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Renovation of the Brogården area to Passive Houses

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1 Background

The interest of Passive Houses in Sweden has grown rapidly during the last couple of years. Within a research project carried out at the Division of Energy and Building Design at Lund University, four passive house projects are studied [Janson 2008]. The Swedish Energy Agency is financing this research project that started in 2005 and includes three new built passive house projects and one renovation project (Brogården). Within this research, which will be finished in 2010, only residential buildings are studied.

The renovation project to passive houses in Brogården is the first of this kind in Sweden. The Brogården project is also part of a European study of renovation to passive houses, within the International Energy Agency [IEA-SHC Task 37 Advanced Housing Renovation with Solar and Conservation]. Within this project, experiences are shared from different renovation projects, especially from Germany and Austria, where renovation to passive house standard has been done for quite some time [Verbeeck, Hens 2004; Poel, van Cruchten, Balaras 2006]. Also, a Swedish study about energy efficient renovation was published in 2008 [Berggren, Janson, Sundqvist 2008].

The method used within the ongoing Swedish research project is to practically participate in demonstration projects, a good way to gain knowledge about actual obstacles in the building process of energy efficient buildings. Being a part of the planning group, advice and support is given to both the consultants and the client. In the planning process there is both a development of conceptual solutions and an identification of lack of components and planning aids. During the construction phase, the work on the building site is closely followed and participants in the building process are interviewed about their work. Feedback about the projects is presented; both regarding positive and negative experiences, so that the concept of energy efficient buildings can be spread and further developed.

The expected result is to find guiding principles and tools needed for planning passive houses, not only describing project specific solutions but making the system solutions usable for planning in more general terms, and also to study the possibilities and limitations of energy efficient buildings in a Swedish perspective and climate. This paper focuses on the renovation project within the above research.

2 The Brogården area

The renovation project in this study is an area in Alingsås called Brogården. Brogården contains of 300 rental apartments owned by the public housing company Alingsåshem and was built in 1970, see figure 1.

Figur 1 The Brogården area

There has been continuously maintenance during the buildings lifetime, but now the buildings are in need of a major renovation. Also, the tenants in the area complain about draught and uneven indoor temperatures and the apartments need to be more suitable for disabled persons. Otherwise, the apartments are popular and there are no vacancies in the area.

Alingsåshem owns many buildings similar to the ones in the Brogården area. Some of them have already been extensively renovated, so this is nothing new for Alingsåshem. However, in some of these renovated buildings, the tenants still complain about draught and uneven temperatures. In the renovation of the Brogården area, the step is taken towards solving the problem as a whole, with the tenants in the centre of the renovation, but also a large focus on the environment and energy consumption. To ensure a comfortable indoor climate for the tenants and at the same time decrease the use of energy for heating, Alingsåshem decided to renovate the Brogården area to Passive Houses.

The use of energy before renovation (2004) was measured by Alingsåshem and presented in table 1 together with early goals for energy consumption after renovation.

Table 1 Energy demand before and after renovation

Energy Demand [kWh/m²a]	Today: (2004)	Goal: Demonstration building
Space Heating	115	30
DHW	30	25
Household Electricity	39	27
Electricity, common area	20	13
Sum	204	95

The planning process of the renovation started in august 2005. In March 2008 the renovation process started of 18 apartments, one building in the area, as a demonstration project. The building is in three storeys with two stair wells. There are in the original building three apartments on each floor in each stair well. The tenants are evacuated during the renovation process. The renovation of the first building will be finished in February 1, 2009.

The project continued in August 2008 with the planning process of phase two, where two more buildings in the area will be renovated. Experiences from the renovation process in the first building are here very much used, where both the consultants and the entrepreneurs are continuously reporting on the demonstration project in an experience-excel sheet.

3 Construction

In the renovation process, major improvements are made on the U-values of the constructions, see table 2. The constructions are described in the text below.

Table 2 U-values before and after renovation

Construction	U-value before renovation W/m^{2}K (calculated)	U-values after renovation W/m^{2}K (calculated)
Outer wall	0.30	0.11
Roof	-	0.30
Attic beams	0.22	0.10
Ground construction	0.40	0.20
Windows	2.0	0.85
Entry doors	2.7	0.75

3.1 Ground construction

In the original construction, the ground construction is a slab on the ground with no insulation. The floor construction contains of the constructional concrete that is followed by sand, to make an even surface for the top concrete layer. In the planning process the top concrete layer and the sand was supposed to be removed, giving some space for expanded polystyrene insulation (eps) to improve the U-value of the construction.

