Solved Exercise Problems in Chapter 2 on Components of Offshore Structures

2.1 Give a figure of a fixed jacket platform structure and name all the components of the structure. Describe the functions of the various components of the platform.

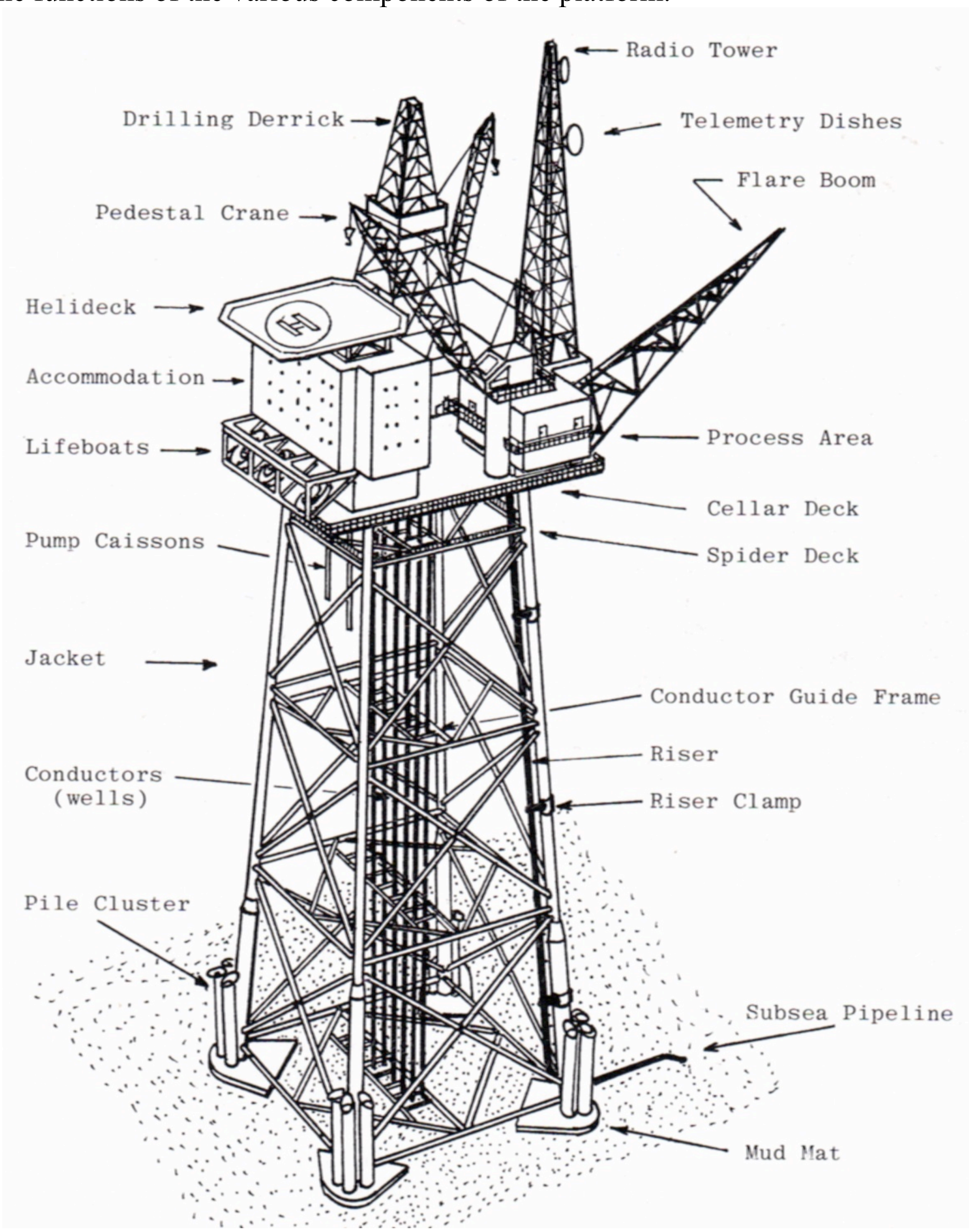


Figure 2.1 Components of a fixed jacket platform [A. Mather, 1995. Offshore Engineering: An Introduction, Witherby & Company, Ltd., p. 19].

The important components of an offshore structure are given in Figure 2.1 as: (i) The steel jacket structure; (ii) The foundations consisting of pile clusters and mud mat; (iii) The topsides consisting of top cellar and spider decks, accommodation quarters and helipad, drilling derrick and flare boom; and (iv) Drilling derrick with the associated components as marine risers and conductors and associated seabed components as sub-sea wells, BOP and others. The steel jacket structure provides a stationary platform for the drilling and other auxiliary operations carried out on the structure; it is designed to resist the forces imposed on it by a 50-year ocean environmental conditions acting on it; in addition the structure is designed in such a way as not to collapse into the ocean when unexpected extreme environmental conditions are acting on the structure.

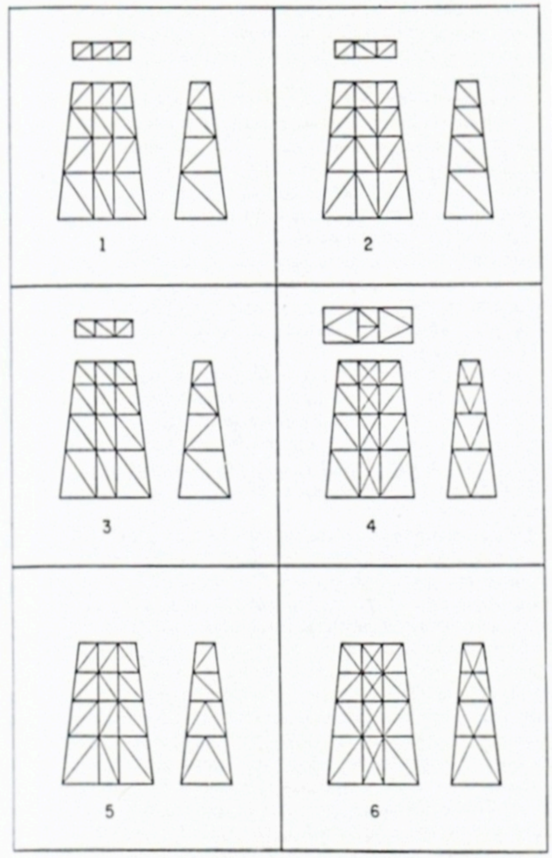
The foundation piles provide fixity to the steel jacket structure by restraining the transverse movement of the jacket structure at its base. The pile clusters penetrate seabed to the required depth. The mud mats provided at the bottom of the main columns of the platform enable the jacket structure do settle down safely on the seabed (during initial installation) by supplying a cushioning effect to the jacket structure. In addition they also act as stiff pile caps through which the piles can be driven vertically into the seabed using underwater hammers.

The topsides essentially consist of components that fulfill the essential functions of an offshore structure, viz., (i) Drilling derricks that provide the structure the capacity to carry the casings, drill strings and drilling fluid during the drilling process, and then carry the risers (with telescopic joints, riser tensioner and choke and kill lines) and conductors to transport the oil and gas to the processing and storage facilities located on the deck and as well to carry injected water to the reservoir to extract oil and gas at higher pressures; (ii) Living quarters for persons operating the derrick and the platform; (iii) Flare boom to burn the excess gas that cannot be stored; and (iv) crane and radio tower.

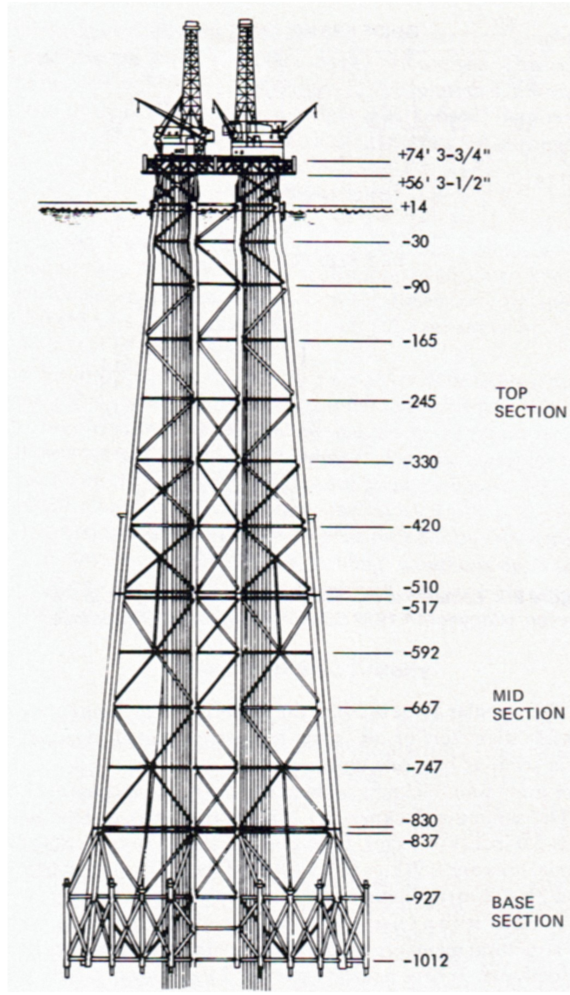
The drilling and other sub-sea components are: (i) Drill pipes with drill collars; (ii) Rotary table with Kelly and Kelly bushing; (iii) Lower marine riser package (LMOP) consisting of blowout preventer (BOP) and choke and kill system, diverters and others; (iv) Guide frame for drill string; and (v) Travelling block or cylinders to offset heave of the riser system.

2.2 Describe, with neat sketches, the various framing plans used for a jacket structure, and explain how they are brought together to form an integral jacket structure.

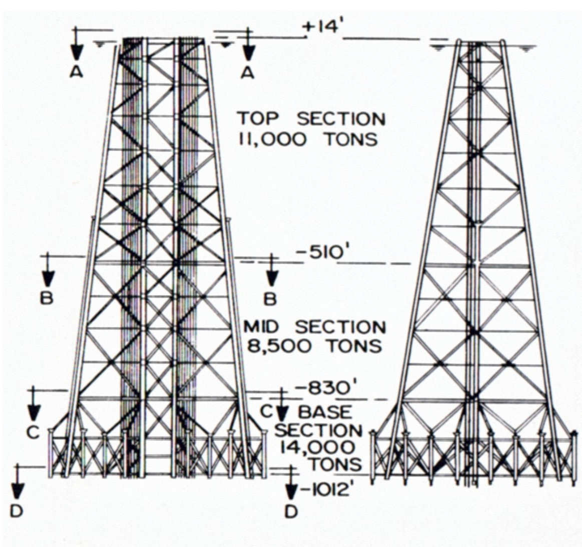
The framing plans and the assembling of the various frames (or members) are in the figures as Figures 2.2 (i), (ii), (iii), (iv), and (v). The figures given in Figures 2.2 (i), (ii), (iii) and (iv) are those of Cognac platform, which was installed in a water depth of 1,025 feet, at an offshore location, southeast of Venice, Louisiana, USA. Figure 2.2 (v) shows how members and frames are brought together to form a single jacket structure; similar methodology will be repeated for the fabrication of Cognac platform structure.

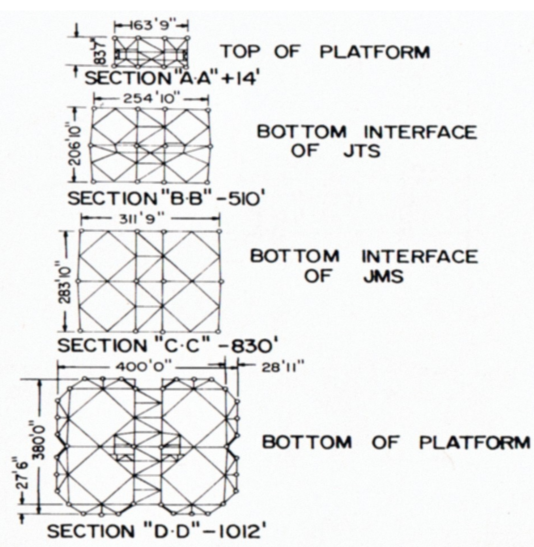


(i) Commonly used jacket framing plans



(ii) Assembled Cognac platform





(iii) Below-water configuration of Cognac platform (iv) Plan dimensions at assembled sub-section. [W.J. Graff, 1981. Introduction to Offshore Structures, Gulf Publ. Co, Houston, USA, pp. 49, 56 & 111].

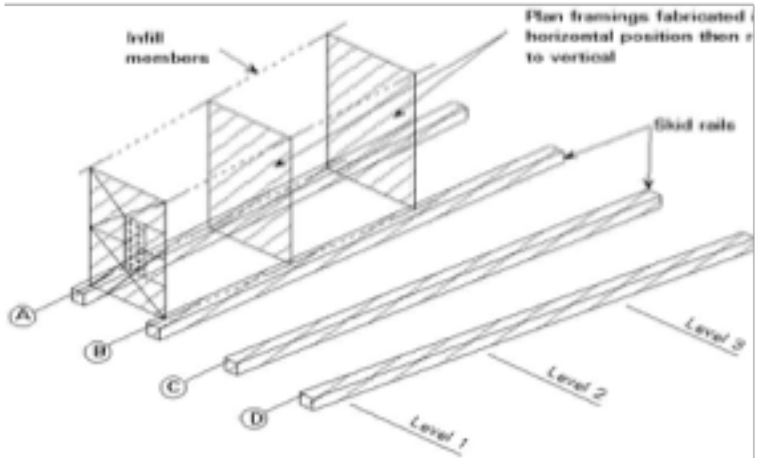


Figure 3a Erection of pre-assembled plan framings

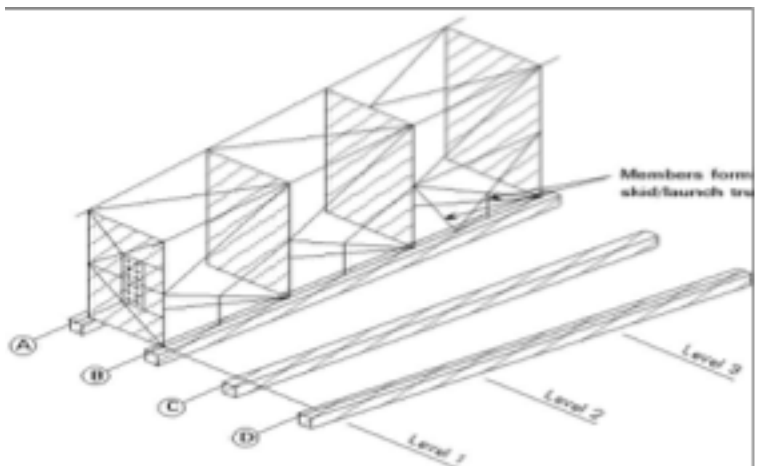


Figure 3b Completion of bay 1

Figure 2.2 Fabrication of a steel jacket frame, part v (continued).

