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**Yu. Rodichev**

*G. Pysarenko Institute for problems of strength of NAS of Ukraine*

# STRUCTURAL STRENGTH OF GLASS AND IMPACT OF SCALE FACTOR

***Summary.*** *Glass is a typical elastic brittle material with a predominant influence of glass surface state on the damaging, fracture and strength of the elements under thermo-mechanical loading. Basing on the continual mechanics as well as on fracture mechanics there were analyzed the regularities of a structural strength for sheet float glass under different modes of stress state. It was shown that fracture resistance, strength and resource of glass structural elements depend on structure of surface cracked layer first of all. This layer is formed during the production of float glass, as well as under the glass cutting and machining of the details. The defects and micro-cracks in this layer are not in the constant state. Their sizes and shapes change permanently in the result of diffuse and localized damaging of the glass surface under the production and installation operations, and under the influence of normal and extreme operation conditions. There were analyzed the experimental methods of structural strength of glass plates evaluation under the bending. The paper shows the need to consider the influence the size of defects in the surface of samples and components during mechanical testing of the structural strength of glass. It was obtained that the depth of critical technological defects, which are typical for large size architectural glass parts is significantly larger than the depth of cracks formed under processing of conventional small and standard specimens for strength control. So the results of these specimens' tests don't reflect the factual values of building structures made of float glass.The use of large specimens with a length up to 3.2 m or more for the experimental estimation of surface quality and the real strength of structural components of sheet float glass is more effective than the use of standard techniques, which specify the use of small samples. To estimate the strength of glass beams with vertical load-bearing plates test method with bending the plates in vertical position is recommended. These methods were proposed for the use at the implementation of complex technical approach for the guaranteeing of required strength and durability of the architectural glass structures. This technical approach was realized in the building industry. It includes the special set of the mechanical tests of small specimens and large size samples of glass with the dimensions comparable with real glass constructions. The full scale experiments on the real building structures may be made to obtain the important data on surface state, types and sizes of typical damages and critical parameters of surface micro-cracks. The estimation of real strength level and durability of load-bearing glass structures was made basing on the results of mechanical tests and micrographs of specimens and structural elements with a fracture focus analysis. The results may be used for the development of glass technology and structures optimized basing on strength and durability parameters.*

***Key words****: sheet glass, surface cracked layer, micro-cracks, damaging, structural strength, scale factor, resource.*

**Ю. Родічев**

# КОНСТРУКЦІЙНА МІЦНІСТЬ СКЛА ТА ВПЛИВ МАСШТАБНОГО ФАКТОРА

***Резюме.*** *Скло є пружним крихким матеріалом з переважним впливом стану поверхні на пошкодження, руйнування та міцність елементів при термомеханічному навантаженні. З позицій континуальної механіки та механіки руйнування розглянуто закономірні особливості конструкційної міцності листового скла при різних видах напруженого стану. Показано, що опір руйнуванню, міцність і ресурс скляних елементів, в першу чергу, залежать від структури поверхневого тріщинуватого шару, який утворюється при виготовленні базового флоат скла, вирізуванні та обробленні деталей і постійно змінюється під час виготовлення, монтажу та експлуатації конструкцій внаслідок поступового розсіяного та локалізованого пошкодження і підвищення дефектності поверхні. Встановлено, що глибина технологічних дефектів, які призводять до зменшення міцності великогабаритних елементів зі скла, є значно більшою, ніж мікротріщини, що є джерелами руйнування традиційних малих та стандартних зразків при контрольних випробуваннях міцності будівельного скла. Запропоновано технічний підхід до експериментального оцінювання конструкційної міцності листового скла з урахуванням неоднорідності критичних поверхневих дефектів, впливу масштабного та інших визначальних факторів, який рекомендовано для використання у лабораторних та виробничих умовах* *для забезпечення належної міцності та ресурсу великорозмірних будівельних конструкцій. Обґрунтовано необхідність збільшення довжини зразків флоат скла до 3,2 м та більше, щоб підвищити достовірність прогнозування міцності та ресурсу великорозмірних будівельних конструкцій. Для оцінювання міцності скляних балок з вертикальним розташуванням несівних пластин рекомендовано метод випробування пластин на згин у вертикальному положенні.*

***Ключові слова**: листове скло, поверхневий тріщинуватий шар, мікротріщини, пошкодження, конструкційна міцність, масштабний фактор, ресурс.*

