



Q-Air – evaluation by experiment

Q-Air trials revealed a build-up of internal heat and pressure within the chambers, which meant a unique solution had to be invented for a clear glass module. Coatings with solar heat rejection were used within the outer glass and an expansion chamber within the module to relieve any excess insulating gas pressure was introduced.

The Q-Air has undergone a series of successful in-house and independent evaluations to verify the product's worthiness during extreme cold and maximum solar radiation.

Various supporting R&D activities are presented as part of historical timeline.

 REFLEX

Q-Air

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Introduction of the expansion chamber

The expansion chamber was already part of the Q-Air multi-cavity opaque glass unit since 2009. Flexible aluminium foil provided for necessary compensation of insulating gas expansion / contraction.

As early as 2010 it became clear that a similar concept will be needed for transparent insulating glass units having cumulatively up to 80 mm argon gas or delimiting glass panes would need to bulge by centimetres under the summer sun.

In 2010 through 2011 a small 60x60x10 cm demonstrator with toughened 3.85 mm expansion glass pane was evaluated for summer and winter behaviour. Polysulphide



edge sealant stretching was observed throughout the seasons as well.

Field measurements on the real-world multipane demonstrator started in June 2012 and were conducted through 2014. It was an 8-pane glass unit with four times 18 mm argon filled chambers in front of the toughened expansion glass pane. Behind the expansion chamber, there were three more opened air chambers with overlapping 25 mm holes accessible from behind. Through the holes, motion of the expansion chamber could be monitored, and temperature measured via the thermal infrared sensor.

The demonstrator was oriented east, south and part west to test for various extremes. Recorded ambient temperatures ranged from -17°C to $+39^{\circ}\text{C}$.

Obtained data was used to validate the first FEM models for the behaviour of the Q-Air expansion glass. Models for intermediate glass pane's temperatures based on the LBNL Window software were validated as well.



Glass thermal stress

One of most important cost-saving features of the Q-Air glass units is their reliance on the plain annealed Low-E coated intermediate glass panes. Calculations with Window software showed that we could realistically expect intermediate glass panes never to approach 45°C temperature difference. It is well established that annealed glass starts to experience thermal stress breakage when these differences exceed 55°C.

We wanted to clearly establish that this critical feature of our glass design can be demonstrated with room to spare.

Around June 21st when the most powerful solar insolation was available, back tilted units were tested for “travelling shadow”.

These tests revealed that even with a good deal of overstress, Q-Air unit functions as conceived.



Expansion chamber – polar winter performance

Through 2014 field testing, appropriate temperatures were reached on the high end, while at the low end, the experienced -17°C was deemed unconvincing. This shortcoming was rectified during the 2014 winter where one Q-Air 5 and one Q-Air 3 were evaluated in twin climatic chamber designed for evaluations of the building skins at polar temperatures as low as -40°C .

Then unit's edge and centre of glass heat fluxes in transient regimen were evaluated for the first time.

Since the climate chamber simulating the interior of the building could simulate various air-humidity loadings, we also tested for Q-Air's expansion chamber edge and corner condensation conditions.

Tested units were evaluated for several weeks for cyclic sealant behaviour at near cryogenic conditions.

