Building Envelope Upgrading on a 70’s Building in Stockholm Suburbs

Renovación de la Envolvente de un Tipo de Edificio Construido en los Suburbios de Estocolmo en los Años 70.

Masters Thesis
No 419

Civil and Architectural Engineering
Building technology
2011 05 30
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# INDEX

- Keywords and summary ................................................................. 3
- Preface ................................................................................................ 5
- Aim of the project .............................................................................. 7
- The building ...................................................................................... 9
  - Original building drawings ......................................................... 11
  - Flat roof characteristics ............................................................. 12
  - Windows ....................................................................................... 13
- Roofing renovation ........................................................................... 14
  - Existing flat roof ......................................................................... 16
  - New flat roof ................................................................................ 19
- Wall renovation ................................................................................ 25
  - Ground .......................................................................................... 27
  - Corner ........................................................................................... 32
  - Upper-part coronation .................................................................. 34
- Windows upgrading .......................................................................... 38
  - Adding insulation on facade and around window frame ............. 40
  - Adding insulation on facade and moving the window’s old frame  42
  - Adding insulation on facade and changing window frames ......... 44
- Calculation ......................................................................................... 46
- Discussion /Experiences ................................................................... 49
- Conclusions ....................................................................................... 52
- References ......................................................................................... 54
KEYWORDS AND SUMMARY
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Keywords:
The Million Programme, energy loss, building envelope, renovation, insulation, flat roof, concrete wall, wood windows.

Summary:
This is a study about how to improve the building envelope from a group of housing belonging to The Million Programme, a housing programme implanted in the Sweden around 70’s. Massive buildings made of concrete, which were constructed really fast because of the pressing time Schedule and were not developed as they should.

This renovation study is explained with examples and drawings and it basically shows how to add thermal insulation on the most conflictive points of the building envelope. It is done in order to improve climatic conditions inside housing, trying to make thermal bridges disappear and reducing energy loss.
PREFACE
This project is done by a student from Barcelona who has been learning Technical Architecture for 3 years. Once Bologna Plan began to work, the studies I was taking turned its name into Building Engineering, which I studied for 2 years more.

The most important fields I have been studying on are: Topography engineering, design and structural engineering, environmental engineering, materials engineering, building engineering, budgets and cost control, planning and organization of work.

Once I was done with all the career subjects I just had to decide about my thesis degree. I wanted to take it abroad, and I wanted to work on it in a nice country and in a place where I could improve my English. That is why I decided to apply for Stockholm, Sweden.

Since I knew I was accepted, I began thinking what my study was going to be about. It should be something interesting and useful but at the same time it had to be something new for me.

I had some ideas about what I wanted to do; the work was going to be related with the energy loss inside a building and how to reduce it. But I wanted to learn also something new and different, and if I was deciding to do a study, it should be focused on a Swedish building to learn in this way more about Swedish ways of constructing.

So once I have read many different articles from how to avoid energy loss in buildings, and once I have talked with Professor Folke Björk (my project supervisor), I decided that what I was going to work on was about upgrading the building envelope from a kind of buildings constructed at the 70’s around the suburbs of Stockholm.
AIM OF THE PROJECT
AIM OF THE PROJECT

The aim of this project is to show how to upgrade the building envelope from a certain kind of buildings constructed at the 70’s around the suburbs of Stockholm by explaining it with help of examples and drawings.

These buildings were not constructed in the best way. In the 70’s many constructions were built too fast, without the necessary consideration of all important details. It was in a time where building demand was very high, and companies did not care at all about what they were doing.

The most important point concerning these building’s envelopes, considering that Stockholm has a very cold winter, is the insulation layer. It is obvious that if these buildings are not enough insulated as required, they will have a high energy loss, and thus very high energy consumption.

That is why it is considered that the main focus should be on this insulation renovation project. How to add it or modify it and even more important, how to solve thermal bridges, are the essential aims of the work.

Trying to make the project clearer, the study is divided in 3 different points depending on the parts from the building that were going to be modified:

1. Roofing renovation
2. Wall renovation
3. Windows upgrading

Every point shows its own constructive details, pointing out the old layers and the new elements. It also includes the process description and the material features.

In fact, the proposal of this study is to learn the different Swedish ways to construct buildings in this hard conditions where degrees can fall to even less than -20 °C.