Glass refers to a specific class of elastic brittle materials, which may possess high strength, reliability and durability in the load-bearing structures under certain conditions. In a difference of usual constructional materials the structural strength of glass as well as of the ceramics, glass-ceramics and other elastic brittle materials is not stable characteristic. The structural strength of glass changes significantly under the influence of many technological, constructional and operational factors. Therefore, a reliable estimate of structural strength of glass in the design of durable load-bearing constructions can be made only on the basis of a holistic set of experimental results that reflect the actual impact of these factors. The fundamental results on structural strength of glass were obtained by solving the problems of strength when creating deep technical equipment and other carrying structures made of glass and ceramics for extreme operation conditions [1 – 6]. It has been found difficult to predict a significant reduction in the strength of glass while increasing sizes of products associated with a complex effect of the scale effect.

The goal is to analyze structural strength of glass taking into account scale factor and the development of technical approach to increase reliability of prediction of large-size architectural structurs carrying capacity.

In the result of the technical progress in the production technology of large size plates made of float glass as well as in the glass processing, physical, chemical and heat strengthening the transparent and strong functional and load-bearing glass structures are used widely in the modern architectural constructions, aviation and other kinds of transport glazing and techniques [7-9]. In the design and operation of glass structures there are new challenges related to improving their safety, carrying capacity and with the uncertainty of the real level of strength due to the lack of proper control of the strength parameters in manufacturing taking into account the influence of scale factor.

Specific mechanical behavior of glass in the load-bearing structures is connected with significant features of its amorphous structure, predominant influence of surface defects on the mechanical properties of glass as compared with other brittle materials (see Table 1).

**Table 1**

Mechanical properties of glass and some other brittle materials

| Properties | Float glass | | | $Al_2O_3$ ceramics | Porcelain | Cast iron СЧ35-56 |
|---|---|---|---|---|---|---|
| | annealed | tempered | chemically strengthened | | | |
| Young's modulus E•10 $^{-5}$,МПа | 0.7 | 0.7 | 0.7 | 3.1 | 0.7 | 1.45 |
| Poisson's ratio | 0.22 | 0.22 | 0.2 | 0.25 | 0.23 | 0.25 |
| Fracture resistance $K_{IC}$, MPa√m | 0.5…0.7 | 0.5…0.7 | 0.5…0.7 | 2,0…5,0 | 0,7…1,0 | 7…20 |
| Depth of surface cracks, μm | 10…150 | 20…150 | 0.15…0.6 | 10…200 | 20…500 | 500…1000 |
| Tensile strength, MPa | 20…70 | 120…200 | 400…1000 | 100…200 | 35…50 | 320 |
| Bending strength, MPa | 40…200 | 150…300 | 700…2000 | 300…400 | 50…150 | 520 |
| Compressive strength, MPa | 1000…2200 | 1500…1900 | 2000…500 | 2000…3500 | 600…2000 | 1200 |
| Limiting tensile strain, % | 0.03…0.1 | 0.14…0.45 | 0,55…1.45 | 0.03…0.06 | 0.04…0.07 | 0.22 |
| long-term bending strength, MPa | 10…30 | 80…150 | 200…500 | 200….300 | 30…90 | 500 |

High Young's modulus of glass doesn't changes at the tension and compression of structural elements up to stress 2000…3000 MPa. Low level of the tensile and bending strength and the significant variations in the strength as compared with ceramics and other brittle structural materials are characteristic of glass. This is due to the influence of cracked surface layer, which is very heterogeneous in the degree of imperfection. A typical range of the depth of surface microcracks 10...150 microns is not controlled in detail by manufacturers of glass. Main features of the glass are very high brittleness and the absence of the plasticity near the stress concentrators and cracks. The critical value of the fracture toughness coefficient $K_{IC}$ is lowest and not exceeds 0.5…0.7 MPa in the result of that. The low level of fracture toughness $K_{IC}$ is the cause of raised and difficult to control damaging of the detail surface.

Lower values of strength were obtained for large size structural glass elements such as rods, beams, plates and shells with enlarged depth of surface microcracks and damages in the result of scale effect influence.

