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O C E A N   S T R U C T U R E S

New Possibilities for Industrial Development

by

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ANNEXES

ABSTRACT

Our time is characterized by great change, stemming from the accelerated progress of science and technology, and by its economic, social and cultural impact.

There are jumps or discontinuities in this process of change; there are, sometimes, real revolutions in the progress of civilizations and perhaps the most singular and promising is the recent feasibility of the occupation and utilization of ocean space.

Globally, the problem is approached in view of contributing, especially in developing countries, to the acknowledgement of the need to "fall in step" to be able to participate in the modern benefits of the sea. This makes us think of a mobilization of local and international capacities leading to a better solution of the present deficit problems by way of a rational and resolute utilization of ocean space. Such a mobilization will have an unprecedented social, technological and political significance and the United Nations organizations may be able, through their stimulus and guidance, to make trascendent contributions.

Specifically, a system approach is adopted -especially as regards great undertakings-, which shows that disaggregation of technologies, by making it easier to enhance local capacity and to generally optimize big projects, is a possible, rational and often advisable practice.

In particular, the case of ocean structures is analyzed, since they play, naturally, an essential role in any ocean industrial development.

It is observed that in their design and construction, technological disaggregation allows to improve costs, reduce times for putting them in operation and, above all, allows participation of a greater number of countries.

It is then concluded that ocean industrial development must today be, for all countries, a high priority goal.

1.- INTRODUCTION

There is a deep sense of the need to enhance local capabilities for ocean industrial development, especially in the developing countries.

In particular, developing countries can not:

a) lose the the recent and current possibilities to accelerate and harmonize their progress by way of a decided and wide utilization of the ocean space and its resources.

b) fail to participate in cooperative projects and international joint ventures with developed countries in their own benefit and to contribute to the benefit of all involved countries. This means that developing countries should raise the level of their capacitation in the specific field of their intervention to harmonize with the rhythm of those more advanced.

This growth of the capacity of many countries for ocean industrial activity can not be postponed, in view of its high economic, social, cultural and politic meaning. This will allow to face with more powerful means critical situations -sometimes dramatic- of their deficits (food, energy, etc.); it will also contribute to a very salutable change of mentality in order to make use of the advances of science and technology to solve better the problems of our times, in accelerated change, by means of adequate technological innovations. It will also allow to multiply the possibilities of cooperation between developed and developing countries in mutual benefit, and achieve at the same time a great progress in the always valuable mutual understanding of peoples.

Ocean structures play an essential role in all kinds of ocean activities and especially in the development and utilization of ocean resources; they are the skeleton, the resistence support of its constructions, vehicles, equipment and tools.

Ocean structures:

- generate for their building an important industrial activity;
- make possible by their function (or the function of the systems they are part of) the utilization of ocean resources and with it a varied and huge industrial activity;
- are well suited to technological disaggregation, which makes easier local participation in their design and building. Moreover, this allows to optimize the whole project economically, technically and politically.

Ocean structures, because of their very nature, the process of their building and their rewarding later projections, are an ideal field for technological disaggregation and broad industrial development.

2.- RECENT FEASIBILITY OF THE UTILIZATION OF THE HUGE OCEAN SPACE

2.1. CONTRIBUTION OF OCEAN ENGINEERING IN OUR SCIENTIFIC ERA

Engineering, which is at the service of mankind, has always constituted an element of progress.

This is the unvarying characteristic of Engineering -its steady component- and it has remained so during centuries.

What has varied is the environment where it operates, the problems it faces, the requirements it must satisfy, the means at its disposal (those which it finds and those which it creates). This is its variable component.

Thus with a clear and permanent guide -that of being at man's service-, its impact on society has also been uninterrupted, taking the shape of an unceasing progress of humanity.

As an antecedent, it is enough to observe the historic evolution of civilization where the two mentioned components can easily be identified.

In the second component -the type and size of social impact-, what is really surprising is the dimension of the change, that has recently become colossal.

Referring, for example, only to the available tools for Engineering development; Fig. 1 and Fig. II-35 (ANNEX II) are by themselves convincing and explain by themselves its growing capacity to solve present society problems.

Coming back to the subject of the contribution of Engineering to the progress of humanity, even though it has always been present -and that was a social constant-, we can not omit pointing out that the size and the importance of this contribution have grown during the last decades in such a way that Engineering has become a decisive key to the big modern social change. It is, in other words, the keystone of the accelerated progress of today.

Within Engineering all this has meant an uninterrupted growth, a diversification and improvement that present this professional activity as a living organism or institution that periodically blooms and fructifies. One of its most recent fruits is, precisely, Ocean Engineering.

In order to bear in mind the contents of this modern branch of Engineering and the frame of reference where it develops, let us remember one of its definitions:

"Ocean Engineering is Engineering in the Oceans." (16)

In other words, it is Engineering in action confronting the requirements of the growing oceanic activity, and being essencially the practice of the engineering profession, it is the application of basic principles to the solving of the various problems arising from the desire or the decision to utilize that vast space covered by the oceans.

To be able to understand these rapid processes, we must remember that we are living in the scientific era when its recent progress and the growth of its power have been explosive. Engineering, which besides being a part of the great constellation of scientific disciplines and participating in the creation of knowledge in research and development activities, further plays a protagonic role in the rapid application of the knowledge generated by almost all the scientific spectrum.

In this sense, the newly-born Ocean Engineering has found favorable circumstances (urgent and important requirements: food, energy, scarce metals, etc.) and in some cases a creative and innovative attitude which have allowed it to start a very rapid develpment associated to a conspicuous industrial development.

2.1.1. Present achievements

Recently, Ocean Engineering has developed and applied technological innovations that have allowed us to build:

- Exploration offshore platforms for oil and gas (Fig. II-14)
- Colossal and varied offshore structures at great and always growing water depths for different functions integrating oil and gas offshore production complexes (Fig. II-12, II-13, II-15, II-16 and II-27)

- Fixed, floating and underwater storage tanks (Fig. II-10)
- Offshore airports (Fig. II-17)
- Offshore terminals
- Temporary harbours
- Tidal power plants (Fig. 2), (1); (3)
- Large and deep vertical pipelines for artificial upwelling
- Platforms for scientific purposes (Fig. II-35)
- Platforms for defense purposes (Fig. II-4)
- Offshore power plants
- OTEC power plants and ocean farms
- Wave energy converters
- Artificial islands for different purposes (Fig. II-18)
- ...
- Giant buoys (for farming, scientific observation and measurements, etc.)
- All kinds and sizes of buoys (for various purposes)
- ...
- Underwater habitats
- All kinds of vehicles (Fig. II-3, II-8 and II-9)
- ...

2.2. OCEAN RESOURCES

In "The Japanese Industrial Challenge" (10), Nicolas Jequier says: "The Oceans are the most important world resources, either in the mining, energetic or food aspect."

There are rich and varied ocean resources which offer interesting development possibilities and which, in some of their aspects, are already mentioned in the present scientific and technical literature. Several United Nations Organizations have been doing contributions in this field.

Table A (following page) presents various ocean resources and attempts a classification.

TABLE A

OCEAN RESOURCES

			Sectors
LIVING	- ANIMALS	- Food	F
		- ...	
	- PLANTS	- Food	F
		- Bioenergy	E
		- ...	
NON LIVING	- WATER	- Tidal energy	E
		- Thermal gradient energy	E
		- Waves energy	E
		- Currents energy	E
		- Salinity gradient energy	E
		- Usable water (salty) (cooling - irrigation)	S
		- Soft water (icebergs, desalinization)	S
		- Self-purification of effluents	S
		- Areas for building	I
		- ...	
	- MARINE SOIL AND SUBSOIL	- Oil	E
		- Gas	E
		- Coal	E
		- Manganese nodules	M
		- Phosphorite nodules	M
		- Heavy metals	M
		- Building materials	M
		- Site for storage (radioactive waste)	S
		- ...	
	- OCEAN AS SPACE	- Sea transport	T
		- Sea communications	C
		- Recreation	S
		- Industrial plants installation	Ind
		- Farming	MC
		- Human settlements	I
		- ...	

