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The effect of glass panel dimension on the fire response of glass façades

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Abstract

Different sizes and shapes of glass products are increasingly employed in building envelopes, but little is known about the effect of glass panel dimension on the fire safety of glass façades. In the present work, two experiments with glass dimensions of 300×300×6 mm^3 and 600×600×6 mm^3 were conducted to verify a finite element method model in the authors' in-house software. Then, a total of 27 numerical cases were designed. The glass panel with dimensions from 100×100 mm^2 to 1000×1000 mm^2 and length-to-width aspect ratios of 400:1, 100:1, 25:1, 25:4, 4:1 and 25:16 were studied. The breakage time, stress distribution and crack path were calculated and demonstrated. It was established that the fire resistance of glass decreases with the panel dimension increase regardless of the mesh size and number. While the glass

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panel with a larger aspect ratio presents better fire resistance. The stress distribution variance caused by size and shape effect is responsible for the different fire performances of glass façades, but the number and distribution of small flaws and defects in glazing are also important. The results are intended to provide references for fire safety optimization of glass façades.

Key words: dimension effect; glass façades; fire response; finite element method

1. Introduction

Glass façades are increasingly used in high-rise buildings, but due to its brittleness, the glass may break and fall out very easily when subject to a fire [1, 2]. The fallout of glass can form a new vent that will allow fresh air entrance and fire spread, accelerating the fire development significantly and initiating the occurrence of flashover or backdraft. In addition, glass surfaces are considered open in current structural fire design, and clear evidence on the breakage of windows and glass façades are missing. The shortcomings of our design assumptions are especially evident in new buildings, where glass façades seem to resist the fire much longer than old windows. Thus, it is of great importance to deepening the understanding of glass façades breakage in fires [3-5].

A large amount of work has been conducted to investigate the breakage mechanism of glass breakage. Pagni et al. [6] developed a mechanical model and implemented it into BREAK1 to predict the glazing breakage time. Shields et al. [7, 8] conducted full-scale experiments in ISO 9705 to investigate the thermal performance of single glazing in the center and corner fire. Harada et al. [9] changed the imposed heat flux and lateral restraint to study their effect on the wired and float glass breakage behaviour. Recently, structural glass behavior in the fire was investigated as well [10, 11]. It was established that many factors can considerably influence the glazing crack initiation, such as the thermal load [7, 8], smoke movement [12, 13], glass installation type [14, 15] and category [9, 16]. A consensus has been reached that the excessive thermal stress resulting from temperature gradient is the primary cause of glass breakage [4, 17].

As the result of an architectural movement in improving the building aesthetics, glass panels with different dimensions are increasingly employed, especially in newly constructed buildings [18], as shown in Fig. 1. The glass panels with different sizes and shapes indeed bring a new sense of construction, but make the buildings face more potential fire risk and fail to comply with the national fire safety codes. This phenomenon is much more common in the Far East, such as mainland China, Hong Kong and Singapore [19]. What is more, the previous study has shown that the size effect has a significant influence on the strength and fire resistance of buildings structures, such as concrete, rock and metal [20, 21]. In particular, the thermal stress resistance of ceramics may also be affected by specimen size and shape [22]. Similar to the above materials, it is anticipated that the fire resistance of glass façades would differ markedly when the panel dimension changes. However, to the authors' knowledge, there has been no study concerning glass panel dimension effect on the fire resistance of glass façades to date, so no adequate scientific reference can be provided to deal with the fire risk caused by glass dimension variance. This ignorance hinders the fire safety design and risk assessment of a construction when considering the glass envelop in engineering [23].

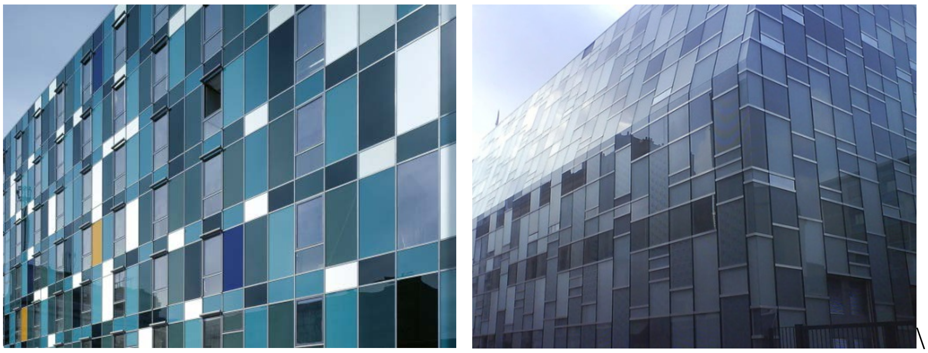


Fig. 1. The glass façades with different dimensions used extensively in modern constructions.

Considering the expense and time-consuming of experiments, it is very difficult to conduct experiments of the glass panel with different dimensions under uniform thermal loading, so it is an important alternative way to investigate this issue using a numerical method. In the present work, two experimental tests are first conducted under uniform thermal loading for the verification of numerical model. Then, focusing on the stress distribution, the thermal performance of glass panel with different dimensions and length-to-width ratios are studied using finite element method (FEM). A total of 27 cases are designed and the breakage time, stress distribution and cracking behaviour are calculated and presented. The results are compared and discussed in detail.

