الأبحاث المنشورة - (1994-2005) فى مجال الطاقة والبيئة

للأستاذ الدكتور محمد عبد الفتاح شامة

Published Papers (1994-2005)

on Energy and Environmental Protection

by Prof. Dr. M. A. Shama

1- "A Projection on the Future Demands and Capability of Offshore Technology" A.M.R.J. (Egypt-1976), Shama, M. A.,. (100%)

2- "A General Outlook to Offshore Technology", Egyptian Society of Marine Engineers and Shipbuilders, Forth seminar, Alexandria, April, (Egypt-1983), Shama, M. A., (100%)

3- "Costs of C02 Abatement in Egypt Using Both Bottom-Up and Top-Down Appr", Energy Policy, (USA-1994)Yehia El Mahgary, A. F. Ibrahim, M. A. F. Shama, A. Hassan, M. A. H. Rifai, M. Selim, I. Abdel Gelil, H. Kokor, Anhar Hegazi, A. Amin, F. Bedewi and Juha Forsstrom, (8%)

4- "Estimation of GHG Emissions in Egypt Up to the year 2020", World Resource Review, Vol. 6, No. 8, (USA-1994), Yehia El Mahgary, VTT-Energy, A. I. Abdel-Fattah, M. A. Shama, Alexandria, Faculty of Eng., M. Selim, I. Abdel Gelil, Anhar Hegazi, NREA, Egypt, M. A. Rifai, Azhar University, A. Amin, F. Bedewi EEA, Egypt, and J. Forsstrom, (11%)

5- "Technical Evaluation of Transport- Related GHG Abatement Techniques", AEJ, April. (Egypt-1995), Shama, M. A., and Hassan, A. (50%)

6- "Ship Casualties Types, Causes and Environmental Impacts", AEJ, April. (Egypt-1995), Shama, M. A. (100%)

7- "Ship Structural Failures: Types Causes and Environmental Impact", AEJ, July. (Egypt-1995) Shama, M. A., (100%)

8- "GHG Emissions Inventory for Egypt and Emission Mitigation Options",VTT, Energy, (Filand-1995), Yehia El Mahgary, VTT-Energy, Finland, M. A. Shama, A. F. Ibrahim and A. Hassan, Alex. University, Egypt, M. A. Rifai, Azhar University, Egypt, I. Abdel Gelil, M. Selim and H. Kokor, ECPO, Egypt, Anhar Hegazi, NREA, Egypt, A. Amin, F. Bedewi EEAA, Egypt, and Juha Forsstrom, VTT-ENERGY,Finland, (8%)

9- "The problem of corrosion of ship structures", MARINES 96, Second Conference, Cairo, October, (Egypt-1996), Shama, M. A., (100%)

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11- "Energy and Env. in Eng. Education", AEJ, Vol.36. (Egypt-1997), Shama, M. A. (100%)

12- "Energy and Environment Dimension in Ship Manufacturing Processes", PRAD's 2001, Sept., 8th Int. Conf. on Practical Design of Ships and other Floating Structures, (China-2001). Shama, M. A., (100%)

13- "Life Cycle Assessment of Ships", Alexandria Engineering Journal, AEJ, (Egypt-2004) Shama, M.A. (100%)

14- "Life Cycle Assessment of Ships", IMAM 05, Sept. International Maritime Association of Mediterranean Sea, (Portugal-2005), Shama, M. A. (100%)

15- "Environmental Dimension in the Ship's Life Cycle", MARDACON 9, December, Int. Con. "Towards a Cleaner and Safer Maritime Context", (Egypt-2005), Shama, M. A. (100%)

جمعية المهندسين البحريين ومهندسي بناء السفن

SOCIETY OF MARINE ENGINEERS & SHIPBUILDERS

الندوة الرابعة

في

صناعات ماوراء الشواطئ

Fourth Symposium

on

Offshore Industry

يوم الثلاثاء الموافق ١٩ ابريل ١٩٨٣

بقاعة المحاضرات بمركز الدراسات العليا والبحوث
جامعة الاسكندرية

"طريق الحرية – الشاطبي – اسكندرية"

٢ ش البورصة القديمة – المنشية – ت ٨٠٩٩٧٣ ص.ب. (٢٤٤٨) أسكندرية مشهرة تحت رقم ٧٤٣/ ٨١

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A GENERAL OUTLOOK TO OFFSHORE TECHNOLOGY

By

M.A. Shama, Ph.D.
Professor of Naval Architecture
Alexandria University

INTRODUCTION

Offshore technology comprises the engineering efforts required to support the exploration, exploitation, production, transportation and storage of offshore resources. The execution of these efforts requires a thorough study of all environmental factors, the development of engineering products, construction of various types of fixed and mobile structure, development of several systems and services, development of underwater technology and last but not least development of an educational and training system.

This paper is intended specially to throw some light on the broad spectrum of offshore engineering and technology and to stress the importance of education and training in this field.

FIELDS REQUIRING OFFSHORE TECHNOLOGY

The broad demands of offshore technology comes from:

1- Exploitation of offshore resources:

- Oil and gas
- Animal population
- Plant population
- Minerals
- Dissolved metals and salts
- Energy

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2- Coastal protection

3- Design of ports and harbours

4- Control of pollution

5- Coastal transportation

The achievement of these demands requires the development of underwater technology, the design, construction and operation of several types of fixed/mobile offshore platforms. These structures should be designed to operate safely and economically in the hostile offshore environment.