F=Food; E=Energy; S=Services; I=Infrastructure; M=Mining; T=Transport; C=Communications; Ind=Industry; MC=Mariculture

In particular, referring only to ocean water resources, we can offer the following scheme:

TABLE B

OCEAN SPACE		WATER RESOURCES
- WATER	- liquid 1.300 x 10^6 km3 - solid	Usable water
- COMPONENTS	- saline elements (3,5 %) - nutrients - deuterium - ...	Raw materials Energy
- WATER BODIES		
CHARACTERISTICS	- Movement - Temperature	Services Energy

To become familiar with orders of magnitude of power which could be used, included below is Table C, taken from the paper "The Marine Environment and Ocean Resources", by Kenzo Takano and Ricagaku Kenkyusho (18). (For greater ease in the appreciation of magnitudes, it has been translated to technical units.)

TABLE C

OCEAN ENERGY (Capable of being used)	
- Currents	$10^4 - 10^5$ MW
- Tides	$10^4 - 10^5$ MW
- Waves	10^6 MW
- Thermal gradient	10^7 MW
- Salinity gradient	10^6 MW

Let us remember that the world capacity of electric power stations is 10^6 KW.

The resources herein mentioned and quantified have very different development levels. Tidal energy production, for example, is at operative level. The 500 MW tidal power plant at La Rance (France) (Fig. 2) is in activity since 1966. Since then, moreover, progress has continued in several of the involved technologies: low head turbines, underwater construction, excavation of large channels, optimization of additional pumping, etc.

The OTEC (Ocean Thermal Energy Converter) power plants, on the other hand, work on a pilot-plant basis. There are important projects in rapid progress.

The utilization of wave energy is moving forward quickly in the development of several different systems. Tests in the sea have already been made. Studies are promissory for low power, and for very low powers (instruments feeding) systems are already operative.

At the October 1984 ECOR (Engineering Committee on Ocean Resources) General Assembly, having as its main theme "Ocean Energy", important technical sessions were devoted to the discussion of the "Report on Utilization of Ocean Energy" (9), especially prepared by the ECOR Japanese National Committee.

Included as ANNEX Ia is a copy of the introduction by Mr. Elmer Weaton (20) as convenor of the special meeting for discussion of the mentioned report on ocean energy, and as ANNEX Ib is a copy of the membership of the Japanese Working Group and the discussors list. ANNEX Ic is a copy of the Table of Contents of the mentioned Japanese report.

The accelerated progress of science and the explosive growth of Ocean Engineering make today possible not only the rapid development of technological innovations but also the quick start of their application. Thus, all leads us to believe that in a few years it will be possible to make varied and massive use of the multiple ocean resources -

including those today in potencial state- and a growing improvement of their economic use will be achieved.

Consequently, in programming industrial development we should consider not only the already established technologies but also those having a good level of development and are very near to entering the operative stage.

We should not forget that in the modern era natural resources (like ocean resources) are the result of adding to the elements offered by Nature the adequate knowledge for their extraction and utilization, i.e. their technology.

Ocean resources, then, have today a highly dynamic component -their technologies- that widens, diversifies and makes more flexible our possibilities. Petroleum and gas were during milleniums in the marine subsoild, but they were able to acquire meaning for man just a few decades ago, when the corresponding technologies for offshore exploration, extraction, loading and transport were developed and applied. This lead to a great industrial development in several countries (developed and developing).

Technologies for this ocean resource (hydrocarbons) have reached a high level and go on widening, progressing and improving. There is no doubt that something similar would happen with ocean mining, the utilization of new energy sources, the utilization of ocean living resources with farming, breeding and new technologies for detection, concentration, catching, etc.

It should be pointed out that there is a growing conscience that the development of technological innovations should be permanently directed to the resolution of problems of utilization of ocean resources by all countries (whatever their level of development). Adequate technologies should be generated for each type of infrastructure; and of course the enhancing of local capabilities should be accelerated and extended.

2.3. ACTIVITIES IN OCEAN SPACE

Present ocean activity (with its corresponding activity on land) is big and an accelerated growth in the immediate future is expected.

2.3.1. Activities for the utilization of ocean resources

Exploration, extraction and transportation of ocean resources (or offshore industrial activity and the subsequent transportation of the processed material) generate an important activity with the participation of various sectors and with the integration of various technologies (traditional and innovative ones) which may, in general, be disaggregated.

If we analyse the list of resources in Table A, we see there are several resources (and services) already being used, which:

a) require industrial and engineering activity to develop, produce, install and operate the facilities making up the offshore stations and complexes;

b) mobilise a big activity (most of it on land) to industrialize the extracted resources and the transported materials;

c) increase the utilization of ocean space, improve the availability of energy, food, usable water, minerals and building materials, etc., all of which stimulates industrial expansion;

d) extend the benefits of development to populations isolated and with limited infrastructure by way of the application of simple technologies (e.g. ferrocement boats for fishing).

2.3.2. <u>Activities for other purposes</u>

The scientific sector promotes interesting ocean activity requiring industrial and engineering support.

The examples below give us an idea of the kind of elements and systems involved and, consequently, of the type and importance of the ocean structures required as starting point for scientific activity at sea. Such equipments or systems have, necessarily, as skeleton their structures which are especially designed and produced to those ends:

a) The Mohole project promoted the development and production of a sea subsoil drilling system at 5,000 m water depths.

b) The outer space project associated to the last launching of the "Challenger" space shuttle put forward the need for ocean activities of search and rescue of debris of the launcher.

c) The FLIP (Floating Instrument Platform) for scientific determinations, especially acoustic, gave rise to important structural problems.

d) (13) mentions some scientific activities at sea, in the field of Oceanography, with support of technological equipment and systems.

e) Archeology and History have underwater activity requirements.

All these activities would be impossible without marine structures (towers, ships, platforms, special vehicles, habitats, anchorages, etc.).

The defense sector has a huge ocean activity, which is not to be dealt with herein, but which is a very important source of ocean structures requirements.

These last two sectors allow a significant "cross-fertilization" and a rapid "horizontal transfer of knowledge" (*)(14) with our own sect.., even with the limitations of the partial reserve in the scientific-technological exchange of the defense sector.

2.3.3. Expected activity

It is in our interest to look at the oceans with a prospective view, in order to have a guide in our development plans for the immediate future.

Ocean space, covering 71 % of our planet's surface, is today explorable, usable and habitable.

Man -thanks to recent technologies developed and applied by Ocean Engineering- can extend his dominium and his economic and cultural activity to the whole surface of our planet.

Today, the boundaries dividing emerging lands from the oceanic area are blurring. We are already citizens of the whole planet and we can now optimize our industrial activity in a much greater and much more varied space.

(*) We talk of "horizontal transfer of knowledge" when knowledges having an advanced level of readiness for application are adapted to new technological purposes.

