

Faculty of engineering, LTH, Lund's university, has presented a study on the refurbishment of a brick building from the 1930. The refurbishment consisted of adding a glass-façade 600mm outside the existing brick wall. The article *Energy saving by adding a glass-façade to a brick building* was presented at CESB 13 - Central Europe towards Sustainable Building 2013 26-28 June 2013 and is a summary of the study made by

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# ENERGY SAVING BY ADDING A GLASS-FAÇADE TO A BRICK BUILDING

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## Summary

When exploring possible energy saving measures for existing buildings different technical solutions should be investigated. In Malmö, Sweden, a 1930s hospital in a park setting has been refurbished with a general sustainability goal. For one of the buildings a glass-façade has been added to an existing 80-year old brick building.

Measurements of relevant temperatures have been made including measurement of the temperature in the cavity, which is about 600 mm wide, between the glass-façade and the brick wall. The measurement period covers outdoor temperatures between  $-4^{\circ}\text{C}$  and  $+18^{\circ}\text{C}$ . It can be concluded that the temperature in the air space between the glass and the brick wall is increased compared to the outdoor air temperature, this increase is between  $+5$ - $20^{\circ}\text{C}$  during 90% of the time. This means that this solution will reduce the building's energy needs in several ways as both the transmission losses and the need for heating the ventilation air will be reduced. The energy saving in terms of kWh is also examined.

**Keywords:** refurbishment, glass-façade, energy use, measurements, passive heating, ventilation

## 1 Introduction

When exploring possible energy saving measures for existing buildings, different technical solutions should be investigated. In Malmö, Sweden, an area with old buildings has a sustainable goal for the refurbishments of the buildings. Several measures such as photovoltaic and solar panels are applied on several buildings. For one of the buildings a

glass-façade has been added to an existing 80-year old brick building. Adding interior or exterior insulation to the brick façade was not considered an option. Instead an exterior glass-structure was added creating a cavity.

This refurbishment measure has three aims in aspects of energy saving: to reduce the transmission heat losses through the construction, to passively preheat the ventilation supply air reducing the energy need for the ventilation system and finally to work as an integrated air-solar collector during day time which includes allowing heat to be stored in the brick wall due to its thermal mass.

The technical measure of adding a glass façade on glass (sometimes called a double skin façade) is treated in the literature [1], [2]. Adding a glass façade to a brick building will however also attain an additional “greenhouse effect” which will heat the air in the cavity from both the sun through the glass façade and from the internal heat loss through the brick façade. The greenhouse effect is obtained when short wave radiation passes through glass and hits the brick wall and is partially transformed into long wave radiation (heat) which cannot leave the space of the cavity. This greenhouse effect has been studied by Gratia et al [3].

The objective is to study the performance of the glass façade in terms of energy. This is done by temperature measurements and energy calculations.

## **1.1 Delimitation**

Only the heating period has so far been studied. During summer when higher outdoor temperatures can be expected another solution has also been installed, a concrete duct in the ground aimed at cooling the outdoor air before entering the glass façade, respectively an option for supply air which by passes the glass-façade. These are not included in the study.

## **2 Method**

### **2.1 Description of the building and the ventilation system**

The building, situated at the main entrance, was erected in the 1930s and was built as a dwelling for the gate-keeper of the area. It consists of brickwork walls which are one and a half brick. It has a living area of about 170 m<sup>2</sup> on the ground floor and an attic above in which the new supply and exhaust ventilation system is placed.

The area has a sustainable profile and when the refurbishment was started to be planned in 2008, passive solutions were strived for. The original brick façade was not to be changed, thus the obvious exterior insulation was not an option. Instead the idea of adding a glass façade came up with the aim of constituting as an additional insulation, as a pre-heater for the ventilation supply air and as a solar collector, the two last features are not possible to achieve by only adding insulation (mineral wool). All the three effects are passive, meaning that the achieved energy saving requires no bought energy.

A possibility of moving the air between the cavities, exist, by a small fan which should mix and equalises the air temperature in the cavities. This feature is intended to move the air from the facade which at present is the warmest to the other facades and thereby distribute the heat to all the three glass-facades. If this fan is used some electricity is needed. Also for this solution has optimisation been studied and shows that most of the time this system can be unpowered.

The space between the existing brick wall and the glass wall is about 600 mm. The glazing consists of 8 mm window glass and the skyward parts at the top of the glass cavity is insulating glass. It is added on the east, south and west façade.

