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DROP TESTS AND DYNAMIC FINITE ELEMENT ANALYSES OF STEEL SHEET CONTAINERS FOR FINAL DISPOSAL OF RADIOACTIVE WASTE

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The use of steel sheet containers is planned for final disposal of non-heat generating radioactive waste in the German Konrad repository. Until now the mechanical safety of the container designs has been proved by drop tests with prototype containers according to the Waste Acceptance Requirements [1]. Alternatively, the safety assessment by calculation is also allowed, if the calculations are suitable and sufficiently verified e.g. by comparison with experimental results. However, reliable numerical simulations of drop tests with steel sheet containers for safety assessment purposes currently do not exist. Therefore, a research project was started in order to develop a realistic finite element (FE) model and explicit calculation procedure for steel sheet containers under dynamic loads.

This paper presents the development of a FE model for the largest steel sheet container Type V with outer dimensions of 3.2 m x 2.0 m x 1.7 m for the Konrad repository, Figure 1. Flat bottom drop tests as well as the drop with the long bottom edge onto an essentially unyielding target are discussed. With glance at the dynamic nature of the impact problem including large plastic deformation and many contacts, the drop tests are simulated using the explicit FE code LS-DYNA. The FE model of the container includes all relevant structural parts (side walls, columns, lid, bolts, etc.). The mesh consists of shell elements for the thin-walled components and solid elements for the rest of the structure. Bolts are modelled by solid elements and are prestressed during a dynamic relaxation phase prior to the explicit analysis. Modelling of realistic bolt behaviour depends on the contact between the bolts and the clamped parts. The transition from shell elements to solid elements is of special interest as well as the modelling of welding seams. Steel sheets are heavily folded in some regions of the model during the impact event. Suitable numerical contact types and parameters are discussed. Additionally, the mesh sensitivity was investigated under consideration of the many structural parts of the model. Material parameters were taken from literature or material tests.

The results of the numerical calculations are validated with experimental results. It could be shown that the developed FE model is suitable to describe the mechanical behaviour of the box-shaped steel sheet container during the short primary impact of the drop as well as the rebound with free bending vibrations of the container walls. In addition to standard strain and acceleration measurements, the whole container shape has been measured before and after the

drop tests using the optical 3D-measurement fringes projection method. It was combined with close range photogrammetry to get the digital all-around surface shape with high precision despite the rather large volume, Figure 2. Furthermore, a stereo photogrammetry approach has been applied in a high-speed camera configuration to investigate the three-dimensional kinematic rigid body decelerations and dynamic deformation of the container and its structural parts, respectively, Figure 3.
Based on this good agreement of the FE model, it is planned to investigate more complex drop scenarios including possible damage or failure of container components. For container safety assessment, an accurate mechanical simulation allows the prediction of container loads and a comparison of different load cases to determine unfavourable, most damaging drop scenarios within future safety assessment procedures.

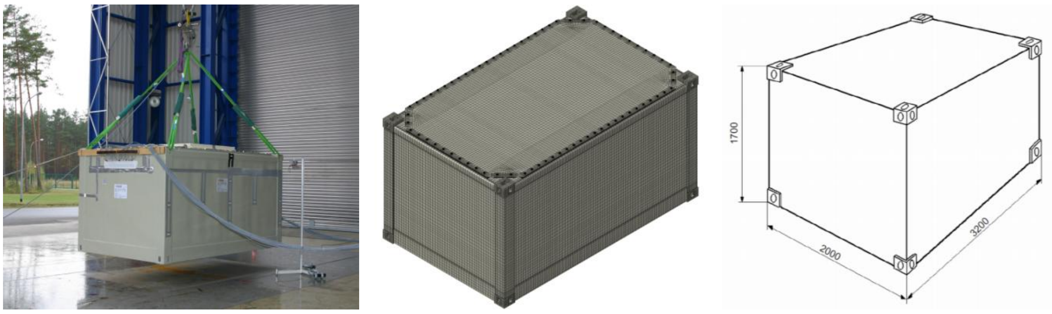

Figure 1. Steel sheet container Konrad Type V: Test object (left), Finite Element model (middle), outer dimensions (right)

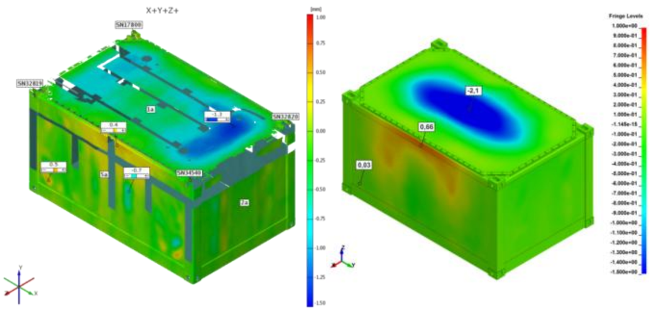

Figure 2. 3D deformation anlysis after 0.4 m flat bottom drop test: Surface digitisation of the test object (left) and FE simulation results (right)

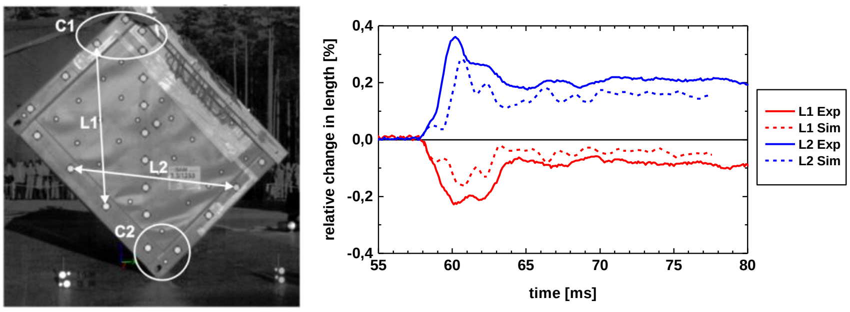

Figure 3. Dynamic deformation analysis during the 5m-drop on the long bottom edge, comparison between simulation and experiment

REFERENCES

[1] Brennecke, P. (Ed.): Requirements on radioactive waste for disposal (Waste Acceptance Requirements as of October 2010) - Konrad Repository (in German), Report SE-IB-29/08-REV-1, Federal Office for Radiation Protection, Salzgitter, 2011