

# Design study of off-shore LMFBR plant

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## 1. INTRODUCTION

Nuclear power plants have been constructed on firm rocks in Japan because of its stability and reliability during earthquakes. However, in the light of the future shortage of prospective rock sites, other siting techniques such as soft rock siting, seismic isolation and off-shore siting have been a matter of concern recently. This study presents a feasibility study on a off-shore LMFBR plant with a special interest on the seismic behavior. Among many different off-shore siting techniques, that of a full-floating platform in a semi-closed basin was selected in the study from the cost and safety point of view.

## 2. CONDITIONS FOR EVALUATION

The plant is a 1,000 MW class FBR. It is assumed that all the facilities except for the spent fuel storage are mounted on the platform. According to the preliminary study, an area of around 140 m x 140 m on the platform is secured as the plant area. Fig. 1 shows the plant general arrangement in the area. The input earthquake ground motion at the bottom of the basin is shown in Fig. 2.

## 3. STRUCTURAL CONCEPT OF THE PLATFORM

Two types of structural concepts are studied. One is a reinforced concrete platform and the other is a steel platform. Fig. 3 shows the reinforced concrete platform. Prestressed lightweight concrete is use for the weight reduction. The outer walls are at the full prestressed status, that is, the outer surface of concrete walls do not allow cracks to open in order to maintain the watertightness of the platform. A consideration is given in the planning so as the tendons permit inspection from the tendon gallery during plant operation.

Structural walls form a grid whose mesh distance is around 15 m. The thickness of the outer walls is 1,200 mm and the inner walls is 600 mm. The height from the bottom to the main deck is 24.5 m. The thickness of the bottom plate is 1.5 m, floor is 0.4 m. Gross weight of the platform is about 360,000 ton including 16,000 ton of ballast. The draft is about 15 m.

Steel platform is also studied based on the same general arrangement of the

plant. The outer dimension of the platform is identical to the reinforced concrete platform except that the height is 23.5 m. Gross weight is 150,000 ton including 8,000 ton of ballast and concrete walls for radiation shielding. As a result, the draft is 6 m in this case.

