Västertorp swimming hall
- Inspection of the structure and inner surface of the pool including overflow drain

Course: Building damages
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Introduction
The Västertorp swimming and sports facility is located in Hägersten in Stockholm. This report includes an evaluation of the inner surface and the structure of the swimming pool including the overflow drainage. The suggestion for renovation will be presented in three levels, basic, intermediate and high performance.

Building description
The facility was built in 1971 and has a larger 25 meter pool which has a depth varying between 0.7-3.8 meters (Stockholms Stad, 2015). The facility also includes a smaller pool. The temperature in the larger pool is held at 27°C and 29°C in the smaller pool. The play pool for small kids is at the moment closed. Furthermore the building has several different sports facilities, these are not included in this inspection.

Previously some renovation of the facility has been carried out. Water used to leak in to one of the corridors, to solve this problem reinforcement of the structure on that side has been done. Also changing of broken tiles is done regularly.

Analysis

Technical functions

Inner surface

Tiles
Not all the tiles are suitable and functional in a submerged installation. If the wrong tiles are chosen the maintenance will be higher (Laticrete International, 2009). In a swimming pool the tiles must have a low absorption rate, being the most water proofing as possible in order not to damage other materials and provide a more durable installation. The most commonly used tile types for swimming pool installations are porcelain and glass, materials with the lowest absorption rate.

Tiles put in horizontal surfaces must also have a high coefficient of friction (Laticrete International, 2009). This is because those are continually wet surfaces, and need to assure the safety for all the people walking in them. Furthermore, it is necessary to install tiles resistant to pool chemicals. Tile should be able to resist any sanitizing type used in the swimming pool such as chlorine, bromine, ozone.

Drainage
The main function of the drains is to not allow the waste to be drained with the water (The Great Lakes-Upper Mississippi River Board of Public Health and Environmental Managers, u.d.). Moreover, this part of the pool is connected to the pump for circulation and filtration. The drains located in the horizontal surface must drain the water in order to prevent the surface from being wet and assure the safety of the users and staff.
**Junctions between tiles**

Junctions between tiles are usually adhesives and mortars. These materials must have high adhesive strength, since tiles installations can experience both shear and tensile forces (Laticrete International, 2009). Furthermore, it is needed the water resistant function. The adhesive must not be in contact with the water after it is fully cured, otherwise it will be required a large degree of protection against deterioration. These materials must have low flexibility because of the differential movements, which can be caused by temperature changes or moisture expansion. It is also necessary to put tile installation materials resistant to pool chemicals.

**Ladder & Starting block**

Ladders shall be located at the shallow end and in the deep end (The Great Lakes-Upper Mississippi River Board of Public Health and Environmental Managers, u.d.). Ladders are used to go in or go out of the pool. Pool ladders need to be corrosion-resistant, to increment their lifetime. They have also to be equipped with slip-resistant treads in order to increment the safety of the swimming pool users.

**Swimming pool structure**

**Load bearing structure**

The concrete is the main material in the swimming pool because of its essential structural function. In addition, usually there are steel bars in order to reinforce the concrete. This material has to resist all the pressure loads caused by all the volume of water that is inside the pool. The reinforced concrete need to be carried out carefully, with the necessary concrete coating in order to prevent corrosion of the steel.

The Swedish standards require that every swimming pool should use concrete of exposition class XD2 against chloride deterioration, so the maximum water-concrete ratio is determined to be 0.45 (Eljertslund, u.d.). The minimum compressive strength is set to 42.5 N/mm². In the swimming pools also has to be done a visual inspection and a regular and systematic measurement of major work.

**Components and materials**

The structure of the swimming pool is composed of different materials which are presented below.

**Reinforced concrete**

Concrete is the main material used for the swimming pool. Concrete is a composite material composed of aggregate bonded together with fluid cement which hardens over time. Concrete is strong in compression, as the aggregate efficiently carries the compression load. However, it is weak in tension as the cement holding the aggregate in place can crack, allowing the structure to fail. The inclusion of reinforcing bars permit to have a higher tensile strength and/or ductility.

Concrete can be damaged by many processes, such as the expansion of corrosion products of the steel reinforcement bars, bacterial corrosion, leaching, water effect creating erosion, physical damage and chemical damage (from chemical products used to treat the water, for example). It will be necessary to guarantee a good waterproof barrier between concrete and the water of the swimming pool.
Tiles
A tile is a manufactured piece of hard-wearing material such as ceramic. In the case of the swimming pool is used for covering the floor and the walls of the basin. Swimming-pools are the ultimate wet areas for tiling, due to severe usage and maintenance conditions. In this case, the tile adhesive needs to have strong bonding and flexibility characteristics.

Tile grouts
Grout is a particularly fluid form of concrete, like a mortar, which is used to fill gaps. It is used in this construction to seal joints between tiles. Grout is generally a mixture of water, cement, sand, often color tint, and sometimes fine gravel. Unlike other structural pastes, grout, when mixed and applied correctly, creates a waterproof seal between tiles.