THE OFFSHORE ENVIRONMENT

The offshore environment relevant to the design, construction and operation of fixed/mobile offshore structures could be divided into:

- Physical and chemical oceanography
  - seawater properties: temperature, density, salinity, chemical composition, sound and light propagation, marine life, marine fouling, corrosive action, etc.

- Geological oceanography

  The geotechnical properties of the seabed include:

  - Marine sediments and deposits (manganese nodules, hot brine, etc.)

- Meteorological oceanography
  - Winds
  - Waves
  - Currents
  - Tides

Winds and waves represent the major factors affecting motions of and loads on fixed and mobile platforms - see fig. (1)& (2). Because of their stochastic nature, they can only be described statistically. However, waves could be related to wind velocity, duration and length of fetch.

For any particular offshore area, the wave system could be represented mathematically by a wave spectrum, which could be derived from data obtained from measurements of wave heights, velocities, accelerations, periods, etc., using wave recorders.

The collection of reliable wave data on offshore wave systems is required for:

1- Study of the dynamic behaviour of fixed and mobile structures.

2- Calculation of wave forces on fixed/mobile structures.

3- Prediction of short and long term wave characteristics.

Surge and astronomical tides have significant influences on the design of fixed and jack-up platforms, particularly in shallow offshore areas.

Studies of light penetration are of increasing importance in view of the greater use being made of divers to make observations, take photographs or carry out maintenance and repair operations.

Improvements of sonar systems are needed for the accurate location and examination of underwater structures, fish detection and exploration of the sea bed. Sound propagation, reflection, scattering, distortion, etc. have to be taken into consideration.

The accurate knowledge of the topology of the sea bed is essential for the navigation of ships in offshore areas as well as the approaches to harbours. The geotechnical properties of the sub-bottom sediments are also required in planning the location and construction of fixed and jack-up platforms, pipelines, etc.

The holding capacity of the sea bed is an essential factor for the safe anchorage of mobile platforms. The ability of the soil to resist vertical and lateral forces is an essential design parameter for bottom supported platforms.

PROBLEMS OF CORROSION AND FOULING

Corrosion is one of the main factors leading to reduced service life of offshore structures. The problem is not only limited to general rusting, but includes also galvanic corrosion, pitting, stress corrosion, intergranual corrosion and hydrogen embrittlement.

Previously, corrosion was considered a maintenance problem. However, the increased use of H.T.S. resulted in using thinner plates and sections, while the corrosion problem remains basically the same. This has a detrimental effect on the strength of the structure as a whole.

Corrosion resistance may be improved by altering the composition of the material, which may require additional cost elements. Therefore, the best methods to control corrosion are to use protective coatings, or cathodic protection, whether by impressed current or by sacrificial anodes.

Internal corrosion is one of the primary risks for damage of pipelines, risers and other important equipment for production of oil and gas. The corrsion attacks are normally caused by impurities which include water, organic acids, dissolved salts, etc. and are promoted by physical parameters such as temperature, pressure, etc.

In order to prevent major oil disasters, soundings of natural frequencies are taken to predict any structural damages as a result of severe corrosion or otherwise.

Marine growth produces two harmful effects:

i- increases the effective projected area;

ii- increases the drag coefficient because of the increased roughness.

These two effects cause the submerged members to be subjected to much higher loads.

OFFSHORE STRUCTURES

The exploration, exploitation and production of oil and gas from offshore areas have required the design and construction of various types of fixed and mobile offshore platforms. These offshore structures are required for drilling, production, construction, pipelaying, heavy lifting operations, etc. The most common types used for drilling purposes are:

i- Ship Type

These are self propelled floating units having ship shape and either single or multi-hull construction, see fig. (3).

ii- Barge Type

These are mostly non-propelled units designed to operate afloat.

iii- Self Elevating Type

The platform lifts itself on legs to the required level above the sea surface, see fig. (4).

iv- Semi-submersibles

These platforms are supported on widely spaced buoyant tubular columns attached to two or more submerged hulls. They are designed to operate afloat, see fig. (5).

v- Tension Leg Platforms

These platforms are constrained vertically but free to move in the horizontal plane. They are based on the principle of excess buoyancy which pull vertically upwards on mooring cables attached to the sea bed, see fig. (6).

vi- Fixed Platforms

These platforms are constructed either from steel (jacket type) or concrete (gravity type). The installation of a jacket type, see fig. (7), requires extensive offshore operations (transport, launching, piling, construction).

Concrete platforms rest on the sea bed stabilised by its own weight, whereas steel jackets are piled to the sea bottom. The concrete platforms have normally storage capacity as an additional feature.

OFFSHORE SUPPORTING UNITS

- Offshore construction platforms
- Loading terminals
- Storage of oil
- Service units
  - Supply vessels
  - Tugs
  - Workboats
  - Firefighting vessels
  - Oil spill recovery vessels
  - etc.

DESIGN OF AN OFFSHORE DRILLING PLATFORM

The design of an offshore structure to operate successfully in winds and among waves should be based on the following main requirements:

i- Minimum motion
ii- Maintenance of position during operation
iii- High load carrying capacity
iv- Adequate safety (strength and stability)
v- Economic operation

In order to fulfill these reuqirements, it is necessary to estimate the wind and wave forces, calculate structural response and evlauate structural safety and the consequences of failure, as follows:

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1) Load Types

- Environmental loads
- Functional loads
- Drilling and towing loads
- etc.