2. Numerical principle and verification

In this study, two models are employed: one is thermal stress model and the other is crack model based on the stress model [24, 25]. The equation of equilibrium governing the linear dynamic response of a system of finite elements is [26]:

$$\mathbf{M}\ddot{\mathbf{U}} + \mathbf{C}\dot{\mathbf{U}} + \mathbf{K}\mathbf{U} = \mathbf{R} \tag{1}$$

where **M**, **C** and **K** are the mass, damping and stiffness matrices; **R** is the vector of externally applied loads; and $\mathbf{U}$, $\dot{\mathbf{U}}$ and $\ddot{\mathbf{U}}$ are the displacement, velocity and acceleration vectors, respectively, of the finite element assemblage. The effective Newmark method is taken to solve the dynamic thermal load response of glass.

A Coulomb-Mohr criterion was employed to predict the crack initiation. Crack occurs when the maximum and minimum principal stresses combine for a condition which satisfies the following Eq. (2):

$$\frac{\sigma_1}{S_{\mathrm{ut}}} - \frac{\sigma_3}{S_{\mathrm{uc}}} \geq 1 \tag{2}$$

where S_{ut} and S_{uc} represent the ultimate tensile and compressive strengths and both σ_3 and S_{uc} are always negative, or in compression.

A Stress intensity factors (SIFs) based mixed-mode criterion is used to predict crack growth in the present work. It assumes cracks start to grow once the following Eq. (3) for the stress intensity factors is satisfied [27, 28].

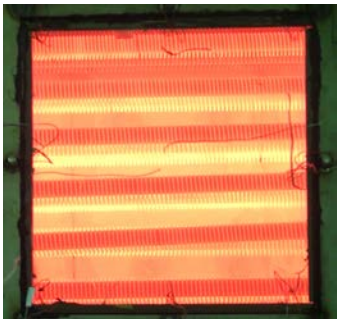
$$\left(\frac{K_{\mathrm{I}}}{K_{\mathrm{IC}}}\right)^2 + \left(\frac{K_{\mathrm{II}}}{K_{\mathrm{IIC}}}\right)^2 = 1 \tag{3}$$

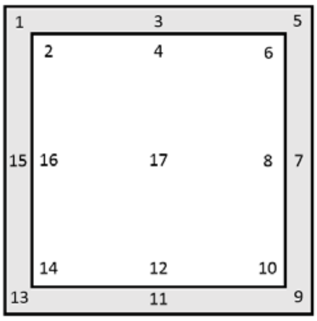
where K_{I} and K_{II} are the stress intensity factors for the fracture modes I and II, respectively, which are obtained from the simulation. K_{IC} and K_{IIC} denote the individual fracture toughness values of the fracture modes I and II.

The above in-house FEM software, called EASY, has been verified by full-scale experimental studies in items of breakage time, crack initiation position and path, all agreed very well with numerical simulations [29]. In addition, it has been proved that the self-developed software can predict as good results as that from BREAK1 [30, 31] and commercial soft software ANSYS [25]. Using the FEM software, it is believed to obtain the reliable results of glass fire performance.

However, if the FEM model is suitable for the calculation of glass panel with different dimensions has not been verified to date. Thus, two tests were conducted to investigate the glass panel size effect on the breakage behaviour. A self-designed apparatus was employed to provide the uniform thermal loading, as shown in Figs. 2(a) and (b). The distance between the radiation panel and glass is 1.5 m and the temperature increase rate was 10 °C/min controlled by an intelligent temperature-controlled meter with a thermocouple located in the small compartment air. After the air temperature reached 600 °C, the temperature will be maintained for 20 min. The glass panels with the dimensions of 300×300×6 mm^3 (Test 1) and 600×600×6 mm^3 (Test 2) were heated to break. The edge of the glass panel was polished. A total of seventeen K-type thermocouples were attached to the fireside surface of glass panel both in exposed and covered areas, as shown in Fig, 2(c). The frame shading width was 20 mm and the gypsum was inserted between the frame and glazing as an insulation material. For more information about the setup, please refer to our previous work [32].

(a) Experimental setup

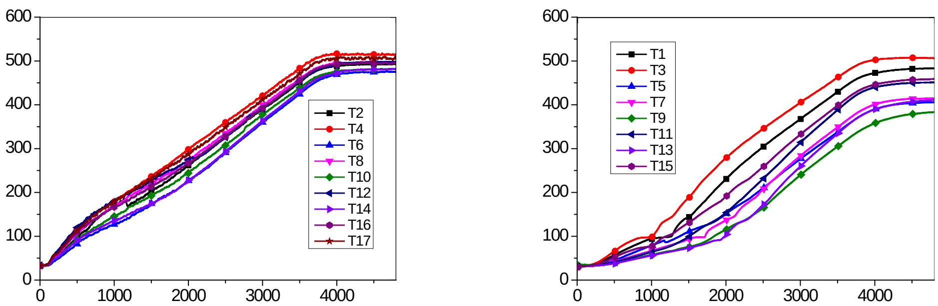




(b) Heating glass (c) Distribution of thermocouples

Fig. 2. The experimental setup and distribution thermocouples.