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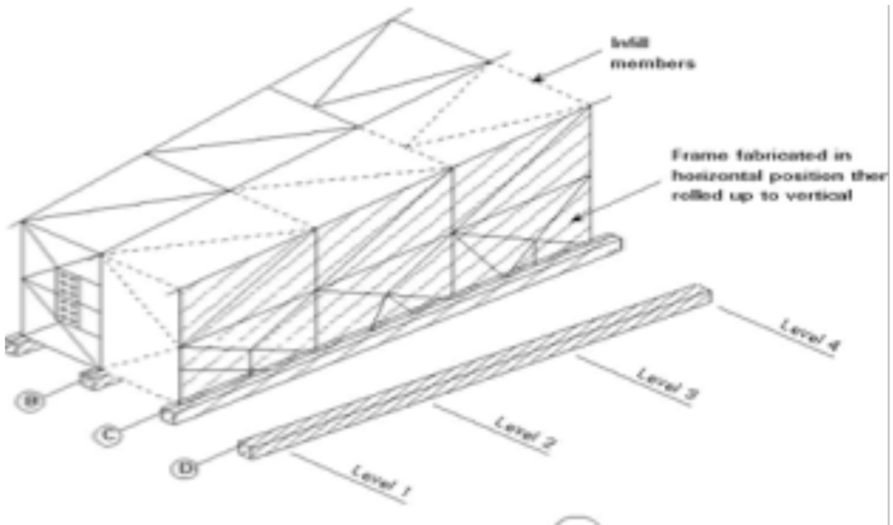


Figure 3c Roll-up of frame C

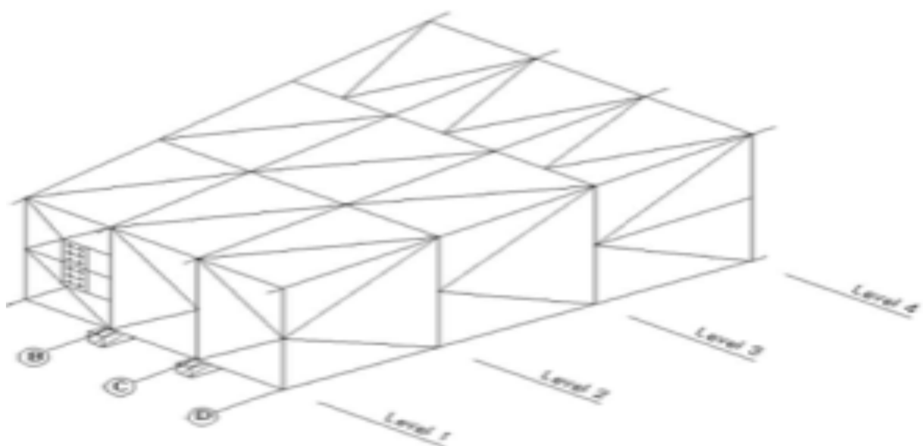


Figure 3e Completed jacket ready for loadout

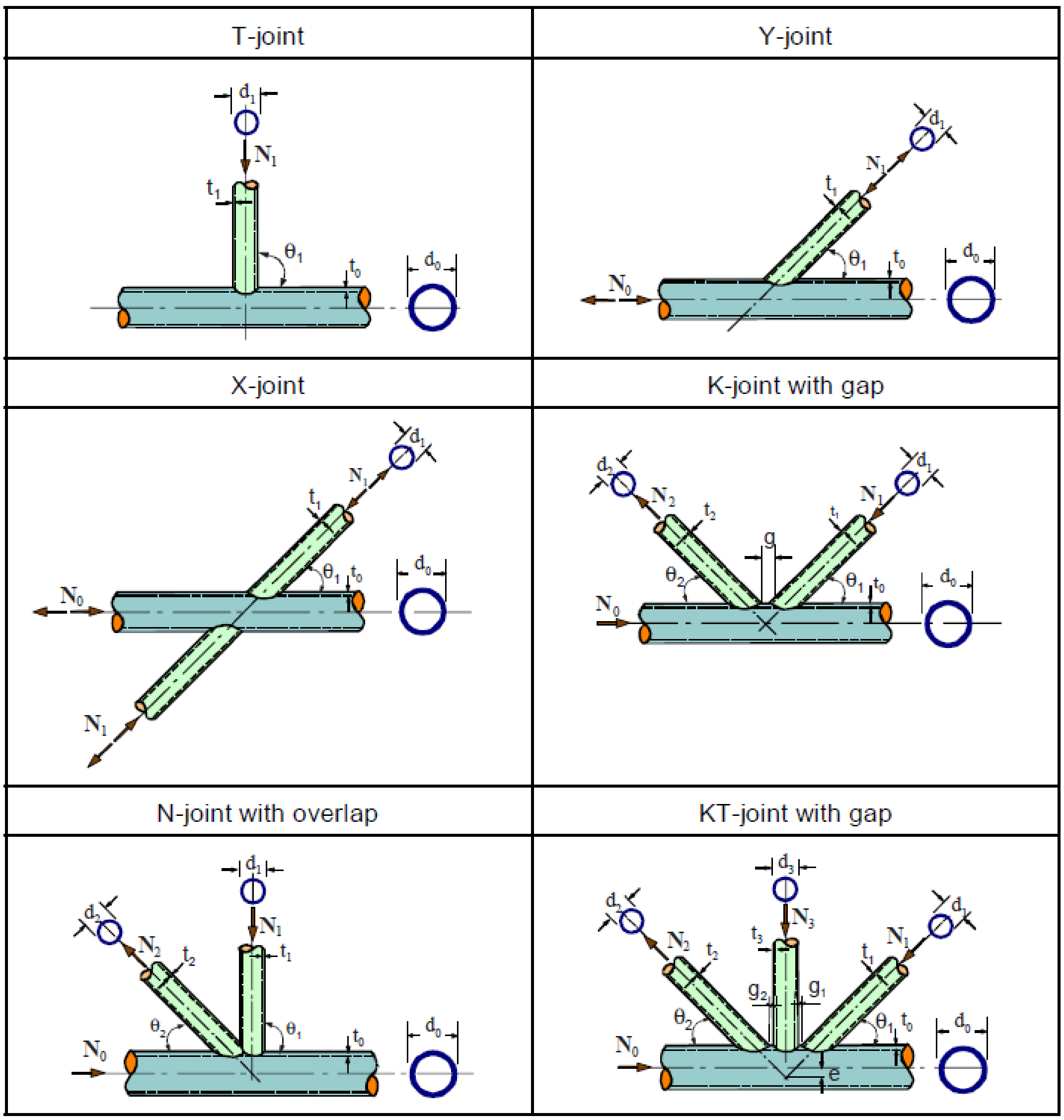
(v) Assembling together of the framing members into a framed jacket structure [http://www.fgg.uni-lj.si/kmk/esdep/master/wg15a/l0800.htm]

Figure 2.2 Fabrication of a steel jacket frame.

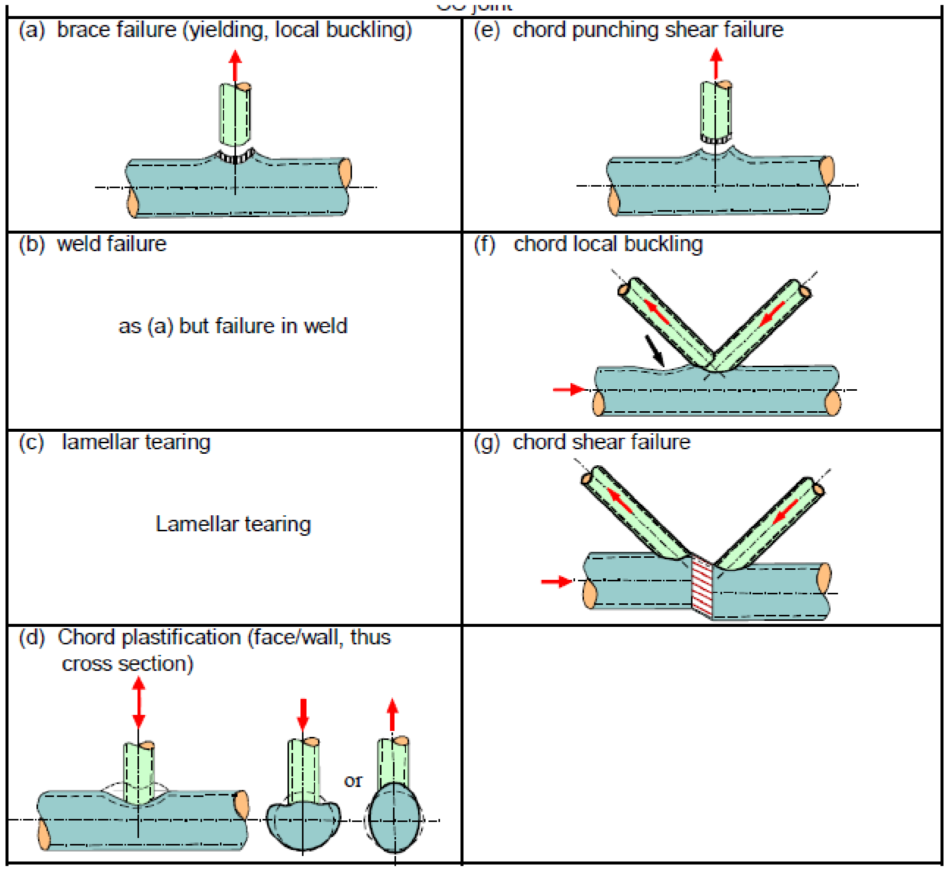
2.3 A steel jacket is to be designed for a water depth of: (i) 100.0 m; and (ii) 500.0 m. Will you follow the same plan of designing and fabricating the jacket structure for both the water depths or something different? If not, outline the difference in the design and fabrication procedures. Also, state the reasons for the change.

The upper limit for installing fixed jacket platform seems to be around 450.0 m; beyond this water depth other offshore platforms such as a TLP or a guyed tower has to be considered.

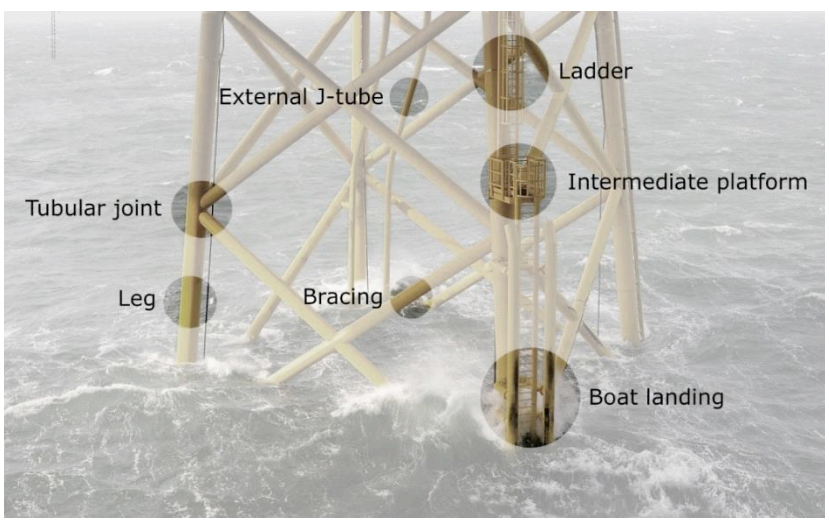
2.4 Assuming that the jacket structure is to be fabricated from tubular steel structural members, explain, with sketches, how the members are connected together to form a complete jacket structure.



(i) Types of possible 2-D welded joints in tubular steel framed structures [J. Wardenier, 2001. Hollow Sections in Structural Applications, CIDECT Technical Commission, p. 8.12]



(ii) Failure modes of tubular joints
[J. Wardenier, 2001. Hollow Sections in Structural Applications, CIDECT Technical Commission, p. 8.13]



(iii) Some possible types of three-dimensional joints
[Jacket – A path to deeper waters. http://lorc.e-kvator.com/Knowledge/Wind/Support-structures/Jacket]
Figure 2.4 A few 2-D and 3-D welded tubular joints in a steel jacket frame.

The two figures given above in Figure 2.4 (i) and (ii) illustrate the possible types of two-dimensional joint connections that are possible when connecting together tubular steel members to form a planar space frame. The figures at the bottom give the possible modes of failure the structural designer and fabricator have to keep in mind as they design and fabricate the tubular joints. Figure 2.4 (iii) show some possible types of three-dimensional joints possible in jacket structures.

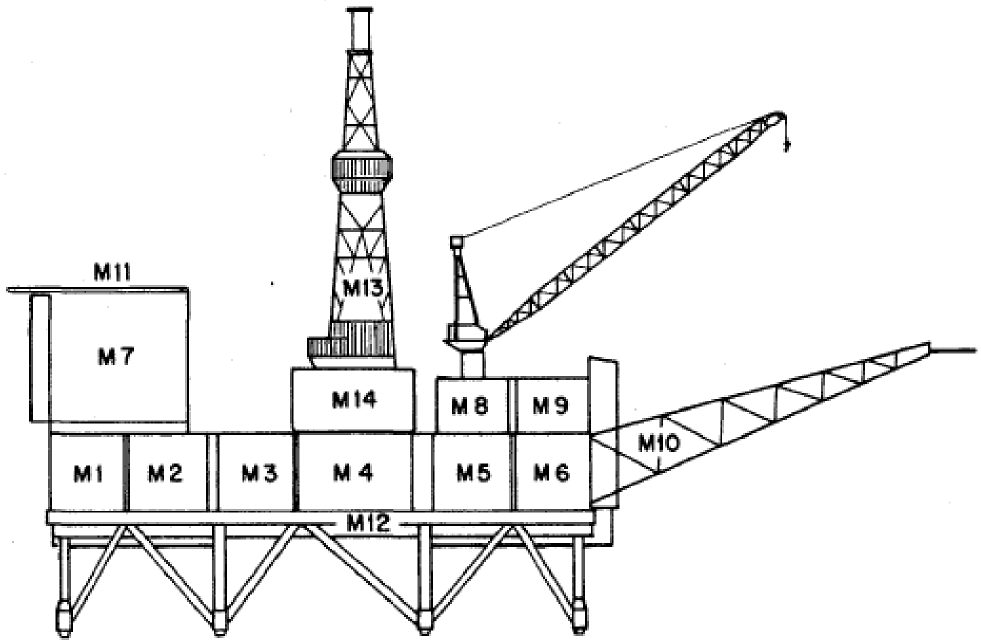
2.5 (a) Describe the various components that form the superstructure of a fixed jacket structure, using a neat figure (or sketches). Describe in detail how the assembled components on the cellar deck and the top deck of the jacket platform structure are configured. (b) Briefly describe the modular construction in a fixed jacket platform, using a building block representation.

