Institut für Brandschutztechnik und Sicherheitsforschung

# TEST REPORT

**Report No.: 320090807-1-en**
Date: 01.02.2021
Date of translation: 17.02.2021
Engineer: Mr. Roland BECK / AM

| | |
|---|---|
| **CUSTOMER:** | **Binderholz Bausysteme GmbH**<br>Solvay-Halvic-Straße 46<br>A-5400 Hallein |
| **TEST SPECIMEN** | **Load-bearing 5-ply cross laminated timber (CLT) element 180 mm [40\|30\|40\|30\|40 (20+20)]**<br>**Type: „Binderholz CLT BBS 180-5s“** |
| **NORMATIVE REFERENCES:** | OENORM EN 1363-1<br>OENORM EN 1365-2 |
| **TEST DATE:** | 13 January 2021 |
| **TESTED SIZE:** | 3000 x 4900 mm (W x L) |
| **FIRE EXPOSE FACE:** | Bottom (bottom-up) |
| **TEST DURATION:** | 134 minutes and 06 seconds |
| **TEST RESULTS:** | Load-bearing capacity (R): 134 minutes<br>Fire integrity (E): 134 minutes<br>Thermal insulation ($I_{mean}$): 134 minutes<br>Thermal insulation ($I_{max}$): 134 minutes |
| **ASSESSOR:** | Mr. Roland BECK |

**This Test Report contains:**

**13** text pages and **44** appendices

Appendices:

| | | |
|---|---|---|
| A: | Photo documentation | (5 Seiten) |
| B: | Measurement data assessment | (32 Seiten) |
| C: | Static calculation, design drawings and residual cross section | (7 Seiten) |



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## 1. Normative references

OENORM EN 1363-1:
Fire resistance tests – Part 1: General requirements
Edition: 15/04/2020

OENORM EN 1365-2:
“Fire resistance tests for load-bearing elements – Part 2: Floors and roofs“
Edition: 15/12/2014

## 2. Test objective / test programme

A fire resistance test was conducted on 13 January 2021 in the testing laboratory of IBS Linz GmbH to determine the fire resistance of a load-bearing ceiling of type “Binderholz CLT BBS 180-5s”. The specimen was tested and assessed with respect to its load-bearing capacity under fire exposure, its fire integrity and thermal insulation. The test specimen was exposed to fire from the bottom.

## 3. Manufacturer / planner

### Total construction

Manufacturer:
BINDERHOLZ BAUSYSTEME GmbH, Solvay Halvic Straße 46, A-5400 Hallein

## 4. Manufacturer of used materials

- **Cross laminated timber (CLT)**

  Manufacturer: BINDERHOLZ Unternberg GmbH., Stranach 26, A-5585 Unternberg

  Type: Part 1:1103 x 4900 x 180 [40|30|40|30|40 (20 + 20)] mm
  Part 2: 977 x 4900 x 180 [40|30|40|30|40 (20 + 20)] mm
  Part 3:1010 x 4900 x 180 [40|30|40|30|40 (20 + 20)] mm
  Quality: Front face: F-AB_ESP
  Rear face: NH-C
  Material: Spruce, grading class*): C24 for lengthwise layers; C24 and C16 for crosswise layers in accordance with the European Technical Approval ETA 060009; volume weight: ~ 450 kg/m³; mean moisture content 12 %

  **) Extract from the European Technical Approval of company Binderholz Bausysteme GmbH:*
  *At least 90% of the single boards (lamellas) with layers running parallel to the longitudinal axis of the element shall at least be of strength class C24 according to EN 338-9, whereas the rest of the boards must at least be of strength class C16.*
  *At least 30 % of the single boards of the crosswise layers shall at least be of strength class C24 and the rest of the boards of at least strength class C16.*