When the sand and the concrete were removed it turned out that the constructional concrete was very uneven, making it not possible to only add eps boards. Instead a layer of cellular concrete was spread out on the constructional concrete. Since the old kept concrete construction is uneven, the height of the cellular concrete varies, to get an even final floor surface. The cellular concrete varies from 3 cm to 6 cm. On top of the cellular concrete is a moisture proof membrane, then a layer of eps insulation of 6 cm and the construction is finished with parquet flooring or a plastic carpet. To be able to guarantee a sloped floor in the bathroom, no eps insulation could here be added. The temperature in the floor construction is measured, to see how the temperature varies according to insulation thickness.

The outside of the ground construction is insulated with 27 cm of eps insulation to minimize the thermal bridge, see figure 2.

Figure 2 Outer eps insulation on slab on the ground

3.2 Outer walls

The apartment building is prefabricated with a load bearing concrete construction. The gables are made of concrete and the long side walls have a wooden construction. The façade brick material is worn out. This is due both to frost and to acid rain that enlarges the mortar and burst the bricks to pieces, see figure 3. Since the façade material needs to be changed anyway, this gives an opportunity to add insulation on the outer walls.

Figure 3 Brick façade before renovation

The original renovation concept included to save the wooden construction in the long side walls. Early investigation of the status of the building showed that the wooden construction had no damages. When the bricks were removed, the wooden construction showed to be in pretty poor shape and was decided to be removed. New long walls are built which also eased the building process for the carpenters. The new long wall construction contains of layers of insulation with a steel load bearing construction, see figure 4. The steel construction was chosen instead of a wooden construction to avoid any mould problems in the wood in the future. There is an installation layer on the inside of the wall to protect the plastic foil. On the outside surface is a thin brick surface mounted on a steel profile, see figure 4. It was important for the client to keep the impression in the area with the original colours and the brick façades.

Figure 4 Outer long side wall construction

The concrete gables are kept and are insulated on the outside, followed by the same brick shield construction as used on the long walls.

In the original construction, the balconies were a part of the building construction, see figure 5. This caused a large thermal bridge with low floor temperatures in the room inside of the balcony.

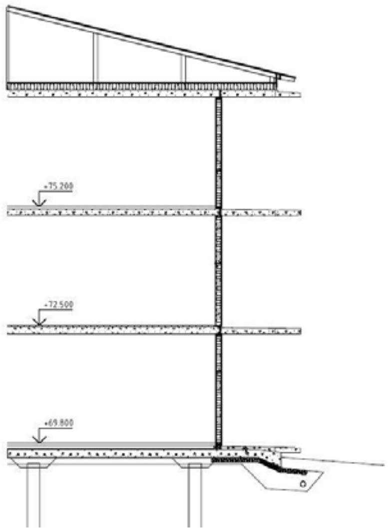

Figure 5 Original balcony construction

To avoid this thermal bridge, the balconies are moved. Since the long side walls needed to be new built, they could be moved to a new position. The outer part of the balcony is removed, giving an even line on the long sides where the new long side walls are placed. The balconies are standing on plinths, mounted on the outside of the façade.

The left picture in figure 6 shows the balconies before renovation and the right picture the balconies after renovation.

Figure 6 Balcony construction before and after renovation

3.3 Inner walls

The walls between the apartments are originally made of 150 mm of concrete. Renovating the climate shell to Passive House standard not only decrease the U-values, but also decrease the noise from outdoors. To avoid any annoyance among the tenants caused by disturbance from the neighbours, the partition-walls are insulated, see figure 7.

Figure 7 Sound insulation of inner wall

3.4 Roof and intermediate floors

There is a load bearing concrete construction between each of the three storeys in the building. On the top floor, where the ceiling on the other side is facing the attic, this system of beams is insulated. The original construction was insulated with 180 mm of mineral wool and a layer of cellulose insulation. All this insulating material is removed and on the existing concrete, 300 mm of new loose wool insulation is added.

