Floor Response Evaluation for Building Subjected to Liquid Filled Missile Impact

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1. Introduction

In case of infrastructures such as nuclear power plant subjected to unexpected external load, the interest in the safety of target structure is increased. The car explosion and aircraft impact is one of the categories of unexpected external load. The loss of structural function for target structure by unexpected external load and the failure of equipment inside the target structure due to vibration after impact are highly important. Thus, vibration evaluation of the structure is essential for safety of the structure. Generally, missile-target interaction method and force-time history method are used in the impact analysis.

Missile-target interaction method can obtain the numerical results more than force-time history method, because of considering stiffness, mass and shape etc. of missile. The liquid filled missile, nodal mass missile and force-time history for the missile are used in this analysis. The difference of results for three cases should be obtained using this analysis.

2. Building and Missile Model

2.1 Building

As shown in Fig. 1, a building model was prepared for the purposes of this paper. The plan dimensions are 29.0m × 38.0m and height is 11.7m, divided to two elevations. The height of missile impact is 9.1m from the base in Fig. 1. The finer hexahedral solid element mesh was employed in the impacted side of the building model. The floor and backside of the building had a course mesh. The translations and rotations at the bottom of building ware restrained as shown in Fig. 1. The RHT concrete material model and parameters in this study are described in Table 1. The node point located roof and floor at which acceleration response spectra were computed is indicated.

Table 1.RHT Concrete Materials Properties

Density (g/cm^3)	2.75
Shear Modulus (kPa)	1.67e7
Compressive Strength(kPa)	3.5e4
Tensile Strength	0.1
Shear Strength	0.18

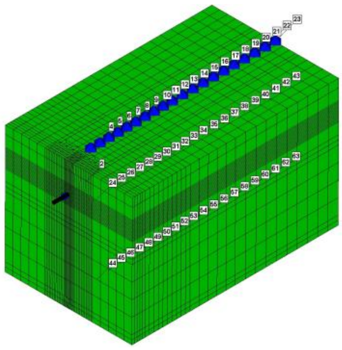


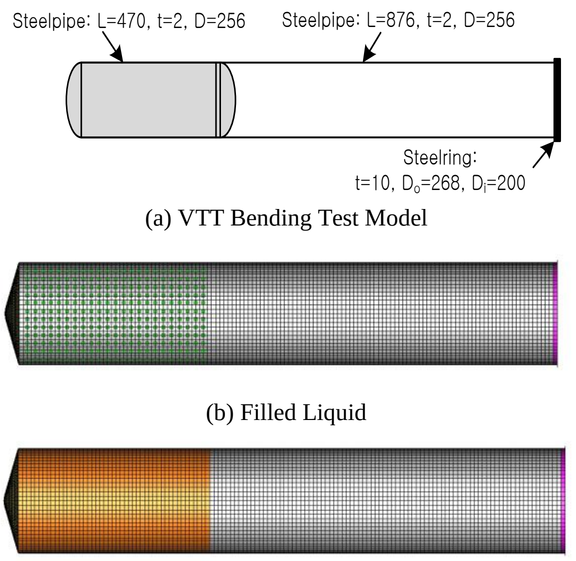
Fig. 1. Auxiliary building finite element model

2.2 Missile

The used missile model in this paper is similar to VTT bending test model [1]. The total mass of missile is about 51kg and the mass of liquid is about 26kg (Fig. 2(a)). The shell elements were employed in the missile. The 2700 particles which are used smooth particle hydrodynamics (SPH) technique were employed in liquid (Fig. 2(b)). To identify the effect for liquid, the mass of liquid was distributed in the shell nodes at the identical location as the liquid (Fig. 2(c)). The initial impact velocity is 111.1m/s. The material properties of missile and liquid are shown in table 2. The liquid behaves as a fluid on the target during the impact. It like hydrodynamic response by using Mie-Gruneisen equation of state (EOS) with negligible strength effects was implemented to liquid model [2].

