15 m Drop Analysis for Spent Nuclear Fuel Transport Cask

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1. Introduction

It is expected that when the spent nuclear fuel cask is transported at a nuclear power plant, a dropping accident can occur at a height of fifteen meters without the impact limiter which are beyond the regulatory hypothetical accident conditions.

Therefore, in this study, transient impact structural analysis model simulating one-third scaled cask is dropped into concrete at a height of fifteen meters without the impact limiter is developed and analyzed.

2. Analysis Model

In the present transient impact analysis model, the cask has an initial vertical velocity of 17.16 m/s, which is the speed at the time of collision to the concrete floor to simulate the dropping from the 15 m height to the concrete floor.

The developed overall analysis model is shown in Fig. 1. The concrete and cask are also modeled as finite elements.

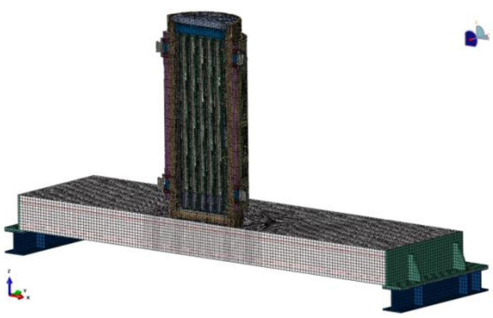

Fig. 1. Overall analysis model.

Inside the cask, there is a fuel assembly model including surrogate fuel rods as shown in the Fig. 1. The fuel assembly model consists of top nozzle, middle grid, bottom nozzle, three surrogate fuel rods and five guide tubes. Since this model is a one-third model, additional mass is added to the top of the fuel rod to apply appropriate impact load on fuel rods.

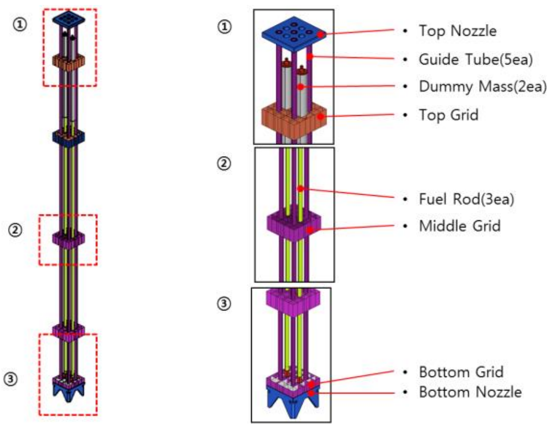

Fig. 2. Analysis model for fuel assembly.

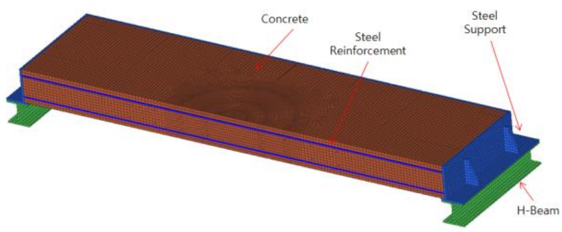

Fig. 3. Analysis model for concrete and support structures.

The concrete has a reinforced structure and supported by steel support at two ends as shown in Fig. 3.

3. Analysis Results

The energy diagram is shown in Fig. 4. Maximum displacement occurred at 0.175 sec after collision with minimum kinetic energy. The displacement at that time is shown in Fig. 5. As shown in the figure, it is observed that the concrete is deflected approximately 140 mm.

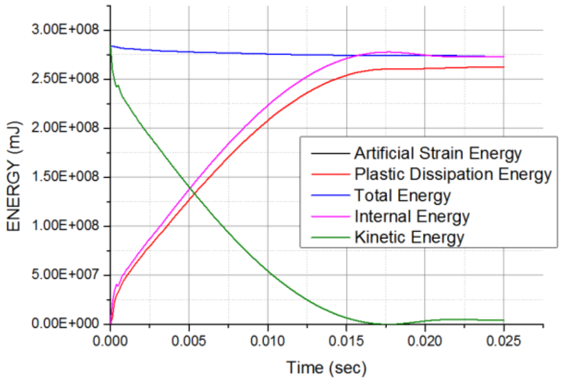

Fig. 4. Energy variation with respect to time.

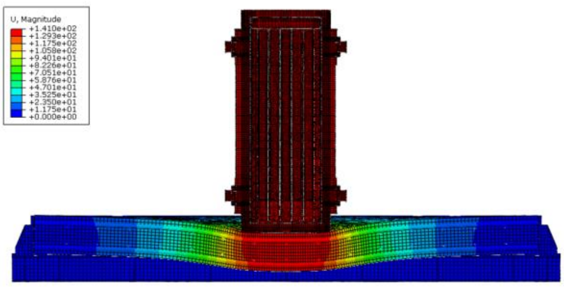

Fig. 5. Maximum displacement after collision.

It was also observed that no plastic deformation occurred in the fuel rods. That is due to that concrete behaves as a shock cushion by absorbing the impact as it deflected.

4. Conclusion

A fifteen meter dropping analysis of the one-third model of spent nuclear fuel transport cask was performed. As a result, the integrity of fuel rod is maintained. That is due to that the concrete behaves as shock cushion like impact limiter. It is expected that more accurate and reliable analysis results can be obtained when the effect of scabbing, spalling and cracking of the concrete is implemented.