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# TEST REPORT

## NO. 022/B-2023/1

This report was issued in three counterparts, two of which were received by the Customer and one was archived

| | |
|---|---|
| **Customer (Ordering Party):** | FILL Krzysztof Góralczyk<br>NIP [Tax Identification Number]: 5512267559, REGON [National Business Registry Number]: 120459323 |
| **Customer's address:** | St. Staszica 7, 32-640 Zator, Poland |

### INFORMATION ON THE PRODUCT

| | |
|---|---|
| **Manufacturer:** | FILL Krzysztof Góralczyk |
| **Manufacturer's address:** | St. Staszica 7, 32-640 Zator, Poland |
| **Product name:** | FILL aluminium pergola |
| **Number of the relevant product standard:** | PN-EN 1090-1 +A1:2012<br>Execution of steel structures and aluminium structures - Part 1: Requirements for conformity assessment of structural components |
| **Reference document:** | PN-EN 1991-1-4 2005 Eurocode 1 – Actions on structures – Part 1-4: General actions – Wind actions<br><br>PN-EN 1991-1-1 Eurocode 1 – Actions on structures – Part 1-1: General actions – Densities, self-weight, imposed loads for buildings |

### INFORMATION ABOUT THE TEST OBJECT

| | |
|---|---|
| **Test object:**<br>**name, description, condition and identification** | Aluminium pergola with module dimensions 4000 x 6000 x 2900 mm, consisting of S01, B01, LD01 components |

### INFORMATION ON THE TESTS

| | |
|---|---|
| **Date of document submission:** | 3 November 2023 |

## 1. Ordering Party:

The tests were commissioned by:

- FILL Krzysztof Góralczyk, NIP [Tax Identification Number]: 5512267559, on the basis of the document "Request for test No. WB/PP- 22/B/-2O22J".

The test results contained in this report belong exclusively to the Ordering Party, and only the Ordering Party has the right to share and use the results at its own discretion.

## 2. Scope of the tests

The scope of the tests includes ITC-type output calculations for evaluating the design of the structure at the ultimate and serviceability limit state (ULS, SLS). The calculations were carried out considering two variants of the product assembly:

- a free-standing pergola
- a lean-to pergola

Additional calculations were also carried out to optimise the structure, including the determination of the limit states.

## 3. Additional information

- Test report No. 022/B-2023/2 consists of 14 numbered pages.
- The document was issued in three original copies, with two copies given to the Customer and one retained for archiving purposes – with no right of inspection by third parties.
- The test results shall apply only to the object tested and the conditions under which the tests were carried out.
- The report shall not be reproduced without a written permission of the Laboratory in any other form than as a whole.
- Measurement sheets drawn up during tests and measurements shall be kept jointly with the original report in the archives of UNILAB CENTRUM BADAWCZE.

## 4. Product identification:

The FILL system pergola is designed as an aluminium structure, composed of powder-coated extruded profiles and stainless steel elements, forming the frame and the movable roof. The frame of the structure is composed of S01 posts and B01 beams with profiles as shown in Fig. 1. The roof of the pergola consists of LDO1 slats that guarantee rotation. The profile of the roof slats is shown in Fig. 1. The slats rotate by means of a mechanism driven by an electric motor. The shape of the slats ensures drainage of rainwater from the roof surface and protection from solar radiation. Details of the construction are shown in drawings and photos Fig. 2 - Fig. 10.

The pergola is manufactured as a free-standing or lean-to version, in a single module or in a set consisting of individual modules connected by mechanical fasteners.

**Table 1.** List of standards declared in the assessment of FILL pergola performance.

| No. | Subject | EU legal basis | PL legal basis |
|---|---|---|---|
| 1. | Movable roof made up of slats in a 200mm module | EN 13659:2015 | PN-EN 13659:2015 |
| 2. | Construction product (CPR) | Regulation 305/2011 of the European Parliament and of the Council | Act of 16 April 2004 on construction products (consolidated text: Dz. U. /Journal of Laws/ of 2020, item 215), as amended. |
| 3. | Essential requirements for machinery | Directive 2006/42/EC of the European Parliament and of the Council | Regulation of the Minister of Economy of 21 October 2008 on essential requirements for machinery (Dz.U. /Journal of Laws/ of 2008, No. 199, item 1228) as amended (Dz.U. /Journal of Laws/ of |
| 4. | Low Voltage Directive (LVD) | Directive 2014/35/EU of the European Parliament and of the Council | Regulation of the Minister of Development of 2 June 2016 on requirements for electrical equipment (consolidated text: Dz. U. /Journal of Laws/ of 2016, item 806) Act of 13 June 2019 on conformity assessment and market surveillance systems (Dz. U. /Journal of Laws/ of 2019, item 544) as amended (Dz. U. /Journal of Laws/ of 2020, item |
| 5. | Electromagnetic Compatibility Directive (EMC) | Directive 2014/30/EU of the European Parliament and of the Council | Act of 13 April 2007 on electromagnetic compatibility (consolidated text: Dz. U. /Journal of Laws/ of 2019, item 2388) Act of 13 June 2019 on conformity assessment and market surveillance systems |

