

Fig. 15. The equivalent plastic strain and phase field at different times under the impact velocity  $v = 10$  m/s by mesh 4.

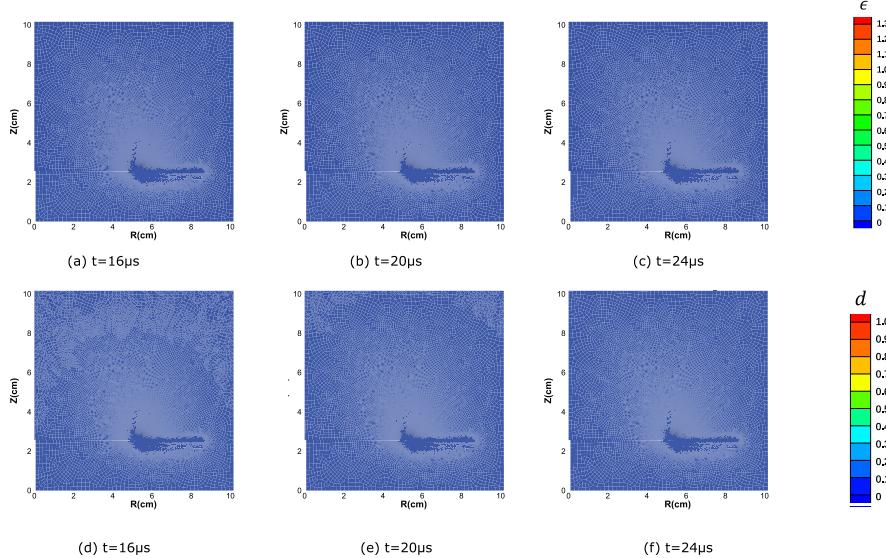


Fig. 16. The equivalent plastic strain and phase field at different times under the impact velocity  $v = 40$  m/s by mesh 4.

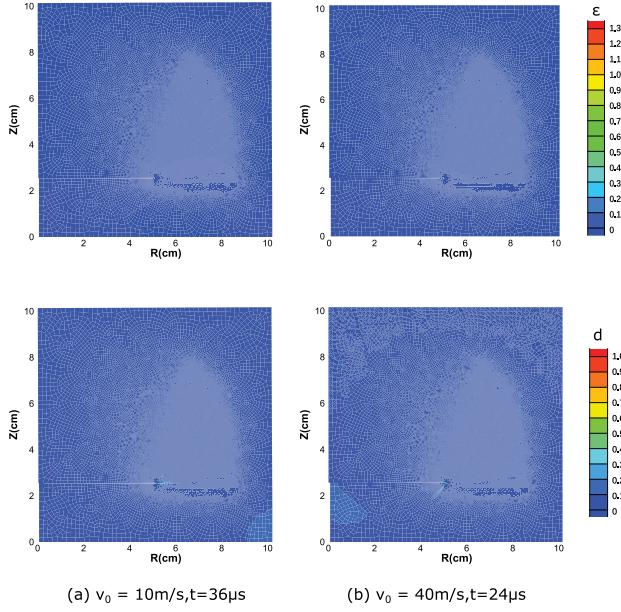
## Appendix. The setup of the sensitivity analysis

Here, the setup of the global sensitivity analysis for the impact of two plates is provided in detail.

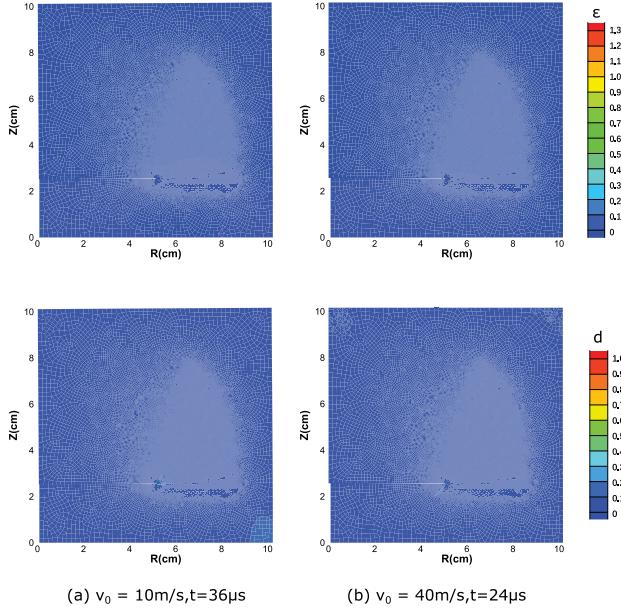
In the ideal case, this analysis requires solving the problem many times. In order to alleviate the time-consuming finite element calculation, a surrogate model based on the polynomial chaos expansion (PCE) [57] with the Latin hypercube sampling method [58] is adopted. One advantage of the PCE-based Sobol' method is that the Sobol' indices can be analytically acquired by the coefficients of PCE [57,59] almost without extra computations.

The entire analysis is performed with the UQLab package [60], a MATLAB-based uncertainty quantification framework. The uncertain parameters are listed in Table A.1.

