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# Load-bearing Behaviour of Laminated Tempered Glass with Reground Edges

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Designers use exposed glass edges to reach maximum transparency, for example within glass steps, glass beams or glass columns. These applications require mechanical finishing to achieve high optical quality and to compensate for the edge notch that results from the manufacturing process of safety glass. Regrinding of annealed glass is allowed without restrictions. In the case of glass with load bearing functions, tempered glass, heat-strengthened glass or fully tempered glass, is required. However, a risk of premature failure occurs when regrinding tempered glass because of a reduction of the compression zone at the edge. A research project at the Institute of Building Construction, Technische Universität Dresden, examined the impact of regrinding tempered glass on the load-bearing capacity of the glass edge. The study showed the load-bearing capacity decreased depending on the regrinding depth. Specifically, the study revealed a significant difference between the weakening of heat-strengthened glass and fully tempered glass due to the different inherent stress conditions of the different types of glass. Accordingly, regrinding heat-strengthened glass is possible up to a certain limit without critical weakening. To extend the previous studies, the project team conducted component tests on laminated glass beams manufactured from fully tempered glass and heat-strengthened glass with and without reground edges. The examination included tensile bending tests. The experimental results show the influence of regrinding on the load-bearing capacity of the glass components. This paper focusses on the evaluation of the component tests as well as the structural design. Moreover, the results of the pre-tests with single pane glass beams are presented and compared with the component tests. The research results will allow the utilization of structural glass elements with the highest optical quality in the future.

**Keywords:** Edge, Tempered glass, Regrinding, Laminated glass

## 1. Introduction

Many applications in structural glass constructions, such as stairs, parapets or beams, have to meet high structural, safety and aesthetic demands; therefore, the use of laminated glass is required. To increase the transparency of such construction elements, the edges are often exposed. However, in many cases laminated glass elements have a visible offset between individual single glass panes due to the manufacturing process. Table 1 shows the maximum allowed offsets in relation to the maximum dimension of the glass component of EN ISO 12543-5 table 5. The European standard requires that the maximum edge offset of laminated glass, which depends on the glass geometry, be less than 6 mm.

Table 1: Maximum allowed edge offset do according to EN ISO 12543-5 table 5.

| Length L or Height H [mm] | Maximum allowed offset $d_o$ [mm] |
|---|---|
| L, H ≤ 1000 | 2.0 |
| 1000 < L, H ≤ 2000 | 3.0 |
| 2000 < L, H ≤ 4000 | 4.0 |
| L, H > 4000 | 6.0 |

However, a displacement between the glass panes decreases the aesthetic quality of the glass element. If the load is systematic introduced into the edge, as is the case with glass beams, the edge offset causes a negative load-bearing behaviour due to eccentric load introduction. Regrinding the edges of laminated glass provides the opportunity to create a flat, transparent and aesthetic surface. Fig. 1 shows two laminated glass components with untreated edges on the top and with reground edges below. This comparison demonstrates the improvement of the visible edge quality. Thus, the potential to increase the transparency of the construction element by regrinding laminated glass components with exposed edges is high.

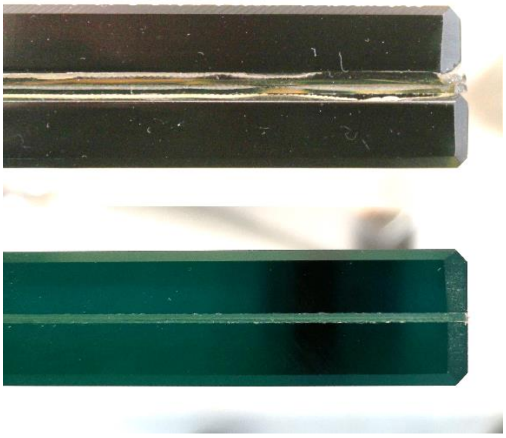


Fig. 1 Details of a laminated glass with an edge offset (top) and with a reground edge (below).

In the case of annealed glass, regrinding the edges of the laminated glass is allowed without restrictions. However, regrinding of tempered glass intervenes in the internal stress distribution and leads to a reduction of the compression zone. Previous research by Lohr et al. (2016) showed that increasing the regrinding depth reduces the load-bearing capacity of single tempered glass panes. As an extension to the previous research, components made of laminated and tempered glass were examined in four-point bending tests. The paper presents the testing procedure, the results and the transferability from single glass panes to laminated glass beams.