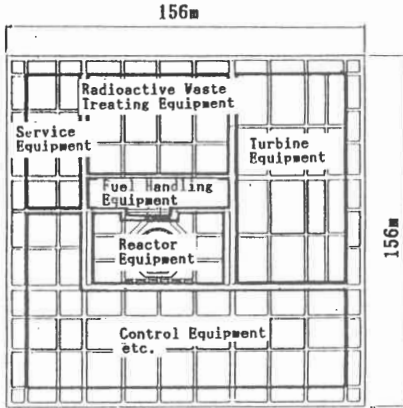


Fig.1 General Arrangement

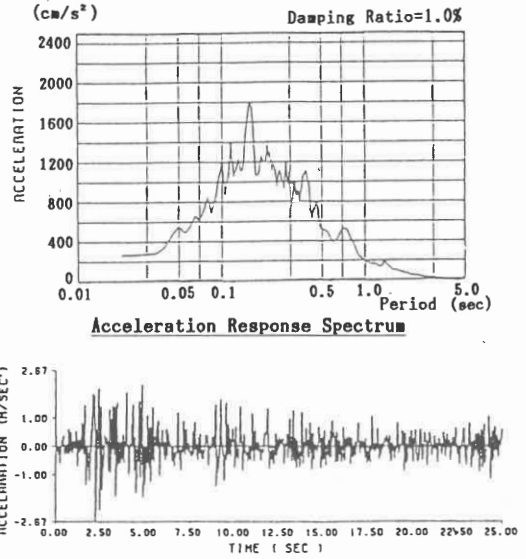


Fig.2 Input Earthquake Motion

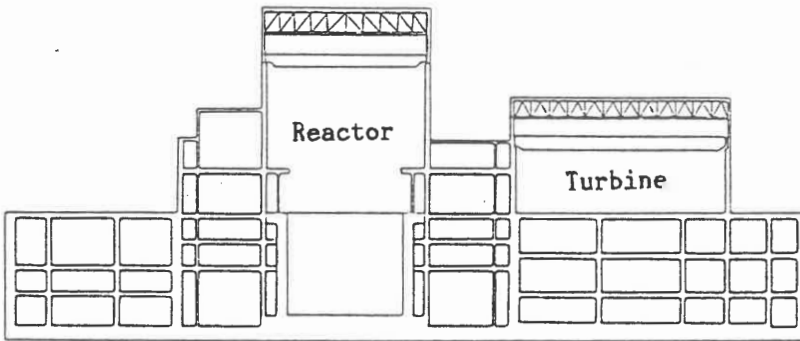


Fig.3 Conception of Floating Platform

#### 4. EIGEN ANALYSIS

First, a parameter study was performed using a relatively simple 2-D analysis model which modelizes the platform as a rigid body, the moor as a linear spring and the basin as a fluid area taking the gravity effects into account. The model is aimed at analysing the vibration of the platform under coupled influences of the elastic moor and the water sloshing. Because the fluid is assumed as an incompressible fluid in the analysis, the results do not stand for the high frequency vibrational characteristics that may be caused by the propagating compression waves due to the water compressibility.

Fig. 4 shows the natural periods for different geometry of the basin and platform without moor. The natural period increases with the increase of the

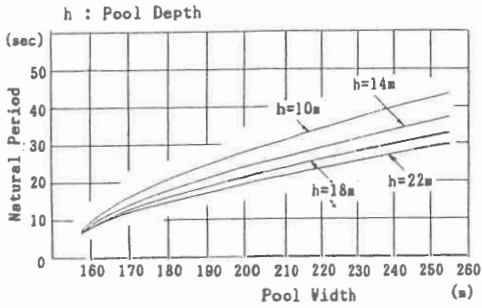


Fig. 4 Natural Period

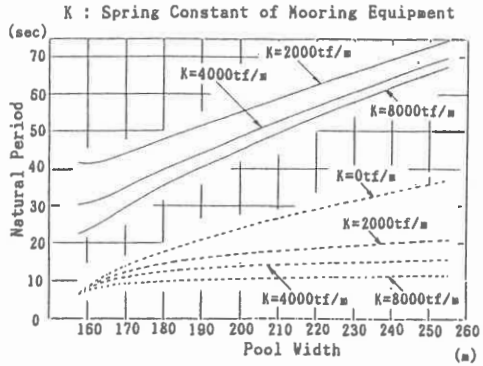


Fig. 5 Natural Period

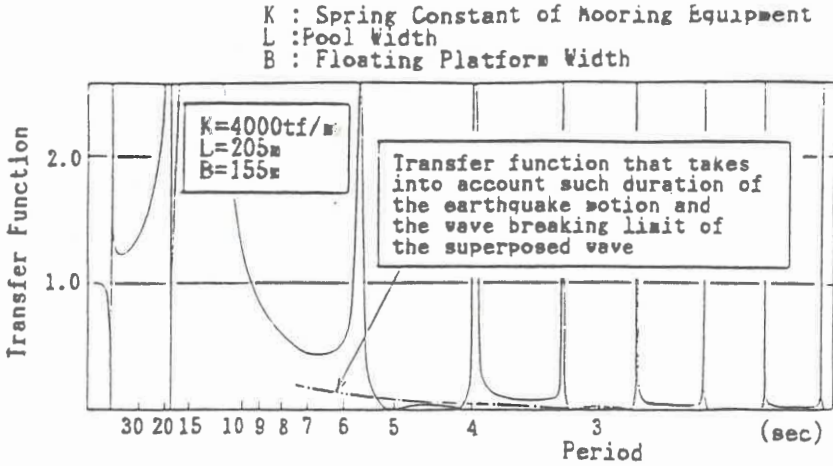


Fig. 6 Transform Function

basin width, and the basin depth from 10 seconds to 40 seconds Fig. 5 shows the natural period as a function of the stiffness of moor and the width of basin. Two natural modes appear in this case. In the first mode, natural period varies from 20 seconds to 70 seconds, sway motion of the platform predominates. In the second mode, natural period varies from 10 seconds to 20 seconds., sloshing of water predominates accompanied by a small sway motion of the platform.

