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FINITE ELEMENT ANALYSIS AND EXPERIMENTAL VERIFICATION OF RESPONSE DURING 9m DROP TEST OF THE ŠKODA 440/84 CONTAINER

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Information, concerning the results of Finite Element Analysis (FEA) and experimental verification of responses during 9 m drop test of the ŠKODA 440/84 container model in the scale 1:2.5 onto reinforced concrete pads consisted of two segments is mentioned in this paper. The measured acceleration and strains will be compared with FEA values. In general the predicted and measured acceleration transients agree well. Agreement between the measured and predicted strains is variable but in many cases the predicted strains provide upper and lower bounds.

1. Introduction.

In order to prove the safety of the ŠKODA 440/84 container for high-level radioactive materials under type B drop tests and handling accident conditions according to Safety Series No. 6, a sufficiently detailed knowledge of the resulting stresses and strains is required. To demonstrate the container safety, different approaches are permitted by the International Atomic Energy Agency recommendations for the safe transport of radioactive materials.

On the one hand, the mechanical behaviour can be analysed by means of calculation methods, under the condition that the used methods and codes describe the global and local packaging behaviour of the container with sufficient accuracy. On the other hand, this can be done by means of experimental verification. In this case it has been decided to use in parallel both methods for the drop test.

2. Target Description and design Assessment by FEA

The 200-tonne hard reinforced concrete target measuring 6 x 5 x 3 m with a 200-mm thick upper horizontal steel plate was built in ŠKODA Bolevec in 1997. This 3 x 3 m steel plate is attached around the edge to the concrete target by means of 20 prestressed anchor bolts. There is a 5-mm thick epoxide resin layer between the steel plate and concrete target.

The FEA was performed by means of software system MARC. A computational model of a quarter of test facility is shown in Fig. 1. The dropped body is simulated by steel block with 15-tonne mass. A subsoil rigidity is respected by means of elastic dip of the bottom concrete target surface. The dynamic analysis was carried out for time dependence of 0 to 2500 μs. The dynamic strain hardening was respected. The upper steel plate and concrete target block were simulated by eight-mode solid elements, the anchor bolts by means of beam elements. The time dependence of displacement z [m] in selected points of central symmetry axis is given in Fig 2.

A concrete stress distribution [N/m^2] in the time interval 160 μs is presented in Fig. 3. The maximum compression is originating in the time range of 700 to 800 μs. The modes 2771 to 2773 are located in the upper steel plate. The node 326 is placed on the bottom concrete block surface. The maximum steel plate displacement of + 1.5 mm in z-axis direction is originating 2 300 μs after impact.

The above mentioned FEA results were used for concrete steel reinforcement design, for dimension of anchor bolts and their prestressing, and for a suitable epoxy resin selection.