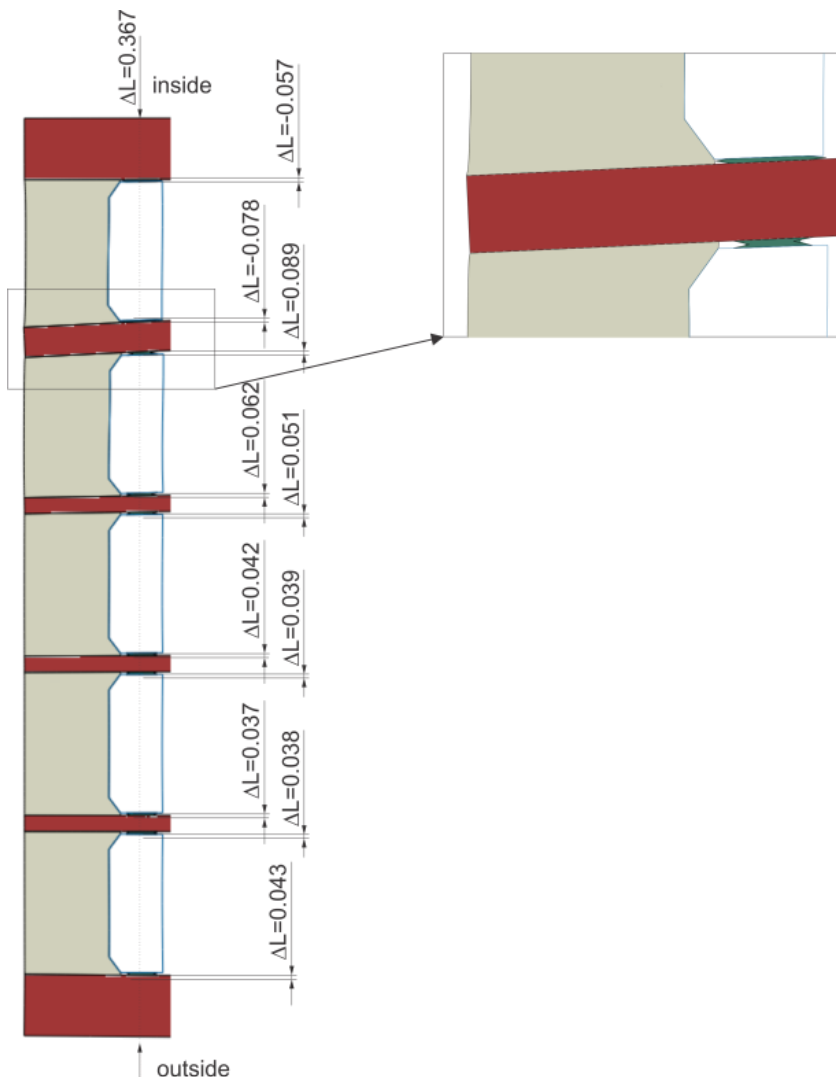
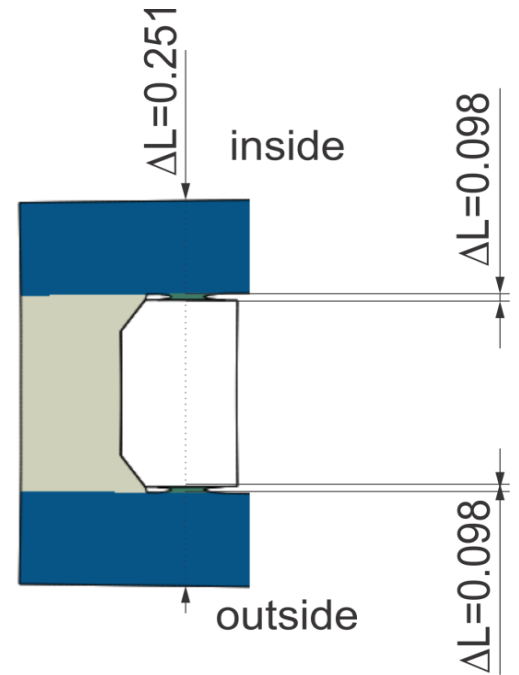


Edge sealant strain

Important to the glass-unit longevity issue is its gas and water vapour permeation resistance. Apart from increased diffusivity through increased sealant temperature, sealant straining is the second parameter that must be controlled by careful product engineering.

Known reference, double and triple glazed units were evaluated for generally permissible primary sealant strains.

These limits were applied throughout the various Q-Air glass unit designs.



