XXIII International Conference MHCL 2019 – Extended Review Abstract

Crashworthiness of protection structures for mining machine operators: Numerical analysis and experimental validation using Optical 3D Coordinate Measuring Devices

P. Działak, J. Karliński and E. Rusiński
Faculty of Mechanical Engineering, Wroclaw University of Science and Technology, Lukasiewicza 5, 50-371, Wroclaw, Poland
e-mail: paulina.dzialak@pwr.edu.pl

Abstract

The aim of the work was to perform comparative tests based on strength analysis and experimental research of the structure protecting the operator of the self-propelled drilling vehicle. The first stage was to develop a numerical model of the protection structure in accordance with the technical documentation provided by the manufacturing company and to analyze it using the finite element method [1, 2]. The analysis was conducted in the dynamic range, taking into account material and geometric non-linearity. Performed calculations included simulation of the strength test of a protective structure's impact with falling mass in accordance with PN-92 / G-59001 (RSPS) "Self-propelled mining machines. Rock slide protective structures. Laboratory tests and performance requirements" [3]. Basing on the documentation, geometric and then dicrete model were developed. As a result of the numerical calculations, courses of displacements, strains and stresses in individual elements of the load-bearing structure were obtained (Fig. 1).
Then, in order to verify the numerical calculations, experimental tests of the analyzed cabin were performed. The experiment was recorded using the VISIONresearch high-speed monochrome digital camera Phantom V12 to determine the dynamic vertical deflection of the cab roof [4] (Fig. 1).

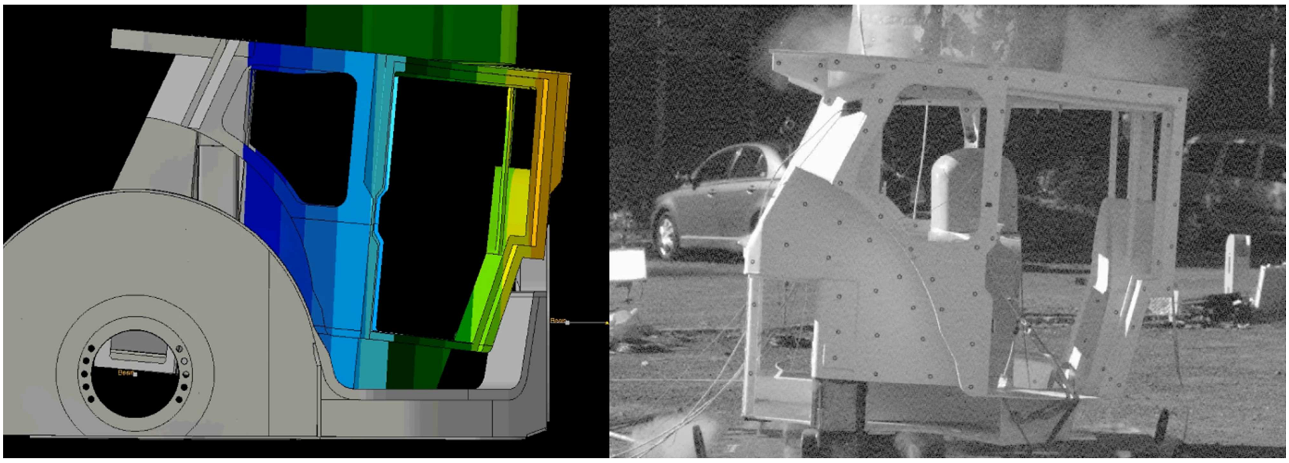

Fig. 1. Operator protective structure test; numerical simulation (left) and high-speed camera image (right).

The protective structure was also measured before and after the test by means of the GOM's TRITOP device used for quick and precise measurements of the coordinates of three-dimensional objects [5]. The system accurately defined the 3D coordinates of the object points. As a result, the cloud of the sampling points and the deflection of the protective structure were obtained (Fig. 2).