Next important peculiarities of glass structure and mechanical properties were identified under the study of strength shells, plates and other structural elements [7 – 11]:

- very small depth of critical surface cracks and problem of their detection under glass structure production and use;
- lower values of tensile and bending strength of annealed glass elements are several times less the average level and directly linked with the largest technological and operational defects in the surface of the glass structural elements;
- low fracture strength of the glass surface upon contact with hard objects results in the creation of critical microcracks and damages of structural elements in the mechanical and thermal treatment as well as during careless operation;
- extremely low ultimate strain in tension and bending (0.03…0.1%) leads to the destruction of structural elements at small strains and displacements, as well as low thermal shock resistance;
- many technological, constructional and scale factors influence on strength and carrying capacity of glass members significantly and can lead to difficult to predict effects and fracture of glass elements;
- long-term tensile and bending strength of annealed glass elements is about 2…3 times lower than strength under short time loading.

Some of mentioned features and shortcomings can be overcome using the thermal, physical and chemical strengthening. The greatest effect of the use of technological methods of strengthening can be obtained in structures which operate in tension and bending under prolonged static and cyclic loading.

The special technical approach was developed to optimize the structural strength of glass control in the laboratory and production line conditions taking into account the demands for architectural and transport glazing. The main objective of the creation of this approach was the consideration of the effect of the scale factor, which takes into account the impact of technological surface defects generated in the production of float glass and during the large size glass element processing and strengthening treatment. Some features of the implementation of this approach in an experimental evaluation of the structural strength of large size glass structures are discussed below.

The structural strength of architectural glass depends on the sizes of currying elements and type of load. The lager glass specimens the less mean and lower values of bending strength [12]. The non-controlled “hidden” technological defects and damages such as surface micro-cracks with a depth about 20…100 µm formed under the glass element processing and handling are the main fracture sources under thermal and mechanical loading of the building structures [13, 14]. The currying capacity of glass structures depends on lower strength values connected with the biggest surface defects, which are the result of glass processing quality [13 – 15]. The larger glass element the larger the probability of deeper surface micro-cracks forming under the mechanical treatment and the lower strength values can be realized in the building structure in service conditions. The bending test of specimens in standing position gives significantly lower mean and bottom limit of strength data in comparing with test of laying specimens [12 – 14]. The results of experimental evaluation of the structural strength of architectural glass and parameters of technological surface defects with influence of scale factor and mode of specimen loading are analyzed. It is shown that method based on the bending tests of standing large size plate specimens (length 3.2 m) is more effective than tests of standard and special small specimens for assessment of the allowable stress at the design of building structures .

In estimation of the bending strength of glass various small-sized samples as rods and plates are commonly used [1, 13, 14]. For architectural units larger standard plate specimens of glass (thickness 3…19 mm, length of the working part not more than 200 mm) under pure bending tests are investigated [15, 16]. Standards EN 1288-3:2000 and EN 12150-2:2004 provide tests of plates with dimensions of 1100 x 360 mm. The test method involves the horizontal arrangement of the plates. Small length of the working part of these samples does not allow to reliably estimate the lower values of the bending strength at a given low probability of failure. Therefore, the number of specimens is increased and statistical parameters of the experimental distribution curves are used to improve the reliability of the results when designing glass architectural units [12, 15]. The minimum tensile strength value at a given probability of failure, which is prepared using mono-and multi-modal statistical Weibull distributions, is used in order to determine the quality of the diamond abrasive machining of glass elements end faces and edges on high performance multi-spindle machines and to make informed choice of working stresses [1, 13]. The expenses on the tests rise significantly when number of specimens increases more than 30…50 pieces. But, despite this, the results of the small specimens' tests give not possibility to evaluate authentically the influence of larger defects which can be formed under mechanical treatment of massive large glass parts with increased contact loads and heavy operation conditions. The significant part of surface edge defects placed in compressed side of the glass under the bending tests in laying position of specimens can not be detected using small and standard specimens. The accuracy of the experimental results obtained with the use of these specimens testing is insufficient on this reason as well.

In beam type structures glass plate are positioned vertically to improve the bearing capacity of the structure. n this case of bending, machined edge of achitectural structural elements are located at the tensioned zone is under stresses close to uniform tearing. In contrast to the horizontal plates all possible major defects of processing end faces and chamfers as micro-cracks, chips, point defects on both sides of the plate undergo the maximum stress level. The lower strength data are mentioned in the result of that. They show more realistically the expected load-bearing capacity of architectural glass parts taking into account the influence of scale and technological factors. The specific mechanical behavior of specimens and building glass elements loaded in staying position under the bending were studied in the paper.