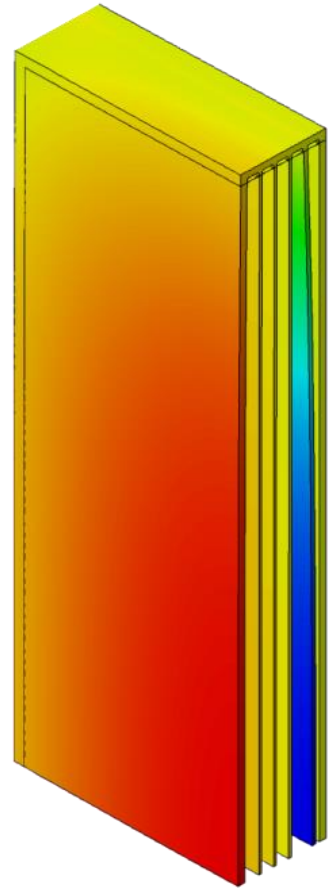
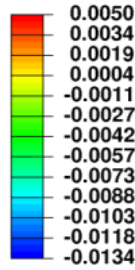
Topological issues

Not all Q-Air units could be rectangular in shape. Moreover, even rectangular shaped Q-Air unit exhibit measurement ranges where it is difficult to meet all engineering requirements.

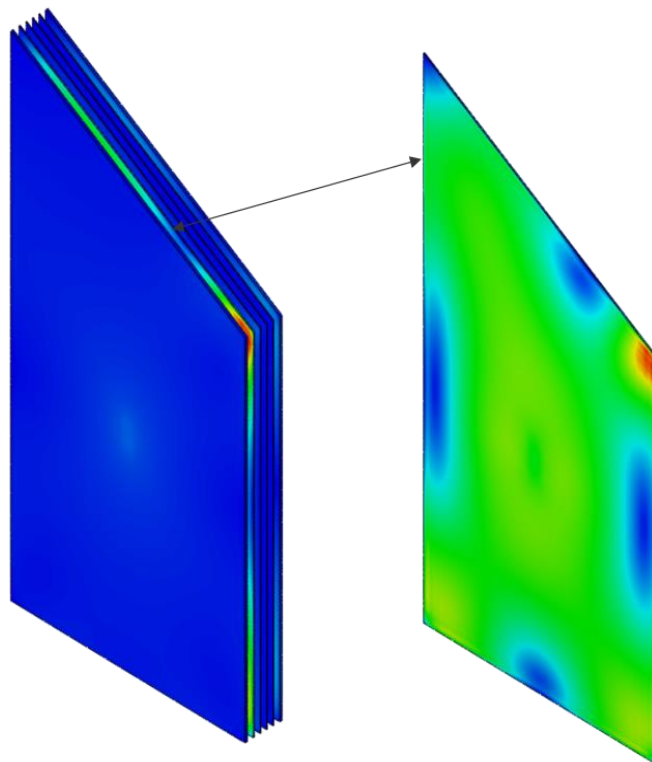
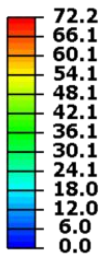
Especially with trapezoid units and narrow rectangle units, there are difficult to manage expansion-glass stresses and edge sealant straining.

Details such as exact location of the stress peaks were observed as toughened glass only receives its "toughness" several millimetres from the edge.

horizontal displacement [m]



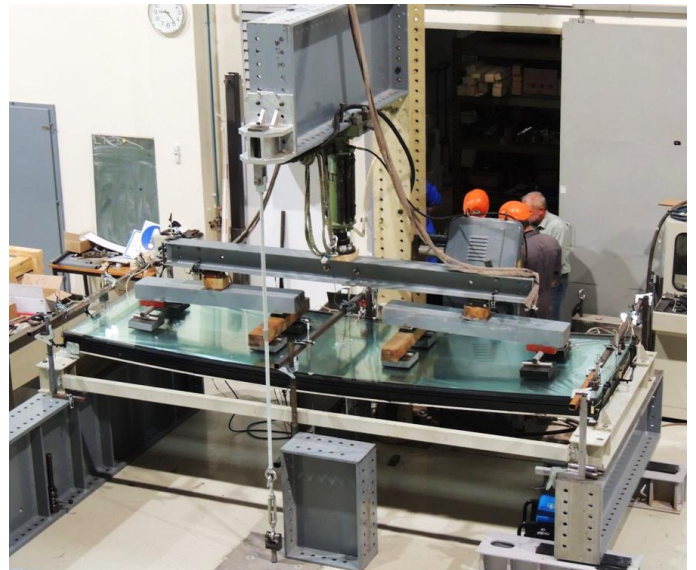
equivalent stress [MPa]



Serviceability limit states

From 2012 to 2015 we conducted several series of glass unit bending tests. Opaque and transparent units were considered. These tests were simultaneously used to evaluate service limit states of the Q-Airs with featured unique double structural look.