The temperature curve and crack path of Test 1 is illustrated in Fig. 3. Although the temperatures in upper layer are slightly higher than lower parts due to compartment hot gas convection, the thermal loading on glass panel was relatively uniform. The breakage times of Tests 1 and 2 are respectively 1160 s and 764 s.



(a) The temperature measured in experiments

(b) The crack path in Test 1

Fig. 3. The experiments in Test 1.

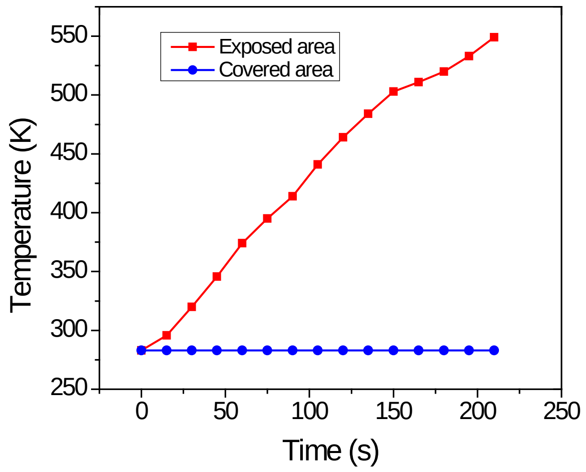
In the numerical model, we assume that the thermal loading is uniform; the temperature in exposed area is the average of T_2, T_4, T_6, T_8, T_{10}, T_{12}, T_{14}, T_{16} and T_{17}; the temperature in covered area is the average of T_1, T_3, T_5, T_7, T_9, T_{11}, T_{13}, and T_{15}. As the experimental conditions in the two tests are identical, both simulations employ the temperature measured in Test 1 as the thermal loading for a comparison. According to the Pagni' research, during the fire, the frame offers no restraint to the glass since the maximum expansion, <1 mm, is less than the normal gap of several mm between the frame and the pane [4]. Thus, there is no constraint around the glass edge in the present numerical model. In the numerical model, the width of the covered area was set as 20 mm, where the temperature was assumed to be room temperature. In our in-house software, the imposed temperature is the primary thermal loading. No heat transit between the glass surface and the ambient. Hexahedron element is used for glass panel and the mesh size is kept constant as 0.003 m × 0.0167 m × 0.0167 in the two simulations. Thus, in the simulation for Test 1, the number of meshes is 18×18×2 and 36×36×2 in the simulation for Test 2. The calculation interval is set as 10 s due to the large time span in experiments. Then from the numerical calculation, the breakage times of Tests 1 and 2 are respectively 1080 s and 730 s which agree well with the experimental results of 1160 s and 764 s. The results confirm that EASY is capable of predicting the breakage time of single float glazing with different dimensions. Since this kind of experiments is very difficult to conduct due to the radiation panel dimension limitation, a series numerical calculations are conducted in the present work.

3. Cases design and numerical results

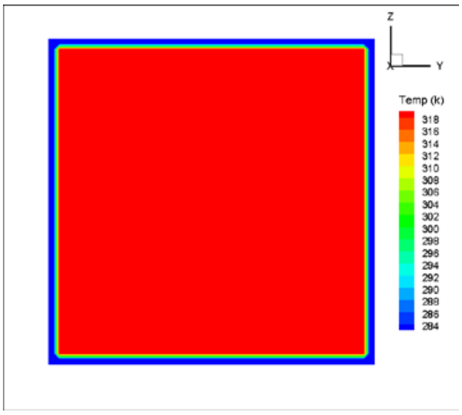
3.1 Cases design

Different from other building material, the thickness of glass panel is not always changed, so in all the cases the thickness was set 6 mm. The exposed framing glass (four edges covered), which is the most extensively used in glass façades, is studied in the present work. Ten different dimensions from 100×100×6 mm^3 to 1000×1000×6 mm^3 (length-to-width aspect ratio=1) were selected to study the glass panel with different areas, named Cases 1 to 10. What is more, six cases, named Cases 11-16, with the length-to-width aspect ratio changing from 400:1, 100:1, 25:1, 25:4, 4:1 to 25:16 were also designed: their areas and mesh number were identical. It should be noted that despite the different glass dimensions and aspect ratios, for comparison the mesh size (0.003 m × 0.0167 m × 0.0167) was kept constant in Cases 1-10 (similar to that in Section 2) and the mesh number (7200) was kept the same in Cases 11-16. The total sixteen cases are listed in Table 1.