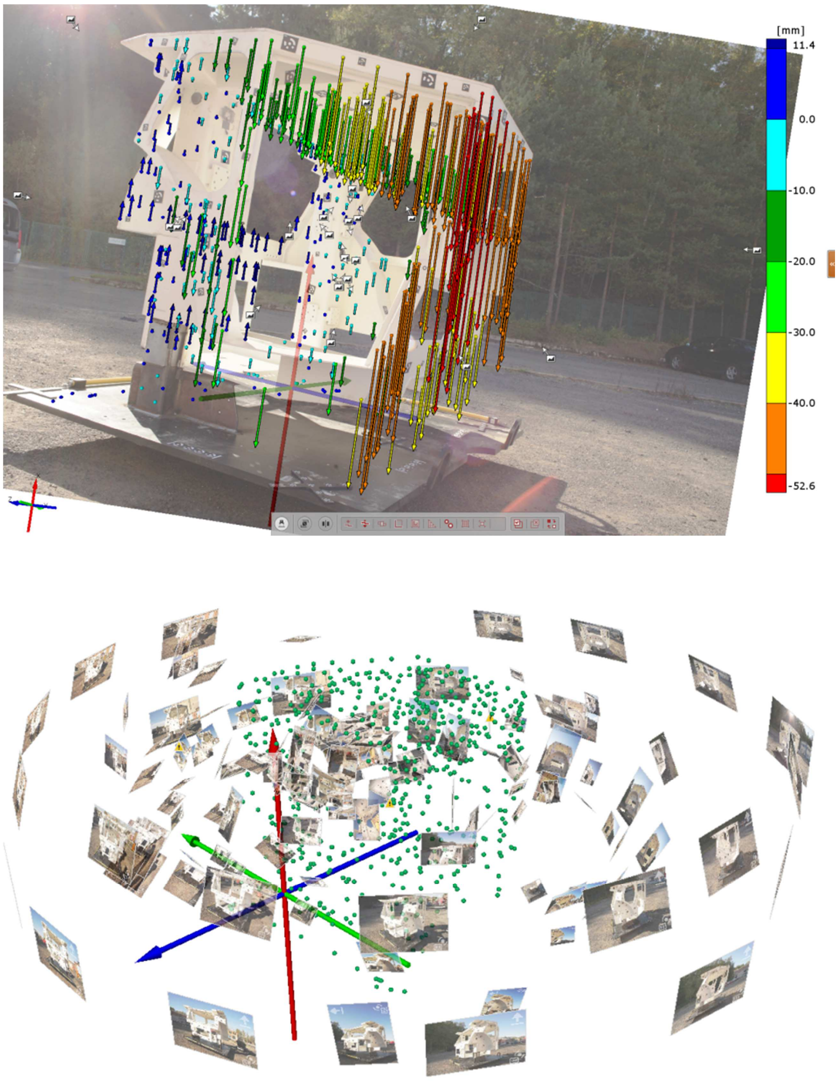

Fig. 2. Deflection measurement of the operator protective structure.

These systems are not usually used to verify safety of the protection structures. Conventionally, the measurement of a deformed structure is performed using a traditional measuring tape [6]. Comparison of the results obtained from the computer simulation and the experiment are presented in Tab. 1.

Tab. 1. Comparison of the results obtained from simulation and the experiment.

Permanent deflection [mm]		Maximal dynamic deflection [mm]	
Simulation	Experiment	Simulation	Experiment
39	33	77	73

Validation of the computer analysis with the use of photogrammetry enabled the authors to verify the numerical simulations of the protective structure of the mining machine operator [7]. The results obtained from the simulation are consisten with the experiment. Additionally, values received from the numerical model are slightly higher, thus meaning that the computational calculations provide a safety marigin in the structure examination.

Keywords: Protective Structure, Finite Element Method, Photogrammetry, Comparative Testing

References

1 **Hughes, TJR.** The finite element method: linear static and dynamic finite element analysis, 2012.

2 **Sun, J.S., Lee, K.H., Lee. H.P.** Comparison of implicit and explicit finite element methods for dynamic problems, *Journal of Materials Processing Technology,* 2000, 105(2), 110-118.

3 **Karliński, J., Rusiński, E., Smolnicki, T.** Protective structures for construction and mining machine operators, *Automation in Construction*, 2008, 17(3), 232-244.

4 **Dziopa, Z., Stefański, K.** Using the high-speed camera as measurement device in the dynamic material tests, *Journal of Vibroengineering*, 14 (1), 2012, 22-26.

5 **Koutecký, T., Paloušek, D., Brandejs, J.** Method of photogrammetric measurement automation using TRITOP system and industrial robot, *Optik - International Journal for Light and Electron Optics*, 2013, 124 (18), 3705-3709.

6 **Clark, B.J. and Thambiratnam, D.P., Perera, N.J.** Analytical and experimental investigation of the behaviour of a rollover protective structure, *The Structural Engineer*, 2006, 84(1), 29-34.

7 **Koruba, Z., Osiecki, J.** The operator protective structures testing for mining machines, *Solid State Phenomena*, 2010, 165, 256-261.