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Case Study – Performances of a Masonry House – Energy Consumption and Air-Tightness

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Abstract: Air-tightness and energy consumption was measured in a one-family house built in 2009 and 2010. The air-tightness fulfilled the goals, which was set to 0.3 L/s·m^2. The energy consumption was measured from the start in May 2010. The figures in this report refer to measurements between May 2010 and October 2013 and are well below the authority demand of 55 kWh/m^2·year.

Key words: Masonry house, air-tightness, energy consumption, case study, measured values.

1. Introduction

In the last decade or so the energy performance for buildings have kept increasing. Focus has shifted from U-values to energy consumption. Houses with thick insulation, taped foils and many layers were in media focus. In the light of this a new sandwich block made of lightweight aggregate concrete has been developed and tested, with focus on how to build air-tight with few layers.

The air-tightness goal was < 0.3 L/s·m^2 which is comparable with the demands for a passive house. Together with a consultant and close discussions with the building company, the air-tightness was measured three times during construction. Minor changes in the construction such as the thickness layer of the rendering and the direction of the plastic foil were made. When the house was finalized the final measurement showed 0.16 L/s·m^2. The energy consumption is approximately half of the authority demands [1-3].

2. Background

In the beginning of 2009, we had developed a new model of a well-tested masonry block. The next step was to put it on the market and build a house with as good performances as possible.

The back ground discussions were that we knew we had a very good masonry block, with a low U-value. Increasing the thickness would not necessarily give better energy performance compared to the cost increase for the product. We needed to work with other parts of the building process and the air-tightness was the obvious next big part, more or less directly connected to our products in order to decrease the energy demand for houses.

A family who was in the process of building a house for themselves was contacted. We agreed that we could follow the building process and do some follow ups. Their aim suited our aims. They wanted to build a low energy house with performances close to the demands for passive houses.

The main criteria were air-tightness and we agreed to have an air-tightness consultant involved in the project from the start.

3. Aim of the Project

The goal for the company in this project, was to verify that with good communication between involved parties and only minor changes in erecting the building,

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it is possible to build a low energy and air-tight house with existing technology and modern architecture.

4. Technical Aspects for the Chosen Materials

The building is a one-family house and is situated just outside Malmö in the south part of Sweden. It is a two story building with 192 m^2 living space (Atemp).

The outer walls of the lower floor consist of a masonry sandwich block with 150mm of polyurethane foam and with 100mm of lightweight aggregate concrete on both sides. On both sides of the wall there is a layer of 10-15 mm of rendering.

The outer wall of the upper part is a wooden frame with mineral wool.

To reduce the cold bridge in the roof beams they look like I-beams made of two wooden load bearing part connected with a wooden fiber board, with a thickness of 500 mm.

The foundation is a massive low density light weight aggregate concrete connected to a concrete slab.

Fig. 1 3D-rendering of the house.

Table 1 Thicknesses and U-values of different building parts.

Building part	Thickness (mm)	U-value (W/m^{2}K)
Outer wall, 1st story, LECA® Isoblock	370	0,15
Outer wall 2nd story, wooden frame	340	0,14
Roof	500	0,08
Windows		0,9