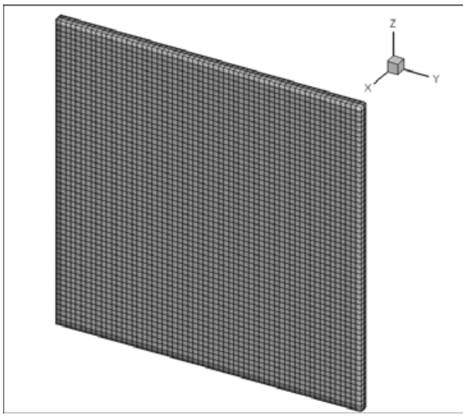
The properties of glass are shown in Table 2. It should be noted that all the properties are room temperature values. Some physical properties are temperature dependent, such as the tensile strength, elasticity modulus and Poisson's ratio. For the thermo-mechanical analyses, the assumption of constant property at different temperatures may cause slightly different results, but it will not significantly affect the accuracy of breakage time prediction [29, 31]. What is more, the purpose of this work is to compare the performances of glass panel with different dimension and aspect ratio, thus it is considered reasonable to ignore the temperature effect on the physical properties. In the designed cases, the width of covered area was set 20 mm, where the temperature was set constant as 283 K. The temperature in exposed areas was designed according to the real fire experimental results to make the numerical results more reasonable than the radiation panel test results [14]. Glass temperatures at exposed and ambient surfaces were assumed uniform to ensure no effect from temperature variance on the numerical results. The thermal loading during the simulation and the temperature distribution at 30 s as an example are shown in Figs. 4(a) and (b). Except the temperature loading, there is no other mechanical loading on glass panel that is consistent with the real situation [4]. Through grid dependence analysis, it was found that hexahedron element is relatively more suitable for glass pane, and the mesh generation is shown in Fig. 4(c).



(a) The thermal loading



(b) Temperature distribution at 30 s



(c) The mesh generation

Fig. 4. The thermal loading and mesh generation in the simulation.

Table 1. The summary of 16 cases.

Case number	Glass panel dimension (mm^3)	Aspect ratio	Mesh number
1	100×100×6	1:1	6×6×2
2	200×200×6	1:1	12×12×2
3	300×300×6	1:1	18×18×2
4	400×400×6	1:1	24×24×2
5	500×500×6	1:1	30×30×2

6	600×600×6	1:1	36×36×2
7	700×700×6	1:1	42×42×2
8	800×800×6	1:1	48×48×2
9	900×900×6	1:1	54×54×2
10	1000×1000×6	1:1	60×60×2
11	20000×50×6	400:1	60×60×2
12	10000×100×6	100:1	60×60×2
13	5000×200×6	25:1	60×60×2
14	2500×400×6	25:4	60×60×2
15	2000×500×6	4:1	60×60×2
16	1250×800×6	25:16	60×60×2

Table 2. The glass properties [33].

Properties	Symbol	Values
Modulus of elasticity (Pa)	E	6.7×10^{10}
Poisson's ratio	ν	0.22
Density (kg/m^3)	ρ	2500
Thermal expansion coefficient (/°C)	β	85×10^{-7}
Reference temperature (K)	T_R	283
Tensile strength (Pa)	σ_b	4.0×10^7
Compressive strength (Pa)	σ_{bc}	4.0×10^8

3.2 Effect of glass panel size

In this section, Cases 1-10 are selected to investigate the effect of glass panel size on the fire resistance of framing glass façades. The time interval is 1 s and breaking time and stress field at each step are obtained in this calculation. When the stress in glazing exceeds its tensile strength, the crack is initiated. From the numerical results, it was found that when the dimensions of glass panel change from 100×100 mm^2 to 1000×1000 mm^2, the breakage time decreases more than 50% that is from 100 s to 48 s, as shown in Fig. 5. It appears to decrease much more significantly when the panel length is smaller than 500 mm. The results suggest that the glass panel size has considerable influence on the fire resistance of glass pane, and with the size increasing, the fire resistance is reduced correspondingly.