(a) The components of the superstructure of an offshore platform are: (i) Deck facilities consisting of main deck on which all the modular components are located; (ii) Cellar deck in which the secondary components such as power generation, sub-sea well injection and control facilities, wellhead with rotary drilling control provisions, and emergency exit provisions are installed; and (iii) The bottom-most deck provides facilities the support base for living quarters, fenders to prevent accidental impacts and boat-landing system. The top deck consists of modular facilities such as: (i) Oil and gas treatment; (ii) Oil and gas storage, offloading and export; (iii) Utility and process support modules; (iv) Drilling derrick, bulk storage and support module; (v) Mud/cement storage and pumping units; (vi) Flare boom; (vii) Cranes and (viii) Helideck. Figure 2.5 (i) given below, gives a list of the modular components assembled on top a steel jacket offshore platform; and Figure 2.5 (ii) shows the placement of the modular assembly of components on the decks. Figure 2.5 (iii) shows details of the components provided on the top deck of an offshore platform.

(b) Figure 2.5 (iii) shows details of the components provided on the top deck of an offshore platform; for additional details of the modular construction of an offshore platform s shown in Figure 2.10 of the text book.

	FUNCTION
M 1	UTILITIES
M 2	POWER GENERATION
M 3	WATER INJECTION
M 4	WELLHEAD
M 5	SEPARATION
M 6	GAS COMPRESSION
M 7	LIVING QUARTERS
M 8	MUD/CEMENT PUMPS
M 9	DRILLING BULK STORAGE & POWER GENERATION
M10	FLARE BOOM
M11	HELICOPTER DECK
M12	MODULE SUPPORT FRAME
M13	DRILLING DERRICK/SUBSTRUCTURE/SUBBASE
M14	SHAKER PACKAGE

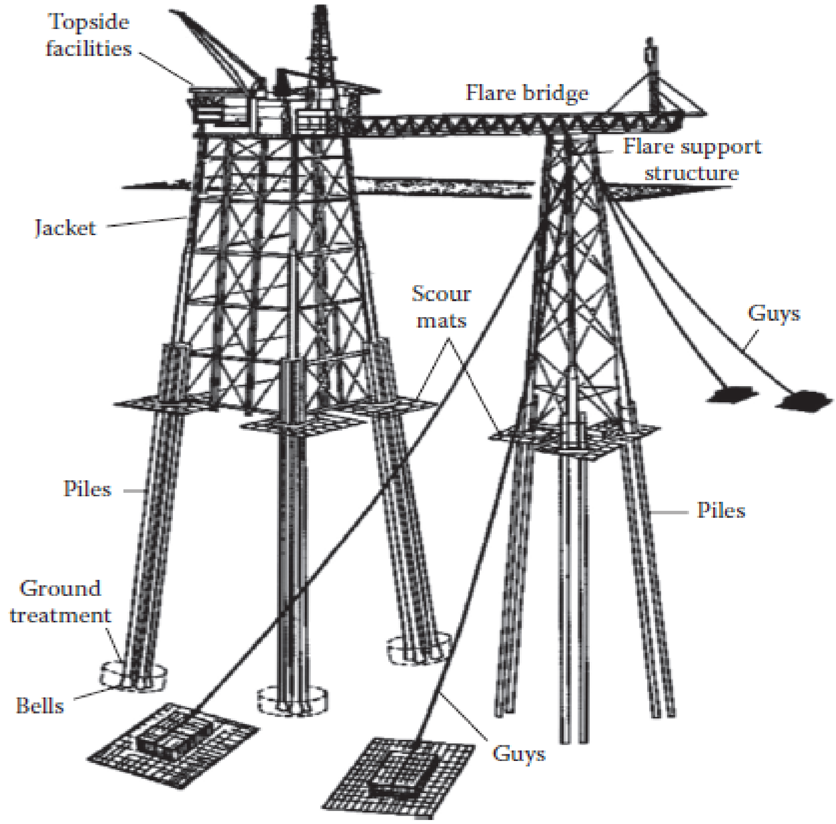
(i) List of modular components located on the top deck of an offshore jacket platform. (T.M.G. Cloughley, 1985. Design, Fabrication, Hookup and Commissioning of North Cormorant Topside Facilities, Journal of Petroleum Tech., p. 125)



(ii) Details of modular components located on the top deck of an offshore platform. (T.M.G. Cloughley, 1985. Design, Fabrication, Hookup and Commissioning of North Cormorant Topside Facilities, Journal of Petroleum Tech., p. 125)

(iii) Details of modular assembly in the top deck and two cellar decks of the steel jacket structure. (Technical brochure, Offshore, ALE. www.ALE-HEAVYLIFT.COM,)
Figure E2.5 Modular construction of the deck of a steel jacket platform.

2.6 A jacket platform is to be installed at an offshore site (150.0 m water depth) where the top layer of the soil is silty and clayey, up to a depth of 100.0 m, with a layer of hard and stiff soil below it. Illustrate with neat figures or sketches, how the jacket structures will be fixed to the seabed.



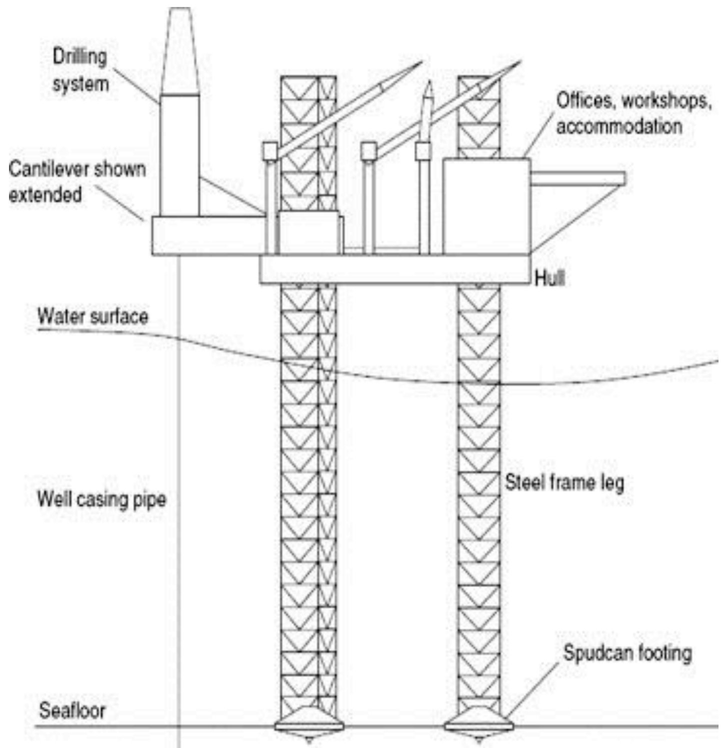
Embedment of the pile clusters in sandy and silty soils (www.iransaze.com/files-for-downloading/ ebglishbook/khak/ challenges_of_Offshore_Geotechnical_Engineering.pdf.2005)
Figure 2.5 Installation and fixing of a steel jacket framed platform to the seabed.

The details of fixity of a steel jacket platform to the seabed are neatly illustrated in the Figure E2.6 given above, consisting of pile clusters, driven through the pile-heads into the soil to the required depth. At the tip of the pile, it is sloped (like a cone) with a bell foundation so that it provides a proper grip for the pile end and resists well any tensile withdrawal forces acting on it; moreover the bottom is bell-shaped so that it will distribute the compression load on the pile properly to the soil below. The pile penetrates more than 100.0 m into the seabed, say 110.0 m, wherein the pile refuses to penetrate into the seabed for number of five to ten blows of the pile-driving hammer.

2.7 Explain the functional difference between a fixed jacket platform and a jack-up steel platform. Give a neat sketch of a jack-up steel structure, describing the function of its various components for: (a) Jack-up platform with spud cans; and (b) Jack-up platform with mat-type foundation.

A **jack-up rig** is a self-elevating drilling rig that consists of a buoyant vessel, connected into an integrated stable unit through a number of vertically retractable legs, having a mat foundation or a number of separate spud-cans, supporting the vertically retractable legs of the platform. The buoyant vessel of the jack-up platform can be raised over the surface of sea so that it will provide a stable platform over the incessantly moving wave surface to carry out offshore drilling operations. The buoyant vessel also enables transportation of the unit and all attached machinery to any desired location by towing. Usually jack-up platforms are not self propelled and are transported by large ships or tugs to the site of installation; they are used as exploratory drilling platforms.

The major differences between a jack-up and a fixed jacket platform are: (i) The fixed platform cannot be moved whereas the jack-up can be moved to any location all over the world; (ii) The jack-up platform is only a temporary structure used for exploratory drilling that assesses the reservoir capacity and flow rate; whereas the fixed platform is a permanent structure on the reservoir site that will be used for drilling and production of oil and gas offshore.

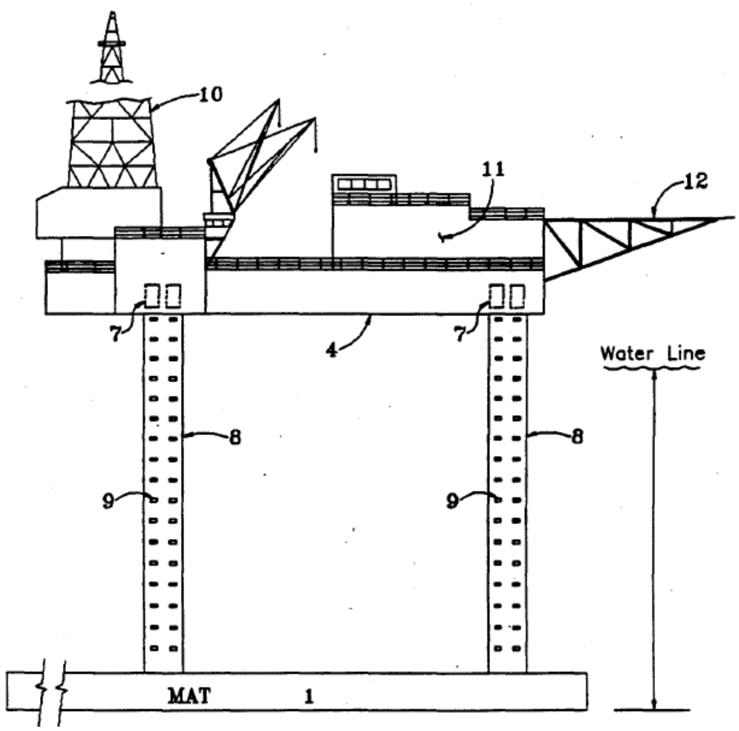


(i) Components of a jack-up platform with spud-can foundations at the bottom. [http://www.google.ca/imgres?imgurl=http://ars.els-cdn.com/content/image/ (sciencedirect.com)]

The various components of a jack-up platform (spud-can type), shown above in Figure 2.7 (i), can be listed as:

(i) The buoyant hull (or vessel) that provides a stationary surface for housing the various components of the platform structures;
(ii) Steel truss-type legs of the platform, often three or four in numbers, which supports the platform over the wavy sea surface:
(iii) The spud-can footing that distributes the loads on the jack-up legs safely to the foundation soil below;
(iv) The drilling derrick, that is supported over a cantilever overhang, that drills the exploratory wells through the casing pipe (or conductors); and
(v) The facilities provided on the deck of the buoyant hull to support the operations, such as: (a) Drilling derrick; (ii) Offices, workshops and accommodation; and (iii) Cranes for hoisting supplies and personnel from supply ships.

The components of a jack-up with mat foundation are shown in Figure 2.7 (ii), given below:



(ii) Components of a Jack-up platform with a mat-type foundation.
[1 – Mat foundation; 4 – Buoyant hull; 8 – Retractable legs; 10 – Drilling derrick; 11 – Offices and Accommodation quarters; and 12 Deck crane.
Figure 2.7 Types of Jack-up platforms used in the exploration for offshore oil and gas [D.S. Nunley, 1993. U.S. Patent # 5,190,410].

2.8 A mat-type jack-up platform structure is to be used for offshore exploration in Bombay High, where the soil is very soft, with a surface bearing strength of 50.0 kPa. The mat-type platform has to resist a maximum vertical load of 10,000.0 kips; in addition, it has to resist an overturning moment of 2000.0 kip.ft. State how you would design the mat so that no tension is developed in the soil.

The surface bearing strength = 50.0 kPa = 50,000 N/m^2.
10,000 kips = 10,000,000 lbs = 4,536,000.0 kgf = 44,498,160.0 N

<u>For supporting the vertical loads, the required supporting area is:</u>

Foundation area required for the mat foundation of the jack-up platform
= (44,498,160.0)/(50,000.0) = 889.96 m^2.

Taking a base size of 40x25 m mat foundation, the soil pressure at base = 44,498,160/1000
= 44,498.2 N/m^2 = 44.5 kPa. Hence the structure is safe for vertical loads.

<u>For resisting the overturning moment, the required footing size is:</u>

Assume that the wind is blowing along the length of the jack-up platform:

Assume that the mat foundation is supported by four vertical retractable legs. Consider the rectangular foundation carrying four supporting vertical columns (or legs), and that each leg is placed at a distance of 17 m from the center of the foundation mat (on the longer side) with 3 m overhang, and at a distance of 10.0 m from the center (on the shorter side) with 2.5 m overhand.

