COMPARISON OF DROP TEST RESULTS AND FINITE ELEMENT ANALYSIS PREDICTIONS FOR A DROPPED WASTE CONTAINER – EXTENDED ABSTRACT

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SUMMARY

INS Innovation Ltd has designed a concept waste container. Several containers were manufactured and subjected to drop tests. Work done by ABS Consulting compares the drop test results with Finite Element (FE) predictions. The purpose of this comparison is to develop a validated FE model for assessing the impact behaviour as the design evolves from concept through prototype to a production model.

An ANSYS/LS-DYNA FE model of the container was developed which has sufficient detail to capture all the significant geometric features of the container. Pre-test predictions of the structural response of the container were made for the three drop test orientations and a rigid, smooth target was assumed.

The container was dropped from a height of 10.5m in three impact attitudes and the main measurements taken were deceleration and deformation. The drop tests were filmed using high speed cameras and the deceleration of the containers measured by accelerometers. The deformations were measured by referencing a grid of punch marks at each corner of the container.

Post test, the FE model was updated to take account of the main differences between the test conditions and those analysed. Subsequently the model gave reasonable predictions of the magnitude and periodicity of the measured decelerations although the peak decelerations are under predicted. The model tends to overestimate the impact displacements but gives close agreement when strain rate effects are taken into account, and can be used with confidence for future predictive analyses.

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1: Pre Test Finite Element Model

The design requirement of the waste container is to withstand a drop from 10.5m onto a flat rigid target without loss of containment. The container is a fabricated stainless steel double walled structure with an aperture width of 1365 mm and a lid secured by 28 M20 bolts. A notable design feature of the container is the internal RHS support frame. This has two functions: it provides a load path for the containers when stacked, and provides internal strength to minimise incursion of the twist lock blocks in lid end impacts.

Three drop attitudes were analysed, namely i) Side, ii) Edge and iii) Corner. For the purposes of this abstract only case ii) is presented. Post-processing of the model gave pre-test predictions for knock back, deceleration, deformation pattern and number of bolt failures, for comparison against the test results.

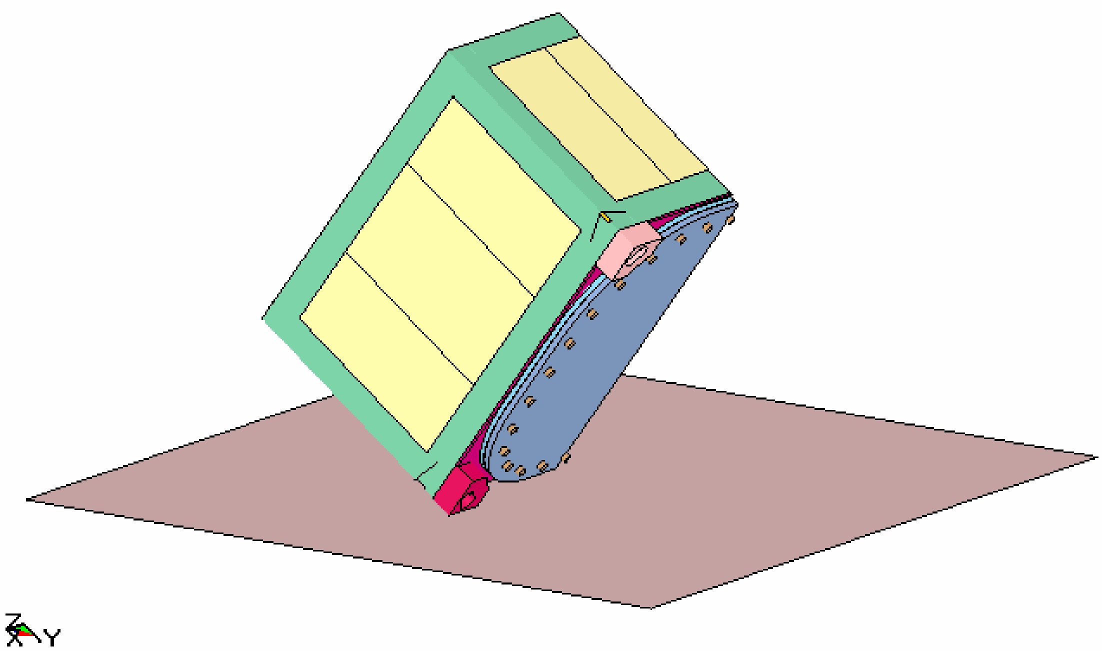

Figure 1: **Finite Element Model of the Container in a Centre of Gravity over Lid Edge Orientation.**

2: Comparison with Test Results.

The measured deceleration traces were overlaid on the pre-test FE analysis traces. This showed that the periodicity and general trend of the measured and predicted curves compares well, however the peak values of deceleration tend to be higher in the test data.

Deformation is localised to the two twist lock blocks and supporting square hollow section. Visually, deformation in the region of the twist lock blocks compared very well (Figure 2), with the general modes of deformation captured. However, metrology of the container showed that the measured knock back was approximately 45% less than the predicted knock. Both the FE analysis and test results showed no bolt failures.

Figure 2: **Comparison of Knock-back Between Finite Element Prediction and Test.**

3: Post Test Finite Element Model.

The FE model has both structural and material idealisations. For example the box walls are modelled as shell elements and the stress strain curve of the box steel is assumed to be bilinear.

Following the drop tests the material properties were updated as measured material properties became available. The model was also adjusted to reflect the precise impact angles realised in the tests.

With these changes the predicted knock-back was still excessive and caused attendant deformation of the SHS. Incorporating strain rate effects into the FE model reduced the amount of deformation giving a predicted knock-back of 29 mm compared to a measured value of 25 mm. The Cowper Symonds strain rate enhancement law was used:

$$\sigma_D = \sigma_o \left(1 + \acute{\varepsilon}/P\right)^{1/D}$$

Where $\acute{\varepsilon}$ is strain rate

In conclusion, the rotation of the twist lock causes the SHS to deform, inducing a larger knock-back prediction than measured. Simulating strain rate effects in the model minimised this rotation/bending and improved the agreement.

4: Conclusion

Analysis of a dropped container is unlikely to realise exact agreement between prediction and test, generally results within 25% of one another are considered acceptable. The success criteria for the FE analysis is that the results are shown to be realistic based on the following criteria;

- Agreement on knock back and distribution of impact damage.
- Reasonable agreement on peak deceleration and impact duration.
- An accelerometer ‘signature’ which resembles that measured.
- Number of bolt failures correctly predicted

In general, the modes and distribution of deformation for all three load cases analysed show good correlation. This adds confidence to the modelling approach and endorses the mesh size, material models, element selection and contact definitions.