It is also really interesting to learn how Swedish society is thinking about environmental issues when they are building.
THE BUILDING
THE BUILDING

The building to upgrade belongs to The Million Programme, a housing programme implanted in the Sweden around the 70’s. Massive buildings made of concrete, which were constructed really fast and not carefully enough.

It has been really difficult to find out how the housing to renovate was exactly built up. The drawings that describe the building are quiet old and they are not legible enough to use them as a source, but after studying them attentively and after a research for the elements that are not understandable by just examining the drawings, the most important points on the building have been quite well described. So the next steps were developed in order to determine the building characteristics:

1. Studying original building drawings
2. Examining a typical flat roof built on those kind of housing
3. Researching which kind of window frames should the building have

Those typical housing built up in the suburbs of Stockholm
1. THE ORIGINAL BUILDING DRAWINGS

The original drawings from the building have made it possible to determine some important issues about how the housing was built:

- Frame is made by structural walls
- The building is divided into three storeys
- Walls are made of lightweight concrete
- Walls are 200 mm thick
- No insulation is fixed on walls
2. FLAT ROOF CHARACTERISTICS

One typical flat roof detail of how the Million Housing Programme building was built shows the main characteristics of the roofing to renovate:

- It is made as a flat roof and it rests on the structural walls
- The frame is made with concrete and it is 200 mm thick
- Next layer is the insulation board, made of glass wool, 200 mm deep
- Above the insulation board, there is the rolling felt, which is to prevent the ingress of moisture
- Mineral wool board is the next element, to prevent fire accidents
- Asphalt roofing membrane covers the whole roof working as a waterproofing
3. WINDOWS

To learn how the windows were built, a book has been really useful where it is explained how different building elements have been evolving during the last century in Sweden called “Så byggdes husen 1880-2000” (How the houses were built 1880-2000). With the next detail window characteristics are displayed clearly:

- Wood frames
- 1+2 glasses with interconnected loops. Simple glass sits in the outer loop.
- Windowsill with sheet metal cover
ROOFING RENOVATION
ROOFING RENOVATION

The roof renovation is the starting point of my project. The housetop is the most difficult part from a building to design. It is the zone where most problems can occur because it is directly exposed to inclemency of the weather. So it is really important to know how to improve the roof to later upgrade walls, grounds and other interesting points as windows.

The roofing to be renovated had been built as a flat roof. There are many different ways to improve these kind of roofs. But after a researching process and considering different information, the best way to upgrade the roof was to remove some old layers but not the old insulation and then add a kind of special insulation boards which help to improve the way to protect the roof from water/snow. These boards are very useful because they are increasing insulation on the roof at the same time that they leave the water flowing outside the roof by increasing the slope. The whole process is described on the next pages.
1. EXISTING FLAT ROOF

The existing flat roof is made of different layers. Firstly there is the frame made of concrete about 200 mm thick. It is the element which supports the loads on the roof, and at the same time it rests on the structural walls.

The next layer is the insulation board, made of glass wool and it is 200 mm deep. It is quite much but not enough for the temperatures the building is subjected to (many times at -20 °C). Above the insulation board, there is the rolling felt, which is intended for preventing the ingress of moisture into the insulation boards and roof structure.

Then there is a mineral wool board which prevents the fire accidents, so it keeps away the fire in case there is any combustion on the roof.

Finally there is the asphalt roofing membrane, which is fixed on the whole roof and it must be fixed at the bottom of the edge to keep it from being lifted by the wind. The upper border of the roll is nailed and covered by the next roll. It just works as a waterproofing.
DETAIL A

ELEMENTS

1. Concrete frame (200 mm)
2. Insulation Glass wool (200 mm)
3. Rolling felt
4. Mineral wool board fire protection
5. Asphalt roofing membrane
• **REMOVING PROCESS**

The process of removal of the old roof cover is described in DETAIL B below. There is a need to remove almost all layers considering that new components have to be fixed correctly.

First of all the rolled asphalt has to be removed from the entire flat roof. Then mineral wool boards have to be removed as well. The next step is about taking the rolling felt out but trying not to damage the insulation boards. These insulation boards are hopefully going to be in a good condition, so that the last step should just be to clean the surface boards.

In the unlikely case that once the executive process is on and it has been observed that the concrete frame is plenty of cracks, the glass wool insulation boards should be removed in order to add above the concrete frame a vapor barrier in order to stop interstitial condensations.

