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6. Kohima Television Tower (India)

Owner & Architect: *All India Radio, New Delhi*
Engineer & Contractor: *Gammon India Limited, Bombay*
Construction: *1986*

Structure

It is a 100 m high RCC-cum-steel TV transmission tower at Kohima, Nagaland, north-eastern state of India, which consists of a circular RCC shaft 57.56 m high above ground level and a 42.44 m high galvanised steel mast over it (Fig. 1). The external diameter of the shaft is 11.5 m at the base, tapering to 5 m at the top. The steel mast on which are mounted TV and FM antennae for II and III Bands, are fixed to top slab of the RCC shaft by high strength friction-grip bolts. There is provision in the design for a future extension of the steel mast by 23 m for installing Bands IV and V antennae. A spiral steel staircase with precast concrete treads is provided within the shaft for access up to 49 m level. The accessories to the tower include two projecting platforms at 33 m and 49 m levels where micro-wave dishes are mounted, aviation obstruction lights, lighting, and lighting protection system.

Design

The tower is designed for dead loads which include weights of various antennae fixtures and micro-wave dishes. Wind force forms the major external applied loading in the design of the tower, and the basis for calculation of wind pressures is the Indian Standard Code of Practice IS:875-1964. The tower is designed for a basic wind pressure of 1.5 kN/m^2 up to 30 m height, and there above increasing in value with height, with a maximum pressure of 1.99 kN/m^2 at the top. These pressures are enhanced by 10% considering gustiness and 100 year return period of the wind. Besides these wind forces, additional wind loads acting on the antenne panels are considered which amount to 100 kN for the Band II panel, and 70 kN for the Band III panel. The drag coefficient used is 0.7 for the circular RCC shaft and for the top 1.8 m dia × 23 m high portion of future extension of the steel mast, while a value of 2.3 and 2.1 is taken for the square shaped steel mast, depending on its solidarity ratio. The dynamic response of the tower is taken into account by the deterministic Gust-Factor approach as developed by Prof. Schlaich of Stuttgart University, which considers a gust factor of 1.35 with respect to 60% of the calculated static wind pressure. This amounts to a global gust factor of 0.6 × 1.35 + 0.4 = 1.21 with reference to the total wind pressure. For the functional requirements, the tip deflection of the steel mast is limited to 1° from the polar axis. For satisfiying this requirement, some of the diagonal bracing members in the lower elevation of the mast required a larger cross-sectional area than those required purely for stress consideration. The calculated tip deflections are 1.119 m for the steel mast only (equal to 0.984°), and 1.25 m for the complete structure including the shaft (equal to 0.575°). The design considered the secondary

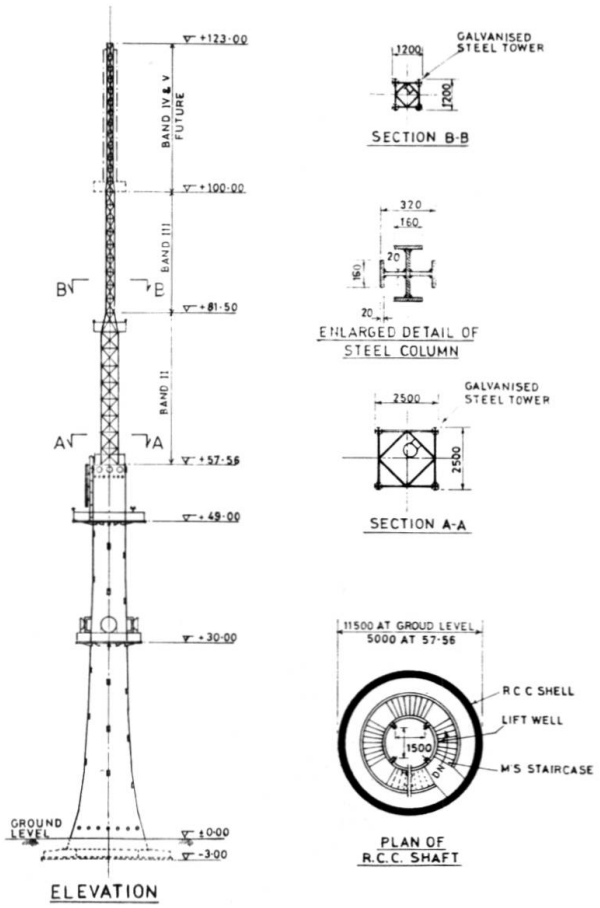

Fig. 1 General Arrangement

effects due to elastic deformation, and eccentricity of loads due to deflection which amounts to nearly 5% of the calculated along-wind moment. The first five natural vibration mode shapes and frequencies obtained from the frequency-mode analysis indicate that the fundamental mode contributes predominantly the dynamic stresses in the concrete shaft, and the second and higher modes are essentially motions of the tower mast portion. Although cross-wind vibrations over part of the concrete shaft is theoretically possible, the critical wind velocity at which this vibration occurs is much lower than the design wind velocity, and cross-wind oscillations if any, would be relatively insignificant. However, a check was made by calculating Mass Damping Parameter (Scruton number), considering logarithmic decrement of damping equal to 0.05, and this worked out to 45 which is much higher than the minimum required value of 20. There are no significant cross-wind oscillations to be expected for the lattice steel mast as its plan shape and cross-sections do not favour periodic shedding of vortices.