Tile grouts need to be resistant to different kinds of attacks. Firstly, the pressure and counter-pressure, since tiles in permanent water immersion are submitted to water pressure or to counter-pressure when the pool is empty. The tile adhesive needs to be enough water-resistant to ensure good adhesion of tiles in all cases.

Secondly, the chemical attacks. The chlorine used in pools and the use of detergents will directly impact the durability of tile grouts. The choice of an appropriated chemical-resistant grout is important to build a long-lasting swimming-pool.

Certain parts of the pool are exposed to more aggressive conditions than others:

- The grout on the pool sides at the waterline may be exposed to greater erosion from water movement.
- Pool surrounds may undergo stringent and frequent cleaning regimes.
- Walls in rooms containing internal pools will be exposed to constantly high humidity and also need to have good water resistance

Waterproofing material
Since the waterproofing materials are hidden inside the structure it is hard to determine which material that has been used at an optical inspection. Due to the buildings age it can be assumed that the waterproofing material is floated asphalt (Björk, 2015).

Loads on the construction
The main loads that could be encountered for the basin and the inner surface of the swimming pool are presented below.

The load of the construction itself
The structure of the basin is principally made of reinforced concrete, which is a heavy material. This is the first load that the basements should successfully support.

The water
The water is certainly the main load we have to be careful. First of all, water creates great pressure on the pool structure. When swimmers are moving in the water, it will also create disturbances and
different flows. In addition, the water is treated with chemical agent like chlorine that could create potential damages to the structure.

**The bather loads, customers**

The bather loads refers to the capacity of a swimming pool. It is the number of customers we can expect to come in the swimming pool at any one time. The maximum bather load should be calculated. It is based on the amount of deck area in relation to water surface area and water depth. The maximum number of persons present in the water must be respected for many reasons such as avoiding excessive load in the pool and always ensure sufficient water quality.

**Ladders and starting blocks**

Additional loads like the ladders and starting blocks are present in the building. This is not the biggest loads for the swimming pool but these elements need to be properly fixed to the structure. The fasteners for ladders and starting blocks are weak point because it provides a high risk for corrosion and risk for leakage in these areas since they are passing the sealing membrane of the pool (Björk, 2015).
Damages to the construction

Pool structure
During the inspection several types of damage occurred at different places. Most of the damage is directly connected to problems with moisture. Underneath the pool and at the exterior side of the pool walls brown stains were detected, these indicate that moisture leaks from the pool into the structure. Most of these stains were found near the connection between the pool and the floor (which is the ceiling in the basement) and can be seen in Figure 1. A larger area with stains from moisture was found in the stairwell close to the reception desk (Vansbro kommun, 2009).

Furthermore several visible and corroded reinforcement bars were found, these can be seen in Figure 2. The reinforcement bars were heavily damaged which have a major decreasing effect on the structures load bearing capability. In areas close to the corroded reinforcement, pieces of concrete have fallen off. The largest area with a damage of this type was found at the entrance to the basement. Missing pieces of concrete were also found on the columns and beams under the small pool, although this might be due to drilling.

Also several areas with salt precipitation were found, which can be seen in Fell Hittar inte referenskälla.. This indicates that the concrete is exposed to moisture transport (Design & utvikling Joomla CMS, 2015).

Large areas with cracks in the concrete walls were also found during the inspection. One of the most damaged places found during the inspection was the pool.
window between the pool and the stairwell. The concrete in that place is heavily damaged with large cracks. Also, the concrete has stains which are due to moisture. It can be assumed that this window does not fulfill the requirement of making the pool watertight. In the window connection mold and deposits of dirt were found. The window can be seen in Figure 4.

**Figure 4: Large damages to the structure at the pool window**

**Inside of the pool and overflow drain**

Since the swimming pools were filled with water the inspection has been carried out by only looking into the pools and their surfaces.

**Large pool**

During the inspection mold was found at several places at the inner surfaces of the swimming pool. Larger areas with mold were found at the connections to the ladders and at the connection between the pool wall and the floor, as seen in Figure 5. The risk with having mold within a construction is that some types of mold produce toxic substances (Rylander, 2008). The smell of mold will get stuck on textiles. The mold growth will be as large as possible when the relative humidity is between 70-80%. It should be noticed that mold occurs in ordinary dust within a building. There are several risks for human health if the mold is inhaled, it will affect the immune system. When inhaling mold a person can develop allergies or unspecific inflammation in the lung system, although allergies are uncommon. These diseases show off as irritation in the lung system, coughing and in some cases itching. It should also be noticed that these symptoms can stay for several years after a person have been exposed to mold.

