Gravity Fixed Platforms

구조적 특징

- Concrete 자체 중량으로 위치 유지
- Skirt로 미끄럼 방지
- 비대한 구조로 인하여 수평력 및 모멘트가 큼
- Foundation이 되는 해저면이 건조한 곳에 유리

(주로 북해에 설치)

중력식 구조물의 장점

- 작업원 및 시설의 안전성이 높음
- Deck상의 설비를 완비한 후 해상의 현장까지 예항하므로 설치시간 및 경비를 최소화 할 수 있다.
- 석유 저장 용량의 조절이 쉽다.
- 강재 Riser관 등을 원통 Shaft가 보호해 줌
- 대형 Deck를 지지 할 수 있다.

단점

- 파랑 또는 조류로 인하여 해저면의 침식으로 구조물 전체를 유실할 우려가 있음
- 현장까지 이동에 어려움이 있음
used for temporary storage of crude oil during operation. As can be seen from Fig. 2.18, the production risers as well as all oil supply and discharge lines are contained in one of the columns, the corresponding piping system for exchange water is installed in another, while drilling takes place through the third column. Up to 48 conductors, each of 0.76-m (30-in) diameter are
loadings for a 200,000-t concrete platform in 140-m waters with a total horizontal force of 460 MN and an overturning moment of 23,000 MNm are about 2–3 times higher than for a comparable piled steel platform. They cause transverse and rocking motions of the structure, the amplitudes of which are around 20 cm at the periphery and 50 cm on the deck [6].

At present, the heaviest reinforced concrete structure is the Gullfaks-C Platform with a total height of 380 m, a deadweight of 750,000 t, and a crude oil storage capacity of 2 million barrels (320,000 m³) (Fig. 2.19). At tow-out this concrete gravity base structure (GBS) had a weight of 1.5 million tons. Erected in 217-m waters, the horizontal force and the overturning moment reach peak values of 712 MN and 65,440 MNm, respectively, requiring concrete skirts at the foundation with a penetrating depth of 22 m [153, 200].

The second structure in Fig. 2.17, the Ninian Platform also has a large-volume caisson on the seafloor tapering off to a monolithic structure as a base.
3–4 m over about 50 years operation because of its sheer weight [10, 168]. The three main towers are raised by inclined slipforming. Large-scale tests showed that an inclination angle of 11° is feasible, so the selected design also promises success for the planned angle of 16°. The three inclined supports are connected to a vertical central column by a huge node called the ‘riegel’, which gives additional buoyancy, so that the structure can be towed at limited draft with fully-equipped deck in a stable floating position. Based on principles of the T300 design the Troll GBS was finally developed for installation in the Troll field.

One of the latest developments in concrete structures is the mono-shaft Draugen platform. The 285 m concrete structure is designed for a water depth of 251 m, and will be towed to the field at a draft of 220 m (displacement at tow 518 000 t).

Increasing the size of the foundation also allows gravity-fixed platforms to be made of steel, as for example the Tecnomare Steel Gravity structure (TSG) for the Maureen Field (Fig. 2.17) [10, 31]. Since the total weight of steel structures is substantially less than of concrete structures draft limitations are not serious. As for concrete platforms, the flotation chambers are used as storage tanks. However, connecting large-volume elements with steel lattice structures could be critical, especially in terms of fatigue damage. Platform stability is ensured through skirts. In softer materials, where deeper penetration (i.e. longer skirts) is required, the limited ballasting potentials may pose a problem. Further, the fabrication of a hexagonal top structure also represents a non-standard construction.

Recently, some ‘light-weight’ concrete or hybrid platforms have been built for oil and gas production from marginal fields or for various special purposes (Fig. 2.20):

- The research platform ‘Nordsee’ is a hybrid structure with a flat concrete foundation and a steel space-frame for supporting the steel deck. Located near the North Sea island Heligoland, it serves as an ocean research center.
Gravity Structures

Template structures, as described earlier, are especially suited to soft-soil regions such as the Gulf of Mexico, where deeply driven piles are needed to fix the structure in place and carry the required deck loadings. In regions where hard soil conditions exist and pile driving is more difficult, an alternative structural form has been developed which, in place of piles, relies on its own weight to hold it in place against the large lateral loads from wind, waves, and current. These structures have large foundational elements which, when ballasted, contribute significantly to the required weight and which spread this weight over a sufficient area of the seafloor to prevent failure. Such structures are generally referred to as gravity structures.