To estimate better the impact of scale and technological factors in the design of glass architectural beams and other structure elements, as well as to select a reliable lower strength values the statistical analysis of the results [12] obtained in tests of some series of specimens of sheet float glass in the form of plates of different sizes (see table 2), cut from a single sheet of glass “Jumbo” 8 mm thick with a width of 3.21 m was made.

**Table 2**

Sizes of specimens and parameters of the bending tests (see figure 1)

| Test parameters | Sizes of plates, м | | | |
|---|---|---|---|---|
| | 3,21x 0,321 | 1,6 x 0,16 | 0,8 x 0,08 | 0,4 x 0,04 |
| Length of working | | | | |

| | | | | |
|---|---|---|---|---|
| part *l*, m | 0,9 | 0,45 | 0,225 | 0,1225 |
| Distance between lower supports *L*, m | 2,8 | 1,4 | 0,7 | 0,35 |

To place all possible coarse defects of machining edge within the working part under the same level of tensile stresses $\sigma_{max}$, the specimens were tested in vertical position (figure 1). After cutting edges of specimens were ground to form a chamfer and polished by the regimes adopted for the automated processing of large glass architectural elements on multi-spindle machines by diamond wheels with proper granularity.

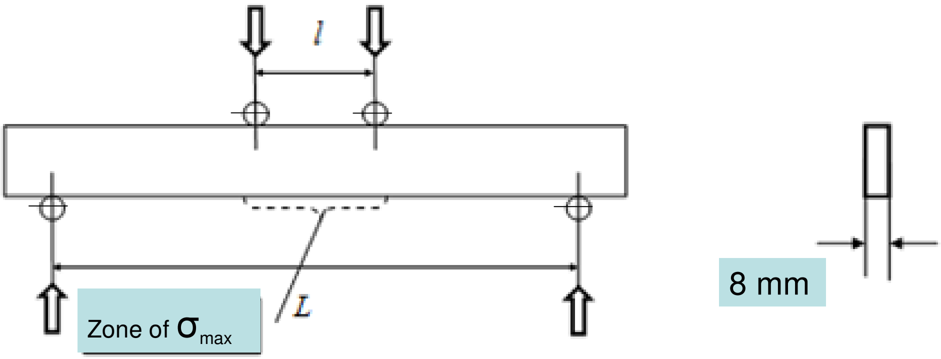

**Figure1.** Scheme of tests for staying specimens of 8 mm float glass

The results of tests and the estimation of minimum tensile strength under bending on the basis of bimodal and unimodal approximation of the experimental Weibull curves are given in the table 3.

**Table 3**

Results of the tests of the staying and laying specimens under bending

| Statistical parameters | Bending strength of the glass plates with different sizes, MPa | | | | |
|---|---|---|---|---|---|
| | length 3,21m | length 1,6m | length 0,8m | length 0,4m | |
| Strength of the plates | 27,73/65.48* | 62,65 | 54,83 | 49,92 | 64,15 |
| | 33,26/56.25* | 41,76 | 49,12 | 59,69 | 59,96 |
| | 33,12/60.21* | 53,17 | 57,61 | 58,29 | 64,43 |
| | 34,92/51.42* | 62,85 | 56,64 | 60,52 | 54,67 |
| | 34,90/40.8* | 49,92 | 51,21 | 60,24 | 53,27 |
| | 34,19/ - | 46,12 | 54,13 | 59,69 | 52,43 |
| | 34,54/ - | 40,11 | 51,91 | 56,90 | 54,94 |
| | 36,30/ - | 39,07 | 57,19 | 57,45 | 57,73 |
| | | 51,03 | 55,80 | 64,43 | 59,41 |
| | | 44,67 | 54,69 | 53,83 | 53,55 |
| Mean value, MPa | 33,6/ 54.8* | 49,1 | 54,3 | 57,8 | |
| Coefficient of variation, % | 7,7/17.1* | 17,4 | 5,1 | 7,1 | |
| Minimal value, МПа | 27,73/40.8* | 39,07 | 49,12 | 49,92 | |

| | | | | |
|---|---|---|---|---|
| Minimal value for probability 5% (be-modal Weibull curve) | **27,0** | **38,0** | **48,0** | **49,0** |
| Minimal value for probability 5% (mono-modal Weibull curve) | 30,1<br>(+11%) | 29,8<br>(-22%) | 46,2<br>(-4%) | 47,3<br>(-4%) |

