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Preliminary Study of Impact Fragility to RC Wall Subjected to Aircraft Impact

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1. Introduction

International experience has shown that internal and external hazard such as fire, earthquakes, and aircraft impact can be safety significant contributor to the risk in case of infrastructures such as nuclear power plants. Since the aircraft accident to the World Trade Center (WTC) on September 11, 2001, an aircraft impact problem has been increasingly interested and is one of important category of unexpected external hazard field. To date, the aircraft impact analysis has almost focused on the response analysis to the target structures [1, 2, 3, 4]. However, this preliminary study carried out the impact fragility analysis to reinforced concrete (RC) wall subjected to aircraft impact. The aircraft velocity is used to the important variable of this study. The impact analysis of the applied Riera's forcing function is used by Abaqus/Explicit [5].

2. RC Wall Model and Riera's Force-Time History

2.1 RC Wall Model

The liner plate is added on the rear of RC walls. The target walls have rectangular shapes with the same 60m width, 25m height and 1.2m thickness. Also, the concrete wall contains 27,000 hexahedral solid elements. The Fig.1 depicts the double reinforced arrangement of rebars.

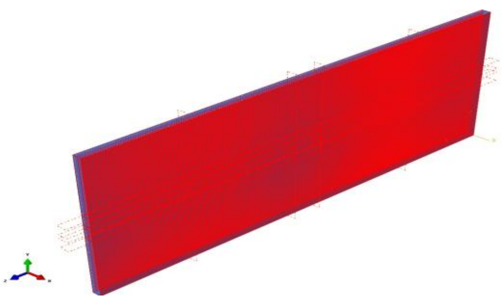

Fig. 1. RC Wall Model

The number of longitudinal bars is 195 and that of lateral ones is 81 using truss elements. They are placed 0.2m inside the front of the wall. And the same number of bars is arrangement 0.1m inside the rear of the wall. The ration of the reinforcement is 0.8 percent. The liner plate is bonded outside the rear of the wall. In addition, the nodes at top, bottom and side face were constrained from movement in all directions. The RC wall has a material properties as shown in Table Ⅰ.

Table Ⅰ: Material Properties of RC Wall

Concrete	Young's Modulus(kgf/cm^2)	310419
	Density(kgf/cm^3)	2.4e-6
	Poisson's Ratio	0.17
Rebar	Young's Modulus(kgf/cm^2)	2038901
	Density(kgf/cm^3)	7.849e-6
	Poisson's Ratio	0.3
Plate	Young's Modulus(kgf/cm^2)	2038901
	Density(kgf/cm^3)	7.849e-6
	Poisson's Ratio	0.3

2.2 Applied Riera's Force-Time History

The aircraft chosen for this numerical analysis is a Boeing 767. The maximum takeoff weight for this model is approximately 200t, which includes the fuel. This aircraft was selected for the reason why the weight of the Boeing 767 envelopes 88 percent of all commercial flight in the United States [6]. The velocity ranges for this analysis assume to be 50~150m/s (180.0~540.0 km/h) as shown in Fig. 2. A selected maximum velocity is 150m/s for the reason why precision flying close to the ground at speeds is extremely difficult [6].

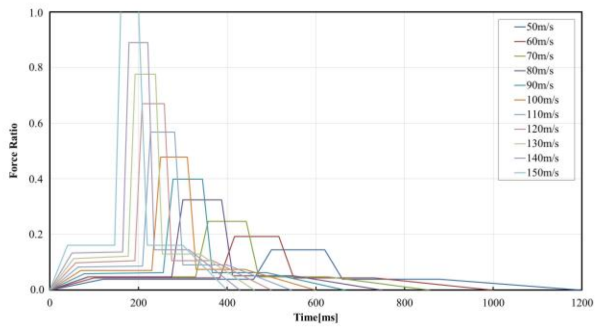

Fig. 2. Riera's Force-Time History according to the Velocity

The Fig. 2 is shown that the load functions are consequently dependent on the initial impact velocity. The velocity decrease shows that the maximum force time according to velocity is appeared later. Also, a maximum force range is gradually broad according to the velocity.

