



Structural Systems

The 2010 PTA

Post tensioned Structure Awards



SOUTH HOOK LNG TANKS

MILFORD HAVEN

PEMBROKESHIRE

WALES

SOUTH HOOK LNG STORAGE FACILITY - Project Summary

Type of Structure	5No. Cryogenic LNG Containment Vessel
Location	Milford Haven, Pembrokeshire, South Wales
Engineers	CB & I
Main Contractor	Taylor Woodrow
Project Value	£6m
PT System	BBR VT Cona Multi-Strand bonded post-tensioning system.
PT Tonnage	2,900 Tonnes of 15.7mm High Tensile Strand 335 No. 1906 Horizontal Tendons up to 156m long 430 No. 1206 'U' Tendons 38,000 wedges
Additional Information	Capable of holding 155,000m ³ of LNG 13,000 Tonnes of concrete per tank 2,500 Tonnes of reinforcement per tank 40,000 Tonnes of excavated material 29km of ducting for vertical tendons 105km of ducting for horizontal tendons 1,000 Tonne of grout 2,180 multi strand anchors 19 strands per anchor

SOUTH HOOK LNG STORAGE FACILITY - Post tensioned Containment Vessels

Due to the ever increasing demand from China, India and Asia, the consumption of LNG has increased fivefold in recent years. This has led to the increase in development of suitable storage facilities throughout the world. Globally, there are sufficient reserves of natural gas and once extracted, it can be exported to suitable receiving facilities which are required to contain and store the liquefied gas. The strategic location of the facility in the West of the UK means that there is a reduced transportation distance from the source.



Environmental & Sustainability

Prior to work commencing on the LNG facility, extensive studies were undertaken to establish the any potential impact on the surrounding environment and community, from the construction and operation of the terminal.

The design of the tanks was specifically so that they are short, squat and in two rows, so that their visual impact from the land or sea is minimised. To further reduce their impact, two million tonnes of earth was deliberately excavated so that the tanks could sit low on the skyline. Up to 40,000 tonnes of excavated soil has then naturally treated and used to landscape the perimeter to further conceal their location.



To further reduce the impact on the landscape, South Hook are creating and enhancing habitats on their land. A large area in excess of 100 acres has been allocated as a conservation area and species that formerly inhabited the developed site have been relocated.

A fleet of large specially commissioned LNG ships will reduce the number of trips required, thereby diminishing the overall environmental impact of our shipping activities.



Design Challenges & Construction Techniques

The design of a storage vessel for LNG has many complications, not least the temperature, which requires the liquid gas to be stored at -162°C in double walled storage tanks. Post tensioning was more favourable over traditional reinforced concrete because of the superior ductile properties on the high tensile steel strand in these conditions. At these temperatures the requirements for the structures are very stringent and post tensioning is ideally suited.

These gigantic 92m diameter tanks are designed to be exceptionally robust and require significant levels of pre-stress, which is installed under tight quality controlled conditions with specifically certified hardware. Capable of holding $155,000\text{m}^3$ of liquid gas, each tank has a circumference of nearly 290m and walls of up to 750mm thick.

Prior to starting the works, a 'trial panel' of the wall for one of the tanks was constructed. The holes in the main wall are the post-tensioning ducts which are stressed from the other side of the buttress. The buttress shows the termination live end points for the tendons coming from the opposite direction.

Each of the five tanks were slip formed to a height of 35m to improve on the original construction programme.



During this process, ducting was placed into the construction at 300mm centres to accommodate both the horizontal and vertical strand. Once the tank walls had achieved the required design strength, the high tensile strand could be feed into the ducts, ready for stressing.

Post Tensioning Arrangements

Vertical 'U' tendons run from the top of the structure towards the bottom, where they turn through 180° and return to the ring beam at the top of the wall. There is a substantial quantity of reinforcement within the capping beam as well as the with both vertical and horizontal post tensioning ducts for the state of the art cryogenic BBR VT Cona Multi-Strand bonded post-tensioning system.

Horizontally, the tendons start at the buttress and travel half way around the tank, terminating at the opposite buttress. Further tendons travel from the same buttress but in the opposite direction through the remaining half, terminating at the initial buttress. This creates a hoop with the two tendons. To gain maximum efficiency from the post tensioning, adjacent tendons are anchored at alternative buttresses, located 90° from the initial buttress.

This procedure of splitting up the tendons with buttresses allows the tank to be stressed in two halves, so reducing friction lose and improving stressing forces. In all, four buttresses where required per tank which allowed the teams to alternate the stressing of the tendons so that the loads are more uniformly distributed around the tank. This process also reduced the stressing loads and overcame some of the construction issues associated with the anchors.

Multi-strand Jacking

Once the strand had been inserted, the stressing process could be undertaken, using a specialist multi-strand jack, which increased the tensile capacity of the concrete to that capable of withstanding a pressure leak from the inner tank.



Quantities

In total, 105km of galvanised ducting was used for the horizontal cables, with a further 29km for the vertical tendons; and 1,000 tonne of grout. 670 No. cable were used to complete the horizontal stressing, each one being up to 156m long.

