Prospect of Mega-Float

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A Very Large Floating Structure (Mega-Float) has been developed as a new method for creating huge artificial floating land on the sea. Technological Research Association of Mega-Float was established in 1995 to perform the demonstrative and confirmation study by installing 300m long experimental pontoon model (Phase-1) and 1,000m long floating airport model (Phase-2) in Yokosuka bay. Using the airport model, flight checks of landing aids and take-off/landing tests are being conducted to prove that airplanes can operate on Mega-float as same as on the land. By completing the corroborative research at the end of March 2001, Mega-Float would be recognized as the best solution to use ocean space.

1. INTRODUCTION

Mega-Float is a new terminology combining a Greek word “Mega” and an English word “Float”, and implies a Very Large Floating Structure. Two structural types exist: one is the semi-submersible type and the other pontoon type. The pontoon-type Mega-Float having simple box-shape, moored in a calm sea area protected by breakwaters has been examined on the sea for the feasibility study. The Mega-Float has many advantages and could be used as an artificial island for an offshore city, a floating airport, or a base for emergency rescue.

Since the Mega-Float is a huge floating structure compared to ordinary ship structures, research and development works require special view points of design, construction, environment, and utilization, etc. Thus, with the cooperation of relevant organizations in the industrial, governmental, and academic sectors, the research and development project has been conducted for six years from 1995. This year corresponds to the final fiscal year, and demonstrative experiments such as airplane take-off/landing tests have been made.

On the other hand, in order to proceed the implementation of the Mega-Float, the committee for the realization of Mega-Float has been organized in the Ministry of Transport, and has actively engaged in various studies from the view points of both technology and law.

2. BASIC CONCEPT OF MEGA-FLOAT

Mega-Float generally consists of a breakwater, the main floating body, a mooring unit, and an access route to land. If the wave condition is not so severe, the breakwater may be omitted. Basically, the vertical loads are supported by buoyancy forces of the floating body, and the horizontal loads are supported by the restoring force of the mooring system. The Mega-Float changes its vertical position
by tide, exhibits relatively small and elastic behavior under external loads such as live load and waves, and undergoes elongation or shortening due to temperature change. Since these effects are considerably different from those of reclaimed island, their influence must be recognized quantitatively. Therefore, the development of basic technologies using a 300m long floating model has been made for three years following 1995 in the Mega-Float project Phase I.

3. DEVELOPMENT OF BASIC TECHNOLOGIES FOR MEGA-FLOAT (Phase I, 1995-1997)

In order to supplement shortage of lands for distribution, transportation, and urban facilities, the need for utilization of offshore areas in deep waters or on a soft seabed had been recognized. The research and development of the Mega-Float that aimed at supplying artificial land was initiated under such social needs. Because of the past insufficient experience assembling such too huge a floating structure to be fabricated in a dock, a Mega-Float model was installed to see if it can be successfully assembled on the sea and to identify the potential problems which would arise during its assembling. The target of the Phase I project was to establish the system technology for the implementation of Mega-Float having a horizontal scale of several kilometers and a service life of more than 100 years. More definitely, the following objectives were set to establish the technology: 1) to design and analyze such an ultra low-profile structure, 2) to construct such a huge pontoon on the sea, 3) to guarantee a lifetime of 100 years, 4) to guarantee functions of facilities on the Mega-Float, and 5) to estimate the environmental impact on such as current and eco-systems.

A model of Mega-Float having a length of 300m, a width of 60m, and a depth of 2m was constructed in Yokosuka bay. The analytical results were verified by the field measurement; on-sea joining technology was successfully developed; the functionality of the facilities on the Mega-Float was checked and verified; and the environmental impact was estimated and verified by the field data. Through the Mega-Float project phase I, each elemental technology has been established.

Fig. 1 Public demonstration of joining operations.