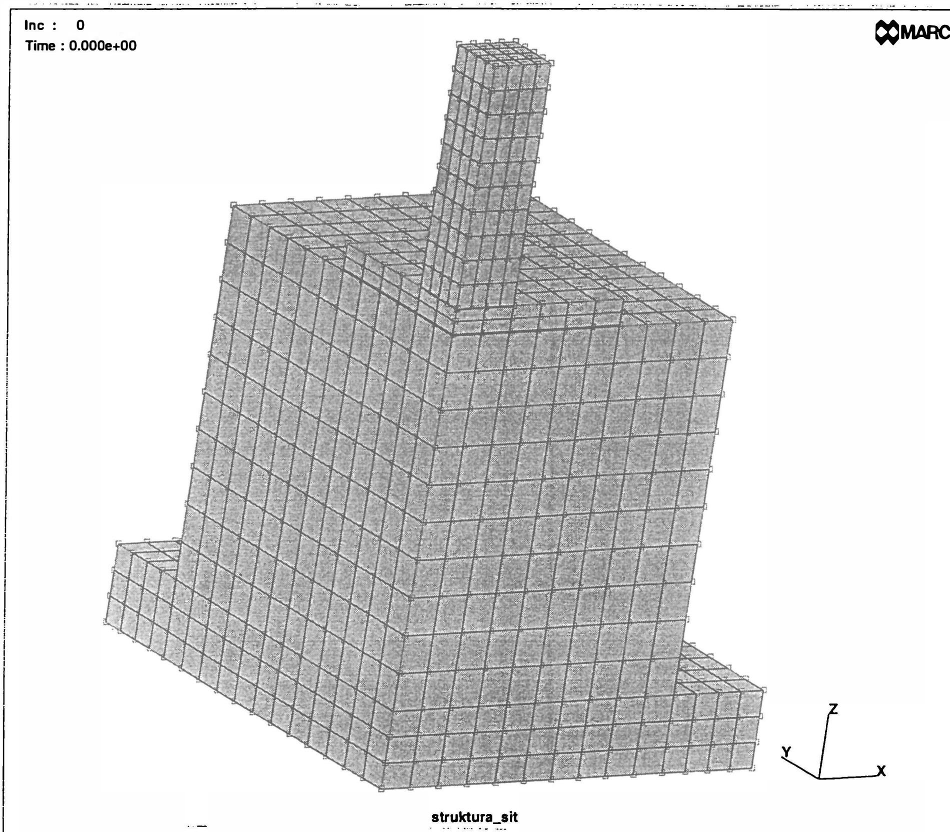

Fig. 1. Computational model of test drop facility

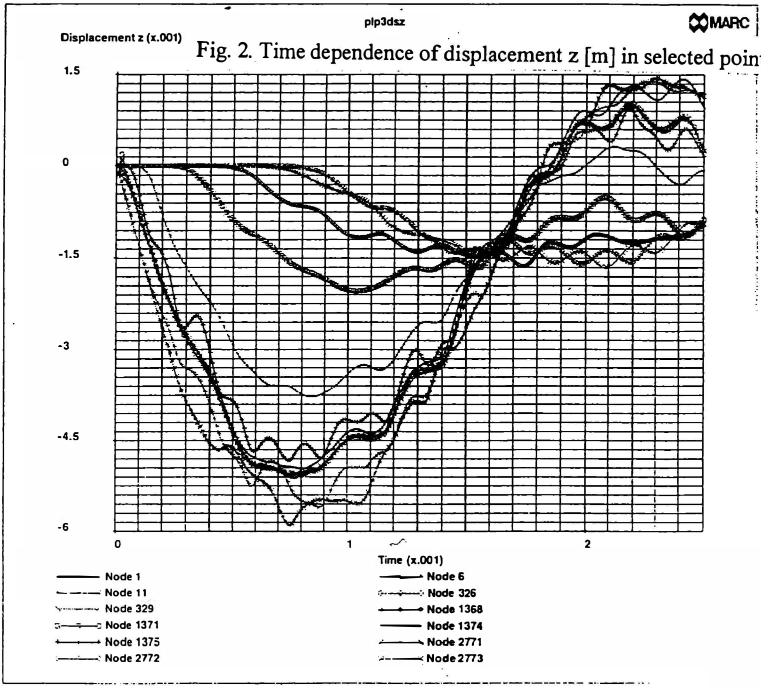

Fig. 2. Time dependence of displacement z [m] in selected points

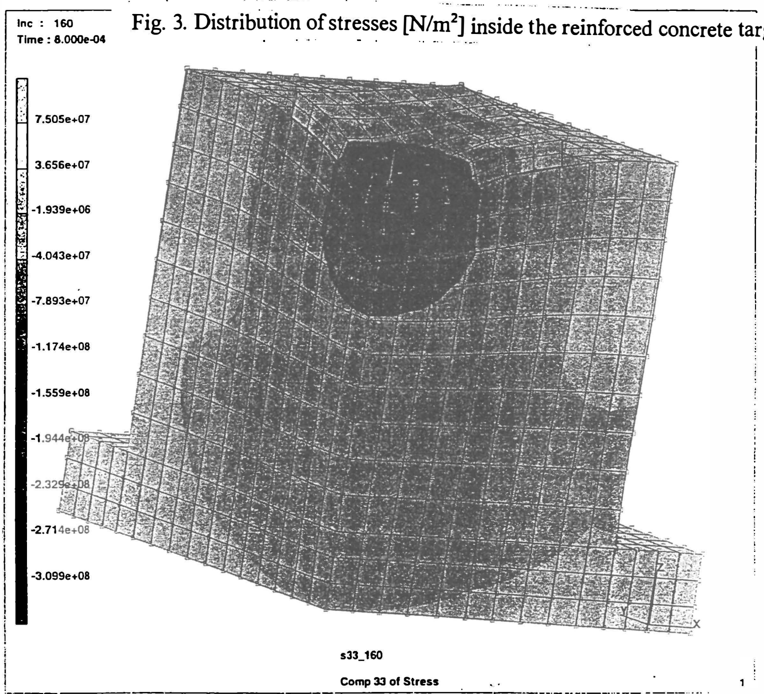

Fig. 3. Distribution of stresses [N/m²] inside the reinforced concrete target

3. Container Design Assessment by FEA

The 9m drop test of a container model onto hard reinforced concrete target is simulated by means of software PAM - CRASH. A computational model of a half of the container is shown in Fig. 4. This model is built up from approximately 9 500 solid beam and shell elements.