Table 2.Materials Properties for Missile and Liquid

Johnson-Cook model for missile	
Density (g/cm^3)	7.7
Bulk Modulus(kPa)	1.59e8
Shear Modulus (kPa)	7.7e7
Yield Stress(kPa)	7.92e5
Constant B(kPa)	5.1e5
Constant n	0.26
Constant C	0.014
Shock EOS for liquid	
Gruneisen coefficient	0.28
C1	1.483e3
S1	1.75



(a) VTT Bending Test Model

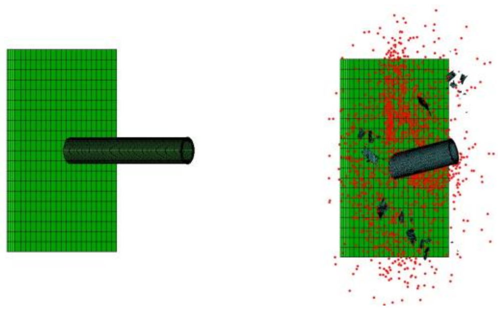
(b) Filled Liquid

(c) Nodal Mass

Fig. 2. Missile model

2.3 Force - Time History Curve for Missile

The rigid target simulation and comparison of force-time histories are shown in Fig. 3 and 4. The liquid spread phenomenon is shown in Fig 3(b). The impact force at used liquid filled missile model (thin blue line) in this analysis is larger than force plate test case [1]. However, the impact force at nodal mass model (orange line) is lower than force plate test case. It is not taken into account the liquid effect. The case of liquid filled missile has an initial peak force, because of shock by the first contact of water and target. The initial peak force should affect the target vibration.



(a) 0ms (b) 10ms

Fig. 3. Rigid target simulation for liquid filled missile

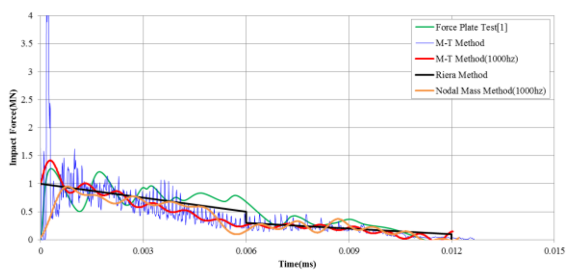


Fig. 4. Comparison of force-time history

3. Numerical Results

The results of acceleration response spectra of node point No. 6 along the impact direction are shown in Fig. 5. In case of liquid filled missile, the acceleration at high frequency is larger than nodal mass missile, because of liquid effect. The results of acceleration response spectra applied damping ratio of node point No. 6 for liquid filled missile are shown in Fig. 6.

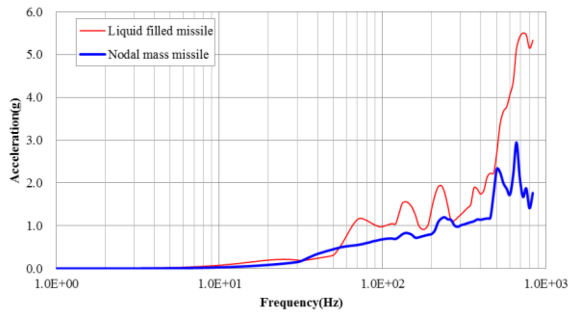


Fig. 5 Acceleration response spectra(ζ =0%) of node point No. 6 along the impact direction

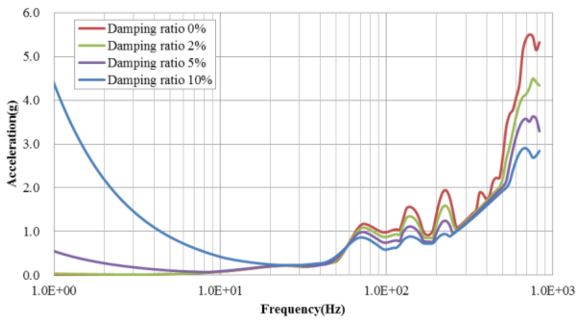


Fig. 6 Acceleration response spectra of node point No. 6 for liquid filled missile

4. Conclusions

The spread phenomenon of liquid in case of modeled liquid should be shown better than nodal mass model. The study for effect of building and inside equipment from high frequency induced by missile impact should be needed.

Acknowledgement

This work was supported by the National Research Foundation of Korea (NRF) grant funded by the Korea government (MSIP) (No. 2012M2A8A4009710)

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[2]Century Dynamics "AUTODYN User's Manual", 2004.