3.- OCEAN STRUCTURES

3.1. TYPES

There is multiplicity of ocean structures types. Very globally, they could be grouped as follows:

Types of Ocean Structures	Symbol
1. Chambers for high internal pressure (Fig. II-6)	Ch
2. High pressure hulls (Fig. II-8 and II-9)	Hhp
3. Low pressure hulls	Hlp
4. Underwater habitats	Hb
5. Ocean reservoirs (Fig. II-10)	R
6. Underwater cables and pipelines	P
7. Offshore platforms (Fig. II-(12, 13, 14, 16, 27 and 4))	Pt
8. Offshore towers	T
9. Offshore structures for berthing and mooring	M
10. Floating horizontal structures without propulsion (Fig. II-17)	Fh
11. Floating vertical structures w hout propulsion	Fv
12. Floating structures with propulsion	Fp
13. Underwater bridges and tunnels	B
14. Underwater industrial systems	UId

Types of Ocean Structures	Symbol
15. Ocean dams and dikes	D
16. Floating cranes	C
17. Artificial islands (Fig. II-18)	I
18. Highly specialized structures	Sp

...

Figures included in this report and in ANNEX II show some structures illustrating the fact that each of the above mentioned groups covers in turn a great variety of structural accomplishments.

As regards, for example, type number 12, "floating structures with propulsion", owing to space reasons, no illustrations of that type of structures have been included, but it is easy to notice that it covers all kinds of ships, propulsed barges, boats, etc., for instance drilling ships like the "Challenger" for deep water drilling, ships for laying out underwater pipelines, ad hoc barges for industrial plan installations and/or operation, prestressed concrete barges of different design for various purposes, offshore platform salvage boats (for launching and navigation), ferrocement boats for fishing, etc.

3.2. ROLE OF OCEAN STRUCTURES IN MARINE RESOURCE DEVELOPMENT AND UTILIZATION

The utilization of marine resources requires an important activity in the ocean space, which in turn, requires installations, vehicles and equipment that can not be conceived without their support skeleton, without their resistance structure, i.e. without the corresponding oceanic structures.

It is clear that there would be no possibility to take advantage of the varied and plentiful ocean resources if we could not build and make use of ocean structures to drill the marine subsoil, extract hydrocarbons, store them, process them and transport them; to install, transport and operate industrial plants using the marine space; to concentrate, cultivate, extract and process the sea's living resources, etc.

Moreover, at sea, man's activity -indispensable in any industrial enterprise- requires wet or dry vehicles, chambers and habitats for a direct action; or unmanned vehicles, automatic installations and remote control stations for an undirect action.

So vehicles, chambers, habitats, tools and the corresponding structures appear to be necessary.

The last decades have witnessed an accelerated growth of the utilization of oceans -it is said, today, that we are living in the ocean era-; however, that utilization can still be expanded further, to a greater number of countries and with a greater participation of the developing countries. This expansion can also cover many other ocean resources still unexploited or not rationally or adequately exploited.

In fact, we are only at the beginning of that big jump in the evolution of the progress of peoples, which we need and which is now possible, since the wide and rich ocean space is today accesible and economically usable.

Anyway, even just two o three decades after the start ot this movement towards the sea, oceanic structures - surprising in their quantity, variety and size- have already been created, developed and built.

The high present level of development of ocean structures explains the significant progress which is being achieved in the utilization of marine resources.

Table D has been prepared to relate ocean structures and resources, taking by way of example just a few cases within the wide ocean resources spectrum.

TABLE D

SECTOR	RESOURCE	STRUCTURES	
		FUNCTION	TYPE
Energy	Oil and gas	Exploration drilling	- Semisubmersible platforms
		Exploitation (drilling, storing, conveying and loading oil, processing, utility, living quarters, ...)	- Fixed platforms - Steel jacquet - Concrete gravity type - Hybrid - Floating platforms - Semisubmersible (anchored) - Vertical mooring - Towers - Guyed - Articulated - Oil storage tan'ks - Underwater facilities
		Transport and installation (of platforms)	- Ad hoc barge for launching - Large floating cranes - Tugboats with special towing equipment
		Pipeline installation	- Ship (or barge) for laying out pipelines
		Iceberg protection	- Tugboats and strong towing wire ropes
	Macrocystis Algae	Ocean farming (with artificial upwelling)	- Manned big buoy with long vertical pipeline

TABLE D (cont'd)

SECTOR	RESOURCE	STRUCTURES	
		FUNCTION	TYPE
Energy	Tidal energy	Damming	- Ocean dam
	Wave energy	Wave energy converter	- Long ocean concrete spine with excentric pieces (salter ducs) - Kaimer system - Cookerell's rafts - Bristol cylinder
Indus-try	Sea transport	Industrial plant installation	- Large ad hoc barge
Food	Fishery	Catching and processing	- Large factory ship
		Coastal fishing (small scale)	- Fishing boats - steel construct. - reinforced plas-tic hull - ferrocement hull

3.3. MATERIALS

Materials for ocean structures must meet certain specific conditions imposed by the ocean environment:

- Durability in high-salinity environments (or technical and economic feasibility of being applied with an adequate proteccion system),
- Resistance to fatigue-corrosion with great number of cycles of loading and unloading,
- High mechanical resistance/specific weight ratio when buoyancy must be taken into account (case of high pressure hulls),
- Very low apparent density for bouyancy material,
- Maintenance of essencial characteristics in spite of ocean environment temperatures.

There is technical literature on ocean materials in general (Masabuchi Koichi (11), B. F. Brown et al (2), etc.) or on specific materials or on specific problems of materials in the marine environment (corrosion, fouling, etc.).

Classification societies publications include requirements and tests for ocean structural materials.

Specialized societies have also made contributions in the field of their competence. By way of example, a copy of the Table of Contents of "Prestressed Concrete Ocean Structures and Ships" of the P.C.I. (Prestressed Concrete

Institute) (17) is included as ANNEX III. ANNEX III also includes one page of the mentioned publication, where the advantages and disadvantages of concrete for sea structures and certain features of modern prestressed concrete sea structures are listed.

Most usual materials for offshore fixed platforms are structural steel (generally tubular) and prestressed concrete.

There are therefore steel platforms, prestressed concrete platforms and also hybrid ones (prestressed concrete basement and steel columns and topside bridge).

Steel needs cathodic protection and prestressed concrete requires a cover of increased width.

The steel used is structural steel, which can be produced locally by many countries, but it requires sheets of sizes for which normal rolling mills are not always prepared.

Concrete must be high-quality (correct and precise dosage, low water/cement ratio, etc.). Cement must be sulfate-resistant, although many normal cements allow the preparation of concretes having reasonably good durability at sea.

Steel bars for prestressing in general are within the local production possibilities of many countries (not necessarily highly industrialized).

In lesser quatities, aluminium is sometimes used in the upper portion of the platforms.

Pressure hulls require materials with a high resistance/specific weight ratio. For this reason, special steels of very high resistance, aluminium and titanium are used. Moreover, research and development is oriented towards composites, glass and ceramics.

For low pressure hulls, besides the well known materials like steel, wood and reinforced plastics, we can mention reinforced concrete for barges of different sizes (especially large ones) and ferrocement for small boats.

3.4. DESIGN AND CONSTRUCTION

There is, in general, a long experience in structural design and construction of works installed on land, and almost all those building knowdedge, technologies and equipment are appliable or at least useful or helpful for the ocean case. Consequently, we shall try to refer almost exclusively to what is characteristic of the ocean, to the influence of the ocean environment (environmental loads, environmental damages and risks, environmental accessibility, etc.); i.e., we shall mention that which is to be added to traditional knowledge in the structural field.

To schematize the influence of ocean environment on structures, we present as Table E a summary of Fig. II-20 (12), where it is pointed out, for example, that waves, animals, floating solids, seismic movements of the marine floor, etc., generate loads on the structures; that bearing capacity of ocean floors and of water (Archimedes' thrust) generate reaction forces; that water salinity and temperature affects the resistance behaviour of building materials, etc.; all of which is related to the effect of loads (Q) and to the resistance (R).