  **Adhesive for CLT surface**

  Manufacturer: PURBOND AG, CH-6203 Sempach Station

  Type: PURBOND HB X102, PUR adhesive, applied quantity: ~ 150 g/m²

- **Connection board**

  Manufacturer: BINDERHOLZ GmbH Massivholzplattenwerk, Gewerbegebiet 2, A-5113 St. Georgen bei Salzburg

  Type: Spruce 3-ply laminated; grading class: at least 94% classified C24, the rest classified C16; volume weight ~ 470 kg/m³; mean moisture content 12 %, 110 x 4900 x 27 mm
  Offset screw fitting with CLT ceiling at a maximum distance of 300 mm

- **Screw fitting connection board**

  Manufacturer: Schmid Schrauben Hainfeld GmbH., Landstal 10, A-3170 Hainfeld

  Type: Rapid 2000 ø6 x 80 mm, e = 300 mm

- **Screw fitting for the half lap**

  Manufacturer: Schmid Schrauben Hainfeld GmbH, Landstal 10, 3170 Hainfeld

  Type: Rapid Komprex washerhead ø8 x 140 mm, e = 300 mm

- **Adhesive tape behind the connection board and on the half lap**

  Manufacturer: SIGA Rütmattstraße 7, CH-6017 Ruswil

  Type: Rissan 60 mm, single sided

## 5. Sampling

A test specimen was selected by the customer. This specimen was taken from the current production. The consignment had not been subject to any official sampling.

The customer delivered the test specimen to the testing laboratory which was subsequently responsible for the proper marking and measuring of the sample. The examination of the test specimen (control of materials and their dimensions) was made by the testing Institute, which did not consider it necessary to require for any additional sample. The above-mentioned examinations partly took place during the installation of the test specimen as well as before/after the fire testing. No deviations to the details and design drawings provided by the customer were recognized. Hence, the testing laboratory could adopt the drawings as attached to this Test Report.

## 6. Test specimen description

### 6.1. Dimensions

| | |
|---|---|
| Total element dimensions: | 4900 x 3000 x 180 mm (L x W x H) |
| Span: | 4700 mm (middle-middle bearings) |
| Fire-exposed area: | 4000 x 3000 mm (L x W) |
| Single panel dimension: | 1103 x 4900 mm + 977 x 4900 mm + 1010 x 4900 mm (L x W) |
| Lamella thickness: | 40\|30\|40\|30\|40 (20 + 20) mm |

### 6.2. General description

Cross-laminated timber ceiling element

The test specimen is a loadbearing ceiling construction of “Binderholz CLT BBS 180-5s” and consists of three single elements. The elements consist of a 6-ply CLT layup of 180 mm thickness [40 | 30 | 40 | 30 | 40 (20 + 20)]. Each layer of the CLT lamellas was face bonded over the entire surface with HB-X adhesive. Only the edges of the lengthwise oriented layers were glued together. The edges of the crosswise layers were not glued together. The visible surface was planed and sanded.

The three parts of the test specimen were placed directly onto the test furnace. The connection between the first and the second element was designed as a half lap and screwed together. The gap of about 3 mm between the two elements was covered with an adhesive tape. The second and the third element were connected to each other on the top surface via a connection board (27 x 110 mm).

The dimensions of the panel groove were 28 x 56 mm. The connection board was fastened to the single elements by screws (Rapid 2000 screws 6 x 80 mm at maximum distance to each other of approx. 300 mm). Under the connection board, an adhesive tape was affixed to cover the element joint.

Any further information on the construction assembly, various thicknesses and dimensions of the materials used for the test set-up shall be available from the enclosed drawings provided by the customer and verified and adopted in unaltered form by IBS.

## 7. Conditioning

The test specimen was delivered several days prior to fire testing and built into a supporting construction (refer to point 8) and stored in a lying position in the testing laboratory. The concurrent ambient temperature was approx. 19 °C and the relative humidity was 48%.

The moisture content values measured prior to the testing were on average approx. 11.0 % at a room temperature of 19 °C.

Due to the nature of the used materials a longer conditioning time was renounced.

