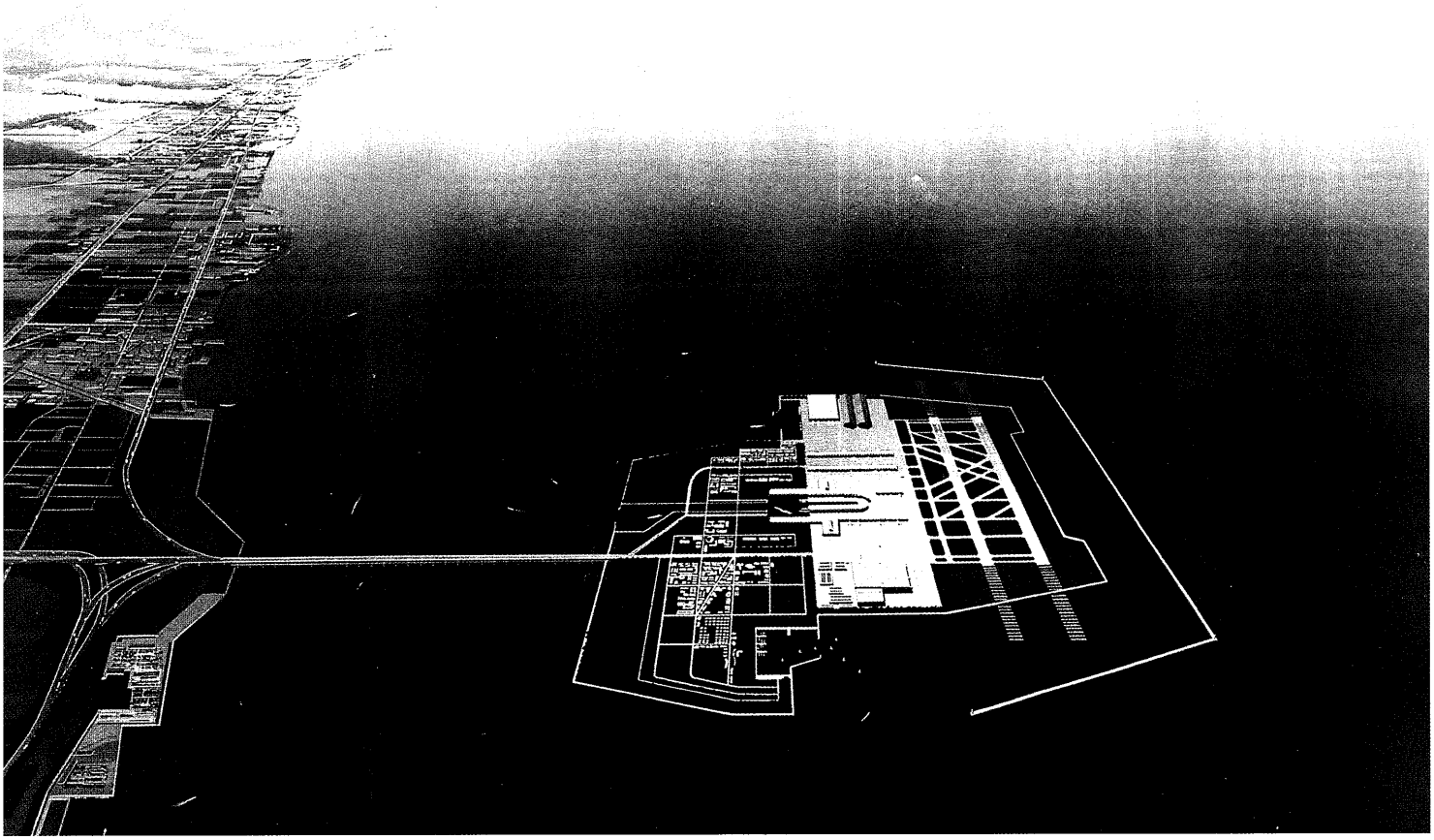
Research and Development of Mega-float



The research and development of Mega-float is attracting a great deal of attention to maritime affairs in Japan.
A Mega-float airport is just one concept under consideration for the future development.

