# FORMAT

Xella

# 15

**built** Blower door test in school gym

**asked** Aircrete for tight building shells

**achieved** Non-residential buildings targeted by EnEV 2009

**explained** More than hot air: fire test

**explained** Playing it safe: firmly anchored sports equipment

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# Tight as tight can be

*Energy efficiency is measurable. By means of a blower door test, Hebel proved the perfect tightness of a school gym in the North Rhine-Westphalian city of Bergisch Gladbach. Built entirely from aircrete wall and roof boards, the structure scored an n50 value of 0.18 $h^{-1}$- a significant improvement on the tightness value of 1.5 $h^{-1}$ stipulated by the German Energy Conservation Act (EnEV 2009) for buildings equipped with air conditioning systems. The result of the test was even below the n50 standard of 0.6 $h^{-1}$ for passive houses.*

*School gym in Gronau, Bergisch Gladbach, Germany*

- *Owner: Municipality of Bergisch Gladbach*
- *Architect: Eduard Kniffler, Bergisch Gladbach*
- *Type of building: Schools and sports facilities, new building*
- *Use: gym*
- *Location: 51469 Bergisch Gladbach, Germany*
- *Completion: 2010*
- *Products: HEBEL aerated concrete wall and roof boards*
- *Particularities: Tightness value of 0.18 $h^{-1}$, better than passive house*

Xella Aircrete Systems had certainly picked the right time to schedule this blower door test on the primary school's single-field sports hall - the coming into force of Germany's EnEV 2009 on October 1 has clearly heightened the importance of energy-efficient construction planners and clients. At the same time, there is a certain insecurity among many decision-makers about how to comply with the new legal requirements and how to verify and document their compliance. This is why the test in the town of Bergisch Gladbach attracted numerous planners, investors, building contractors and architects, some of whom had never before attended an actual blower door test. In view of the test result, they were all convinced of the advantages for the tightness of buildings offered by aerated concrete boards.

Franz Kuhagen, Marketingleiter von Xella AircreFranz Kuhagen, marketing director of Xella Aircrete Systems, said: "Of course we wanted to demonstrate that correct installation of our wall and roof elements makes it easy to meet the new EnEV requirements. In addition, we wanted to show how principals and planners can verify whether a building complies with the requirements of energy-efficient construction."

### Certificate of tightness

A blower door test provides certified proof of tightness of a building, thereby allowing to forecast and determine its sustained energy efficiency. As a first step, all openings in the building shell such as windows, chimney flues, doors and air conditioning lines were sealed by the specialists from ean50, the firm conducting the test. A powerful blower was installed on one of the doors of the gym and then connected to additional measuring units inside the building.

The blower fixed to the door was first set to generate a negative pressure of 50 Pascal. This allowed to spot any remaining leaks e.g. at the joints in the door areas. Draughts of this kind can be identified simply by touching the area with bare hands; a smoke pencil can make such leaks visible too. As expected, the joint on the large entrance door proved to be particularly important. Subsequently, an overpressure of 50 Pascal was generated. This pressure corresponds to a wind speed of nine metres per second.

The n50 value to be measured is defined in DIN 4108 T7. This standard describes how much time is required to exchange the entire air volume of the building. In case of the n50 standard of 1.5 stipulated by EnEV, this corresponds to one and a half air exchanges within one hour. The average value of 0,18 $h^{-1}$ measured in Bergisch Gladbach means that a complete exchange of air takes five hours. The rule is: the higher the value, the more unfavourable the energy efficiency of a building. The results of the test were recorded in a manipulation-proof log. The procedure itself is described in DIN 13829.

### *Cost, time and energy saved*

What might seem to be a major effort can actually be implemented quickly and at low cost. The entire test including preparation work took less than six hours. The costs for the test amounted to about EUR 1,000. In return, the building owner received a certificate proving the tightness of the gym with a floor area of just under 810 square metres and a volume of 4,134 cubic metres. The excellent test values translate into economic advantages in day-to-day operation of the gym. A tight building shell means that up to seven percent less primary energy is required per year. Unpleasant draughts are not an issue, either. Importantly, the construction of the building will ensure that these results are maintained in the long term.