4 m tall, 1.25 m wide, standard Q-Air unit with composite sidebar reinforcement can be loaded by as much as 25 kN of wind pressure or suction equivalent. Units may flex by as much as 200 mm without intermediate glass breakage.



Case study, wind, driving rain

In 2015, while preparing for the first large-scale commercial application of the Q-Air 5 units, project specific, wind-load, airtightness and driving rain evaluation were performed by the Ift Rosenheim institute.

Evidence of performance

Air permeability, Watertightness static, Resistance to wind load



Test Report
No. 15-001278-PR01
(PB-B01-02-en-01)

Client Trimo d.d.
Prijateljeva cesta 12
8210 Trebnje
Slovenia

Product Curtain walling

Type Unitised construction

Designation Qbiss Air system

Material Aluminium profiles with thermal break

Overall dimensions (W x H) 3,600 mm x 6,080 mm

Construction project¹⁾ Wergelandsveien, Oslo - Norway

Special features -/-

Basis
EN 13830:2003-09

Test standards:
EN 12153:2000-06
EN 12155:2000-06
EN 12179:2000-06

Corresponds to the national standards (e.g. DIN EN) Representation



Instructions for use
The results obtained can be used by the manufacturer for preparing the Declaration of Performance in accordance with the Construction Products Regulation 305/2011/EU. The provisions of the applicable product standard have to be observed.
¹⁾ According to the manufacturer, the originator from the specified construction project and was selected by the consultant as representative building component

Results

Facade construction

Air permeability
EN 12152:2002-02

Class AE

Watertightness - static
EN 12154:1999-12


Class R7

Resistance to wind load
EN 13116:2001-07

Design load
+ 1.00 kN/m²
- 1.20 kN/m²

Safety load
+ 1.50 kN/m²
- 1.80 kN/m²

ift Rosenheim
16.10.2015


Thomas Stefan, Dipl.-Ing. (FH)
Head of Testing Department
Construction Product Testing


Herbert Niedermeier
Operating Testing Officer
Construction Product Testing

Validity

The data and results refer solely to the tested and describes specimen. Classification remains valid as long as the product and the above basis remain unchanged. The results can be extrapolated under the manufacturer's own liability subject to observation of the relevant specifications set out by the applicable product standard. This statement to be made on any further characteristics regarding performance and quality of the construction presented, in particular the effects of weathering and ageing were not taken into account.

Notes on publication
The Ift-Guidance Sheet "Advertising using Ift test documents" applies. The cover sheet can be used as an abstract.
The report contains a total of 35 pages.