2) Load Prediction

The prediction of the most unfavourable load combinations should take account of the uncertainties associated with each type of load.

3) Design Values

There are two approaches:

i- Design wave approach
ii- Irregular wave approach

i) The Design Wave Approach

This is rather a common approach and is generally based on the 50 or 100 year recurrence wave period. The wave loads are calculated by Morison's equation as given by:

$$F = \frac{1}{2} \rho C_D A |\bar{v}| \bar{v} + \rho C_M V \cdot \dot{\alpha}$$

where: $\bar{v}$, α = water velocity and acceleration
A , V = cross-secitonal area and volume
C_D , C_M = drag and inertia coefficients

ii) The Irregular Wave Approach

This approach is based on the random nature of sea waves. The sea surface may be regarded as a sum of an infinite number of elementary sine waves of different frequencies and direcitons and with random phases and therefore could be represented by a wave spectrum. The prediction of wave loads is generally divided into:

a- a short term prediction

b- a long term prediction

In the short term prediction, the statistical parameters of the sea state are assumed to remain constant.

In the long term prediction, the statistical distribution of the significant wave height and average wave period are considered.

The most probable extreme wave height could be estimated as follows:

$$H_{max} = H_s \cdot \sqrt{\tfrac{1}{2} \log N}$$

where N = No. of cycles

H_s = significant wave height

In this approach, the wave spectrum is used together with the transfer functions to determine the response spectra.

4) Structural Response

4.1 - Structural modelling

Structural modelling should simulate the behaviour of the actual structure. Either 3-D framework or a finite element idealisation, or a combination, may be used.

4.2 - Structural analysis

Overall structural analysis is required to determine the boundary conditions for the critical regions. This analysis is generally carried out using a coarse mesh finite element idealization or a space frame.

4.3 - Stress analysis

Stress analysis of the critical joint connections are carried out using a fine mesh finite element model and the boundary conditions obtained from the overall structural analysis.

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The accuracy of the stress analysis depends a great deal on the assumed boundary conditions.

4.4- Design evaluation

The evaluation of the safety of the design is based on a set of design criteria. These criteria are based on the expected modes of failure, consequences of failure and the degree of safety required:

a- Modes of failure

- yielding - buckling - fracture (fatigue and brittle fracture)

b- Consequences of failure

- danger to human life
- danger to economy
- danger to ecology

c- Degree of safety

The required degree of safety is ensured either by a set of safety factors or on an acceptable degree of risk. Structural safety depends on structural capability, accuracy of analysis, quality of material and fabrication, maintenance of design conditions.