## 2. Basics

### *2.1. Regrinding tempered glass*

The production of tempered and laminated glass elements occurs in three steps. First, the annealed glass panes are cut and ground. Then, the glass panes are tempered as heat-strengthened glass (HSG) or fully tempered glass (FTG). The tempering process creates a tensile stress in the centre and a compression zone at the surface, which increases the load-bearing capacity. The third step is the lamination process, in which two or more glass panes are connected with the use of interlayers, such as polyvinyl butyral (PVB). To achieve a good connection, the lamination process is carried out at high temperatures, which causes the interlayer foil to transform into a viscous state and it begins to “swim”. Therefore, laminated glass elements could have an offset between the individual glass panes. Furthermore, the cutting and grinding of the glass before lamination could lead to deviations in the glass dimensions and angularity. This could induce an edge offset as well. Regrinding tempered glass results in an intervention in the compression zone at the surface of the edge. Thus, the load-bearing capacity decreases. Because of this intervention, it is possible that the grinding process causes major defects on the edge surface, which could lead to a premature fracture.
Fig. 2 shows the cross section of two individual pre-stressed glass panes with an offset. The stress distribution of the single glass panes show the tensile stresses in the centre and the compressive stresses at the surface. To obtain a smooth and transparent edge and compensate for the displacement of the individual glass panes, the minimum regrinding depth $d_{gr}$ equals the sum of the depth of the chamfer $d_c$ and the maximum edge offset $d_o$. The red line demonstrates how regrinding tempered glass intervenes in the compression zone at the edge $d_{(-),E}$. Because of the danger of reducing the load-bearing capacity by regrinding the edges of tempered glass, the EN 12150-1 and EN 1863-1 standards exclude tempered glass with reground edges. Thus, components made of tempered glass with reground edges are unregulated products.

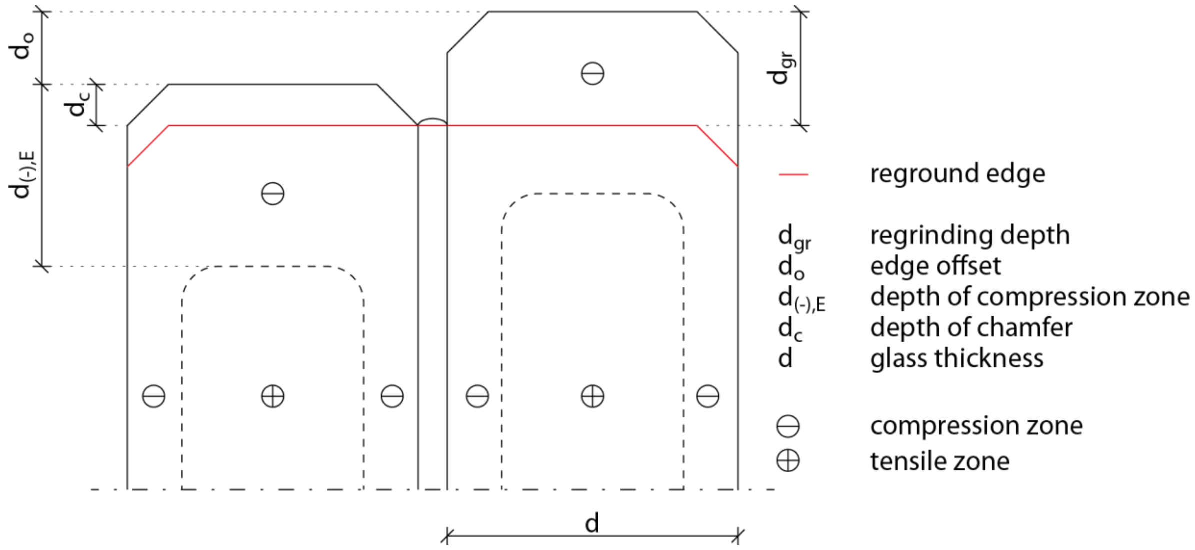



Fig. 2 Detail of an edge offset in a laminated glass including the residual stress distribution of the single glass panes.

### *2.2. State of the Art*

Glass constructions in public buildings such as shopping malls, cultural institutions or university buildings often show exposed edges that have an offset between the individual glass panes. Due to the exclusion of tempered glass with reground edges from the standards, planning with these components always requires an approval for individual cases. Previous research by Lohr et al. (2016) examined the influence of regrinding the edges of tempered glass on its load-bearing capacity. Single glass panes made of FTG and HSG were tested in a four-point bending test according to EN 1288-3 to determine the maximum tensile stresses. The thicknesses were 6, 8 and 10 mm. In total, there were ten specimens per series each with 1 mm, 2 mm, 3 mm reground edges and one group with untreated edges as a reference. To compare all results with each other, only the specimens with a thickness of 10 mm are considered. These results have not yet been published. For the specimens with 1 mm and more reground depth, the values for the FTG specimens with 10 mm thickness fall below the characteristic tensile strength of 120 N/mm². The mean value for the 3 mm reground specimens was 38 % lower than the mean value for the untreated ones. The results for the HSG specimens showed a similar behaviour. In contrast to FTG, the values for HSG did not fall below their characteristic tensile strength of 70 N/mm². The difference between the mean values of the untreated edges and the 3 mm reground series was 4 %. Based on the tests, it can be concluded that the compression zone and the compressive prestress are reduced by regrinding but the effect is much higher for FTG than for HSG.
Another study by Lohr et al. (2018) examined the influence of the regrinding process of tempered glass on the residual stress distribution at the edge. The tests were carried out with single glass panes with different thicknesses and reground depths. The depth of the compression zone and the magnitude of the surface stress at the edge were measured with photoelastic measurements. The results showed that the depth of the compression zone stays constant as the regrinding depth increases. In addition, the regrinding follows in a redistribution of the residual stress state at the edge. In contrast, the compressive stress at the edge surface decreased by to up to 35 % between the untreated specimens and the ones with 3 mm reground edges. Thus, the expectation that the compressive prestresses at the edge would be reduced by regrinding, which was based on the previous research (2016), was confirmed.
The first studies concentrated on experimental examinations on single-glass panes. We assumed that one of the glasses has to be reground with the highest regrinding depth. The following studies focus on laminated glass.

