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LOW-MEDIUM LEVEL RADIOACTIVE SOLID WASTE CASK DROP ANALYSIS AND TEST

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ABSTRACT

Objective: To understand the effectiveness of finite element analysis in verification of the mechanical property of nuclear power plant equipments. The cask was designed to ship low-medium level radioactive solid waste of nuclear power plant. The China standard EJ1076-1998 demanded to maintain the cask integrity after the drop test. Methods: A simulation of drop process used nonlinear Finite element code MARC was carried out . And a drop test of the cask was done afterwards. Results: The drop test showed: the corner of the container was destroyed and the seal of the container was destroyed. The finite element analysis got the same results as the drop test. The results of analysis were instrumental in the success of the drop tests. And these results also had been validated by the drop test. Conclusion: The nonlinear finite element analysis can effectively predict the mechanical property of the cask drop process. This paper described the process of FEA, and compared the analysis results with the test results.

Keywords: low-medium level, solid waste, drop test, drop analysis.

1. SCOPE

The low-medium level radioactive solid waste cask that complied with EJ1076-1998 requirements was being designed to transport solid waste of nuclear power plant. According to EJ1076-1998, a drop test was required for the cask. The standard requirements included hypothetical accident involving a free drop from 0.6 meters onto an unyielding surface. One of the requirements for the cask was to demonstrate it must maintain the integrity after being dropped from 0.6 meters onto an unyielding surface. To meet these requirements, the solid waste must be maintained when dropped in the orientation most likely to cause failure. Before the drop test, we did analysis with nonlinear FEA code MARC, computing the stress and deformation. The propose of the analysis was to guide and revise the design, help to arrange the strain gauge, by study the stress distribution of the cask, when it dropped in different postures. We found the corner of the cask destroyed, cask cover lost sealed. The results of analysis instructed in the success of the drop tests. And these results had been validated by drop test. This paper described the process of FEA, and compared the analysis results with the test.

2. INTRODUCE

The cask was a steel box. The corner of cask was mounted reinforced angle steel. The door on the upper of cask provided access to the solid waste. The door was latched with 24 fasteners at the top of the cask.

The main parameter of the cask:

Overall size: 2500mm×1900mm×1100mm
Net weight: 1200kg (Empty Condition)
Total weight (including content): 10000kg (include solid waste)

The distance of free falling: 0.6m

The material of cask was Q235.The material of girder, columniation and corner parts were Q345.

3. ANALYSIS METHOD

The drop analysis used the nonlinear FEA software of MARC, simulated the dropping process. This was a nonlinear problem including contact, material nonlinear and large deformation. We did the transient dynamic analysis, the step time was 0.00001seconds, and the sum time was 0.04 seconds, the sum steps were 4000.

Our hypothesis, the weight of solid waste in the cask was the maximal rated load. By demanded, the cask must be dropped at three kinds of orientations that were most damaging to it. Such orientations include horizontal, vertical and the top corner inclined drop onto an unyielding surface. As defined in Figure 1.

4. ANALYSIS MODEL

In the mechanic analysis, the primary step was constructing the numerical model. The model included shell elements for the wall，beam elements for the stiffeners and solid elements for the solid waste, which were shown in figure 2. According to the property of the cask, 683 nodes and 912 elements were used to model the cask. The solid waste's yang's module was used according to soil, and density and volume were calculated according to the practical weight.

The drop and impact processes were nonlinear contact-impact problems. In the contact-impact processes, the cask was deformable, and the ground was rigid. The analysis used NewMark-β direct integration approach. Time interval was 0.00001 seconds. The convergence criterion was absolute displacement. And damping was specified as Rayleigh damping. These parameters and methods were determined by numerous trial calculations.

5. ANALYSIS RESULTS

The equivalent stress distribution shows: the walls, top cover and bottom plane were not destroyed under the three postures. When the cask inclined dropped and impacted on the ground with the corner, the corner largely deformed, the seal of the container might be destroyed.

The maximum equivalent stress of the cask parts show inTable 1 (UNIT: MPa).

	Top cover	Bottom plant	Corner parts
Horizontal drop		120	345.8
Vertical drop	150	150	Local yield
Inclined drop	200	<15	Large-scale yield

The stress distribution of inclined drop show in figure 3.

6. COMPARISON OF THE RESULTS OF ANALYSIS AND TEST

The results of inclined drop analysis showed: the corner parts local largely deformed and the stress was large-scale yield. The stress of the girder and columniation that connected to the corner parts reached to 180MPa，but did not exceed the allowed stress. The stress of top cover did not exceed the yield stress, but in the impact process, the cover largely deformed, the seal of the container might be destroyed. The test results validated the analysis prediction.

The results of inclined drop test showed: the walls, the girder and columniation were not large deformation by eyeballing，and the contacted corner parts were destroyed as brittle fracture. Some bolts of fasteners at the top of the cask were broke off and dropped out. The solid waste leaked out.

