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Research Article

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Finite element analysis of metal boxes falling which hits the ground

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ABSTRACT

A hit by a falling of a metal box is a canonical contact problem. This article uses ABAQUS software to analyze the collisional procedure about the dropping of a metal box in four types of ground contact as triangular bulge, semicircle arc bulge, rectangular bulge and plane, and then compare different mechanical behaviors of the contact-material in different types of contact, which bores out the symmetry of symmetrical structures loaded symmetrically in Structural Mechanics. Besides, it has analyzed effects made by different types of contact on time which needs to re-balancing contact, stress concentration and engineering application of contact problems.

Key words: metal box; contact problem; stress concentration

INTRODUCTION

In the modern production and life, the study of contact problems is of great significance [1-3]. For example, home appliance products may impact and collide more or less in loading or transporting, the in-consequent design of products and packaging will probably wear or damage products, causing economic losses to the enterprise. Research developed by PD Design Center of Qingdao Haier Group about the drop impact of washing machines based on the finite element analysis [4] solved the problem perfectly. Moreover, in the aerospace industry, we also use contact problems to solve the problems of landing stability, energy-absorbing and load buffering when building and developing the lander, which occurs during the contact between landing legs and lunar soil in the process of lunar soft landing [5]. The result demonstrates that high stress concentration exists around the contact surface area and the peak stress in contact area of brittle material influences the strength of the device seriously [6], so we need analyze the contact stress precisely.

This article will use the finite element analysis tool, ABAQUS, to make analysis on the typical nonlinear problem of metal boxs' falling, then introduce the purpose and significance of the research, meanwhile introduce the application of numerical analysis method, furthermore comprehend effects on stress made by contact through the same model in different contacts.

EXPERIMENTAL SECTION

Establishment of finite element model

The external dimensions of the box are 1m×0.6m×0.8m, and the plate thickness of the box is 0.002m. The ground is a rectangular of 1.6m×1m. The box drops from the height of 0.05m above the ground at a speed of 10m/s, and we should analyze the influence on mechanical behaviors of box brought by four operating modes about different ground conditions.

The body material is DQSK36, and the density is 7850kg/m^3, modulus of 207GPa, Poisson's ratio is 0.28, and material-plastic mechanic parameters are shown in Figure 1.

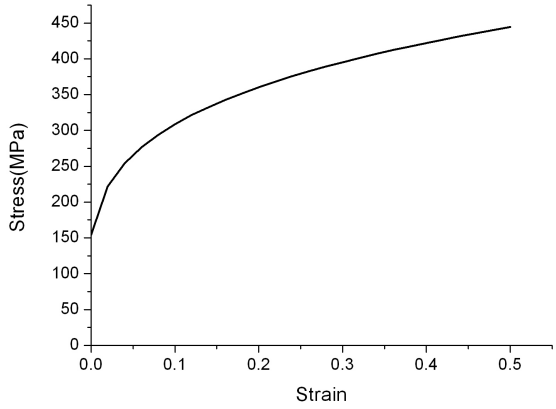
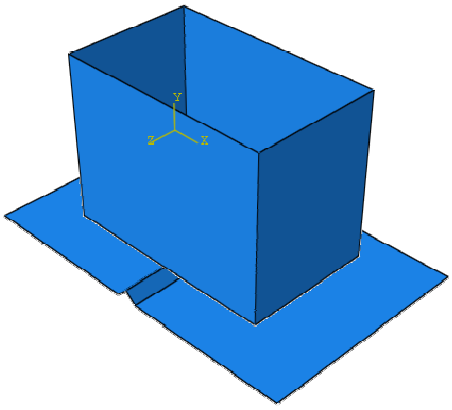
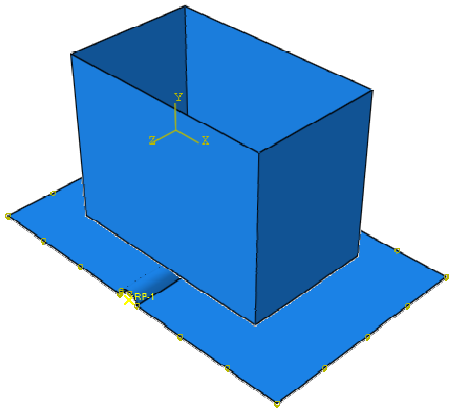


Figure 1 Plastic mechanic parameters of material

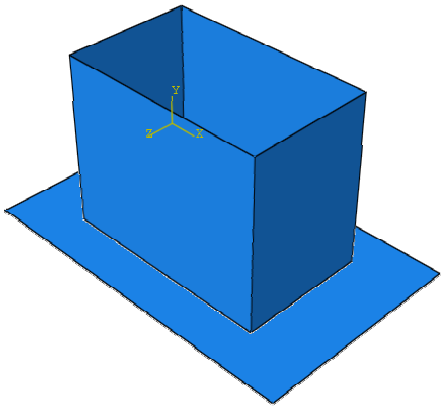
This essay use ABAQUS software to conduct finite element analysis on the metal box crashed on the four types of ground which are the first condition(triangular bulge), the second condition(semicircle arc bulge), the third condition(plane) and the fourth condition(rectangular bulge). Establishments of three-dimensional contact model are shown in Figure 2.