• **STEPS**

   a) Remove asphalt roofing membrane from the entire flat roof
   
   b) Remove mineral wool board fire protection
   
   c) Remove old rolling felt trying not to damage the layer below
   
   d) Clean insulation glass wool surface without removing anything more

**DETAIL B**
2. NEW FLAT ROOF

The new flat roof will be characterized by an insulation method, which makes by itself a slope on the roof, and by the system that covers the coronation wall (DETAIL C).

This new flat roof will be made of some old elements that are not detached from the old roof, the concrete frame and the insulation glass wool layer, and some new elements that will be added.

So once the removal process is done, there is a new overlaid insulation going to be added, *Hardrock Takfall* from *Rock wool firm*, which allows not only save energy inside housing but also makes a slope on the roof in order to conduct water to the downspouts. These boards are in fact designed tapered, and they create by themselves a water circulation way until the middle of the roof where the downspouts are placed. The benefits are considerable, both of the two main problems on a roofing designing are solved with the same element; insulation and water redirection.

The next layer is the *Monorplan FM membrane*. It is fixed in order to reduce impact associated with inclement weather conditions. It is based on the use of tubular fasteners, washers and plates that allow the membrane to be attached mechanically on the insulation boards. The system is quickly able to be applied.

It is also important to mention the system (DETAIL C’) that covers the coronation wall. It is a design that joins the new flat roof with the upper-part of the wall. The wall will be thickened by 200 mm by adding a new concrete slab. This slab will support the metal flashing.
• ELEMENTS

1. Concrete frame (200 mm)

2. Vapour barrier
   - This layer won't be needed for a concrete structure unless there are a high number of cracks.

3. Insulation Glass wool (200 mm)

4. New overlaid insulation: *Hardrock Takfall kilskiva 1:40 (Rock Wool)*
   
   Technical characteristics are described in the next table:

<table>
<thead>
<tr>
<th>Tekniska egenskaper</th>
<th>Beskrivning</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Varmekonduktivitet</td>
<td>$U_e = 0.03$ mW/mK</td>
<td>EN 12668</td>
</tr>
<tr>
<td>Brandklass</td>
<td>EuroKlass A1</td>
<td>EN 13501-1</td>
</tr>
<tr>
<td>Vattenabsorptions drip</td>
<td>Kontin. WS ≤ 1 kg/m²</td>
<td>EN 16002</td>
</tr>
<tr>
<td>Vattenförmåga av plåttak</td>
<td>MU = 1</td>
<td>EN 12086</td>
</tr>
<tr>
<td>Spelnsnittsförhållande</td>
<td>Vinkelrätt med stolna, TR 16 kPa</td>
<td>EN 1907</td>
</tr>
<tr>
<td>Punktlast</td>
<td>PL(5): 700 N</td>
<td>EN 12430</td>
</tr>
<tr>
<td>Dimensionssäteviskelighet</td>
<td>Vid förhöjd temperatur och fuktighet, D5(T5) ≤ 1 %</td>
<td>EN 1604</td>
</tr>
<tr>
<td>Tjocklektolerans</td>
<td>T2</td>
<td>EN 823</td>
</tr>
<tr>
<td>Densitet</td>
<td>C = 180 kg/m²</td>
<td>EN 826</td>
</tr>
<tr>
<td>Tryckstabilitet</td>
<td>Tryckstabilitet vid 10% kompression, CS 80 kPa</td>
<td>EN 826</td>
</tr>
<tr>
<td>Trompfasthet</td>
<td>Produktets stabilitet under normalt viktnivå och lättfallssäteviskelighet. Tål normalt beträdande i samband med utförande och inspektion.</td>
<td>EN 826</td>
</tr>
<tr>
<td>Beskrivningsskod</td>
<td>MM: EN 3162-T2-D6(T3)-CGO OJ80-TRI 5-PL(5)-700-WS-KU1</td>
<td></td>
</tr>
</tbody>
</table>

5. *Monarplan FM membrane (Icopal)*

   - A thermoplastic membrane made of a mixture of polymer compounds (PVC-P) extruded to achieve a consistent and homogenous sheet.
   - As it is marked on the next table, the *Monorplan* product chosen is *FM 1,2 mm* thick which is enough to protect the roof working on.
6. **Monarplan tubular fasteners, washers and plates.**

- **Monarplan Tubular Washers** are precision molded from high grade polyamide and they are resistance to extreme temperatures and mechanical stresses.
- The fasteners are positioned within the overlap. They are waterproofed and protected by hot air, welding the overlapping adjoining sheet.
- Insulation should be attached at the minimum rate of 11 tubes & fasteners per 1.2 x 2.4m per insulation board.
- The roof build up depth is about 400 mm, so according to the table above, there are needed a **Monorplan Tubular Washer** of 225 mm and a **Monorplan Fastener** of 220 mm.