7. CONCLUSIONS

Through compared the finite element analysis results with the drop test results, the finite element analysis showed coincidence results with the drop test. Therefore, carrying out the impact analysis of cask by nonlinear finite element method，can effectively simulate the impact process. And in this study, the results from the finite element analysis guide the layout of strain gauge of the test. Accordingly, we need to pay more attention to the finite element analysis. It can help us to make the design more reasonably and economically.

REFERENCES

1. MSC, Dynamic analysis with MARC, 1998.5.

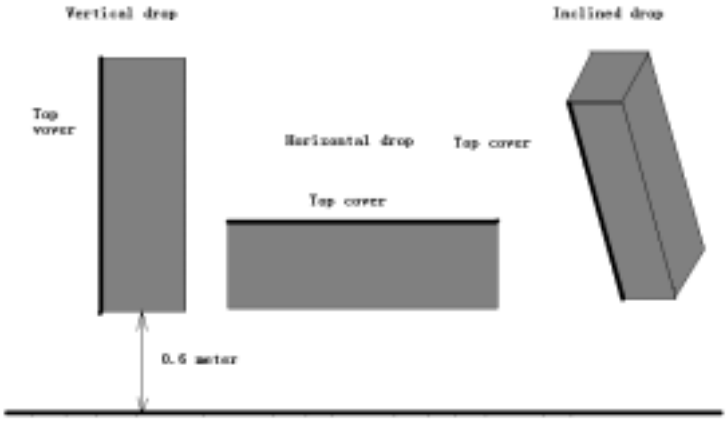

Fig. 1

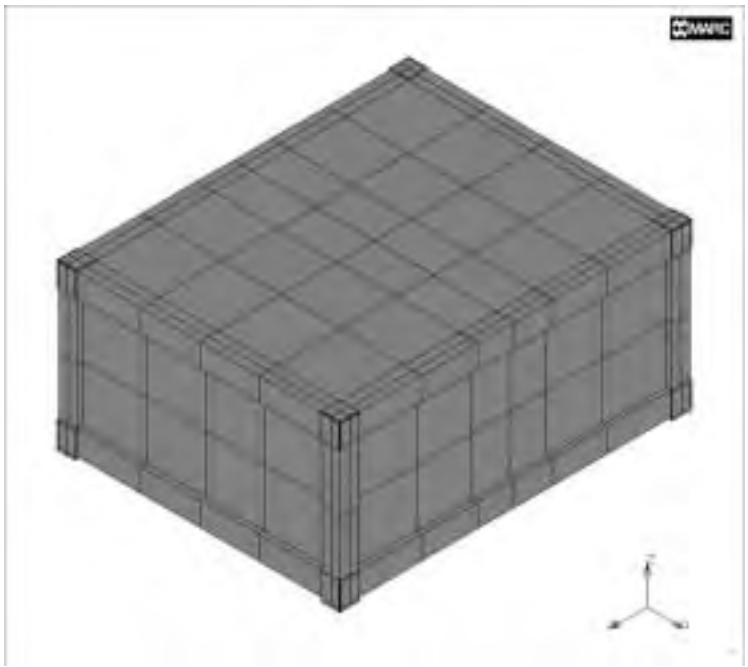

Fig. 2

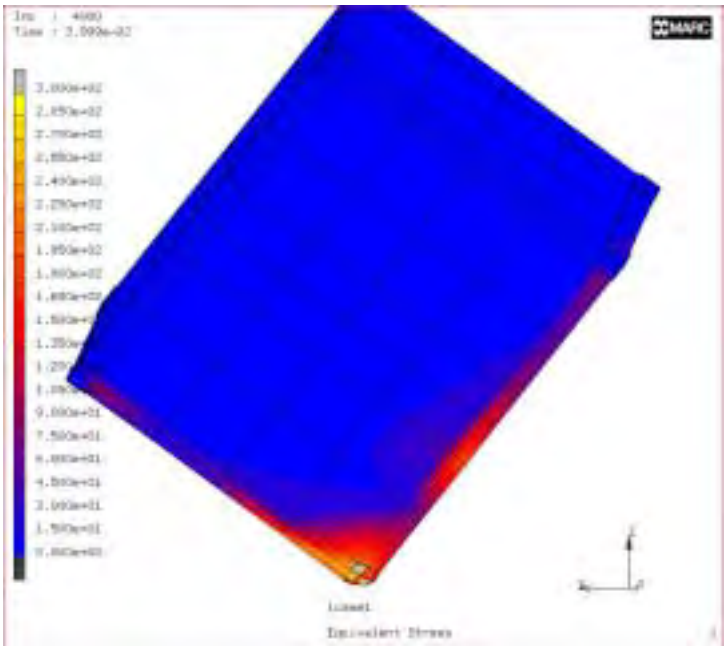

Fig. 3