21st International Conference **ENGINEERING MECHANICS 2015**
Svratka, Czech Republic, May 11 –14, 2015
Paper **#024, pp. 190–191**

Failure of Window Glass Plate under Blast Load

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Keywords: window glass, blast load, dynamic response, assumption, failure

Abstract: The paper deals with the response analysis of interaction of a gaseous shock wave and a glass plate structure with particular reference to the character of excitation wave and material characteristics of structure. The goal of this analysis is the determination of hypothesis of failure of window glass plate on the basis of the actual plate rotation during extreme plate displacement. Pressures greater than the ultimate stress or plate rotation bring to the collapse of the glass plate structure.

Introduction

The explosion of an explosive medium generates a pressure wave in the centre of the explosion. Its intensity and history are determined by the chemical properties of the explosive and its reaction with ambient environment. The pressure wave begins propagating from the explosion centre in approximately spherical wave fronts which reflect from and are modified by their impact on the surface of window or other structure parts. The effect of pressure in the propagating wave, together with the reflected wave form the magnitude of the load applied to the structure and its history. Particularly in closed spaces of rooms, industrial halls, etc., in which multiple reflections take place, it is the very size of such closed spaces that is dominant for the load intensity [2].

The explosion, consequently, generates a pressure wave (Fig. 1) the dominant effect of which on a standard window structure is manifested, as a rule, by the flexure of the glass window plate.

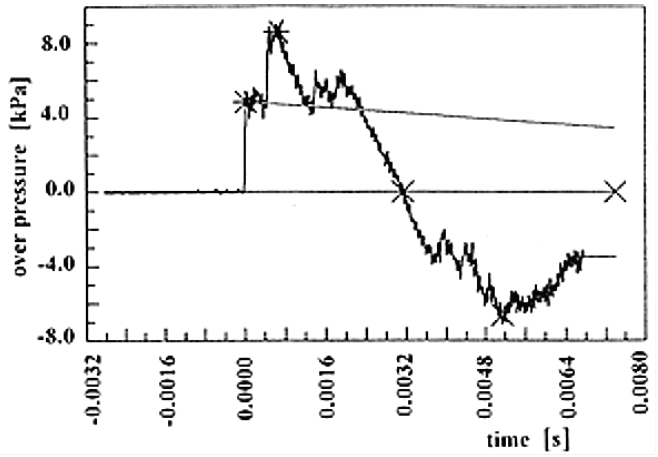

Fig. 1: Example of measured time history

Window structure response and its assumption

For determination of static load bearing capacity of glass plate the bending four-point tests was carried out. By static load test the resulting load bearing capacity is lower then it should be found by dynamic test. Consequently the static load test indicates safety enough values of load bearing capacity of glass plate structure and its resistance. In case of more complex dynamics accidents, it is possible to use approximately the following characteristics determined by comparison of static and dynamic test of window glass plates (3 mm thickness and span of about 1 m): flexural dynamic strength in tension (for time duration of blast load about 1 ms) is 56 MPa in relation to the mean

long-term (static) strength 13 MPa. The uncertainty of the so determined ultimate bearing capacity is usually approximately 30 % with the exception of glass types of distinctly different strength and strain characteristics. The dynamic strength for window and approximately for common window glass is 56/13=4.3 times higher. The stress/strain ratio can be considered linear in the whole load interval up to the ultimate strength (the deviation from linearity does not exceed 3%).

Experimental verification [1] has revealed that the moment of glass plate failure is influenced decisively by the rotation of the glass plate middle plane. Under the overpressure in the shock wave the glass plate first deflects in the load direction. These extreme glass deflections take place only under the effect of the underpressure phase, i.e. in the load direction towards the explosion centre. These extreme deflections correspond with the actual limit rotation 6°of the glass plate. The way of damage (failure) is based on the location of the place where the ultimate rotation is exceeded in the dominant vibration mode [3]. Physically this is manifested by the fact that for the analysed load the first cracks open in the 1/3 - 1/4 of the span of the analysed glass structure. The diagram of limit bearing capacity of square glass plates (for new and 10-year old glass) for overpressure p_m of incident wave and time of its duration τ is given on the Fig. 2.

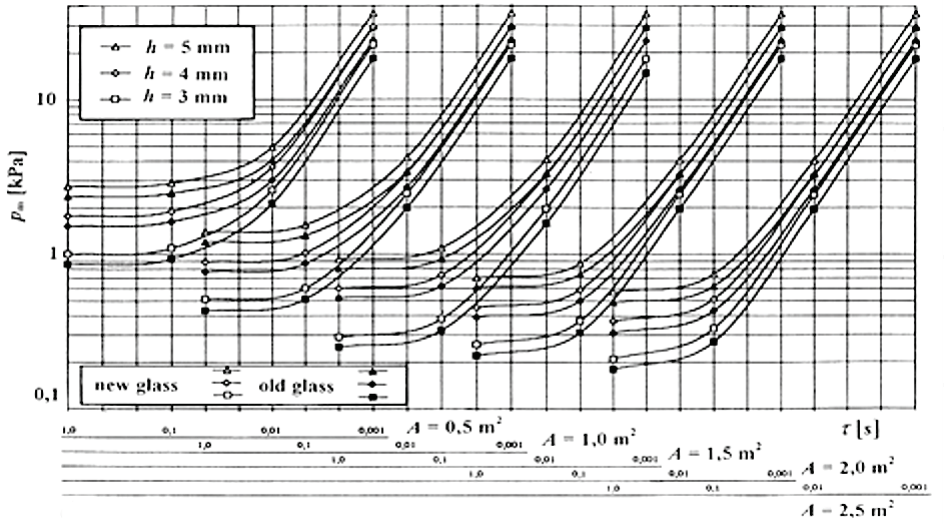

Fig. 2: Limit bearing capacity of glass plate under blast wave load

Conclusion

Analyses of dynamic bending of window glass plate, depending on the parameters of the structure and the impact wave have been computed and compared with experimental results. The limit angle of window glass plate and its limit bearing capacity are derived and discussed. The excess of these parameters result in the collapse of the structure.

Acknowledgment: The paper is based on outcomes of the research project VG20122015089 supported by the Ministry of the Interior of the Czech Republic, for which the authors would like to thank the Ministry.

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