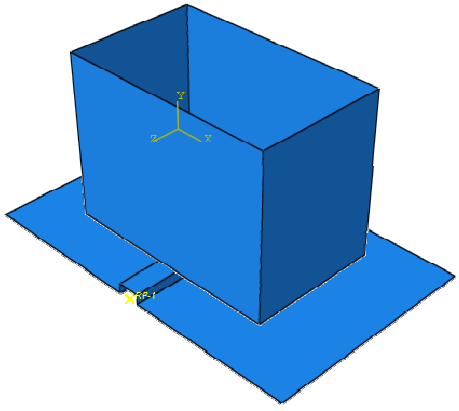
(a) triangular bulge contact



(b) semicircle arc bulge contact



(c) plane contact



(d) rectangular bulge contact

Figure 2 Four types of ground conditions

RESULTS AND DISCUSSION

Plot contour of normal stress at the time reaching the stress peak respectively and contact force-time curves on nodes of 304, 305 and 306. Node 305 is the side midpoint along the x-axis on the bottom of the box, and node 304 and node 306 are around it, so their positions are shown in Figure 3. The location of nodes in the second condition, the third condition and the fourth condition is the same, so we do not have to list again.

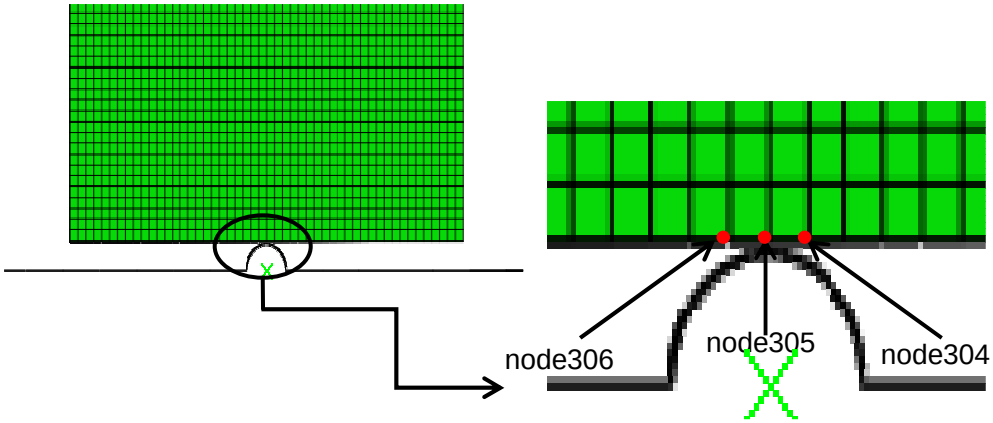
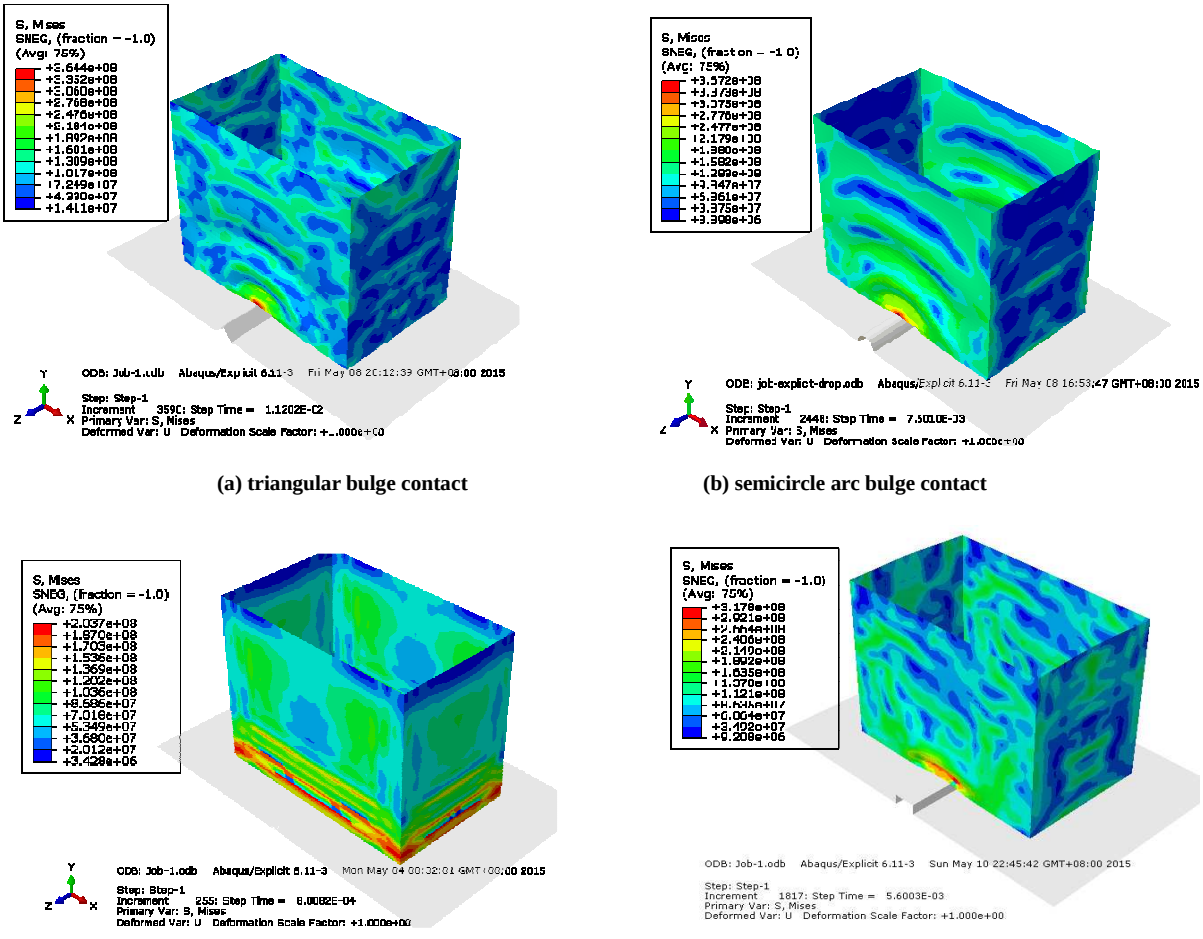