The project documentation displayed at the test site showed that this solid single-shell construction using aircrete wall and roof elements cost only EUR 3,100 more than a construction with a steel sheet roof and conventional brickwork. The total investment amounted to EUR 131,000. The cost saved in the coming years – especially in terms of energy consumption – will soon result in a clear cost advantage for the municipality; the annual A/C power consumption alone will be reduced by 33 percent. With regard to the heat insulation certificate, EnEV now includes new limits for the average thermal conductivity values which were easily reached here. In addition, the gym has a primary energy requirement (a measure of the total energy efficiency) of 256 kWh/($m^2$a) which clearly stays below the requirements of EnEV 2009 (303 kWh/($m^2$a)).

### *Rapid construction progress with Hebel wall boards*

Thanks to the finished surface of the boards, rendering was neither required on the inside nor on the outside. The shell was erected within eight weeks. The rapid construction was one argument that convinced the city of Bergisch Gladbach of using Hebel wall boards. The requirements imposed by the city council included energy-efficient construction. In addition, the favourable properties of aerated concrete with regard to the carbon footprint also pay off in the environmental balance sheet.

In the summertime, aircrete does not conduct the heat of the sun directly into the interior of the building, allowing the girls and boys to do sports without dripping with sweat. Expensive cooling of the hall is not required. Compared to a sheet metal construction, the room climate is six degrees cooler in times of peak temperatures. This saves more than 9,000 kWh in electricity per year.

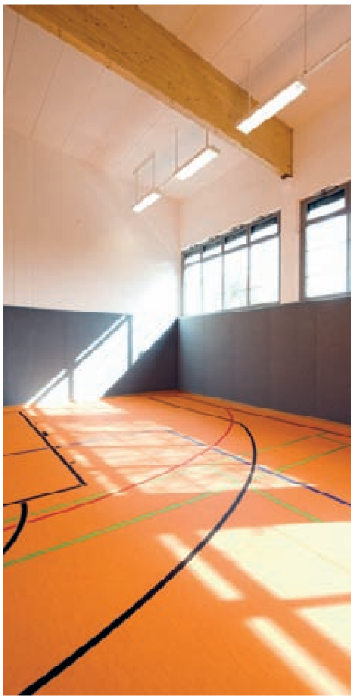
After coordination with the Kniffler architecture firm with regard to the aircrete construction of the wall and roof areas, the assembly was carried out by Cologne-based Die Lente Porenbeton GmbH. The contractor's representatives followed the blower door test with particular interest because the results were also a reflection of their workmanship in installing the aerated concrete boards.

### *Consistent planning and implementation*

In view of the requirements made to the tightness of a building, Franz Kuhagen points to new challenges to be addressed by planners and builders: "The focus will shift to a consistent and integrated approach." If, e.g. an electrician installs a cable shaft or a socket in a finished wall, these penetrations may have negative effects on the n50 value.

Other critical points are e.g. the transition between the roof and wall constructions or the points where the roof beams penetrate the walls. This fact also became evident to the professionals attending the test. For the demonstration, a 2 by 25 cm joint between the concrete elements was deliberately left unsealed - a negative pressure of 50 Pascal caused a whopping 100 cubic metres of air to leak through this narrow groove alone.

Bright colours, a friendly atmosphere, a balanced room climate: the homogeneous wall and roof construction made from aerated concrete boards provides for perfect tightness and optimum energy efficiency at this school gym in Bergisch Gladbach, Germany.



# asked

## Quick, efficient, safe

*Hebel aerated concrete elements enable perfectly tight construction. This was impressively underlined by the sensational result of the blower door test carried out in a gym in Bergisch Gladbach, Germany. However, aerated concrete offers a number of additional advantages above all for the construction of non-residential buildings. FORMAT talked about this topic with Eduard Kniffler, the architect of the school gym.*

*Eduard Kniffler, architect*

- *born 1957*
- *1979 – 1988 Work with various architecture firms*
- *set up his own architecture firm, Kniffler Architektur in Bergisch Gladbach, in 1988*
- *Focus on residential construction, building within or on top of existing buildings, commercial buildings*
- *officially accredited expert for noise and heat insulation*
- *certified expert for damages on buildings*

**FORMAT:** What were the reasons for specifying Hebel aerated concrete for the construction of the sports hall?
**Kniffler:** The client, the city of Bergisch Gladbach, had allocated a relatively tight budget and set a challenging deadline for the implementation of the project. When it came to specifying suitable construction materials for the school gym, we therefore soon opted for wall and roof boards made from aerated concrete. The finished surfaces of these elements do not require on-site rendering, resulting in short completion times. The ability to complete the shell in only eight weeks' time also convinced the city officials.