**Table 2.** Technical parameters of the pergola.

| No. | Characteristic | Properties |
|---|---|---|
| 1. | Material | Aluminium, 6061-T6 |
| 2. | Maximum width* | 4000 mm |
| 3. | Maximum height* | 2900 mm |
| 4. | Maximum projection* | 6000 mm |
| 5. | Slat spacing | 200 mm |
| 6. | S01 post dimensions | 127 x 127 x 3 mm |
| 7. | B01 beam dimensions | 127 x 200 x 4 mm |
| 8. | Slat dimensions | 40 x 220 x 2.5 mm |

* – external dimensional tolerances ±10 mm.

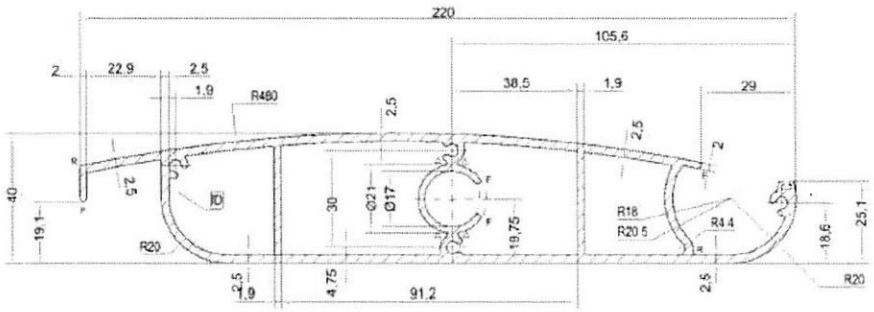


Fig. 1. LD01 slat – profile cross-section.

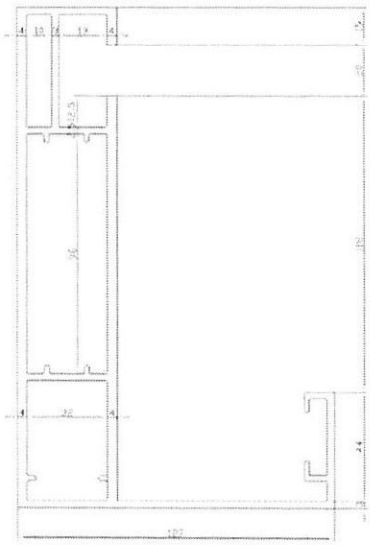

Fig. 2 B01 beam – profile cross-section.

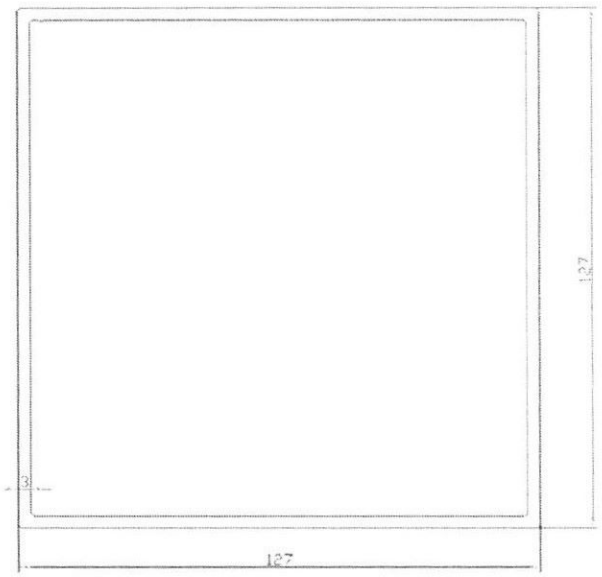


Fig. 3. S01 post – profile cross-section.