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ISO 9001
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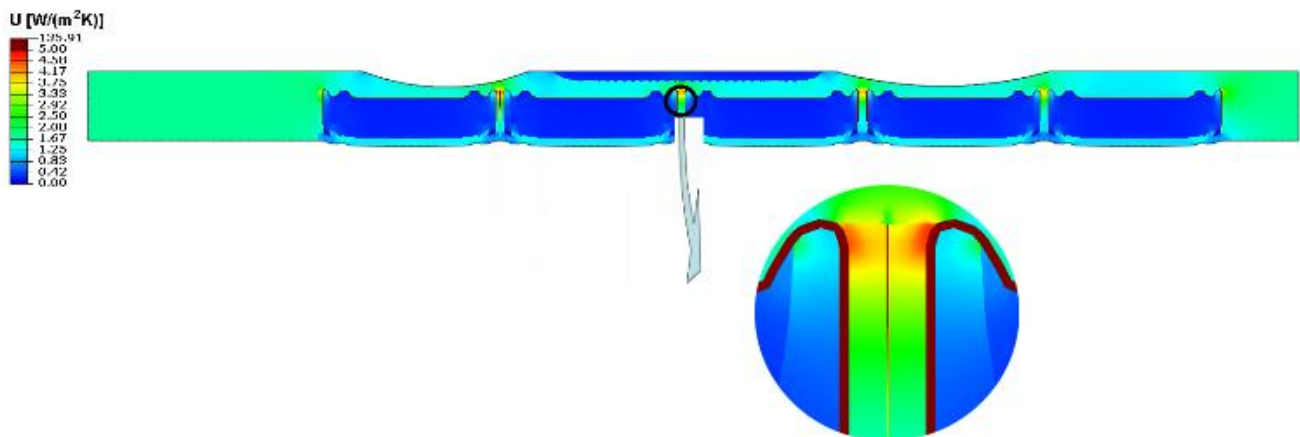
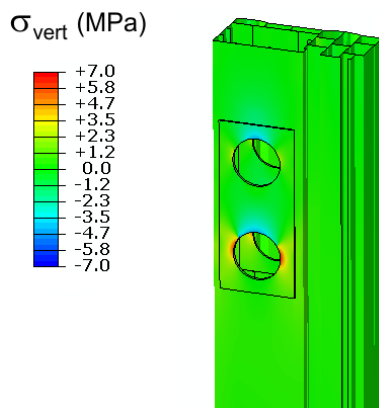
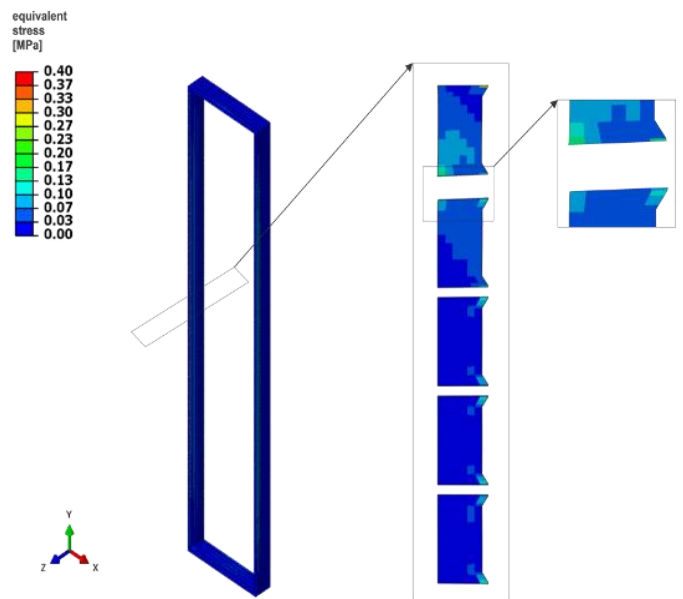
DAkkS
Zertifizierung
DIN EN ISO 9001
DIN EN ISO 14001
DIN EN ISO 45001



Miscellaneous FEM modelling

Since 2009 numerous FEM models were created to evaluate or simulate various mechanical and thermal properties of Q-Air units.

These comprised evaluations of linear heat transfer coefficients, glass unit manipulation deformations needed to design for the installation issues, various strain-stress relations of the edge sealant combined with expansion glass movement, long-term viscoelastic self-weight problems and many others.



Building physics (hourly simulations)

