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5. Egg-Shaped Prestressed Concrete Digester Tanks, Yokohama (Japan)

Owner:	*Sewage Works Bureau of Yokohama City*
Construction designer:	*Nippon Jogesuido Sekkei Co. Ltd.*
Contractor:	*Kajima Corporation*
Works' duration:	*40 months*
Commissioning year:	*1987*
Capacity:	*6800 m³ × 12 units*
Dimensions:	
maximum diameter:	*22.7 m*
height:	*33.6 m*
Material quantities per unit:	
concrete:	*1350 m³*
reinforcement:	*100 t*
prestressing tendon:	*66 t*
liner:	*1900 m²*

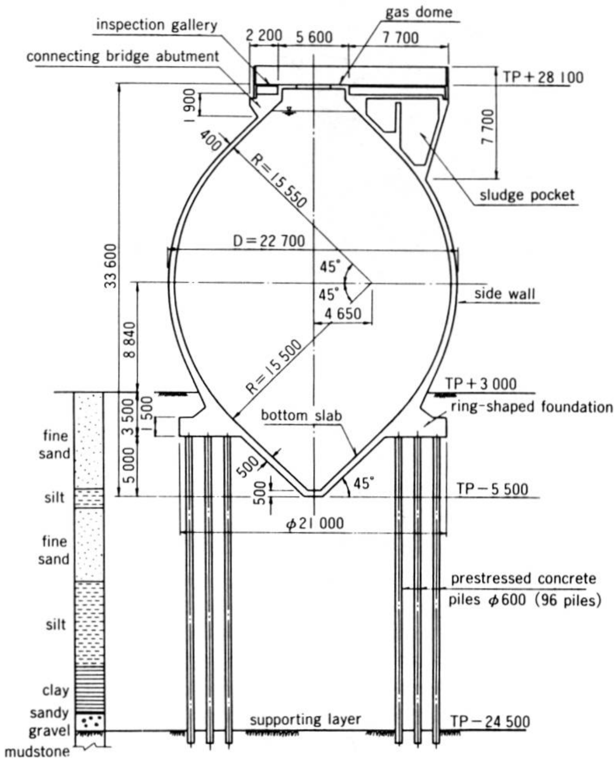

Fig. 1 Section

Introduction

In Yokohama, the second largest city in Japan, the amount of sewage treatment has rapidly increased due to the increase in both population and rate of sewer system usage. This led to more than 14 million tons of sludge per year being produced in the sewage treatment process, making it necessary for the sludge treatment facilities to be expanded. In view of this situation, 12 units of digester tanks of egg-shaped prestressed concrete, the first of this type in Japan, have been constructed by the Sewage Works Bureau of Yokohama City.

Design

After due consideration of the loose soil condition on the site, a ring-shaped foundation supported by piles was applied (Fig. 1). This was also to ensure the stability of the tanks during earthquakes.

Due to the lower stiffness of the soil beneath the tank compared with the piles, no soil reaction in this type of foundation is expected. Thus tensile stress occurs even in lower part of the shell caused by the liquid load of sludge. To counteract this, a prestress was introduced in both circumferential and meridian directions with helically positioned tendons since the underground anchorage of circumferential tendon outside the shell was not available (Fig. 2).

The structural analyses were carried out using the axisymmetric finite element method for the dead loads and an asymmetric one for seismic loads. In addition to the static analyses, dynamic analyses were carried out to estimate the distribution of the hydrodynamic pressure by means of the finite element method in which the interaction of the tank, liquid and the surrounding soil was taken into consideration. Observations of ambient vibration were carried out on the completed tank. Predominant frequencies approximately agreed with the analysis.

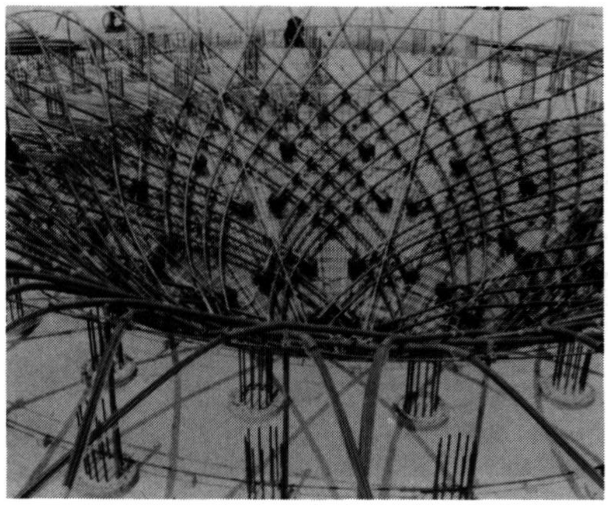

Fig. 2 Helically positioned tendons

Construction

The concrete shell of 350-500 mm in thickness was constructed by 1.5 m lift by the Dywidag jump form method (Fig. 3).

Concrete shell is required to provide high water- and air-tightnesses. To secure these requirements the following methods were employed:

1) a concrete of mix proportion with low water cement ratio as well as low cement content was used
2) after careful case study, the optimum order of concrete placing was determined
3) moderate prestressing was applied
   By combining the above methods it was expected to control the thermal cracking due to heat of hydration. During the construction a few crackings occurred, which were repaired by means of epoxy injection
4) a concrete joint treatment with set retarding agent and water jetting was used to provide good bonding of construction joints.

