Dynamic Behavior of Thin Glass Panel under Ball Drop Impact

Liang Xue[1], Claire R. Coble[1], Hohyung Lee[1], Da Yu[1], Satish Chaparala[2], SB Park[1]

[1] Department of Mechanical Engineering, State University of New York at Binghamton, Binghamton, NY

[2]Corning Incorporated, Corning, NY

Introduction

➢ Glass presents a wide variety of applications in daily life, and helps to protect displays for smartphones, tablets, PCs, and TVs from everyday wear and tear. As the demand on touch screen technology is higher, it warrants harder, stronger, yet thinner glass that resists scratches, survives in drop impacts.

➢ In this work, the dynamic analysis of glass under ball drop impact will be investigated based on energy level. The deformation and the strain of the glass will be obtained by the Digital Image Correlation (DIC) system.

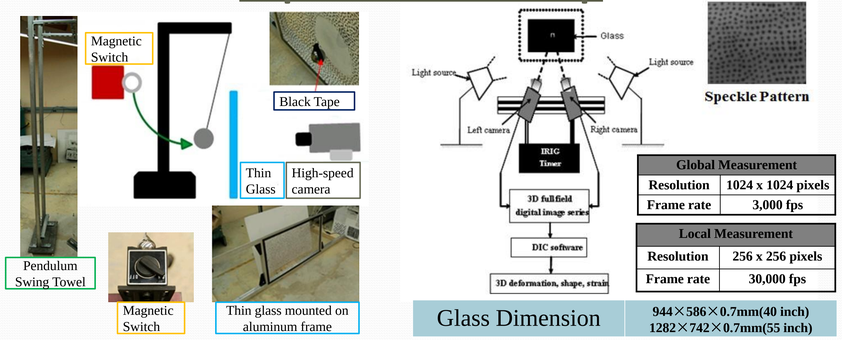
Objectives

➢ A new approach of non-contact optical measurement, Digital Image Correlation (DIC), will be applied to investigate the dynamic responses of glass under ball drop test.

➢ The effect of initial potential energy, impact ball size and the dimension of the glass will be discussed.

➢ Finally, a FEA model will be developed using ANSYS/LS-DYNA to provide a comprehensive understanding of the dynamic response of the glass.

Experimental Setup



Global Measurement	
Resolution	1024 x 1024 pixels
Frame rate	3,000 fps

Local Measurement	
Resolution	256 x 256 pixels
Frame rate	30,000 fps

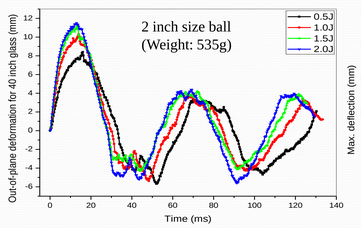
Glass Dimension	944×586×0.7mm(40 inch) 1282×742×0.7mm(55 inch)

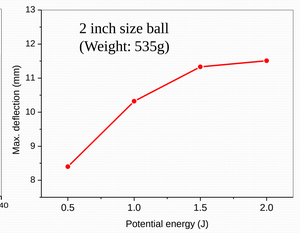
➢ **Digital image correlation (DIC)** is a full field optical measurement technique.

➢ In this study, the different size steel balls(0.75inch, 1inch, 2inch) impact the glass panels from different heights.

Experimental Results

Effect of Initial Potential Energy:

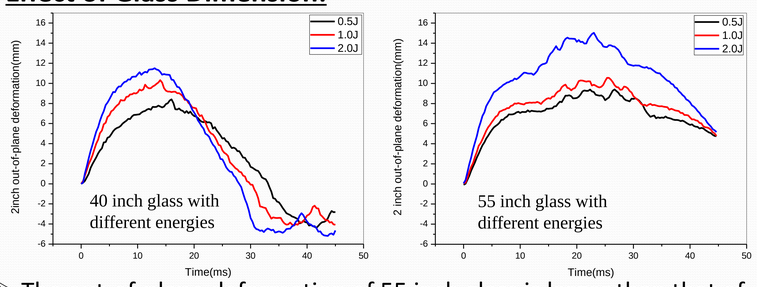




Drop Energy (J)	Drop Height (m)	Time to Max. deformation (ms)	Max. deformation (mm)
0.5	0.095	16	8.40
1.0	0.191	14	10.32
1.5	0.286	13	11.32
2.0	0.381	13	11.51

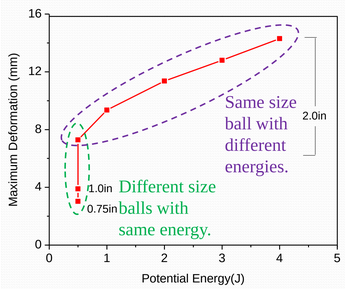
➢ Test results show a nonlinear relationship between the maximum out-of-plane deformation and the initial drop energy.