TABLE E

OCEAN ENVIRONMENT

(ITS INFLUENCE ON STRUCTURES)(*)

			IMPLIES	
OCEAN ENVIRONMENT	WATER	Waves, currents, hydrostatic pressure	Loads	Q
		Archimedes' thrust	Reaction forces	Q
		Salinity, temperature	Behaviour Material	R
		Animals	Loads	Q
			Structural damage	R
		Floating solid bodies	Loads	Q
	AIR	Wind, snow	Loads	Q
	FLOOR	Ocean soils	Reaction forces	Q
		Ocean soils seismicity	Loads	Q
MAN & OC.	MAN PENETRATION	Diving (depth and coast) Vehicules Robots	Inspection and Repair	
	ENV. PROTECTION	Accidents, effects of pollution Control of pollution	Environment damage (risk)	

$$R = f_{ij}\ (Q)$$

R=Resistance; Q=Effect of loads; f_{ij} =function (safety and reliability)

(*) Condensed from Fig. II-20.
Source: (12)

As regards the present capacity of man to penetrate the marine environment and his responsability in preserving it, references are made to allow the definition of safety and reliability concepts and parameters.

The variety of ocean structures being so great, there is naturally a great quantity of different design problems.

This report is circumscribed to the consideration of just two types of structures:

a) offshore fixed platforms, and

b) ferrocement boats for fishing.

The former, being a rather complex case, will allow an understanding of the multiple aspects where the environmental influence is apparent -Ocean Engineering is an environmental science- and will show as well that the design and construction of ocean structures requires the cooperation of several disciplines and technologies. Thus it results that, because of their nature itself, this type of ocean structures is well suited for the disaggregation of technology packages, the flexibilization and acceleration of achievements and the widening of participation possibilities.

The latter example (the ferrocement boat) is a case where a single design may generate the construction of many unities, and this in the most distant places. It is -in contrast with the former example- a very simple construction, with unexpensive materiales and at the reach of everybody, which can be produces locally and individually with no need for specialized personnel. In spite of its simplicity, its social projection is obvious in coastal areas in developing countries.

This latter example, extremely simple, has no great design problems; its structure is limited to the hull. It has many traditional elements: its loading conditions, static and dynamic stability, etc. These are problems arising out of the ocean environment but which can be solved with the knowledge of traditional Naval Architecture. Moreover, the possibility to build many units justifies verifications on physical models and even at natural scale and real operating conditions.

What is an important innovation in this example is the use of ferrocement as building material for hulls; this allows a great simplicity of execution which makes its construction possible, even with very modest elements.

This case of the ferrocement boat is well suited for social promotion organizations wishing to buy a design and then make it available to local inhabitants interested in building it for themselves. The FAO has already started a good experience in this sense.

In the following sections, we will make reference almost exclusively to the former example (offshore fixed platforms), which has untraditional problems as regards design topology, loading conditions, structure behaviour, foundations and anchoring, etc., and their constructive process.

3.4.1. Design conditions

Fixed offshore platforms can be either concrete or steel or hybrid. There is also a project for a sand platform with membrane and hydrostatic pressure (Fig. II-13).

In petroleum complexes, they are built to perform different functions: drilling, production, hotel, etc., separately and sometimes integrating two or more functions.

Fixed offshore platforms are built in part on land (sometimes at different sites), and in part at sea at their permanent installation site, which generates unusual conditions to be taken into account on design, construction and installation.

Moreover, at the end of the useful life of a structure, it has to be removed or demolished partially or wholly to preserv the usefulness of the ocean environment (to avoid navigation risks, etc.). Because of all this, the following design conditions have to be considered:

- Construction
- Transportation
- Installation

- Operation
- Abandonment

It is also worth pointing out some characteristics arising from the ocean environment and having an influence on the structural behaviour:

- Corrosion
- Fatigue-corrosion
- Fouling
- Hydrostatic pressure
- Unconsolidated sediments

In the design of fixed offshore structures, several limit states should be taken into account according with:

- Maximum load carrying capacity
- Fatigue-corrosion damage caused by repeated loading
- Progressive collapse reached by structural damage caused by accident (or misuse)
- Serviceability

There is already interesting technical-scientifical literature, from the very theoretical to the very pragmatic, oriented to easing the design.

Moreover, there is a good and always growing production of research and development papers on very specific and specialized aspects of ocean structures, which constantly contribute to the better knowledge of the complex problems involved.

Any design must be made bearing in mind that it afterwards it should be constructed without requirements beyond what is reasonable. This is particularly true in the case of offshore fixed platforms. Ben Gerwick stresses this aspect and introduces the concept of "contructibility" (7).

Classification societies, besides their functions, or rather for the better fulfillment of them, do research work and publish standards including basic data for design and construction.

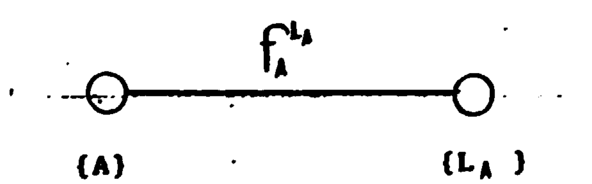
By way of example, included as ANNEX IV is a copy of the Contents of a publication by Det Norske Veritas, called "Rules for the Design, Construction and Inspection of Offshore Structures" (5). We can see there the items it covers.

Other institutions, like the FIP (Federation Internationale de la Precontrainte), the API (American Petroleum Institute), etc., issue publications oriented to their purposes and which constitute an important contribution to the problem of design and construction of offshore structures. Included as ANNEX V is a copy of the Contents of the FIP publication called "Design and Construction of Concrete Sea Structures - 1988" (6).

3.4.2. Loading conditions

Based on the fact that it is known how to calculate and process usual loads (structures on land and in shallow waters and conventional ships), we shall refer only to the offshore environmental loads, i.e. those arising out of the installation of structures in ocean space and not in shallow waters.

Fig. II-29 shows that, knowing the data characterizing the different phenomena present in the ocean environment (waves, currents, etc.) {A}, different methods or algorithms allow us to calculate the generalized forces integrating the state of environmental load $\{L_A\}$, which is represented in the following graph:



where

{A} = set of data characterizing the ocean environment

$\{L_A\}$ = set of data characterizing the state of environmental load

$f_A^{L_A}$ = application of set {A} in set {L }

i.e. $f_A^{L_A}$ symbolizes the algorithm to predict the environmental loading state.

To make each load-generating ocean phenomenon explicit and to arrange the whole collection of environmental data, we may write

{A} = { {Wv}, {C}, {p}, {Wd}, {Sn}, {a}, {So}, {e},...}

forming set {A} with all the subsets of partial data collections characterizing each ocean phenomenon:

{Wv} = waves

{C} = currents

{p} = hydrostatic pressure

{Wd} = wind

{Sn} = snow

{a} = animals

{So} = floating solids (*)

{e} = earthquakes

It is possible to disaggregate easily the package of knowledge of methodology to predict the loads produced by waves, or the wind, or the impact of floating solids; and the language of sets presents this very clearly. At this point, it is worth pointing out that waves and currents are treated together after finishing separately their respective fist stages of calculation (determination of their kinetic values).

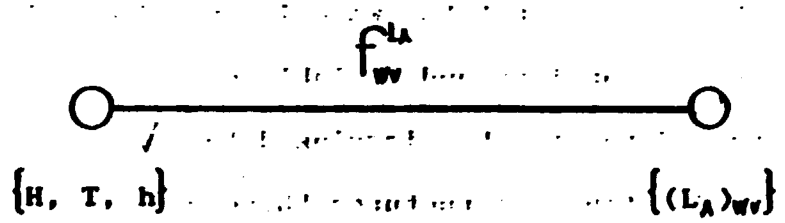
(*) Fendering and mooring loads are included in living loads.