**FORMAT:** : How do you feel about the result of the blower door test?
**Kniffler:** The result of the test is spectacular. Of course, we had expected that we would stay within the legally stipulated limits as was the case in previous tightness tests we had performed on other properties. However, no-one had really expected that the gym would reach a tightness value of 0.18 $h^{-1}$, which even improves on the passive house standard. It is hardly possible to do this any better. But the fact is that we tried right from the beginning to achieve maximum building efficiency without incurring excessive technical complexity. With a view to the construction we attached particular importance to the tightness of the window and ceiling joints. The use of aerated concrete for both the walls and the roof was very advantageous in this respect.

**FORMAT:** Will the good test result influence your future specifications for other non-residential buildings?
**Kniffler:** I would use the construction system any time for comparable projects, because it enables us to offer our clients excellent quality at an attractive price. We are currently planning a fire and emergency station which is much more complex, however, making different requirements on the construction materials than a sports hall. Nevertheless, we will use aerated concrete elements for the top floor ceiling here too.

**FORMAT:** What are the main arguments that usually convince clients to opt for Hebel aerated concrete?
**Kniffler:** In non-residential construction, it is above all the finished surfaces which enable a short construction time and contribute to reducing the cost for interior finishing. The solid material is able to store heat as well as cold to provide for pleasant temperatures inside all year round. Moreover, it offers effective noise and fire insulation. The increased tightness of the building achieved by means of aerated concrete elements helps owners save energy and keep their heating and A/C costs low.

Blower door test: The necessity of tight seals became most obvious in critical areas like the points where the roof beams penetrate the walls. For demonstration purposes, a narrow joint was left unsealed, allowing strong draughts to be measured here.

# achieved

## Improved insulation and tightness

*For the first time, the German Energy Conservation Act EnEV 2009 stipulates limits for the average thermal conductivity values of the building shell. While this will contribute to reducing transmission heat loss, loss due to insufficient tightness will be felt all the more keenly. A homogeneous shell made from Hebel wall and roof boards is therefore the best basis for energy-efficient non-residential buildings.*

On an insulation area of one square meter with a standard climate and low air pressure difference, an untight joint results in 4.8 times more heat being lost than through the area itself. In addition, the effect of heat insulation is based on the inclusion of air in the cavities of the insulation material. If, however, the latter is subject to air streams due to untightness, heat will be withdrawn and the insulating effect is lost. Very special physical laws also apply to noise transmission. Even narrow grooves allow noise to penetrate a wall. The noise-transmitting effect of small grooves is often underestimated, but it is really important.

An airtight building shell made from aerated concrete helps to kill several birds with one stone: it saves energy and thus heating costs, provides for a healthy and comfortable room climate without draught air and also offers optimum noise protection. In addition, it helps prevent humidity damage within the building. If untight connection joints allow hot, humid air to get from the interior rooms into colder areas of the building, the water vapour contained in it may condensate. After all, cold air absorbs less water than hot air. The condensing humidity may become an ideal breeding ground for mould and other fungi. This means that the entire

**Exemplary calculation:**
Hall with interior temperature > 12°C and < 19°C

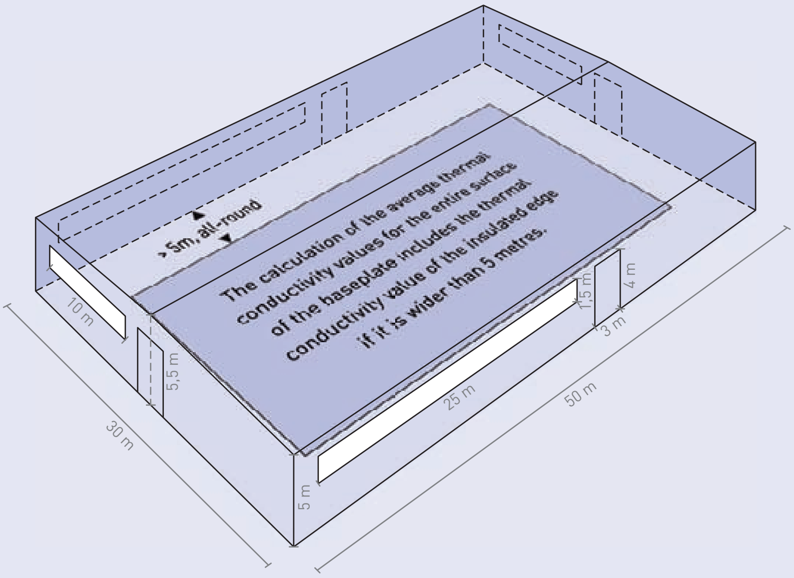
Gates:
Steel sheet sectional gates;
$U = 2.9$ W/(m²K)

Windows:
Windows are calculated separately as transparent construction elements.