The basic procedure of performing the sensitivity analysis is listed below:



**Fig. 17.** The equivalent plastic strain and phase field with  $\chi = 0$ .



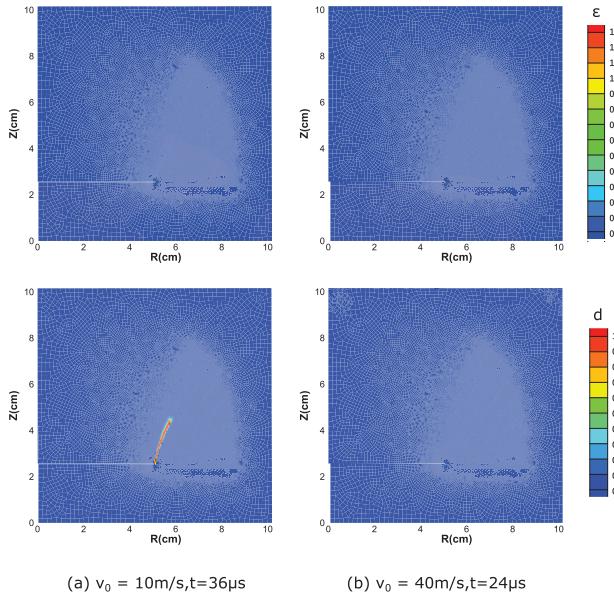
**Fig. 18.** The equivalent plastic strain and phase field with  $\chi = 0.5$ .

Step 1: Define and generate the input parameters by Latin hypercube sampling method. Here, the total number of sampling points is  $N = 120$ , of which 100 are used to calculate the coefficients of the PCE, which is enough to acquire accurate coefficients [57] empirically, and the remaining 20 are used as a validation set for the setup of the PCE models.

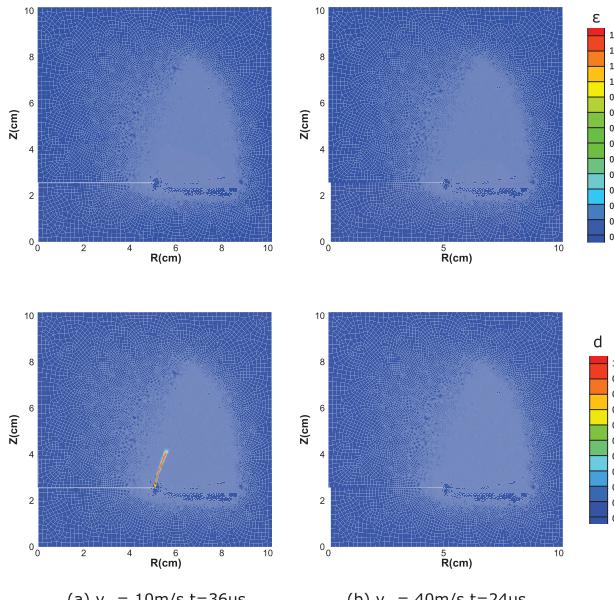
Step 2: Perform the finite element computations using the data of the sampling points as inputs, and extract the corresponding outputs.

Step 3: Calculate the coefficients of the third-order PCE model by the inputs and outputs based on the ordinary least squares method.

Step 4: Analytically estimate the second-order Sobol' indices by the coefficients of PCE, and visualize the Sobol' indices.



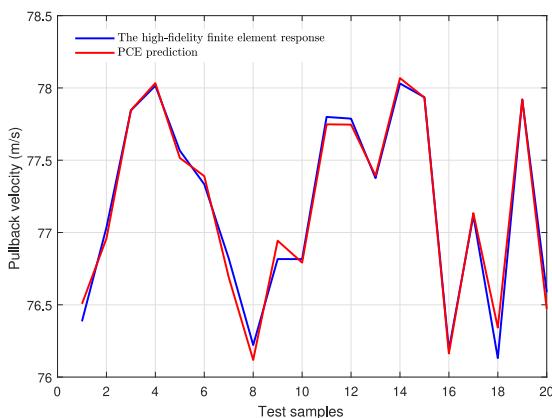
**Fig. 19.** The equivalent plastic strain and phase field with  $\chi = 0.7$ .



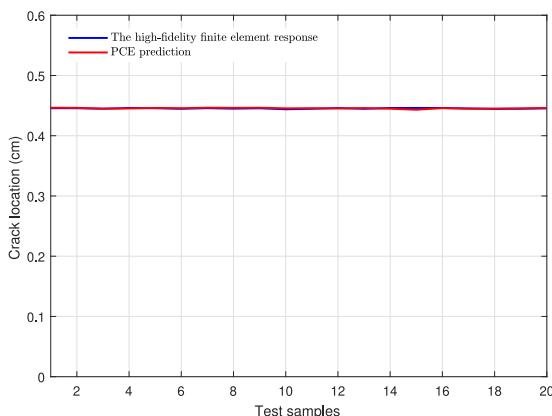
**Fig. 20.** The equivalent plastic strain and phase field with  $\chi = 0.8$ .

**Table A.1**  
The uncertain input parameters.

Parameter	Distribution type	Unit	Mean/ Lower bound	Standard deviation/ Upper bound
$g_c^{\text{vol}}$	Normal	N/mm	0.88	0.1
$g_c^{\text{dev}}$	Normal	N/mm	22	2.2
$\chi$	Uniform	—	0.5	1



**Fig. A.21.** The pullback velocity of right end surface from the high-fidelity finite element responses and predictions by the PCE model. The maximum absolute error is 0.1307 m/s, which is 0.17% of the maximum value of the high-fidelity finite element response among the samples.



**Fig. A.22.** The crack location from the high-fidelity finite element responses and predictions by the PCE model. The maximum absolute error is 0.0029 cm, which is 0.65% of the maximum value of the high-fidelity finite element response among the samples.

In the above process, the finite element computations (Step 2) are the most time-consuming, and the time for the remaining parts is negligible.

Figs. A.21 and A.22 plot the pullback velocity of the right end surface and the crack location predicted from the finite element computations and the PCE model for the 20 sampling points from the validation set to verify the setup of the PCE model. From these figures, we see that there is only a tiny difference between the high-fidelity finite element response and the predictions, which shows that it is appropriate to substitute the high-fidelity finite element model by the PCE model setup.

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