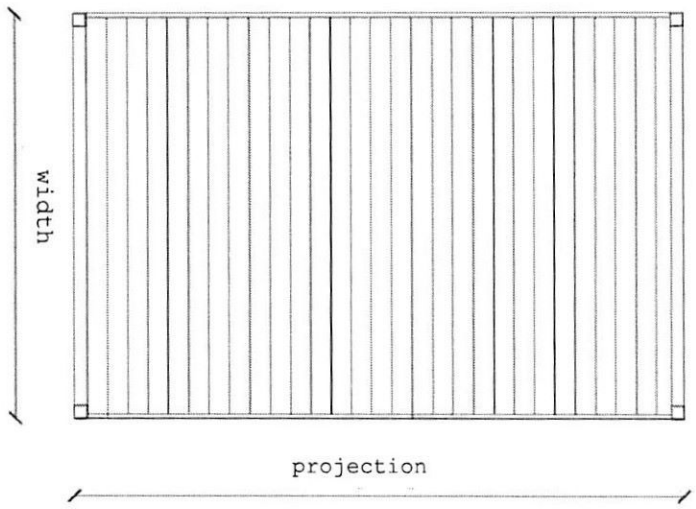


Fig. 4. Plan of a single FILL aluminium pergola module.

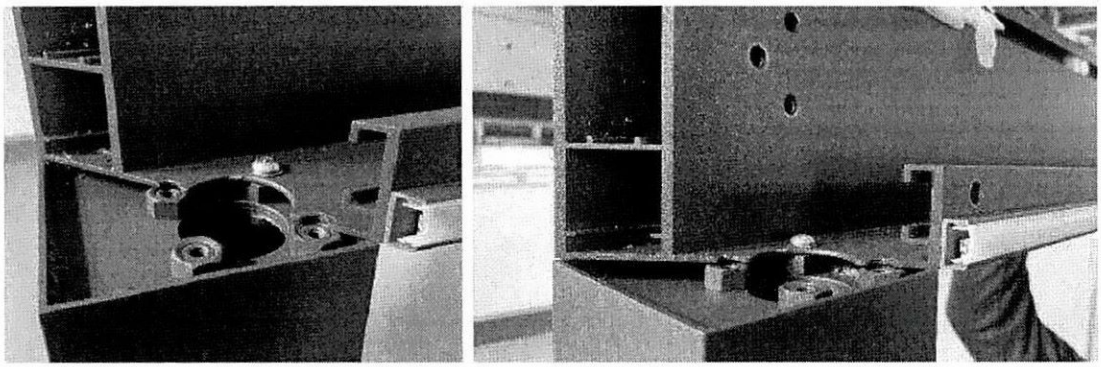

Fig. 5. Connection between the B01 beam and the S01 post.

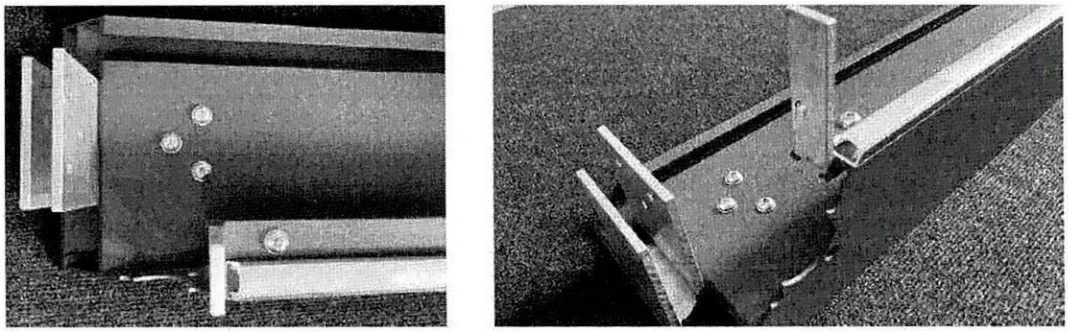

Fig. 6. Steel angle brackets where the B01 beams are joined.