![Roof Build Up Depth Diagram](image)

**Dense Concrete Deck Applications**

**Fastener Product Name:**
- Monarplan Carbon Steel Fastener (Dense Concrete)

**Tubular Washer Product Name:**
- Monarplan Tubular Washers (Concrete)
  - Minimum deck penetration to be 30mm
  - Pilot hole diameter to be 5mm
  - Drill depth to be 45mm
  - 6.3mm fastener diameter

7. Fasteners aprox. 8”O.C.
8. Exterior plywood on cleat to provide slope
9. Seal top of flashing with fabric and mastic
10. Base flashing
11. **Monarplan FM membrane (Icopal)**
12. Fiber cant strip
**DETAIL C**

1. Concrete frame (200 mm)
2. Vapour barrier
3. Insulation Glass wool (200 mm)
4. Hardrock Takfall kilskiva 1:40
5. Monarplan FM membrane
7. Fasteners aprox. 8”O.C.
8. Exterior plywood on cleat to provide slope
9. Seal top of flashing with fabric and mastic
10. Base flashing
11. Monarplan FM membrane
12. Fiber cant strip
• **INSTALLING PROCESS**

a) Increase vertical wall high (200 mm more) with adding a concrete slab in order to solve the distances that are going to be created between wall coronation and the new sloped flat roof. Above the slab is fixed an exterior plywood board to provide slope on top of the wall coronation. It is fixed by fasteners on both faces of the wall. On the top of it there will be attached a light metal parapet cap in order to let the water slopes above the edge wall.

b) The joint between the wall coronation and the sloped roof edge is solved with a fiber cant strip which makes a small slope to remove water of this point. It will be covered first with the *Monarplan FM membrane* and then with a base flashing.

c) Add the new overlaid insulation above the old insulation boards: *Hardrock Takfall kilskiva 1:40*

- Boards are designed individually and marked with a positional code corresponding to the detailed layout drawing provided by the firm.
- The board layout should strictly follow the way shown on the drawing, and to avoid error each board is to be placed temporarily in position before the attachment.
- Fix new insulation mechanically with *Monarplan tubular fasteners*, washers and plates.

d) Install *Monarplan FM membrane* mechanically fixed on the top of *Hardrock Takfall* with *Monarplan tubular fasteners, washers and plates*. The fasteners are positioned within the overlap. They are waterproofed and protected by hot air, welding the overlapping adjoining sheet.

In this picture it is possible to appreciate how single ply overlapping sheets can be welded together to form a homogeneous lap using hot air equipment.
**DETAIL D**

In this drawing it is illustrated how the roof slope is solved. Both roofing sides are redirecting water into the same way, so the downspouts are placed on the line that divides the roof of the wide side.

**DETAIL D’**

This drawing shows how the slope is created by the insulation boards. So the numbers above every board refer to how high they are in mm. measures.

The last black boards on every side are made with a 60mm + a 55mm board above it.

Every 3.45 meters the slope is increasing by 0.15 meters.
WALL RENOVATION
WALL RENOVATION

Once the roof renovation system is clear, the essential issue is to decide how to proceed on the walls. The renovation executive process is going to be much easier if the renovation material is similar to all the different parts of the building.

In this chapter there are two matters treated, not only how to improve the energy savings with the insulation boards, but also how to still have an attractive building. So it is important to find a kind of insulation which suites to the later rendering layer.

The wall is 200 mm thick and it is made by concrete blocks. It doesn’t have any insulation board applied on it.

There are three different important points that need extra care when designing the wall:

- **Ground**
  
  How to connect the thermal insulation at the wall and to the ground.

- **Corners**
  
  How to join the system at the corner that forms two different facades.

- **Upper part-coronation**
  
  How to connect the thermal insulation at the upper part of the wall to the coronation wall.

In fact is the system going to be the same for the 3 points, but there are going to be different components that will be really useful depending on which part of the wall is being concerned.
1. **GROUND**

**DETAIL A**

**DETAIL A’**

**ELEMENTS**

1. Rockshield adhesive mortar
2. Rockshield insulation
3. Rockshield base coat
4. Masonry sealer
5. Reinforcing mesh
6. Rockshield decorative coat
7. Rockshield base profile
8. Metal flashing
9. Universal corner profile
10. Rockshield slab fillet
• PROCEDURE

The way how to install insulating walls at the ground area in the building is the next one:

The first layer, next to the old rendering from the concrete blocks is an adhesive mortar (1) in order to add the insulation boards then (2). These insulation boards, as explained later, can be Rigid Slabs or Facade Lamellas. In case Rigid Slabs were chosen, a mechanical fixing would be also needed.