Background to research and development of Mega-float

As an island nation with limited land resources, Japan has long resorted to the reclamation of land by land filling and draining. The first recorded instance of land reclamation was at Fukuhara (now in Kobe) during the Heian era (12th century). Subsequently there have been many instances of land reclamation for increasing the area of useable land, particularly during the Edo period (1603-1867 A.D.). Reclamation continued even after the Meiji era, but it was only after World War II and during Japan's period of economic development that extensive land reclamation was carried out in urban areas, such as Tokyo Bay and Osaka Bay. With increased socio-economic development, the need for utilizing ocean spaces is likely to increase even further in the future, and most shallow-water areas in Japan that can be utilized have already been reclaimed. The country is therefore being compelled to embark on the development and utilization of deep-water offshore areas as well as other ocean areas with a soft seabed. Since reclamation of such areas is difficult compared to conventional reclamation methods, consideration is being given to the utilization of very large floating structures, or Mega-floats.

To this end, a technical association was established. The Technological Research Association of Mega-Float, as it was named, is made up of seventeen shipbuilders and steel manufacturers, which are carrying out joint research and development for the creation of a large-scale floating structure. The term, Mega-float, which is Japanized English, was coined by the Ministry of Transport at the association's inauguration in March 1995.

Characteristics of Mega-float

Fig. 1 shows the main components typically associated with a floating structure. Until now, production, storage and service facilities of various types have been built almost exclusively on land with its many advantages, which may be regarded as a 'platform' for these activities. However, shortages in available land have demanded a turn to the sea for new 'platform' sites - first by reclaiming land from various shallow water areas, and now by the development of independent off-shore structures such as Mega-float to provide stable 'platforms' on the surface of the sea itself. Aiming to help meet ever growing construction needs, Mega-float offers a promising alternative to land-based platforms, and a range of other potential advantages in addition to the requirement for space alone. A number of different advantages and items needing to be addressed with regard to Mega-float vis-a-vis the two other types of platforms, i.e. land and reclaimed land, can be presented as shown below.

(1) Some characteristics of Mega-float as a sea-based platform as opposed to land-based platforms:

- Freedom in deciding upon its size and location
- Facilities which make use of the sea or sea water can be easily utilized on the structure.
- Although some costs may be incurred, the utilization of ocean space in urban areas has greater economic benefits than constructing facilities on land in adjoining areas.
- A calm-water area is created between the structure and land.
- Means of access to the floating structure must be provided.
- Effects of very long waves or tsunami need to be considered.

(2) Characteristics of Mega-float as a floating structure compared with a structure built on reclaimed land as a platform for various facilities:

- Floating structures can be shifted to different locations, though a mooring arrangement must be provided.
- The floating structure can be easily extended, expanded, or scrapped.
- Effects of water depth and consistency of the seabed are relatively insignificant.
- Because earth and sand are not required for construction, the problems related to gathering and transporting them to the site are eliminated.
- The floating structure is free from damage by earthquakes and ground liquefaction phenomena.
- The total period of construction can be significantly shortened by constructing the individual units and upper facilities of the floating structure simultaneously.
- The sections below the deck of the floating structure can be effectively utilized.

