THE FRACTURE MODE OF A GLASS PLATE STUCK WITH THIN FILM UNDER A LOW-VELOCITY IMPACT

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1. Introduction

The impact resistance improvement is important for glass members to protect people from injury. Although it was reported that sticking a thin polymeric film on the glass plate is an effective way to easily reinforce the glass plates against impact loads [1], the reinforcing mechanism is still unclear. We should understand the fracture characteristic of the glass plate with the two modes, bending mode fracture and Hertzian type fracture [2] for recognizing the mechanism. In this study, impact fracture behavior was investigated experimentally with a glass plate stuck with thin polymeric film.

2. Method

An impact experiment was conducted using the drop ball test. Figure 1 presents the schematic of the experimental apparatus used in the study. Impact loads were applied to the glass specimen through the impact bar of SUS304. The tip of the impact bar was rounded with 5 mm in radius. By using the impact bar, the applied impact load can be measured with stress wave analysis in the bar. The glass specimen was a 130×130×6 mm float glass plate stuck with 0.19 mm thick polymeric film (ULTRA S600, 3M Japan Ltd.) at the non-impact face. The specimen was cramped by the steel plates and rubber plates with a 40 mm hole in the center of it. The dropped ball was made of a steel, SUJ2 in Japanese standard, and its diameter was 82.5 mm. The drop height was 1 m above the top of the impact bar. During the experiment, impact load was estimated from the strain gauge output at the impact bar. The stress distribution and fracture behavior of the specimen were recorded by the high-speed video camera (Phantom VEO-710, Vision Research Inc.) with the photoelastic method in 5800,000 fps. The experiment was conducted in three times in the same condition.

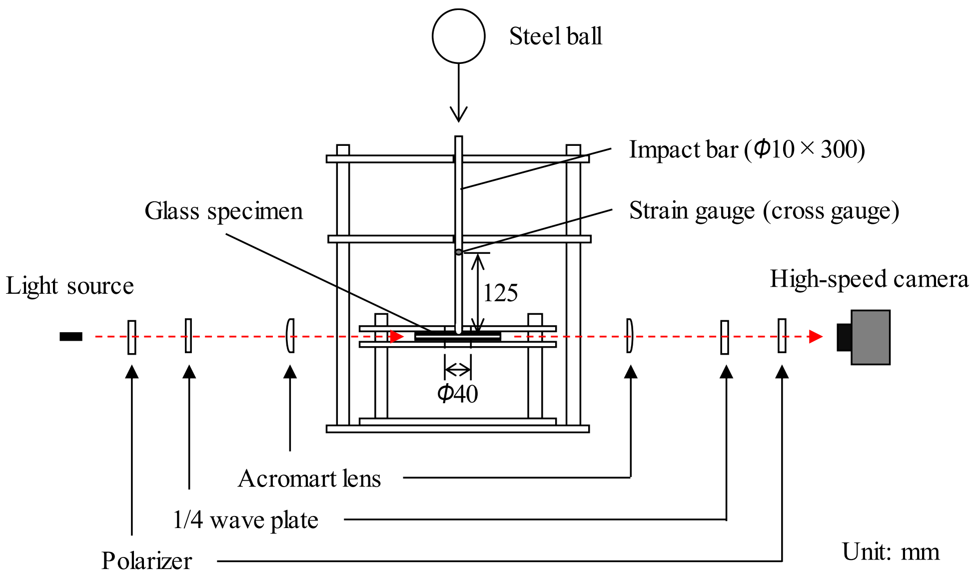

Figure 1: Schematic of the experimental apparatus used in the study.

3. Results and discussion

Figure 2 shows the representative data of the impact load history obtained at the impact bar. The history until about 0.2 ms is the load applied to the impact bar before fracturing of the specimen. The images in Figure 3 present the fracture initiation of the specimen and show the crack initiated from the bottom (non-impact face) and propagated to the horizontal directions in the specimen. This crack propagation indicates the occurring of the bending fracture and the trapezoidal crack appeared above the initial crack after 0.191 ms. This trapezoidal crack shape signifying that the crack propagated along with the tensile stress distribution from the impact point which can be explained by Hertz's contact theory. Therefore, it may have a similar characteristic with Hertzian type fracture. In this way, it was clarified the glass plate was fractured in a mixed mode of the bending fracture and Hertzian fracture in the impact condition at the velocity, i.e., a low-velocity impact. In addition, it appears that the bending fracture was dominant in the present experiment. Sticking the film to glass plate seemed to delay the fracture initiation without affecting the fracture mode.

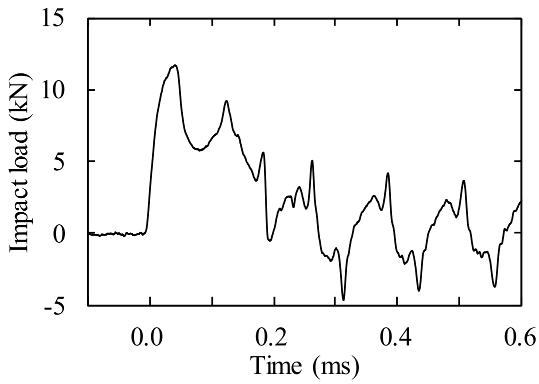

Figure 2: Impact load history.

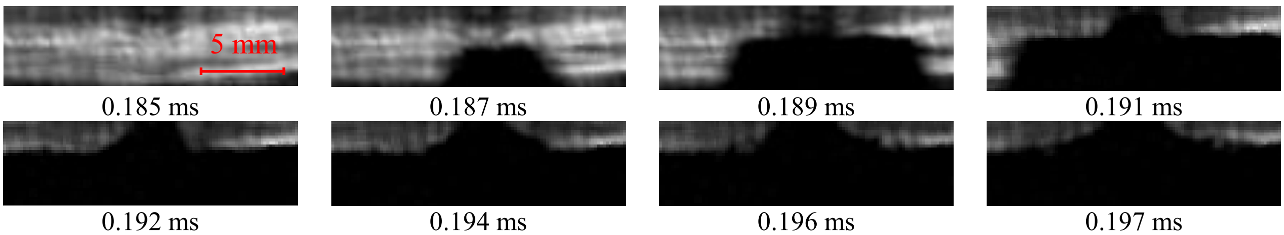

Figure 3: Stress concentration and crack propagation in the glass plate after the impact.

4. Conclusion

An experimental investigation was conducted for the impact fracture mode of a glass plate stuck with thin film. It was clarified the glass plate was fractured in a mixed mode of the bending fracture and Hertzian fracture and the former was dominant in the present experiment. Further study is needed to clarify the condition for a transition of the fracture mode and its relation with the impact resistance of the glass plate.

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References

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