## 8. Supporting structure

The test specimen was installed directly above the test furnace of IBS Linz GmbH.

The longitudinal sides in fitting direction of the CLT ceiling towards the oven walls were installed to leave a free edge and were sealed off with mineral wool and aerated concrete blocks (refer to Appendix C).

## 9. Test specimen installation

The assembly took place on the day before the fire test by the customer's staff and was effected directly above the horizontal test furnace. The test specimen was lying directly onto the steel beams of the furnace on the broadsides. On the longitudinal sides the aerated concrete blocks were stacked and sealed off with mineral wool strips.

The construction consisting of the test specimen and the blocks formed the upper terminating element of the test furnace.

## 10. Test description

**Test date:** 13 January 2021

### 10.1. Fire exposure

Flame impingement of the bottom side of the test specimen.

### 10.2. Test start

The initial temperatures recorded by the thermocouples were verified no later than 5 minutes prior to fire testing to ensure consistent measurement results and to specify reference values. Homogeneous reference values e.g. for deflection, if applicable, were set and the initial condition of the test specimen was established. The recording of measurement values started in the “0” testing minute (please refer to Appendix B).

### 10.3. Ambient temperature

During the entire fire test duration, the ambient temperature was continuously measured and recorded with a thermocouple type K with a thickness of 3 mm. The measuring was conducted by a measurement system located in proper distance to the test furnace. These temperature values are listed in Appendix B.

### 10.4. Heating system of the furnace

The furnace was heated by extra-light furnace fuel oil (according to OENORM C1109).

### 10.5. Temperature in the furnace

Standard temperature-time curve as per clause 5.1.1 of OENORM EN 1363-1.

### 10.6. Temperature measurement inside the furnace

For the measurement of temperatures inside the test furnace, eight plate thermocouples complying with the requirements of clause 4.5.1.1 of OENORM EN 1363-1 were used in combination with NiCr-Ni (type K) thermocouples with a wire diameter of 1 mm. The thermocouples were placed as far inside the test furnace as possible to ensure a regular measurement of the entire fire-exposed surface of the test specimen.

The clearance between the test specimen and the plate thermometers was approx. 100 mm.

## 10.7. Pressure in the furnace

The pressure in the furnace was operated in such way that the pressure measured 100 mm below the test specimen surface would not exceed 20 Pa.

## 10.8. Temperature measurements on unexposed face

In order to record the increase in temperature on the unexposed side of the test specimen against the initial temperature, NiCr-Ni thermocouples (type K, wire diameter 0.5 mm) meeting the requirements of clause 4.5.1.2 of OENORM EN 1363-1 were applied and arranged in accordance with the attached test protocol “Thermocouples on unexposed face”.

Each thermocouple was provided with an inorganic insulating covering (density approx. 900 kg/m³) with the dimensions 30 x 30 mm and was glued onto the test specimen (adhesive “Furtol Core”).

Furthermore, the customer had placed additional thermocouples on the test specimen to record the temperatures in the different layers.

The temperature increases on the unexposed side as compared to the initial values measured were recorded by the measuring system and can be found in the tables and charts of Appendix B.

## 10.9. Load application

### 10.9.1. Test load determination

The testing laboratory was requested by the customer to apply a uniformly distributed load of ~7.25 kN per m² on the test specimen for the fire simulation (compare OENORM EN 1990, standard series OENORM EN 1991 and OENORM EN 1995).

Due to the specified distributed load of ~ 7.25 kN/m², the total load accounted for 120.1 kN or a static shear force of approx. 20.0 kN/m at a distance of 1000 mm to the support.

The consequent bending moment amounted to approx. 22.4 kNm/m with a shear force of 22.1 kN/m (Load applied and weight of the test specimen). This load corresponded to a hydraulic pressure of 110.6 bar based on the used load unit. Since the load was applied over two load lines, the load distance was set to exhibit a uniform maximum static moment.

The loading was force-controlled and was constantly regulated during the entire test duration. Detailed records on how the load was regulated during fire testing can be found in Appendix B (Test protocol).