In general, the study of the influence of each ocean phenomenon on the structure's loading state, is in itself a specialized field.

If we take just one case, that of waves, for example, the classical collection of data necessary for characterizing it is: H,T,h (height, time, water depth), so that

$$\{Wv\} = \{H, T, h\}$$

and the graph for prediction load is:



The package of knowledge for predicting loads generated by waves is then symbolized by

$$\bigcirc\!\!\!\!\!\!\; f^{L_A}_{Wv}$$

This $f^{L_A}_{Wv}$ is one of several applications determining environmental loads as a function of each one of the considered ocean phenomena.

Similarly, $f^{L_A}_{Wd}$ and $f^{L_A}_{e}$ are the applications corresponding to wind and seismic movement and symbolize different knowledges and methodologies.

Expressing this in a general way, we would have

[f_i^{LA}] with i varying from the case of the wave (Wv)... to the case of the earthquake (e).

We can say that each f_i^{LA} defines a well delimited field of study.

The wave's mechanic influence on the structure, has been the object of important theoretical-experimental studies and there is still much to be researched to easily predict loads with greater accuracy and reliability.

We must remember that the wave is an estochaotic phenomenon requiring long and reliable observations and measurements and the further issuing data processing.

For fixed offshore structures there are already publications guiding and offering the necessary professional tools (methods, procedures, parameters, etc.) allowing the explicit determination of the corresponding load states, i.e. the development of the necessary calculations for the application f_{Wv}^{LA}, for example, to result in the specific numbers required for the design.

Section 3.3.1.1. of ANNEX II summarizes the problem of forces generated by waves and makes reference to some of the calculation procedures in use.

Coming back to the general subject of the state of load of the fixed offshore structures, it is worth pointing out that the applied forces system has large and high horizontal components; that there are dynamic forces and forces with a very high number of repetition ($\sim 10^8$ during the structure's useful life), which should be taken as datum for calculating the fatigue-accumulated damage.

In brief, they are structures with a very great overturning moment and with severe fatigue problems with dynamic loads stochastically fluctuating in their direction and amplitude.

3.4.3. <u>The structure</u>

The structure itself, including its basement for foundation, is the part of the structural project which comes wholly out of man's hand. The engineer creates it, designs it, builds it, installs it, maintains it and, at the end of its operative life, removes or destroys it for environment protection reasons.

The structure, then, generates engineering activity and industrial activity for planning, design, production, assembling, transportation, operation and inspection. Moreover, it employs important quantities of materials, whose production, transportation and storage also increases industrial activity.

This technical activity promotes, naturally, trade (domestic and foreign) and economy, since it sustains profitable utilizations of the ocean resources.

We have already referred, in section 3.1., to the types of ocean structures in general and we observed there is a very wide range of structures, from the very complex to the very simple. It should be noticed that this range will go on widening, because construction is extending to greater depths, to artic regions, to countries with different infrastructures, and besides, because we are now coming fully into the creation of ocean structures with their own philosophy, optimizing the solution of design and construction of those platforms to be installed and operated at sea, far from shore. Let us remember that the first platforms installed in water were just an adaptation of structures on land.

In the various ocean structure, logically, the whole range of structural elements (bars, beams, frames, plates, shells, etc.) appears, but it is worth pointing out here that in the ocean structural systems, anchoring are very frequent and under very special conditions.

It is also worth mentioning the piles which in ocean constructions reach very singular sizes and have to be driven into marine subsoils - often under great water depths-.

There are platforms (steel jacket type) with 150 m long piles, driven into sea floors under more than 300 m water depth. In these cases there are interesting design and construction problems (piling), besides the production of equipment (heavy underwater pile-driven hammers, etc.) and the piles themselves.

Offshore anchoring is a very specific and very important technological field. We shall not consider here dynamic anchoring (dynamic positioning) because it is an automatic control problem.

In general, static anchoring resistance systems may be classified as follows:

- Catenary type
- Vertical mooring (or tension legs)

The former use chains, wire ropes, nylon ropes, etc., or a combination of them. The latter use clusters of bars.

There is a great variety of anchors, gravity ones, percussion ones, etc. Amon_ these latter, there are anchorage elements which enter the marine subsoil through explosive charges.

The structure must meet the requirements of the function or functions of the platforms as regards space for equipment and facilities, and resistance (to ensure no limit state may be reached).

The definition of the functions or purposes of each one of the platforms in an offshore complex depends in turn on the type of structure. The concrete gravity type, for instance, has (because of its base and columns) a lot of hollow cylinders that offer room enough for storing a very large quantity of petroleum. In this case the platform would perform, among other functions, that of storing petroleum.

A global optimization at the level of the whole petroleum complex, considering the total required functions and the set of platforms and general installations to be built, will allow the determination of the functions of each specific platform.

Once the functions defined, it will be possible to determine the general layout of the top side decks, later to design the top side bridge and then go on with the rest of the structure, with special consideration of the ocean environment.

Since the structure of a fixed offshore platform involves a major project with many elements, subsets and interdependent conditions, the system design techniques with continuous feedback are the inevitable choice, since they allow the creation and design of coherent units.

The resistance study requires theoretical and experimental stress analysis, especially of its hot points (joints or nodes and other points of regidity variation). The theoretical and experimental structural analysis must include the consideration of dynamic behaviour. The waves corresponding to the various sea states cover a very wide range of frequencies and, naturally, structures with their own frequencies, far from the foreseeable wave frequencies, have to be designed. Moreover, the calculation of the fatigue-accumulated damage makes it necessary to know the structure's frequency reponse to the excitation of its applied forces system.

3.4.4. <u>The foundation and anchoring</u>

The first thing to be studied is the foundation soil, which in this case is the ocean soil and subsoil.

Ocean Soil Mechanics is a very important field, very specific to the sea and which is developing very quickly. It is based on the same basic principles as the traditional Soil Mechanics, but has great differences because of its very peculiar environmental conditions and, consequently, has a big quantity of ad hoc technologies.

It is easy to notice that the building of offshore foundations at 100 to 400 m water depths requires studies, technologies and equipment more complex than those necessary for foundations on land.

The very recent progress of man's penetration in the sea (greater diving depths, availability of minisubmarines, robots, etc.)and the improvement of survey equipment (high resolution seismic sounders, television and sonar systems, in situ tests, etc.) allow foundations more reliable and more easily built on the sea floor.

From the foundations' point of view, fixed offshore platforms could be grouped in the following way:

- Steel jacket platforms → pile foundation
- Concrete gravity platforms → mat footings
- Tension leg → buoyancy and vertical mooring

The last group, at sea floor level, is an anchorage. Its real foundation is, by flotability, near the free surface of waters. We may consider water as a "foundation soil" with specific bearing capacity, not very high but not null either.

For anchorage on the sea floor, tension piles are also being used, whose behaviour to resist the uplift force is being actively investigated.

Foundation by compression piles is done with steel tubular piles or with hollow prestressed concrete piles.

If, in spite of previous studies for choosing the type of structure and the type of foundation, rocks hindering the piling should appear, there are available technologies for breaking and extracting any rocks which might appear.

Publications by Classification Societies offer standards and parameters useful for the design and construction of foundations of pile-supported structures.

Gravity platforms have a foundation with special footings allowing the transfer of loads applied to the structure to a very extended area of the sea floor, achieving a good distribution. Their design is such as to allow an adequate penetration of special edges, thus increasing the capacity to bear horizontal shear forces and avoid sliding.