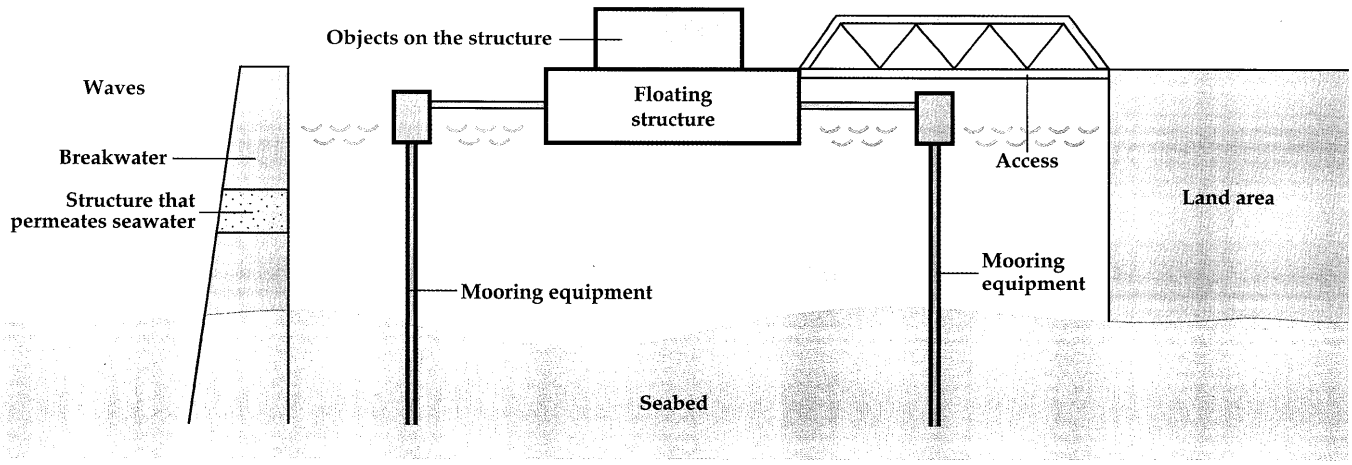


Fig. 1 Main components typically associated with a floating structure

- Quality is more easily assured, because the floating structure can be manufactured in a factory with good quality control system.
- While environmental influence and pollution due to water flow and construction are minimal, other environmental changes may occur beneath the floating structure.
- A floating structure as an artificial platform can be constructed inexpensively although maintenance and upkeep costs must be considered.
- Vibrations and deflections induced by waves and displacement due to load variations will act on a floating structure, even though they may be minimal.
- The floating structure can move vertically with the motion of the sea surface as the tide changes, but its absolute height varies.
- There is a limit to the durability of the structure.

While the term 'floating body' immediately brings the words 'pitch' and 'roll' to mind, the Mega-float will be massive in comparison to the waves that cause pitching and rolling. A more realistic way of imagining the Mega-float is as a ship in very small waves or ripples. It is unlikely, therefore, to pitch and roll to any significant extent. For this reason, the structure is expected to be able to provide a stable base for building facilities offshore instead of on land.

Mega-float research topics

Floating structures are widely used in various types of facilities, such as petroleum storage and oil drilling and production units, floating piers, and so on. However, there is no example of a floating structure constructed as a replacement for facilities on reclaimed land - especially a massive structure spanning several kilometers in length such as the Mega-float. In view of the paucity of data related to such structures, the association decided to use a large experimental model of the floating structure with a length of 300 meters and breadth of 60 meters, formed by joining at sea nine independent floating units (Fig. 2) each measuring 100 meters in length, 20 meters in breadth, and 2 meters in depth, as well as to carry out demonstration tests and research to compensate for the lack of available data. The research topics include not only problems with construction techniques for such a large structure, but also user problems associated with its massive size. The main topics of research are described below.

Floating structure design technology

Calculation techniques that compute the effects of very small deflections are indispensable in the design of the Mega-float, similar to the requirement of accurately calculating very small deflections in huge structures such as high-rise buildings. Precision design techniques will be established by preparing various programs, carrying out model tests in testing tanks and verifying these programs through demonstration tests using large experimental models at the site. Results will be presented as graphic displays (Fig. 3) for easy understanding. External forces, such as the forces of wind and waves, are not applied uniformly on a very large structure but vary depending on the location. Technology for correctly estimating such external forces must also be developed.

Offshore construction technology

The completion of such a massive structure that cannot to be accommodated within a dockyard requires the construction of several independent floating units in a building dock and then later joining them at sea. However, the joining of independent floating units while they are being rocked by waves, no matter how small the motion, requires the establishment of special construction technology that is highly reliable and efficient. For this purpose, demonstration tests were carried out in which independent floating units were joined at sea, and results of the tests were analyzed for establishing rational offshore construction technology.