Figure 3 Node location map

We could get the contour of normal stress when the metal box crashed on different ground conditions through numerical simulation using finite-element analysis, which shown in Figure 4. Results display that there is a high stress concentration at contacts, and the maximum stress of conditions of triangular bulge and semicircle arc bulge contact are respectively 364.4MPa and 367.2MPa, which indicates there is not exactly a huge difference between the two conditions. The stress value of rectangular bulge contact is 317.8MPa, because contact area is large when the ground is flat, which leads to no stress concentration, then the maximum stress of this time is 203.7MPa. So the box falling to plane is the most secure.



(a) triangular bulge contact **(b) semicircle arc bulge contact**

(c) plane contact **(d) rectangular bulge contact**

Figure 4 The contour of normal stress on box under different images

Figure 5 shows contact force-time curves about nodes of 304 and 306. Apart from the instability when the box drops and touches the triangular bulge ground, which results in the asymmetry of the contact force-time curve, the

two-node contact force-time curve under the other three remaining conditions is identical. And this consequence is consistent with the theory request when we solve internal force of symmetric structure in Structural Mechanics, in the case that symmetrical structure is under the symmetrical load and symmetric internal force (like bending moment and axial force) and displacement are symmetrical.

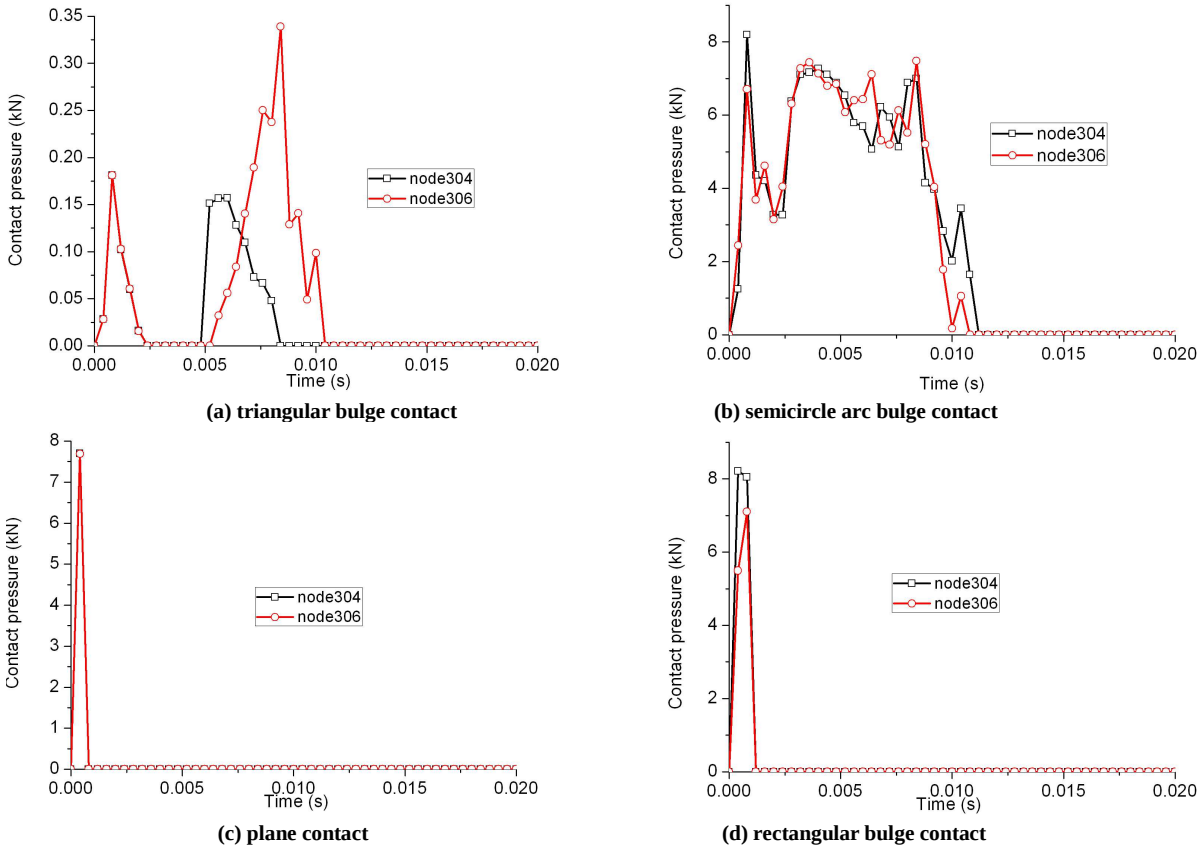


Figure 5 The contact force-time curve at node 304 and node 306