Effect of Glass Dimension:



➢ The out-of-plane deformation of 55 inch glass is larger than that of 40 inch glass under the same loading condition and the time to the maximum deformation for 55 inch glass is longer.

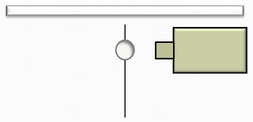
Effect of Ball Size:



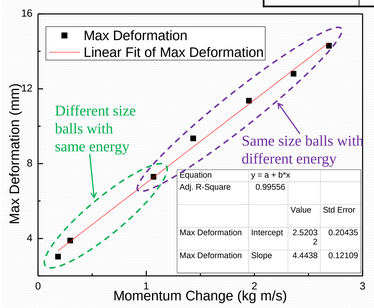
➢ Nonlinear relationship between the maximum deformation and the drop energy for different size balls.

➢ Energy, as a metrics for impact test, should be replaced with a new parameter. Momentum change is proposed.

Rebound test:



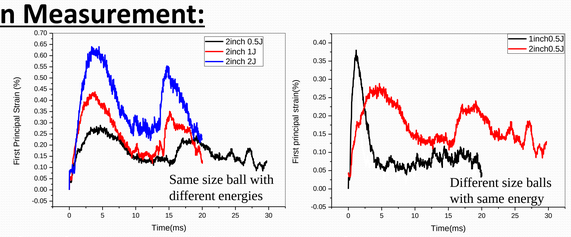
Impact ball diameter (inch)	Input energy (J)	Experimental impact velocity (m/s)	Rebound velocity (m/s)	Energy loss (J)	Momentum change (kg·m/s)
0.75	0.5	5.76	0.98	0.45	0.19
1	0.5	3.77	0.68	0.46	0.30
2	0.5	1.35	0.65	0.38	1.07
2	1.0	1.87	0.81	0.76	1.43
2	2.0	2.65	1.00	1.61	1.95



➢The impact ball size increases, the momentum change during impact increases.

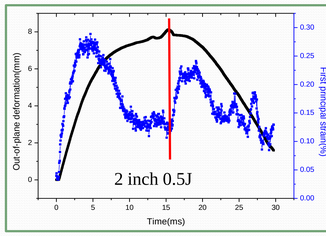
➢ Linear relationship between out-of-plane deformation and momentum change.

Strain Measurement:



➢ Drop height increases, first principal strain increases.

➢ A second peak is observed in strain responses with 2 inch steel ball.



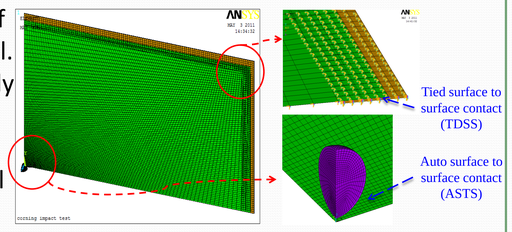
➢ The first peak of strain is appeared earlier than that of out-of-plane deformation.

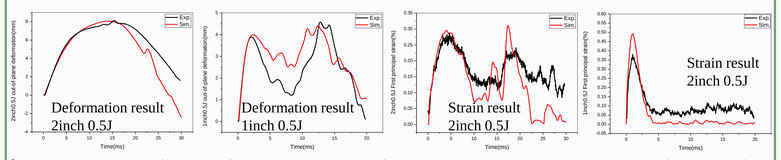
➢ When the ball just hit the glass, the glass will deform larger in local.

FEA Validation

➢ The model consists of glass, tape and steel ball.

➢ Due to symmetry, only a quarter of the glass (472mm×293mm, 40 inch glass) and steel ball are modeled.





➢ Good correlation between simulation and experiment is obtained both in out-of-plane deformation and first principal strain.

Conclusions

➢ The capability of DIC optical technique to be used glass product development is demonstrated.

➢ The DIC is used to measure the out-of-plane deformation and first principal strain during the ball drop impact test on the glass panels. Excellent correlation in deformation and strain is obtained between the measurements and predictions.

➢ Out-of-plane deformation is related to momentum change of impact ball rather than its initial potential energy.

Future Work

➢ More tests will be done to check whether momentum change is a reliable metrics for impacting testing.

➢ The tests that glass is impacted by the projectiles with different shape and different material will be performed to figure out how these influence the dynamic behavior of glass.

Acknowledgement

➢This work was supported by the Corning Incorporated.

➢The authors would like to thank all the members of Opto-Mechanics and Physical Reliability Lab at Binghamton University.