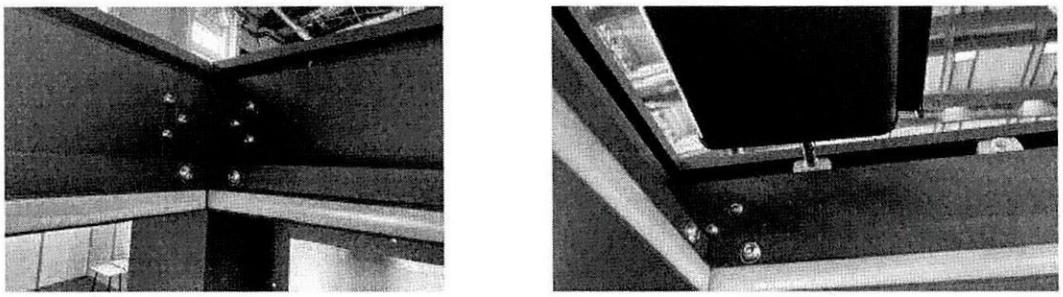

Fig. 7. Connection between B01 beams and the S01 post from the interior.

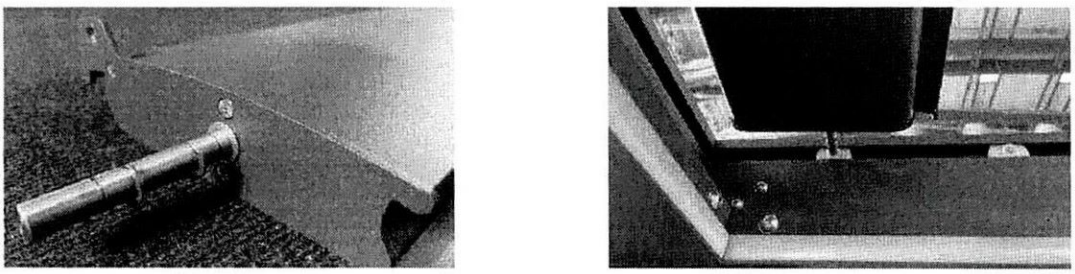

Fig. 8. LD01 roof slat together with aluminium pin.

Fig. 9. Side view of the FILL aluminium pergola in the free-standing version.

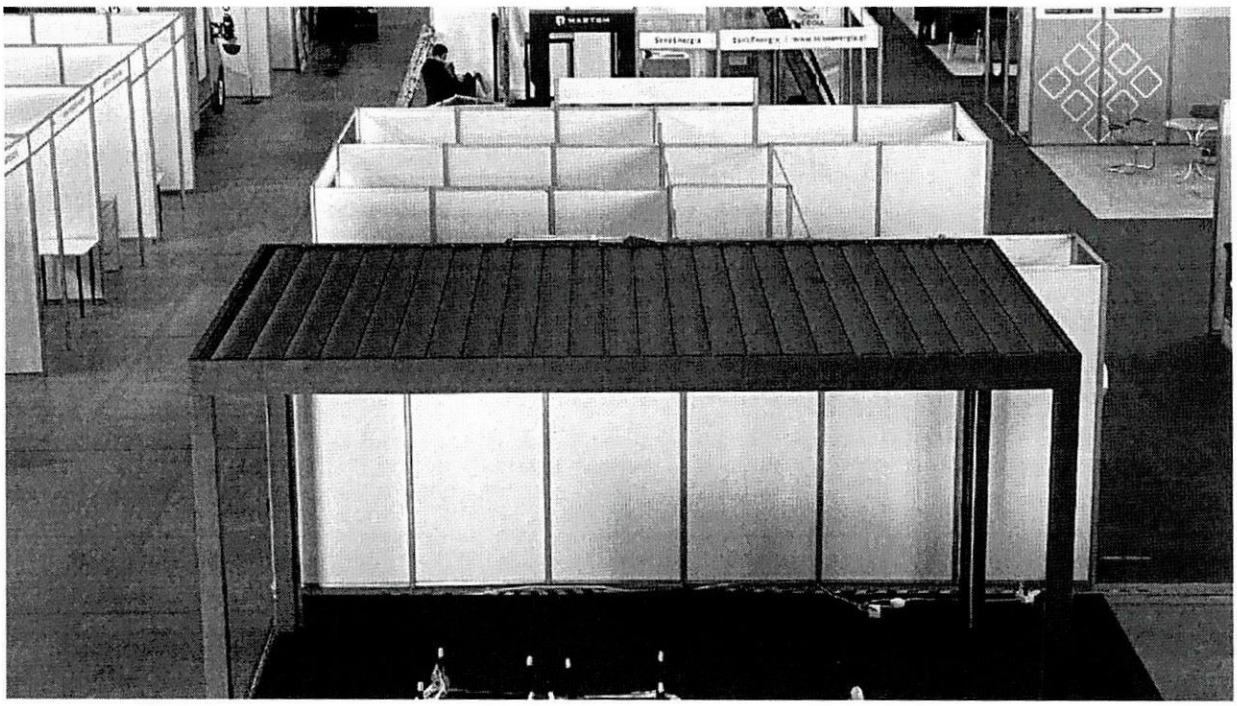

Fig. 10. Front view of the FILL aluminium pergola in the free-standing version.