3.5. HUMAN RESOURCES

The starting point for marine resource development is the education of human resources, so that, with them, each country may:

a) rearrange its institutional structure, creating, if necessary, new institutions capable of reaching the best solutions to societal problems, promoting rational and effective developments and applications of the new ocean technologies;

b) have adequate counselling in the elaboration of national development plans where utilization of ocean space should start to play a major role;

c) count on capable professionals at all stages of those projects chosen according to the previously established priorities;

d) have groups of scientifical-technical researchers, since Ocean Engineering has a strong scientific component and is, moreover, a field where it is difficult to predict future technological evolution.

All countries, whatever their levels of development, should educate their own human resources so that their ocean activity may be efficient and adequate to their real values and needs.

We must not forget that Ocean Engineering allows, on the one hand, to carry out projects of very easy execution and, on the other hand, large-scale projects, whose treatment is today made easier thanks to the simple but powerful methodologies of System Engineering.

In developing countries, young engineers often have to take on global and important responsibilities; consequently, their education must be solid and include an adequate amount of general knowledge.

Engineers should be educated to contribute to the awareness of ocean utilization feasibility, to handle consulting and construction contracts, to perform functions of project management, research and development, design, construction, operation, repair, etc. of ocean structures in their numerous varieties.

Within all this, each country should focus its effort on that which is more necessary or adequate in its priority areas and considering the development stages of the different programs. This, naturally, with a certain advance to compensate delays due to the time elapsing from the start of education of engineers and technical workers until their availability.

Besides those resources having priority utilization, there are basic subjects which are common to all types of ocean utilization. Structures is, precisely, the most basic subject and a common requirement of all types of ocean industrial activities.

On University curricula on Ocean Engineering, the UNESCO publication "Ocean Engineering Teaching at University Level - 1983" (19) may be seen. Included as ANNEX IX is a copy of its Fig. 3 (IX-3), "Ocean Engineering decision analysis matrix (for curricula design)", where a graphic shows the estimated weight of the relationship between academic disciplines and Ocean Engineering activity.

In (15) some remarks are made which are especially related to developing countries, as regards the important role that research and development groups may play in the education of human resources, offering courses and working places for doing research and development, on the one hand, and contributing to mobilizing and enabling, through cathalitic action, the whole local community of engineers for sea activities, on the other hand.

We have stressed the need to have local core groups to promote and guide Ocean Engineering development in the present time, where there is an unavoidable need to optimize the functioning of the technology-society system.

To form a core group it is essential to achieve the participation of certain engineers -at least one person- with permanent creative intelligence and with an education and experience having allowed him to get a very wide general knowledge and at the same time deep specialized knowledge in one or two fields. It is not easy to find professionals educated in this way, but even though the quantity of them is very limited, it is important to look for them and give them responsibility in the great mobilization for the bold utilization of ocean space.

For the future education of human resources, what has just been said should be object of a special concern. Fortunately, modern Engineering and especially Ocean Engineering, which requires a strong scientifical base and which moreover is interdisciplinary, is well suited for that type of formation.

4.- REMARKS ON STRATEGIES FOR PROMOTION OF OCEAN INDUSTRIAL DEVELOPMENT

Today there are urgent needs: deficit of food, energy, scarce metals, etc. These needs afflict in one way or another the developing and the developed countries, affecting seriously many of them.

Natural resources on land have endured during centuries an intense and growing extraction under the pressure of the population growth and of some improvement of living conditions. These two aspectos will continue to grow in the immediate future and, consequently, so will the seriousness of the mentioned deficit, if alternative resource sources are not found.

In front of this situation, ocean industrial development has to be an unescapable goal.

The available means to undertake this task are today worth taking into account.

There is a very rapidly growing Ocean Engineering , which has developed important technologies that could be more widely applied.

The introduction of Ocean Engineering in countries having very different development levels is easy and quick if adequately planned.

This new branch of Engineering can offer significant contributions to industrial development, applying existing technologies, adapting them to countries with different infrastructures and, above all, it can develop technologies -sometimes easily appliable- capable of solving urgent and important industrial development problems.

Ocean structures, in particular, are sine qua non elements for the utilization of ocean resources and are consequently a key factor of the great ocean industrial development. Notwithstanding it, the construction or production of ocean structures means in itself an important industrial activity.

4.1. CATALITIC EFFECT OF OCEAN ENGINEERING

As we have said, the constellation of ocean structures is very varied and includes all types and sizes of them. As their complexity and importance grow, they require a greater participation of Engineering, Industry and Building sectors of the involved country.

These activities can enrich themselves and widen their potentials by way of bilateral and international cooperation and joint ventures in this field of ocean structures, that is very well suited to technological disaggregation.

Ocean activity, because of its variety and magnitude, requires a readiness for it (at least potential) on the part of all the community of engineers (including all the traditional branches), all Industry and all Building sectors. Ocean Engineering is interdisciplinary and multisectorial. [illegible] was born out of the contribution of many of the tradition[illegible] [illegible]nches of Engineering in close cooperation with all the scientific spectrum, especially Physics, Mathematics, Oceanography, Medicine (of Diving), etc.

Ocean Engineering is strictly and authentically Engineering -it is one of its recent branches- and, as it was to be expected in our present time, has a strong scientific component.

Those countries which have not yet started their preparation for industrial activity in the ocean, or which have done it incipiently or partially, will find that, if to all the knowledge and experience Engineering already has for works on land they add the additional essential knowledge imposed by the seas (environmental loading conditions, marine soil foundations, fatigue corrosion damage of steel and prestressed concrete in ocean space, etc.), all Engineering quickly passes from its responsible self-limitation to act in ocean works, to a serious and firmly-based possibility to have an intense participation in the ocean industrial activity.

This requires the organization of a core group -which can be broadened according to circumstances- consacrated to the study and knowledge of what is characteristic of structures when they are installed or they operate in the vast ocean space.

The presence of a core group like the one we mention produces a remarkable cathalitic effect, which is easy to understand. With what the group produces, and organizes to be produced, and what it advises to obtain, local Engineering can, in a short time, get ready to participate in the ocean industrial activity.

In the local Industry and Building sectors, where Engineering naturally plays an essential role, this cathalitic effect also takes place and the core groups can give those sectors their advice and the multiplying effect. The possibility of joint ventures, cooperation, etc. may also be added to these results.

From all this the need arises for a rational and vigorous mobilization of the potential local capacities to develop engineering and producing capacity of offshore structures in their various types, sizes and functions. This shall undoubtedly be a strong contribution to industrial development.

Pioneers in this mobilization may be Universities and research and development centers, engineers' associations, Industry and Building Chambers, etc, and, of course, government institutions (as they get ready to deal with and direct the development plans taking well into account the recent and important possibilities of the technological revolution in the ocean field).

Included as ANNEX VI is a copy of a declaration (dated March 15, 1980) by the UADI, Union Argentina de Asociaciones de Ingenieros (Argentine Union of Engineers Associations), called "Petroleum, Ocean and National Engineering", where the underlying notion of technological disaggregation can be found and which shows, as regards one of the ocean resources -offshore petroleum-, its stimulus and contribution to the mobilization of local capacities in that field and especially in relation with offshore structures.

Included as ANNEX VII is a copy of the declarations on Ocean Engineering by the 3rd. Argentine Congress on Engineering Policies organized by tha CAI (Centro Argentino de Ingenieros/Argentine Engineers Center) in 1985 in Buenos Aires, which also shows its concern for a timely and adequate mobilization, to which end it offers certain criteria and recommendations.