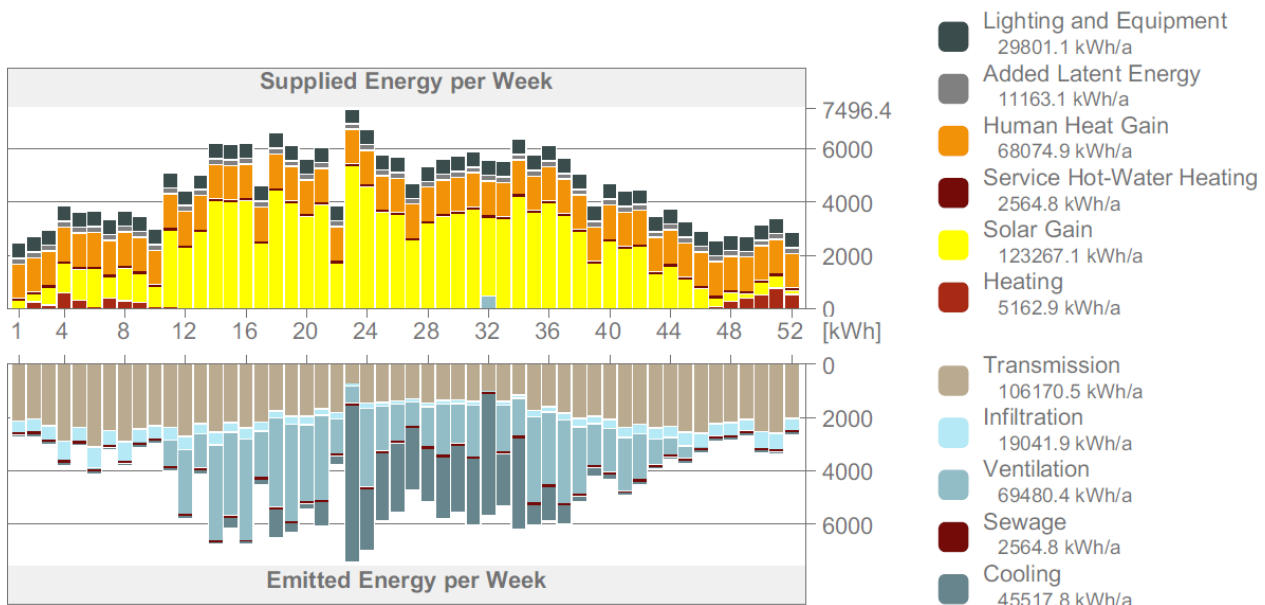
Since Q-Air projects have not relied on dynamic shading, so it is necessary for the solar heat gain (g value) to be adjusted appropriately to match client's priorities and building physics requirements.

Since 2014 we adjust building parameters through hourly simulations.

It is worth emphasizing that building simulations designed by daily or even longer time-scale averages yield significantly biased results towards better than realistic. Especially passive and near zero energy buildings give false, better than real-world results if daily, monthly or even yearly energy balance calculations¹.



Project Energy Balance



¹ M. Hall and A. Geissler, Different balancing methods for Net Zero Energy Buildings - Impact of time steps, grid interaction and weighting factors, Energy Procedia **122** (2017) 379–384.

Certificates and external evaluations

Numerous evaluations and tests were performed by various accredited certification bodies.

Q-Air is referred to by its previous name “QATT” in many older documents. Not all documents are available in English.

Q-Air is a new glazing unit system for curtain walls. Traditional glazed facades are equipped with sealed insulating glass units (IGUs) per EN 1279. These sealed units are double or triple glazed, i.e., single or double gap. EN 1279 might also be extended to recently introduced quad glazed units as well. To manage considerable volumetric changes of the insulating gas in the many-gap sealed unit, Q-Air introduced an opened gap which serves as an air-breathing expansion chamber. Therefore, use of the EN 1279 proves difficult. Q-Air uses EN 1279 certified primary and secondary seal materials, while the whole unit falls into the scope of closed cavity or unitised double skin systems. To assure full functionality of the sealed part of the many-gap Q-Air unit, provisions were made to assure that edge seal elements of the Q-Air never exceed climatic load stress as it would be with EN 1279 certified double gap (triple glazed) unit. More precisely, provisions were made in the Q-Air design to maintain long-term gas permeation performance on par with best sealed glazed systems.

As most buildings with Q-Air are custom builds with respect to framing, we certify these framing systems by individual type approval.

We report and certify individual properties.

The Q-Air glass unit:

Sealed glazing unit materials performance	EN 1279
U _g value	EN 673
Light transmission & g-value	EN 410

The framing system or the whole assembled unit:

U _{cw} -value	EN ISO 12631
Reaction to fire	EN 13501-1
Resistance to driving rain under pulsating pressure	EN 12865
Air permeability	EN 12114
Airborne sound insulation	EN ISO 10140-3

And others as needed.