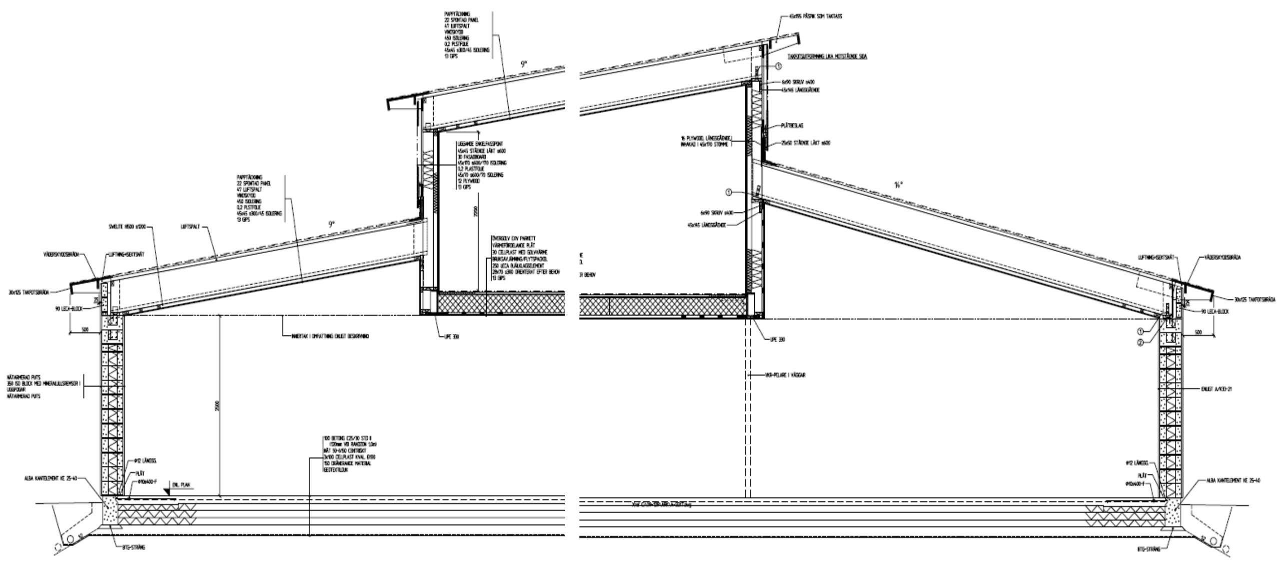

Fig. 2 Cut through of the house with the different construction details.

The installations consist of a heat pump, solar panels and a storage pump (in a separate building).

5. The Building Process

Together with the construction company and the consultant we held a few meetings regarding important and critical points in the building process in order to achieve as good air-tightness as possible. Therefore, everybody was "on their toes" already from the start.

The first layer of rendering is critical. Not only the façade part of the masonry needs to be rendered. But it is also very important to render the top of the masonry and door- and window-openings before doors and windows are installed. This is to ensure the air-tightness of the masonry structure.

Of equal importance was the way to connect the plastic foil from the roof to the masonry, which was pinched with expanding rubber tape between the top of the masonry and the roof construction.

The joints of the plastic foil were as far as possible taped and connected lengthwise to the roof beams in order to minimize air leakage.

Before closing the building with the finalizing layers we did an air-tightness measurement. This was to be able to do some enhancements if there might be some obvious errors. But after connecting the blower door we could not even achieve the proper pressure difference to get a value. It was, however, very easy to locate where the air leakages were and in this part of the process very easy to fix them. It was a few misses in the taped plastic foil joints and misses with the rendering in window openings. These were easily corrected in this phase of the building process.

We did a second blower door test with a fairly good result and some minor adjustments where done and then the building was finalized.

The air-tightness of the house was measured according to EN 13829 "Thermal performance of buildings - Determination of air permeability of buildings - Fan pressurization method (ISO 9972:1996, modified)", commonly referred to as the "Blower Door Test". And a Blower Door Modell 4 was used to receive an overpressure of 50-100 Pa.

Fig. 3 Pinching of the plastic foil between top of the masonry wall and wooden beam.

Fig. 4 The finalized house.

6. Results

The third and final blower door test was carried out in 2010 and gave us at the time a very good result. The few leakages were typically between frames and walls in both the masonry part and the upper wooden frame part.