## 5. Test methods and results

Table 3. Aluminium 6063T6 material properties.

| No. | Properties | Value |
|---|---|---|
| 1. | Density | 2.7 g/cm^3 |
| 2. | Coefficient of thermal expansion | 23.5 |
| 3. | Thermal conductivity | 218 W/mK |
| 4. | Specific heat | 920.000 J/kg-C |
| 5. | Modulus of elasticity | 68947.570 MPa |
| 6. | Poisson's ratio | 0.330 |
| 7. | Yield point | 275.790 MPa |
| 8. | Breaking stress | 310.264 MPa |
| 9. | Elongation % Elongation min. A | 8 [%] |

Table 4. List of limit states assumed in the calculations.

| No. | Limit state | Calculation method | Harmonised technical specifications |
|---|---|---|---|
| 1. | Load bearing capacity | PN-EN 1999-1-1 | EN 1090-1:2009+A1:2012 |
| 2. | Deformation at the serviceability limit state | PN-EN 1993-1-1; PN-EN 1999-1-1 | EN 1090-1:2009+A1:2012 |

Table 5. Summary of loads assumed in the calculations.

| No. | Property | Calculation method |
|---|---|---|
| 1. | Self-weight | PN-EN 1990 |
| 2. | Snow | PN-EN 1991-1-3 |
| 3. | Wind | PN-EN 1991-1-4 |

Table 6. Summary of self-weights assumed in the calculations.

| No. | Component | Self-weight |
|---|---|---|
| 1. | S01 post | 4.02 kg/m |
| 2. | B01 beam | 6.48 kg/m |
| 3. | LD01 roof slat | 3.66 kg/m |

## 5.1 Calculations

The calculations were carried out for ultimate limit states ULS and serviceability limit state SLS in accordance with PN-EN 1090-1+A1:2012. Load combinations were adopted in accordance with PN-EN 1990 (Basis of Structural Design). The design of the product means that it is treated as a shed-type object – objects with roofs, without fixed walls. In the case of such objects, it is necessary to take into account the wind friction load on the roofing surface. The numerical model and calculations were carried out using Solid Edge 2023 software. The calculations were carried out with the following limitations:

- location in wind load zones 1, 2 and 3 up to a height of 300 m above sea level.
- location in category I, II, III or IV terrain (wind)
- maximum wind resistance class in accordance with EN 13659: class 6 (closed slats)
- snow load 50 kg/m2
- Basic wind velocity: $v_b$ = 26 m/s
- Peak velocity pressure: $q_p(z)$= = 0.76 $kN/m^2$
- Deformation condition at the serviceability limit state $u_{lim}$ = L/300

The following wind action zones were assumed for the pergola roofing

Table 7. Summary of net pressure coefficients.

| No. | Load type | A | B | C |
|---|---|---|---|---|
| 1. | Maximum, pressure | *+0.5* | *+1.8* | *+1.1* |
| 2. | Minimum, suction φ=0 | *-0.6* | *-1.3* | *-14* |

Table 8. Summary of pressures acting on the structure.

| No. | Pressure value for | A | B | C |
|---|---|---|---|---|
| 1. | Maximum, pressure | 0.29 $kN/m^2$ | 1.03 $kN/m^2$ | 0.63$kN/m^2$ |
| 2. | Minimum, suction φ=1 | -0.34 $kN/m^2$ | -0.74 $kN/m^2$ | -0.80 $kN/m^2$ |

Wind friction on pergola surface

Coefficient of friction for rough surfaces: $c_{fr}$ = 0.02

Reference area: $A_{ref}$ = 2 • 6 • 4 = 48 $m^2$

Friction force: $F_{fr}$ = $c_{fr}$ • $A_{ref}$ • $q_p(z)$= 0.02 • 48 • 0.57 = 0.55 *kN*


**Fig. 18. Snow load limits depending on the width and projection of the pergola.**

### 5.1.1 Pergola 4000 x 6000

The calculations were carried out for a pergola with the following dimensions:

- 4000 mm width
- 6000 mm projection

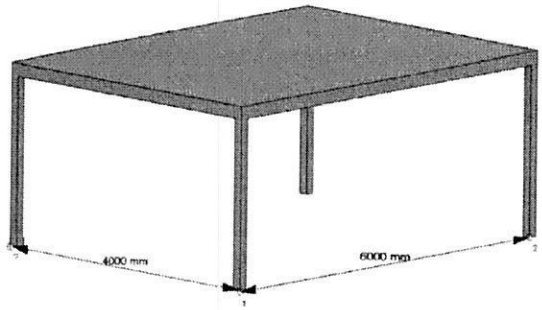


Fig. 11. Diagram of the pergola adopted for the calculations.

