Sensitivity analysis to evaluate misalignment effect of drop angle in the drop test of IP-2 type metallic container

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1. Introduction

In this study, the misalignment effect of drop angle in a drop test on a IP-2 metal rectangular container is evaluated. For the purpose of verifying the similarity theory of the drop impact, a bottom vertical drop test was performed on the IP-2 type metal rectangular container, and inconsistencies in verifying the similarity were analyzed through a computational drop analysis. The analysis results will be utilized to re-establish test conditions for verification of the similarity theory of the IP-2 metal container.

2. Drop Test of the IP-2 metal rectangular container

This chapter describes the drop test for the IP-2 type metal rectangular container. Figure 1 shows test models of the IP-2 metal container and simulant of the concrete waste foam as a content to be loaded in the container. A scale-down container having a scale ratio of 1/2 was produced, and weight of an original scale container is approx. 16 tons and weight of the scale-own container is approx. 2 tons. This test model aims to verify the similarity theory of the drop impact of the metal rectangular container with a decommissioned concrete waste as its contents, and it is planned to perform a comparison of the 1/2 and 1/4 scale-down containers.

Fig. 1. IP-2 metal rectangular container and simulant of the concrete waste foam

The 0.3m drop test which corresponds to the normal transport condition of the IP-2 type container [1] was performed as shown in Fig. 2, and strain gages were attached as shown in Fig. 3 to examine the behavior of the container. The strain results in this study are shown by filtering with a cut-off frequency of 300 Hz.

Fig. 2. Drop test of the IP-2 metal rectangular container

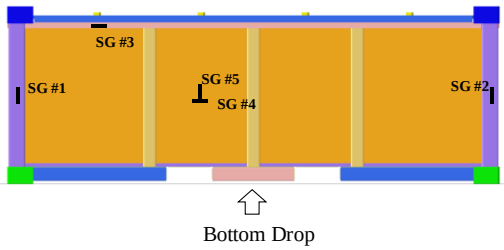

Fig. 3. Positions of strain gages attached on the test model

Since the strain gages SG # 01 and SG # 02 are attached at symmetrical positions, these two strain results should ideally exhibit the same response in the vertical drop. However, as shown in Fig. 4, it can be seen that the two strain results have very large differences in reaction time and peak value. One of the reason of these differences is the misalignment of the drop angle between the target and the container. This misalignment is caused by uncertainties from measuring the angle and length and producing the container. This uncertainty in the drop angle strongly leads to inaccuracy in the verification of the similarity theory of the drop impact for the 1/2 and 1/4 scale-down containers.

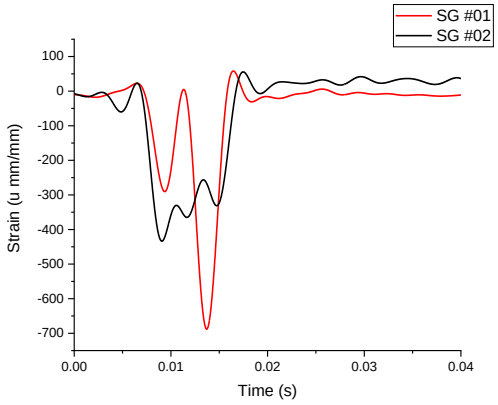

Fig. 4. Strain results of the drop test

3. Sensitivity analysis to evaluate the misalignment effect in the drop angle

In order to analyze the experimental factors causing these inconsistencies in the drop test of the IP-2 metal container, a sensitivity analysis is performed with respect to the misalignment of drop angle using a computational drop analysis. LS-DYNA was used for

the computational analysis, and the finite element model for the drop analysis is shown in Fig. 5.

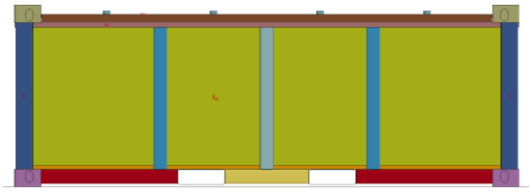

Fig. 5. FE model for the drop analysis of the IP-2 container

Figure 6 shows the strain results obtained through the test and the analysis. In the analysis, SG # 01 and SG # 02 ideally shows the same behavior, and the strain result of the analysis in SG #02 shows the underestimation compared to the test.