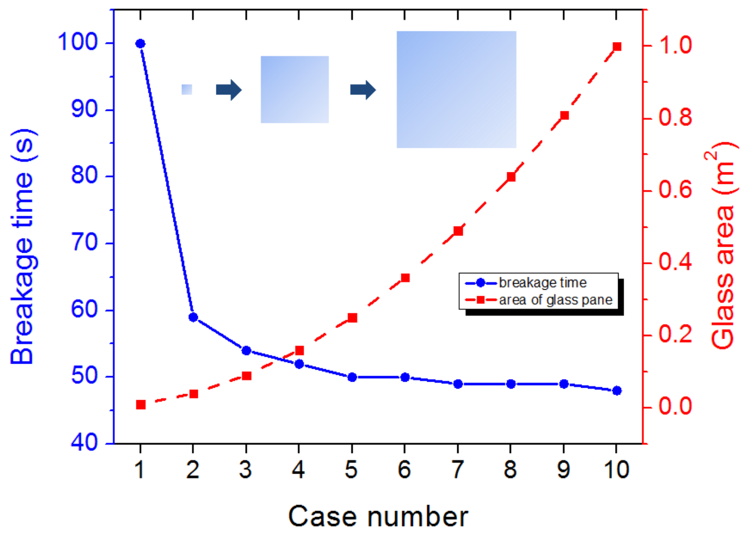


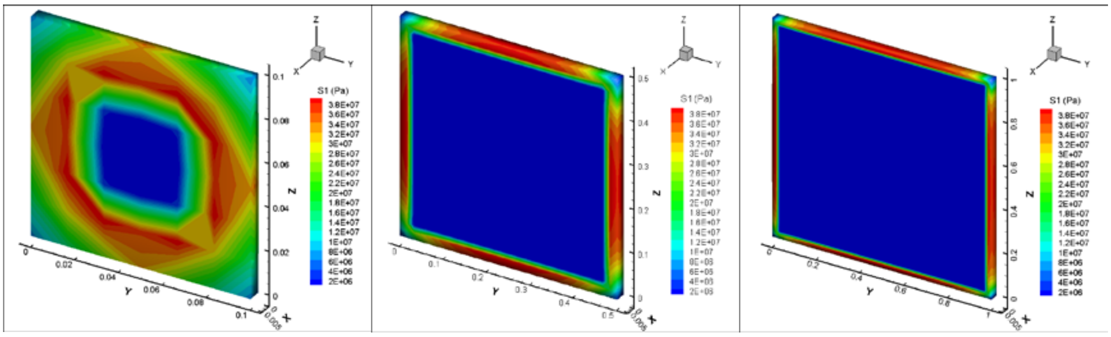
Fig. 5. The breakage time variance of glass panes with different sizes.

According to the quasi-static tensile experiments, the tensile strength of glass in this simulation is set 40 MPa. It should be noted that the glass tensile strength shows great probabilistic characteristic [32, 34], the strength here is an assumption which is normally used in glass in fire research. It can be found that at the time of breakage, the maximum stresses in all cases also fall in a small range of 39.87-40.84 MPa, as listed in Table 3. The agreement confirms that the stress distribution, especially the tensile stress, determines the glass crack initiation regardless of the panel size. As typical examples, the stress distribution of Cases 1, 5 and 10 are presented in Figs. 6(a)-(c), in which the axis is added to show the dimension of the glass panel with the identical legends for comparison. It can be seen that the contour is axisymmetric: the maximum tensile stress normally locates at the borderline of exposed and covered areas; the comprehensive stress primarily locates at the central part of the glass. Thus, the cracks are more prone to initiating from the glass edges. This is consistent with the previous theoretical analysis [35], which indicated that the different thermal expansions in fire exposed and shaded areas would cause large tensile stress at glass edges. It should be noted that in these cases, although glass size changes, the shading width is maintained 20 mm and, so the ratio of shading width and side length is varying between cases. Thus, besides the primary cause of size change, the shaded width may also be responsible for the different stress distribution.

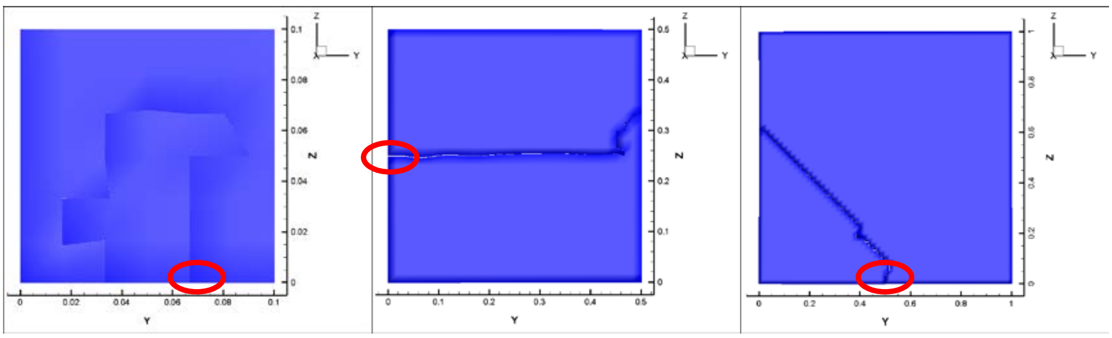
Table 3. The breakage time and first principle stress at breakage time, different glass panel sizes.

Case number	Breakage time (s)	First principle stress (MPa)
1	100	39.87
2	59	40.24
3	54	40.48
4	52	40.84

5	50	39.99
6	50	40.75
7	49	40.18
8	49	40.55
9	49	40.84
10	48	39.95



(a) Stress distribution, Case 1 (b) Stress distribution, Case 5 (c) Stress distribution, Case 10



(d) Crack path, Case 1 (e) Crack path, Case 5 (f) Crack path, Case 10

Fig. 6. The first principle stress distribution and crack path, Cases 1, 5 and 10.

The number of meshes at the crack tip may automatically increase once a crack initiates and they also change into various shapes for grid refinement. The cracking occurred in all cases, and the crack paths in Cases 1, 5 and 10 are selected to be presented in Figs. 6(d)(e)(f), where crack initiations are highlighted for comparison.

