Zeitschrift: IABSE structures = Constructions AIPC = IVBH Bauwerke

Band: 7 (1983)

Heft: C-27: Recent structures: Part I

Artikel: Reactor building for Narora Atomic Power Project (India)

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DOI: https://doi.org/10.5169/seals-18275

1. Reactor Building for Narora Atomic Power Project (India)

Owner: *Department of Atomic Energy*
Engineers: *Power Projects Engineering Division, Bombay and M/s. STUP Consultants Limited, Bombay*
Contractor: *M/s. Hindustan Construction Company Limited, Bombay*
Works duration: *45 months*

The Department of Atomic Energy is constructing a Nuclear Power Station consisting of 2 units of 235 MW each at Narora in District Bulandshahr of Western Uttar Pradesh. The present article describes broadly the design and construction aspects of the Reactor Building Structure for the above project.

Description

The Reactor Building houses the Reactor Vessel, Primary Coolant System, Steam Generators and other allied equipment and piping. The functional requirements calls for this system to be enclosed in a building, technically termed as Containment Building, which forms the ultimate barrier between the inside atmosphere and outside environment. The building is also required to provide shielding against radiation and to contain released activity in case of an accident.

The building is of cylindrical shape with overall diameter of 46 m capped with a segmental dome. The total height of building is 71.6 m above ground with about 17 m portion below G.L. The internal details are shown in Fig. 1.

The building consists of double containment with primary containment consisting of prestressed concrete internal containment wall (ICW), prestressed concrete containment slab and secondary containment consisting of reinforced concrete outer containment wall (OCW) and dome. The containment is supported on RC raft which is 5 m thick at the periphery and 4 m thick in the central portion.

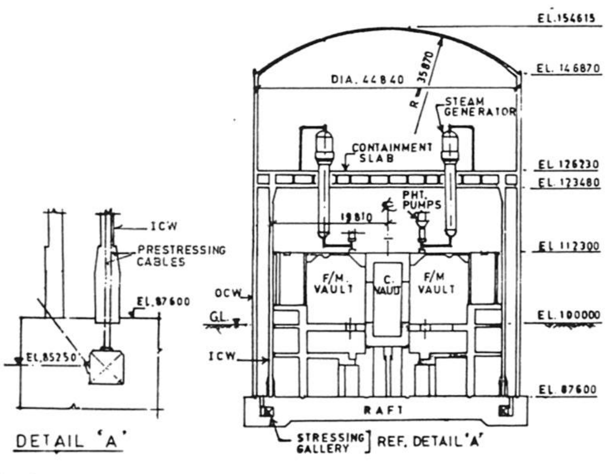

Fig 1

At the periphery suitable prestressing gallery has been provided for placing anchorages for the vertical cables and subsequent prestressing operations.

For prestressing the inner containment, high tensile strands have been used in a system known as 12 T 13 Freyssinet System. The system uses 12 strands of 13 mm diameter for prestressing cable which provides force of 200 MT per cable. For this purpose special steel anchorages, prestressing jacks and sheathing were required to be developed.

Design Aspects

The building is situated in seismic zone No. IV as per IS classification. This structure being an important structure has been subjected to detailed dynamic analysis. The ground acceleration for safe shut down earthquake has been arrived at 0.3 g and 0.15 g for operating basis earthquake.

Structure has been founded on Aluvium with bed rock available nearly at 500 m. Aluvium has clay-bands spreading horizontally. This calls for proper design for limiting the total settlement and differential settlement.

The studies of liquefaction of soil under dynamic forces were undertaken for design of the foundations.

The structure has been designed for combination of various loads which include mainly the following loads:

- dead loads including equipment loads,
- operating loads,
- variation in operating temperatures,
- safe shut down earthquake/operating basis earthquake,
- abnormal conditions occurring both in temperature and pressure due to postulated accident.

Specific design problems arise due to large openings which are required to be kept in containment cylindrical shell as large stresses concentrate around the openings. Building is also required to be designed for limiting the cracking in order to render the containment leak proof.