A modern mechanical supply and exhaust ventilation system with heat recovery is installed. The outdoor air passes through the cavity before entering the ventilation unit with filters and heat exchangers, when there is no need for preheating the supply air, ventilationsystem choose to by-pass the cavity by supplying the outdoor air from an intake on the north façade directly to mechanical the air-handling-unit. A secondary fan system was also installed only to, as mentioned, making it possible to move the air between different facades to attain the highest heating possible; moving from south to east and west to even out the temperature. This system is also used as a last alternative to evacuate hot air from cavity during the summer. The two separate ventilation systems are controlled using thermometers on the brick facades. The air flow is 90 l/s. The renovation was finished in 2011. The glass-façade and building is shown in **Fig. 1** and the cavity in **Fig. 2**.



*Fig. 1. Added glass façade on the brick building with south façade to the left and east façade to the right.*

*Fig. 2. Cavity on west façade.*

## **2.2 Description of the measurements**

Temperature measurements have been made in several positions in the building and the ventilation system. HOBO loggers which measures temperature and relative humidity have been used with an accuracy of  $\pm 0,4^{\circ}\text{C}$ . The loggers were positioned 3 m above the ground in the cavity. The measurement period was between 13<sup>th</sup> of March and 2<sup>nd</sup> of May 2012 measuring each 10<sup>th</sup> min. covering outdoor temperature between  $-4^{\circ}\text{C}$  to  $+18^{\circ}\text{C}$ . Measurement of the air flows in the different spaces has also been performed however not presented here.

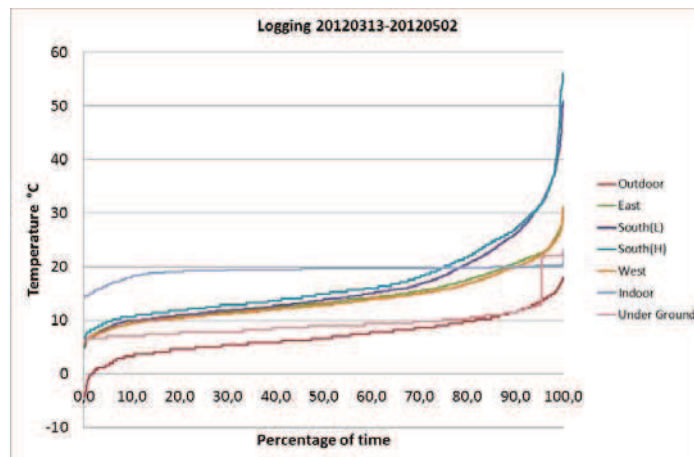
## **2.3 Description of the energy calculation**

Two types of calculations have been performed; one based on the temperature measurement and one based on output from a simulation program called DEROB-LTH. The energy need for a whole year has been calculated with this dynamical program which deals with the cavity and the radiation from the sun in a sufficiently exact way. The calculations are elaborated in [4]. This paper focuses on the temperature measurements.

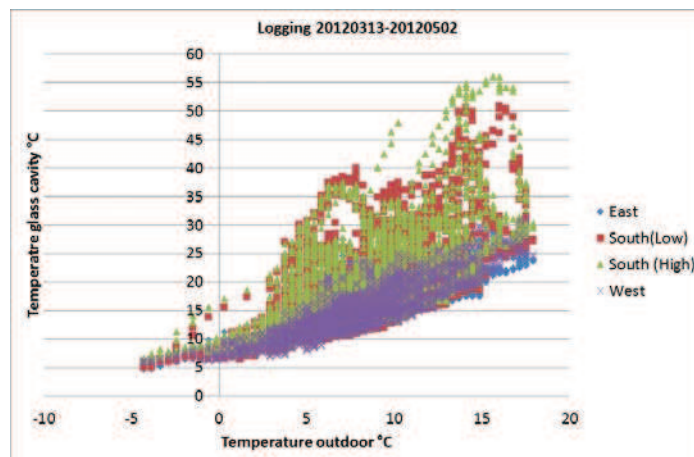
### 3 Results

#### 3.1 Measurements of temperature

The measured temperatures in the cavity and the outdoor temperature are shown in **Fig. 3** and **Fig. 4**. These are sorted as a function of temperature and the percentage of time during the measured period.



*Fig. 3 Measured temperature incl. outdoor and in cavity on the three façades; east, south and west.*



*Fig. 4 Measured temperature in cavity on the three façades as a function of outdoor temperature.*

In **Fig. 3** the temperatures are sorted in increasing temperature meaning that different façades do not coincide for the same time on a vertical level. It can be seen that temperatures above 13°C in both east and west façade is attained during half the period. During the measurement period the temperature in these two directions has been between +6°C and 20°C during 90% of the time. For the outdoor climate conditions that have been present during the measurement period the outdoor air has always been increased to at least +5°C when passing the cavity. It is increased to between +5°C and + 20°C during 90% of the time.