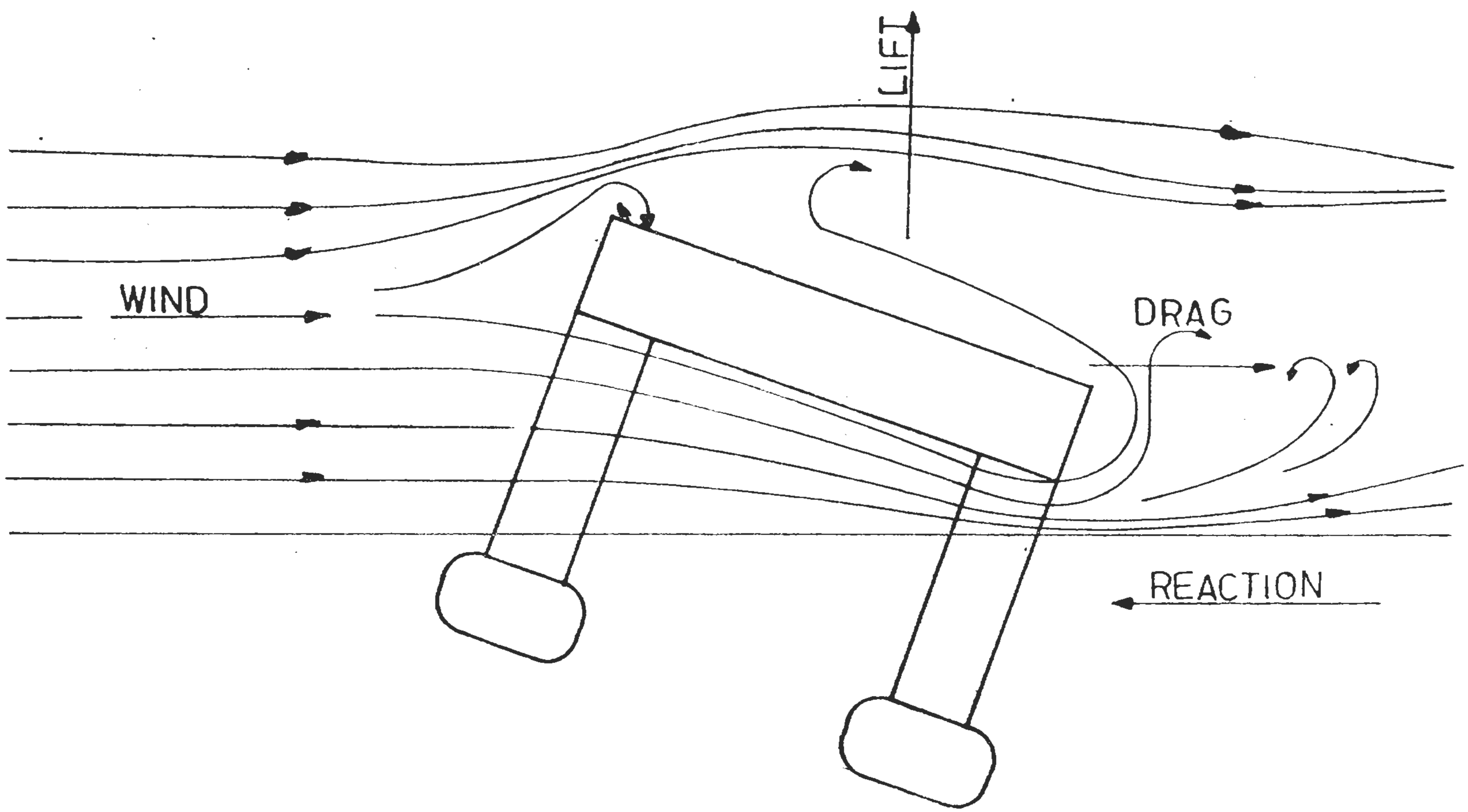
EDUCATION AND TRAINING

The broad spectrum of offshore engineering problems requires specialists in the various disciplines of science, engineering and technology.

It is not possible at present to graduate students covering all the fields of offshore engineering. However, it is possible to introduce one or more courses covering the statics, dynamics and structural design of mobile offshore structures. This course has been introduced successfully as a special course to a group of the B.Sc. students in the Naval Architecture Department, Alexandria University since 1982.

CONCLUDING REMARKS

Offshore engineering and technology is a new field devoted to the exploitation of offshore resources, particularly oil and gas. The safe operation of offshore structures depends on the methods of their design and the accuracy of data collected on winds, waves and tides, and sea bed. An understanding of basic drilling practice, equipment and systems is important to the naval architect and the marine engineer. Since offshore technology comprises of several engineering disciplines, proper education and training is essential for the successful oepration and safety of personnel and offshore units.