The exact course of test loading which was applied moment-equivalent over both line loads in dependence of the testing time can be found enclosed, too.

10.9.2. Description of test load set-up

Two line loads were placed on the test specimen, each at 1000 mm distance to the support. Each line was loaded by two hydraulic stamps which were located in the outer quarter points of the total width of the element on a load-bearing filled steel beam (100 x 100 x 4 mm) (refer to enclosed drawing).

## 10.10. Deformation measurement on unexposed face

In order to record any deformations of the test specimen, a measuring point was located in accordance with OENORM EN 1365-2. The position of these measuring points and the results can be taken from Appendix B.

## 11. Observations during / after fire testing

### 11.1. Test protocol – 13 January 2021

During the fire test, the following changes could be observed:

| Testing minute | Test specimen face[1] | Observations |
|---|---|---|
| 5 | U | First smoke emissions can be detected coming between the furnace and the test specimen. |
| 6 – 130 | U | No further significant changes were found during the entire fire test. |
| 135 | U | 134 minutes and 06 seconds.<br>The test was ended after consultation with the sponsor because a failure of the “R” criterion was to be expected. |
| Termination of fire test in the 135th testing minute | | |

The extinguishing time of the specimen was 5 minutes and 0 seconds.

[1] U: fire unexposed face, E = fire-exposed face

## 11.2. Conclusions after test end

### 11.2.1. Test specimen condition after test end on unexposed face

The test specimen shows no changes.

### 11.2.2. Test specimen condition after test end on fire-exposed face

The specimen shows the typical appearance of burnt CLT.

## 12. Comparison of test results with standard criteria

| | Standard | Performance criterion | Failure criterion | | 13 January 2021 |
|---|---|---|---|---|---|
| 1 | | | Total test duration | | 134 minutes 06 seconds |
| 2 | OENORM EN 1363-1, clause 11.1 | **R** | Exceeding of maximum deflection | $D = \frac{L^2}{400 \cdot d}$ | not possible |
| 3 | | | Exceeding of maximum deflection rate | $\frac{dD}{dt} = \frac{L^2}{9000 \cdot d}$ | not possible |
| 4 | OENORM EN 1363-1, Clause 10.4.5.2 | **E** | Cotton pad ignition | Conducted: | no |
| 5 | | | Penetration of test specimen with a 6 mm gap gauge | Gap gauge could be inserted ≥ 150 mm into a gap | not possible |
| 6 | | | Penetration of test specimen with a 25 mm gap gauge | gap gauge penetrated the test specimen | not possible |
| 7 | | | Flames on fire-unexposed side | Flames > 10 s on fire-unexposed side | no occurrence |
| 8 | OENORM EN 1365-2, Clause 9.1.2.2 | **I** Average temperature increase | Overrun of allowable mean temperature increase compared to the initial temperature on the unexposed side of the test specimen. **max. allowable average value = 140 K** | testing minute | no overrun |
| 9 | | | | max Δ T – mean in K | 0 |
| 10 | OENORM EN 1365-2, Clause 9.1.2.3 | **I** Maximum temperature increase | Overrun of allowable average temperature increase compared to the initial temperature on the unexposed side of the test specimen. **max. allowable single value = 180 K** | testing minute | no overrun |
| 11 | | | | at measuring point | 6 |
| 12 | | | | Δ T in K | 19.0 |
| 13 | OENORM EN 1363-1, clause 5.6 | | Ambient temperature at test begin | in °C | 19.7 |
| 14 | | | Δ T max. = +20 K<br>Δ T min. = -10 K | Δ T in K | -8.8 |
| 15 | OENORM EN 1363-1, clause 9.2 | Furnace pressure | Pressure in fire room on top edge of test specimen | in Pa | 5.4 – 20.3 |

## 13. Summary of test results

The cross laminated timber ceiling element of series “Binderholz CLT BBS 180-5s” achieved the following results:

| Criterion | Achieved test results |
|---|---|
| “R” – Load-bearing function | **134 minutes** |
| "E" – Flame > 10 s | **134 minutes** |
| "E" – Gap gauge | **134 minutes** |
| "E" – Cotton wool pad | **134 minutes** |
| "I" – Thermal insulation mean value | **134 minutes** |
| “I” – Thermal insulation max. value | **134 minutes** |
| Fire test termination | **In the 135$^{th}$ testing minute** |

The fire test was terminated by mutual agreement with the customer.