* Data for tests of laying specimens

** Difference from bimodal Weibull curves is given in brackets

The results of the statistical data processing are presented in figure 2. Shape of the experimental distribution curves for all types of specimens is bimodal, reflecting the presence of two types of determinative technological edge defects. The major part of processing defects is approximated by almost unimodal shape of the curve with different slope, reflecting the degree of homogeneity of technological defects which determine the strength of the plate's edges. For the small size plates (length 0.4 m and 0.8 m), the quality of treatment can be high. The scattering of data is small and has a small coefficient of variation of 5 – 7%.

Increasing the length of parts up to 1.6 m leds to higher spread and reduction of the tensile strength per 49MPa. This is due to the increased risk of formation of coarse edge machining defects that reduce the minimum strength up to 39 MPa. The slope increased and the coefficient of variation rose to 17%.

The use of larger samples in the form of plates with a length up to 3.2 m led to higher probability of detecting the most serious technical defects. Average and minimum levels of strength decreased significantly and reached 33 MPa and 27 MPa, respectively. In this case, the uniformity of surface edge defects increased again, the scattering reduced and coefficient of variation decreased to 8%.

The need to consider the deviation of the lower values of strength from the linear mono-modal shapes of the Weibull curve (represented by solid lines) at probability of failure less than 25% is obvious. Positions 1 – 4 show the experimental curve pieces plotted taking into account a significant deviation of the lower strength values (dashed lines).

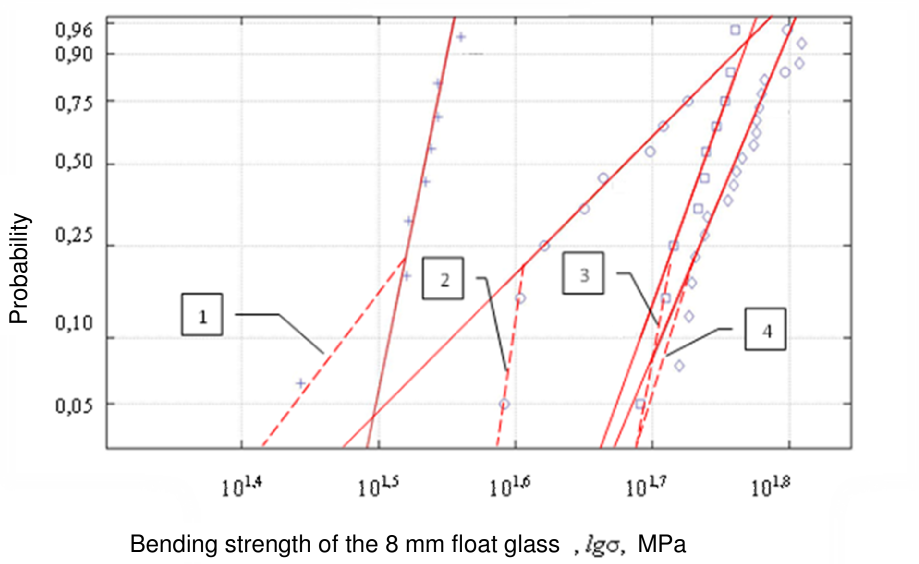

**Figure 2.** Experimental Weibull curves for standing specimens with a different length (1, 2, 3 и 4 – lower parts of bimodal mode of the curves for length – 3.2; 1.6; 0.8 and 0.4 m)

Table 3 shows the results of the assessment of the lower boundary of strength at failure probability of 5%, made on the basis of refined form of the lower parts of the experimental Weibull curves (position 1 – 4). Comparing these results with those obtained on the basis of mono-modal shapes of the Weibull distribution, shows the lack of reliability of the latter. The error can reach 11 – 22%. It will still grow in assessing the lower bound of strength for the probability of failure less than 1%, which is usually taken in the design of responsible load-bearing structures of glass in building.