Fig. 12. LD01 slat model with a length of 4000 mm, adopted for the calculations.

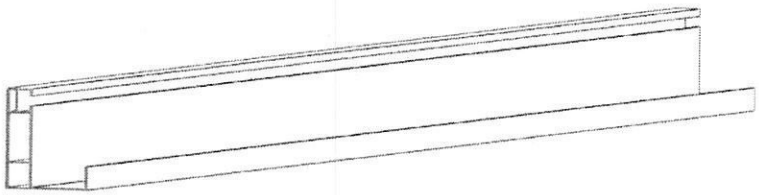

Fig. 13. B01 beam model with a length of 6000 mm, adopted for the calculations.

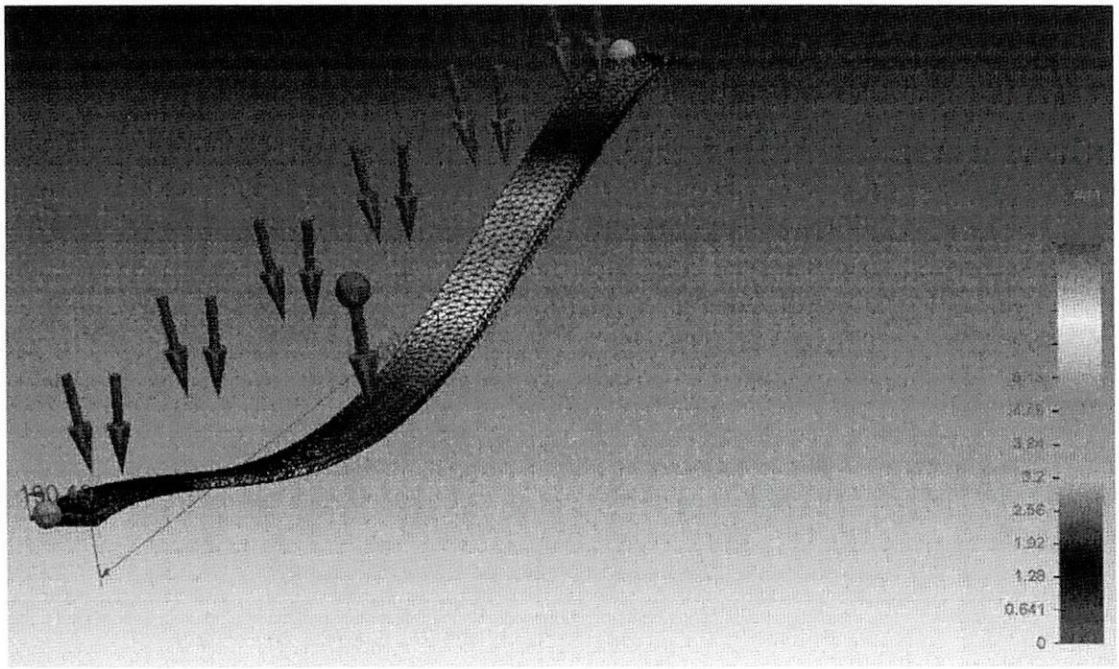


Fig. 14. LD01 slat deflection, SLS.

LD01 slat deflection limit condition: $u = 7{,}69\ mm < u_{lim} = \frac{L}{3040} = \frac{4000}{300} = 13{,}3\ mm$ has been met.