**Figure 5: Mold and missing mosaic tiles close to the ladder**
Furthermore loose tiles were found at the sides of the pool, one example of this is shown in Figure 6. There are several occasions that can cause loose tiles. One occasion is that the pool is emptied in a too high speed. In this case the water pressure in tiles and joints will not be lowered enough and the pressure will make the tiles crack or loose (Franjic & Ramadan, 2013). Therefore emptying of a pool should always be done at a low speed. It can be caused if the tiles are fastened before the concrete has dried out. It can also be caused by water that penetrates into the structure and comes in behind the tiles. A solution for that cause is to glue both the sealants and the back side of the tiles, this will give a higher tightness between the tiles. To avoid that the glue loosens it should have a high moisture resistance and resistance against chloride penetration. Loosening of tiles can also be prevented on beforehand, this is then done by using tiles with a low water absorption to avoid penetration of water. Furthermore tiles can loosen due to the high wear that occurs in swimming pool buildings. Also, the tiles are always affected by the chemicals that occur in the water which will lead to a lower tightness. This can be avoided by using epoxy in the joints instead of cement based materials.

Deposits of undefined dirt were detected in the overflow drain during the inspection, as seen in Figure 7. The swimming pool also have a point drain system, which should be avoided since water can get stuck on the floor which might lead to water penetration and damages to the structure (Ljungfelt & Svensson, 2006). A better solution is to use continuous overflow drains. Rust stains were also found in the overflow drain and around steel lids on the floor. Damages to the tiles in the connection between the pool and the floor were detected and some of these were more or less temporarily repaired. Loosen mosaics on the floor near the pool were also found.

**Small pool**

In the small pool leakages were detected at the side where the small stair on the pool side is located. Salt deposits were also found on the mosaic at the same side, this is shown in Figure 8. Some parts of the mosaics were also cracked or loose. On the swimming pool bottom rust stains could be seen, as sown in Figure 9.
Renovation

Basic
For a basic renovation, a proposal is a solution that seems a low cost for the owner of the swimming pool. We will do several things to repair the swimming pool to avoid the possibility of the building damages to expand. Below are some things that are needed to do so that the pool does not fall apart presented.

Exchange of broken or protruding tiles

Several tiles were starting to fall off from the basin. The consequence is that the sealing is not totally assured by the tiling. In this way, the water can leak into the structure and meet the waterproofing material. If the waterproofing membrane is bit old it might have loosened some of the waterproofing properties and therefore it can lead to potential damages for the structure. The water of this swimming pool is treated by chlorine and could give chemical attacks to the structure.

Repair the damaged parts of the concrete

The concrete was broken at different small parts of the structure of the swimming pool. Add concrete cover at broken parts and extra protection at damaged reinforcement. Fill the cracks with caulk and apply plaster when it’s dry. The procedure is shown in Figure 10.

Finding hollow spots

It is best and cheapest to repair potential trouble spots while repairing the pool’s entire surface. These can be identified places by gently tapping on the pool’s sides. At places where the plaster is separating, we can hear a hollow sound. At the location of the sound, remove the loose plaster and replace it with the mixture used to fill cracks and holes.

Remove mold
White water mold is a naturally occurring fungus that has a white mucous or tissue paper-like substance. It can remain a contaminant even after treatment. It can re-contaminate long after it
appears that it has been destroyed (includes pool toys, floats, ladders, etc.). Mold can be typically caused by improper water and pool maintenance, environment, or poor circulation.

The treatment of the mold must be quick and total. The swimming pool and all the affected surfaces must be cleaned. All the visible mold must be removed. An initial dosage of algicide (copper sulfate for example) should be added to the pool. Do not use the swimming pool until the pH level in the pool is in the ideal range and the chlorine level is greater than 1 ppm.

**Remove salt**

The salt is another problem we saw at different spaces around the structure of the swimming pool. The cleaning can be carried out by following the steps presented below. The procedure can also be seen in Figure 11.

**Cleaning the surface**

Clean all salt, dust, grit, and concrete pieces off the surface we are repairing. This step can be performed with an high-pressure washer for example.

**Covering the surface**

Then, it will be necessary to cover the surface with an acid rinse or an acidic cleaning agent to remove all the active elements and avoid potential new damages.

**Applying a fill mixture**

Apply a mixture for example of white concrete, white sand, acrylic cement bonding agent and enough water to create a good fill material and cover all the cleaned surface.

![Figure 11: Removal of salt](image-url)
Intermediate
Renovation at an intermediate level is more intrusive than at basic level. From inside the pool repairs and renovations can be executed to improve the prevention of moisture and damp entering the concrete structure and spillage water from staying on the floor with better drainage. The main problem in this swimming pool, as in most, is the water.

The drainage

The risk of surface problems such as mold is greatly connected to high RF, moisture and temperature (Burström, 2012). In a swimming pool the temperature and RF are quite high.

As mentioned before, the swimming pool currently has a point-drainage system which causes the water in between to generally stand still. By changing the system from a point-drain to a continuous drainage, preferable all around the pool the amount of water that stands still are reduced. This is the common procedure in newly built swimming pool since it has shown that the problems greatly reduce.

Change of tiles

A more extensive version of changing damaged tiles is to change all the tiles at the same time. By doing this the opportunity to create a more watertight barrier inside the tile layer which could decrease the moisture and chemicals transferring into the concrete and reinforcement bars.