The geometrical properties and dimensions of contact areas are shown in Fig. 3. The contact area of fuselage is 52.43m^2 and an engine area is 8.71 m^2 respectively. All loads of aircraft are assumed that it is applied on the contact area.

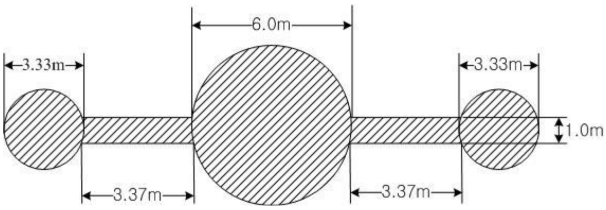

Fig. 3. Geometrical properties and dimensions of contact areas[7]

3. Numerical Results

A maximum strain for liner plate is shown in Fig. 4. The impact fragility depending on aircraft velocity is estimated using the strain result of liner plate.

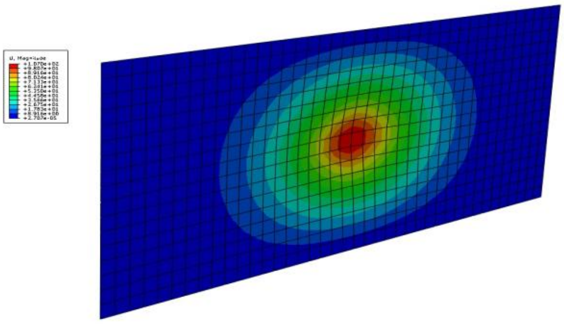

Fig. 4. Deformed Shape for Liner Plate

As shown in Fig. 4, the failure of liner plate is occured at the center of the wall. An maximum displacement and the strain of liner plate at impact velocity of 100m/s is 1.07m, 0.05758 respectively.

4. Fragility Evaluation

Fragility analysis is generally used for assessing to withstand a specified event such as seismic analysis in the nuclear industry. In this paper, fragility analysis is applied to RC wall subject to an aircraft impact. Also, the lognormal cumulative distribution function (CDF) is used in this analysis. The log normal CDF is described by,

$$F_R(x) = \Phi\left[\frac{\ln(x/m_c)}{\beta_c}\right] \qquad (1)$$

in which $F_R(x)$ is the probability of failure for an applied impact load equal to x, $\Phi[\;]$ = standard normal probability integral, m_c = median capacity, and β_c = logarithmic standard deviation. In this study, variations set up a m_c = 0.05 (failure strain of liner plate) and assumed β_c = 0.3.
The median capacity sets up a velocity of 97.2m/s and HCLPF(High Confidence of Low Probability of Failure) value is a 84.66. It is illustrated the fragility curve for liner plate as shown in Fig. 5.

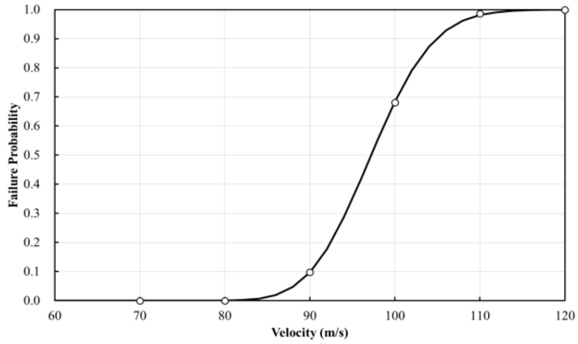

Fig. 5. Fragility Curve for Liner Plate Failure

5. Conclusions

In this paper, a fragility analysis for aircraft impact velocity is performed for the RC wall bonded liner plate. It is not deliberated that the variable impact degree, aircraft mass, and the material properties uncertainty of concrete and steel etc. However, this preliminary study proposes the fragility analysis for aircraft impact velocity. Thus, we will perform the various fragility analyses in the nuclear power plant subjected to aircraft impact.

Acknowledgement

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