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Hydraulic Mass Calculation of Component Storage Racks in Pool

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1. Introduction

In a research reactor, disposed components are stored in the pool for lifetime of the reactor because of radiation concerns and cost issues. As the research reactor has various facilities for many purposes. As a result, there are various shapes of wasted components, so storage racks are designed and utilized according to these shapes for efficient storage.

The component storage rack is designed as Seismic Category II, and its structural integrity shall be maintained under the seismic load. For the dynamic analysis of the racks submerged in the pool water, hydraulic mass shall be considered. Because they are placed in a frame with narrow gaps, they dynamically affect each other through the pressure field in the fluid.

In this paper, to account for the effect of the fluid, the hydraulic mass is calculated using harmonic analysis with acoustic elements.

2. Methods and Results

2.1 Analysis Model

The racks and frame for the analysis are shown in Fig. 1. 11 racks are closely arranged in a frame. Actually, the fluid surrounding the objects, excluding the objects, is considered, and the size of the fluid volume reflecting the actual pool size and upper platform is used for the analysis. ANSYS is used, and the pool water is modeled with the FLUID220X acoustic element.

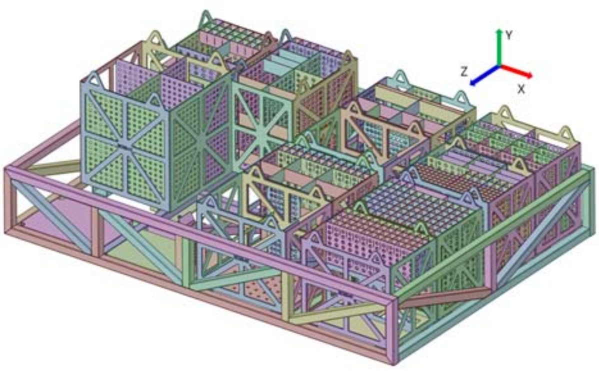

Fig. 1 Component storage racks and support frame

2.2 Harmonic Analysis

The hydraulic mass is affected only by the shape of an object. Therefore, the calculation is possible by reflecting the shape of the object, without structural modeling.

When an object is accelerated, the pressure field which is proportional to the acceleration and interferes with that motion is generated. By dividing the force from the pressure field by the acceleration, the mass is determined and is called hydraulic mass. If the objects are sufficiently close, the pressure distribution is generated on the surface of the other object. Coupled effect between the objects can be calculated by integrating the pressure and determining the hydraulic mass.

In the acoustic harmonic analysis using ANSYS, acoustic velocity is used as an excitation. Since velocity and acceleration have 90-degrees phase difference, the effect of acceleration is reflected by considering a 90-degrees phase shift in velocity. The frame and rack units are assumed to be rigid, and the same acceleration is applied to the entire boundary surface of the object.

In the case of using velocity without a phase shift, equivalent damping coefficient by the fluid can be calculated by the same method.

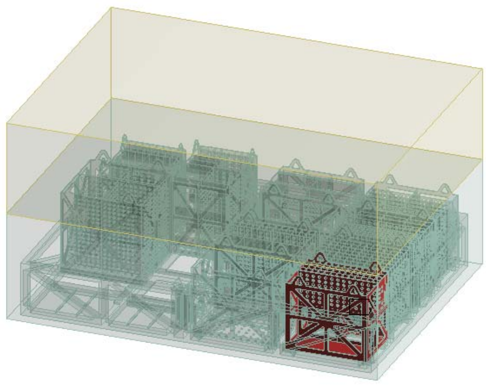

Fig. 2 Acoustic region and acceleration exciting surface for a rack (rack01)

2.3 Center of the hydraulic mass

When an object is symmetrical with respect to a certain plane, the center of the hydraulic mass is said to be in that plane. However, if asymmetry is significant, it should be considered in the analysis. By integrating the pressure on the surface that is in contact with an object, forces and moments can be calculated in specific coordinates. Then, the center of the hydraulic mass is approximately determined by the following equation.

$$min_{\vec{r}}\ :\ norm(\vec{r} \times \vec{F} - \vec{M})$$

2.4 Analysis result

Fig. 3 shows the pressure distribution in the fluid when rack RC01 is accelerated along the Z-axis. High pressure breaks out in the narrow gap between RC01 and RC01. Fig. 4 depicts the hydraulic mass of RC01, RC02, RC03 and RC04, respectively. The closer to the RC01, the larger hydraulic mass occurs. The negative mass means a force in the opposite direction to the acceleration of RC01, caused by the effect of the fluid pressure field.