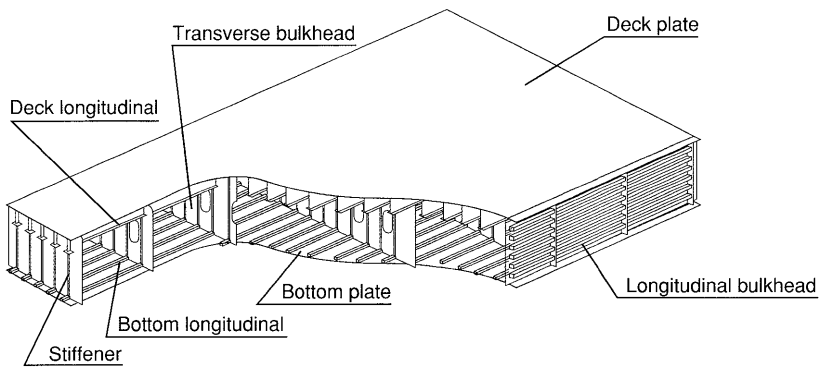
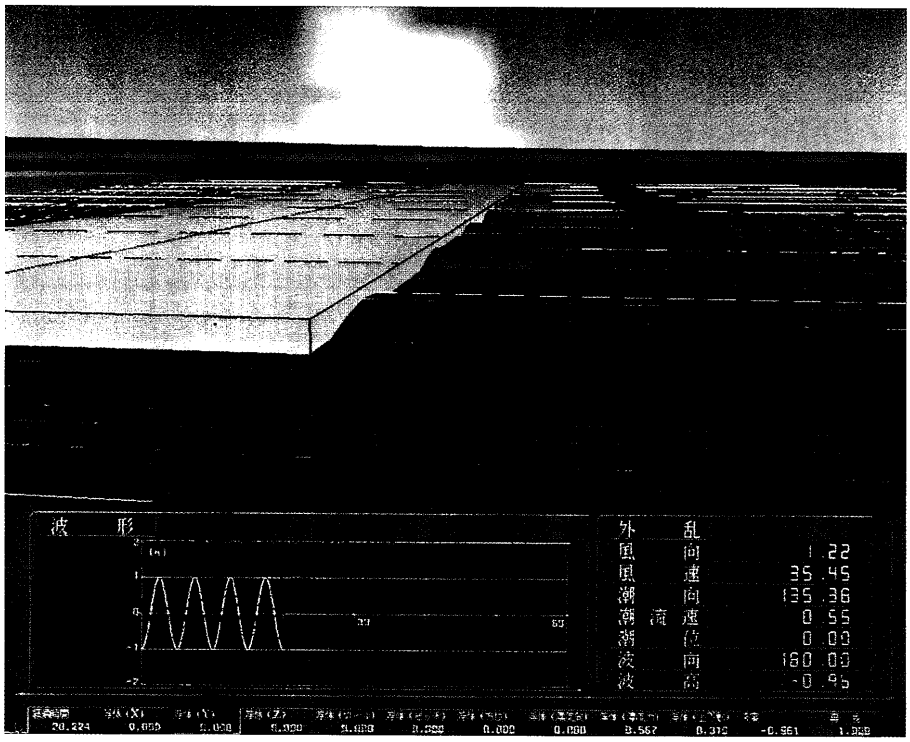


Fig. 2 Cross section of one of the floating units comprising the large experimental model



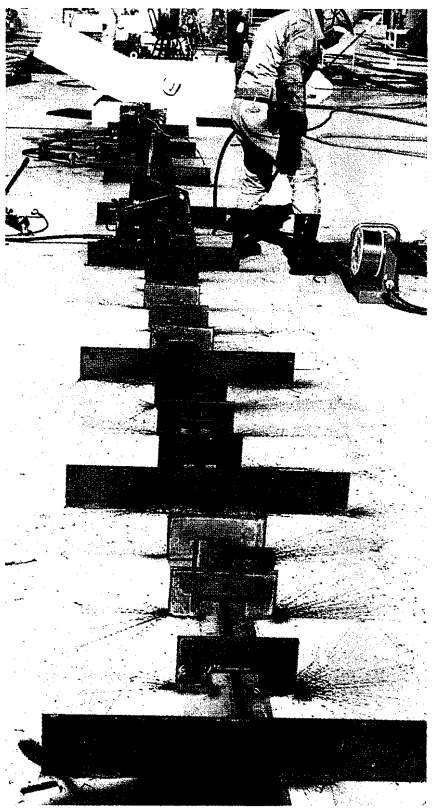
Example of the advanced graphic display program for floating structure design technology

Technology for ensuring long-term durability

Various methods may be considered for durable use of the floating structure over a long period, such as a hundred years. However during the present research work, studies will be carried out related to the application of new materials with semi-permanent corrosion resistance as well as a maintenance control system that integrates monitoring equipment for early detection of the location of damage and repair equipment for repairing damaged parts. These materials and systems will be tested and verified, and the technology for ensuring long-term durability of the structure will be developed as a result.