Assuming that the maximum pressure on the mat foundation is p_1 kPa at one end and the pressure at the other end to be zero kPa, the moment resisted by the mat foundation of the platform (around its center) = $(1/2)(0.0 + p_1)(25.0)[(2/3)(40) – 20.0]$ = (2,000,000.0)(0.4536)(9.81)(30.48/100) N.m
= 2,712,607.83 N.m.

p_1 = 33,556.31 N/m^2; this pressure is less than the allowable maximum of 50,000.0 N/m^2. Hence the designed structure is safe of resisting the overturning moment also.

2.9 Differentiate between the deck structural components of a fixed jacket production structure and an exploratory jack-up type structure with mat-type foundation; use neat sketches.

The details of the deck structural components of a steel jacket platform and a jack-up rig are shown in Figures 2.1, 2.5 (i), (ii) & (iii), and 2.7 (i) & (ii), and the sketches of jack-up platform rig is given in Figures 2.19 (a), (b) and (c) of the Text Book.

The topside facilities of a template steel jacket structure consists of three decks with two living quarters, comprising a total of 20 rooms and 30 beds as well as helideck and process facilities to house nearly 30 personnel in the platform. Built-in flexibility allows the removal of one of the living quarter modules. The original operating weight of the topsides was around 4,000 to 5,000 m.tons. However, initial design could also make provision for the addition of another future compression module as well as a skidded drilling derrick and associated drilling loads on the weather deck. The topsides module has overall dimensions of approximately 32.5m (north-south) by 60m (east-west). Electricity is supplied to the platform through two Caterpillar generators with two diesel-driven engines.

Major Equipment in the deck include: (i) A compression module with after-cooler facilities; (ii) Production separator; (iii) Flare system (cold and hot); (iv) The production separator with 2-phase or 3-phase operation; (v) A de-sanding system; (vi) Wet gas coolers and scrubbers; the pumps provided in the wet gas coolers could also be utilized as firewater pumps; (vii) Main generator drives to provide power for the platform; (viii) Production separator condensate pump (20-PA001) and wet gas scrubber, with pumping facilities to maintain the export pressures; (ix) Drilling rig with conductors and risers; (x) Chemical storage and injection; (xi) and Spare chemical and diesel tanks.

The topside facilities provided in a jack-up rig are given as: (i) Personnel quarters and office space for 20 to 30 persons; (ii) Crane and heli-deck; (iii) Drilling derrick with a rotary table and conductors; (iv) Pipe storage racks; (v) AC/DC generators; (vi) Drilling water and drilling mud storage facilities; and (vii) Auxiliary pumps

2.10 Describe, in detail, the functions of various structural components of a gravity platform structure giving the roles played by each.

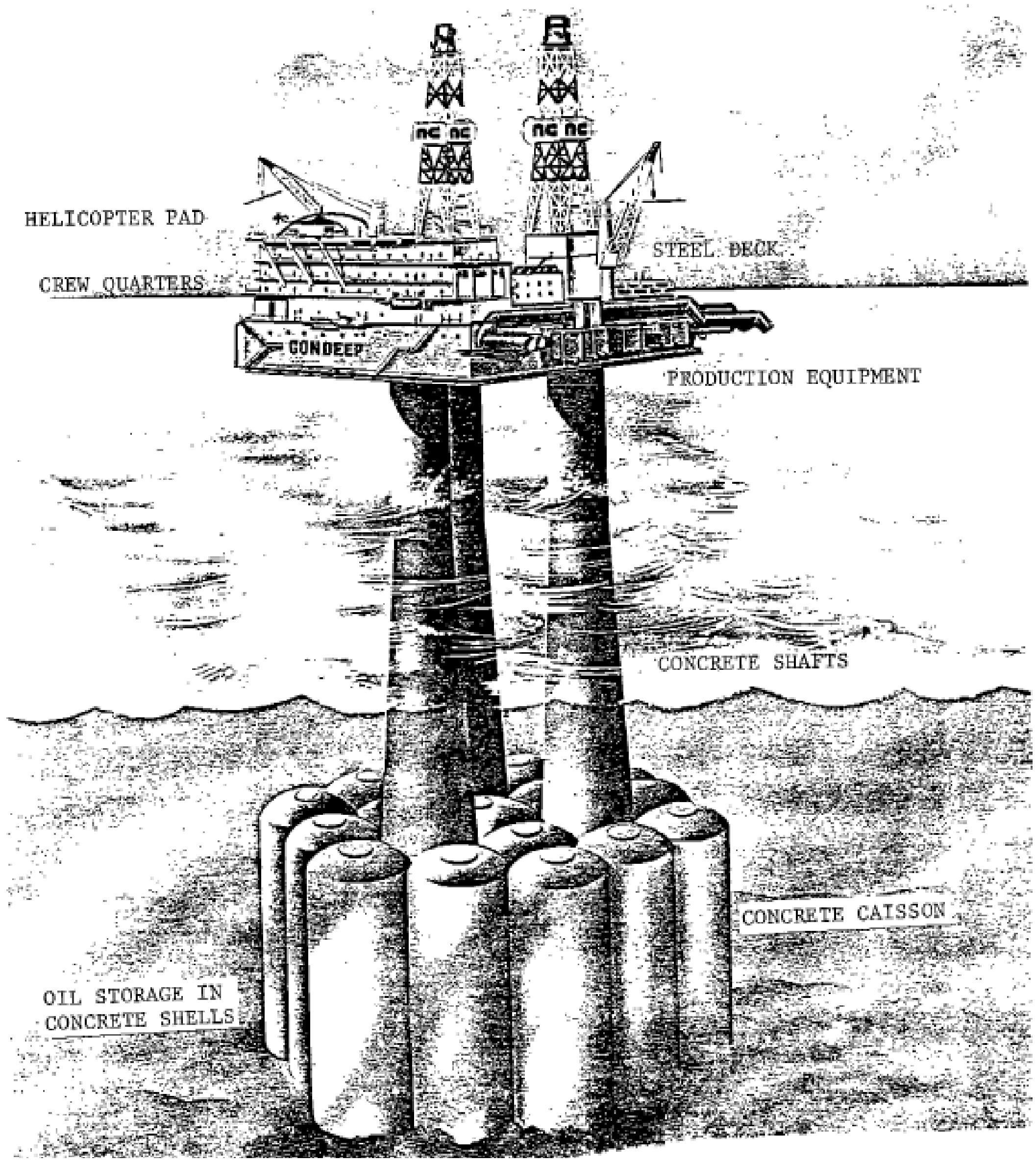


Figure 2.10 General features of a three-column condeep platform [O.H. Burnside and D.J. Pomerening, 1984. Survey of Experience in Using Reinforced Concrete in Floating Marine Structures, Ship Structure Committee Report 321, USCG, Washington, D.C., USA, pp. 3.24].

The main structural components of a gravity platform, shown in Figure 2.10, are: (a) The topsides of the platform modular assemblies of the various essential components in an offshore structure such as: (i) Drilling derrick with a rotary table and conductors; (ii) Control room for operations; (iii) Marine risers; (iv) Helicopter pad; (v) Cranes; (vi) Crew quarters; (vii) Cellar decks with oil and gas production equipment; (viii) Power generators; (ix) Mud-storage tanks and pumps; (x) Gas compressors and separators; (xi) Water injection facilities; and (xii) Bulk storage facilities. Since the gravity platform will be far-away from the land, the structure may have facilities for more than 100 persons to stay in the platform at one time. Then the concrete caissons support the topsides over the wave surface. The cylindrical caissons at bottom are used to store oil from which they can be unloaded to oil tankers dispatching then to the shore.

2.11 Give a cross-sectional view of a storage tank and the column of a condeep-type gravity platform, and name the salient structural components.

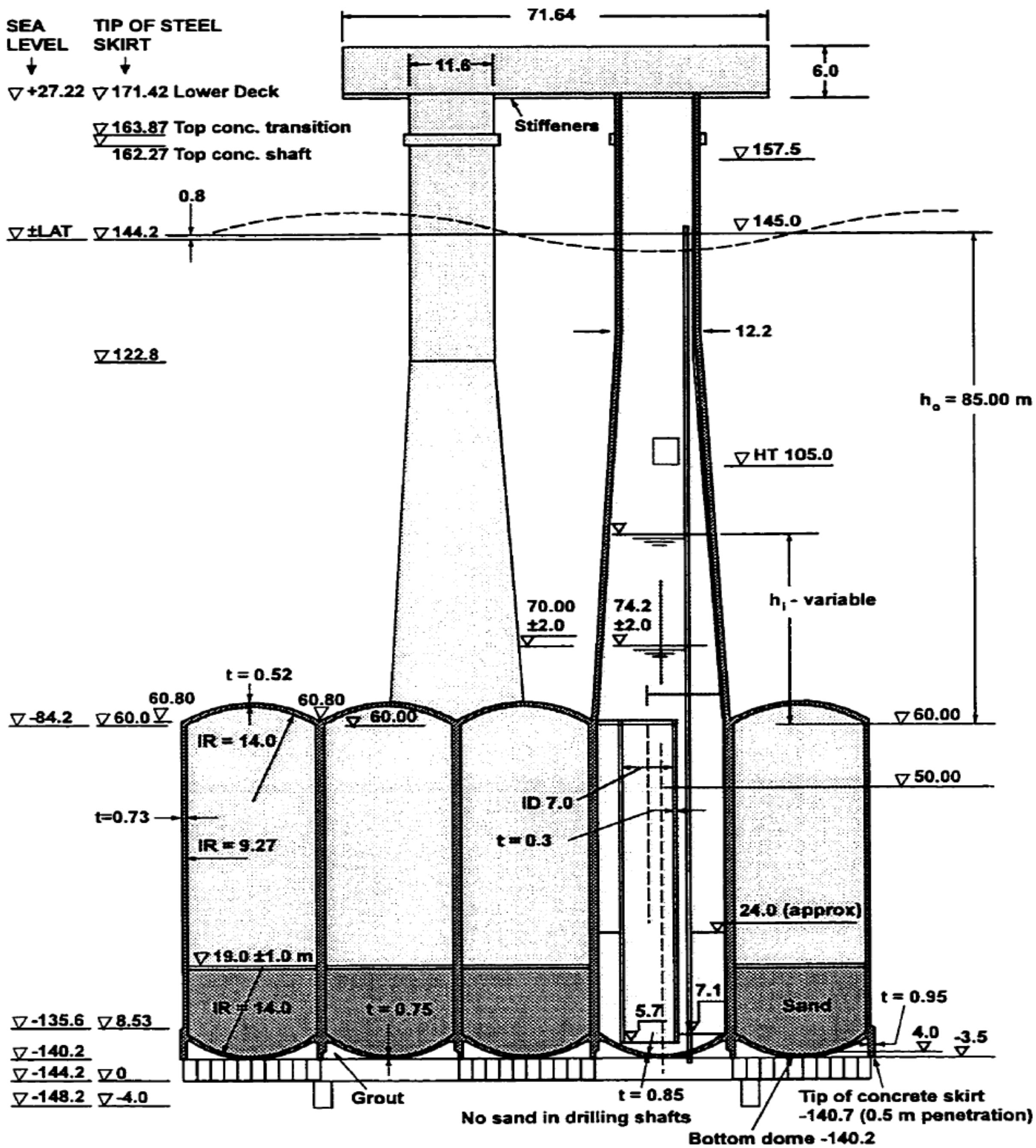


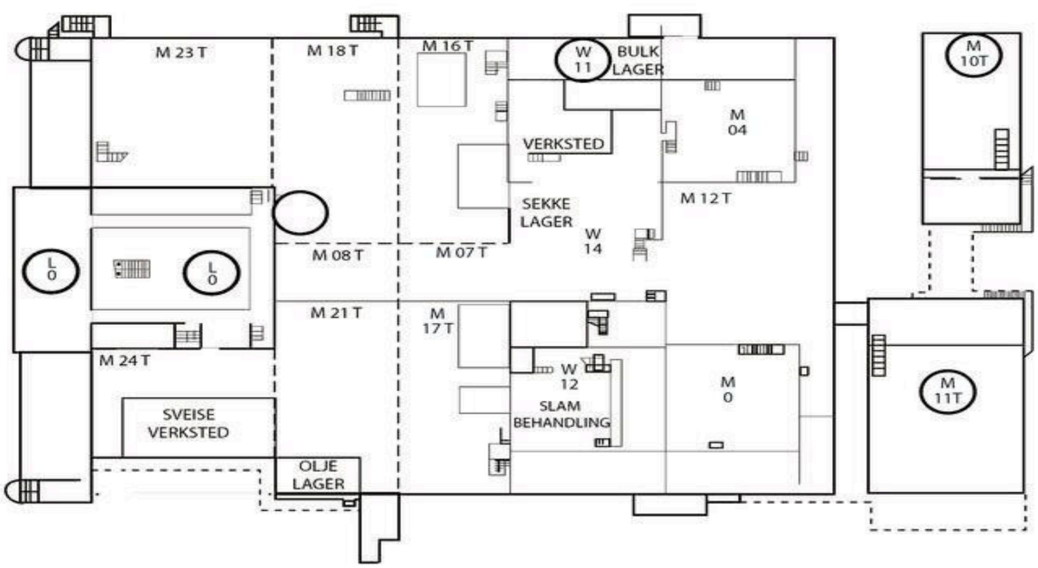
Figure 2.9 Typical cross section of condeep platforms, used earlier in the North Sea.

[A.I.I. Helmy, 1998. Behaviour of Offshore Reinforced Concrete Structures Under Hydrostatic Pressures, PhD Thesis, Civil Engineering Department, University of Toronto, page 2].

The salient components of the bottom caissons, shown in Figure 2.11, are: (i) Drilling caissons, containing the conductors, and risers; and (ii) Storage caissons containing the ballast and LNG.