Next to the insulation boards, there is the base coat whose alternatives are also explained below. An adequate option is Rockshield TC (3) which is built in with the masonry sealer (4) and with a glass fibre reinforcing mesh (5) that gives strength to the system.

Finally, there is the decorative coat (6), also to be chosen from different finished options; Grained or dragged. The main property Silcoplast decorative coat offers is that it allows breathing, so the Rockshield system will be helping to eliminate the condensation problems. The rendering chosen is grained texture with 2.5 mm grain size (available 1.5/2.5/3.5 mm). It is available in many different colours.

To sustain the system at the bottom it is necessary to install a base profile (7) below the insulation board. It will be fixed mechanically to the wall.
• **ALTERNATIVES**

**Alternatives for insulation boards:**

There are two different possibilities in order to decide on the insulation boards, either Rigid slabs or Facade Lamellas.

- **Rigid slabs** are adhesive and mechanically fixed. The maximum thickness is 200mm and the boards are sized 1200 x 600mm. They must be bonded by means of glue and fixed mechanically, minimum 4 dowels per slab.

- **Facade lamellas** are thought to just be adhesively fixed, so they are ideal for substrates that are not adequate for mechanical fixing. The maximum thickness is 300mm and the boards are sized 1000 x 200mm. They have to be fully bonded to the base with adhesive. The surface of the base must be free of dust, grease, oil, etc. The fibres of the lamellas must be bonded edgewise and the lamellas must be bonded tightly to the base. It is important to fill the joints. If there is need to secure fastening fittings placed for every 600 mm horizontally and 3000 mm vertically could be used.

![Trowels installing Rockshield base coat](image1)

![Different layers of this system](image2)

![Trowel fixing lamellas adhesively](image3)
Here is drawn how facade lamellas would be fixed around windows and doors and how they are organized.

So both solutions are fitting in the building, but Facade Lamellas are more suitable for rebuilding practices. The executive process is much faster and easier because no mechanical fixation is needed. Another point is that Rockwool designs Facade Lamellas with a 100mm thickness limit higher than on Rigid Slabs, so if it would be necessary to add 300mm thick insulation boards, it would just be possible with the lamellas.

Alternatives for base coats:

There are two different alternatives for the base coat:

- **Rockshield TC** which is a thin coat system (6-8 mm)
- **Rockshield LW** is 8-12 mm thick and it can be more resistant on irregular substrates.

Both systems are resistant to the temperature stresses which are imparted to thick, sand/cement renders.
In fact, the preferably layer to be applied in the building is *Rockshield TC*. There is no need to use the *Rockshield LW* because it is appropriated to being used on irregular substrates, and this is not the case.

*Rockshield* offers also the possibility to add an additional high impact coat for areas which are subject to high levels of impact. So it is not necessarily required to use this coat.
2. CORNER

DETAIL B

ELEMENTS

1. Rockshield adhesive mortar
2. Rockshield insulation
3. Rockshield base coat
4. Masonry sealer
5. Reinforcing mesh
6. Rockshield decorative coat
7. Rockshield base profile
8. Metal flashing
9. Universal corner profile
10. Rockshield slab fillet
• PROCEDURE

The setting up process in the corner of a wall is the same as the one for the ground. But there are two new components that have to be mentioned: The universal corner profile (9) that helps to join together insulation boards from different facades and also the Rockshield slab fillet (10) which is thought to absorb temperature changes and to permit that the system doesn’t collapse.

In addition, the corner profile will also improve the wall constructions resistance against mechanical damages.
3. UPPER PART- CORONATION

DETAIL C
**DETAIL C’**

**ELEMENTS**

1. Rockshield adhesive mortar
2. Rockshield insulation
3. Rockshield base coat
4. Masonry sealer
5. Reinforcing mesh
6. Rockshield decorative coat
7. Rockshield base profile
8. Metal flashing
9. Universal corner profile
10. Rockshield slab fillet
• PROCEDURE

The way to proceed when restoring the building envelope at the upper part is just the same as at the ground and at the corner but there is a new decisive element to add at the top of the insulation boards: A metal flashing (8) will be necessary to protect the new frame fixed on the wall from the water leaks.