3.5 Windows

The existing windows have been renovated earlier, where the outer pane in the window construction was removed and changed to a low energy double pane construction. Still, the U-value of these windows was too high. This, together with the discontentment with the plastic frame of the windows, was behind the decision of changing the windows. When needing to change the windows anyway, new windows with a very low U-value were chosen.

3.6 Installation system

The Brogården area is, before renovation, heated by water borne radiators using district heating. The district heating is supplied from the local energy company Alingsås Energi. There is today exhaust ventilation, with one fan for each stair-well (9 apartments) with exhaust air devices in each kitchen and bathroom. The supply air comes from ventilation slits in the window frames and by using a ventilation window. There is no heat recovery.

To improve the indoor climate, a new ventilation system is installed. This new system contains both supply and exhaust air and to save energy an air-to-air heat exchanger is installed with a very high efficiency. Since the existing system only contains exhaust ventilation, new pipes had to be added.

Different solutions of ventilation system have been discussed during the planning process. A central ventilation system can be used with one ventilation unit for all apartments. Another solution is to use small ventilation units, one in each apartment. Some advantages with a central ventilation system are less maintenance and easier to find space for silencers and insulation. The unit is quite large and needs a room in the building. In this building there were no cellar to place the ventilation unit and the attic needed extensive reconstruction to fit a large ventilation unit. The choice was therefore to install a small ventilation unit in each apartment.

The apartments will be heated by air. Each ventilation unit has a heating battery. The heating battery is water borne, using district heating as the heating source. There will be an electrical towel-dryer in each bathroom.

In the future, Alingsåshem wants to buy domestic hot water from solar panels and from district heating. This is now discussed with Alingsås Energi who will own the solar panels, but this is still in the planning process.

4 Measurements

In the initial investigation of the status of the building performed by SP, the Technical Research Institute of Sweden, the air tightness of the building was measured. 6 apartments were measured and the mean value of the air leakage at an air pressure of +/- 50 Pa was 2 l/s, m^2 (surface related to leaking area). By using a thermal camera the major air-leakages were discovered. Most of the air leakage was traced to connection points between the prefabricated concrete elements and around windows, where up to 10 mm air gaps were visible.

After renovation the air leakage was measured again. The new measured result show a mean value of the air tightness of 0.19 l/s, m^2 (surface related to leaking area) at an air pressure of +/- 50Pa.

To investigate if the fear of high moisture content in the outer wall construction has any justification, measurements are performed in all layers of the wall of RH and temperature. In the attic, measurements are made of temperature and moisture quota in the raw tongue and around the roof hatch. As a reference, both the temperature and RH in the attic and outdoors are measured. The temperature in the floor construction is measured in one apartment. This measurement is made to see how the small amount of insulation in the ground floor construction influences on the floor surface temperature.

Measurement of actual energy use is made by Alingsås Energi; the use of domestic hot water, house hold electricity, electricity for common areas and energy use for space heating is measured. Also indoor temperature and outdoor temperature is measured. The measurements will be started when the tenants move in, February 1 2009. The measurements will be analysed within the above described research project.

5 Additional experiences

The building process started with a day of education. All carpenters, plumbers, electricians and others building the project listened to information about passive houses, energy and moisture issues in building projects and discussed how they wanted to work in the project and what the special goals should be.

Experiences from the planning process and from the building process have been collected trough out the project in an excel sheet. Here the client and the entrepreneur can find information about “do’s and “don’t’s” for future projects.

There have been some problems in the project finding materials and building components needed. For instant it has been difficult for the entrepreneur to find entrance doors and windows with the required U-value. The retailers of roof hatches have never been asked before to insulate the openings. The air-tightness measured by the retailer of the doors in the hallway, how much will that decrease when putting in a peep-hole? And what happens to this door if you add a bell? Different types of supply air devices have been tried, to assure a good air flow in the rooms.

The entrepreneur here has an advantage being a large company, with the ability of getting help with these kinds of questions. Still, the local staff working with purchase has been needed to put much effort in solving these problems.

The work with the Brogården project continues within the research project with analyses of measured results, a close look on experiences from the building process and interviews with the tenants. Interviews will also be made with the client and the project leaders.

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