Next, a more sophisticated FEM analysis was performed. As shown in Fig. 6, many natural periods appear not only in a long period range but also in a short period range. The first two natural periods longer than 20 seconds correspond to those obtained by the former simple analysis model. The modes whose natural periods are smaller than 6.0 seconds corresponding to the higher sloshing mode. Because the transfer function is calculated assuming no damping and linearity, the magnification factors at resonant periods become infinity. But in an actual case, the wave height will be limited by the following reason.

The maximum possible waveheight is determined as a function of the wave length and the water depth as follow.

$$H = 0.102 \lambda \operatorname{tanh} \frac{2\pi}{\lambda} h \quad \text{----- (1)}$$

H : wave height  
 $\lambda$  : wave length  
h : water depth

Furthermore, growth of wave height during transient earthquake response may be limited as follow.

Velocity of a propagating surface wave is given as follow.

$$v = \frac{\pi f}{k} \left( 1 + \frac{2kh}{\sinh 2kh} \right) \quad \text{----- (2)}$$

v : wave velocity  
f : frequency of wave  
k :  $\frac{2\pi}{\lambda}$

For example, a wave whose frequency is 0.7 Hz having the velocity of 1.2 m/s needs 10 seconds in order to propagate across the 25 meters distance, so 20 seconds to come to a stationary state of vibration. Taking into account this transient response, the transfer function is moderated (denoted by a dotted line in Fig. 6). Magnification at resonant periods is drastically reduced. The reduction has a tendency to become notable for shorter periods. The components shorter than 1 second are not transmitted actually. But it has to be noted that high frequency vibration energy may be transmitted as a compression wave which is not taken into account in the modelization. This point will be discussed in the earthquake response analysis.

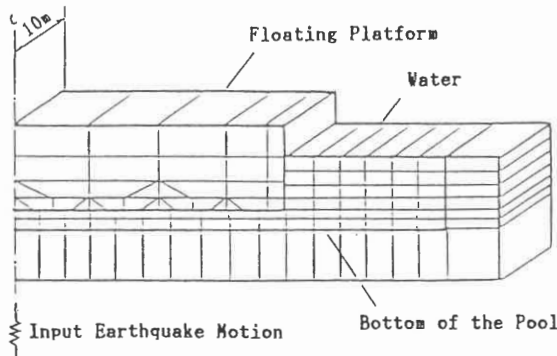


Fig.7 Analytical Model

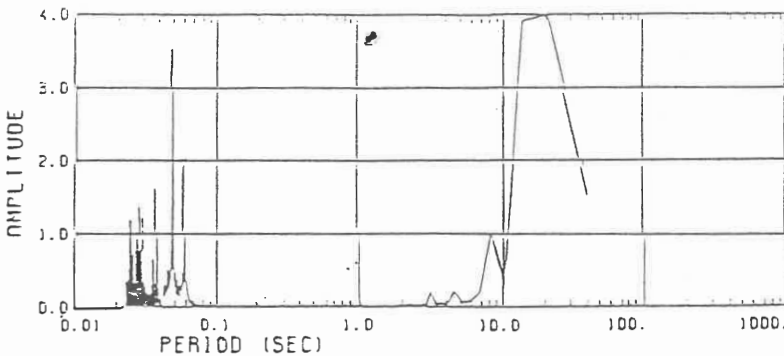


Fig.8 Acceleration Transfer Function