Design and Construction for the Largest Underground LNG Storage Tank: Toho Gas Chita-Midorihama Works No.3 LNG Tank

「世界最大級の LNG 地下式貯槽の建設における部材の薄肉化と各コンクリート部材の施工 ―東邦ガス知多緑浜工場 No.3タンク―」の概要


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1. Introduction

An underground liquefied natural gas (LNG) storage tank (hereinafter, an LNG tank) is an underground structure for storing LNG effectively and safely. The Toho Gas Company Chita-Midorihama Works constructed its No.3 LNG tank with a capacity of 220,000kL [1]. An overview of this tank is provided in **Fig.1** and **Table 1**. It was constructed as follows: (i) the slurry wall was constructed, (ii) the internal soil was excavated, (iii) the bottom concrete slab was placed, and (iv) the side wall was placed.

The No.3 LNG tank comprises high-strength concrete and reinforcement bars for efficient construction. Therefore, the member thickness was reduced by 10–20% compared with the previous underground LNG tanks.

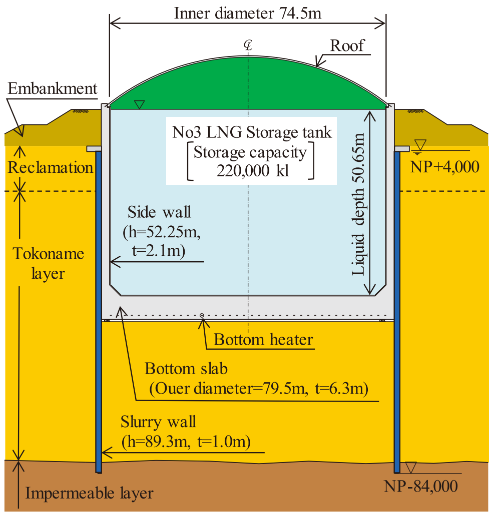

Fig.1 Structural diagram of No.3 LNG tank

Table-1 Thickness and volume of members

	Thickness of member (m)	Reinforcing bar volume (t)	Concrete volume (m^3)
Slurry wall	1.0	2,000	24,000
Bottom slab	6.3	5,500	31,500
Side wall	2.1	5,700	28,900

2. Outline of Design and Construction

(1) Design to Reduce Member Thickness

To reduce member thickness, the slurry wall used high-strength concrete (f_{ck}=60N/mm^2). The bottom slab and side wall adopted high-strength reinforcing bars (SD390). The design of the slurry wall considered imbalance of the circumference foundation and positional error in the placement of elements. The design of the bottom slab and side wall considered the dead load, gas pressure, fluid pressure, hydraulic pressure, roof load, temperature load, earthquake load, and total load. Nonlinear material analysis was used to check that the concrete members would not be damaged in an earthquake.

Fig.2 Excavator used for slurry wall

Fig.3 External view of slurry wall

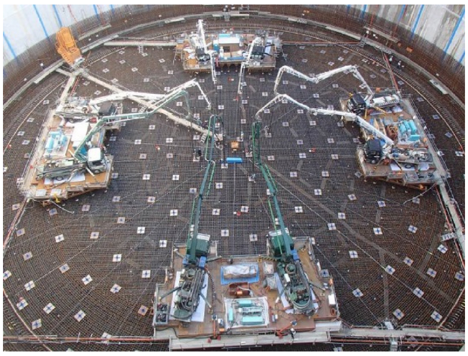

Fig.4 Concrete casting of bottom slab

Fig.5 External view of bottom slab

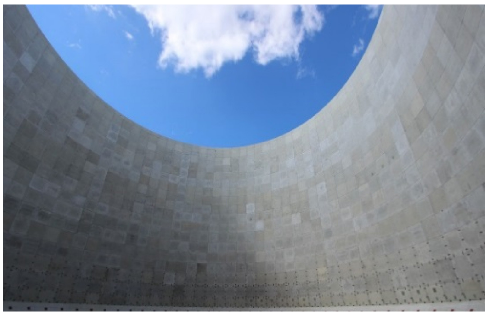

Fig.6 External view of side wall

Fig.7 220,000 kL underground LNG tank

(2) Slurry-wall Concrete

To prevent clogging of the tremie pipe and outbreak filling of the slurry wall, self-compacting concrete was used. An exclusive excavator with an on-board angle meter was used to drill the internal soil (**Fig.2**), and the vertical drill accuracy was controlled below 1/2000. This prevented outbreak filling and water leakage (**Fig.3**).

(3) Bottom-slab Concrete

The bottom slab must withstand the upward groundwater pressure. Therefore, its concrete was thick and construction had to be done in a single phase.
This project used mass concrete placement, with a thickness of 6.3m, an area of approximately 5,000m^2, and a concrete volume of 31,500m^3 (**Fig.4**). A detailed preliminarily construction plan was drawn up to place the mass-volume concrete, and it was installed using a construction information control system. This allowed the concrete placement to be completed in 100 hours according to plan and with no thermal cracks (**Fig.5**).

(4) Side-wall Concrete

Self-compacting concrete and mid-fluidly concrete was used for the side wall. A test execution was run to adopt fresh concrete quality and construction method. This avoided any outbreak filling (**Fig.6**).

3. Conclusion

This underground LNG tank has the world's largest capacity of 220,000kL. The total concrete volume was approximately 85,000m^3. The No.3 LNG tank of this project began operation in August 2016 (**Fig.7**). The construction techniques used in this project won the Award of the Japan Concrete Institute in 2017.

References

[1] Sasaki, T., Hayashi, T., Maeda, K., Sakurai, K.: *Design and Construction for Large Underground LNG Storage Tank –Toho GAS Chita Midorihama Factory No3 LNG Tank–*, Concrete Journal, Vol.54, No.10, JCI, Tokyo, pp. 1015-1021, Oct. 2016. (in Japanese)