Structural Analysis

The structure is divided into following structural subsystems for the purpose of structural analysis:

1. Bottom raft supporting the containment structure and other internals is analysed by finite element method accounting for proper soil structure interaction.
2. Inner containment consisting of prestressed concrete wall and circular slab.
3. Outer containment consisting of RC wall and dome.
4. Internal structure consisting of RC walls and floor slabs, structural steel columns and beams.

Fig 2 General view showing construction of containment walls

Special Provisions

Following additional provisions were required to be considered for conceptual design.

Provision of Closure Panel

The Reactor is a leak tight structure while in operation. A separate provision of closure panel was introduced and this panel was required to be closed after all the equipment has gone in the Reactor Building and installed. The time span for closing this panel was around 3 years after construction of inner and outer containment walls.

Erection of Steam Generators

Four steam generators each weighing about 100 t are required to be erected at an elevation of 30 m above ground to be supported on containment slab. For this purpose separate steel structure was installed outside the R/B (known as phase-3 structural steel). An opening of size 3 m x 5 m is provided between containment slab and dome for entry of steam generators inside the Reactor Building.

Suppression Pool System

Vapour suppression pool has been provided at the base of Reactor Building with about 2.5 m of water for condensing steam in case of accident conditions. For this purpose special arrangements consisting of steel shaft, reinforced concrete distribution headers, and metal pipe down comers are provided to lead the released steam to vapour suppression pool.

Construction Aspects

The permanent water table is approximately 9 m below ground level. The elaborate dewatering arrangements were required to be made to maintain the water table below the foundation throughout the construction period. Sheet pile cut off along with deep well pumps were utilised for dewatering purposes.

Containment walls were constructed in continuous rings of 1.5 m height. In order to render the containment leak proof the PVC gas barrier was utilised and groves provided on internal face of construction joint were caulked with polysulphide compounds.

The precautions were taken to fix embedded parts by providing jigs and fixtures in the earlier pours projecting out for supports. The prestressing strands were laid first in position and lead coated sheath was pushed over the strands manually. This enabled practically no damage to sheathing conduits.

The concrete was cooled so that placement temperatures were below 23° C. This was done to reduce possible shrinkage cracks due to hydration.

As an additional precaution against leakage the entire containment has been painted from inside with polyvinyl paints having overall thickness of 10 mils. The flat containment slab received similar treatment on its internal faces.

All the embedded parts were required to be carefully placed and caulking was provided around embedded parts on the inside face.

The containment slab is a cellular slab and the bottom tire is in prestressed concrete. This was cast separately. Over the prestressed slab ribs were cast and precast planks were utilised as left in shuttering for casting the top portion of the slab. This was done in order to avoid of use of timber on account of fire hazard and economy.

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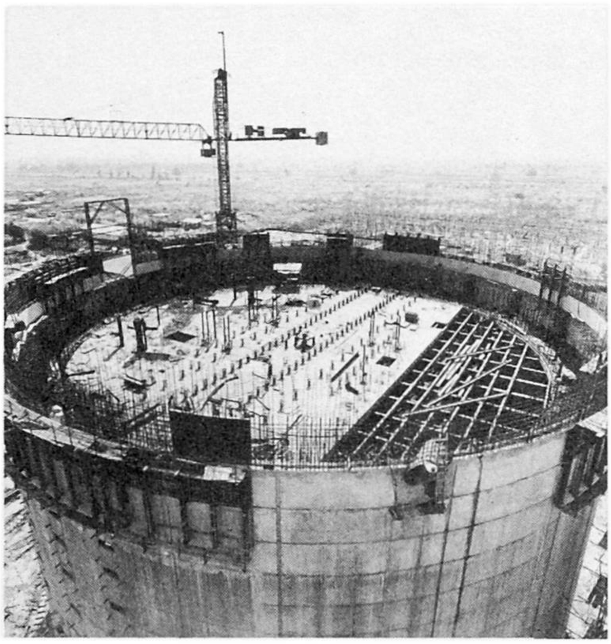

Fig 3 View showing construction of containment slab