

Construction of PC LNG Tanks — The U.S.’s Largest Receiving Terminal “GULF LNG” —

PCLNG 地上式貯槽の施工 — 米国最大級受入基地 “GULF LNG” —



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Synopsis

“GULF LNG,” the liquefied natural gas (hereinafter “LNG”) receiving terminal that was constructed in Mississippi in the United States is the largest such facility in the U.S. It has two Prestressed Concrete (hereinafter PC) LNG tanks that have a capacity of 160,000m³ with a supply capacity of approximately 12 million tons per year.

Structural Data

Capacity: 160,000m³ x 2 nos.

Height: 52.145m

Width: 81.484m in diameter at Base Slab

Owner: Gulf LNG Energy

Designer: IHI Corporation and Aker Solutions.

Contractor: IHI Corporation and Aker Solutions.

Construction Period: Jan. 2008 – Jun. 2011

Location: Pascagoula, Mississippi, U.S.

1. Introduction

The demand for natural gas as an alternative energy source has been growing rapidly around the world due to the increase in the cost of crude oil and fears over the continued use of nuclear energy in recent years. The U.S. is one of the greatest energy consumers in the world and accounts for approximately 25% of natural gas energy consumption over the whole earth. In addition to traditional imports via pipelines, the increase in demand for natural gas has led to imports taking place through LNG receiving terminals and many such terminals have been built. Currently, there is the prospect that self-sufficiency will become

possible through the establishment of shale gas mining technology and plans are being drawn up to convert existing receiving terminals to export terminals in order to export the surplus. This paper reports on the construction of the PC LNG tanks through the “GULF LNG” from both the point of view of civil engineering construction work and mechanical construction work.

2. Structure Summary

The PC LNG tanks in this paper consist of a total of three layers: In the “inner tank” made of steel with air-tightness to directly maintain the LNG at extremely low temperatures of -165°C, in the concrete dike “outer tank” with liquid-tightness to prevent against external discharge in the event LNG leaks from the inner tank, and also “insulation layer” between the inner and outer tanks. The outer tank is supported by steel pipe piles, while the base slab and roof dome are RC structures. The outer wall is a partially prestressed concrete structure with post-tensioning tendons in 86 stages in the circumferential direction and 48 U-shaped tendons in the vertical direction. Two construction openings (width: 6500mm / height: 3800mm) were set up on the outer wall as service entrances for the heavy machinery used in the construction work of the inner tank. In addition to fly ash (20%), silica fume (5%) was mixed into the concrete facing the outside air to satisfy the required service life of the tanks from the point of view of durability. The plan and section of the outer tank is shown in **Fig. 1**.