## **3.** Experimental studies

### *3.1. Approach*

Beams could be constructions with systematic load application into the edge. Consequently, an offset between the individual glass panes causes an eccentric load introduction. The load is introduced into one glass layer, which generates a shear stress in the interlayer foil. Thus, in addition to the negative aesthetic aspect, the displacement of the individual glass panes results in unfavourable mechanical behaviour. Therefore, regrinding of the edges provides the opportunity to create a smooth edge for a centric load application.
The experimental examinations included laminated tempered glass beams. First, the edge offset of the specimens was measured to get the dimensions and the minimum regrinding depth, which equals the sum of the maximum edge displacement and the depth of the chamfer. To examine the load-bearing behaviour of the beams before and after regrinding their edges, four-point bending tests were carried two times. EN 1288-3 regulates the setup and procedure of the test. The first test was non-destructive and carried out until the stresses at the edges of the beams reached the characteristic tensile strength. This test method ensures that no specimen had a defect on the edge that could cause a

premature fracture to allow comparisons of the stresses at the different edges. Furthermore, the difference between the stresses at both edges was measured to compare it with the measured edge offset. After the first test, all specimens were reground in steps of 1 mm until a maximum depth of 3 mm was reached. This process compensated for the displacement of the individual glass panes. After the regrinding process, the specimens were destructively tested using the four-point bending test to determine the fracture stresses at the edges.

### *3.2. Specimens*

According to EN 1288-3 and previous research, the dimensions were selected to be 1100 mm in the length and 125 mm in the height. Each glass pane had a thickness of 10 mm and the PVB interlayer had a thickness of 1,52 mm. Fig. 3 shows a specimen and its dimensions. Table 2 shows the types, the layer thicknesses and number of the specimens. In total, there were five specimens made of HSG and FTG.

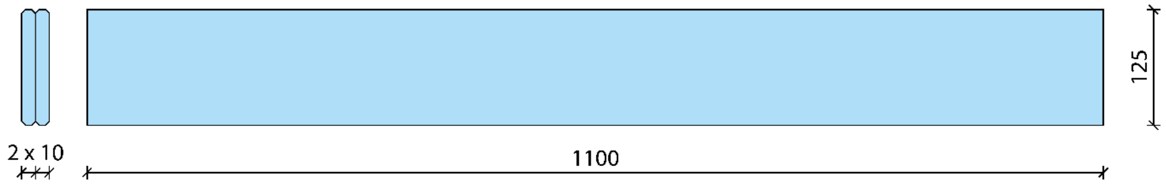



Fig. 3 Dimensions of the beams.

Table 2: Number of specimens.

| Glass type | HSG | FTG |
|---|---|---|
| Layers | 10 mm glass<br>1.52 mm PVB-foil<br>10 mm glass | |
| Number of specimens | 5 | 5 |

### *3.3. Experimental procedure*

First, the edge offset was measured at twelve points on each side of the beam (Fig. 4). The use of a dial gauge with an accuracy of 0.1 mm gave precise results. Fig. 5 shows a specimen that is fixed on the left and right sides and a dial gauge on the edge of the beam.