FIG(1): Wind Flow around a Semisubmersible

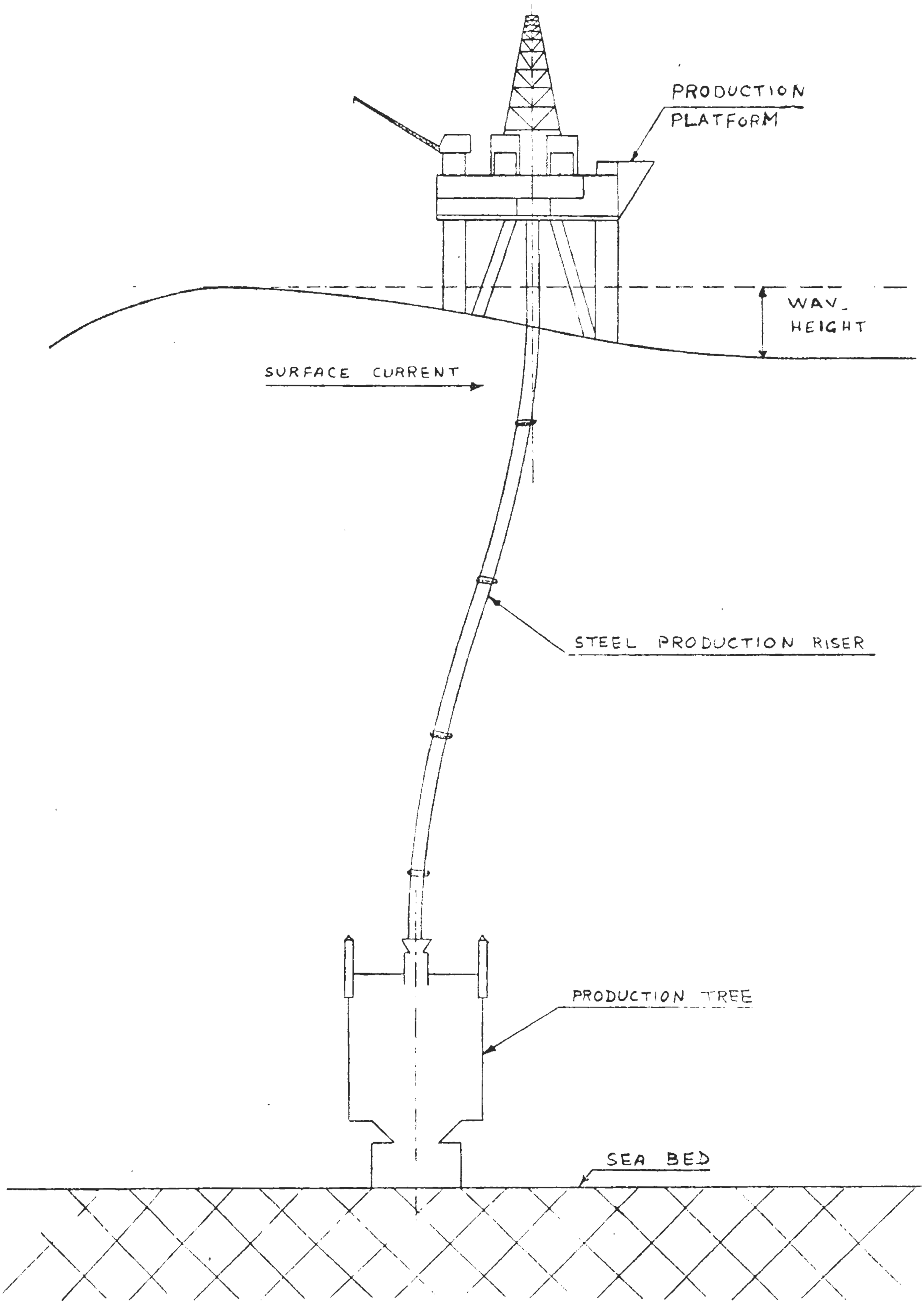


FIG.(2) MOTION CHARACTERISTICS

General Arrangement