In this roof renovation system it is an option but not a need to attach an XPS insulation board between the old concrete block and the new one. It would not reduce energy loses enough to make an effort for it.
WINDOW UPGRADING
WINDOW UPGRADING

Window upgrading is really important for improvement of the building envelope. Windows are one of the main focus of the energy loses from a building. It is quite hard to design and to build details around the windows and much easier to lose energy through them. They are built in holes in the wall which frame designing has evolved recently. So there is a huge contrast between frames built 40 years ago and frames built nowadays.

Focusing on the windows of the studied building, they were made of a wood frame which is really close to the facade edge. The glazing combination is 1+2 glasses with interconnected loops and the simple glass sits in the outer loop. The windowsill is made with sheet metal cover.

In this way, the fact is appreciable that windows placed on the building could be greatly improved. They have become obsolete and they often can have more energy leakages than years before. Frames could be renovated but also glazing system could be improved with installing glazing with low emission covering and also combining the panes into insulation glass packages. So it is clear that by solving this problem, energy loss will be reduced significantly.

There are multiple ways of proceeding, so all pros and cons about windows upgrading as well as different possible solutions are explained carefully in the next pages with the following structure:

1. Adding insulation on facade and around window frame
2. Adding insulation on facade and moving the window’s old frame
3. Adding insulation on facade and changing window frames
1. ADDING INSULATION ON FACADE AND AROUND WINDOW FRAMES

This first solution is about adding insulation boards not only on the facade around the window, but also between the facade and the window frame. In this way, thermal bridges can be reduced between window frame and facade.

The insulation method applied around the window and between window frame and facade is the same one as used in the wall renovation chapter (Rockshield boards adhesively fixed with rendering finishing).

But once the details of this solution are drawn (DETAILS A/A’), it is appreciable that there is a small space where insulation boards can be installed because the window frame is almost on the same line as the facade edge. Hence these boards would be very thin and consequently they could not be fixed correctly. Wind or other weather inclement could detach them from the window.

There is another difficulty. If boards are fixed in those places around the windows, the light incidence in these housings would be substantially reduced, which means that energy costs would increase through a higher artificial light consumption and heating.

Thus applying this solution would make it possible to reduce energy leakages around the windows but there would be other important problems derived from this method of renewing windows.
DETAIL A

1. LWC Wall
2. Inner Window sill
3. Existing window frame
4. 1+2 glazing
5. Window sill
6. Rockshield insulation boards
7. Insulation window sill-glazing
8. Insulation wall edge-frame
2. ADDING INSULATION ON FACADE AND MOVING WINDOW OLD FRAME

The second solution is thought to reduce the energy loss through correcting the windows and how sunlight can be exploited to the most possible in housing. The aim of this method is about breaking thermal bridges by moving window frames to the edge of the facade, so energy loss that originates between the frame and the facade edge, will be reduced. There are also insulation boards that are covering the critical points on the facade around windows, so that the thermal problems on windows would be solved just with these two interventions.

But making the facade 300 mm thicker, with adding insulation boards around windows, could be a problem because sunlight coming inside would be highly reduced. So the next mediation (DETAILS B/B’) is to remove material from the insulation boards at the corners of the windows from 90° to 45°, in order to let natural light come from wider angles.

In addition to this, it would be useful to continue thinking about how to make more natural lighting coming inside to improve energy savings. The way to proceed is to also reshape the inner walls to 45° just in the corners, so shading the incoming sunlight will be avoided by cutting the edges or the walls, and so increase the amount of incoming sunlight.

This way of upgrading windows is very interesting because with just moving windows until the edge of the facade, adding insulation boards with retailed corners on the facade walls, and removing inner corners from surface facade walls is possible to gain much energy savings, not only by thermal issues but also with taking advantage of natural sunlight.
**DETAIL B**

1. LWC Wall
2. Inner Window sill
3. Existing window frame
4. 1+2 glazing
5. Window sill
6. Rockshield insulation boards
7. Insulation window sill-glazing
8. Insulation wall edge-frame
9. Inner wall changed corner
10. Insulation changed corner
3. ADDING INSULATION ON FACADE AND CHANGING WINDOW FRAMES

The third solution deals with replacing old window frames with new elements. Existing shells were built about 40 years ago, and they might be worn out. So a really good option is to remove old frames and fixing new window structures compounded by elements that are designed with high air-tightness and at the same time they are well drained and ventilated. In DETAILS C/C' it is drawn how the frame is built up.