From the diagrams, it can be seen that all the cracks are initiated from the edges of glass pane that well corresponds to the maximum stress locations. However, due to the probabilistic characteristics of cracking [32, 34], the crack initiation may locate in different edges. A large number of defects and flaws initially distribute in glazing, especially the glass edges, and easily become macroscopic cracks due to stress concentration, rendering these areas more dangerous for the crack occurrence. The numerical results confirm the previous experiments [8, 15], in which almost all cracks were initiated at glass edges. Therefore, to improve fire resistance of regular glass panes, one has to pay attention to the edge finishing of the panes as well as to the edge constructions.

After initiation, cracks are more prone spreading to the glass central section, and then ceased when researched the edge. It should be noted that different from the numerical results, in a real fire condition, multi-cracks may be initiated, bifurcated and intersected with each other, which makes this problem much more complicated. After crack crossing, some islands may be formed, causing the occurrence of glass fallout.

3.3 Effect of aspect ratio

To investigate the effect of length-to-width aspect ratios on glass fire performance, Cases 11 to 16, with ratio of 400:1, 100:1, 25:1, 25:4, 4:1 and 25:16 were designed and calculated. Between the six cases, the glass area and number of meshes were kept identical for comparison. The time to occurrence of first cracking and the first principle stress at breakage time are summarized in Table 4. It can be seen that the breakage time decreases gradually from 72 s to 44 s, around 40%, with the length-to-width aspect ratio decreasing. The degradation of fire resistance is significant. The variance can be found more clearly in Fig. 7, which suggests that the breakage time and aspect ratio demonstrate the similar tendency. The variance from Case 14 to Case 16 is not as large as Cases 11-13 since the relatively small change in aspect ratio. It is believed that the fire resistance may be optimized with larger ratio aspect, but due to the aesthetic sense of buildings, it would unlikely be employed in construction engineering.

Table 4. The breakage time and first principle stress at breakage time, different aspect ratios.

Case number	Breakage time (s)	First principle stress (MPa)
11	72	40.65
12	64	38.41
13	54	40.27
14	48	40.49
15	46	40.91
16	44	40.65

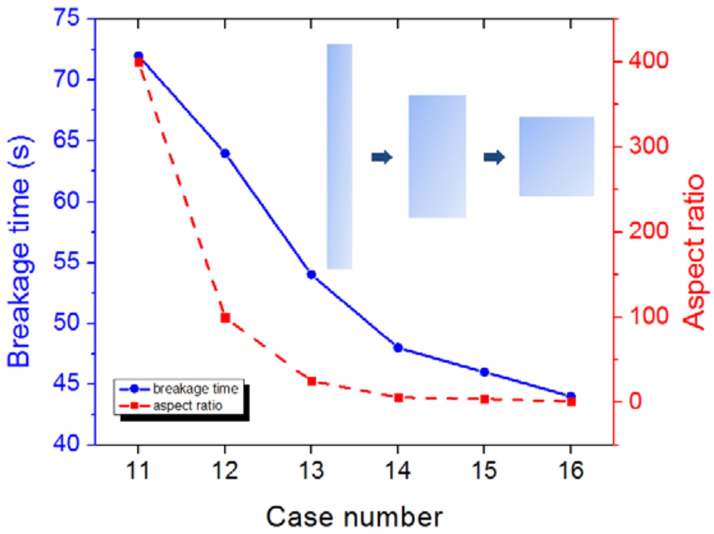
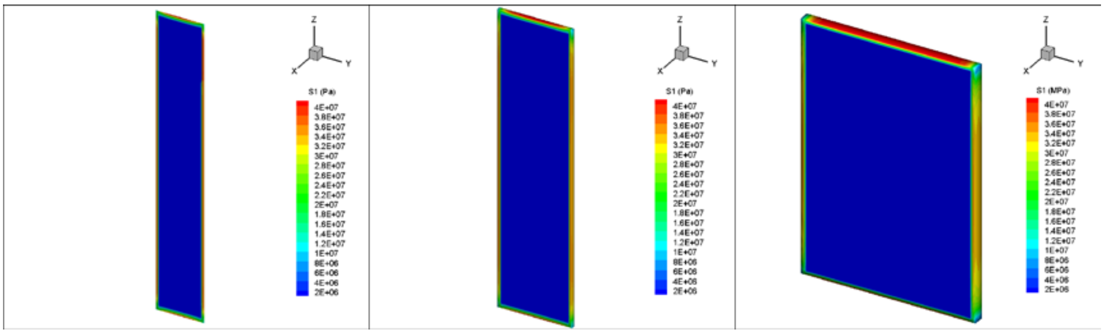
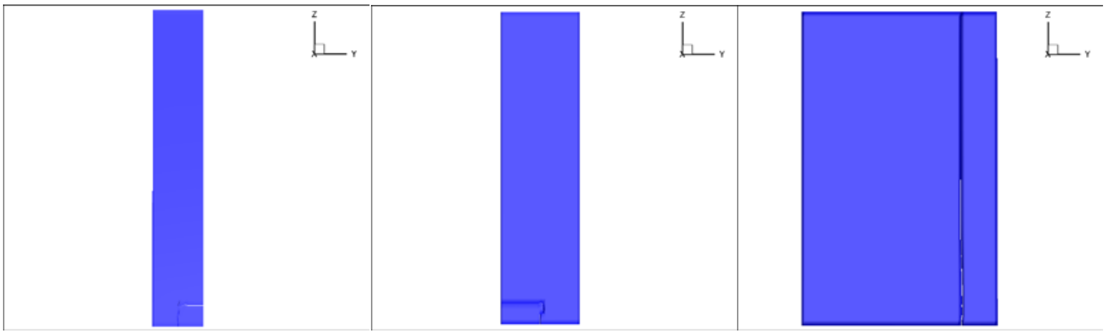