Membrane

If the exchange of all the tiles is performed, a membrane can be put inside the tiles to protect the concrete from the water and especially the chloride (Ljungfelt & Svensson, 2006). Some example of membrane might be PVC-foil, plastic reinforced with glass fiber, steel or PVC-panels, stainless steel elements, epoxy based system together with tiles. For some cases the membrane might not need the tiles, in such cases as the steel panels.

Stainless steel pool

Another option is to the common repairs of tiles and membrane is to put a steel pool inside the concrete structure (SteelPool sweden AB, u.d.). The stainless steel pool have according to the producers it creates a water proof with very long life span that requires a low maintenance fees. It can be constructed only as a covering and protection but if the concrete bearing capacity is not enough the steel structure can also be built to carry the structure also. But that might be a more high performance renovation. The initial building cost may be high but a LCA can show that is can be a better long term option. It is also considered a recyclable material (RenoSys, u.d.).

Reinforcement of structure

As have been mentioned and shown previously, in certain areas concrete has fallen of and showing corroded reinforcement bar. When the bars corrode, the steels strength greatly reduces and since the area of the bars also expand it can create internal strains in the concrete. Is the bearing capacity...
of the concrete and reinforcement bars considered enough, reinforcement of the structure from the outside can be an option.

The deeper part of the swimming pool have already been reinforced during a previous reparation after severe leakage when water could be seen flowing down the walls. While the leakage at this point isn’t as severe the corroded steel is still a major concern and strengthening methods should be considered to avoid such major problems in the future.

High performance

Swimming pool structure

The third and high level of renovation would be the high performance. For the part of the swimming pool structure there are several options, depending on the material chosen for it. In the high performance stage of renovation the suggestion is to remove the old swimming pool structure and build a new swimming pool within the old building.

Reinforced concrete

First of all, it could be used the same material as there is now, reinforced concrete. The difference from the intermediate state is that the whole concrete structure should be replaced in this stage.

When casting the concrete it should be done in as large sections as possible and pauses in the casting should be avoided (Ljungfelt & Svensson, 2006). Often it is not possible to make the concrete as watertight as needed, due to the economical aspect. In these cases it is very important to use a good watertight membrane. Different types of membranes that are good options for a concrete structure is mentioned in the chapter about intermediate renovation. On top of the concrete and the membrane tiles should be placed for protection of the membrane and for esthetical reasons.

Steel structure

Another choice could be change the material and build the whole structure with steel, as it is shown in Figure 12 and Figure 13. As it can be seen, there is a concrete basement form on which is standing steel walls. The walls will be around the swimming pool. Furthermore, to support the construction several diagonal steel bars are installed, going from the top of the walls to the basement, as it can be seen in the images. It has to be done in order to reinforce the steel core structure so can be resisted all the pressure loads produced by the volume of water inside the pool.

It is necessary to comment some disadvantages in doing the renovation with only steel. The main one is the necessity of good connections between the different parts of the walls and the diagonal bar in order to have high waterproofing. On the other hand, using this kind of
material do not allow you to make curve and strange shapes and surfaces.

**Glass structure part**

Another possibility for the high level of renovation could be use glass for a swimming pool structure part, as there is shown in Figure 14 and Figure 15.

This choice would consist on do part of the structure with reinforced concrete, as there is now, but complete it with some glass walls. As there is a big swimming pool of 25 m large, the glass structure part should be thick enough to resist the water pressure load. In addition, the connection between the wall of concrete and the one made of glass must be well waterproof with a good sealing because it is the most dangerous part. Finally, as an aesthetic function, the glass wall should be the connection wall between the swimming pool and some fitness room.
References


The swimming pool building at Västertopshallen has been visited and each part of the building has been examined by a group of students. This report will focus on the inner and outer facades as well as the windows of the building.

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1/ Technical functions of the building (walls and windows)

a/ The technical functions

In this building the walls and windows have to be specially equipped in order to keep a high temperature inside the swimming pool building. They also have to be well protected against the moisture provoked by the swimming pool, as well as the high temperatures.

The mechanism of the windows has to be resistant to moisture and condensation on the windows should also be avoided.

The walls should also be well protected from infiltration through the foundation (rising damp) and rain. Such a problem can be very visible from the outside and can cause cracks, damage the concrete as well as the reinforcement bars.

b/ The components and the materials that gives these functions

The walls of the building are made of cast-in-place (probably light-weight) concrete, with of course reinforcement bars. The walls are covered with a layer of plaster in order to protect the concrete and make the building look better. This means the building has a mass storage wall system composed of 2 layers¹ (concrete on the inside and plaster on the outside) in order to be protected from the outside weather. The wall that surrounded the swimming pool itself was a light-weight (or aerated) concrete, cavity wall (visible from the roof). The reason behind it is probably to have better insulation and to have space for the water pipes and the electric cables. Also there could be some ventilation going through the cavity in order to keep the windows condensation free².