Q-Air case with Aluminium profile

1. IFT Rosenheim certificate: Air permeability, Watertightness static, Resistance to wind load

Q-Air with composite sidebar

STRUCTURAL PROPERTIES

1. Translation of report about the testing of the flexural strength of Qbiss Air (VITP) facade elements (No. P 0436/11-630-1)
2. Translation of report about the testing of the flexural strength of short test specimen of Qbiss Air (VITP) facade elements after exposure in a climatic chamber (No. P 0438/11-630-1)
3. Translation of report about the testing of the flexural strength of an assembled test specimen of Qbiss Air (VITP) facade elements by means of cyclic loading (No. P 0437/11-630-1)
4. Translation of report about the testing of the safety in use properties of Qbiss Air (VITP) facade elements (No. P 0439/11-630-1)
5. Report about the testing of the safety in use properties of facade elements Qbiss Air (SL WIP) (No. P 0203/11-630-1)
6. Numerical model of the Qbiss Air panel
7. Strains and stresses in Polysulphide adhesive in Qbiss-Air: External pressure, thermal loading and dead weight
8. Service limit state (SLS) calculation using a numerical model of the Qbiss-Air panel
9. Dokaz pritrdilnega elementa v skladu z EN1993-1-1
10. Dokaz obešala za pritrjevanje fasadnega elementa Qbiss Air v skladu z EN 1993-1-1
11. Self-supporting Light Weight Insulation Panel »Qbiss Air« determination of resistance to tearing for structural sealant according to ETAG 002:1999, A:2011 (No. P 203/11-520-8)
12. Self-supporting Light Weight Insulation Panel »Qbiss Air« determination of elastic recovery for structural sealant according to ETAG 002:1999, A:2011 (No. P 203/11-520-9)

FIRE RESISTANCE & REACTION TO FIRE

13. Fire resistance test of non-loadbearing wall made of panels Qbiss Air (VITP) (No. P 0008/11-530-1)
14. Reaction to fire by thermal attack by a single burning item according to SIST EN 13823:2011 Qbiss Air (VITP) (No. P 0669/12-530-1)
15. Report on Qbiss Air (VITP) panels testing according to the procedures defined in standards SIST EN 12114:2001 and SIST EN 12865:2002 (No. P 1324/12-520-4)
16. Reaction to fire test according to SIST EN ISO 11925-2:2011 (TIOELAST TM IZO CBS)
17. Reaction to fire test according to SIST EN ISO 11925-2 EPDM gaskets for SLWIPs (No. P 0669/12-530-3)
18. Classification report (replacing No. P 0669/12-530-2) classification of reaction to fire in accordance with EN 13501-1:2007 Qbiss Air (VITP) (No. P 0669/12-530-4)
19. Classification of fire resistance performance in accordance with SIST EN 13501-2:2008 Non-loadbearing wall made of panels Qbiss Air (VITP) (No. P 0008/11-530-2)

SOUND INSULATION

20. Laboratory measurement of Airborne sound insulation of facade element Qbiss Air (VITP) (No. HR1272)

APPROVALS

21. Slovenian technical approval (STS-11/0023)
22. CUAP for European Technical Approval 04.04/54 Self-supporting light weight insulation panel system (version July 2012)
23. Draft ETA
24. IFT: Evidence of performance: Of the physical attributes of the edge seals of insulating glass units according to DIN EN 1279-4 (test report 10-000881-PB01-H01-09-en-01)
25. IFT: certificate of conformity RX warm, RX sun, RH phone, RX safe

THERMAL TRANSMITTANCE

26. Report on initial type calculation of U_g of Qbiss Air panel according to SIST EN 673:2011 for temperature regime 0 °C outside and 20 °C inside (No. P 0447/11-520-9)
27. Report on initial type calculation of linear thermal transmittance of horizontal and vertical joints of Qbiss Air panel (No. P 0447/11-520-6)
28. Report on calculation of point thermal transmittance of fixing elements of Qbiss Air according to standard SIST EN ISO 10211:2008 (No. P 0447/11-520-8)