The container consist of a cylinder side-wall body, two lids, one canister with fuel assemblies (a weight-equivalent dummy only) and two impact absorbers. There are twelve binding contacts among all components.

The lids are attached to the container body by 42 bolts. The impact absorbers are filled with battens made of spruce wood. The dynamic strain hardening of material, large deformations and plastic strains are respected.

Detailed results of solution will be presented during the conference.

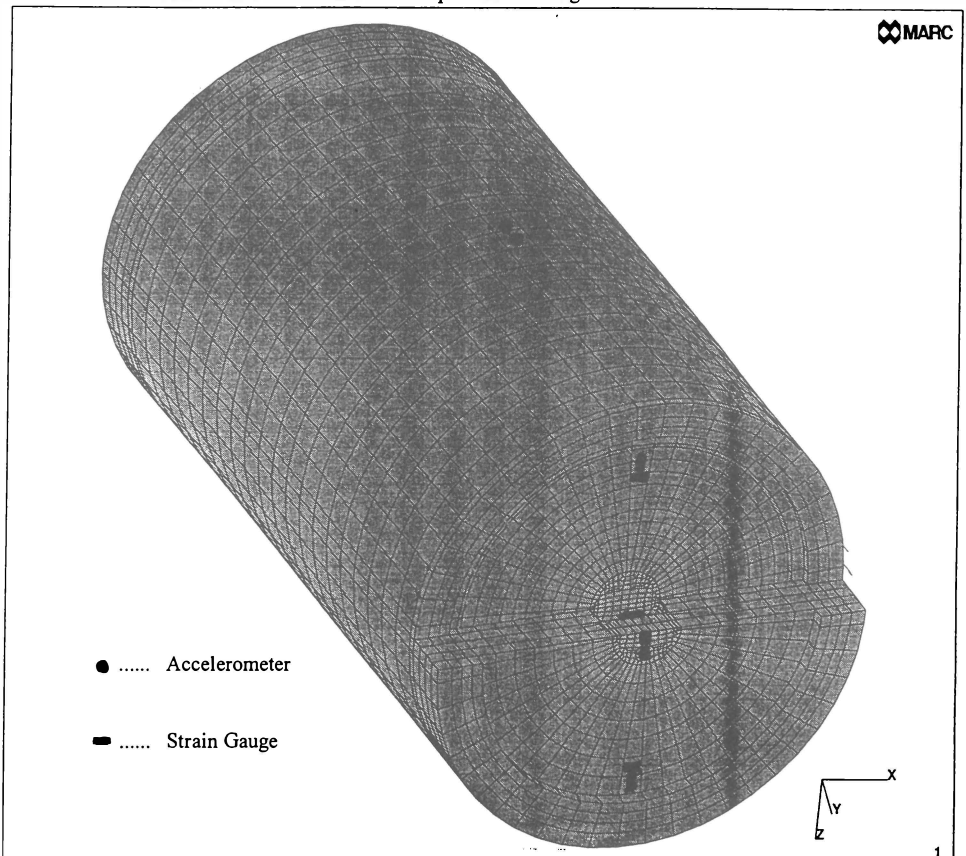

Fig. 4. Computational model of the containerwith spacing of some strain gauges and accelerometers

