Concrete tank, steel platform marriage sets development scheme

Marginal field in production without laying pipeline

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How can an operator best transport oil from a marginal field where an oil pipeline does not exist?

The solution for a field in the U.S. Gulf of Mexico was to construct an underwater concrete storage tank and marry it to a steel production deck. The water depth at the site was 55 ft. Production Management Structural Systems, employed innovative design, construction, and installation techniques to solve this problem for ELF Aquitaine operating in Highland, Block 208. The concrete tank is a gravity-based structure that has the capacity to store 10,000 bbl of oil 9,000 bbl in a dry oil compartment and 1,000 bbl in a wet oil compartment.

The tank measures 116 ft by 102 ft by 14 ft, including a horizontal shell. The purpose of the shell is to reduce the load to the soil and to add scour protection. The steel production deck (facilities designed to treat 1.5MMcfd of gas and 1,200 b/d of oil) consisted of a main deck measuring 38 ft by 50 ft at the +83 ft level, a cellar deck measuring 37 ft by 48 ft at the +63 ft level, a subcellar deck, an oil loading boom deck, and an oil caisson access deck.

The concrete tank was set on the seafloor in 55 ft of water. Four 48-in. diameter steel pilings were then driven through the tank. The pilings support the production deck and furnish horizontal resistance from storm forces on the tank.

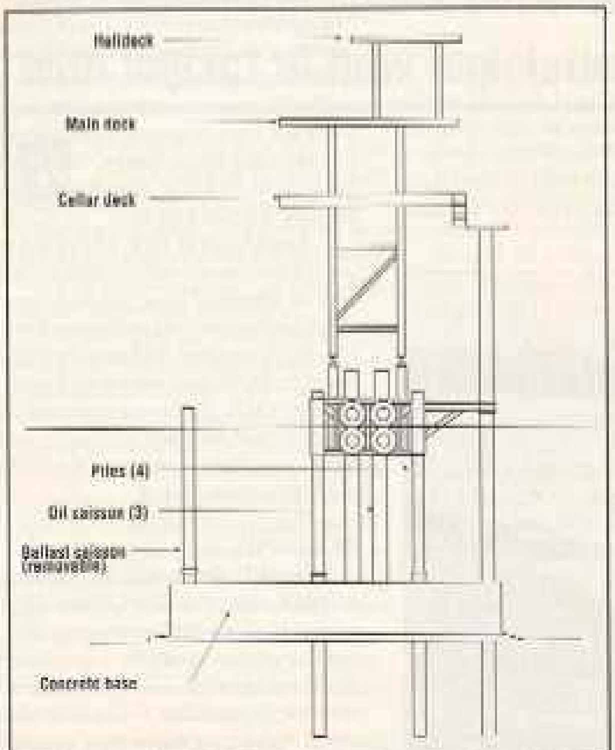

Figure 1: This side elevation view drawing shows the tank and steel platform as they are mated offshore.

A transition structure, stiffening the piling and connecting the piling to the deck, was set atop the piles. The structure and deck were set as a unit. Flexible connections from the deck to the tank allows for any settlement of the concrete tank.

Structural design

The APIM, the ACI, and the US government's Mineral Management Services (MMS) demand that specific requirements be met relative to design, construction, and in-place operation of the structures. API's RP2A, *"Planning, designing, and constructing fixed offshore platforms,"* and ACI's 357R, *"Guide for the design and construction of fixed offshore concrete structures,"* define specific safety factors.

As examples, a minimum factor of safety of 2.0 is required for soil-bearing pressure and a factor of safety of 1.5 is required for sliding resistance during a 100-year storm.

Criteria controlling a gravity structure's in-place design are sliding resistance, overturning resistance, and soil bearing pressures, as well as stability during towing, installation, and recovery. The structures installed in OCS waters are subject to approval by the MMS, and the design is reviewed by this agency.