Q-AIR TRANSPARENT

Q-Air with composite sidebar

STRUCTURAL PROPERTIES

1. Self-supporting Light Weight Insulation Panel »QATT« determination of tensile strength for structural sealant according to ETAG 002:1999, A:2001 (No. P0073/15-520-1)
2. Self-supporting Light Weight Insulation Panel »QATT« determination of **residual** tensile strength **after ageing** for structural sealant according to ETAG 002:1999, A:2001 (No. P0073/15-520-2)
3. Self-supporting Light Weight Insulation Panel »QATT« determination of **shear strength** for structural sealant according to ETAG 002:1999, A:2001 (No. P0073/15-520-3)
4. Report about the performance of an impact resistance test using a soft body on the Q-Air facade elements: QATT5 and QATT3 (No. P 0073/15-630-1)
5. Določitev mejnih vodoravnih pomikov za sistem samonosilnih fasadnih panelov Q-Air (Št. P 0073/15-630-6)
6. Report about the performance of a load-bearing capacity test to own weight of the Qbiss Air facade element (QATT3) (No. P 0073/15-630-7)
7. Report about the testing of the flexural strength of short test specimens of Qbiss Air (QATT5) facade elements after exposure in a climate chamber (No. P 0073/15-630-8)
8. Self-supporting Light Weight Insulation Panel »QATT« determination of tensile strength for structural sealant according to ETAG 002:1999, A:2001 (No. P 0983/15-520-1)
9. Self-supporting Light Weight Insulation Panel »QATT« determination of shear strength for structural sealant according to ETAG 002:1999, A:2001 (No. P 0983/15-520-2)
10. Self-supporting Light Weight Insulation Panel »Qbiss Air« determination of resistance to tearing for structural sealant according to ETAG 002:1999, A:2001 (No. P 0983/15-520-3)
11. Self-supporting Light Weight Insulation Panel »QATT« determination of tensile strength for structural sealant according to ETAG 002:1999, A:2001 (No. P 0983/15-520-4)

THERMAL PROPERTIES

12. Report on initial type calculating of U_g of panels QATT3 and QATT6.24 according to SIST EN 673:2011 for temperature regime 0 °C outside and 20 °C inside (No. P 0073/15-520-4)
13. Report on the initial type calculation of the linear thermal transmittance of the horizontal and vertical joints of the system and of the panel QATT3 according to the standard SIST EN ISO 10211:2008 (No. P 0073/15-520-5)
14. Report on the initial type calculation of the linear thermal transmittance of the horizontal and vertical joints of the system and of the panel QATT5 according to the standard SIST EN ISO 10211:2008 (No. P 0073/15-520-6)
15. Report on the initial type calculation of the linear thermal transmittance of the horizontal and vertical joints of the system and of the panel QATT6.16 according to the standard SIST EN ISO 10211:2008 (No. P 0073/15-520-11)
16. Report on the initial type calculation of the linear thermal transmittance of the horizontal and vertical joints of the system and of the panel QATT6.24 according to the standard SIST EN ISO 10211:2008 (No. P 0073/15-520-12)
17. Report on validation of calculation procedure for calculation of solar heat gain coefficient and light transmission of panels QATT according to SISZ EN 410:2011 (No. P 0073/15-520-13)

THERMAL PROPERTIES (CBS INSTITUTE)

18. QATT solar heat gain coefficient (g), light transmission (LT) according to FprEN 410
19. QATT curtain wall heat transmission coefficient (U_{CW}) according to EN ISO 12631:2012
20. QATT centre of glass thermal transmittance (U_g) values according to SIST EN673

SOUND INSULATION

21. Laboratory measurement of airborne sound insulation of the test specimen QATT3 – sample 1 (No. P 73/15-520-9)
22. Laboratory measurement of airborne sound insulation of the test specimen QATT3 – sample 2 (No. P 73/15-520-10)

REACTION TO FIRE

23. Reaction to fire test according to SIST EN ISO 11925-2:2011 (No. P 0073/15-530-1)
24. Classification of reaction to fire in accordance with EN 13501-1:2007+A1:2009 RX LAMISAFE (No. P 0073/15-530-2)

SUMMARY

- 25. Summary report about the testing and calculations of the Qbiss Air Transparent and Translucent (QATT) modular facade elements, performed at Slovenian National building and Civil Engineering Institute, in 2015 (No. P 0073/15-630-9)**