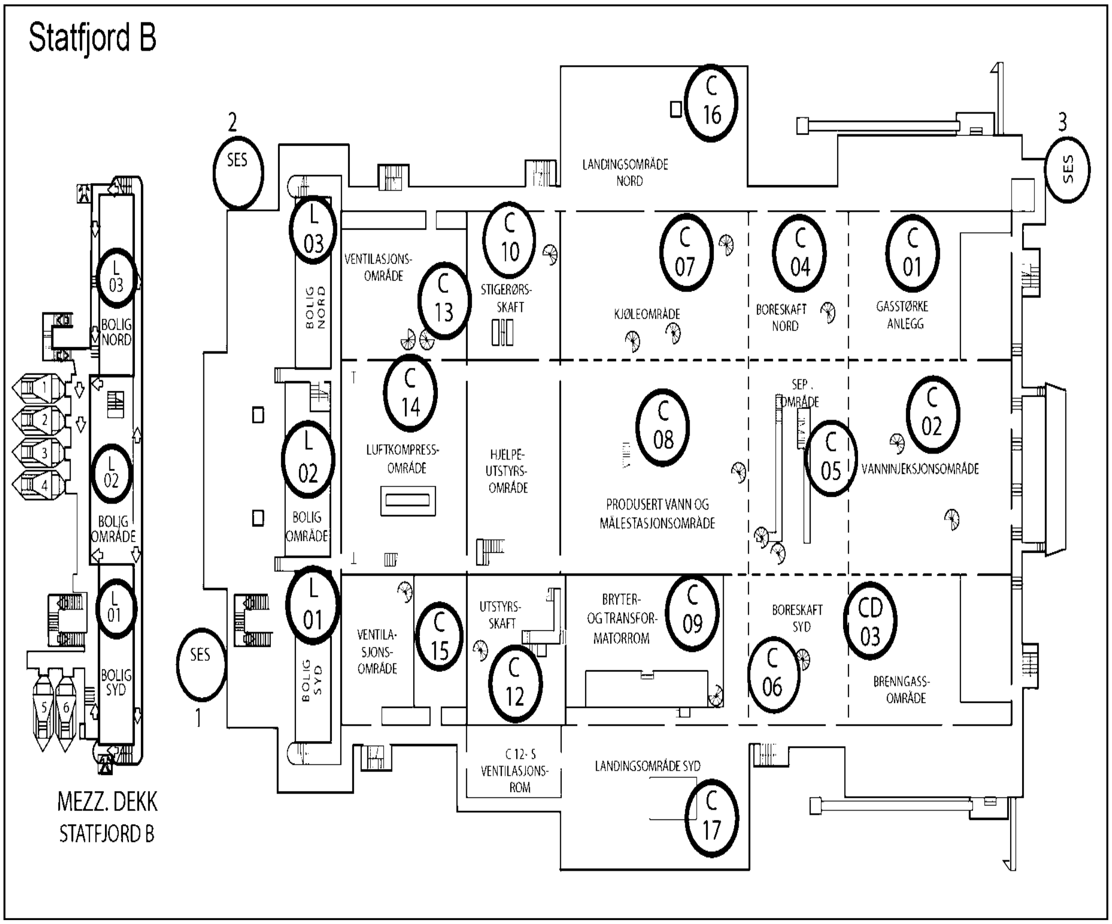
2.12 Briefly describe, with neat sketches, the structural configuration of a gravity platform deck.

Figure 2.12 Concrete Gravity Statfjord B platform
[H. Tonneson and F.H. Sandberg, 1983. Statfjord B Platform].



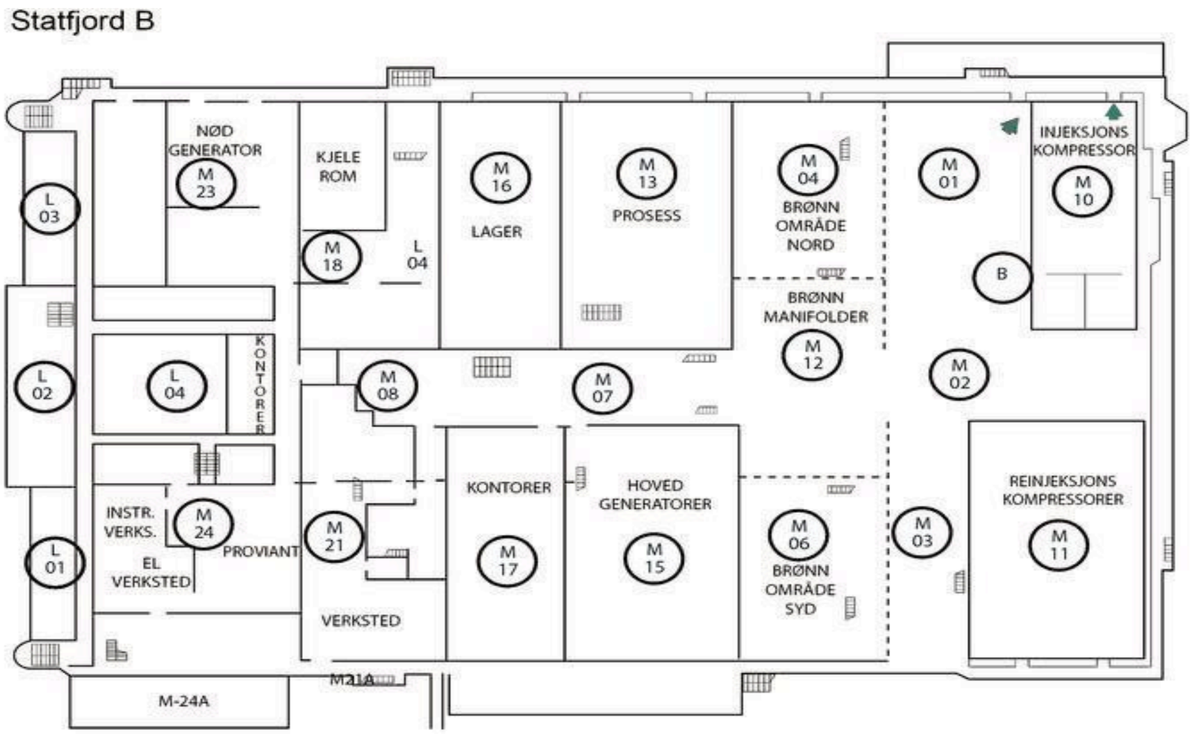
Sveiseverksted = welding shop; oljelager = oil storage; sekke lager = sack stock; verksted = workshop; slam behandling = sludge treatment; bulk lager = bulk storage.

Figure E2.12 (i) Cellar Deck of a Concrete Gravity Platform.
[H. Tonneson and F.H. Sandberg, 1983. Statfjord B Platform].



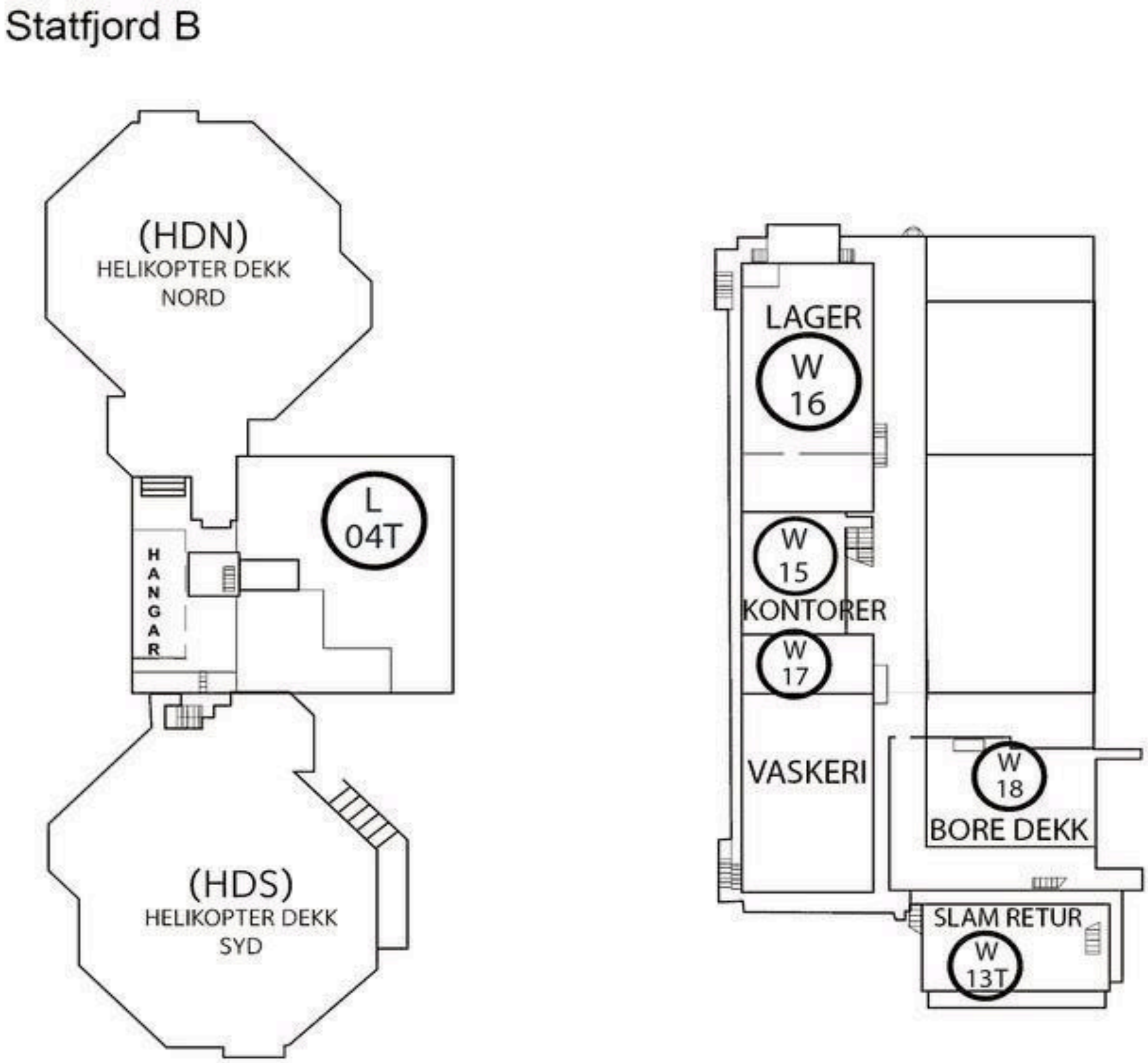
mezz. deck = in between storage deck; bolig syd = residential south; bolig syd = residential area; bolig syd = residential north;
ventilasions omrade = ventilation territory; luftkompress omrade = air compressor territory; ventilasions rom = ventilation room; hjelpe-utstyrs-omrade = ancillary equipment territory; utstyrs-skaft – Equipment shaft; landings-omrade nord = landing territory north; kjøleområde = cooling area; produsert vann og måle stasons område = produced water and measuring stations area; bryter-og transfor-mator rom = switch and transformer room; landings-omrade syd = landing territory south; boreskaft nord = drilling shaft north; sep område = landing area; boreskaft syd = drilling shaft south; gasstørke anlegg = gas drying plant; vann injeksjons område = water injection area; brenngass område = fuel gas area.

Figure E2.12 (ii) Mezzanine Deck of a Concrete Gravity Platform
[H. Tonneson and F.H. Sandberg, 1983. Statfjord B Platform].



nød generator = emergency generator; kontorer = offices; instr. verks. el verksted = Power plant and instrumentation; proviant = provisions; kjele rom = boiler rooms; verksted = workshop; lager = stock; kontorer = offices; prosess = process; hoved generatorer = main generators; bronn område nord = well area north; bronn manifolder = well manifolds; bronn område syd = well area south; injeksjons compressor = injection compressors; reinjeksjons compressor = reinjection compressors.

Figure 2.12 (iii) Weather (or Main) Deck of a Concrete Gravity Platform
[H. Tonneson and F.H. Sandberg, 1983. Statfjord B Platform].

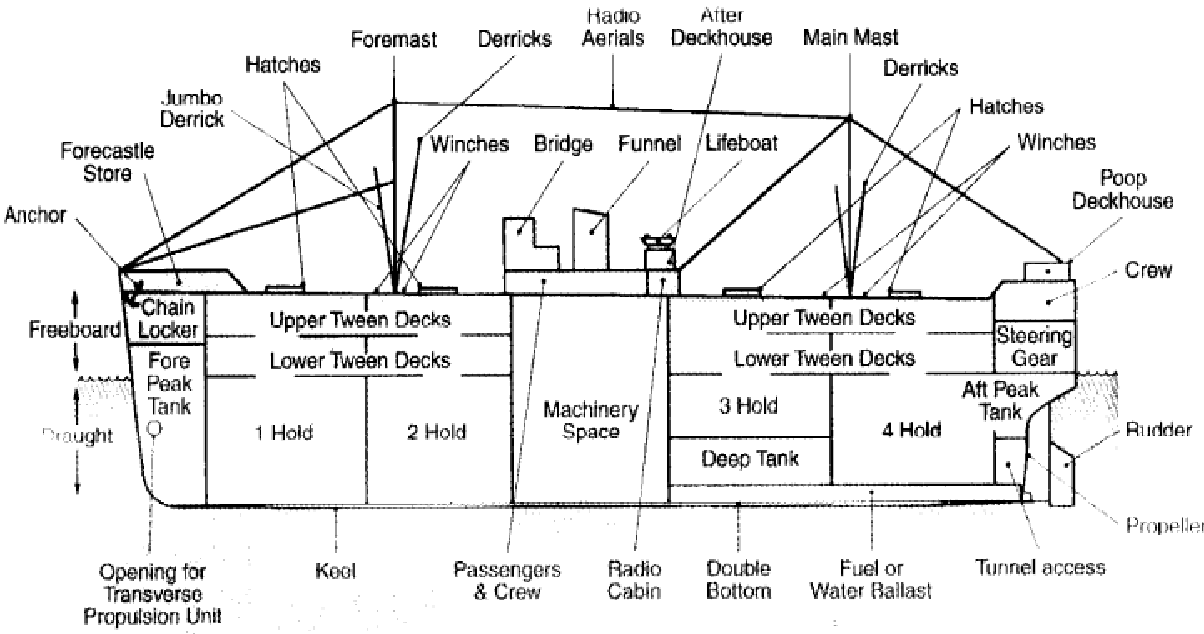


Helicopter deck nord = North helicopter deck; hangar = hangar; Helicopter deck syd = South helicopter deck; lager = stock; kontorer = offices; vaskeri = laundry; bore deck = drill floor; slam retur = sludge return.