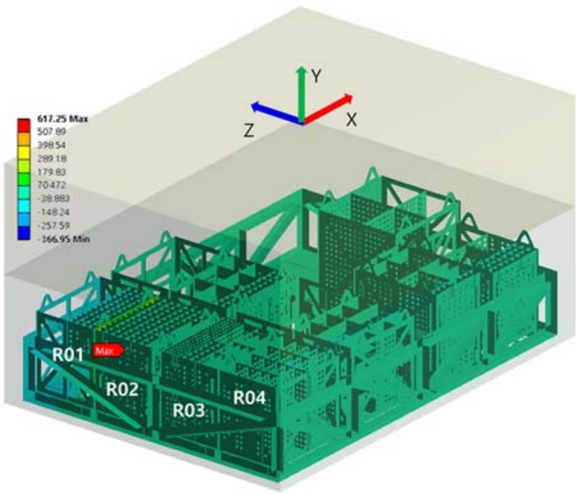

Fig. 3 Pressure distribution

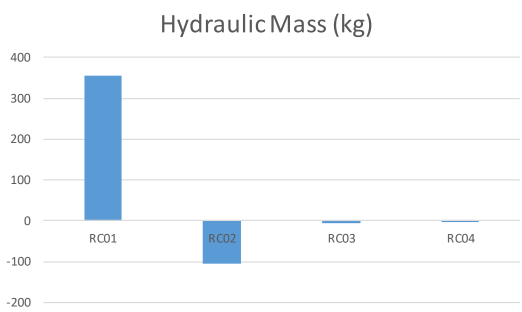

Fig. 4 Hydraulic Mass under R01 excitation

In Fig. 5, the hydraulic mass is compared to the structural mass of the racks and frame. Even though some racks have similar mass values, the hydraulic mass can vary depending on the geometry or whether they have baffles.

And it also shows that the hydraulic mass is large enough to be considered necessary when analyzing objects in a fluid.

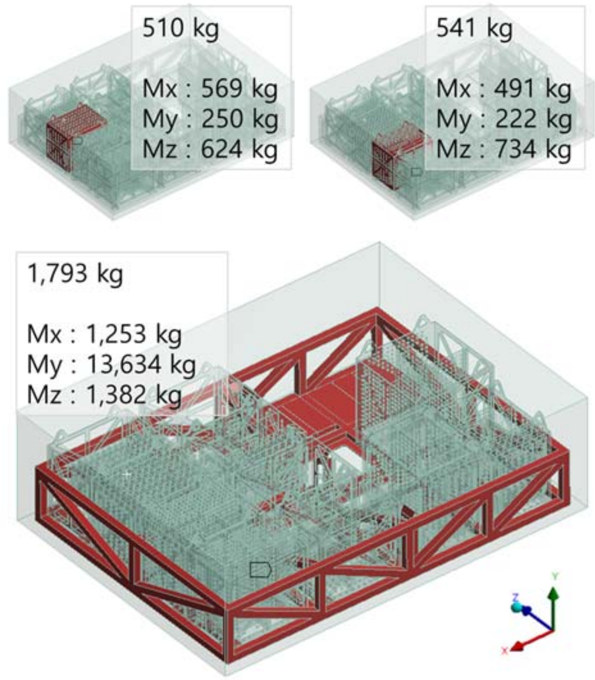

Fig. 5 Structural mass and hydraulic mass

3. Conclusions

In this paper, hydraulic mass of the component racks and frame in the pool is calculated using the harmonic analysis with acoustic elements.

ACKNOWLEDEMENT

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