Strength of annealed glass under short time bending and tension depends on shape and depth of the largest technological surface micro-cracks placed in the working part of structural elements with maximal level of stress. According to linear fracture mechanics (LFM) the tensile breaking stress σ perpendicular to the crack with the initial crack depth $b_0$ can be calculated using the critical stress intensity factor $K_{IC}$ and factor γ which is concerned with the crack geometry and loading conditions

$$\sigma = \frac{K_{IC}}{y\sqrt{b_0}}. \qquad (1)$$

So the depth of critical micro-cracks created under mechanical treatment of the edges of glass plates can be evaluated by formula

$$b_0 = \left(\frac{K_{IC}}{y\sigma}\right)^2 \qquad (2)$$

Figure 3 shows the fracture source at the sharp edge of glass specimen blunted with the ground chamfer 0.7 mm x 45º. The long surface cut with the depth about 30 μm was detected in the result of micrograph analysis of the fracture source in the mirror zone of the fracture surface of the specimen tested in lying position at the 4 – point bending. Critical value of stress intensity factor $K_{IC}$ for this glass was 0.45 MPa√m. Calculated value of factor γ for long surface crack in plate lying specimen under the bending was 1.8.

Basing on the equation (2) and in view of the value factor $K_{IC}$ for high quality float glass can be about 0.5 ± 0.05 MPa√m it is possible to assess preliminary the depth of the technological edge cracks for specimens with the different sizes tested in standing position.

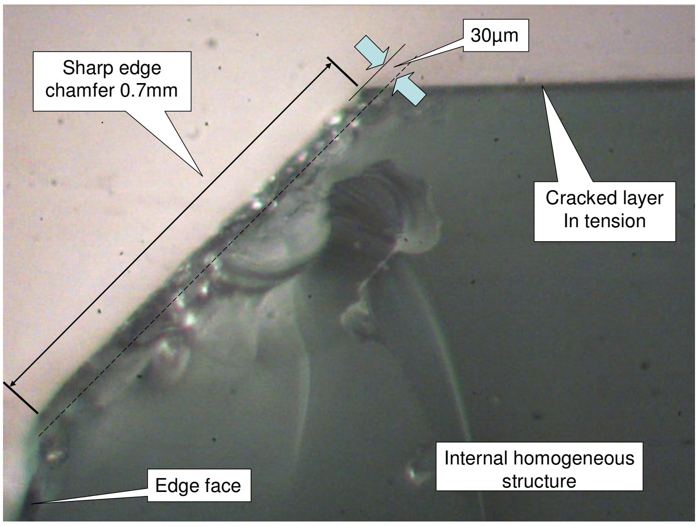

**Figure 3.** Technological edge micro-crack in the fracture focus of glass plate tested under the bending in lying position

In accordance with linear feracture mechanics the geometrical factor γ for the edge part of the plate under tension was calculated for different kinds of the surface cracks [17]:
- for a semicircular crack with a depth b and width 2c, b/c =1(figure 4)

$$y = \left(\frac{2}{\sqrt{\pi}}\right)\left[1 + 0{,}2\left(\frac{2\theta}{\pi}\right)^2\right] \qquad (3)$$

where θ - angular coordinate of a point on the counter of the crack relative to the normal to the plate surface, $\theta = 0$ for a deepest point of crack counter and $\theta = \pi/2$ for two surface points of crack counter;

- for a semielliptical crack with a depth b and width $2c$, $b/c = 1$, 0.5 and 0.1; $b \ll h$ and $b/h \approx 0$

$$y = \sqrt{\pi}\frac{\left[1{,}12 - 0{,}48\frac{b}{c} + 0{,}13\left(\frac{2\theta}{\pi}\right)^2\left(\frac{b}{c}\right)\left(\frac{3b}{c} - 2 - \frac{b}{h}\right)\right]}{\left[1 - \left(\frac{b}{h}\right)\left(1 - 0{,}75\frac{b}{c}\right)\right]} \qquad (4)$$

when $0 < b/c < 1$ , $0 < b/h \leq 0{,}4$ .