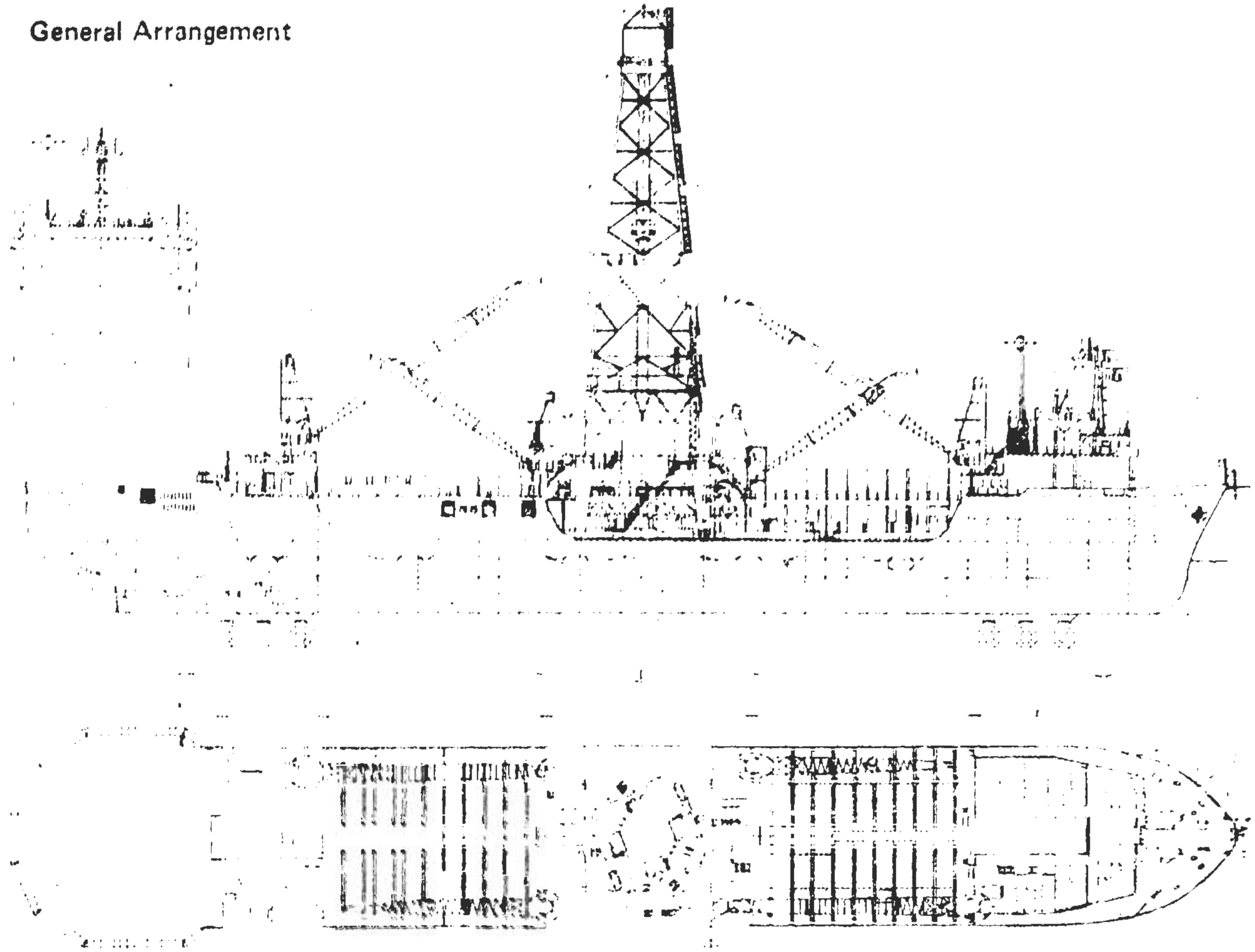
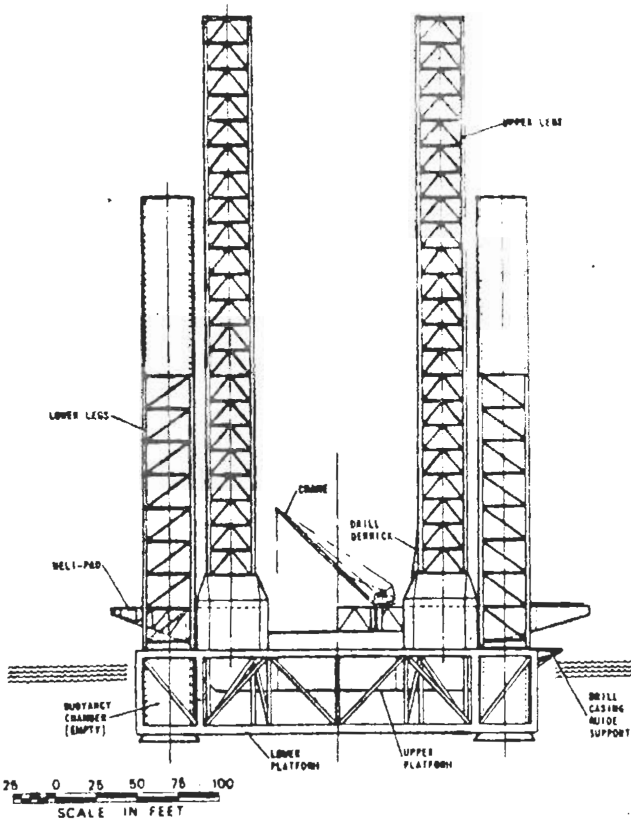
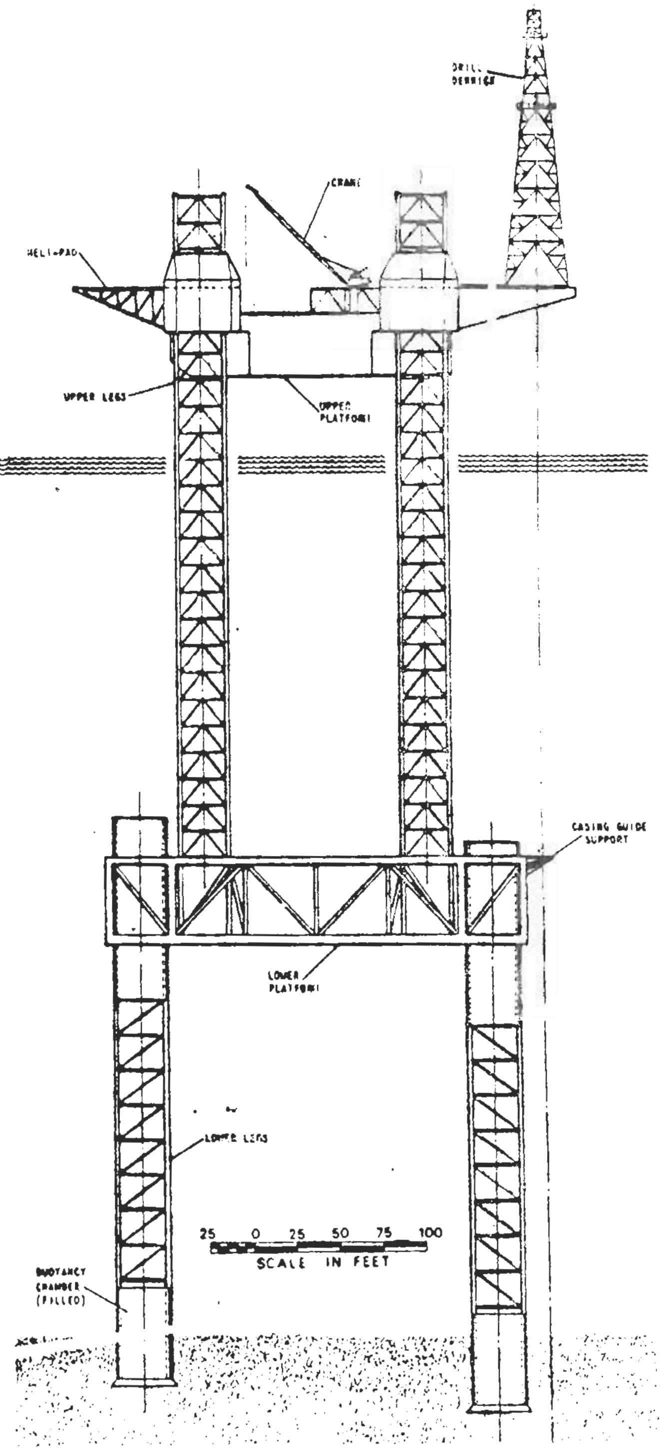