Technology for ensuring the operational functions of facilities on the floating structure

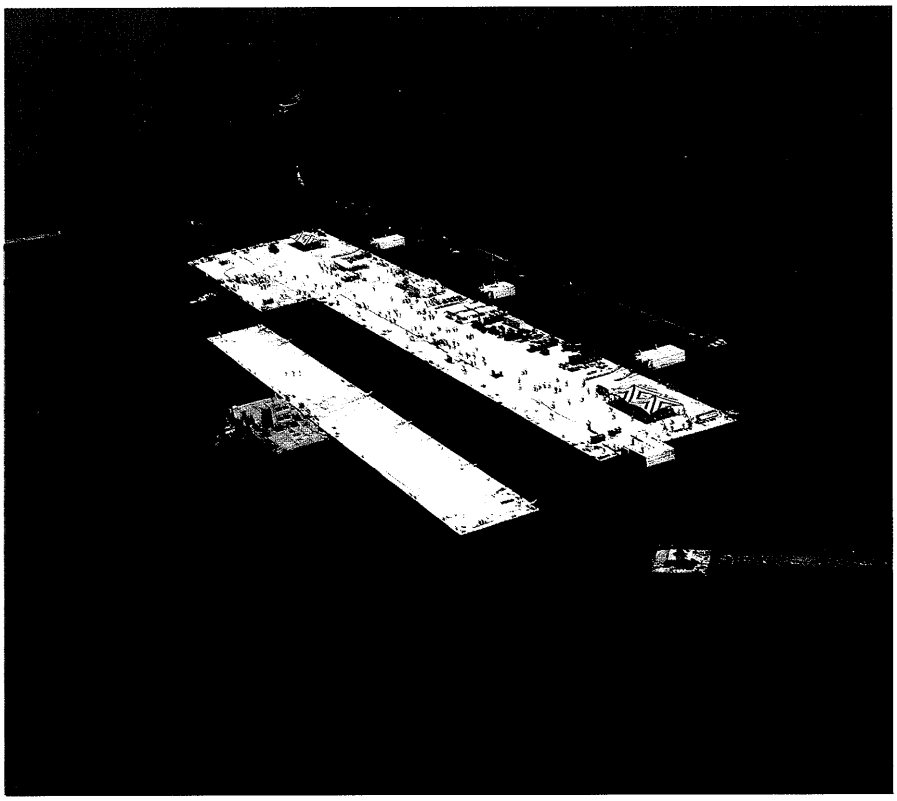
In principle, a variety of facilities could be installed on the Mega-float as an artificial platform and these will be expected to perform the same operational functions as similar facilities on land. It will be necessary to eliminate the adverse effects from very small deflections, vibrations, noise, and temperature in the floating structure. Focusing on specific examples of facilities, the association will develop the technology for ensuring operational functions of the facilities on the Mega-float. This will be done by studying the functions required for these facilities, developing equipment for ensuring these functions, and carrying out demonstration tests of prototypes on the large experimental model.