Walls:
250 mm thick Hebel wall boards,
$\lambda = 0.14$; $U = 0.51$ W/(m²K)

Ceilings:
200 mm thick Hebel roof boards,
$\lambda = 0.14$; with 60 mm insulation,
$\lambda = 0.04$; $U = 0.32$ W/(m²K)

Floor:
200 mm reinforced concrete, $\lambda = 2.5$; all-round 40 mm perimetric insulation, $\lambda = 0.04$ in a width of 5 m; $U = 0.80$ W/(m²K)




Calculation of the average thermal conductivity value of the opaque construction elements:

$$\bar{U} = \frac{0.51 \times 662 + 2.9 \times 48 + 0.32 \times 1500 + 0.80 \times 1500 \times 0.5}{3710}$$

$$\bar{U} = \mathbf{0.42 < 0.50}$$

*This means that the requirements of appendix 2 table 2 of EnEV are complied with.*

Average thermal conductivity value of the opaque construction elements:

| Construction elements | U-value W/(m²K) | Surface m² |
|---|---|---|
| Outer wall (opaque element 1) | 0.51 | 662 |
| Gates (opaque element 2) | 2.9 | 48 |
| Roof (opaque element 3) | 0.32 | 1500 |
| Baseplate (opaque element 4) | 0.80 | 1500 |

The better the insulation of a building, the more important its heat losses due to untight transitions of construction elements. The permanent air tightness of joints can be proven in a blower door test.

building may be damaged in the long term.

A lack of tightness of the building shell may also impact the function of mechanical ventilation systems which are often found in non-residential buildings. Originally, they are meant to prevent uncontrolled ventilation losses due to undefined leakages. After all, air will only stream when there is a pressure difference. This is also the reason why the requirements made to the tightness of buildings with air-conditioning systems are usually higher.

### *Air tightness to EnEV 2009*

This is the reason why the German Energy Conservation Regulations that came into force on October 1, 2009 stipulates that new buildings must be airtight. Section 6 says: "New buildings must be erected in such a way that the heat-transmitting enclosing area including the joints is permanently insulated air-tight in line with the generally accepted state of the art." If the tightness of the building is certified by a measurement to DIN EN 13829: 2001-02, a bonus is added to the heat insulation certificate. The value measured may be used for the calculation of the energy requirement to DIN 18599. If no measurement is made, the standard values of DIN 18599-2, table 4 are entered.

### *Heat insulation to EnEV 2009*

In addition, the revised regulations state maximum permissible values of the average thermal conductivity coefficient for new non-residential buildings to be erected. Section 4, para. 2 says: "Non-residential buildings to be erected must not exceed the maximum values of the average thermal conductivity coefficient of the heat-transmitting enclosing area as defined in appendix 2 table 2."

The individual construction elements such as wall, roof, window, etc. are categorised as follows in line with their properties: opaque (non-transparent) exterior construction elements, transparent exterior construction elements, curtain walls as well as glass roofs, skylights and light domes. In line with the individual share of the surface, the average thermal conductivity value for each of these four groups of construction elements must be calculated separately and an individual maximum value must be complied with. The minimum heat insulation to DIN 4108-2 for individual construction elements must always be ensured.

For areas with different target temperatures, the calculation is made separately. The permissible maximum values depend on the utilisation of the room and thus of the target temperature. Thermal conductivity coefficients of construction elements against unheated rooms or soil are weighted with a factor of 0.5. In case of baseplates reaching down to the ground, the thermal conductivity value of surfaces which are more than five metres away from the outer edge of the building is not considered. The thermal conductivity value for this peripheral strip is applied with a correction factor of 0.5 to the entire surface of the construction element.

### *No problem with aerated concrete*

As a solid construction material, aerated concrete combines high temperature insulation with the capacity to store heat and cold. The climate-balancing property provides for pleasant temperatures all year round inside the building. In addition, permeable surfaces of construction elements may also balance the ambient humidity in the room.