FIG (3): DRILL SHIP



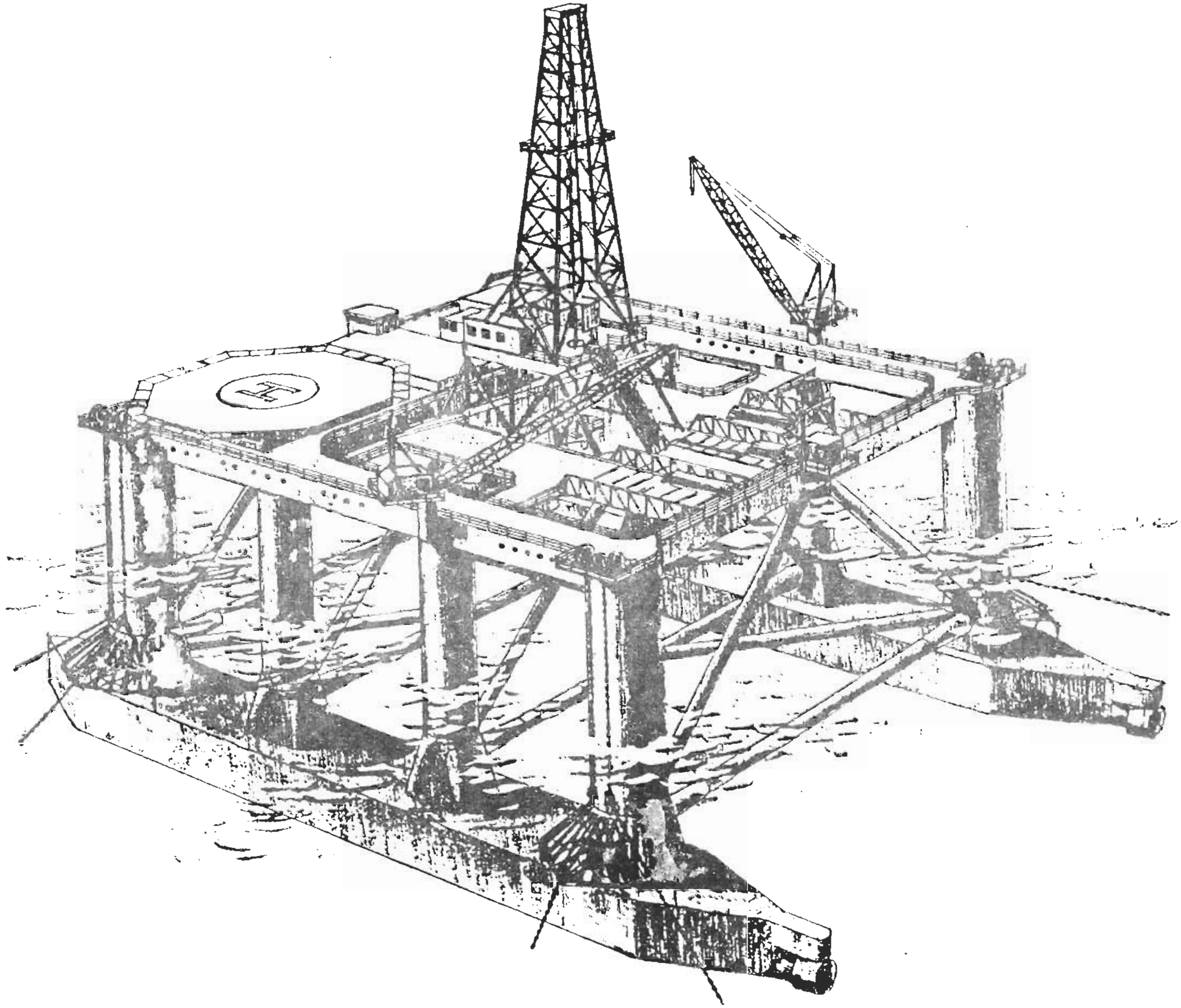
Drilling platform prior to erection.



Drilling platform fully erected.

FIG (4)