Fig. 7. The breakage time variance of glass panes with aspect ratios.

Cracks are initiated in all cases when the maximum stress reached around the glazing tensile strength, as shown in Table 4. In addition, the maximum stress normally locates at the areas of glass edges no matter how the aspect ratio changes. Figs. 8(d)(e)(f) presents the crack paths of Cases 14-16, in which all the positions of crack initiations are at the lower edges. The glass panels in other cases also cracked in this way. Nevertheless, among Cases 11-16, the crack propagation through the whole pane, causing the whole pane failure, only occurred in Case 16 whose aspect ratio is minimum. In other cases, due to the comprehensive stress in the central areas, the crack would like to turn the spread direction after a short propagation towards the center. This will not form large islands relative to the long edges, and thus cannot make a serious failure as the square panel or the rectangular panel with small aspect ratio. Therefore, increasing the aspect ratio not only significantly increases the breakage time, but also reduces the risk of whole failure and fallout occurrence.



(a) Stress distribution, Case 14 (b) Stress distribution, Case 15 (c) Stress distribution, Case 16



(d) Crack path, Case 14 (e) Crack path, Case 15 (f) Crack path, Case 16

Fig. 8. The first principle stress distribution and crack path, Cases 14, 15 and 16.

4. Comparison and discussion

From the numerical simulations, it was established that both the glass pane size and aspect ratio have a significant influence on the fire performance of glass façades. During the calculations, the mesh size is controlled identically in Cases 1-10; the mesh number is the same in Cases 11-16. As the dimension and aspect ratio change significantly in the present simulations, the mesh effect cannot be ignored. To further verify the conclusion, additional five cases were designed in which the number of meshes was kept the same (7200) although the glass size changes, as shown in Table 5. The breakage time predicted in Cases 17-21 are respectively 68 s, 67 s, 63 s, 57 s, 52 s. The result suggests that regardless of the mesh size and number, the fire resistance would degrade when glass pane size increases. The stress distribution and crack path are similar to those in Section 3.1. In addition, in the aspect ratio study, although the mesh numbers in Cases 11-16 are the same, the mesh size is different as the glass shape differs between cases. Thus, additional six cases, named Cases 22-27, are designed as well. All the mesh sizes are identical (0.003 m × 0.0167 m × 0.0167), as listed in Table 5. It was found that the breakage times gradually decrease from 118 to 49 s which confirms that the mesh size and number have no effect on the conclusion that fire resistance will be reduced with the aspect ratio decrease.

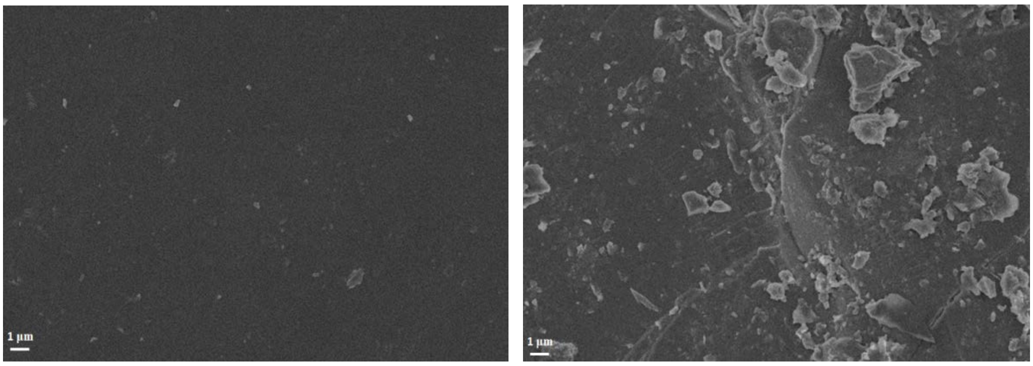
Table 5. The additional eleven cases.

