Concrete-steel platforms offer shallow water option

Gravity base structure with steel deck provides extra space, strength and operational/removal flexibility for water depths to 100 ft

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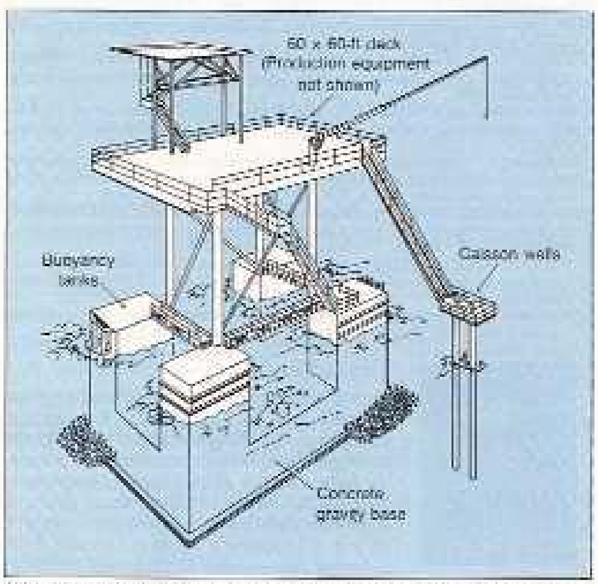
OPERATORS OF OFFSHORE properties have an alternative to both traditional and "minimal" steel structures as platforms for shallow-water (less than 100 ft) and/or marginal developments. That alternative is the hybrid steel and concrete gravity structure developed by Production Management Structural Systems, Inc. and Production Management Industries, Inc., both Production Management Companies.

The hybrid platform is a natural design evolution from earlier all-concrete structures, the first of which was installed in the U.S. Gulf of Mexico OCS in 1979, and which remains in service. To date, seven all-concrete or hybrid structures have been placed in OCS service offshore, in water depths to 30 ft and up to 25 miles from shore. Earlier structures have survived numerous hurricanes and tropical storms to attest to their strength and integrity.

The most recent installation in 23-ft water was completed for an independent operator in South Marsh Island Block 253 in December 1988, to produce two caisson wells, bridge connected to the structure. Following a general description of the hybrid platform's design/installation/removal features, the SMI 253 installation is detailed to illustrate and document the concept.



HYBRID CONCRETE-STEEL platform installed in 23-ft Gulf of Mexico water. Production equipment for 40 MMcfd and 6-man accommodation building are not shown.

Advantages. While its initial cost is not as low as that for some minimal platforms, the hybrid concrete and steel gravity structure offers several distinct advantages over *both* traditional and minimal steel-piled structures. Its principal advantages are:

- Available deck space is equivalent to areas found on traditional jacketed structures, thus allowing for large-capacity production trains as well as additional equipment such as compressors and personnel quarters;
- The structure offers an opportunity for substantial produced-liquid storage capacity within gravity base compartmentation;
- It is more easily removed than traditional pile supported structures; and the recovered gravity-structure facility offers more opportunities for reuse, with minimal rework; and
- Installed cost of gravity structures is comparable to installed cost of a steel-pile-jacketed structure, with the added bonus of much higher salvage values—often approaching 70% of new-facility cost.

Design features. Design of a gravity structure for offshore Gulf of Mexico waters is regulated by API, the American Concrete Institute (ACI), and the federal government's Minerals Management Service (MMS). All of these agencies address the minimum requirements relative to design, construction and in-place operation of gravity-based structures. API's RP2A, *Planning, designing and constructing fixed offshore platforms*, and ACI's publication 357R, *Guide for the design and construction of fixed offshore concrete structures*, both define specific safety factors applicable to gravity-based structures. As an example, a minimum safety factor of 2.0 is required for soil bearing pressure capacity.

Principal criteria controlling a gravity structure's in-place design are sliding resistance, overturning resistance, and maximum/minimum soil bearing pressures, as well as criteria for stability during towing, installation and recovery. All structures installed in federal OCS waters are subject to MMS approval, so the design must also be reviewed by this agency.

Since a gravity structure's foundation design is controlled by topsides loadings in conjunction with specific bottom conditions at the particular well site, an accurate soil analysis is necessary as is typical for pile-supported structures. Depending on bottom conditions, final design may vary from one simply placed on-bottom (in hard soils with a high shear strength coefficient) to one which may require shallow dredging and placement of a shell pad foundation similar to those used for submersible drilling rigs.

In rare instances, i.e., very soft bottoms with low shear strength, spud piling may also be necessary to provide satisfactory sliding resistance. In these applications, it is a simple matter to cast spud wells into the gravity base. And, spud piling does not significantly hinder gravity base recovery since the piling may be pulled, without cutting or blasting below the mudline, to allow for deballasting and recovery.

Fabrication/construction. Once design is finalized, both gravity base and deck topsides are readily constructed utilizing time-proven methods.

Since the gravity structure supports a full-sized steel deck assembly, much greater latitude is available to topsides designers relative to equipment placement and piping configurations. And deck space is available for additional equipment such as quarters and compressors. As deck and base are fabricated independently, very fast construction schedules are typical, averaging 14–18 weeks from contract award to installation and facility start-up.