Statements concerning the conformity with the test results were made applying the decision rules established with the customer.

## 14. Determination of mass burning rate

The following procedure was chosen to determine the mass burning rate:

Three strips with a width of 200 mm were cut out crosswise to the longitudinal layers from each of the test specimen's elements by means of a circular saw to determine the remaining cross-section at a distance of 100 mm of the cut surface. The residual cross-section was measured to be 91.48 mm on average. The exact values and the position of the strips in the test specimen can be taken from the appendix.

**Overview:**

| | **BINDERHOLZ CLT BBS 180-5s** |
|---|---|
| Total thickness of element | 180 mm |
| Mean burn-up | 88.52 mm |
| Total fire duration*) | 139 minutes and 6 seconds |
| Mass burning rate | 0.64 mm/minute |

**) The total fire duration shall be defined as follows: The total fire duration shall be the time of exposure to flame by the burner acc. to OENORM EN 1363-1 less the duration until overrun of the Isothermal line on the bottom side of the CLT element of 250 K (mean value) or 270 K single value (in this case at test beginning), and the time duration until the element on the fire-exposed side has extinguished completely.*

## 15. Field of direct application

<table>
<tr><th>Normative reference on item:</th><th>Allowable deviations of the tested construction with assessments and amendments in relation to the test results</th></tr>
<tr><td>13.</td><td>The test results are directly applicable to a similar untested floor or roof construction provided the following is true:</td></tr>
<tr><td>13.a.</td><td>With respect to the structural building member:<br>The maximum moments and shear forces when calculated on the same basis as the test load shall not be greater than those tested.</td></tr>
<tr><td>13.d.</td><td>With respect to the inclination of roof constructions:<br>- For trussed rafter roof construction where the inclination is equal to the tested inclination of ≤ 10°, the test results shall be valid for installation in practice at inclinations of 0° up to 80°.<br>- For apex or monopitch roof construction as defined in 6.3.2 b) the inclination shall be ± 15° in accordance with Table 1.<br>Table 1: Inclination for apex or monopitch roofs
<table>
<tr><th>Tested at a° from the horizontal</th><th>Valid for installation in practice</th></tr>
<tr><td>≤10° (nominally 'horizontal')</td><td>0° up to 15°</td></tr>
</table>
</td></tr>
</table>

## 16. Summary / result

On 13 January 2021, a cross laminated timber element of system series “Binderholz CLT BBS 180-5s” was subjected to fire resistance testing in accordance with OENORM EN 1365-2.

This Test Report provides a thorough description of the manufacturing and assembly processes, test conditions and results achieved by the tested structural member in accordance with the testing procedures set down in EN 1363-1 and EN 1365-2. Any substantial deviation with respect to sizes or structural designs – except for deviations tolerated in the fire test procedures for the direct field of application – shall not be covered by this Test Report.

Due to the nature of the fire tests establishing the fire resistance, and the subsequent difficulties connected with quantifying the degree of uncertainty while measuring the fire resistance, it is not possible to determine the degree of exactness of this result.

This Test Report shall only be applicable in its full length together with the appendices listed and marked.

**IBS-INSTITUT FÜR BRANDSCHUTZTECHNIK UND SICHERHEITSFORSCHUNG GESELLSCHAFT M.B.H.**
**Akkreditierte Prüf-, Inspektions- und Zertifizierungsstelle**

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|---|---|
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Mr. Josef STOCKINGER
Authorised Signatory

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