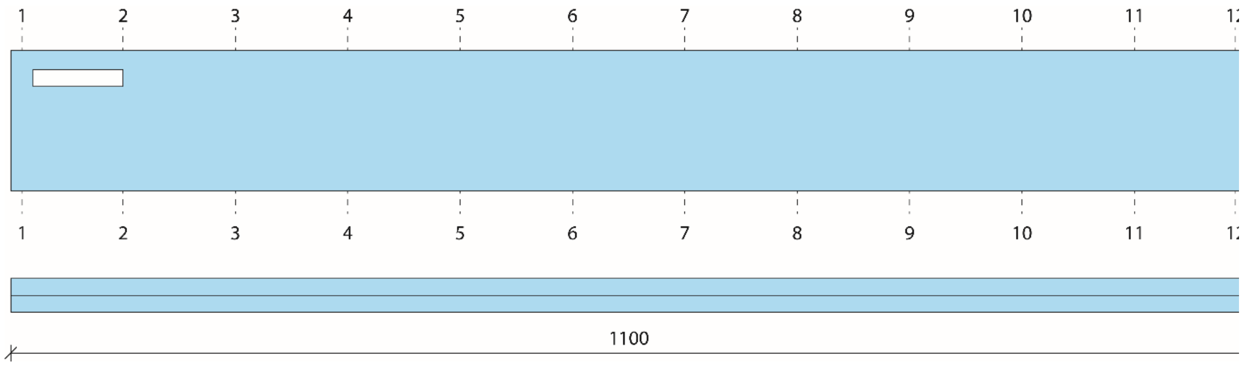


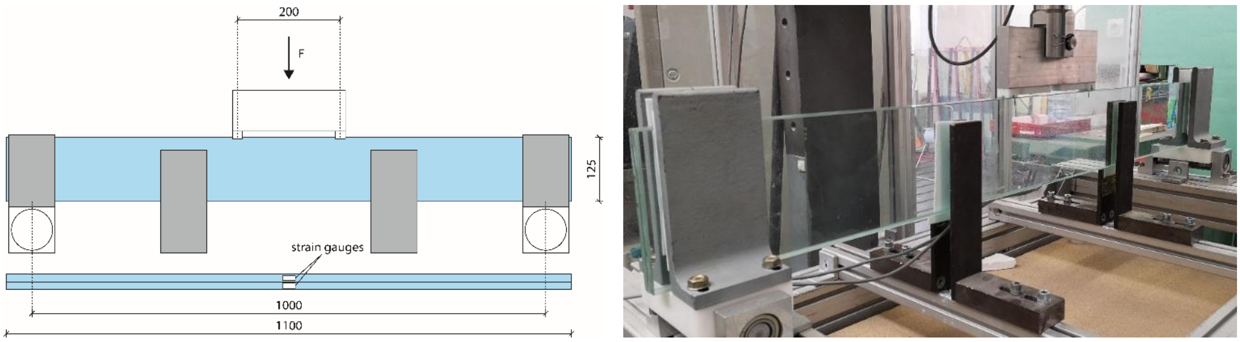

Fig. 4 Measurement of the edge offset and position of the strain gauges.

Fig. 5 Measuring the offset with a dial gauge.

The four-point bending test was carried out to examine the stresses of the specimens at the edges. This test is regulated in EN 1288-3 about the weak axis for glass panes with a length of 1100 mm and a width of 360 mm. To test the beams about the strong axis, the setup had to be modified, which can be seen in Fig. 6. This picture shows the schematic structure of the test (left) and the finished setup with a built-in specimen (right). The illustration includes a glass beam in a vertical installation. The bearing elements were pinned end using ball bearings. L-channels made of steel, arranged at four points, prevented the glass beam from buckling during the test. Strips made of polyoxymethylene (POM) prevented contact between the glass and steel at all points. POM-blocks were used for properly inducing the load into the top glass edge. The span of the bearing elements is 1000 mm and the distance between the two load introduction points is 200 mm.

Strain gauges were applied in the middle of each individual glass pane to obtain the maximum tensile stresses in the centre of the beam. Fig. 6 shows the position of the strain gauges on the bottom of the specimen. We compensated the edge offset at the upper side of the beam with a hard rubber interlayer between the load introduction and the glass. This results in a centric load application to the upper side while the bottom side stayed unaltered. Due to the eccentric load transfer into the supports because of the edge offset, the individual glass panes may carry different stresses. The stress difference due to the edge offset was examined. The test was performed until reaching the characteristic tensile strength of HSG (70 N/mm²) or FTG (120 N/mm²). The goal was to examine the relation between the edge offset and the expected difference between the tensile stresses of each individual glass pane. The second goal of the first run was to show that the edges of the glass panes had no defects, which lead to a premature fracture of the specimens.

The destructive run of the four-point bending test was carried out until failure of the specimens to examine the influence of regrinding the edges of the laminated glass.




a) b)

Fig. 6a) Schematic test set up, b) built-in specimen of the four-point bending test about the strong axis.

### *3.4. Results*

By measuring the edge offset, we gained precise knowledge of how the individual glass panes are positioned in relation to each other. Fig. 7 shows the schematic structure of the specimen in the four-point bending test with the two individual glass panes, the two supports on the bottom side, the load introduction on the upper side and the strain gauges on the bottom of the beam (sg). The right glass pane is glass 1 and the left glass pane is glass 2. Table 3 shows the results of the measured offsets of each specimen. The value is the difference between glass pane 2, which is the reference layer, and glass pane 1. A negative value means that glass pane 2 is overhanging. The course of the three values are not in a linear relation to each other, which means that the single glass panes are not straight over the entire length.

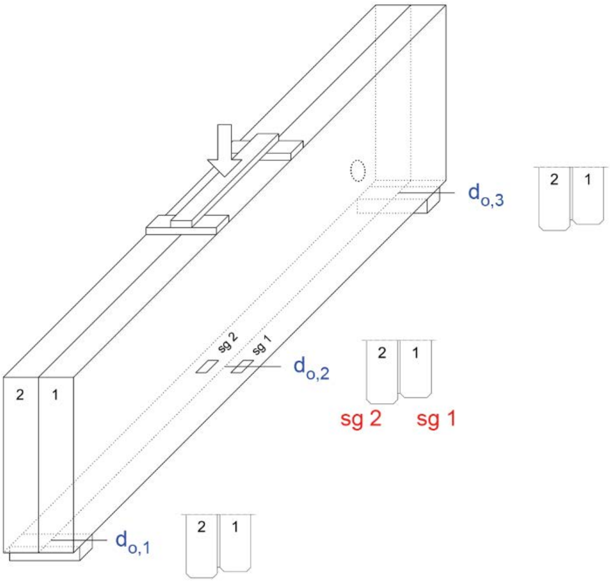


Fig. 7 Schematic structure of the specimen and the four-point bending test with d0 edge offset (blue) and sg stress on the strain gauges (red).