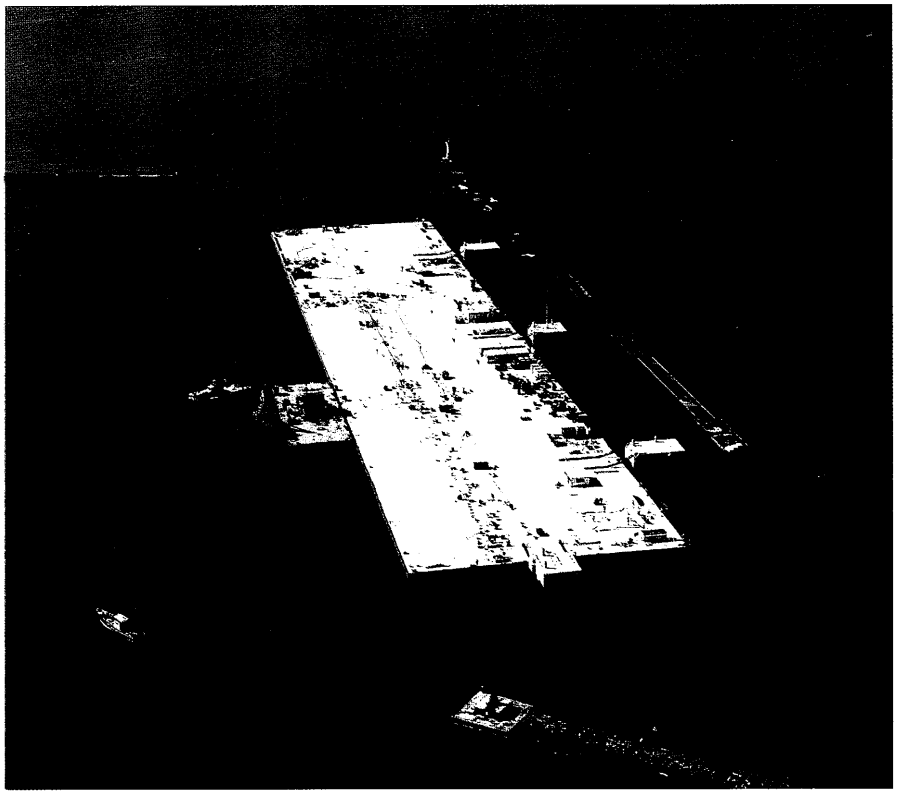

Welding of independent floating units during being rocked by waves

Environmental assessment technology

Floating structures are generally considered to have comparatively little effect on the environment, but this assumption needs to be verified. The absence of adverse effects on the environment in the case of the Mega-float needs to be confirmed to ensure its viability. Techniques for predicting changes in the flow around the floating structure and any impact on the ecosystem will be studied using model tests and large experimental models at the actual site.

The research into floating structure technology spans various engineering disciplines. Guidance and assistance from professionals in various fields is being sought in carrying out this research. The entire research project is scheduled for three years, from 1995 to 1998, and all tests will be carried out at the Yokosuka offshore area in Tokyo Bay.





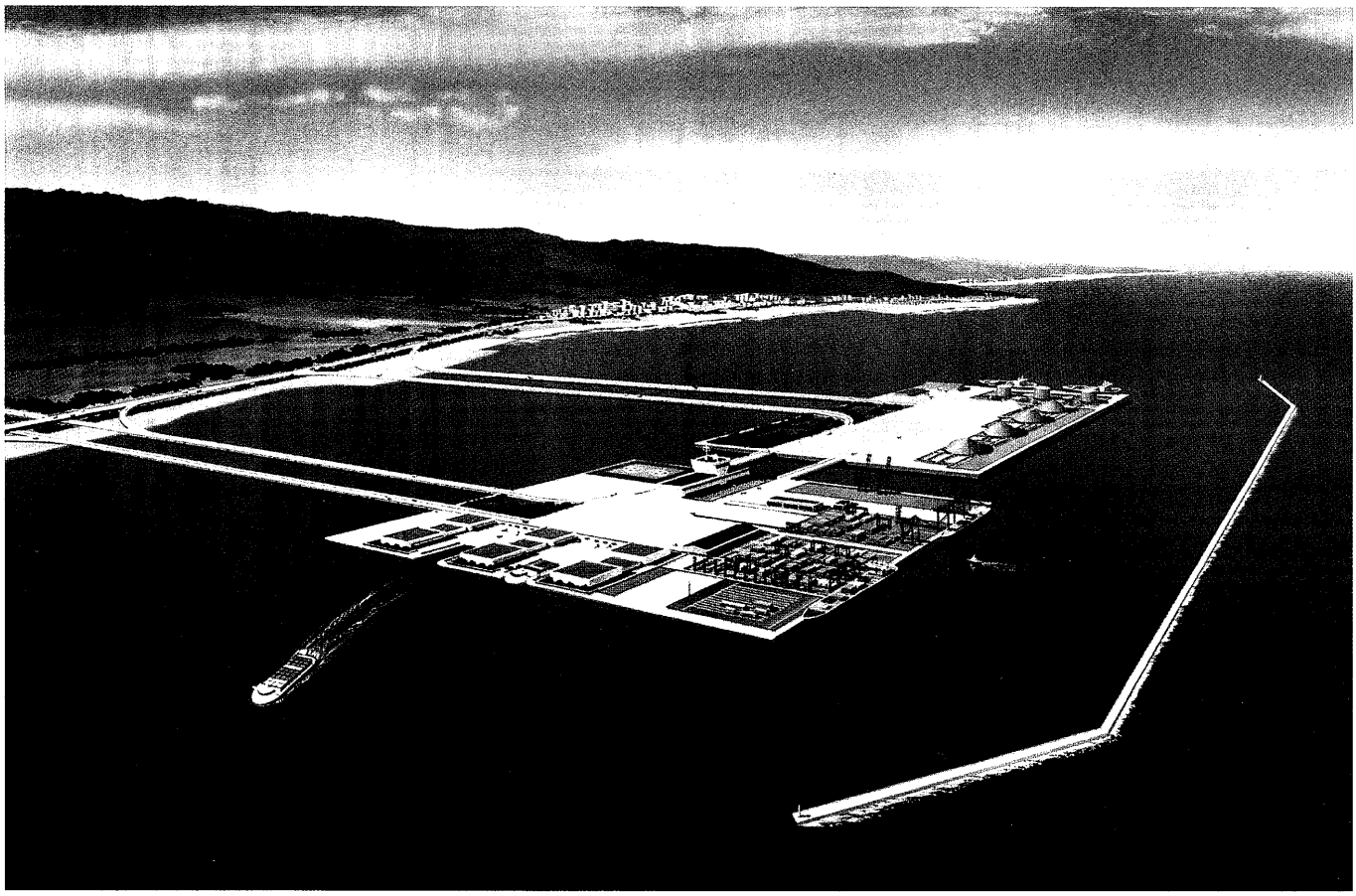
The final demonstration test of the Mega-float showing the test condition for joining units at the site was performed successfully on July 18, 1996. About 550 persons from the press and various maritime related individuals boarded the large experimental model and observed various kinds of experiments. (above) before joining final structural unit (below) joining completed

