A Safety Analysis of the Polymer Concrete Container in Free Drop

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The development of radioactive waste container to transport safe and store for a long time is a very important problem. The radioactive waste containers that have been developed by this time have generally been made of steel or polyethylene materials. These materials are so expensive and have a weakness of storing for a long time. Consequently, it has been substituted a polymer concrete material by steel and polyethylene to make up for these weaknesses. The radioactive waste container made of steel has been studied in domestic research work[1,2]. The radioactive waste container must be designed to ensure safe under all potential accidents. Especially, under free drop accident, the radioactive waste container must be maintained integrity.

In this paper, a finite element analysis is carried out to evaluate structural safety on free drop condition of two polymer concrete container types using ABAQUS explicit code. Polymer concrete radioactive waste container is consisted of two parts. One is a container body that is similar to cup in shape. The other is a lid. Container body and lid were made of only polymer concrete material. The height and out-diameter of the container body are 1260, 1200 mm respectively. The wall thickness of the container body and the bottom is 50 mm uniformly. The first container type has a typical shape. The modified container has a 50 mm radius round in bottom and lid. The height and diameter of the container lid are 100, 1200 mm respectively. The property test of polymer concrete material was carried out on the Korea Institute of Construction Materials(KICM). Uni-axial tests of polymer concrete such as the compressive, tensile strength, Young's Modulus and Poisson's ratio were accomplished. Three specimens have been tested respectively. Applied material properties for analysis were used a mean value respectively. Generally, compressive strength of the polymer concrete is a greater than tensile strength. As the result of test, compressive strength, tensile strength, Young's Modulus and Poisson's ratio of polymer concrete material were 117.8 MPa(N/mm^2), 14 MPa, 21764 MPa, 0.16 respectively. The compressive strength test is presented in Figure 1 and Young's Modulus and Poisson's ratio test are presented in Figure 2.

Fig. 1 Compressive strength test

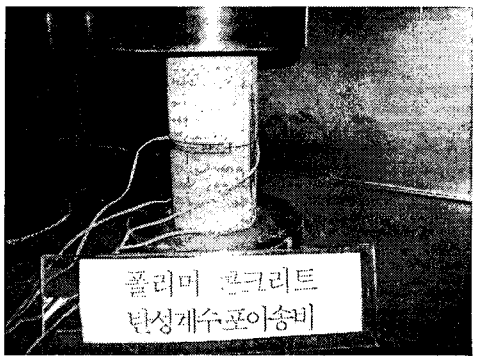

Fig. 2 Young's Modulus and Poisson's ratio

To investigate the structural safety of the polymer concrete container, three hypothetical accident types were considered. These accident types were vertical, horizontal and corner free drop. Applied

distance between ground and bottom of container was 1.2 m. Angle of corner free drop was 45°. Ground was assumed as rigid. Gravity, 9810 mm/sec^2 for free drop, was applied in all of cases. Initial speed of container was 4850 mm/sec too. Two container types were used 1/2 model with the symmetric condition. Contact condition between cylindrical container body and lid was applied tie contact condition. Friction between rigid ground and polymer concrete was neglected.

Principal stresses were compared with uni-axial compressive and tensile strength. In case of corner drop in first container, maximum principal stress of bottom corner of container was greater than uni-axial compressive strength as shown Figure 3. That means failure is occurred in bottom corner of container in this case. Maximum principal stress of modified container in corner drop was larger than uni-axial compressive strength too, as shown Figure 4. But principal stress of modified container analysis was less than principal stress of the first container.

In order to evaluate structural safety of two polymer concrete container types in cases of vertical, horizontal, corner free drop, a finite element analysis was carried out using ABAQUS explicit dynamic code. Principal stresses were investigated to interpret the fracture of container. Maximum positive principal stress and minimum negative principal stress were compared with tensile strength and compressive strength respectively. The first and modified polymer concrete container is fractured in corner and horizontal drop cases not vertical drop. That means two container type designs are not ensured structural integrity under hypothetical drop accident. So this polymer concrete radioactive waste container must be reinforced with reinforcement material or shock absorber.

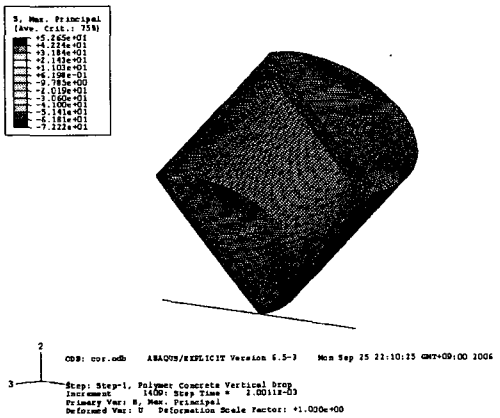

Fig. 3 Max. principal stress distribution of the polymer concrete container in corner drop.

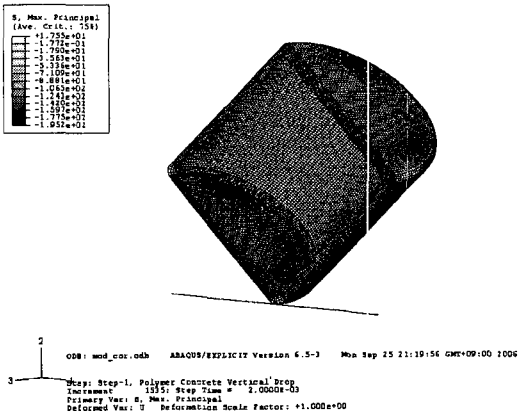

Fig. 4 Max. principal stress distribution of the modified polymer concrete container in corner drop

References

1. Dong Hak Kim, Ki Seog Seo, Joo Chan Lee, Ki Jeong Jeong, Byeong Il Choi, Yeon Do Lee, Heong Young Lee, "Evaluation of Overturn Analysis of Spent Fuel Storage Container", Proceedings of the Korean Radioactive Waste Society Spring 2005, pp. 385-386, 2005.
2. Dong Hak Kim, Ki Seog Seo, Chen Hyeong Jo, Kyoung Ho Lee, Byeong Il Choi, "Experimental Test of the Overturn Accident of Storage Container", Proceedings of the 2006 Korean Society of Pressure Vessel and Piping Conference, pp. 726-735, 2006.