This two references are from Argentina, a country having an intermediate development level and therefore comparabble to a great number of countries.

4.2. DISAGGREGATION OF TECHNOLOGIES

Ocean structures -especially the more complex ones- are, by their nature and importance, ideal cases for disaggregation of knowledge, experiences and technologies in their design and building.

It is enough to refer, for example, to the fields of wave loading condition and of marine soil foundation and anchoring. These are two fields where work can be done separately (with different technologies groups for their measurements, tests and data processing). This does not exclude, logically, a subsequent integration and study of the interesting problems of the interaction fluid-structure-marine soil of the whole structural system, as a final synthesis.

Different design conditions (construction, transportation, installation, etc.) -which correspond to the homologue building stages- are also well suited to disaggregation.

Fig. VIII-4-1, ANNEX VII (8) shows a list of technologies involved in offshore platform design, classified in four big groups, but even within these groups some of their technologies may, in principle, be disaggregated.

Also within each of the above mentioned design conditions -transportation, for example- disaggregation is possible and often advisable.

Let us consider the transportation problems in the case of a gravity type platform of prestressed concrete for the usual functions at an offshore petroleum complex.

The mentioned transportation case involves the following tasks, with their corresponding technologies:

- Towing of the lower section of the structure (the gravity base) from an ad hoc dry dock.

- Towing of the gravity base with columns to the assembling site.
- Transportation and lifting of the top side bridge.
- Towing and lifting of the top side bridge to the assembling site.
- Transportation and lifting of modules.
- Towing of the platform to installation site.
- Transportation and laying out of pipelines.
- ...

As we can see, there is transportation and lifting on land, at sea near the coast and at sea far from the coast; all of which allows disaggregation of activities and technologies.

It is interesting to notice, moreover, that the offshore location (site of installation) is defined by the location of the oil wells to enter into production, while for choosing the assembling site and the dry dock site (temporary ad hoc dry dock) there are very different and very distant alternatives thanks to present technologies. There is even a possibility to modify substantially the design philosophy of the platform according to local geographic conditions and the availability of acceptable bids.

Production and building of the platforms and their associated transportation systems also offer clear disaggregation possibilities. Their large areas are:

- structure of the platform (base and columns)

- structure of the bridge (topside)
- topside modules
- bridge/platform assembling
- pipelines
- loading systems.

Even within each of these areas it is possible and often advisable to disaggregate.

If we take the case of the structure of the platform, we notice that it is possible to disaggregate even the production of some of fragments;

Planning, for instance, a project of steel jacket type platforms for the North Sea, we can find that U.S., or Japanese, or U.K. shipbuilding yards can do the best bid for producing the joints or nodes, while Norway, France or Spain can be competitive for assembling and erection.

This shows that even the production of some parts of a structure may be disaggregated to obtain better costs and/or better delivery times or to reduce the total production time, or to widen capacities.

This example shows, moreover, the need for important transportation operations, even for elementary parts of the structure.

Fig. 3, showing a steel structure node and taken from W. J. Graff (8), allows a better understanding of the mentioned problem at its real scale.

These examples and remarks that we can find in real activity coincide with which may be foreseen in the conceptual or theoretical level if we remember that Ocean Engineering involves many disciplines -it is interdisciplinary by nature-; and that the system approach is always at hand as a powerful and adequate tool for integration of the previously disaggregated technological packages.

5.- SUMMARY AND CONCLUSIONS

The essential contribution of Ocean Engineering to the possibility of utilization of ocean space has been pointed out. Technical and economic feasibility of the exploitation of varied and rich marine resources has been achieved recently and this process continues to extend and improve.

Some of the current achievements are listed and exemplified, involving very varied ocean structures, some complex, other simple, for the exploitation of very different resources, but always solving singular and important problems which may be faced thanks to present industrial development.

A general list of ocean resources is included, with different degrees of development, pointing out that, given the permanent and rapid scientific-technological progress, industrial development plans can not fail to take into account even those resources whose exploitation is very near to entering the operative stage.

It is stressed that the technological component of ocean resources is highly dynamic, which widens, diversifies and flexibilizes possibilities both in developed and developing countries.

Present exploitation of ocean resources expands industrial activity, increases utilization of ocean space and availability of energy, food, usable water, minerals, etc. Potencial current capacity to create technologies will allow the extension of industrial development benefits even to the most isolated populations.

Ocean activities not having as goal the utilization of resources -defense, for instance- also require varied and important structures and the cooperation of all sectors may achieve a fruitful "cross-fertilization" and a rapid "horizontal transfer of knowledge".

A prospective view of ocean technological development allows us to make plans for industrial development based on utilization of a much more extended and rich space, considering lands and seas globally.

The groups of ocean structures types are reviewed and they are related to the corresponding ocean resources, which stresses the essential role of structures.

The great majority of structures use, as building material, steel and/or prestressed concrete, without ruling out the use at a smaller scale of aluminium, reinforced plastics, ferrocement, etc.

Besides making a reference to an extremely simple structure having an important social projection, to consider the problem of structure design and construction, the specific case of fixed offshore platforms is discussed and the ocean environment influence on them is analysed. Moreover, the present advancement as to man's penetration in the sea and its consequences on inspection and repair tasks are taken into account. Finally, it is pointed out that the environmental protection responsibility requires availability of equipment, risk analysis studies and definition of criteria and levels of safety.

Contrary to traditional structures on land, ocean platforms must meet special design conditions and must also be protected against several limit states (different types of collapse or serviceability loss).

Loads generated by the ocean environment are discussed and it is pointed out that their studies and the associated technologies may be easily disaggregated.

The state of load of these platforms is characterized by a big overturning moment and by generating a dynamic state of stress with a high number of repetition of load and unload cycles with estocastic variations of amplitude.

The offshore platforms structure generates by itself an important industrial and engineering activity, promote trade and reinforce the economy.

At the technical level, it is interesting to mention the variety and importance of anchorages and pilings in marine floors.

The analysis of the structure's dynamic behaviour becomes necessary for stability reasons as related to fatigue and resonance problems.

The need for system design to achieve harmonic and coherent unities with disaggregated technology is underlined.

The importance of marine soil mechanics, whose present development already allows reliable and singularly big foundations, is stressed.

The importance of each country's education of its own human resources to achieve an efficient ocean activity, fit to its values and needs, is pointed out.

Some remarks are made on the definition of purposes and goals of Ocean Engineering education, especially in developing countries.

Ocean structures are a basic subject, its need being common to almost all types of ocean resource utilization; consequently, it should be one of the goals of human resource education.

It is generally acknowledged -especially in developing countries- that it is necessary to establish as soon as possible the core groups which are to be the key factor in the guidance and promotion of local capacities mobilization for ocean industrial development, always in search of the optimization of the functioning of the system technology-society.

Engineers who, having deep knowledge in one or two fields, also have a very extended general knowledge, are of vital importance in the integration of core groups.

The importance of research and development groups in the education of human resources and the cathalitic mobilization of local capacities is stressed.

Today, when there are large and critical deficits on the one hand and recent and promisory possibilities on the other, an accelerated ocean industrial development becomes a first priority goal.

It is pointed out that, given the nature of Ocean Engineering, a benefic cathalitic action is possible in the necessary rapid enabling of local capacities (industrial and engineering).

It is noted that offshore platform structures are an ideal case for disaggregation of knowledges, experiences and technologies in their design and construction, to which end specific references at different levels are made.

From all that has been said, the following conclusions arise:

Ocean structures offer the possibility to disaggregate knowledge and technology in the previous studies, in design, in construction and installation and in the included specialized transportations.