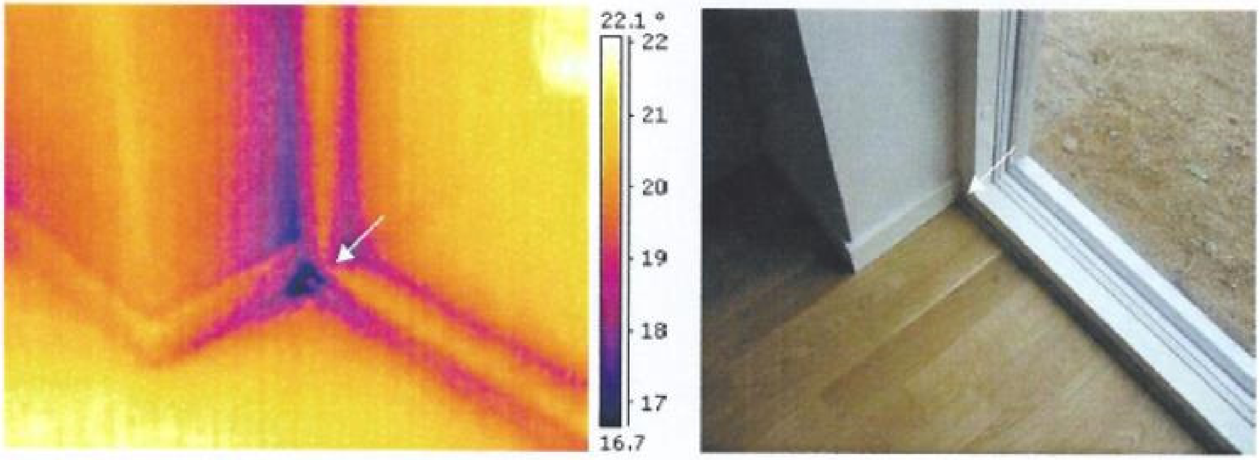

Fig. 5 Small leakage between window and corner floor/wall, bottom floor.

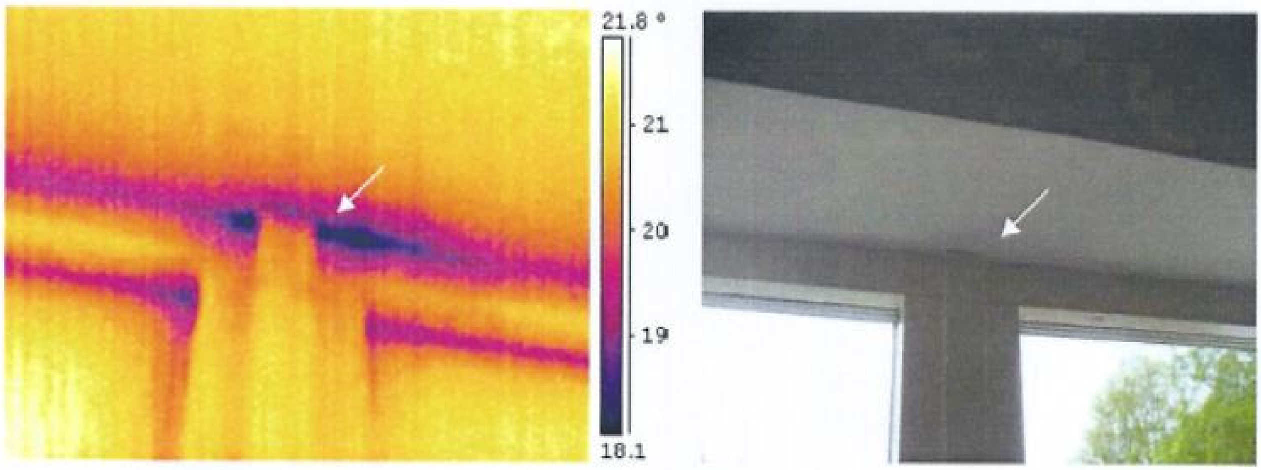

Fig. 6 Small leakage between window frame and wall, upper floor.

The air leakage measured to 0.16 L/s·m^2, compared to the goal of < 0.30 L/s·m^2. This goal was taken from the Swedish passive house regulations, FEBY.

The energy consumptions figures up to today are also very encouraging.

The separate storage pump building (heated) of 32m^{2}is not taken into account, which would have been beneficial for the calculations.

In this house it is possible to separate the energy consumption for hot water. And looking at the total monthly consumption for the summer months one can make a good estimate for the energy for lightning, TV, appliances etc.

