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Parametric Study on Important Variables of Aircraft Impact to Prestressed Concrete Containment Vessels

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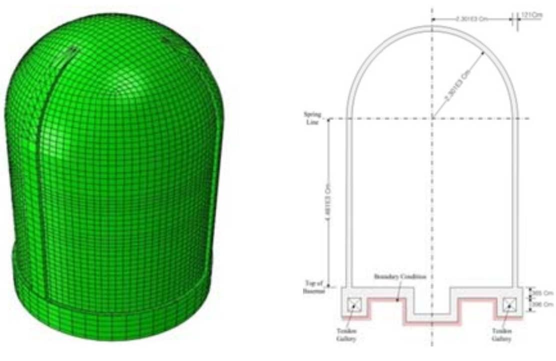
1. Introduction

Research on aircraft impact has grown gradually in a theoretical and experimental way since Riera [1] method was first introduced. Studies on the structure of global and local damage subjected to aircraft impact have been done primarily by many researchers until now [1, 2, 3, 4]. In order to detect the damage of the target structure, Missile-Target Interaction and Riera's Time-History Analysis Method have been used primarily in the aircraft impact field [5, 6, 7]. In this paper, to find the damage parameter, it is necessary to use many analysis cases and the time reduction. Thus, this paper uses a revised version of Riera's [8] method. Using this method, the response has been found a Prestressed Concrete Containments Vessels (PCCVs) subject to impact loading, and the results of the velocity and mass of the important parameters have been analyzed.

2. Prestressed Concrete Containments Vessels and Materials Model

2.1 Prestressed Concrete Containments Vessels Model

The 3-D finite element analysis model and size of the PCCVs are shown in Fig. 1. The wall and basement are modeled by linear tetrahedral elements of type C3D8R. The buttress is modeled by quadratic elements of type C3D10. Also, the tendon is modeled by truss elements, and the solid elements contain the rebar modeled surface elements. The bottom of the PCCVs was constrained from movement in all directions.



(a) (b)
Fig. 1.Containment Structure Model

2.2 Materials Model

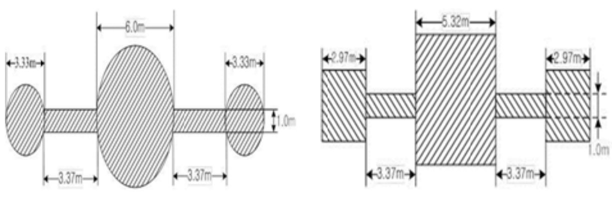
The PCCVs have the material properties shown in Table 1. In order to show the nonlinear behavior of concrete, the concrete material model is defined by using the damaged plasticity model [9]. Also, rebar is modeled as a material compression, and the tension area has the same stress-strain curve.

Table 1. Materials Properties

Concrete Materials Properties		
Young's Modulus (kg/cm^2)	Poisson's Ratio	Density (kg/cm^3)
3.10E5	0.17	2.403E-6
f_{cu} (kg/cm^2)	f_{ct} (kg/cm^2)	
425	42	
Rebar Materials Properties		
Young's Modulus (kg/cm^2)	Poisson's Ratio	Density (kg/cm^3)
2.039E6	0.3	7.849E-6
Yield Stress (kg/cm^2)		
4218.4		
Tendon Materials Properties		
Young's Modulus (kg/cm^2)	Poisson's Ratio	Density (kg/cm^3)
1.968E6	0.3	7.849E-6
Yield Stress (kg/cm^2)		
16873.7		

3. Various Forcing Functions

In this paper, because lots of analyses are needed, it is necessary to simplify the analyses. In order to simplify the analyses, Fig. 2(b) is transformed into Fig. 2(a) [8]. The contact area of the fuselage is 28.30m^2, and the engine area is 8.82m^2.



(a) (b)
Fig. 2. Applied Forcing Function Area

All loads of Fig. 3 and 4 are assumed to be applied on the contact area at Fig. 2(b). As shown in Fig. 3, the load reduction of the maximum impact velocity of 200m/s occurs in approximately 90% compared to minimum velocity 50m/s. Also, as shown in Fig. 4, the load reduction of the maximum fuel 90% occurs in approximately 73% compared to the minimum fuel at 30%.

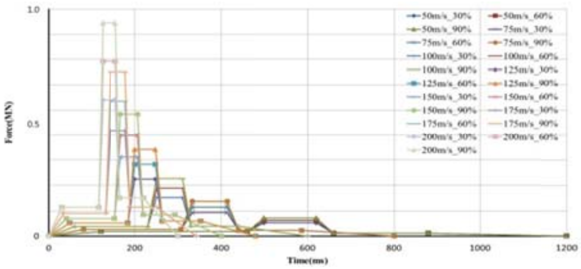


Fig. 3. Forcing Function by Velocity Change

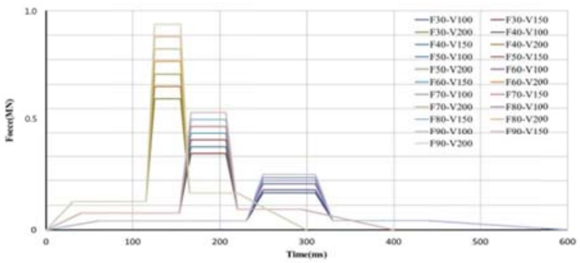


Fig. 4. Forcing Function by Fuel Change

4. Numerical Analysis Results

The center of an aircraft impact position assumes that it is 11.32m away from spring line on the PCCVs in the surface direction. It is also assumed that there is no fall at the aircraft fuselage because of the strength of the PCCVs. Thus, an impact force is continuously applied on the PCCVs.

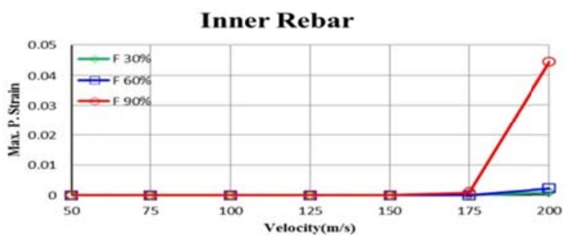


Fig. 5. Max. Plastic Strain depending on the Velocity

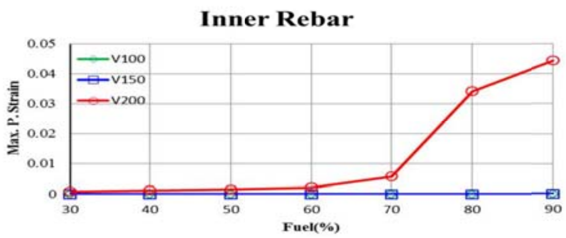


Fig. 6. Max. Plastic Strain depending on the Mass

The results of maximum plastic strain on an inner rebar are shown in Fig. 5 and 6. The maximum plastic strain at the inner rebar is sharply increased at more than V175m/s and F90% in Fig. 5. Also, it is sharply increased at more than F70% and V200m/s in Fig. 6. In the response of the PCCVs, is the impact velocity is more governable than the aircraft fuel, as shown in Fig. 5 and 6.

5. Conclusion

To find the response of the PCCVs subjected to aircraft impact load, it is made that a variable forcing functions depending on the velocity and fuel in this paper. The velocity variation affects more than fuel percentage, and we expect that the severe damage of the PCCVs with the same material properties is subject to aircraft impact load (more than 200m/s and 70%).

Acknowledgement

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