In their more popular form, gravity structures are constructed with reinforced concrete and consist of a large cellular base surrounding several unbraced columns which extend upward from the base to support a deck and equipment above the water surface. Structures of this kind were installed in the North Sea during the mid-1970s. Figure 1.9 illustrates the main features of these structures. This particular structure is referred to as a CONDEEP (concrete deep-water) structure and was designed and constructed in Norway.

The construction of concrete gravity platforms is altogether different from that employed for template-type structures. Figure 1.10 illustrates the typical construction sequence employed for the North Sea structures. As illustrated, the base is constructed in a drydock, after which it is floated out and moored in a deep-water harbor. The construction is then completed by slip-forming the large towers in a continuous operation until they are topped off. The structure is next ballasted down and a steel prefabricated deck floated over the structure and attached to the top of the towers. Additional deck modules are then set in place and the entire structure refloated for towing to its offshore site, where it is again ballasted down to its final operating position.

Figure 1.11 shows a typical concrete gravity platform under tow and at its final offshore site in the North Sea in approximately 390 ft of water. The base structure consists of 16 hollow concrete cells, 66 ft in diameter and 164 ft high, with wall thicknesses of about 2 ft. The three main columns extend upward a distance of 327 ft above the top of the base cells, with outside diameters tappered from 66 to 39 ft. The deck weight, with equipment, is approximately 50 million pounds and the weight of the support structure is approximately 600 million pounds.
One advantage of the gravity structure over the template type is the reduced time needed for on-site installation. This is especially important in hostile areas such as the North Sea, where unpredictable weather conditions make it highly desirable to limit the construction time needed to fix the structure in place. Another advantage is the very large deck weights that can be carried by the massive concrete columns. With equipment, the deck of the structure shown in Fig. 1.11 weighs more than 20 times that of typical steel template structures.

The construction of large gravity structures of the type described above obviously requires deep harbors and deep tow-out channels. The Norwegian fjords have provided such conditions for the North Sea platforms.

Not all gravity structures need, of course, to be made of concrete or to be of the mammoth scale of those discussed above. Steel gravity platforms have, for example, been designed and installed off Nigeria, where the presence of rock close to the seafloor ruled out the possibility of using piles to fix the structure in place against lateral loadings (Watt, 1978).

A very simple illustration of a steel gravity platform is also provided by the towers installed by the U.S. Air Force off Florida in the Gulf of Mexico for purposes of monitoring pilot training and performance. These towers consist of a steel tubular column supported by a boxlike steel base containing rock ballast. Figure 1.12(a) shows one of these towers being towed to its offshore site, and Fig. 1.12(b) shows the structure before being sunk to the seafloor by flooding the base. Figure 1.12(c) shows the structure in its final operating position. The total height of the structure is approximately 200 ft, with about 100 ft beneath the water surface. The seafloor in this region of the Gulf consists of a thick layer of sand which provides firm support for the structure.

Deep-Water Design Forms

For water depths greater than about 1000 ft, the weight and foundation requirements of traditional offshore structures make them less attractive than other design forms. Two such forms are the guyed tower and tension-leg platform.
The guyed-tower concept is illustrated in Fig. 1.13. It consists of a uniform cross-sectional support structure held upright by several guy lines that run to clump weights on the ocean floor. From the clump weights, the lines then run to conventional anchors to form a dual stiffness mooring system. Under normal operating loads, the clump weights remain on the seafloor and lateral motion of the structure is restrained. However, during a severe storm, the clump weights are lifted off the seafloor by loads transferred from the structure to the clump weights through the guy lines. This action permits the tower to absorb the environmental loadings on it by swaying back and forth without overloading the guy lines. The guyed-tower concept is presently considered to be applicable to water depths of about 2000 ft.

Figure 1.14 illustrates the tension-leg concept. In this design, vertical members are used to anchor the platform to the seafloor. This upper part of the structure is designed with a large amount of excessive buoyancy so as to keep the vertical members in tension. Because of this tension, the platform remains virtually horizontal under wave action. Lateral excursions are also limited by the vertical members, since such movements necessarily cause them to develop a restoring force. A major advantage of the tension-leg concept is its relative cost insensitivity to increased water depths. At the present time, it appears that the main limitation on the tension-leg platform arises from dynamic inertia forces associated with the lateral oscillations of the platform in waves. These become significant at water depths of about 3000 ft (Lee, 1981).
Fig. 1.10. Illustration of construction and installation procedures for concrete gravity platforms. (Courtesy of the Mobil Oil Corporation.)