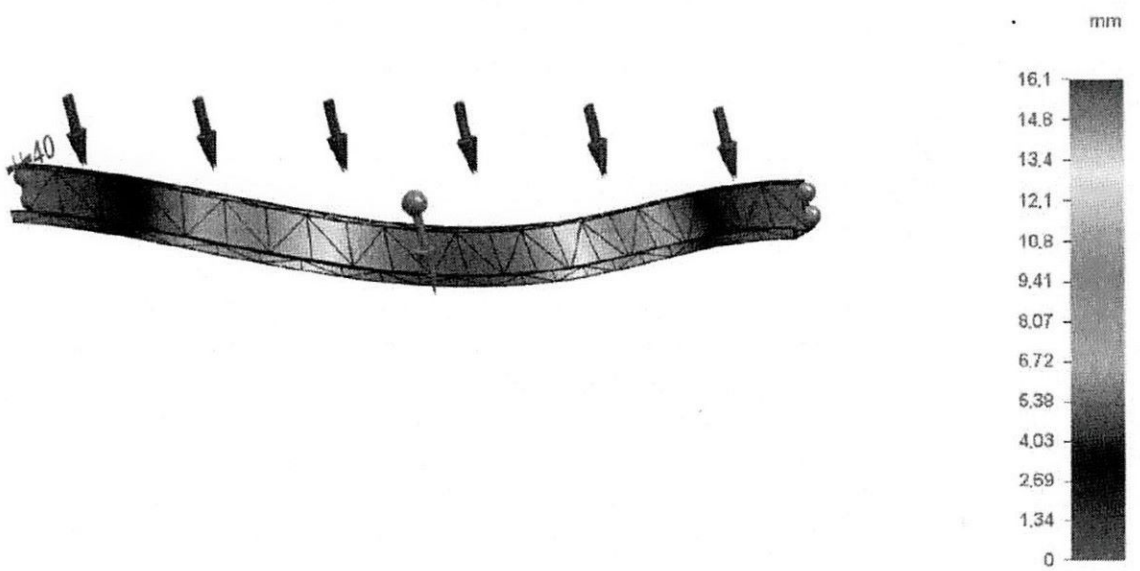


Fig. 15 Deflection of the B01 beam, SLS.

BO1 beam deflection limit condition: $u = 16.1\ mm < u_{lim} = \frac{L}{250} = \frac{6000}{300} = 20\ mm$ has been met.

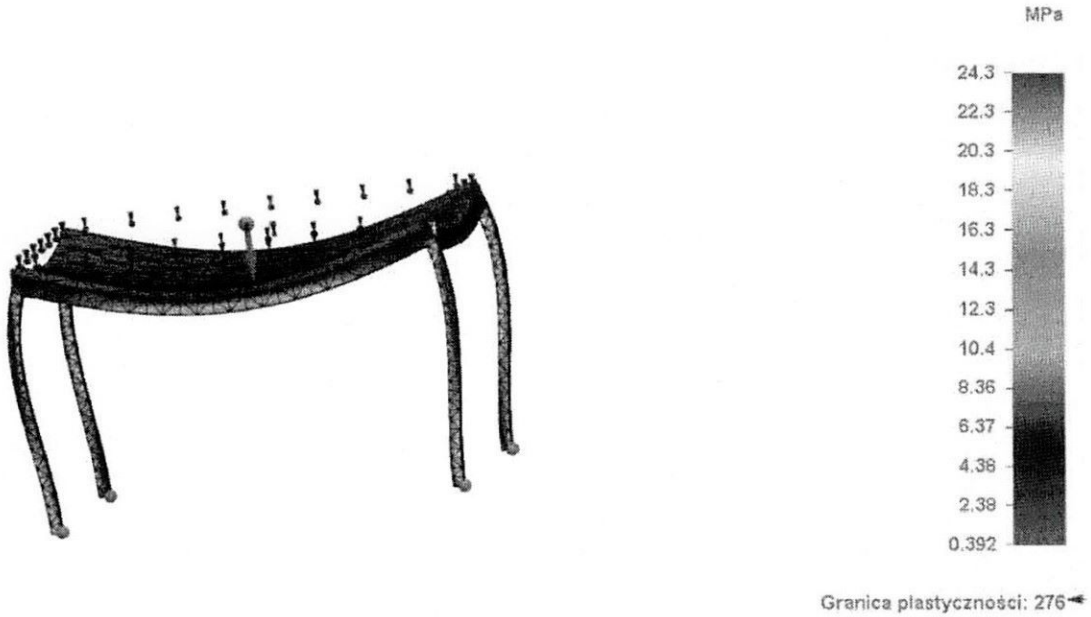


Fig. 16. Stress occurring in the structure, ULS.
Granica plastyczności – Yield point