From this it results, moreover, that developing countries may organize themselves to have an active participation in the design and construction of ocean structures, even the most important and complex ones, even if they can not cover all the aspects of the varied technologies involved. Thanks to this possibility of technological disaggregation, developing countries may reach to important goals:

- To face their national problems, benefiting from the recent additional possibilities for industrial ocean development. To this end they may take in charge the corresponding structure projects disaggregating technologies in the adequate quantity and levels to optimize the benefits of foreign cooperation or participation.

- To participate in bilateral and international projects, enhancing, when necessary, their own capabilities in the field of their participation.

To these ends, actions undertaken by United Nations organizations are invaluable. In the field of ocean structures and the industrial utilization of ocean space which they serve, those organizations will achieve a projection always more trascendent in the benefit of many countries to which they can offer an external motivation, the inicial impulse and guidance for the right identification of their problems in this greatly changing present society.

Ocean structures, some because of their simplicity, other because of their complexity, are well suited to promote and intensify the development of Industry and of Engineering in all countries and all their regions.

Ocean industrial development, because of all its promises, because now it has become technically and economically feasible and because its inherent cathalitic effect allows an accelerated enlistment of local capabilities, must today be for all countries, coastal or not, a high priority goal.

REFERENCES

(1) Brin, A., "Les Energies de la Mer" A.A. L'Architecture d"Aujourd'hui". Sept-Oct 1974, p. 42-45.

(2) Brown, B. F., et al. "Materials and Testing". Handbook of Ocean and Underwater Engineering (Ed.-in-chief Myers, J. J.). McGraw Hill, 1969, p.7-1, 7-92.

(3) CAI (Centro Argentino de Ingenieros) "Ingenieria Oceanica". Anales del 3er. Congreso Argentino de Politicas de la Ingenieria". Buenos Aires 6-8 Noviembre 1985, p. 555-563.

(4) Charlier, R. H., "Tidal energy". Van Nostrand Reinhold Co. 1982.

(5) Det Norske Veritas, "Rules for the Design, Construction and Inspection of Offshore Structures". D. NK. V., Oslo 1977.

(6) FIP (Federation Internationales de la Precontrainte), "Design and Construction of Concrete Sea Structures". Thomas Telford Ltd. London 1985.

(7) Gerwick, B. C., "Constructibility, an essential requirement in ocean Engineering Education". Proceedings ECOR International Conference 1984. Vol II, p. 290-300.

(8) Graff, W. J., "Introduction to offshore Structures". Gulf Publishing Co. Houston 1981.

(9) Homma, T. et al., "Report on Utilization of Ocean Energy". Proceedings of the Technical Session on Ocean energy - ECOR Fifth General Assembly. Buenos Aires, Oct. 1984. Ed. ECOR. London 1984.

(10) Jequier, N., "El desafio industrial japones". Ed. Aguilar 1973.

(11) Koichi Masubuchi, "Materials for Ocean Engineering". M.I.T. Press 1970.

(12) Lara, A. C., "Estructuras oceanicas". Recursos Oceanicos - FAEM (Fundacion Argentina de Estudios Maritimos). Buenos Aires 1984.

(13) Lara, A. C., "Beneficial Symbiosis in Oceanography and Ocean Engineering". IOC (Intergovernmental Oceanographic Commission). 14th Session of the Assembly IOC - XIV/ Inf. 2. Paris 1987.

(14) Lara, A. C., "Differing Needs for Ocean Engineering Technology Exchange". Proceedings of the ECOR Third General Assembly. Washington D.C. 3-6 May 1978, p. 107-123.

(15) Lara, A. C., "Grupos de investigacion y desarrollo en la formacion de los Recursos Humanos de Ingenieria Oceanica". Proceedings of ECOR International Conference 1984. Buenos Aires 2-5 Oct. 1984, Vol II, p. 307-319.

(16) NACOA (National Advisory Committee on Ocean and

Atmosphere), "Engineering in the Ocean". Washington D.C. Nov. 1974.

(17) PCI (Prestressed Concrete Institute),"Prestressed Concrete ocean Structures and Ships". PCI, Chicago 1975.

(18) Takeno K. and Kenkyusho R., "Marine Environment and Oceanic Resources". IOC (Intergobernmental Oceanographic Commission). 11th Meeting of the Assembly. Paris 1981.

(19) UNESCO, "Ocean Engineering Teaching at the University Level". UNESCO 1983.

(20) Weaton, E., "Discussion on Report on Utilization of Ocean Energy". Proceedings of ECOR International Conference. Buenos Aires 1984. Vol II, p. 455-462.

ILLUSTRATIONS

Fig. 1. Testing beams (XVII century)

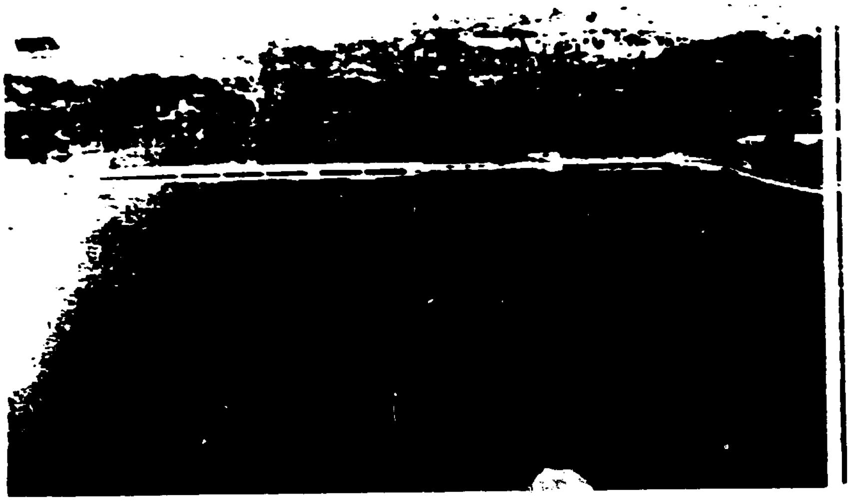


Fig. 2. Tidal Power Plant (La Rance, FRANCE)
Source: (1) Brin, A.

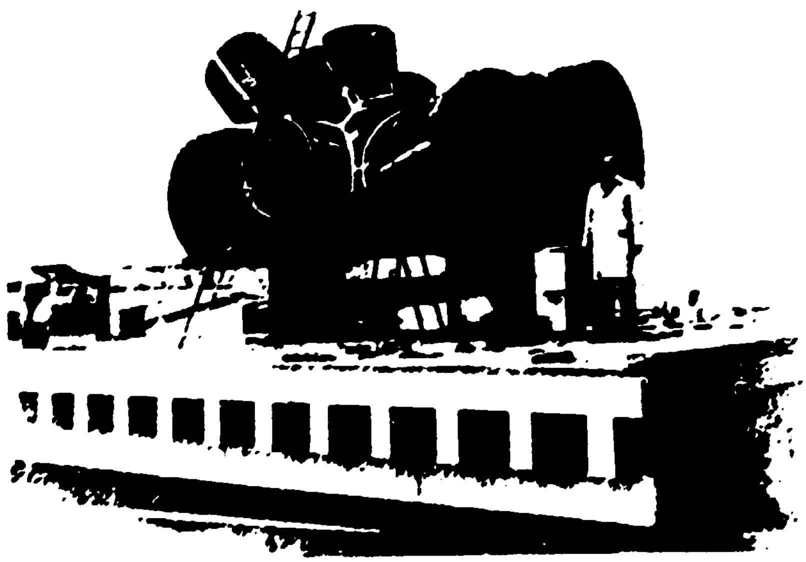


Fig. 3. Node of a steel offshore structure
Source: (8) Graff, W. J.