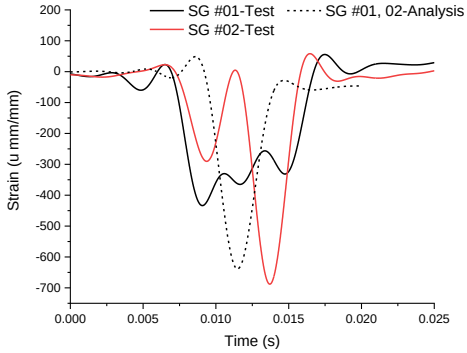

Fig. 6. Strain results of the drop test and analysis in the bottom vertical drop

In order to analyze the effect of the misalignment of the drop angle, the drop analysis with misalignment angle 0.5° was performed. The analysis results are as shown in Fig. 7, and it can be found that the analysis results having the misalignment angle show similar behavior to the test. For this reason, it can be seen that the inconsistencies between the two strain gages shown in the test is due to the misalignment of the drop angle.

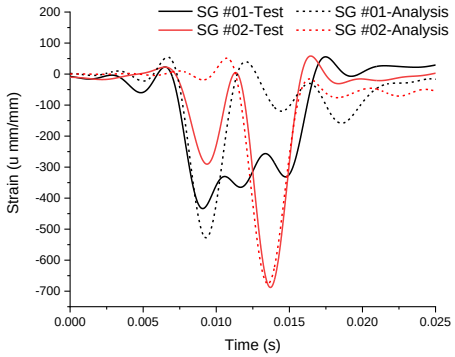

Fig. 7. Strain results of the drop test and analysis with misalignment angle 0.5° in the bottom vertical drop

Figure 8 shows the result of an oblique drop with drop angle of 5°, and it can be seen that in the oblique drop, the effect of the misalignment angle is significantly reduced. Table 1 shows the sensitivity of the strain with respect to the misalignment angle in the vertical and oblique drop. Through these results of the sensitivity analysis, it can be seen that the oblique drop is significantly less affected by the misalignment of the drop angle. Therefore, in this study, in order to verify the similarity of the drop impact of the metal square container having the decommissioned concrete waste as its contents, the drop test will be conducted with an oblique drop orientation. Furthermore, in order to statistically evaluate the uncertainty of the misaligned drop angle, the repetitive drop tests should be required.

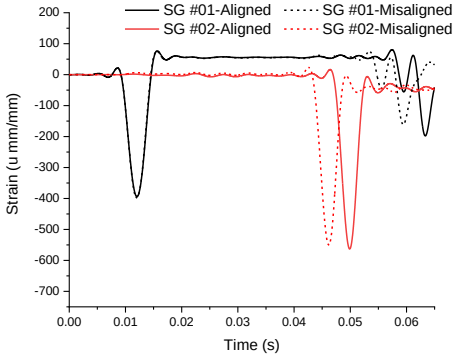

Fig. 8. Strain results of the drop analysis with and without misalignment angle 0.5° in the oblique drop

Table 1: Sensitivity of strain with respect to misalignment angle (unit: umm/mm/°)

	Bottom vertical	Oblique
SG #01	255.3	9.3
SG #02	98.1	23.2

3. Conclusions

In order to evaluate the effect of the misaligned drop angle, the sensitivity analysis using the computational drop analysis is performed. It is found that the oblique drop is more robust with respect to the misaligned drop angle while the misalignment of drop angle significantly affects the behavior of the metal container in the vertical drop. In the future work, these results of the sensitivity analysis will be utilized to establish test conditions for verification of the similarity theory of the drop impact of the IP-2 type metallic container.

ACKNOWLEDGMENTS

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REFERENCES

[1] Korea NSSC Notice No. 2019-7, Regulations for the Packaging and Transportation of Radioactive Materials, 2019