Once the frame is renovated, there are multiple choices concerning the way how which kind of window system has to be fixed:

A. Inward opening windows
B. Outward opening windows
C. Turn windows
D. Side swing windows
E. Fixed windows
F. Right/left hanging windows
So the determination about what kind of window system to install depends on the resident’s priorities, but whatever will be the final decision, it does not change the energy issue.

Then the decision to take is about which combination of glazing should be used on the window. There are a number of choices, but the best option is fixing three glasses that are tightly bound together by an intermediate metal strip. Heat and sound proofing are assured by the air or argon gas situated between the glasses. It will reduce U-value from 2.5 W/m2,K (old glazing system 1+2) to about 1.4 W/m2,K or better.

Referring to the insulation boards, they are applied in the same way as the second solution. They are also retailed on the corners until 45°. The corners that form the wall with the window hole are filed with a 45° as well.

Concluding, this alternative can be quite expensive because the whole window is restored step by step and apart from that there is a fixing insulation work to be done. But on the other hand this solution solves notably the issues about energy leakages what means that the renovation price (is) paid is going to be amortized later because energy consumption costs will be reduced as well. Natural lighting is guaranteed as much as in the second solution.
1. LWC Wall
2. Inner Window sill
3. Existing window frame
4. 1+2 glazing
5. Window sill
6. Insulation boards
7. Insulation window sill-glazing
8. Insulation wall edge-frame
9. Inner wall changed corner
10. Insulation changed corner
11. New glazing (3 int.glasses)
12. New window frame
13. Chalking(mineral wool)
14. Back up material
15. Sealant
16. Inner cover strip
CALCULATION
CAlCULATION

In the next lines are the calculations in order to obtain the already existing walls U-values, and the rebuild walls with mineral insulation boards 0.1m and 0.3m thick added:

- **Lightweight concrete 0.2m**

  \[
  U_{\text{value}} = \frac{\text{Thermal conductivity}}{\text{Thickness}} = \frac{0.1}{0.2} = 0.5 \text{W/m}^2\text{K}
  \]

  \[
  \text{Thermal resistance} = \frac{1}{U_{\text{value}}} = \frac{1}{0.5} = 2 \text{m}^2\text{K/W}
  \]

- **Mineral wool 0.1m**

  \[
  U_{\text{value}} = \frac{\text{Thermal conductivity}}{\text{Thickness}} = \frac{0.04}{0.1} = 0.4 \text{W/m}^2\text{K}
  \]

  \[
  \text{Thermal resistance} = \frac{1}{U_{\text{value}}} = \frac{1}{0.4} = 2.5 \text{m}^2\text{K/W}
  \]

- **Mineral wool 0.3m**

  \[
  U_{\text{value}} = \frac{\text{Thermal conductivity}}{\text{Thickness}} = \frac{0.04}{0.3} = 0.13 \text{W/m}^2\text{K}
  \]

  \[
  \text{Thermal resistance} = \frac{1}{U_{\text{value}}} = \frac{1}{0.13} = 7.5 \text{m}^2\text{K/W}
  \]

- **Wall= Lightweight concrete + mineral wool 0.1m**

  \[
  \text{Sum thermal resistances} = 2 + 2.5 = 4.5 \text{m}^2\text{K/W}
  \]
Building Envelope Upgrading on a 70’s Building in Stockholm Suburbs

Wall=Lightweight concrete + mineral wool 0.3m

\[ U_{value} = \frac{1}{\text{Thermal resistance}} = \frac{1}{4.5} = 0.22 \text{W/m}^2\text{K} \]

\[ \text{Sum thermal resistances} = 2 + 7.5 = 9.5 \text{m}^2\text{K/W} \]

\[ U_{value} = \frac{1}{\text{Thermal resistance}} = \frac{1}{9.5} = 0.105 \text{W/m}^2\text{K} \]

**COMMENTS**

Referring to the calculations above it is possible to distinct three different U-values:

- **The old wall** \( U_{value} = 0.5 \text{W/m}^2\text{K} \)
- **Rebuild wall with 0.1m thick insulation boards** \( U_{value} = 0.22 \text{W/m}^2\text{K} \)
- **Rebuild wall with 0.3m thick insulation boards** \( U_{value} = 0.105 \text{W/m}^2\text{K} \)

That means that adding 0.1m thick insulation boards of mineral wool reduces the U-value by 56% from the original wall and adding 0.2m further the U-value is reduced by 79%. So with just 0.1m thick boards, energy losses through the walls could be reduced to less than half of it which should be enough for the building. However, the system could be really improved by further 47% if insulation boards provided were 0.3m thick, but it might also become a problem for the building appearance.

