Post-tensioned Digester Tanks - Germany

Circumferential and vertical post-tensioning allows thin-shell design for the world's largest digester tanks.

▲ *With a capacity of 15,000 cubic metres, they are the largest tanks of their kind ever constructed*

Egg shaped sludge digesters are gaining increasing utilisation and acceptance throughout the world, due to the shape's inherent advantages for more efficient processing, continuous construction procedures, and aesthetics.

The need for high durability of these structures, combined with the desirability of lightweight, thin-walled shells, have made post-tensioned concrete the most practical and effective method of construction. In addition to providing the necessary strength for the tank walls, post-tensioning greatly reduces the amount of reinforcing steel that would otherwise be required, thus reducing steel congestion and facilitating construction.

The four prestressed concrete digesters at Bottrop, Germany, each with a capacity of 15,000 cubic metres, are the largest tanks of their kind ever constructed.

Each tank is 47.47 metres tall, with a diameter of 27.16 metres at the midpoint. The tanks rest on massive reinforced concrete bearing pedestals measuring 20.6 metres in diameter and 6 metres high. The construction contract also included a central four storey building with a stair and elevator tower, and four connection bridges between the tower and the tanks. The project commenced in 1988 and was completed in a 21/2 year period by general contractor Ed. Züjblin AG.

To allow a minimum shell thickness without buttresses, specially developed VSL type Z tendons and anchorages were used for the circumferential post-tensioning.

A total of 115 horizontal tendons were installed, stressed, and grouted in each tank. The anchorages of these tendons are designed with unusually small anchor heads, thereby keeping the block out dimensions to a minimum, and allowing relatively thin wall thicknesses of between 40 cm and 7.5 cm. To provide an even distribution of the post-tensioning forces, the anchorages were placed so that every 6th anchorage was on the same meridian.

Scope of works performed

- Development and installation of 115 horizontal VSL type Z tendons.
- Anchorages with small anchor heads for the circumferential post-tensioning.

The required horizontal prestressing force was accomplished with only one layer of tendons. Three sizes of tendons were used: VSL Z6-4, Z6-6, and Z6-12, The tendons were spaced between 20.5 cm and 50 cm apart. The four strand tendons were stressed to a maximum force of 273 kN, the six strand tendons were stressed to a maximum of 545 kN, and the twelve strand tendons were stressed to a maximum of 1635 kN. The vertical post-tensioning for each tank was accomplished with 12 looped tendons equipped with VSL type E 6-7 anchorages. Looped tendons were chosen for this project because their use results in a significant reduction of the number of anchorages which would otherwise be required. This minimized steel congestion and greatly accelerated the installation and stressing of the post-tensioning materials. The tendons were pushed through the previously placed ducts from the top of the structures, and looped 180° with a radius of 1.38 metres at a location approximately 12.5 metres below the equator of the tanks.

The installation of the post-tensioning duct, strand, and anchorages was accomplished quickly, and performed off the project's critical path. To maximize the efficiency of labour activities, the duct and anchorage blockouts were placed at the same time as the reinforcing steel, followed by the concreting of the egg-shaped shells. As each shell section was completed and the formwork was jacked upward, exposing the anchorage blockouts in the concrete below, the post-tensioning strand was pushed through the duct with specially designed VSL equipment. To facilitate the construction schedule even further, the tendons were stressed only after all concreting was completed. Upon completion of stressing, the tendons were grouted and the blockouts were filled with concrete to provide a smooth and continuous shell surface.

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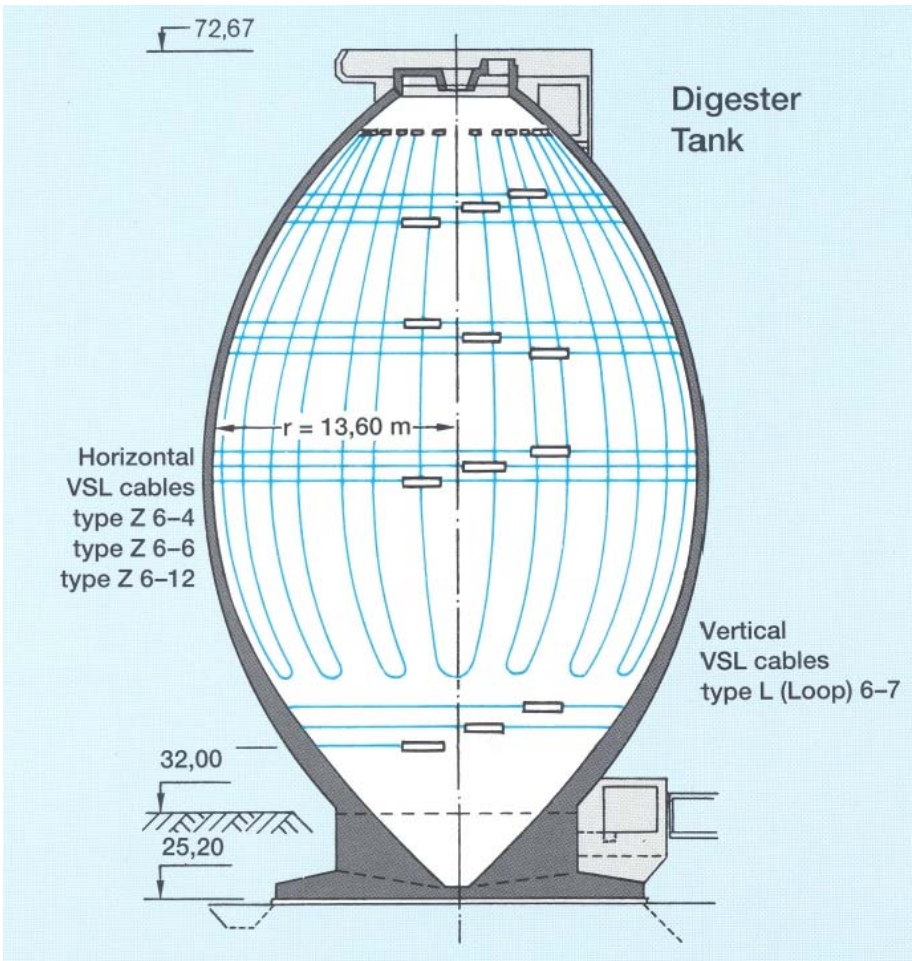
▼ *Schematic drawing of the 47.47 meter tall egg-shaped digester tank*



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