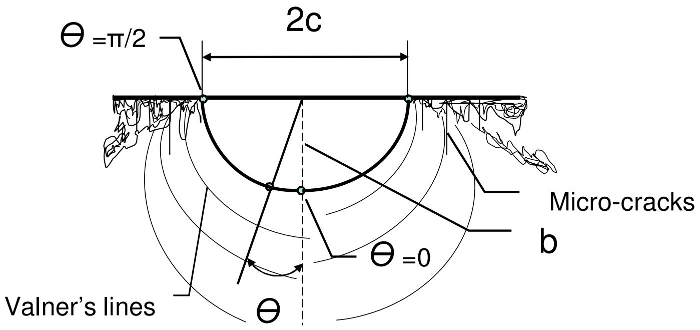

**Figure 4.** Scheme of semicircular surface crack and other micro-cracks of the surface cracked layer of float glass

The scheme shows: the fracture source – semicircular crack surface, other micro-cracks placed near it in the cracked surface layer of glass, Vallner's wavy lines on a smooth surface of the mirror fracture zones of glass, formed in the result of dynamic interaction of a counter of growing semicircular crack with other surface micro-cracks. It was shown using the results of micrograph analysis that the preferable direction of the crack growth is connected with movement of deepest point with $\theta = 0$ [18], where internal nanoscale amorphous structure of a glass is free from defects which hamper the growth of crack. The movement of both surface parts of the crack counter near the points with $\theta = \pi/2$ retards under the increased crack resistance of specific structure of cracked surface layer of a float glass. The shape of Vallner's lines reflects the specific post-critical movement of mentioned parts of surface crack contour (figure 4).

The shape of semielliptical surface crack in the fracture focus of float glass, fragments of surface cracked layer near the crack and preferable direction of crack growth are shown in the figure 5.

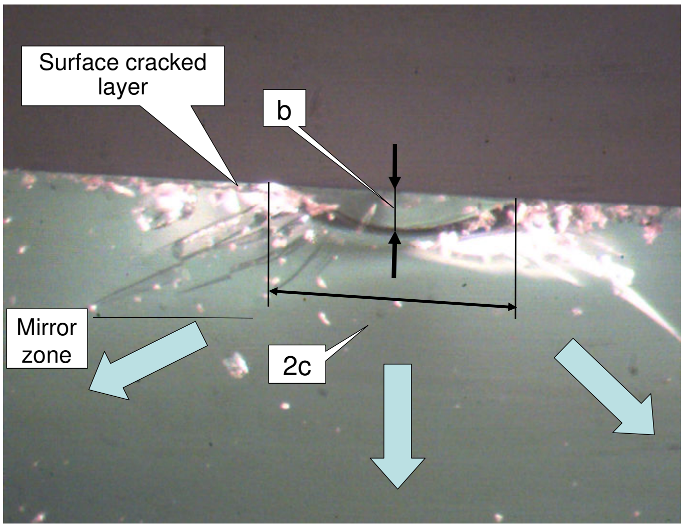

**Figure 5.** Semielliptical micro-crack with ratio $b / c = 0.4$

The calculated results of geometrical parameter γ assessment for different mode of surface micro-crack in fracture focus for standing plates under the tests are given in the table 4. There are presented the data for deepest point (θ = 0) and for two surface points (θ = π/2).

**Table 4**

Calculated values of geometrical parameter $y$ for different mode of surface micro-crack

| Shape of surface crack | Ratio $b / c$ | Position of point on a crack counter and factor $y$ | |
|---|---|---|---|
| | | deepest point, θ = 0 | two surface points, θ = π/2 |
| Semicircular crack,equation (3) | $b /c = 1$ | $y = 1.128$ | $y = 1.35$ |
| Semielliptical crack, equation (4) | $b / c \approx 1$ | $y = 1.134$ | $y = 1.365$ |
| | $b / c = 0.5$ | $y = 1.56$ | $y = 1.5$ |
| | $b / c = 0.1$ | $y = 1.9$ | $y = 1.86$ |

The higher value γ the less the strength of glass elements σ determined from equation (1) for critical micro-cracks with constant depth b. The set of technological factors connected with quality of float glass production line and factual technological modes, with glass element mechanical treatment and handling as well as with shape and dimensions of architectural glass parts influence the shape and depth of surface crack. So the use of mechanical tests for assessment of parameters γ and b dependent on quality of building glass elements is an important way to increase the building structures strength and to guarantee their durability and safety.

It was shown [2, 4 and 7] that lower data on glass strength are characteristic for specimens with long cracks having the shape closed to semielliptical crack with the ratio b / c ≤ 0.2…0.1. The maximal value of parameter γ about 1.9 is accepted for all points of the counter of these cracks. Minimal value of parameter γ = 1.128 is typical for deepest part of semicircular surface micro-crack counter (θ = 0). This type of short technological point defect leads to increasing the critical level of strength as compared with long cracks. It was decided to accept two values of $y$– minimum 1.9 and maximum 1.128 to assess the influence of crack type on the magnitude range of critical crack depth for specimens with the lower values of strength obtained in this study.