This means that aerated concrete buildings offer major advantages over light-frame constructions. It is much easier to achieve air-tight connections between the individual Hebel wall and roof construction elements. Any special, usually very time-consuming measures such as the application of foils are not required here at all as the standard system from Hebel already provides for a perfectly air-tight building. Even after the introduction of limits for the average thermal conductivity values of the building shell, it continues to be possible to erect buildings of all temperature ranges with one solid shell made from Hebel wall and roof boards. Specific calculations and practical tests like the one carried out in the single-field gym in Bergisch Gladbach have proven this clearly.

# explained

## More than hot air

*Aerated concrete versus metal polyurethane sandwich panels: Xella Aircrete Systems carried out a test of the flammability of two equal-sized buildings made of these two materials. While the steel sheet structure was destroyed only shortly after inflammation, the aerated concrete building emerged completely intact from the blaze.*

Two equal sized buildings erected on the premises of the Gelnhausen hazard prevention centre – one made of aerated concrete, the other of metal polyurethane sandwich panels – were charged with a fire load of 1,000 kg in the form of wood pallets. The floor area of the buildings was 18 square metres with three solar modules installed on each roof. During the entire test, measurements were performed at five different points of both buildings. These were then analysed by the fire protection experts from the Endreß consulting firm in Frankfurt/Main.

### *Results of the fire test*

Shortly after being ignited, both buildings showed a quick temperature increase to the level of the standardised fire test temperature which was temporarily even exceeded. In case of the metal polyurethane sandwich panel construction, this resulted in a rapid destruction of the structure with parts of the ceiling and walls gaping. This allowed the hot combustion gases to evaporate, causing the interior to cool down clearly. Due to the strong temperature fluctuations, the polyurethane was not fully combusted, resulting in a high contamination in the environment of the fire.

In contrast, the Hebel aerated concrete construction remained completely intact during the entire measurement and even after the extinguishing process. There were neither any material deformations nor cracks in the aerated concrete, joints and transitions remained safely closed, i.e. no gas or smoke evaporated. Aerated concrete being a purely mineral construction material, no toxic gases were produced as a result of the fire. Even the solar panels on the roof remained intact while they were combusted completely in the sandwich panel construction. Thanks to the low thermal conductivity of aerated concrete, it was even possible to touch the outside of the construction with bare hands during the test.

The test set-up: the aerated concrete building on the left, the construction made of metal polyurethane sandwich panels on the right. While it was possible to touch the aerated concrete walls during the fire, the other building already showed clear signs of a fire. After the fire test, the aerated concrete building was intact on the inside as well as on the outside. In contrast, the sandwich panel construction suffered clear deformations and the polyurethane insulation was combusted.

# explained

## Solid and sturdy

*More and more people favour indoor sports – especially in gyms benefiting from a pleasant ambient climate and functional architecture. Both requirements can be met easily with Hebel aerated concrete elements. In addition, this construction material is resistant against impact from balls etc. and sports equipment can be anchored in the solid walls, too.*

All kinds of sports equipment can be anchored safely in aerated concrete elements using anchor plates and undercut anchors.

No matter whether it is basketball hoops, wall bars or goals: with aerated concrete elements from Hebel as a basis, you are always on the safe side. The construction measures for the installation and fixing of sports equipment are regulated by DIN 18032-6: 2009-04 which stipulates early planning of the fixtures anchoring such equipment to the building shell.

### *Easy anchoring of equipment*

In order to support architects and engineers in the planning process, Xella Aircrete Systems GmbH has prepared detailed rules for the three most frequently installed types of sports equipment – basketball hoops, climbing frames and climbing poles as well as wall bars. As a general rule, individual solutions can be found for all other pieces of sports equipment to be fixed to aerated concrete bases in coordination with Xella. The only prerequisite is that precise specifications are available with regard to the pieces of equipment and their position.

Wall bars, climbing frames and basketball hoops can be fixed quite easily by means of anchor plates which are installed into the wall elements with undercut anchors permissible for aerated concrete. However, more elaborate, heavy-duty subconstructions are also possible with horizontal steel profiles or struttings.

### *Aerated concrete resists hard shots*

The material testing institute of the University of Stuttgart has proven that Hebel aerated concrete elements are extremely tough and resistant. During the test carried out with hand and hockey balls, an untreated aerated concrete board with a size of 2 x 1.80 metres and depth of 25 centimetres was not damaged by a total of 66 shots. This result confirmed the unlimited compliance with DIN 18032-3 (ball impact resistance).


***Impressum***
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Xella Neues Bauen

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