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PRACTICAL COLLISION ANALYSIS OF FLOATING WAVE POWER GENERATING DEVICE

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Abstract

Through the collision analysis on the typical main member of floating wave power generating device, we calculate the impact energy absorption of the structure in the collision situation. The ship is assumed to collide head to the weakest brace. Conservation of the energy requires that the kinetic energy of the impacting ship is transferred into the elastic deformation energy and the plastic dissipation of energy in ship and platform. The load-displacement curve, including the geometrical and material nonlinearities for a given load, is obtained. The absorbed energy is calculated by integrating the area under the curve in the load-displacement relations. We carried out the collision analysis of the FWPGD based on the FEM analysis

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through the ANSYS LS-DYNA. Comparative study between rigid-plastic method and FEM analysis results were carried out to determine the credibility of the analysis methods. Resulting in the provision of the safe analysis approach guidelines for the floating wave power generating device in collision situations.

1. Introduction

The elastoplastic behavior of the pendulum type floating wave power generating device (FWPGD) on collision with such ship as supply vessel was analyzed. FWPGD was designed by KRISO (Korea Research Institute of Ships and Ocean Engineering) [1-3]. As for the impact loads for collision, DNV rule requirement was used. The impact energy and extent of damage was evaluated using the load-displacement curve of main structural parts based on rigid-plastic theory and the large deformation analysis of FEM system (ANSYS LS-DYNA) [4, 5].

The present study relates to a particular aspect of the collision problem. ANSYS LS-DYNA provides explicit dynamics solutions for the structural problems with complex contact and short duration events with severe loadings.

2. Relevant Structural Analysis by Rigid-plastic Method

2.1. Basis of the analysis

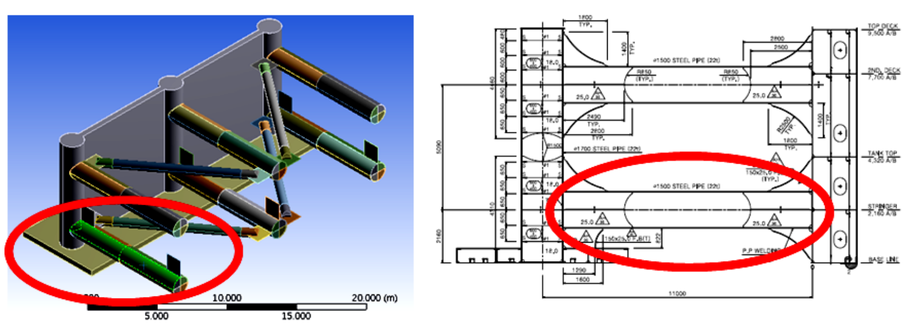

Figure 1. Structural part to be analyzed.

The most thin part of the structure is tubular part whose size are $D = 1.5\text{m}$, $t = 0.022\text{m}$, $L = 11\text{m}$, respectively. The absorbed energy by structural part whose displacement is W caused by the load applied to the center of the member, can be got by integrating area under the load-displacement curve using rigid-plastic method [5, 6].

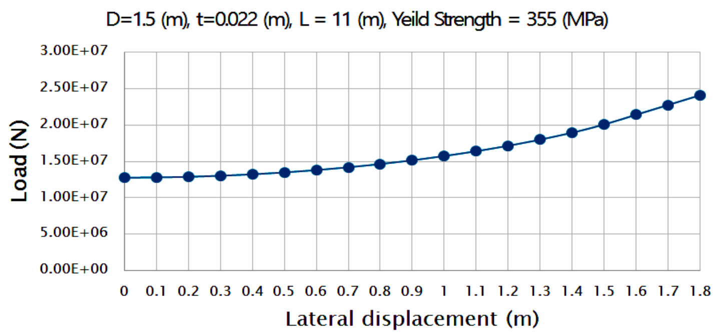

Figure 2. Load-displacement curve by rigid-plastic method.

2.2. Analysis results

The impact energy absorbed by structural part was calculated by increasing W by 0.1m from 0 to 1.8m while t is 0.022m, as shown in Table 1.

Table 1. Impact energy according to various values of W while $t = 0.022\text{m}$

W/D	W(m)	E(MJ)	W/D	W(m)	E(MJ)
0.00	0.0	0.00	**0.67**	**1.0**	**13.8**
0.07	0.1	1.28	0.73	1.1	15.4
0.13	0.2	2.56	0.80	1.2	17.0
0.20	0.3	3.86	0.87	1.3	18.8
0.27	0.4	5.17	0.93	1.4	20.6
0.33	0.5	6.51	1.00	1.5	22.6
0.40	0.6	7.87	1.07	1.6	24.7
0.47	0.7	9.27	1.13	1.7	26.9
0.53	0.8	10.7	1.20	1.8	29.2
0.60	0.9	12.2	1.27	1.9	31.3

From results of Table 1, the displacement W which coincides with the DNV requirement for collision analysis (14MJ for lateral collision) was calculated as follows. It is shown in Figure 3.

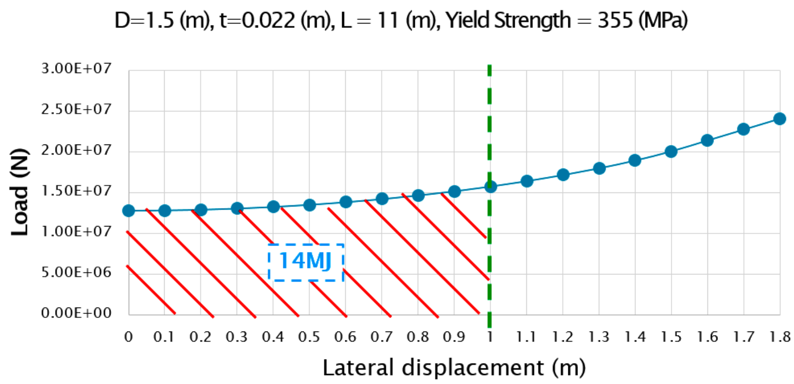

Figure 3. Load-displacement curve by rigid-plastic method.