The water filling and air pressure tests carried out after completion of tanks proved that the water- and air-tightnesses were satisfactory.

Another requirement was the durability of the concrete shell against the chemical action of sludge and digestion gas that might cause deterioration and neutralization of the concrete as well as corrosion of reinforcing steel. To achieve greater durability than by concrete alone, a 350 micron lining of tar-epoxy resin was applied to the entire inner surface. A higher degree of durability was required of the surface in contact with the digestion gas, so the tar-epoxy liner of this part was reinforced with glass cloth.

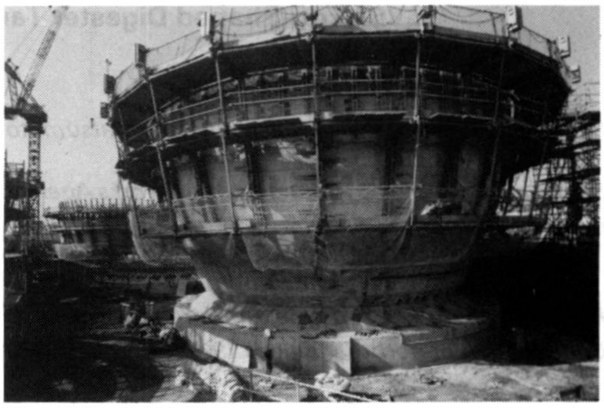

Fig. 3 Construction by jump form method

Since starting the operation in April, 1987, these 12 units of tanks have ably proved their digestion efficiency. It is also expected that they will display an excellent long term durability and earthquake resistance.

(Y. Nojiri)

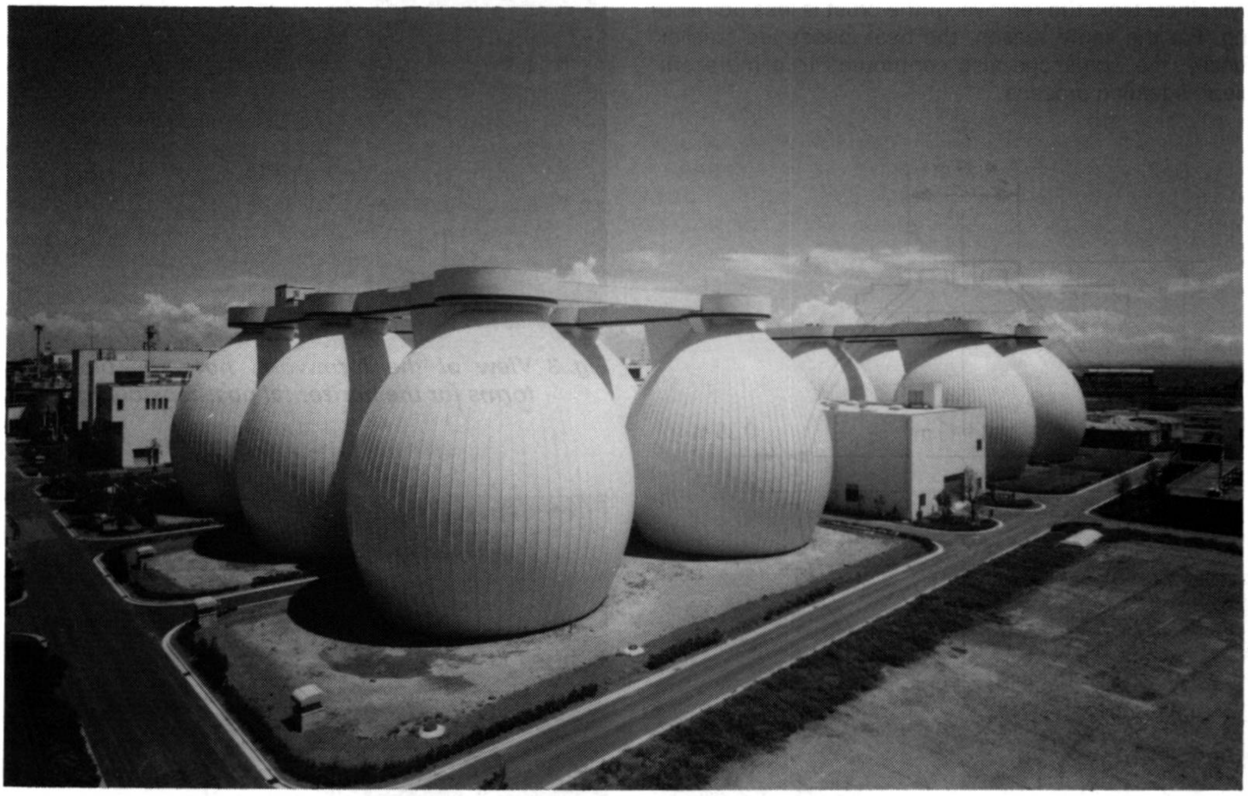

Fig. 4 Prestressed concrete digester tanks