As Kohima falls in the severe seismic zone of the country, the design looked into seismic effects on the structure as per IS:1893-1975, by using the response-spectrum method for the first five modes of oscillation,

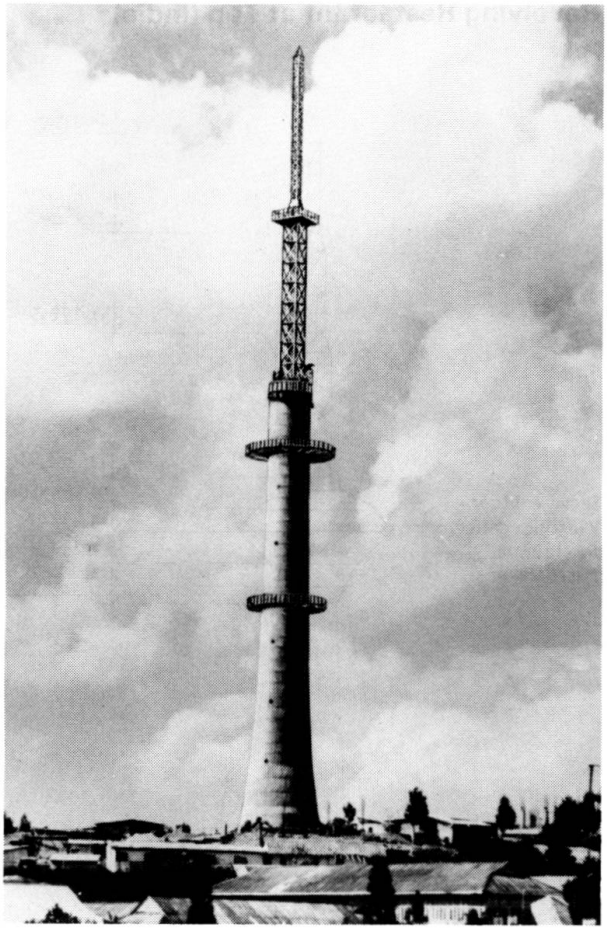

Fig. 2 View of the completed structure

considering 5% damping, zone factor of 0.4, and importance factor of 1.5. The design seismic accelerations for the five modes in order are 0.29, 0.65, 0.88, and 1.12. The seismic moments are calculated on the basis of root-mean-square of the value of the five modes for the combined effect. The maximum seismic displacement is 0.105 m in the fundamental mode, and 0.122 m in the combined five modes. It is seen from Fig. 2 that the seismic moments are not critical, and only wind moments govern the design. It is worthwhile mentioning at this juncture that the tower has withstood well, without any structural distress, the effects of a severe earthquake of the magnitude of 6.5 on the Richter scale which occurred in the region, in the first week of August 1988.

The design also looked into the effects of a temperature gradient of 10°C across the RCC shaft and asymmetrical effects of sun radiation, and these were found to be insignificant in the design. An annular ring RCC foundation of 19 m outside diameter and 9 m inside diameter, is provided at 3 m depth below ground level, for a maximum bearing capacity of soil equal to 250 kN/m^2, and allowing no tension in the soil. The calculated factor of safety against over-turning is 2.19 under minimum dead load condition. As the structure is sensitive to wind loads, increase in permissible stresses in materials and in bearing pressure of soil normally permitted in practice und the wind load case, is not considered in this design. The steel mast is connected to the 1.4 m deep RCC cap of the shaft by using 28 nos. 27 mm diameter high strength friction-grip bolts of 10.9 grade at each leg of the mast. The maximum design forces acting at the connection are 4110 kN tension, and 130 kN horizontal shear due to wind.

Construction

The annular RCC foundation, in M20 grade concrete was cast in six segments with vertical keyed joints between the segments. The RCC shaft was constructed in M25 grade concrete by jump-form method. During the shaft construction, 85 nos. mild steel inserts were provided at the desired elevations, for the purpose of connections to steel members providing lateral support to the internal spiral staircase and lift-frame structure, and to steel beams supporting the external platforms. The laps in vertical reinforcement of the shaft are staggered, and a minimum lap length of 70 × diameter of bar is provided to account for fatigue and whip-lash action of wind. All connections between members of the steel mast were by bolting only using 8.8 grade high tensile steel bolts. Welding was restricted to connections of gusset plates to mast members and at the base location. The steel mast was erected in segments by using a purpose made derrick. The tightening of high strength friction-grip bolts at the base of the mast was carried out by using a calibrated torque wrench.

(N. Prabhakar)