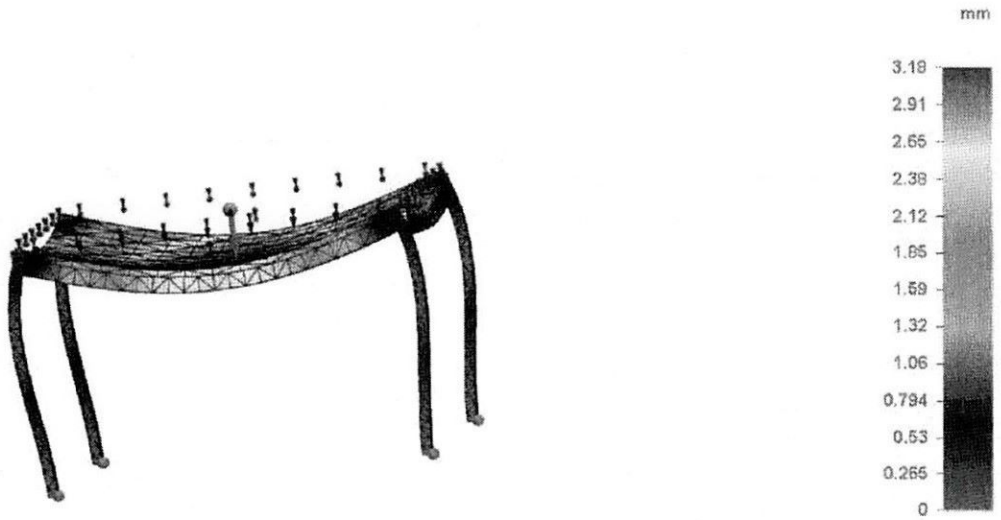


Fig. 17. Structural displacements, ULS.

## 6. Assessment of product performance

On the basis of the tests carried out, compliance with the requirements was established in relation to the properties tested.

Table 9. Summary of the test results

| No. | Test object | Properties<br>Test result | Conformity assessment<br>Assessment result | Reference document |
|---|---|---|---|---|
| 1. | Load-bearing resistance of the LD01 slat under bending | 0.97 < 1.0 | Compliant | PN-EN 1999-1-1 |
| 2. | Load-bearing resistance of the LD01 slat under shear | 0.79 < 1.0 | Compliant | PN-EN 1999-1-1 |
| 3. | Deformations at the serviceability limit state of the LD01 slat with a length of 4000 mm | 7.69 < 13.3 | Compliant | PN-EN 1999-1-1 |
| 4. | Load-bearing resistance of the beam B01 under bending | 0.47 < 1.0 | Compliant | PN-EN 1999-1-1 |
| 5. | Deformations at the serviceability limit state of a B01 beam with a length of 6000 mm | 16.1 < 20 | Compliant | PN-EN 1999-1-1 |
| 6. | Load-bearing resistance of the post under bending and longitudinal force | 0.88 < 1.0 | Compliant | PN-EN 1999-1-1 |

Table 10. Range of production capabilities.

| | | Projection, [P] | | | | | | | | | | 6 posts |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 m | 1.5 m | 2 m | 2.5 m | 3 m | 3.5 m | 4 m | 4.5 m | 5 m | 5.5 m | 6 m | 6-12 m |
| Width, [W] | 1 m | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| | 1.5 m | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| | 2 m | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| | 2.5 m | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| | 3 m | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| | 3.5 m | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| | 4 m | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| | 4.5 m* | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | | |

* location in wind zone 1 only

Implemented limitations:

- location in wind load zones 1, 2 and 3 up to a height of 300 m above sea level.
- location in category I, II, III or IV terrain (wind)
- maximum wind resistance class in accordance with EN 13659: class 6 (closed slats)
- snow load 50 kg/m2 – no snow drifts or accumulated snow cover
- for conditions exceeding the above-mentioned limitations, an individual static and strength assessment by a person with structural engineering qualifications is required.

Person responsible for testing and performance assessment:

mgr inż. Piotr Kruszyński

Person authorising the report:

dr inż. Marcin Małek

The Testing Laboratory hereby declares that the test results concern only the tested object. The Report shall not be reproduced without a written permission of the Testing Laboratory in any other form than as a whole.

Warsaw, 3 November 2023

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I, Małgorzata Borowska, a sworn translator of English, listed in the register of sworn translators of the Minister of Justice with number TP/120/14, hereby certify the conformity of this translation with the document presented to me.
Katowice, 18 March 2024
Repertory number: 361/24

Małgorzata Borowska