4.1 Construction of the Airport Model

The floating airport model has a length of 1,000m, a varying width from 60 to 121m, and a depth of 3m (a draft of 2m), and is composed of six units which have been joined together on sea by welding. The total area is 8.4ha, the weight is 40,000t, and it is the world's hugest floating structure that has been registered in the Guinness book of records. The strength of the floating structure has been designed for the wave height of 10 years return periods (the significant wave height $H_{1/3}=1.5m$), the airplane
loads equivalent to YS-11 (total weight 23t), and A-class live load for automobiles. Specially, it is designed such that it will never be destroyed by tidal waves (tsunami) and abnormal wave actions corresponding to 100 year return periods. Fig. 2 shows the general plan, and Fig. 3 shows an example of elastic response of the structure.

Fig. 2 General plan of Phase-II floating airport model.

Fig. 3 Deflection of phase-II model subjected to design waves.

Each unit was fabricated from June 1999 at several domestic shipyards such as in Iae bay, towed to the installation site, and then moored to the mooring system. The floating airport model is horizontally restrained by using six mooring facilities located along one longitudinal side, where rubber fenders are installed between the floating body and the mooring systems. The mooring system allows the floating body to move vertically due to tidal changes, whereas it restricts the horizontal motions within several 10 centimeters. Fig. 4 shows the structural details, where the fenders touch the reaction wall supported by the steel jacket structure.

Fig. 4 Jacket fender-type mooring system.
Because the experiment continues for two years, the design return periods have been decided to be 10 years for wind waves, 2 years for design loads during construction stages, and 100 years for abnormal wind waves. The ultimate strength of main structural members have been analyzed using the frame structure model, and the safety has been checked.

The following matters have been carefully considered during its construction: 1) to guarantee the accuracy of sizes of each unit, common gages have been used at plural shipyards; 2) to compensate the unit deformation due to temperature difference between the air and the sea water at the on-sea joining stage; 3) method of joining with the re-used unit of the Phase I Mega-Float model; 4) towing in the open sea of the paved 300m long unit; 5) the rapid construction method for the mooring system, where the mooring beam is dropped down; and 6) method of large amount of rapid pavement works on the sea.

Although the basic developments concerning design and construction of the Mega-Float had been completed at the Phase-I project, verification of the existing programs and modification of the construction procedure have been attempted using the airport model. In order for the verification, atmospheric and oceanographic data such as wind direction, wind speed, wave height at the offshore and near the floating body, air temperature, humidity, atmospheric pressure, sunshine, and ultra-violet rays have been recorded periodically together with structural data such as vertical acceleration of the floating body, strains, slope angle at the base of the PAPI (Precision Approach Path Indicator), slope angle at the GS (Glide Slope), the acceleration at the top of the GS, deformation of the mooring fenders, and the position data of the GPS (Global Positioning System). When the typhoon 3 (July 8, 2000) came very close to the airport model, the lowest atmospheric pressure of 977hPa, the maximum wind speed of 29.7m/s, and the maximum wave height of 1.7m were recorded. At that time, the motion of the floating body was not recognizable in the control room, whereas it was almost impossible to walk on the floating body because of strong winds and rains; this experience would ensure the livability of the Mega-Float.

4.2 Verification test for the ILS (Low-pass test)

The ILS (Instrument Landing System) is a system which guides airplanes to the landing path by using a radio wave, and is equipped at large civilian airports. The ILS is composed of LLZ, which indicates approach direction and GS, which indicates approach angle. In case of a floating airport, it is necessary to verify whether the horizontal motion of the floating body or the elastic deflection due to wave excitation would influence the radio waves from the ILS. A flight checker aircraft was used to check the ILS of the Mega-Float airport model. The flight checks were made for the runway without pavement (with steel deck) and with pavement of 8cm thickness, and the effect of the pavement was examined. The effect of elastic deformation due to wave excitation was also examined.

Table 1 summarizes the flight checks made on the airport model. Through these flight checks, it has been clarified that the ILS works correctly on the Mega-Float.