Figure 1: The cavity wall (on the left) as seen from the roof top

² Powerpoint presentation swimming pool building
The walls on the inside of the building, especially the ones surrounding the swimming pool itself have to be well protected against moisture and water infiltration. This can be realised by using a good protective paint layer and good sealing joints.

The window frames consist of wood and are therefore quite sensitive to moisture. A good protective coating is important, as well as good sealing joints.

c/ Loads on the construction

The loads and stresses on the construction have, for a big part, already been explained. The walls have to withstand the weight of the construction on top, the weather, the moisture provoked by the swimming pool, and perhaps the water infiltration from the soil. The windows do not have to carry the construction but have to be able to protect the inside of the building from the weather. The wooden window frames have to be waterproof (no water infiltration) and have to be protected against mould. Moisture can also provoke movements from the material (expansion).

2/ Possible and encountered damage
   a/ Possible damage

Before visiting the swimming pool building, a list of possible damage was made. The damages are separated in 2 parts: windows and walls.

Windows

- Properly installed
- Leakages
- Condensation (bad joints/sealing)
- Mechanical damages (closing/opening)
- Paint/protective coating
- Damages on frame (rotten wood etc.)

Wall construction

- Cracks
- Leakages
- Quality of painting/Coating
- Water infiltration (DPC...)
- Effect of equipment (radiators for instance) on the interior walls
- Effect of moisture on the interior walls/windows
b/ Encountered damage

First the outside walls and windows will be covered, and afterwards the inside.

Outside walls/structure/windows:

Lower roof (we went on the roof to study the windows and walls on top of the building):

- The coating on the wooden frames was old leaving the frames damaged at certain places. Sometimes the frames were even eaten by wood worm and some of the sealing joints were damaged. Clearly water infiltration could be a problem here. See
The sealing joint should be like this:\(^3\):

\[\text{Figure 5: Sealing joint window}\]

- One side of the building, especially the window frames, was more affected by the sun. The wood was more worn out and the coating had disappeared for a big part:

\[\text{Figure 6: Side where the sun shines less}\]
\[\text{Figure 7: Side where the sun shines more}\]

- There were many opportunities for water to infilt rate due to broken or loose pan els:

\[\text{Figure 8: Broken panel}\]
\[\text{Figure 9: Loose panel}\]

- Structural problem on the 4 main columns of the upper part of the building. On each of these columns, very big cracks were visible. They were on the inside of the building, but only visible when standing on the roof. This is probably due to the cavity wall. Both parts of the wall

\(^3\)Taken from powerpoint presentation 'The effect of moisture or damp on a number of important building materials', Ur SFR – Rekommendation 3
might have moved over time. The columns are connected to both parts of the wall and couldn’t withstand those movements. This caused the cracks.

- At certain places, the plaster was detaching and the paint on certain walls was in bad condition.

- On the walls from the entrance, the concrete was very damaged and the reinforcement bars were visible. This can cause corrosion problems, and water infiltration.
Inside walls/windows:

On the inside the building was in quite a good state, even though the damp ratio is very high, as well as the temperatures. The coating/the paint on the walls was in good state. A few notable things will be presented below:

- Certain doors were in bad state. They were made from wood and did get affected by the moisture. Some parts were starting to rot. On the picture below it is the joint that is affected.

- Some of the window frames had the same problems as seen on the outside: the coatings were old and sometimes almost disappeared

- There were also some signs of water infiltration through the tiles on the walls:
3/ Renovation possibilities

The renovation possibilities and processes will be divided into three levels: basic, intermediate and high performance.

a/ Basic renovation

Outside walls/windows

- In order to prevent growth of mould and insect attacks, the window frames get treated with Boracol\textsuperscript{4}. This product is made with boron, which is commonly used in the prevention of fungi growth and insect attacks.
- Broken panels should be replaced, otherwise water could infiltrate in the walls. Some panels were still in good state but slightly loose. These should be fixed properly.
- The structural problem concerning the columns can’t be solved very easily. The main danger here is that water infiltrates the column and provokes corrosion of the reinforcement bars. Also water could infiltrate into the cavity wall and provoke all types of damage: cracks, chemical reactions (for instance crystallisation of salts)... One way to prevent further damage is to patch the cracks with concrete-repair caulk\textsuperscript{5}. This might sound as a cheap solution, but more cannot really be done. In order to fully repair these columns, new ones should be placed, containing expansion joints. Further details will follow later on in the report.
- The visible reinforcement bars, at the entrance, should be treated against corrosion. In order to do this, the weak concrete around the visible bars should be removed for the bars to be

\textsuperscript{4} http://www.boracol-shop.de/?q=node/83
\textsuperscript{5} http://www.quikrete.com/athome/Video-Repairing-Sealing-Cracks.asp
easily accessible. The bars should be cleaned by sand-blasting\(^6\). If the bars are too corroded, they should be cut out and replaced by new, anti-corrosion, identical bars. Otherwise the present bars should be treated with a highly alkaline product: the high pH will protect the bars against corrosion (see footnote 6 for reference). Finally the bars will be covered with mortar.