The global minimum offset $d_{o,2}$ in the centre is 0.1 mm and the maximum is 1.01 mm. Thus, all beams conform to EN ISO 12543-5, which specifies a maximum offset of 2 mm. The measurements show different types of the displacement. Almost all specimens have a constant negative or positive edge offset, which we define as the normal displacement. The measurement of specimen "HSG-02" shows a different offset along the length. This means that the individual glass panes were twisted in relation to each other.

Table 3: Edge offset at three points.

| Specimen | | Edge offset [mm] | | |
|---|---|---|---|---|
| Type | Number | $d_{o,1}$ | $d_{o,2}$ | $d_{o,3}$ |
| FTG | 01 | -0.35 | -0.52 | -0.76 |
| FTG | 02 | -0.37 | -0.27 | -0.49 |
| FTG | 03 | 0.44 | 0.28 | 0.59 |
| FTG | 04 | -0.60 | -0.33 | -0.72 |
| FTG | 05 | -0.32 | -0.17 | -0.49 |
| HSG | 01 | -0.54 | -0.16 | -0.35 |
| HSG | 02 | 0.36 | -0.10 | -0.02 |
| HSG | 03 | -1.00 | -1.01 | -1.10 |
| HSG | 04 | -0.10 | -0.22 | -0.08 |
| HSG | 05 | -0.09 | -0.10 | -0.02 |

In the non-destructive four-point bending test, the specimens were loaded until the characteristic tensile strength was reached. Table 4 shows the results of the edge stresses of each specimen. This includes the tensile stresses for both individual glass panes and the difference between the stresses. In addition, this table shows the edge offset $d_{o,2}$ in the centre of the specimen on the bottom side to compare it with the stress difference. In the last column, the difference per mm as a ration comparing the values is shown. We expected a higher edge offset to result in a higher difference of the edge stresses. In this non-destructive test, no specimen broke under the load. This proved that the beams had no major defects on the edges from the grinding process. The maximum difference between the stresses was 13.26 N/mm².

Fig. 8 shows two specimens with their edge offsets $d_o$ in blue at the fringes and in the centre of the beam. A cross section of the edge displacement at these three points is shown to provide a better understanding of the position of the individual glass panes relative to each other. The tensile stresses in the centre of the beam are shown in red. The first picture shows the beam with the maximum edge offset of 1.01 mm. This beam has the highest difference between the tensile stresses at the edge in the group of the HSG specimens. Glass pane 2 bears more load than pane 1 because of the high displacement of the individual layers.

The second picture includes the beam that has the individual glass panes twisted in relation to each other. The twisting can be seen in the different cross sections and values of the edge offset at the points of the supports. The minimum difference between the stresses reflects this twisting.

According to Table 4, the maximum difference between the stresses did not correlate to the highest offset. The beam "FTG-01" had the highest offset of the FTG specimens but a lower stress difference in comparison to the other ones. The values of the ratio of the difference of the stresses to the edge offset vary between 6 and 58 N/(mm² × mm). These values show that there is no clear correlation between the offset and the stress difference.

Table 4: Maximum tensile stresses of the non-destructive tests.

| Specimen | | Tensile stress in … [N/mm²] | | Difference | $d_{o,2}$ [mm] | Difference / mm |
|---|---|---|---|---|---|---|
| Type | Number | Strain gauge 1 | Strain gauge 2 | [N/mm²] | | [N/(mm² × mm)] |
| FTG | 01 | 108.88 | 117.97 | 9.09 | -0.52 | 16.83 |
| FTG | 02 | 119.69 | 128.05 | 8.36 | -0.27 | 29.86 |
| FTG | 03 | 129.24 | 119.34 | 9.90 | 0.28 | 36.67 |
| FTG | 04 | 118.57 | 131.84 | 13.26 | -0.33 | 39.00 |
| FTG | 05 | 119.01 | 128.82 | 9.80 | -0.17 | 51.60 |
| HSG | 01 | 69.38 | 74.93 | 5.55 | -0.16 | 37.01 |
| HSG | 02 | 72.49 | 71.03 | 1.46 | -0.10 | 11.24 |
| HSG | 03 | 67.96 | 74.13 | 6.17 | -1.01 | 6.17 |
| HSG | 04 | 71.65 | 73.17 | 1.53 | -0.22 | 7.27 |
| HSG | 05 | 71.06 | 71.92 | 0.86 | -0.10 | 8.60 |