Case number	Glass panel dimension (mm^3)	Aspect ratio	Mesh number	Breakage time (s)
17	100×100×6	1:1	60×60×2	68
18	200×200×6	1:1	60×60×2	67
19	300×300×6	1:1	60×60×2	63
20	400×400×6	1:1	60×60×2	57
21	500×500×6	1:1	60×60×2	52
22	20000×50×6	400:1	1200×3×2	118
23	10000×100×6	100:1	600×6×2	68
24	5000×200×6	25:1	300×12×2	54
25	2500×400×6	25:4	150×24×2	51
26	2000×500×6	4:1	120×30×2	50
27	1250×800×6	25:16	75×48×2	49

From the numerical results, it was found that the maximum stress normally exists at the glass edge. Meanwhile, glass strength depends strongly upon the treatment and handling of its surface [36]. The flaws and cracks would significantly result in weakening and failure in brittle materials. Scanning Electron Microscope (SEM) tests were herein conducted and the micro defects were found on the clear surface and edge cross section, as shown in Fig. 9. It can be seen that a large number of micro defects randomly distribute, especially severe existing on the unpolished edge cross sections, where macrocrack may be formed very easily under tensile stress. According to fracture theory, the relationship between critical strain and micro-cracks is [37]:

$$\varepsilon_b = K\left(\frac{\gamma}{EC}\right)^{\frac{1}{2}} \tag{4}$$

where ε_b is the critical breakage strain, *E* is modulus of elasticity, *C* is the size of microcrack, *K* is a constant and γ is breakage energy. This equation shows that glass critical strain decreases with the increase of the microcrack size. Thus, the random distribution and size of microcracks lead to different critical breaking stresses. When subject to a fire, due to stress concentration around these microcracks [35], the tensile strength is much easier to be achieved than comprehensive strength, hence the location of macroscopic crack initiation is very scholastic. Meanwhile, microcracks have a significant influence on the crack propagation direction.



(a) SEM image of glass surface (b) SEM image of glass edge cross section

Fig. 9. The distribution of flaw on glass surface and edge.

Once a crack is initiated in a glass pane, it will normally fail, so the breakage of glass can be analyzed by the weakest link theory [38]. According to the Weakest-Link Discrete Model, the failure probability of a chain as whole is [39]:

$$P_f(\sigma) = 1 - e^{-NP_1(\sigma)} \quad (5)$$

where N is the element number, P_1 is the possibility of failure of one element, and P_f is the failure possibility of a chain. For the glass panel in fire, it can be assumed to be a continuous, homogeneously stressed body and $N=V/V_r$, where V is the volume of the glass panel and V_r is a representative volume of glass. Then, Eq. (5) can be changed to:

$$P_f(\sigma) = 1 - \exp[-\frac{V}{V_r} P_1(\sigma)] \quad (6)$$

This equation can be applicable to glass that is brittle and contains some kind of randomly distributed flaws or defects. As there is no intrinsic size scale, the “size effect” of glass can follow the Weibull’s classical formulation, which is different from concrete and other quasi-brittle materials [40]. As larger panes contain more flaws than smaller ones, its possibility is increased as each flaw has a small probability of failure. Therefore, the failure of glass in fire is dependent on the panel volume or dimension, and with the dimension increasing, the possibility will increase correspondingly.

Both the probabilistic (weakest link) and deterministic (stress distribution) analysis suggest that larger glass panes are more prone to breaking in a fire than a small one. However, to the authors' knowledge, there is no experimental study that focuses on the effect of glass size and aspect ratio on its fire performance, although the importance of this issue has been emphasized by some researchers [23, 34]. Mowrer [41] conducted small and large-scale tests, respectively employing glass panes with the size of 390 ×280 mm^2 and 810×610 mm^2. Almost all breakage times of large glass panel were smaller than 50 s that is much smaller than that of a large glass (normally more than 100 s. The very limited data can support the numerical results. However, as the focus of the previous work was not the glass dimension and aspect ratio, the experimental conditions and other variables were not controlled strictly. Meanwhile, the numerical simulation in this work assumes the glass panel to be imposed by uniform thermal loading, considering the smoke layer and fire characteristic, more experiments need to be performed in the future to investigate this issue.

5. Conclusions

In this work, two glass panels with different dimensions were heated under uniform radiation condition in experiments. The measured temperature and breakage times were employed to verify the effectiveness of size effect analysis of glazing using the in-house FEM software. After validation, a total of 27 numerical cases were designed to investigate the influence of glass size and length-to-width aspect ratio on the fire performance of glass façades. The glass size changed from 100×100 to 1000×1000 mm^2 and the aspect ratio from 400:1 to 25:16. The important parameters, in terms of the first principle stress distribution, breakage time and crack path were predicted. The primary conclusions are as follows:

1) The glass panel dimension has a significant influence on the glass fire performance: the fire resistance of glass panel will be monotonically decreased when the size increases or the aspect ratio decreases.

2) The mesh size and number do not affect the numerical results concerning the glass size and aspect ratio, which confirms the reliability of the calculation.

3) Based on the randomly distributed flaws and defects on glass surface found in SEM tests, weakest link theory was confirmed suitable for the explanation of the dimension effect on glass fire performance, which can substantially support the numerical results.

4) The experimental results in the present and previous work provide evidence of dimension effect on glass fire performance. The numerical simulation is the first step, much more experiments need to be conducted to quantitatively reveal this issue.

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