Included in the figures for bought energy there is a huge computer server that uses 3000 kWh per year. I have pulled that out from the calculations. Below the table show a summary for the two complete years of 2011 and 2012, regarding energy and hot water.

To make an estimate of the energy for lightening, washing machines etc I looked at the summer months for 2012 and 2013, where there are measured values.

The mean bought energy for 2011 and 2012 was approximately 12 000 kWh per year. This is for heating, hot water, light and appliances and the server. Looking at the summer months for 2012 and 2013 the bought energy is 744 kWh per month, that is 8928 kWh per year. This is then energy for the kitchen appliances, TV, light, hot water etc and the server. Hot water is a little more than 200 kWh per month, which gives 2687 kWh per year.

Table 2 Summary of energy, taken from the appendix.

Year	Bought energy	Solar gain	Hot water
2011	12072	3204	2963
2012	11957	1344	2412
Mean	12014		2687

Table 3 Summary of summer months, taken from the appendix.

Year	June	July	August
2012	710	703	710
2013	757	773	812
Mean	744		

The total energy demand for heating and hot water is then 12,000 – 8,928 + 2,687 = 5,759 kWh per year. The heated area is 192 m^2. The energy demand per square meter and year is 30 kWh. This is a little more than the level for electrical heated passive houses according to FEBY. But on the other hand, this was not meant to be a passive house, since the installed heat exchanger had too high effect according to the FEBY-regulations at the time.

7. Conclusions and Discussion

The goals that were set up where fulfilled. The level of the air-tightness was reached by far (0.16 L/s·m^2). The energy consumption for heating and hot water is well below the regulations for normal houses (30 kWh/m^2·year). And it is a modern architecture.

There are some obvious energy loss points:

- First you have the storage tank that is situated in a separate building, which means that it is impossible to utilize the heat loss inside the house.
- Then there are losses from the pipes leading from that building into the house.
- The house has fairly normal windows with a U-value of 0.9 W/m^{2}K.
- And from an energy point of view, the architecture is not optimal.
- Another big source for the energy demand is that the indoor temperature in the house varies between 22 and 23 ºC, according to the inhabitants. This is more than the 21 ºC that is normally calculated.

Acknowledgements

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References

[1] LTH rapport EBD-R-12/36; IVL rapport nr B 2027; ATON rapport 1201 (2012). FEBY12 “Kravspecifikation för nollenergihus, passivhus och minienergihus – Bostäder.

[2] Boverkets regelsamling, BBR.

[3] AK-konsult, Tätning och termografering, ordernummer 18556.

Appendix

Monthly energy figures.

Month	Bought energy (kWh)	Solar gain (kWh)	Hot Water (kWh)
2010-05	1053		
2010-06	1053	492	230
2010-07	1053	548	240
2010-08	1053	474	194
2010-09	1053	456	206
2010-10	1053	325	219
2010-11	1053	0	181
2010-12	1053	59	264
Sum 8 months:	8424	2354	1534
2011-01	1006	21	321
2011-02	1006	178	247
2011-03	1006	417	258
2011-04	1006	618	330
2011-05	1006	592	310
2011-06	1006	706	291
2011-07	1006	112	201
2011-08	1006	112	201
2011-09	1006	112	201
2011-10	1006	112	201
2011-11	1006	112	201
2011-12	1006	112	201
Sum 12 months:	12072	3204	2963
2012-01	1460	112	201
2012-02	1236	112	201
2012-03	1016	112	201
2012-04	912	112	201
2012-05	726	112	201
2012-06	710	112	201
2012-07	703	112	201
2012-08	710	112	201
2012-09	798	112	201
2012-10	910	112	201
2012-11	1134	112	201
2012-12	1642	112	201
Sum 12 months:	11957	1344	2412
2013-01	1599	112	201
2013-02	1452	51	185
2013-03	1374	517	229
2013-04	993	615	243
2013-05	791		
2013-06	757		
2013-07	773		
2013-08	812		
2013-09	819		
2013-10	1044		
Sum 10 months:	10414		

Bold figures are calculated mean.