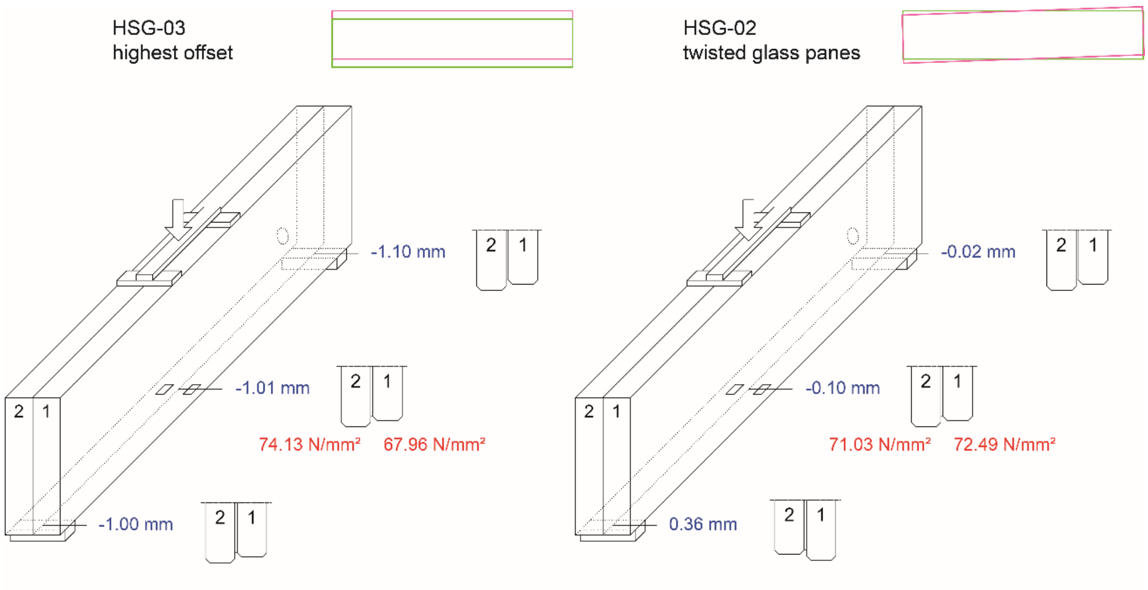



Fig. 8 Examples of specimens from the first run of the four-point bending test.

The destructive run of the four-point bending test after regrinding the edges was carried out until failure of the specimens. Table 5 shows the detailed results of these tests, including the maximum tensile stresses for each glass pane. Determining which glass pane failed first was not possible for all the specimens. Thus, the minimum of both stresses is defined as the fracture stress of the beam to be on the secure side. Glass pane 2 of the specimen “HSG-05” broke at a stress of 109 N/mm². When pane 2 broke, pane 1 bears the full load, which resulted in a large increase of the stress up to 155 N/mm². Only three of the ten results show which individual glass pane broke first.

Table 5 shows the mean value and the standard deviation of the two series of specimens. Fig. 9 shows the fracture stresses of these examinations in comparison with the results from the unpublished research in a diagram with the minimum, maximum, mean value and individual values. All values are for the specimens with 3 mm reground edges and the thickness of 10 mm (single glass panes) or 2 x 10 mm (laminated glass beams). The results of the FTG and the HSG are presented on the left and right sides of the figure, respectively. The red lines represent the characteristic tensile strengths of FTG (120 N/mm²) and HSG (70 N/mm²). The values of fully tempered glass show that one of the five specimens in each case broke below the characteristic tensile strength of FTG. The other values were higher than their characteristic tensile strengths. The difference between the mean values of the FTG specimens is 8 %. In contrast, the difference for HSG is 41 %. Additionally, the scattering of the values are high due to high brittleness of glass.

Table 5: Maximum tensile stresses of the destructive run of the reground specimens (3 mm).

| Specimen | | Tensile stress in … [N/mm²] | | Fracture stress | Mean value | Standard deviation |
|---|---|---|---|---|---|---|
| Type | Number | Strain gauge 1 | Strain gauge 2 | [N/mm²] | [N/mm²] | [N/mm²] |
| FTG | 01 | 131.35 | 140.23 | 131.35 | | |
| FTG | 02 | 122.66 | 126.55 | 122.66 | | |
| FTG | 03 | 129.17 | 128.84 | 128.84 | 123.25 | 7.75 |
| FTG | 04 | 129.20 | 124.37 | 124.37 | | |
| FTG | 05 | 155.48 | 109.05 | 109.05 | | |
| HSG | 01 | 105.61 | 99.38 | 99.38 | | |
| HSG | 02 | 112.12 | 85.94 | 85.94 | | |
| HSG | 03 | 124.92 | 94.13 | 94.13 | 97.92 | 7.70 |
| HSG | 04 | 114.32 | 109.18 | 109.18 | | |
| HSG | 05 | 109.67 | 100.99 | 100.99 | | |