The calculated results of technological cracks depth assessment for different sizes of plates obtained basing on minimal strength values for bimodal Weibull curves (table 2, fracture probability 0.05) are given in the table 5.

**Table 5**

Depth of technological cracks depending on their mode

| Type of crack and parameter *y* | Calculated value of the critical crack depth for glass plates with different sizes | | | |
|---|---|---|---|---|
| | length 0,4 m | length 0,8 m | length 1,6 m | length 3,21 m |
| long cracks, $y = 1.9$ | 29.0 µm | 30.0 µm | 48.0 µm | 88.0 µm |
| short cracks, $y = 1.128$ | 82.0 µm | 85.0 µm | 136.0 µm | 270.0 µm |

It can be concluded from the data in the table 5 that quality of technology and factual regimes of architectural glass processing can influence significantly on lower boarder of structural strength of glass. The range of critical surface defects depth of large size glass elements is very wide – from 80 to 270 µm. Some of these defects like long thin cracks and the deepest point defects like short surface cracks can be detected under precise optical control and using the mechanical tests of building glass elements in production conditions.

Dependences of the lower limits of the bending strength at failure probability 5% on the length of specimens obtained basing on unimodal and bimodal versions of Weibull plots as well as the range of critical crack depth change are shown in figure 6.

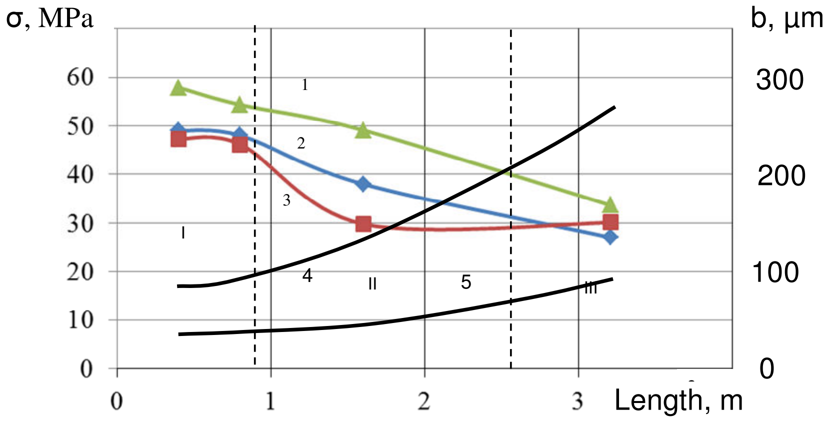

**Figure 6.** The dependences of the lower limits of the bending strength and depth of critical micro-cracks on the length of standing specimens: 1 – the average bending strength; 2, 3 – the lower limit of the strength for bimodal (2) and unimodal (3) Weibull curves; 4 – depth of short semicircular cracks; 5 – depth of long semielliptical cracks

It can be concluded from the data in the table 5 and figure 6 that depth of critical technological defects which are typical for large size architectural glass parts (range III in figure 6) is significantly larger than depth of cracks formed under processing of small and standard specimens for strength control (ranges I and II in figure 6). So the results of these specimens' tests don't reflect the factual values of building structures made of float glass.

**Conclusions.** Results of this study show:

When considering the conditions of loading of machined plates from sheet float glass the pieces of the experimental curves of distribution strength at failure probability ≤ 25% are significantly different from unimodal Weibull curve, accepted in calculation of strength of architectural glass components.

The use of large specimens with a length up to 3.2 m or more for the experimental assessment of surface quality and the real strength of structural components of sheet float glass is more effective than the use of standard techniques, which specify the use of small samples.

Because of significant differences of diamond processing conditions small samples do not reflect the quality and imperfection of large heavy construction components of glass. The estimation of bending strength, obtained in the result of such tests are overstated, because they do not take into account the features of the technology of machining of large glass products related to the increase of cutting force, rise of machining allowance, grinding depth.

For accounting the scale-technological factor in choosing operating stresses is recommended to use the minimum values of tensile strength with adequate probability of failure defined in the tests of large specimens-plates up to 3.2 m or more in the loading conditions typical for the designed building structures.

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