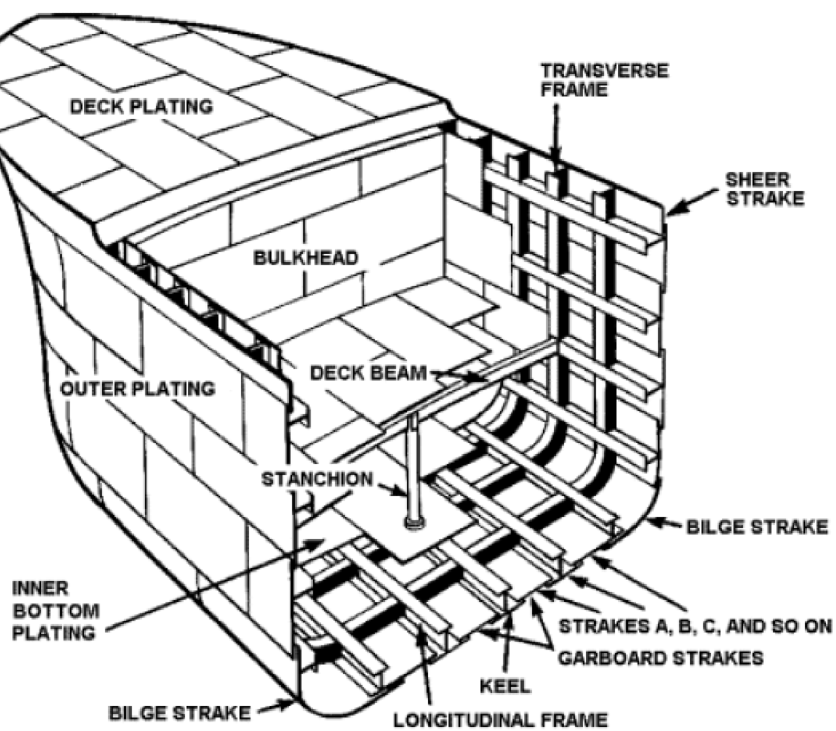
Figure 2.12 (iv) Upper Weather Deck and Living Quarter Module of a Concrete Gravity Platform [H. Tonneson and F.H. Sandberg, 1983. Statfjord B Platform].

The structural configurations of the concrete gravity Statfjord B platform are given in Figures 2.12 (i) to (iv). The salient components are: (i) Cellar deck; (ii) Mezzanine deck; (iii) Main or weather deck; and (iv) Upper weather deck with the heli-pad and living quarters module. The facilities provided in each deck are explained below each sub-figure.

2.13 Give simplified transverse and longitudinal cross-sectional views of a typical light ship. Describe the major structural and auxiliary components of a typical ship.



(i) Longitudinal cross-sectional view of a typical light cargo ship
[Ships and Ship's terms. http://www.pfri.uniri.hr/~bopri/documents/03-ME-2011_000.pdf]



(ii) The exposed transverse cut-out of a light cargo ship.
[Ships and Ship's terms. http://www.pfri.uniri.hr/~bopri/documents/03-ME-2011_000.pdf]

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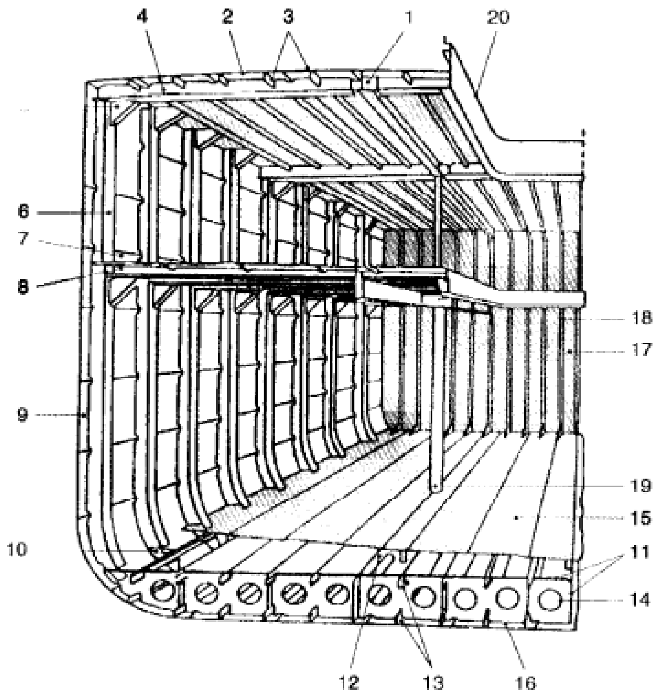


1. central stringer
2. deck plating
3. deck stringers
4. deck beam
5. knee, angle bar
6. frame
7. 'tween-deck plating
8. 'tween-deck beam
9. side plating (strakes)
10. margin plate
11. central girder
12. side stringer
13. bottom and double bottom stringers
14. floor
15. tank top, inner bottom
16. bottom plating (strakes)
17. cross bulkhead
18. bulkhead stiffener
19. hold pillar
20. hatch coaming

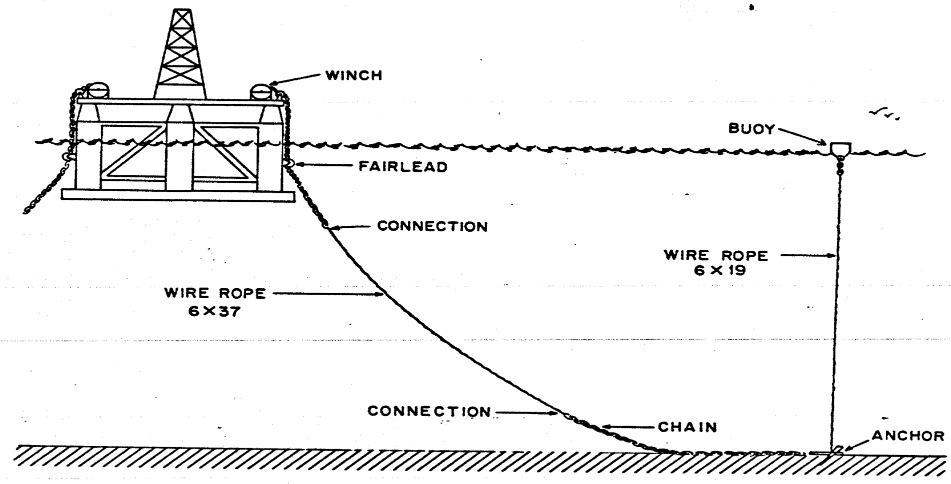
(iii) Cross-section of the cargo-hold of a ship

Figure 2.13 Simplified transverse, longitudinal and cross-sectional views of a typical light ship [Ships and Ship's terms. http://www.pfri.uniri.hr/~bopri/documents/03-ME-2011_000.pdf]

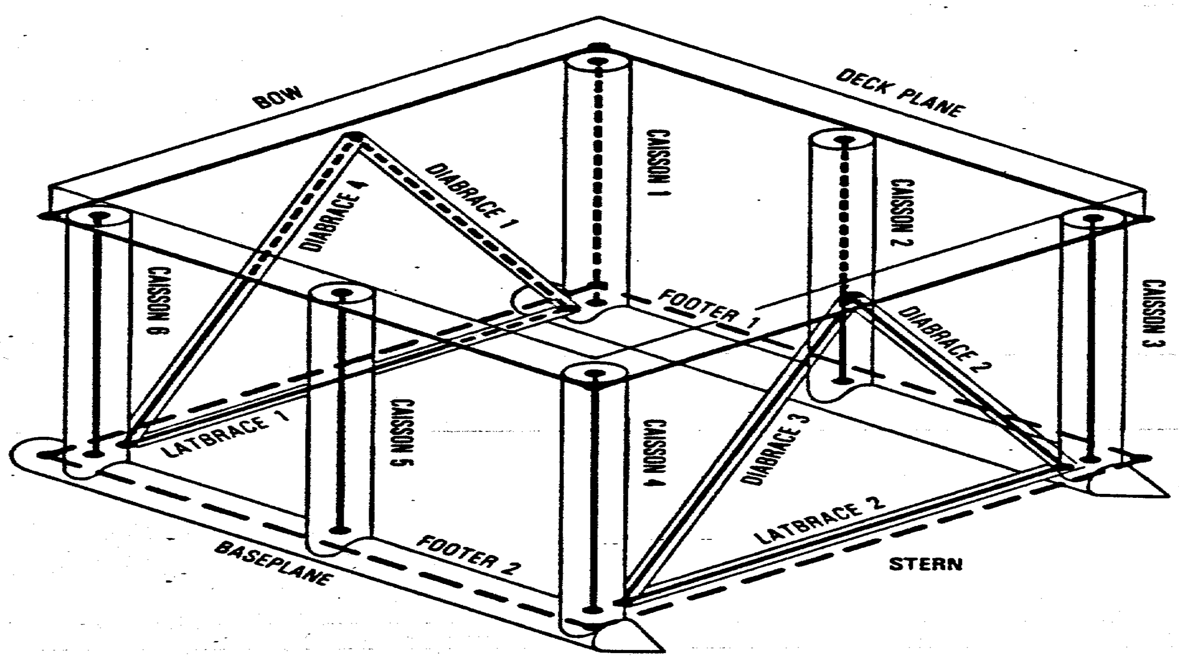
The various longitudinal and cross-sectional views of a light cargo-ship are shown in Figures 2.13 (i), (ii) and (iii). The cargo ship has various cargo-hold areas, which usually extend to the full width of the vessel. The equipment for cargo-handling is arranged on the main deck of the ship; access to the cargo holds will be provided by hatch openings. The accommodation area provided in the ship will be sufficient for to meet the needs of the crew. There will be a navigating bridge between the accommodation and the communication centre. The machinery space will house the essential equipment necessary for the transportation of the ship and it will also contain the auxiliary equipment necessary in a ship.

2.14 Describe the load-resistant skeletal structure of a semi-submersible platform, giving neat sketches. Also give the outer structure of this skeleton that actually bears the load coming on the semi-submersible and safely transmits it to the underlying skeletal structure.

The general arrangements in a semi-submersible are shown in Figure 2.14 (i) which shows the main derrick, the six columns of the semi-submersible that support the top deck above the wave surface and as well provide additional buoyancy besides that provided by the two submerged and buoyant horizontal pontoons. The semi-submersible is kept in station by the mooring wire ropes that is connected to the heavy anchors in the seabed; when it is required to move the semi-submersible the anchors can be lifted from the sea by using the winch provided on the too deck of the semi-submersible. Figure 2.14 (ii) shows the skeleton the semi-submersible that resists the longitudinal bending, transverse bending and torsional forces and deformations that occur in the semi-submersible structure.



(i) Semisubmersible with a spread mooring.

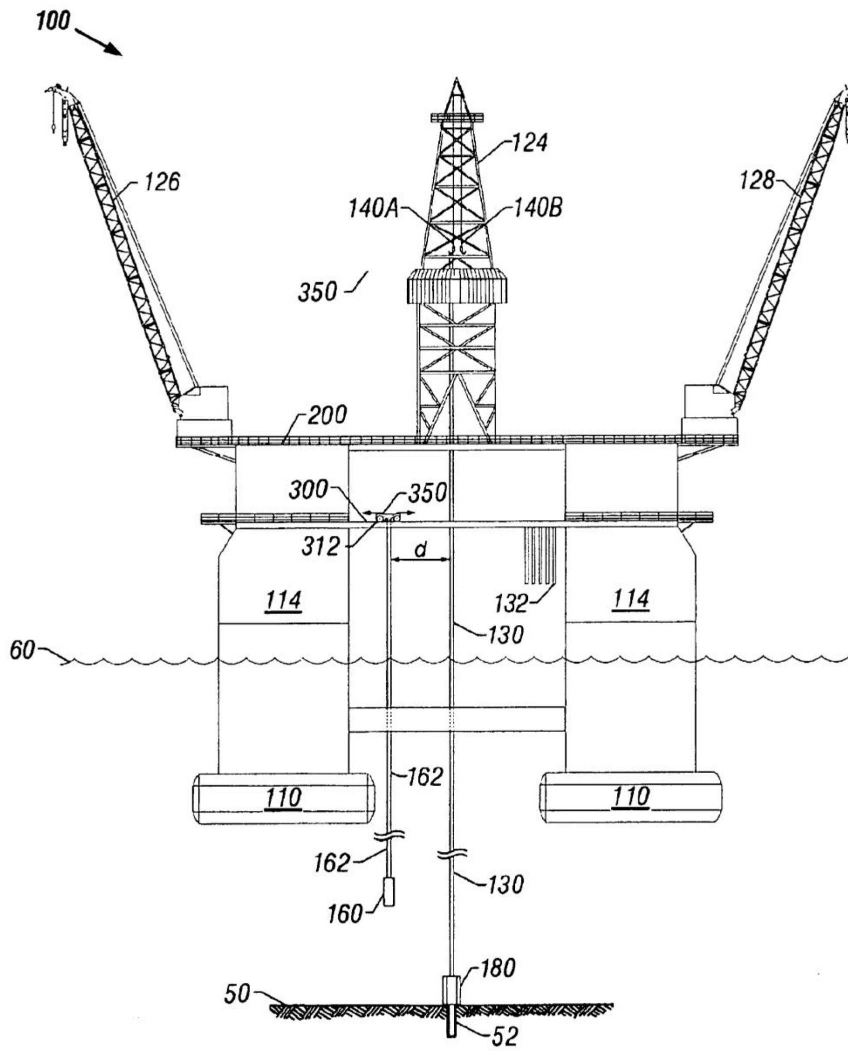


(ii) Load-resistant skeletal structure of the above semi-submersible
Figure 2.14 Skeletal structure of a semi-submersible structure.
[L.A. Kahn and D.B. Dillon, 1986. Verification of spread mooring system for floating drilling platform: Vol. III – Dynamic modeling for spread moorings, TARB TR-8B4-120-3, Metals and Minerals Service, Reston Virginia, p. 2]

2.15 Explain, with a neat sketch, the oil & gas processing and other auxiliary facilities provided on the cellar deck of a semi-submersible.

The oil and gas processing and other auxiliary facilities provided on the cellar deck of the semi-submersible are similar to the ones provided in the mezzanine deck of the gravity platform, shown in Figure 2.12 (ii).

2.16 With a neat sketch describe the drilling facilities provided on the deck of a semi-submersible (and in the other parts of the semi-submersible).



