Containment slab of Narora Atomic Power Project, India

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Dalle pour l'enceinte du réacteur nucléaire de Narora, Inde

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S.G. JOKLEKAR
Princ. Consult.
STUP Consultants Ltd.
Bombay, India

1. THE PROJECT AND THE CHALLENGE

The containment structure of Narora Atomic Power Project is the prototype of this series of 235 MWe PHWR reactors. In all four such containments at two sites have been constructed and tested. The containment design is based on the double containment philosophy with inner containment in PSC and outer containment in RCC (Fig.1) A special feature of this containment is the provision of flat slab on top of cylindrical walls on which the main steam generators (SGs) are supported. They are partially inside the containment in which portion the radioactive primary heat transfer systems are located and project outside the containment in which portion the light water/steam circuits are located. Apart from SGs several equipment are located on this slab which require large number of embedded steel parts. This unusual arrangement has put number of functional and behavioural demands on the containment slab much beyond its function as pure containment. A highly innovative solution has been evolved to meet this challenge.

2. THE SOLUTIONS

2.1 Minimum Weight in High Seismicity Zone

The Design Basis Earth-quake has peak acceleration of 0.3g at ground level and of about 1.0g at slab level. A cellular slab solution was therefore evolved which has a low mass to strength ratio.

2.2 Support for Steam Generators

SGs are mainly supported on containemnt slab. The functional requirement demanded no relative movement between SG and inner reactor building, whereas the slab has a relative deflection with respect to internals. Specially designed spring supports were developed in such a way tht the relative position of SG and the internal structures does not change and the deflection of containment slab relative to SG's is absorbed by the variation in spring length without modifying reactions appreciably.

2.3 Choice of Composite Construction

More than 250 t of embedded parts are provided in the top of the containment slab, the locations of which were inflexible. Thus prestressing cables could not be located in any practicable way in the top slab and the containment slab had to be designed as a RCC structure for resisting upward pressure. On the otherhand to give a leaktight containment boundary the lower slab was prestressed separately before casting of the webs and top slab by orthogonally placed cables. By this method creation of negative moments in the containment slab by eccentrically placed cables was avoided and thereby the requirement of prestressing was also minimised.

2.4 Monolithic Connection to Outer Containemnt - Design & Construction Aspects

A large difference in downward self-weight of 4.5 t/m^2 and upward pressure of 14.4 t/m^2 combined with seismic amplifications under vertical excitation would have required higher structural depth and more massive slab. To reduce the net effect of both of these factors the cellular slab was connected to outer containments so that the inner and outer containments together provide substantial fixity effects to containment slab, thus achieving more favourable distribution of bending moments. However, for constructional purpose it was not possible to link up sequencing of outer containments with that of containment slab. Hence the containment slab was designed to span as simply supported slab on inner wall alone carrying its self weight and then subsequently connected to outer containment by means of RCC connections. This decision gave additional advantage of inducing larger positive bending moments at the centre of the slab requiring upward pressure more than the equivalent self weight to nullify the pre-compression thereby resulting in reduction of reinforcement.

2.5 Construction Sequence and Flexibility

The bottom slab was cast in panels on the full staging and prestressed. RCC webs and top slab were also cast on staging. The composite slab was decentered carrying its full self weight which is supported on I.C wall. The connection with outer containments was concreted subsequently. The total construction period was 12 months.

The shrinkage/creep time histories of IC wall, OC wall, bottom prestress slab, RCC webs and top slab, RCC connection between IC and OC are all different. The exact analysis accounting for these histories was carried out for 2 or 3 construction sequences thereby permitting flexibility in the planning of the construction activity. This slab under construction is shown in fig. 2.

2.6 Testing Facility

Provision is made for positive pressurising of cellular volume to enable location of any leaks across the prestressed bottom slab from below. This is required since the cellular volume is not accessible for inspection during main leak testing when inside of the containment is pressurised.

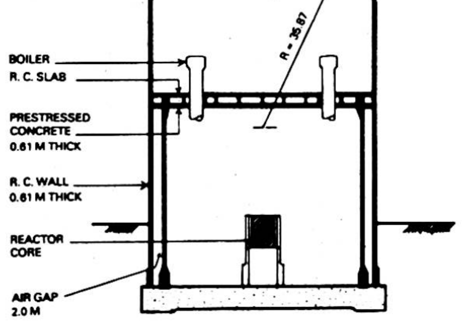

Fig. 1 Cross Section

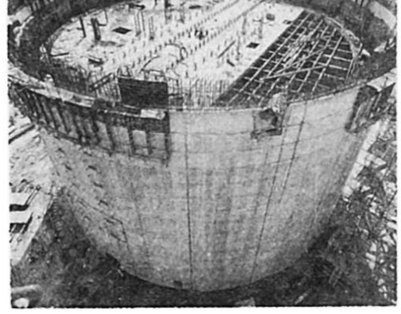

Fig. 2 Containment under Construction