3. Result of FEM Analysis by ANSYS LS-DYNA

3.1. Loads and material properties

Loads used in rigid-plastic method are also used in FEM analysis [7]. Material used is AH 36 steel and properties are listed in Table 2. Figure 4 shows FEM model used.

Table 2. Material properties

AH 36 Steel	Value
Density	7850Kg/m^3
Young's modulus	2.1E+05MPa
Poisson's ratio	0.3
Yield strength	355MPa
Tangent modulus	1E+03MPa

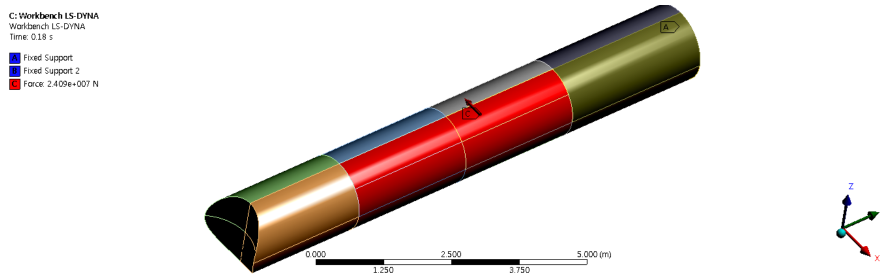

Figure 4. Load and boundary condition of FEM model.

3.2. Analysis result by LS-DYNA (Figure 5)

Table 3. Central deflection

P(N)	W(m)	P(N)	W(m)
P = 1.28E + 07	0.197	P = 1.34E + 07	1.352
P = 1.35E + 07	0.557	P = 1.38E + 07	1.619
P = 1.32E + 07	0.974	P = 2.41E + 07	1.915

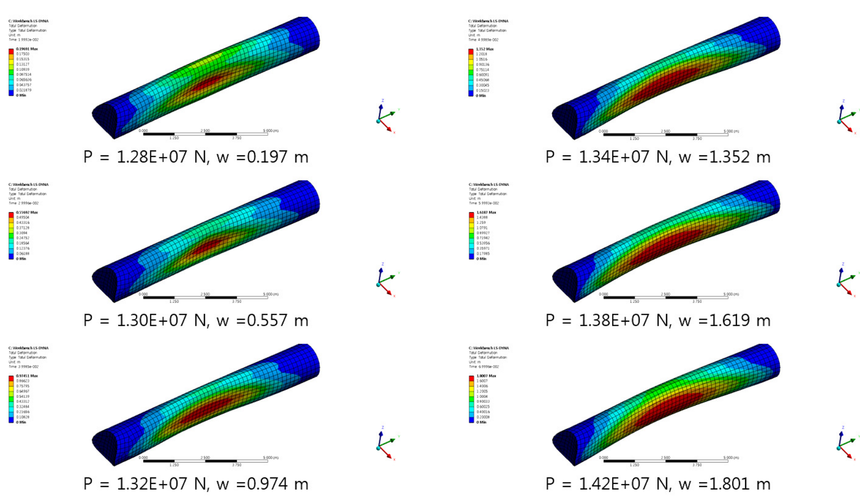

Figure 5. Results by LS-DYNA.

Results of deflections at central part are shown in Table 3 and Figure 5. As load increases, structural collapse occurred locally rather than overall bending of structural part. It might be from the difference between simple beam model and three dimensional FEM model. The amount of absorbed energy was smaller than that of rigid-plastic method as shown in Figure 6.

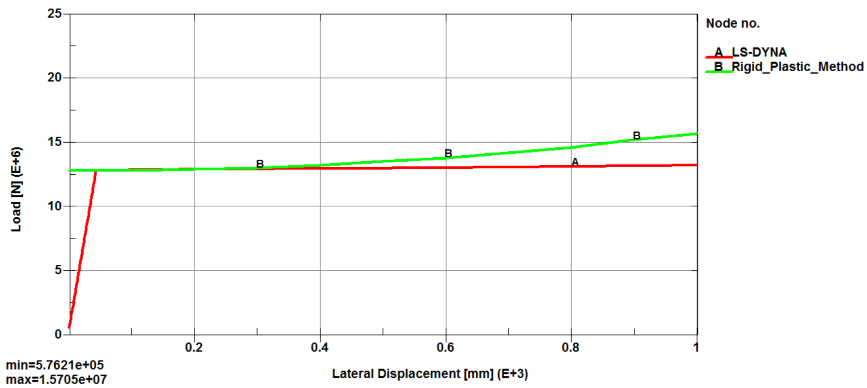

Figure 6. Comparison of result of absorbed energy.

4. Conclusions

Collision analysis was done for FWPGD by rigid-plastic method and ANSYS LS-DYNA system. With a load-displacement graph the amount of absorbed impact energy was calculated and compared with the result of FEM system. We see the rigid-plastic method could be a simple way to estimate the impact energy absorbed during the collision between a FWPGD and a ship. The criterion of 14MJ of Collision energy by DnV classification rule is proved to be satisfied based on the FEM analysis using ANSYS LS-DYNA.

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