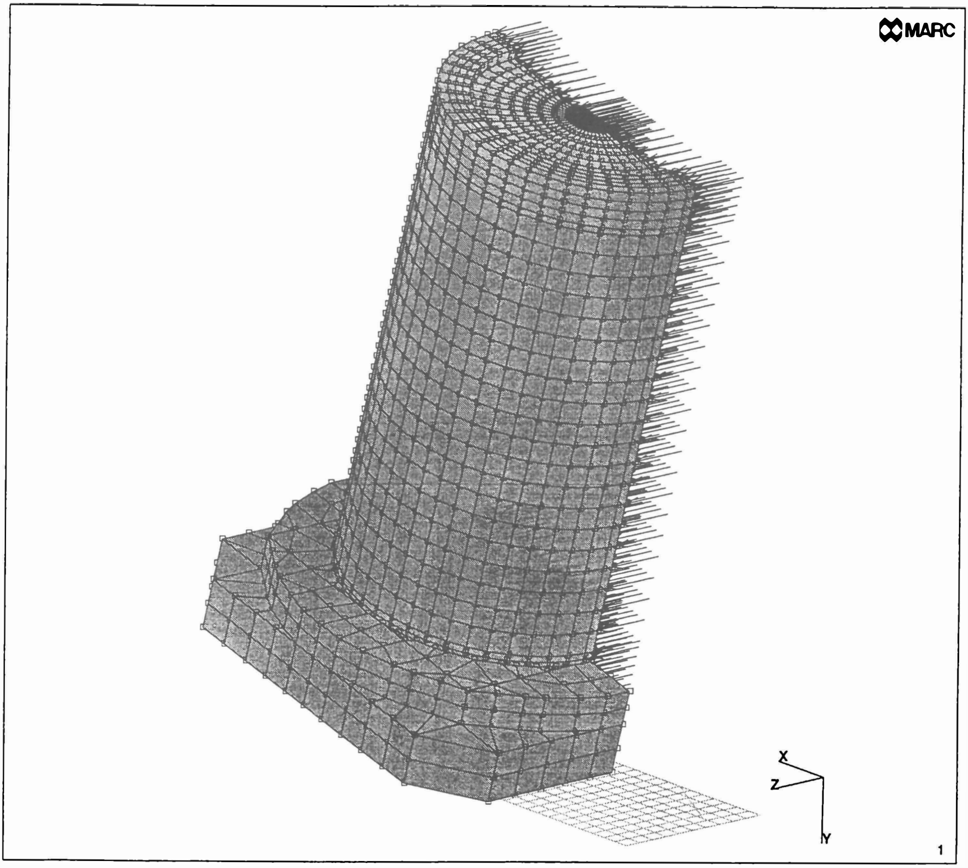

Fig . 5. Computational model of the container with an impact absorber

4. Istrumentation.

A total of fifteen Hottinger Baldwin Messtechnik (HBM) strain gauges of types LY 11 and LD 20 were applied in areas subject to impact deformation for a 9 m drop. Additional five strain gauges were anticipated in order that complete replacement of strain gauges could be made in the event of local impact damage.

Four single axis piezoresistive shock accelerometers of type KD 91 having a ±2500 g range were attached on the container body. The spacing of strain gauges and accelerometers is shown in Fig. 4.

Instrument cables were fixed to the test container model via strain relief points with clamps, attached by spot welding and were deployed such that no induce cable loading during or after drop test.

Instrument power supplies, signal conditioning and recording equipment were sited within a provisional control room located about 15 m from concrete target.

All strain gauges, including four of them capable of measuring up to 10 % strain, were connected to strain gauge DC amplifier units of types HBM KWS 30-20 and MM System 2100. The accelerometers were connected to B&K 26-26 amplifiers. Multichannel FM tape recorders, a TEAK XR - 5000 and a RACAL STORE 14 DS, were used to record accelerometer and strain signals during drop test. The eight chosen channels were recorded into internal memory of computer simultaneously.

5. Conclusions

The recorded data were analysed and evaluated by computer and the time history output data obtained. Filtered plots of recorded and derived accelerometer and strain gauge data were obtained using the same system. These data were used for experimental verification of dynamic FE stress analysis performed with PAM - CRASH software.

The more detailed results will be presented during the conference including a colour video record of the impact process.

References

[1] Dolhof V.: Project of experimental measurements during drop test of PSK ŠKODA 440/84 container. Research report VZVU 1058, Pilsen 1995.

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