**Inside walls/windows**

- The windows are treated the same way as outside. The reason is that they are also exposed to a lot of moisture inside the building because of the swimming pool. The sealing joints will be replaced if necessary.
- No further renovation on the inside.

**b/ Intermediate renovation**

The main difference in this renovation are the windows. In this case, all of the windows are replaced instead of only repairing the most damaged ones.

**Outside walls/windows**

- All the windows should be entirely replaced. The new windows should be pressure-treated and have a Boracol coating. This way deterioration of the window will be prevented as good as possible. The sealing joints are one-stage joints:

![Figure 15: One stage joint](http://www.sodamco-weber.com/technical-repair/help-and-advice/cases-solutions/repair-of-damage-with-exposed-steel-reinforcement.html)

- Where necessary the plaster will be replaced.
- All panels will be replaced with new, watertight panels.

Redo the paint and the protective coating from the walls and windows. The effect of the sun on certain sides of the building should be taken into account: these sides should have a thicker and more effective protection.

The renovation solution for the structural problem will still be treated the same way as before.

The reinforcement bars will be repaired the same way as explained before.

**Inside walls/windows**

- The windows are replaced on the outside, which means they are also replaced on the inside. They will get a good protective coating against moisture and mould. To avoid condensation, the ventilation system that was installed underneath the windows (see figure below) will be kept and cleaned up to ensure good ventilation.

![Ventilation at the windows](image)

- The broken tiles should be replaced in order to avoid water infiltration.

**Outside walls/windows**

- The whole upper roof structure should be replaced in order to place new columns. This way the windows can also be replaced easily. This is the only way to repair this structural problem with the columns. The new columns will contain expansion joints in vertical and horizontal direction. One of the joints will be placed at the base of the column in horizontal direction to allow vertical movement. The other joint will be placed in the length of the column, in vertical direction. This way the column will be able to resist the vertical and horizontal movement of both parts of the cavity wall.

- The other windows will still be replaced and treated the same way as explained before.

- The visible reinforcement bars will be entirely replaced instead of partially, in order to assure a very good renovation. The process has been explained before.

**Inside walls/windows**

- The windows are treated as explained before.

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7 Powerpoint presentation 'The swimming pool building – a short introduction', Folke Björk
8 Powerpoint presentation 'Best practice or typical errors' – part concerning foundations – Folke Björk
The paint of the walls was slightly damaged at certain places. This is nothing too worrying but can eventually result in moisture damage. The paint should be redone and be resistant against high temperatures and moisture rates.

The old doors should be replaced by glass and metal framed windows. The metal should of course be treated against corrosion.

Conclusion

As a conclusion, the windows and facades of this building were overall quite damaged at certain places, especially on the outside. On the inside there was not too much damage and we expected to find more due to the high moisture rate and the high temperatures. If the renovations are done as explained in the high performance part, the building will still be usable for many years.
In general, we can say, that the building of the swimming pool, including the interior is damaged a lot (luckily for our exercise). Our task was „Indoor surfaces – especially the flooring“. First of all, we want to show you floor as a whole and than concentrate for some details. On the picture 1, we can see slope of the flooring into the drainage.

There are separated drainages, one is for water from cleaning floor and the second is for pool water and it is situated inside the pool, as we can see on picture 2. The drainage could be also make as one, but the water from pool and from cleaning still has to be separated, because pool water goes to filtering process and cleaning water goes to sewer. From these pictures, floor looks almost perfect, but if we look closer, it is not so optimistic.

Lets start from the beginning, we dont know the reason, why they used probably the smalest tiles, which u can buy, for the whole floor around the pool. We think, that using bigger tiles would be much more easier to do and also – the less mortar you use, the less potencial problems you will have. Even, that they used tiles sized 1x1cm, they had to make halves of it. We found this thing funny. And another thing is, that for some reason, they just
stopped to halve the tiles and they used mortar or concrete instead. Maybe they were too tired and bored about halving these really small tiles. That is the thing, that should not be seen (halving the tiles) especially, when you use tiles 1x1cm.

**Basic solution:** Remove concrete (mortar) and put the tiles instead.

**More complicated solution:** remove all the tiles (whole floor) and replace it with new bigger tiles.

![Halving of tiles](Picture 3 - Halving of tiles)

Another problem was missing silicone in some places. For example on Picture 4. It is bottom of the springboard. The problem is, that because of missing silicone or similar material, the water can easily penetrate between the tiles and causing problems there. Another thing is that it is unaesthetic and it looks, it is not finished.

**Basic solution:** Clean the gap and fill it with silicon

**Luxury solution:** Remove floor tiles, remove tiles from springboard and replace it with new ones.

![Missing silicone](Picture 4 - Missing silicone)
This is not a damage or something badly done. This is good example, how you have to design flooring for swimming pools. Here we can see part of stairs and how the outer tiles have chamfered edges. This is because of sharp edges could be dangerous, because most of people does not use shoes in the pool area. We also have to say, that floor has very good properties in case of slippery. Even we tried to slip with wet foots it was very hard.