To successfully utilize concrete in this marine environment, several elements were incorporated into the design to ensure a sound structure:

- **Design:** Proper structural design to resist in-place, external, and internal loadings.
- **Water-cement ratio:** A low water-to-cement ratio was specified.
- **Cement factor:** A minimum quantity of cement-per-cubic-yard of concrete was specified.
- **Calcium chloride:** The use of calcium chloride (CaCl) in mixing and curing water was avoided.
- **Concrete cover:** Adequate cover over the reinforcing steel was specified.
- **Dense impermeable concrete:** This was obtained by maintaining a low water cement ratio, requiring good consolidation (vibration) to eliminate voids near the reinforcing steel, requiring good curing procedures, and requiring a smooth surface finish.

Construction

Once the design was finalized, the gravity-based concrete tank and the steel deck were constructed using proven techniques. The steel deck and concrete tank were fabricated independently, making fast construction schedules possible.

The steel deck was constructed by mating two salvaged decks. These decks were of standard steel beams supported by tubular steel substructure members. The deck was 99% outfitted onshore, which allowed for minimum offshore hookup.

The concrete tank was constructed of steel-reinforced, high-strength concrete. The concrete mix was designed to have a minimum of 7,000 PSI compressive strength, and a water-cement ratio of less than 0.30. This resulted in extremely dense concrete having a very low permeability. Much of the structure was built of flat cast panels later assembled and joined on a floating drydock. Once the bottom, top, and joints were cast, the drydock was submerged, and the newly completed tank was launched.

Figure 2: Concrete tank compartments are being fabricated onshore.

Outfitting of the tank, including internal hot oil re-circulating lines, venting and flooding piping and valves, etc. was then completed. The gas sales line is run across the deck and up the oil caissons. Three oil caissons, two into the dry oil and one into the wet oil, extend from the tank bottom to 20 ft above the water line.

These caissons function as access, tank venting, a high level shutdown system, and oil pump conduits. Two submersible pumps and one vertical shaft pump were installed in the caissons for discharging the 10,000 bbl in slightly over four hours. The tank was designed to remain on the bottom when empty of oil (by flooding perimeter ballast tanks) and not to overstress the soil when full. These criteria must be met during normal operating conditions as well as the 100-year hurricane conditions. This results in nearly 6,000 lb/sq ft hydrostatic load on the elements of the tank. The bottom is 15.5-in. thick.

Installation

The installation of the total facility required coordination of each element. The concrete tank came from one location; the deck came from another location; and the piling came from a third location. Each arrived at the site to meet a derrick barge coming from a fourth area.

The concrete tank, weighing 3,500 tons, was towed down the Mississippi River Gulf Outlet, around the mouth of the Mississippi River, and westward along the Louisiana coast to the High Island area offshore Texas.

The total trip length was 400 miles. Once at the site, it was ballasted to predetermined hook weight of 110 tons and lowered to the seafloor by controlled ballast. The total lowering operation took approximately four hours. Once positioned around the existing well caisson, the pilings were stabbed through the tank and driven to their required depth.

The transition structure, which included the two boat landings and well caisson clamp, was set over the four piles and welded. The remaining deck was set onto the transition structure stabbing guides and welded in a conventional operation. The entire installation, once each element was on location, took only 48 hours. Removal, and potential reuse, of the facility can be accomplished by reversing the procedure.

Figure 3: The concrete tank is show starting its 400-mile voyage to its offshore site.

Company

PMSS is a subsidiary of Production Management Companies. The firm offers operating and management services for producing oil and gas properties in the US Gulf of Mexico and worldwide. The firm is a single source for production facility and process equipment design, fabrication, hook-up and start-up, as well as offshore painting and fabrication.

Established in 1982, PMSS has pioneered the use of concrete offshore in the Gulf of Mexico. Using relatively recent developed concrete technologies and conforming to the latest American Petroleum Institute (API) and American Concrete Institute (ACI), PMSS has designed, constructed, and installed nine such structures in the offshore waters of the US Gulf of Mexico since 1982. ■

BIOGRAPHY

Frank L. Anastasio, Jr. *is president of PMSS, located in New Orleans. He has worked in design and construction of concrete structures (drydocks, piers, barges) for the marine environment for the past 19 years. He founded PMSS in 1982. He holds a civil engineering degree from Louisiana State University and is a registered professional engineer.*