What has shown in figure 6 is the contact force-time curve of node 305, from the figure we could see that the time, which needed by the process that the value raise from zero to maximum and then fall back to zero, and it is longer in the first condition and the second condition (line contact with face)than in the third condition and the fourth condition (faces' contact). Inside, the time needed in first condition and second condition is roughly the same, and so do with third condition and fourth condition, so we can know that sizes of contact surface and contact state have effects on the response time of contact about re-balancing, moreover it will be shorter with the increase of contact surface when parameters of contact body are identical, and sizes of contact surface influence the peak stress.

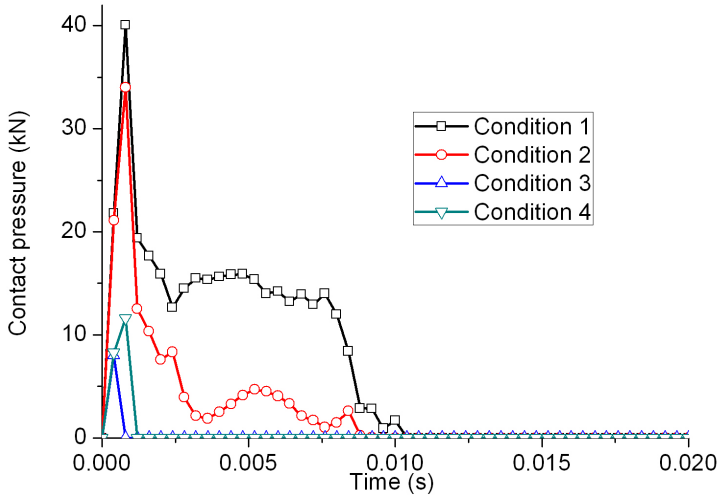


Figure 6 The contact force-time curve at node 305

CONCLUSION

(1) Contact problems are often associated with stress-concentration problem, and we get that it occurs more apparently in line to face than face to face through numerical simulation.
(2) Sizes of contact surface influence the response time of contact about re-balancing, and we could infer that it will be shorter with the increase of sizes in the same model.
(3) The peak stress has the important influence on the strength of brittle material equipment. We can see that sizes of contact surface influence the peak stress by observing the contour of normal stress, and we can infer that the peak stress would be small along with the decrease of the sizes of contact surface in the same model through the result of numerical simulation, and it was founded inversely.

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