There were 19 No. 15.7mm diameter high tensile steel strands per anchor with an additional 420 No. 70m long 'U' tendon cables used for the vertical post tensioning, with 9 No. strands per anchor.

2,180 No. multi-strand anchors with 38,000 strand wedges were also used in the construction of the tanks.

The horizontal post-tensioning strands were stressed from the live-end anchorages using a 500 tonne stressing jack. Each tendon ran around the half-perimeter and were stressed from opposing buttresses. Each live end consists of 19 No. 15.7mm strands.

Reinforcement to the top of the convex steel lid to each of the tanks was a complex issue. Each lid was fabricated within the tank and then 'floated' into position using compressed air. The steel liner was then used as permanent formwork to the in-situ concrete dome.

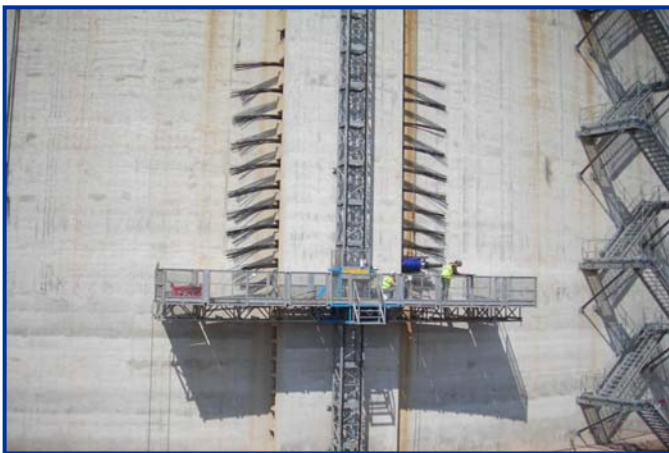




Construction of the tanks with the roof about to be floated in to place



Construction of the heavily reinforced concrete roof of the tanks



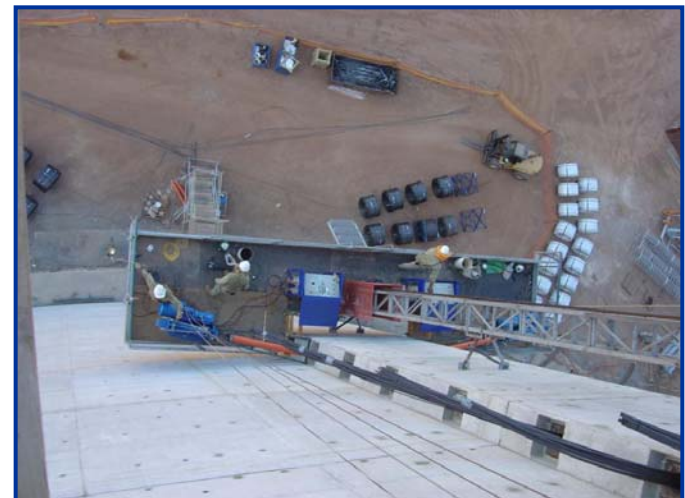
Climbing platform for stressing the horizontal tendons



Construction of the tank nearing completion



Electronically controlled to stop at a given length, the high capacity strand pusher push the tendons into place



Climbing platform for stressing the horizontal tendons was not for the faint hearted

The 2010 PTA POST-TENSIONED STRUCTURE Awards

Entry Form

NAME of building or structure South Hook LNG Tanks

LOCATION Milford Haven Pembrokeshire, South Wales

TYPE OF STRUCTURE (*please tick*)

☐ Building ☒ Civil Engineering ☐ Other

DATE OF COMPLETION

(Note: The Award is for structures completed in a structural sense between 1st January 2009 and 14th May 2010).

NAME(s) of persons and/or **ORGANISATIONS** submitting entry

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Signature: 

Date: 13th May 2010

OWNER

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ARCHITECT (name including partner/principal involved with scheme)

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Telephone No: N/A

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CONTRACTOR (including name of director/principal involved in the scheme)

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OTHER CONTRACTOR (including name of director/principal involved in the scheme)

Contact Name & Organisation:

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SUPPLIER OF THE POST-TENSIONING SYSTEM.

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(Continue below if there are more relevant firms involved)

DESCRIPTION OF PROJECT

Please provide below or on a separate sheet, a summary describing the structure (max 1000 words). The summary should describe the project and its use, explain the post-tensioning system used and detail how the project meets the judging criteria stated above.

Please refer to attached document

SUBMIT YOUR ENTRY

Submit your entry by 6pm on 14th May 2010 to:

Kevin Bennett
PTA Awards Committee
Freyssinet Ltd
6 Hollinswood Court, Stafford Park 1, Telford, Shropshire, TF3 3DE
kevin.bennett@freyssinet.co.uk

CHECKLIST

- ☐ This entry form
- ☐ 1000 word max report (One hard copy and one electronic copy)
- ☐ Photographs and drawings (One hard copy and one electronic copy)
- ☐ Entry fee (£100+VAT for PTA members, £250+VAT for non-members and Associate Members). Cheques payable to Post-Tensioning Association.
- ☐ Written approval of the owner of the project for it to be submitted for the award.

Electronic copies may be submitted by email or on CD.