110 – Pontoons; 114 – Columns; 128 – Cranes; 124 – Drilling derrick; 140 A & B – Primary and secondary top drive or rotary table for rotating the tubular structures (consisting of drill pipe, casing, risers, etc.); 130 – Drill pipe; 132 – Vertically stored riser sections; 160 & 162 – Riser and BOP; 180 - X-mas tree assembly and BOP; 52 – Drill hole.

(i) Transverse cross-section through the drilling derrick of a semi-submersible. [Multi-activity offshore drilling facility having a support for tubular string, US Patent 6.766,860 B2, July, 2004, p. 3]

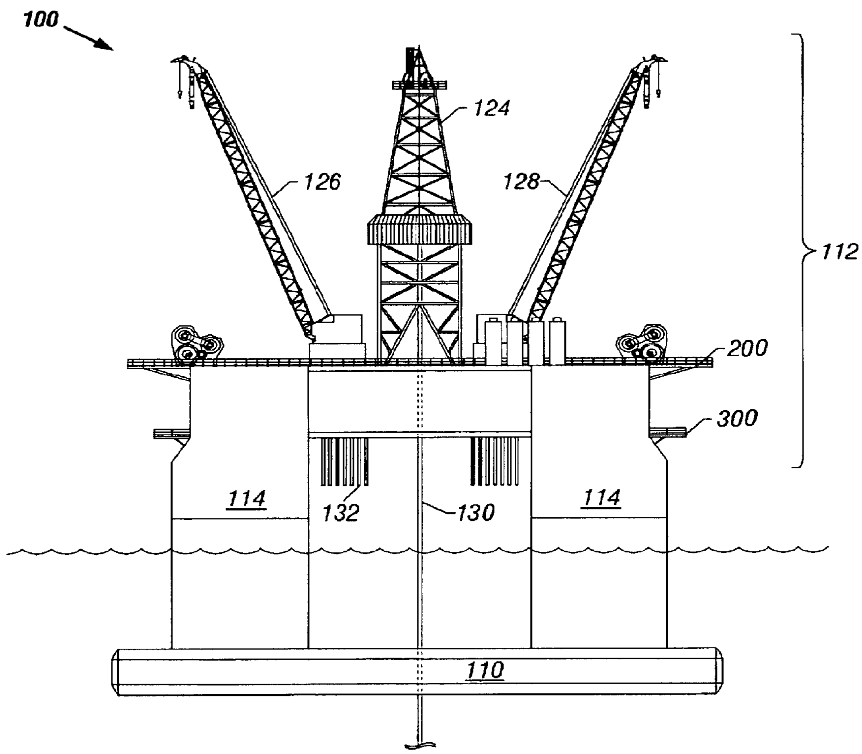
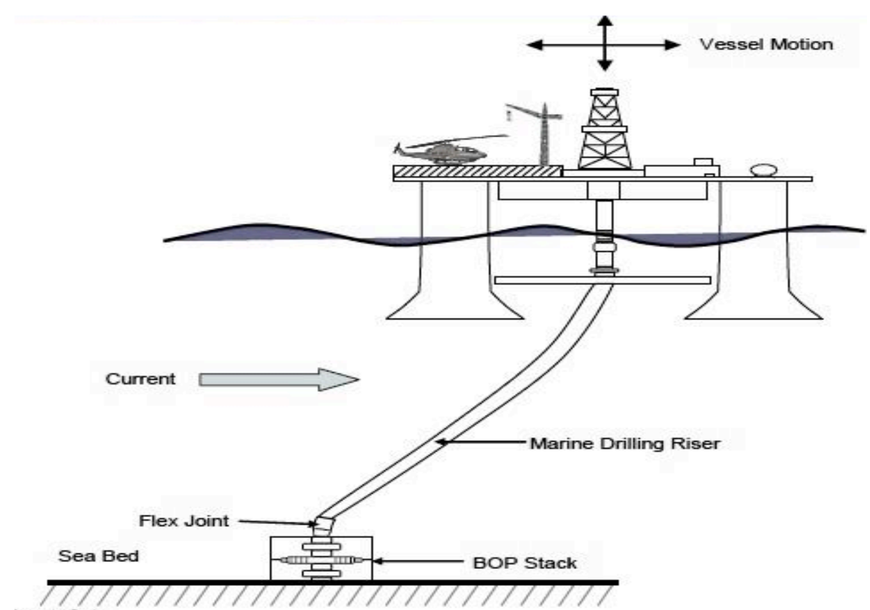
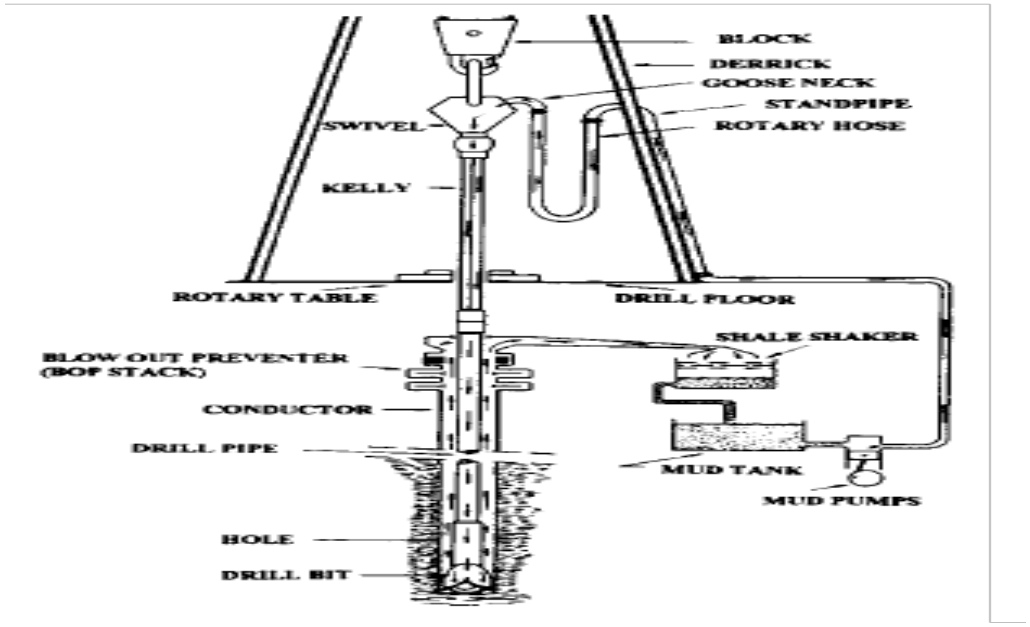


FIG. 1A

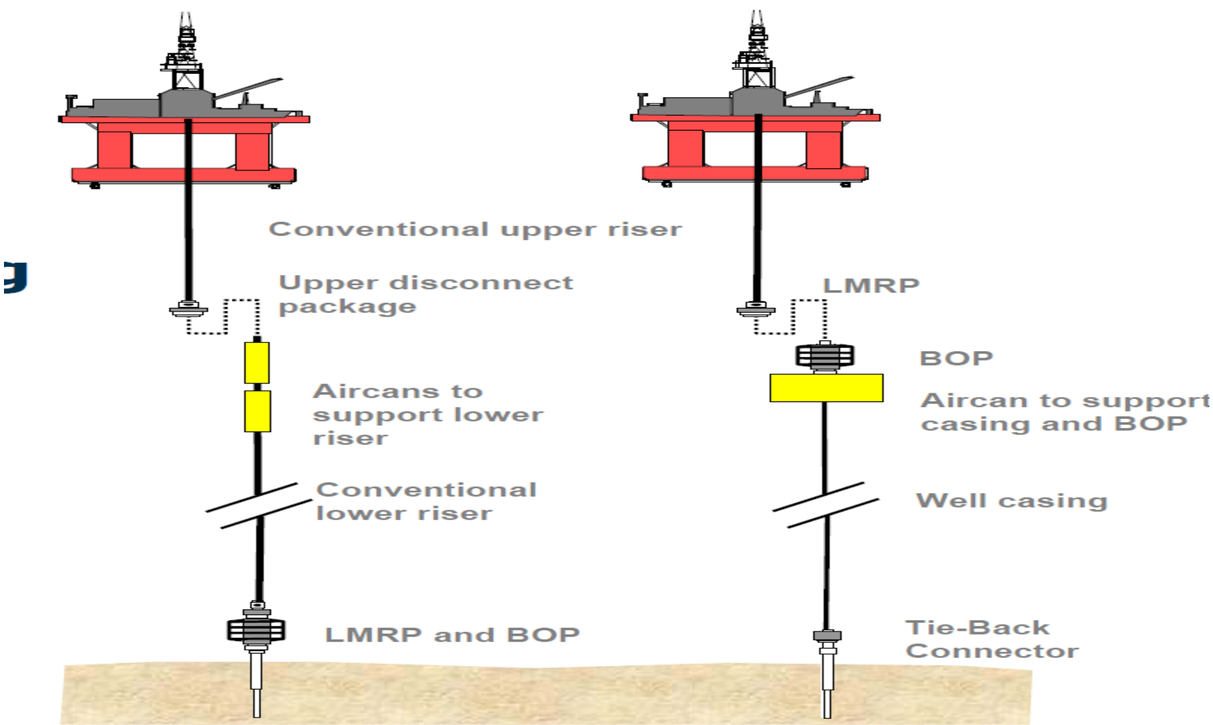
(ii) Longitudinal cross-section through the drilling derrick of a semi-submersible. [Multi-activity offshore drilling facility having a support for tubular string, US Patent 6.766,860 B2, July, 2004, p. 2]



(iii) Flexible connections of the marine drilling riser to the BOP stack [Investment media, Offshore Rigs. http://investmentpedia.net/]



(iv) Offshore drilling equipment – More details
[Offshore Structures. http://www.scribd.com/doc/111986514/Offshore-Structures]



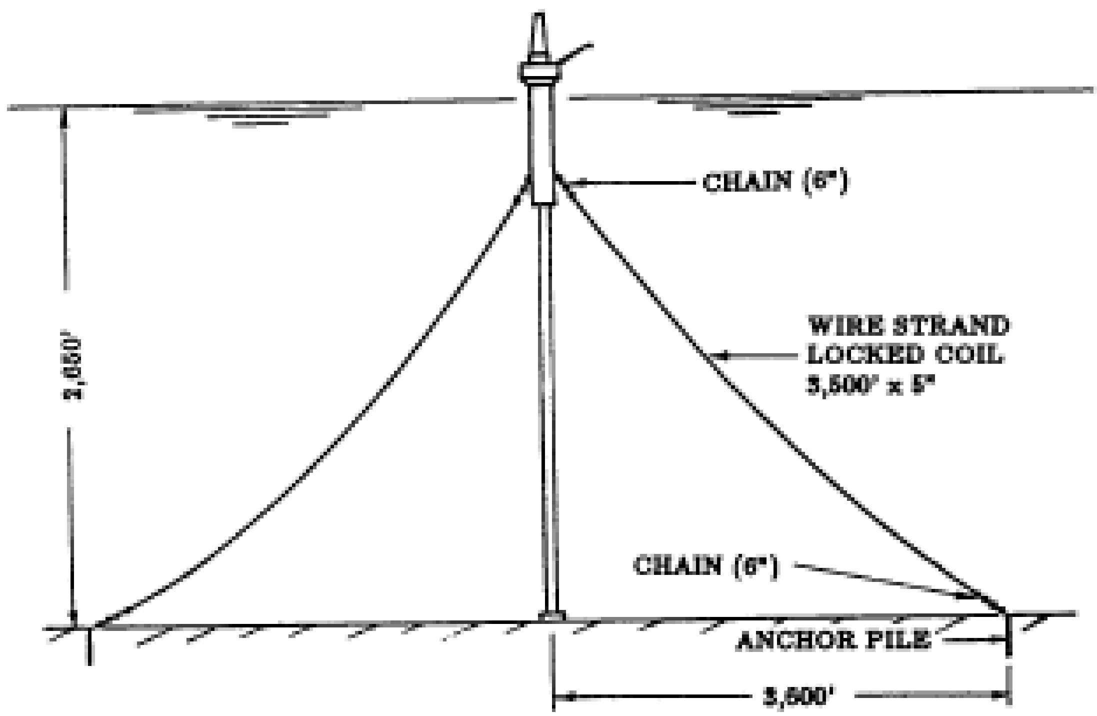
LMRP – Lower Marine Riser Package
(v) Conventional deepwater LP drilling riser
[B. Middleditch, 2011. Deepwater Drilling Riser Trchnical Challenges, 2H Offshore Engineering, London, UK. http://www.2hoffshore.com/]
Figure 2.16 Drilling Facilities provided in a Semi-submersible Platform

The drilling facilities provided in a semi-submersible are neatly illustrated in Figures 2.16 (i), (ii), (iii), (iv) and (v). Figure 2.16 (i) and (ii) show the drilling rig, drilling floor with the rotary table for rotating the tubular structures (consisting of drill pipe, casing, risers, etc.), X-mas tree and BOP, risers and BOP, and drill hole. Figure 2.16 (iii) shows the flexible joints needed for the proper functioning of a riser as the semi-submersible executes sway motion. Figure 2.16 (iv) shows the details of the components involved in a drilling operation, such as kelly (with swivel joint and goose-neck connection), BOP, conductor, shale shaker, mud tanks and mud pumps, etc. Figure 2.16 (v) shows how the drilling details are slightly altered for deep-sea operations with flexible well-casing, LMRP and BOP (or with a tie-back connector with raised BOP).

2.17 The production semi-submersible houses a number of modular structures on the deck. Describe with neat sketches, the deck modules required in the production platform.

The modules available in the semi-submersible decks are clearly given in Figures 2.12 (i), (ii), (iii) and (iv).