All detailing are drawn with a general insulation board 0.08m thick, but depending on the final decision, the thickness could change at the most until 0.3m. Rebuilding procedure would though stay the same.
DISCUSSION/EXPERIENCES


DISCUSSION/EXPERIENCES

- ROOFING RENOVATION

After a research process about how the existing roof was, next features can be identified: It is made as a flat roof and it rests on the structural walls, the frame is made with 200 mm thick concrete, then there is a 200 mm deep glass wool insulation board which is covered by the rolling felt. Finally there are two last layers; mineral wool board and above that and on the top of the roof there is the asphalt roofing membrane.

Once known how the roof was built and where the troubles were coming from, it was time to describe which way was the best to proceed with the renovation on top of the building.

Different kinds of methods were studied, but finally the one that fit better in this renovation process was the system proposed by Rockwool firm. It reduces energy loss inside the building but at the same time it is compounded by tapered boards that create a slope in order to conduct water until downspouts.

The first step to take is about removing some layers of the old roof and preparing at the same time the surfaces in order to fix correctly new elements. Old layers to be removed are placed above insulation glass wool boards.

First of all the rolled asphalt has to be removed from the entire flat roof. Then mineral wool boards have to be detached as well. The next step is about taking the rolling felt out but trying not to damage the insulation boards. Hopefully, these insulation boards are going to be in good conditions, so the last step should be just to clean the surface boards.

Coronation walls connecting with flat roof are the points that have to be explained carefully and drawn in details.

- WALL RENOVATION

Once the most problematical part of the building is arranged, it is time to describe how to proceed on the walls. This way to proceed can be easier, once the executive process is on, if materials applied in it have characteristics similar to those of components on the roof.

The wall is 200 mm thick made by concrete blocks and there are no insulation boards applied to it. So one good way to renovate walls is adding Rockshield insulation boards (Facade lamellas) 300mm thick, and covering them with the Rockshield TC system as a
base coat. There is a decorative grained coat as a rendering layer which allows the whole system to breath.

The connection between the coronation wall of the roof and the thermal insulation on the walls, how insulation is applied on corners and also at the ground, are critical points that have to be explained carefully and with proper drawings.

- **WINDOWS UPGRADING**

Window frames in this building are made of wood, which is really close to the facade edge. The glazing combination is 1+2 glasses with interconnected loops and the simple glass sits in the outer loop. The windowsill is made of sheet metal cover.

Improving these windows characteristics, energy savings inside buildings can be highly increased. Energy leakages can be appearing easily around windows over time, so not only the glazing system can be improved with glazing made of low emission covering and with different ways of combining the panes, but also frames can be replaced.

Different solutions can be applied on the windows, like adding insulation on facade and around window frames, fixing insulation on the facade and displacing a windows old frame, or placing insulation on facade and changing window frames.

The last of the three solutions above is probably the one that guarantees the best result. However, it can be a high first investment but at the same time it can be easily amortized (increases the value of the building).
CONCLUSIONS
CONCLUSIONS

Once studied different ways to renovate the building, following data is conclusive:

- The best way to solve flat roof problems is about first removing layers above insulation glass wool boards and then adding a *Rockwool* insulation system so that it is not only reducing energy loss inside but also it is compounded by tapered boards that make a slope so they conduct water (until)to downspouts.

  Difficult details: Coronation walls connecting with flat roof.

- Walls have to be highly improved because they are just built with lightweight concrete so energy savings are not that high. A good solution how to renovate this envelope’s area is adding *Rockshield* insulation boards (Facade lamellas) 300mm thick, and covering them with the *Rockshield TC* system as a base coat. There is a decorative grained coat as a rendering layer which allows the whole system to breath.

  Difficult details: The connection between the coronation wall of the roof and the thermal insulation on walls need extra care. How insulation is added on corners and at the ground is also considered in drawings.

- Three different solutions can be applied on the windows, but a really good one is about replacing window frames and adding insulation around the apertures with a method that allows more light to come in. It can be a high first investment but at the same time it can be easily amortized (increases the value of the building).
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“Så byggdes husen 1880-2000”