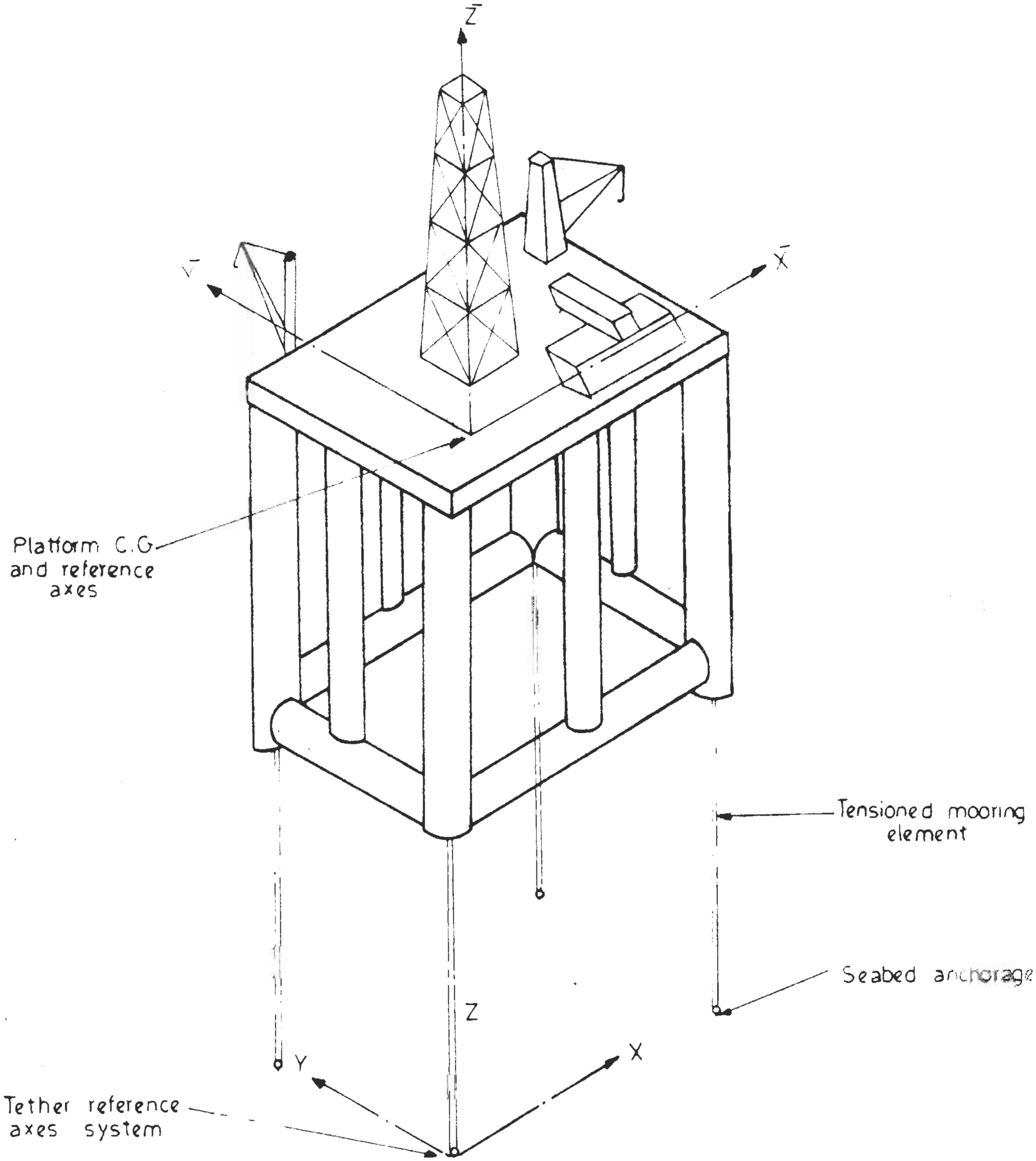
JACK UP DRILLING PLATFORM



Selfpropelled semi-submersible drilling rig.

- Ability to operate in rough water.
- Favourable wave motion response characteristics.
- High degree of mobility.
- Large storage capacity.
- Optimum use of structural steel.

FIG (5)



FIG(6): TLP STRUCTURE AND BASIC NOTATION.

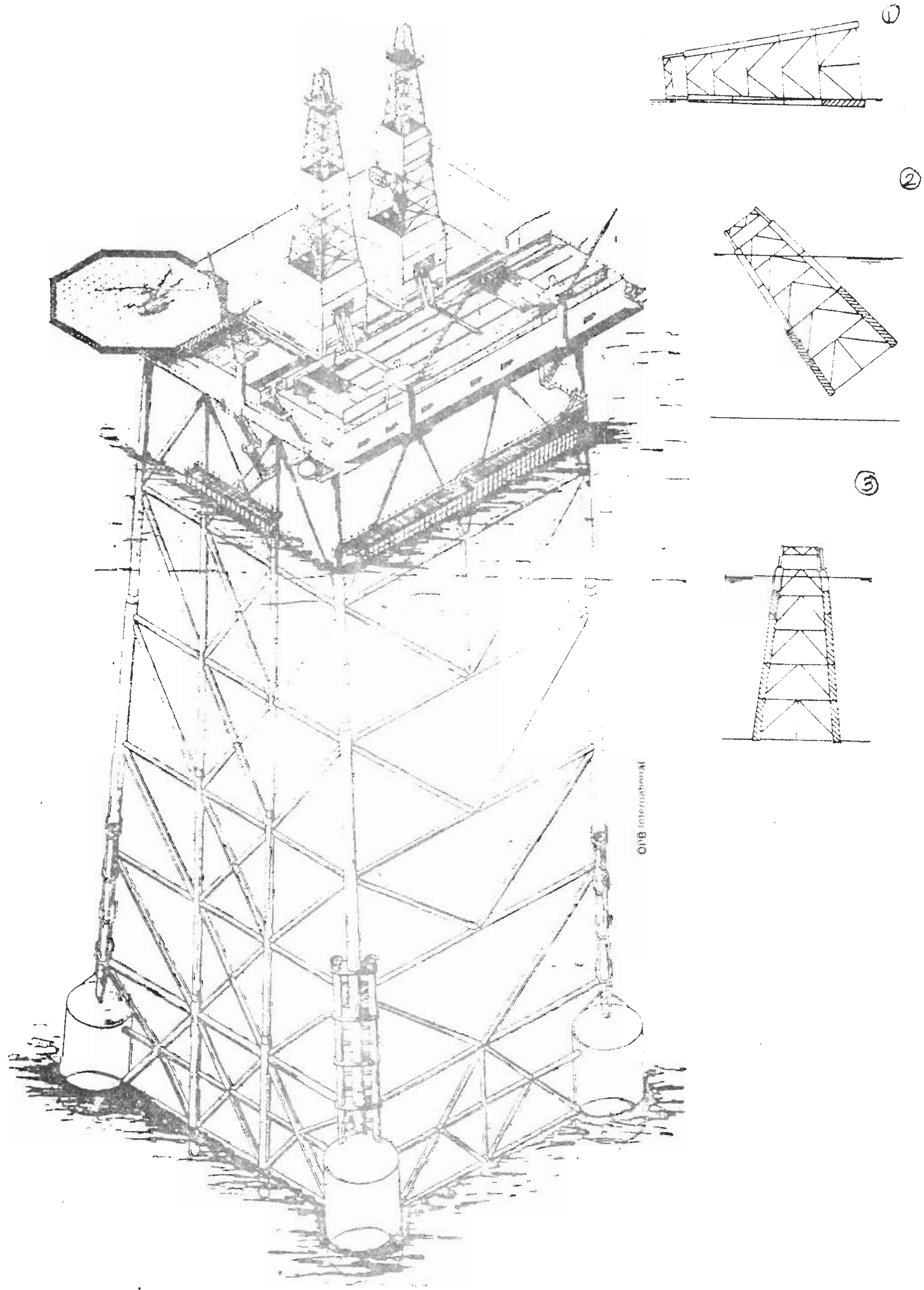


FIG.(7): STEEL JACKET PLATFORM