The gravity base is constructed using traditional steel-reinforced concrete casting techniques. Although both slip formed and pre-cast modular technology have been used, the pre-cast modular method—where much of the structure is built of flat cast panels later assembled and joined via cast-in-place pilasters—has proven more efficient, regarding both scheduling and costs.

The production deck assembly is constructed of standard steel beams supported by a tubular steel substructure, so fabrication procedures are the same as those used for steel jacket decks. However, the deck can be fully outfitted onshore, thus minimizing offshore hookup.

The gravity base's exact dimensions are determined by topsides loadings and soil configurations. The base component is equipped with a cast concrete skirt which extends horizontally beyond the outside walls. This skirt provides added in-place stability and also, in conjunction with rip-rap placement, reduces scouring.

Cast on top of the gravity base are four buoyancy tanks. These perform several functions: (1) they ensure that the base maintains stability during the offshore ballasting; (2) they provide an above water work surface for mating steel deck legs to the gravity base; (3) they serve as supports for boat landings and walkways; and (4) they also may be used as a sump tank.

In deeper water, greater than 40 ft, buoyancy tanks extending above water may not be economically feasible and may be eliminated. In this situation, the gravity base ballasting procedure is controlled from a valve platform and stability is maintained by this controlled ballasting and by using a minimal positive hook load provided by a crane or derrick barge.

Installation. The hybrid structure may be installed in one of two ways, depending on total topsides loading, length of tow, available weather window, the structure's dimensions and water depth.

PRODUCTION DECK for SMI 253 platform being offloaded from cargo barge for installation on submerged gravity base.

GUIDE CONES on gravity base guide deck legs into place before final welding.

The first method involves mating the deck to the base at the fab yard and towing the free-floating unit in one piece to the site. Although this minimizes offshore construction, it may not be an option due to overall height of the completed unit in its floating configuration and overhead clearance limitations during the inland tow.

The second method is to tow the unit out in two pieces (1) the self-floating gravity base component with boat landings, handrails, walkways, rubrails, risers, and other accessories preinstalled, and (2) the fully outfitted deck assembly, preassembled to its substructure and towed on a separate cargo

Once the bottom is prepared, i.e., debris removed, soft mud dredged and the shell pad placed, if necessary, the installation sequence is to set the base on bottom and then weld the steel deck to it.

Lowering the concrete base to bottom is accomplished by free-flooding. For this purpose, sea chests are piped with PVC piping to a PVC caisson with valves to numerous separate internal watertight compartments. Control of the flooding valves is from above-water tank tops. The actual lowering operation requires some 6 hours, with the structure remaining very close to trim during the procedure. Once hard on the bottom, base and buoyancy tanks are completely flooded and remain so during operational life.

The fully outfitted steel deck section is set onto the stabbing guides, which are inverted steel cones cast into the tops of the buoyancy tanks. The deck is then welded in place and flowlines/sales lines are completed. For scour protection, rip rap is placed around the base on the shelf and some 3 ft up the wall.

Removal. Ease of removal is one of the principal advantages of the system, and can be readily accomplished with minimal environmental disruption. After proper decommissioning of wells, pipelines and process equipment, the deck assembly is cut free of the base, lifted and tied down on a cargo barge in a manner similar to that for a traditional structure. The base is then dewatered by closing sea-chest valving and placing submersible pumps into the caissons within the base. Once positive buoyancy is achieved, the gravity base returns to its self-floating configuration for towing to a new location.

For in-field moves, and others where a proper weather window is available, it may not be necessary to remove the deck from the gravity base prior to deballasting. In these instances, the complete structure can be refloated, moved, installed/hooked-up and readied for production in a matter of days.

The SMI 253 installation. This structure consists of a 58 × 58 × 11-ft high gravity base with four 14 × 14 × 20 ft high buoyancy tanks. Mounted on the gravity base is a deck assembly measuring 60 × 60 ft and elevated 46 ft above the water line. There is a 27 × 27-ft heliport at the plus 72-ft level.

Process equipment includes a 40 MMscfd gas production train designed to produce four wells, with deck space provided for future gas compression needs. Utility systems on the platform include dual power generation sets, a six-man quarters building, a 10-t hydraulic crane, and a Lact (custody transfer) unit on the main deck. Potable water, sewerage and sump systems are located on cellar deck assemblies.

The structure was placed adjacent to two side-by-side producing wells, each supported by a 30-in. caisson. A clamp-on, 18 × 8-ft wellhead access deck is located at the plus 25-ft level; and the two wells are accessed from the main deck via an inclined stairway. This unit was placed into production just 16 weeks after contract award. ■

The author

Frank L. Anastasio, Jr., president, Production Management Structural Systems, Inc., New Orleans, Louisiana, graduated from Louisiana State University in 1970 with a B.S. degree in civil engineering. From 1970 to 1972, he was a structural design engineer. For the past 17 years, he has worked in design and construction of concrete structures for the marine environment including barge supported facilities, drydocks, piers and gravity structures, serving in various engineering/executive capacities. He was named president of PMSS in 1982. Mr. Anastasio is a registered professional engineer.