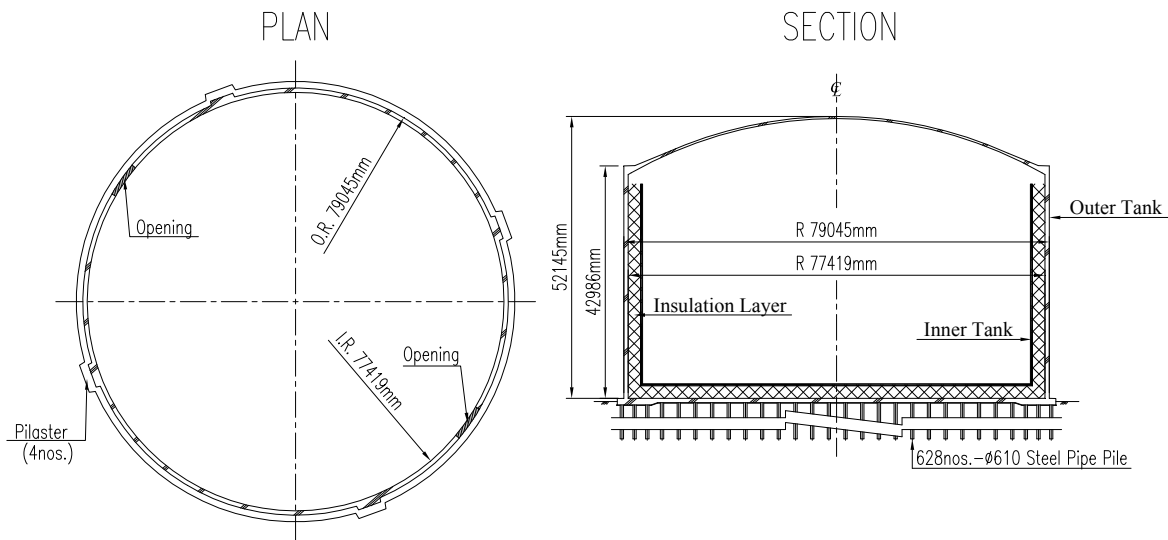


Fig. 1 Plan and section of outer tank

3. Construction Work Summary

(1) Pile Foundation

The outer tank is supported by 628 steel pipe piles with a diameter of 610mm and a length of between 40.3m to 43.2m. The piles were driven into two and driven. The lower piles were driven using vibratory hammers (Fig. 2). The upper piles were driven using diesel hammers after welding with the lower piles. The steel pipe piles were driven into place after confirming that settlement was below 1 inch (=25.4mm) with 20 hits. The insides of the steel pipe piles were packed with compacted sand up to a depth of 600mm from the head of the piles. The heads of the piles were filled with concrete at the time of the placing of the concrete of the base slab. In order to achieve the integration of the steel pipe piles with the filled concrete of the pile heads, shear plates were welded to the heads of the piles at two levels. Electrolytic protection was applied as a measure to prevent the corrosion of the steel pipe piles. A total of approximately three months were needed from the



Fig. 2 Driving piles by vibratory hammer

start of the implantation of the steel pipe piles to the application of the electrolytic protection.

(2) Base Slab

The placing of the concrete of the base slab was divided into five stages. Fig. 3 shows the division schedule of the construction of the base slab. Through the construction in advance of the base slab directly under the outer wall (1st and 2nd stage construction), it was possible to perform the construction of the outer wall and base slab in parallel.

This led to a shortening of the construction period. The amount of concrete placed in the base slab was 1,000m³ in each stage of construction with 12 hours of continuous construction due to the supply capacity of the plant. Two months were needed for the construction of the base slab from the arrangement of the reinforcing bars to the placing of the concrete. After the completion of the construction of the base slab, the progress continued on the civil engineering work of the outer wall on the outside, while work started on the steel sheet laying in the inside (Fig. 4).

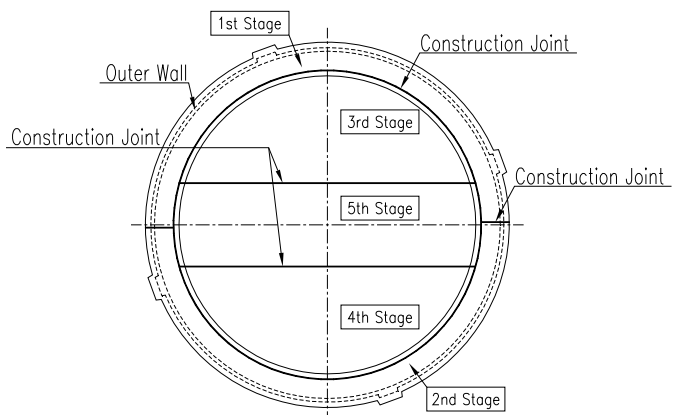


Fig. 3 Division schedule of base slab



Fig. 4 Installation of base plate



Fig. 7 Installation of prefabricated rebar and sheath

(3) Outer Wall and Inside of the Tank

1) Construction of Outer Wall

Fig. 5 shows the division schedule of the construction of the outer wall. The placing of the concrete of the outer wall was divided into 10 stages and climbing form was used (**Fig. 6**). The main rebar and sheath of the outer wall were prefabricated on the ground and were then hung using a tower crane (**Fig. 7**). During the placing of the concrete, the position of the formwork was measured in accordance with the movement of the pump nozzle (**Fig. 8**). When the formwork became swollen due to the pressure of the fresh concrete, it was immediately tightened up. Through this work, it was possible to construct with high precision. Five months were needed for the construction of the outer wall.

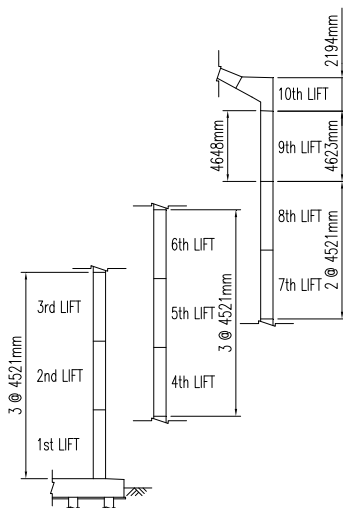


Fig. 5 Division schedule of outer wall

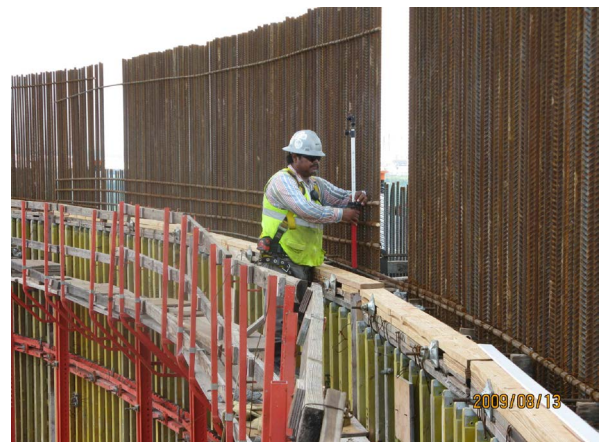


Fig. 8 Measurement of form position

2) Raising of Roof Steel Plate

After the completion of 3rd lift of the construction of the outer wall, the block split roof steel plates were hung on the inside of the outer wall (**Fig. 9**). After the completion of 9th lift of the construction of the outer wall, circumferential steel plates were welded to the top of 9th lift to weld the roof plates. In order to seal the compressed air internally, sealing material was installed on the outermost part of the roof steel plates. The raising of the roof steel plates by compressed air was performed at a rate of about 30cm per minute (**Fig. 10**).



