and melted and converted into the rebar's for the use of the foundation. (<https://www.Intecc.com>)



**Figure 4 (a) Beinging Work of Statue of Unit (b) Bailey Bridge
(www.moneycontrol.com)**

For the transportation of the materials and the workers access two bridges are constructed one is built up rock bridge which is constructed at normal flood level for the worker access and second one is constructed above high flood level which consist of two lanes, one is for vehicles and material movement and second for the worker access. Bailey bridge is a temporary structural steel. The bridge is joining sadhu hill to existing road. The diameters of reinforcements is 8mm, 12mm, 16mm, 20mm, 25mm, 32mm etc. plasticizer are used is of BASF brand for the protection against the effect of weathering and temperature and helping to maintain the product functionality.

B. Construction techniques

The statue of unity is the irregular structure, on the all the four corners the raft foundation is done of size 34m*44m*3m. Raft foundation the thick concrete slab reinforced with the steel which covers the entire contact area of the structure like a thick floor. The 4354cum of concrete is poured in continues 132 hours from the 15/12/2015 to 20/12/2015.

812MT bars reinforcement are used for the raft foundation. The workability of concrete is very much, reinforcement was used in huge amount and aggregate is not more used than 10mm for foundation concrete and the slump is 150mm.



Figure 6 Raft Foundation Details (deshgujarat.com)

The embedded structural steel shapes within the concrete core with the bolted connections. The cylindrical cores houses the lifts and stairs are constructed. The construction of the core Walls they used the jump from formwork system which is designed by M/s PERI. The units is individually lifted off the structure and relocated at the next construction level using cranes. They used luffing cranes of 16-20 MT capacity with boom lift of 50m for the installation Steel and bronze at that height. The diameters of core wall at outer ellipse is 8m*11m and at Inner ellipse is 6m*9m and the thickness is varying form 0.6m to 1.2m.

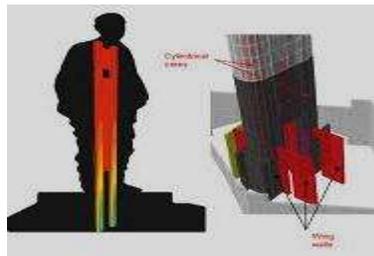


Figure 7 Wing Walls (global.ctbuh.org)

The diameter of the Cores is taken as the extent of the leg diameter.

Wing wall is a smaller wall attached or next to a larger wall or structure. The wing walls is constructed for better stiffness and both the cores behave same and homogenous during earthquake-coupling walls are added to increase the stability and the stiffness.

Cladding is the requirement of the sculptor that the statue must look like exact sardar Patel as per client requirement. Minimum cladding bronze thickness is 8mm for the design life of 100 years minimum. 8-10mm joint are kept intentionally by the designers for the expansion and contraction of bronze metal Marco panels for thermal stress. In the cladding the load transfers from bronze to steel to concrete cores to foundation to sadhu hill. All steel to steel and steel to Bronze connection is bolted. (<https://www.michaelgraves.com>)



Figure 8 Cladding Work (indianexpress.com)

Wind is the critical factor in the design of super-tall structure, the statue is shaped so as to minimize the wind force the statue. Structural simplicity and constructability is also key drivers of the design. For the lateral loads due to wind they did the wind tunnel study with full scale mock up with bronze panel almost up to 10 story height with the help of jetting propeller. (<https://www.sciencedirect.com>)

For the statue of this height and shape, wind force acting on the cladding is not accurately predicted using standard code tables or formulas. The codes recognize and permits the determination of loads by means of specialized wind tunnel testing. The testing takes into account specifics of building geometry, local climate and surrounding details.

The statue basis raised above the design flood level of 56+ meters to prevent against flood loads. Additionally flood loads to 63+ meters in monsoon season is significant to the overall Structural lateral design.



Figure 9 Statue of Unity
(www.quroa.com)

RESULT AND CONCLUSION

The project was first announced in 2010 and the construction of statue started in October 2014 by lasern and toubro and other partners in consortium, apart from US-based turner, include Michael Graves and associates, also from US, and mind heart from Germany. The contract received for 2,989crore. (<https://www.michaelgraves.com>)

The statue of unity is much larger replica of a statue of the leader installed at Ahmedabad international airport. The expression, posture and the pose justify the dignity, confidence, iron

will as well as kindness that his persona exudes. The head is up, a shawl flung from the shoulders and the hands are on the side as if he is set to walk". Three models of the design measuring 3feet (0.91m), 18feet (5.5m), and 30 feet (9.1m) were initially created. Once the design of the largest model was the approved, a detailed 3D-scan was produced which formed the basis for the bronze cladding cast in the foundry in china. The monument is constructed on a river island named sadhu Bet, 3.2 km away from the facing the Narmada dam downstream. The statue and its surrounding by 12km long artificial lake formed by the garudeshwar weir downstream on the Narmada River. (<https://indianexpress.com>) For HVAC (heating, ventilation and air conditioning) system-3 chillers and 2 cooling towers are constructed to cool the entire facility from 37.78°C to 32.78°C and for environmental comfort.

The statue base also stands above the highest flood level recorded over a 100-year period of the nearly Narmada dam. A detailed hydrological study was conducted by a specialist consultant to ascertain the river level and the flow during various conditions.

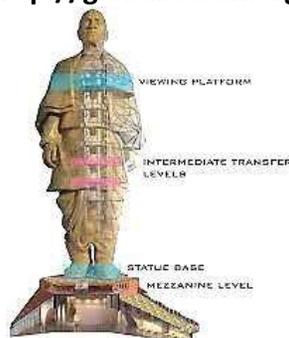
Altogether, the statue is divided into five zones. Up to its shin is the first zone, comprising three levels, including an exhibit floor, mezzanine and the roof. It will contain a memorial garden and a large museum.

Zone 2 extends up to the statue's thighs at 149 meters, while zone 3 goes up to the viewing gallery at 153 meters.

Zone 4 and zone 5 would be out of the reach of the visitors, with the zone 4 comprising the maintaince area and zone 5 the head the shoulders.

The viewing gallery will be accessible through two elevators located in the statue's core with a carrying of 40 peoples each. The gallery, with space to accommodate up to 200 peoples at a time, will have a view point where Madhya Pradesh, Gujarat and the Maharashtra meet. Visitors can also get a distant view of the sardar sarovar reservoir, and 12km along the garudeshwar reseriover the latter will help ensure there is always water around the statues, which is located from the Narmada dam.

Figure 10 plan of statue of unity
(<http://global.ctbuh.org>)



In the lobby area at the entrance of the statue, a museum and audio visual gallery will features 15 minutes presentation on the life of the Patel and the tribal cultural of Gujarat. (<https://www.thehindu.com>)

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