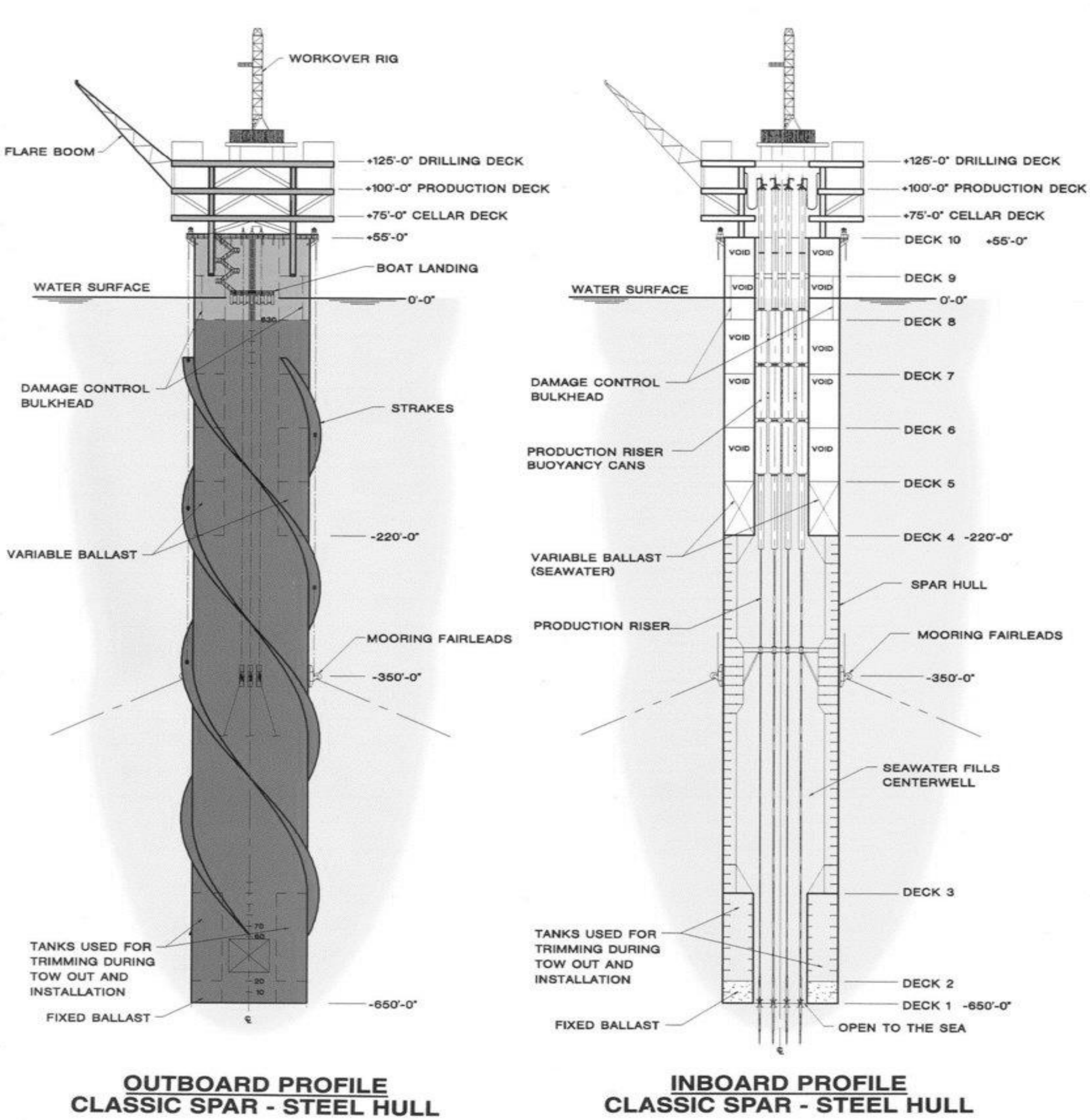
2.18 With a suitable figure, describe the salient features of a Spar Oil and Gas Productions system, giving an overview of the various components that contribute to its location-maintenance and the resistance to applied forces in the ocean.



2.18 Location-maintenance of a Spar oil and gas production system
[R.S. Glanville, J.R. Paulling, J.E. Halkyard and T.J. Lahtinen, 1991. Analysis of the Spar Floating Drilling Production and Storage Structure, Paper # 6701, Offshore Tech. Conference, Houston, p. 64]

The components that contribute to the location maintenance in a Spar oil and gas production system, shown in Figure 2.18, are the wire strand mooring cables anchored to a pile that is driven into the seabed.

2.19 Give neat sketches of the internal components of: (i) The main columnar portion of the classic Spar; and (ii) The submerged portion of the Truss Spar.



(i) Internal and External Components of a Classic Spar[Spar Platform, http://www.globalsecurity.org/military/systems/ship/platform-spar.htm]

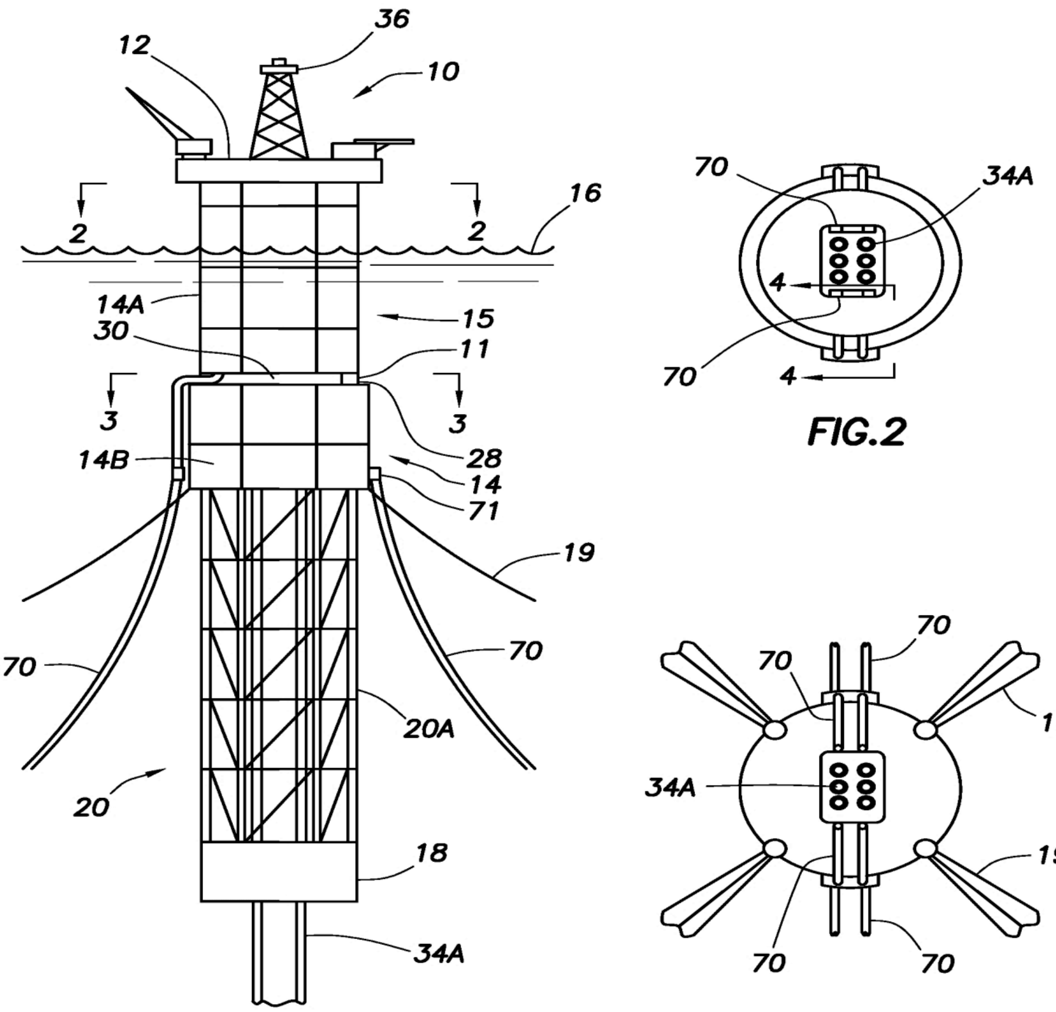


FIG. 1 FIG.2 FIG.3

(ii) Fig.1 Truss Spar; Fig.2 – Section 2-2; Fig.3 – Section 3 – 3.

12 – Deck of spar; 14 – Vertically-oriented buoyant hull; 14A and 14B – Upper and lower buoyancy section; 15 – Buoyant tank assembly; 18 – Counter-weight ballast; 19 – Mooring lines; 20 – Counter-weight spacing truss structure; 20A – Open truss framework; 11, 28 & 30 – Horizontal open spaces separating top and bottom buoyancy sections; 34A – Production risers; 70 – Import and export risers.

[Spat Platform; Patent # US 6263824 B1. http://www.google.com/patents/US6263824 accessed on April 16, 2013].

Figure 2.19 Figures of: (i) Classic Spar; and (ii) truss spar

Figure 2.19 (i) and (ii) give the essential internal and external details of the components of a classical spar and a truss spar offshore structure, respectively. Figure 2.19 (i) gives the internal components of a classical spar such as: (a) Damage control bulkhead; (b) Production riser buoyancy cans; (c) Variable seawater ballast tanks; (d) Production risers; (e) Tanks used for trimming during tow out and installation operations; (f) Fixed ballast at the bottom; (g) Internal decks 1 to 10; and (h) Center-well filled with seawater. Figure 2.19 (ii) also gives the external details of truss spar consisting of: (a) Drilling, cellar and production decks; (b) Work-over rig; (c) Flare boom; (d) Cylindrical spar hull; (e) Helical strakes; (f) Boat landing system; and (g) Mooring fairleads.

Figure E2.16 (ii) shows the internal details of a truss spar consisting of: (a) Decks of spar; (b) Upper and lower buoyancy sections; (c) Buoyancy tank assembly; (d) Counter-weight ballast; (e) Open truss framework; (ef Production risers; and (g) Import and export risers.

2.20 With suitable figures (or neat sketches) describe the important components of a Sub-sea production system.

The essential and important components, of a sub-sea production system, are shown in Figure E2.20. It consists of: (i) Topsides components of: (a) Master Control station controlling sub-sea power and communicating unit, uninterruptible power supply, topside umbilical termination unit, electrical/optical junction box, hydraulic/chemical junction box, chemical inspection unit, accumulation skid, hydraulic power unit and electrical network. (ii) Umbilical distribution units consisting of: static umbilical, J-tube, weak link, splicing kit and transition joint, sub-sea router module, umbilical termination head and sub-sea distribution unit. (iii) Cluster and satellite subsea drilling units consisting of individual Xmas trees, sub-sea control module with hydraulic/chemical/electrical jumpers, Xmas trees and umbilical termination assembly; and (iv) Template solutions with alternative satellite tie-ins consisting of satellite drilling unit, Xmas tree with umbilical termination head, bend restrictor and step-out alternatives.

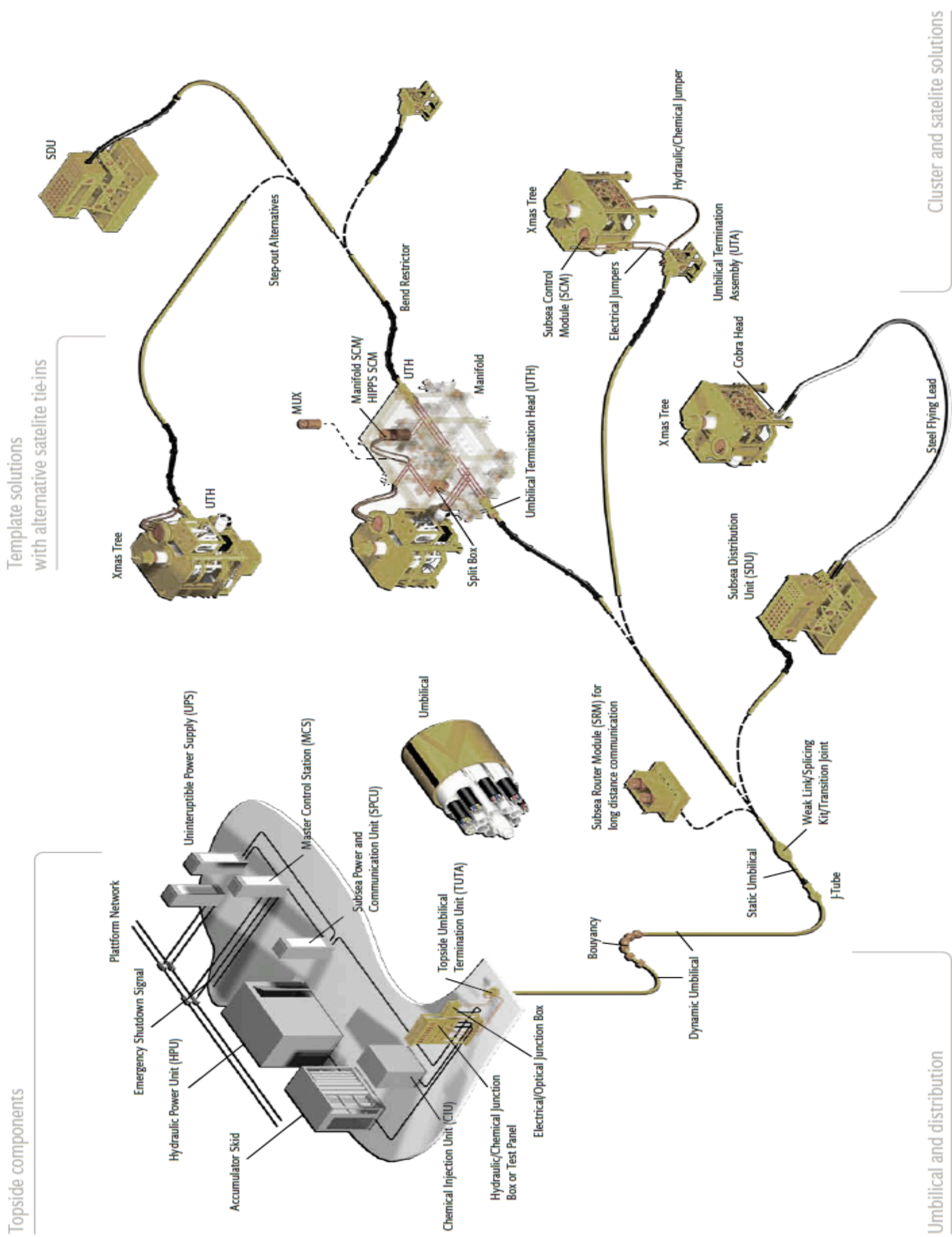


Figure 2.20 Sub-sea Control System [www.fmctechnologies.com]