<table>
<thead>
<tr>
<th>Operator</th>
<th>Type</th>
<th>Times</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ministry of Transport</td>
<td>YS-11</td>
<td>287</td>
<td>Good</td>
</tr>
<tr>
<td>Electronic Navigation R.I.</td>
<td>B-99</td>
<td>16</td>
<td>Good</td>
</tr>
<tr>
<td>National Aerospace</td>
<td>Do-228</td>
<td>14</td>
<td>Good</td>
</tr>
<tr>
<td>Laboratory (NAL)</td>
<td>MU-2000</td>
<td>29</td>
<td>Good</td>
</tr>
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4.3 Take-off/Landing experiment

After removal of the ILS equipments, the take-off/landing experiments were made from the beginning of July until the end of October. This was the first time in the world that an actual aircraft landed on and took off the floating runway except for aircraft carriers. Using 900m runway excluding over-run area at both ends, the take-off/landing experiments were conducted as summarized in Table 2. The objectives of the experiment are to obtain the evaluation by the pilots, to accumulate measurement
data and the experiences for aircraft services. The take-off/landing experiments were made using various planes from a small aircraft like the Islander (2.9t, 9 passengers) to a larger one. A number of take-off/landing experiments were made using many kinds of aircrafts and pilots under different weather conditions, and the influences on instruments of different aircrafts and the control feelings by different pilots were examined.

The new instrumental landing system called FANS using GPS was also demonstrated to work well on the Mega-Float airport model using a B-99 aircraft of the Electronic Navigation R.I. Fig. 8 shows snapshots of the landing test.

5. APPLICATIONS OF MEGA-FLOAT

The range of applications of Mega-Float is wide because the surface can be utilized as an ordinary artificial island and at the same time the inner space can also be utilized. Expected applications include a floating airport, a floating container terminal, and a floating city where its wide area is utilized. It is also suitable for leisure facilities such as a base of leisure fishing, offshore marine park, and a
floating hotel, where its friendliness to water is utilized. Fig. 9 shows the public demonstration of the utilization as an emergency response base.

Fig. 9 Public demonstration of the utilization as an emergency response base.

The efforts for expanding the applicable sea site are also being made. For example the corporation for advanced transport and technology, ministry of transport, has funded the following research themes as new types Mega-Float\cite{5}: 1) Fundamental study of semi-submersible type Mega-Float, 2) Fundamental study of very large floating structure utilizing natural reef sea, 3) Fundamental study of the Eco-Float, 4) Study on Mega-Float with energy absorbing plate-type breakwater, and 5) Study on environmental impact of Mega-Float. These studies aim the practical application of Mega-Float, thus are expected to link their outcomes to actual projects.

A unique proposal has also been made, where several large floating units are linked together by mechanical joints, and they may be separated and towed in case that they have to be used as emergency response bases.\cite{6}

6. FUTURE PROSPECTS\cite{6,7}

Through the five years' demonstrative research work made by Technological Research Association of Mega-Float, it is now widely recognized that the construction of a floating structure having several hundreds hectare is technically possible. In future, it is expected that Mega-Float would be utilized as an artificial land in deep sea or on soft sea-bed, where conventional reclamation is not applicable. Mega-Float is recognized qualitatively that it has several advantages such as availability in deep sea or on soft sea-bed, environmental friendliness, isolation from the earthquake motion, and availability of the utilization of the inner space. For each project, these matters have to be evaluated quantitatively, and such tools are now ready to be available. Those include response analysis program of Mega-Float capable of arbitrary shape of the floating body, arbitrary variable sea-depth, and independent weather/sea conditions of the site.

The target of the Mega-Float development will shift to the improvement for economical construction and maintenance, the reliability, and the preparation of the technical guidelines and the related laws. When the Mega-Float is applied to an actual project, the technologies developed mainly based on shipbuilding technology may have to be modified to fit to each requirement as new technologies keep on developing. When the Mega-Float is utilized for multiple purposes, applied guidelines may not be diversified, and thus the design method of the Mega-Float as the base should be made versatile.
7. CONCLUSIONS

Technological Research Association of Mega-Float has successfully constructed a large scale floating structure as a prototype and made practical researches with the cooperation of Universities, research sections of the government and private companies, and related organizations. Now, the Mega-Float is internationally recognized as an original technology initiated and developed in Japan. It is hoped in the future that Mega-Float is widely applied as a new methodology for supplying infrastructures, at the same time Japan is recognized as a leading nation which proceeds creative technologies.

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REFERENCES