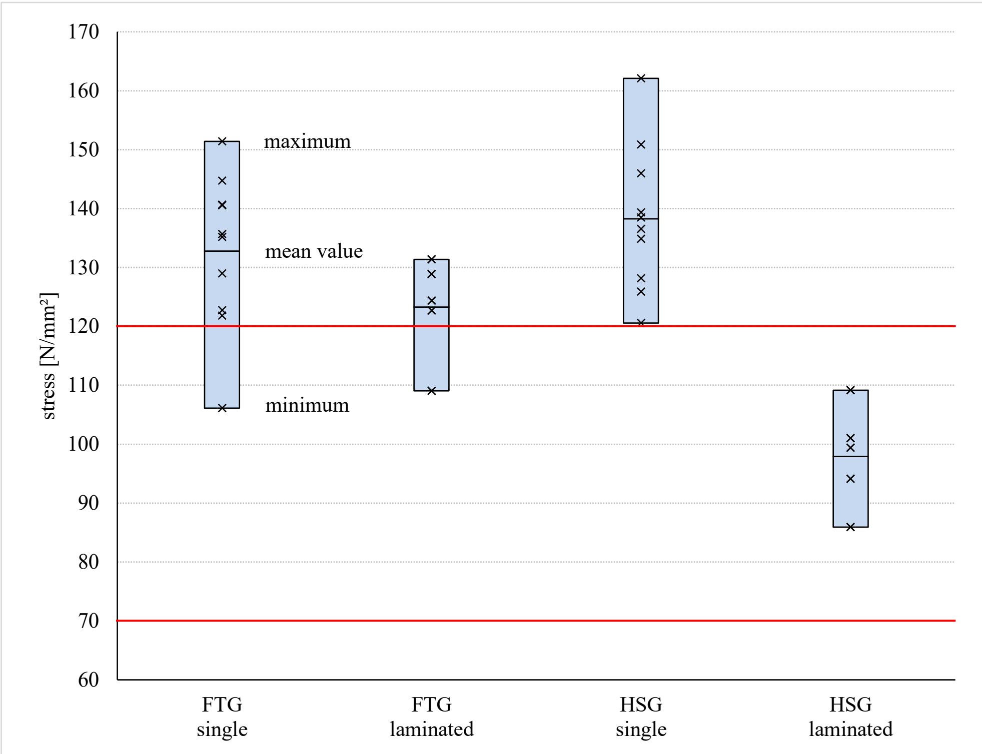



Fig. 9 Fracture stresses of the beams with 3 mm reground depth with minimum, maximum, mean value and individual values.

### *3.5. Discussion*

The measurements show that every specimen had a displacement or even a twist of the individual glass panes. The edge offset conforms to EN ISO 12543-5, but it influences the aesthetic quality and the load-bearing behaviour. A closer look at the individual glass panes revealed that the edges were not straight over the entire length. The edges of eight of ten specimens formed a parabolic shape; however, the magnitude of this lies within a range of 0.1 mm. This unevenness may cause from the accuracy of the manufacturing process of grinding. It cannot be avoided without increasing the costs of the process. Depending on how high the deviations are, they could lead to an edge offset, which influences the load-bearing behaviour.

The non-destructive run of the four-point bending test showed that the edge offset causes a difference in the stresses between the individual glass panes. One of the glass layers has to bear more load than the other one. According to Table 4, the stresses of each run and the edge offset in the centre of the specimen are not correlate to each other. Therefore, a high edge offset does not necessarily lead to a high difference of the stresses between the individual glass panes.

The results of the destructive run showed the influence of regrinding tempered glass. Due to the small number of specimens, the results must be regarded with reservation. These serve to confirm the results for the single glass beams and as an outlook for further research on this topic. According to the one FTG specimen, which broke below the characteristic tensile strength, the FTG series showed that regrinding the edges influences their load-bearing capacity and decreases the strength. These results confirm the behaviour of testing single glass panes in previous research. For the HSG specimens, the results for the single glass beams were 41 % higher than the laminated glass beams while the difference for FTG was 8 %. The larger percent difference may be caused by the manufacturing process of HSG. The specifications of HSG are that the strength is 70 N/mm² or higher and the fracture pattern has to match a typical HSG pattern. Manufacturers prefer to induce a higher prestress in the glass to reach the regulated strength. The two series were from different production lines, which may be the reason for this high difference in the maximum tensile stresses. The fact that no specimen broke below 70 N/mm confirms the results from previous research with single glass panes.

The number of individual glass panes in the laminated glass beam is relevant for the load-bearing behaviour of the construction with reground edges. With more glass layers the chance of defects at the edges increases in dependence of regrinding. In contrast, there is another approach, which could reduce the chance of failure. Fig. 10 shows a laminated glass with two glass panes, which are twisted in relation to each other. The blue line represents the reground edge. The dimensions "a" and "b" are the regrinding depths in the centre and the right side of the beam. The figure shows that the measured "b" is higher than "a", which means that at the sides of the laminated glass more material is removed than in the centre. The intervention in the compression zone is higher than in the centre. The four-point bending test and the regular use of beams introduce the load mostly in the centre of the beam and create the maximum stresses there. Thus, the sides of the construction are not the most stressed parts. Therefore, more glass interlayers could have a positive influence on the load-bearing behaviour of the component with reground edges. This is a relevant part for the regular regrinding process of laminated glass. For these examinations the specimens were regrind with a constant depth of 3 mm to be able to compare them with each other. In the regular process, the manufacturer grind in steps of 1 mm until the edge is smooth. Thus, they rarely regrind with the maximum depth of 3 mm.