Fig. 6 Jumping-up of climbing form



Fig. 9 Installation of roof block

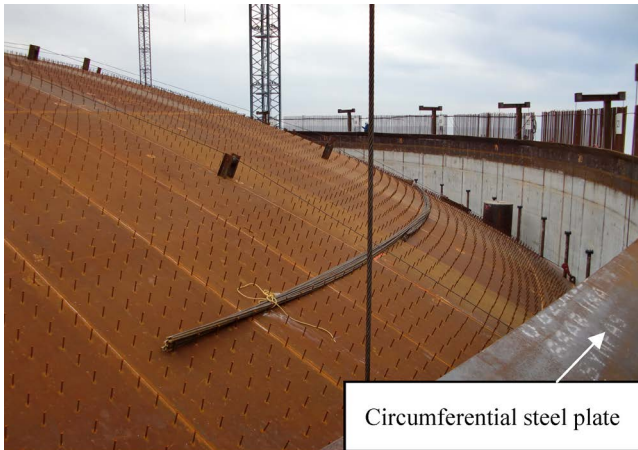


Fig. 10 Raised steel roof by compressed air



Fig. 12 Full-scale test for decision of slump

(4) Roof Dome

The construction of the roof dome was divided into seven stages as shown in Fig. 11. The maximum incline of the roof is 45%, so it was necessary to use concrete with stiff consistency. Accordingly, a decision was made to use slumps of concrete at 3.5 inches (9cm) in terms of the filling performance and workability after conducting a full-scale test (Fig. 12). The workers were divided into a daytime group and nighttime group. Every day, the daytime group placed the concrete with buckets while the nighttime group performed the chipping construction joint and cleaning work for curing and as preparation for the next stage of construction. Due to the impact of the wet weather, the construction of the roof for the No. 1 tank took nine days against the scheduled seven, while it took eight days for the No. 2 tank.

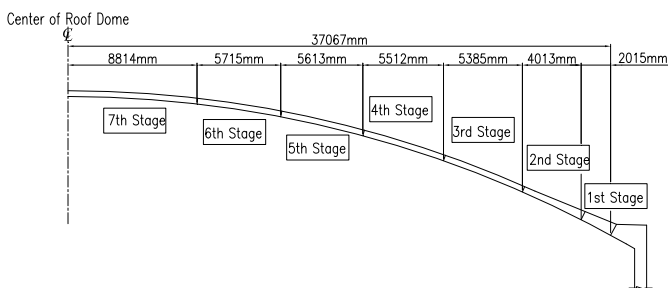


Fig. 11 Construction schedule of roof dome

4. Conclusion

After the finish of construction of outer tank, the prestressing and grouting work of post-tensioning tendons were done and steel structure such as inlet and outlet pipe were constructed on roof dome. The mechanical work, construction of inner tank, and trial run of this LNG receiving terminal “GULF LNG” was successfully completed with LNG container ships being received from June 2011 (Fig. 13). Currently, the U.S. is changing direction from the import to the export of LNG due to the establishment of shale gas mining technology. The demand for PC LNG tanks is expected to continue being great in the future, so it would be good if this paper can be of reference for this.



Fig. 13 First receiving of LNG container ship

概要

米国ミシシッピ州に建設された LNG 受入基地” GULF (ガルフ) LNG” は、容量16万 m³の PCLNG 地上式貯槽 2 基を有し、年間1,200万トンの供給能力を持った米国でも最大級のものである。2 基の PCLNG 地上式貯槽は LNG を直接保持し気密性を有する鋼製の内槽と液密性を有するコンクリート製の外槽、そして内・外槽間で断熱性能を有する保冷層の 3 層から構成されている。PC 鋼材は19S15.2を外槽側壁円周方向に86段、鉛直方向に48本 (U 字型) 配置している。

基礎型式は628-φ610の鋼管杭による支持構造とし、底版 (一部 PRC 構造) および屋根ドームは RC 構造、外槽側壁は PRC 構造としている。

本 LNG 受入基地の工事は無事に完了し、2011年 6 月に第 1 船の LNG コンテナ船を受入れており、運転が開始されている。