![Edges of stairs tiles](image)

*Picture 5 - Edges of stairs tiles*

On picture 6, we can see lower part of the column, which supports the diving tower. The problem here is the corrosion of steel bar. We think, that i tis caused by carbonatation of concrete. Regardless of what is the reason, it is very likely, that i tis going to be worse and worse. Because tho corrosion on the bar is going to be bigger and bigger and it will cause again disruption of concrete and again and again. It is like a circle.

**Basic solution:** Basic solution could be just to apply the anticorrosion substance on the bar and refill space with concrete.

**Advanced solution:** We can expose more the steel bar, than clean it with steel brush, apply the adhesion and then refill with special substance.

**Luxury solution:** The most expensive solution would be completely remove the diving tower and build new one. (Because of this one looks pretty old)
Picture 6 - Exposed steel bar
Detached tiles

Some of the ceramic tiles have come off because mortar between the tiles has washed up badly. Adhesive layer’s thickness isn’t enough everywhere on floor and there is something wrong with mortar because mortar can dissolve in water. It seems there has used the same mortar to fill the gabs between tiles and stick the tiles to floor.

Renovation method:

Basic: Cleaning an area where aren’t tiles. Adding some tile adhesive and install tiles on it rapidly before the adhesive dries. After this an epoxy-based mortar will be added to the seams.

Intermediate: Renovation method is the same as above except the whole floor should be cleaned and mortar will be added to all tile seams. Then seams condition is better than above but tiles are still in bad condition.

High performance: Tiles, mortar and possible waterproof membrane will be crushed with big breaker machines and the waste is transported to the nearest recycle center. Concrete slab should be hoovered up all the dust and after that all possible holes on the floor are filled with a stiff plaster. Several layers of levelling compound are applied on the floor in order to get waterproof structure. Waterproofing membrane should be installed joints and on corner of wall and floor. After waterproofing has dried adhesive layer will be applied on floor and tiles will be installed right away. If adhesive layer dries too much, it should replace with a new layer of adhesive. When tiles have installed and the adhesive layer has dried it’s possible to pour epoxy based tile grout on the whole floor in order to fill the gaps between tiles. After 20 minutes tile grout is cleaned from tiles before grout has completely hardened. Silicone is applied all the joints and corners.
**Dissolved mortar in the tile seams (stairs)**

Tile seam mortar has washed up because water has dissolved mortar away with time. Mortar consistency seems uncommon because the diameter of sand particles is about 2-3 mm. The typical mortar in the seams doesn’t contain that large grain of sand. Too large grains in the seams can come off easier compared to smaller ones.

**Renovation method:**

**Basic:** New tile grout can be added on the top of older mortar but it’s not recommended because of the new tile grout won’t fasten to the older layer.

**High performance:** Both the tiles and mortar between them are in poor condition so the best renovation method is to demolish all flooring structure (tiles, com and water proofing) and build a new one. Renovation should be carried out the same way as the high performance renovation of the detached tiles (previous one).
Lime in the stairs.

Lime permeates through the concrete structure and lime is gathered on the surface of steps. Lime is from mortar which is used in the seals.

Renovation methods:

Basic and intermediate: Cleaning of lime on the surface is one solution to get rid of this eye-catching problem but it doesn’t stop the lime leakages.

High performance: All tiles will be demolished in order to locate the concrete cracks. All cracks on concrete will be injected with polyurethane so all leakages dry up and lime can’t penetrate the structure anymore. Once the concrete is watertight enough it’s possible to carry out the same renovation method as case detached tiles (cleaning, filling the holes, membrane and leveling to make structure waterproofed, adhesive, tile installation, tile grout into seams).
There is not silicone in full-length at tiles’ movement joints but there should be. The distance between movement joints is about 4 meter. Usually mortar isn’t used in the movement joint because mortar doesn’t make possible tiles’ movement. Material in movement joints should be elastic, for example silicone.

**Renovation method:**

**Basic:** Silicone will be added to movement joints

**Intermediate:** All movement joints and tiles right next to them will be crushed with breaker machine. The waste is recycled and crushed areas are cleaned. Adhesive layer will be applied on floor and tiles will be installed. In the end silicone is applied to movement joint to enable tiles’ movement.

**High performance:** All flooring structure above concrete slab will be crushed with a breaker machine. The waste is recycled and crushed areas are cleaned. Renovation method is similar to high performance renovation method of detached tiles but silicone will be applied to sealing movement joints. (This renovation method contains waterproofing).
Connection of floor drain and floor

There isn’t silicone around a floor drain and structure seems suspicious because water can penetrate into floor structure by that gap between floor drain and tiles.

**Renovation methods:**

Basic: Mortar will be added to the gap between tiles and floor drain. Not good renovation method but cheap and better compared to current solution.

Intermediate renovation:

Tiles are crushed around floor drain and waste is delivered away. Area is cleaned after that. One layer of levelling compound and floor drain reinforcement sheet will be applied on the floor in order to get waterproof structure. Tiling and applying of adhesive layer will be done the same way as the detached tiles renovation.
The membrane should be applied properly on the whole floor and the joint between floor drain and waterproof should be sealed properly.