Status of research and development

Research is progressing in accordance with the scheduled completion date of three years. Roughly half of the three-year period has elapsed at the time of writing. Research on various topics related to construction of experimental models has been completed, and the remaining tests for joining structural units at sea were completed in August 1996. Tests carried out last year confirmed the possibility of joining units in waves as much as 0.5 meters high. This year, research is being carried out to establish other rational joining methods.

Research on topics other than offshore construction technology has also been progressing well. Part of the research has already been successfully concluded, and results from most of the main research topics are expected to have been gathered by the end of this year. Substantive results have not yet been achieved due to the wide range of research topics and the need for numerous verification tests to be carried out, both for ensuring operational functions of facilities on the floating structure and for assessing its environmental impact. Examples of successfully completed research in disciplines other than offshore construction are, however, given below.

- Preparation of a program for calculating general external forces
- Formulation of a theory for elastic response analysis
- Preparation of a program for simplified elastic response analysis
- Preparation of a graphic simulation program
- Preparation of a program for analytical calculations of mooring characteristics
- On-site joining of titan-clad steel members



The Mega-float project has great potential for utilizing ocean spaces. This integrated distribution base is one example of its utilization.

Future developments

Mega-float is a new creative endeavor for the country. Its realization will create new demands in various fields and lead to increased industrial development in the future. Therefore, the swift completion of the project is eagerly anticipated. Mega-floats could be used as bases for various types of facilities in the future. Facilities difficult to construct on land, those which need to be isolated because they generate pollution or noxious substances, facilities which need to be protected from earthquakes, or which can be utilized easily if located in ocean spaces, are just some examples. Fig. 4 illustrates the concept of a Mega-float integrated distribution base. In addition, port facilities, waste treatment facilities, facilities related to fisheries, and sports and leisure facilities are also being considered. We hope that Mega-float will be developed for using ocean spaces in novel ways and will serve as a platform for new social and economic activities in the future.

E. Isobe, Managing Director
Technological Research
Association of Mega-float

The large experimental model of Mega-float was classed by Nippon Kaiji Kyokai in September 1996. ClassNK is participating in the research on "Floating structure design technology," "Offshore construction technology," and "Technology for ensuring long-term durability" as observer and adviser.

ClassNK