### **3.2 Energy calculation**

The calculation is complex as energy reduction should be achieved for several aspects at the same time. A theoretical model has been developed which addresses both the energy need for heating due to the transmission and the ventilation. The technical solution of adding a glass façade reduces energy needed for heating the house. This energy saving can be expressed in different ways: as a wall with a reduced (even negative) U-value, as an extra heat exchanger for inlet air with high efficiency, as a solar collector with a certain efficiency etc. Perhaps the best way to describe the system is to use the analogy of a heat exchanger. The efficiency of this heat exchanger will sometimes be more than 100% due to the effect of the sun. The model is described in detail in [4]. The measured or simulated temperatures are used to calculate the energy needed to heat the house with and without the cavity. The measured energy saving for the period March to May was calculated to be 2260 kWh.

The energy reduction for a whole year calculated by the dynamical computer program DEROB-LTH was 9840 kWh, this only includes the transmission. It is as mentioned complex to simulate the technical feature of the cavity as the computer program must treat the radiation of the sun coupled to the inlet air in the glass cavity.

## **4 Conclusions**

It can be concluded that the temperature in the air space between the glass and the brick wall is increased compared to the outdoor air. This means that the energy need for heating the building will be reduced.

## **5 Discussion**

This technical solution, with an added glass façade, offers an alternative passive solution to the traditional adding insulation. Covering a limited period of time the results indicate the temperature rise that can be achieved in this type of technical solution and can contribute as a part of a basis for the performance in aspects of energy when considering different technical measures in the design stage.

If a ventilation heat exchanger also is applied the results indicates that the increase in temperature is to such an extent that no need of bought energy exist for heating the supply ventilation air when using the solution, the cavity and the heat exchanger will together heat the outdoor air without any need of extra energy. This passive heating by the cavity makes it interesting for ventilation applications in existing buildings as no heating energy is needed for the increase of the temperatures nor is electrical energy needed, which for other solutions as heat exchangers must be included, thus offering a sustainable solution.

The temperatures attained on the different façades shows a variation in temperature increase. Higher temperatures are attained on the south and more even temperatures on east and west. This difference can be applied differently. If a large temperature increase is the aim all air should be passed through the south façade. If even and somewhat lower air temperatures are aimed for which could be the case for preheating of ventilating supply air, air could be passed trough the east and west façade. In this case it fulfills the requirement that the temperature of the supply air should be some degrees below the room temperature in order to create sufficient air movements and avoid short circuiting of the air in the

rooms, avoiding that too hot air stays at ceiling level with insufficient air quality as a result. One remarkable discovery was found when simulating air temperatures in cavity. Highest temperatures were obtained during spring and fall when sun was at low altitude. In summer the insulating glass at skyward part of cavity and the angle of which sun is hitting the façade made the exposed area of greenhouse effect smaller.

This technical solution, with an added glass façade, offers an alternative passive solution to the traditional adding insulation. This may be a possibility if the original façade is to be kept unaltered. The impact the glass façade will have on the architectural appearance and the preservation of the building is a matter of independent judgement. The profitability of the solution has not been studied and the cost for the glass façade could be compared to the energy saving achieved. The results however indicate the temperature rise that can be achieved in this type of technical solution and can contribute as a part of a basis for the performance in aspects of energy when considering different technical measures in the design stage (for various climates and conditions). The measurement shows the performance for outdoor temperatures between -4°C to +18 °C.

The summer period has not been studied. The design of the glass-façade covering the windows on three facades, excludes the possibility of passive cooling by opening the windows in the brick façade, in three directions. This means that too high indoor temperatures may arise during summertime. An outdoor air intake is also positioned on the north façade which has no added glass. The ventilation system is controlled so that the outdoor air may be supplied directly to the building, by-passing the cavity, for periods when no heating is needed, thus theoretically offering a cooling possibility during warmer periods.

One possible application is that the air volume between the glass and the brick could be expanded and thereby forming a nice additional living space as a greenhouse. Then the quality of the supply air must be observed.

When implementing this method there is a couple of pitfalls that must be investigated. One great challenge is to be sure of what conditions the system will be programmed by. When the sun is shining it will also be a powerful source for errors. If regulation of system is made by measuring temperatures then the thermometers must be carefully protected and mounted from direct sunlight or indirect longwave radiation from surrounding materials.

Another great challenge is to determine how to control the systems for air supply and when to use the cooling options.

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