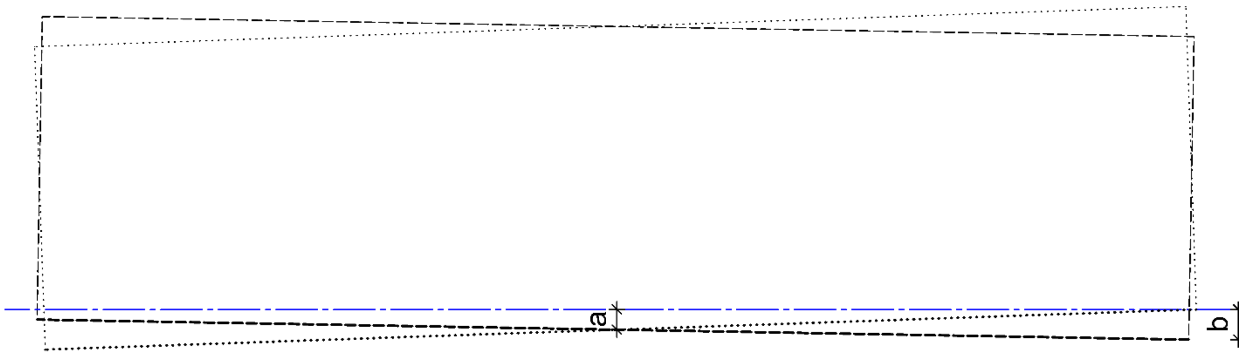



Fig. 10 Schematic illustration of a laminated glass with twisted individual glass panes.

## 4. Summary and Outlook

Due to the high verification costs, glass beams are rarely used in building construction. Although they offer maximum transparency, the displacement between the individual glass panes could lead to an optical degradation and an adverse mechanical load-bearing behaviour. Therefore, the regrinding of the edges offers an optical and mechanical improvement. The main goal of the examinations was to obtain a more precise knowledge of the load-bearing behaviour of components made of tempered glass with reground edges.

The measurements showed that each specimen had a displacement between the individual glass panes. In addition to the optical degradation of the component, a negative load-bearing behaviour in dependence to the edge offset could be proved. The examinations showed that one individual glass pane bears more load than the other one. Future research could concentrate on the relation between the edge offset and the difference between the stresses at the edges, to achieve a better knowledge how the offset influences the load-bearing behaviour of the laminated glass. In addition, the load-bearing behaviour of the PVB-foil influences the stress distribution between the individual glass panes. Future work could examine how the PVB-foil behave under the systematic load introduction into the edge of the laminated glass beam. Current solutions use setting blocks in the load introduction and the supports to compensate the edge offset and achieve a centric load introduction. That is only a provisional solution, because the optical degradation due to the edge offset remains. The transparency is reduced and the interlayer foil is vulnerable to external influences.

Regrinding the edges improves this offset, but the examinations showed that regrinding the edges of laminated and tempered glass beams reduces the load-bearing capacity. The results confirm the behaviour of the single glass panes of previous research by Lohr et al (2016). The FTG specimens fall below the characteristic tensile strength of 120 N/mm². The fracture stresses of the HSG specimens were higher than the characteristic tensile strength of 70 N/mm², which confirms the results of previous research. The results of the examinations showed that the edge offset and regrinding the edges of tempered glass influence the load-bearing behaviour of laminated glass beams. Especially, the load-bearing capacity of the FTG specimens decreases below the critical level of 120 N/mm². Thus, the advice for future researches is to prefer HSG specimens with reground edges. Additionally, it shows an outlook for further future researches because not only the glass beams have the high potential of regrinding the edges.

Constructions with parapets or steps made of glass show exposed and visible edges too. To achieve a precise knowledge about regrinding laminated glass future researches have to carry out tests with the statistic relevant number of ten specimens each series. This will result in secure strengths for different constructions with different number of glass layers, regrinding depths and glass types. They have to define the maximum regrinding depths for both glass types in order to achieve approvals for these components.

## 5. Acknowledgements

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## 6. References

EN ISO 12543-5: Glas im Bauwesen – Verbundglas und Verbund-Sicherheitsglas – Teil 5: Maße und Kantenbearbeitung. Deutsches Institut für Bautechnik: Berlin (2011)

Lohr, K., Weller, B., Engelmann, M.: Influence of Regrinding Depth on Edge Strength of Tempered Glass. In: Challenging Glass 5 – Conference on Architectural and Structural Applications of Glass, Ghent (2016)

Lohr, K., Weller, B., Engelmann, M.: Residual stress distribution in tempered glass with reground edges. In: Challenging Glass 6 – Conference on Architectural and Structural Applications of Glass, Ghent (2018)

EN 12150-1: Glas im Bauwesen – Thermisch vorgespanntes Kalknatron-Einscheiben-Sicherheitsglas – Teil 1: Definition und Beschreibung. Deutsches Institut für Bautechnik: Berlin (2015)

EN 1863-1: Glas im Bauwesen – Teilvorgespanntes Kalknatronglas – Teil 1: Definition und Beschreibung. Deutsches Institut für Bautechnik: Berlin (2012)

EN 1288-3: Glas im Bauwesen – Bestimmung der Biegefestigkeit von Glas – Teil 3: Prüfung von Proben bei zweiseitiger Auflagerung (Vierschneiden-Verfahren). Deutsches Institut für Bautechnik: Berlin (2000)

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