High performance:

The same renovation method as intermediate but the whole floor structure will be crushed and floor drains will be replaced with new ones. The reconstruction follows the detached tiles’ high performance renovation solution.
Mold on the corner of floor and wall

There is mold in the corner of wall and floor. There has been a sufficient amount of humidity and impurity in the corner. Temperature has been about 20 degrees so there has been all the factors which mold needs to grow.

**Renovation methods:**

Basic: removing the mold with an effective acid.

High performance: Tiles and adhesive needs to be removed in order to find out what has caused mold growing. If there were leakages, those should be injected with polyurethane.
Building Damages AF2403

Renovation manual for the roof and ceiling of Västertorps Sim & Idrottshall

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TECHNICAL FUNCTIONS OF THE BUILDING:

Raining water drain:
One of the main purposes of the roof is the drain of the rain water. The entire roof is set at an angle. At most parts of the roof the angle is minimal. Because of the angle the rainwater will flow to the exterior of the roof. The entire roof surface should be waterproof otherwise there will be leakage inside the building.

Climate conditions:
Because it’s a swimming pool the climate inside is hot and tropical. That’s pleasant for the people who visit the swimming pool. Another function of the roof/ceiling is keeping that conditions. And try to keep the energy consumption as low as possible. For this reason it must be good isolated.

Ventilation:
The tropical climate inside the swimming pool will cause a high humidity inside the building. Without good ventilation there will come a lot of molt stains on the ceiling. Molt stain will weaken the material and are unhealthy for the indoor air quality.

Components that gives these functions:
The raining water will go to the edge of the roof. Because of the small angle in the roof it will flow to the exterior. At the sides of the roof there are gutters attached to the roof. All the water will flow into the gutters. The gutters are then attached to vertical drainpipes. This will lead the water into the sewer.

Figure 1 Gutters

The isolation material, located between the roof surface and the beams, makes sure the indoor temperature does not get influence of the outside temperature. It keeps a stable climate inside the swimming pool.

Figure 2 Isolation material

For the ventilation there are several devices placed on the roof. These devices keep the air flowing through the building and makes sure the humidity does not stay at the ceiling of the building (which causes molt stains).
Snow is probably the normative component for this kind of flat roofs. Because there can be a lot of snowfall in Sweden. To make sure the roof doesn’t collapse there is a light weight concrete layer above the wooden beams. The lightweight concrete will give the strength to the roof. It is probably a pretty thick layer because it’s a flat roof. Flat roofs are more likely to get a lot of snow stacking up. Wind isn’t a normative feature. Because it is a flat roof there won’t be any air sucking/compressing on the roof.

As you can see in the pictures above. Wind doesn’t have any influence on flat roofs. Wind is a factor that the people of the walls should bring in consideration (These are the Dutch norms for wind, I am not sure how you calculate wind loads in Sweden). The numbers at the picture are the factor you should multiply the wind load with.

**Type of the roof: Bituminous felt roofing**
The covering consists of built-up layers of felt based on organic, asbestos or glass fibre bonded together with a bitumen compound. The use of this material has become widespread during the past 40 years particularly for domestic properties, mainly because it is cheap compared with other roof coverings. Bituminous felt is designed to be fixed to the main roof structure with special adhesives, heat welding or solvent welding. It has good flexibility, but there have been problems due to water penetration through inadequately bonded joints and mechanical damage.
INVENTORY OF DAMAGES

1. Cracks in the roofing and detachment of covering material

The felt is liable to crack mainly because of differential movement between the felt and the substructure and the shrinkage of the base due to thermal changes. In addition, shock impacts with objects or negligence of people while they are walking on the roof can cause holes in the coverage. Holes in the roofing let rainwater flow into the roof causing to adjust the strength of holding layer underneath the roof surface. Also insect and bugs can enter through the cracks and ruin the insulation.

2. Damp patches on the ceiling

Damp patches on ceiling are generally the result of the high humidity inside the swimming pool. Because of the tropical climate the ceiling is more likely to gain molt stain. Another cause can be condensation or moisture: condensation occurs when humid air from the interior makes contact with the underside of the roof surface and the water vapor is carrying turns into liquid water. Free water between the roofs layers can makes material softer, dilutes components in the material, change the physical dimension of the details and cause frost weathering during winter. In addition, water is a prerequisite for many microorganism and water surfaces collect dirt.
3. **Air blisters under the roofing**

![Figure 11 and 12 air blisters under the roofing](image)

As mentioned before, condensation can present serious problems in roofs of this type. Moisture can be prevented from entering the roof by the provision of a vapor barrier such as plaster board and ventilation in the roof void to prevent fungal growth. The entrapped air or moisture between the layers of felt or between the felt and the substructure will cause the felt to lift in the form of ‘blisters’. The blisters are not necessarily a sign of failure, but should be carefully examined to see whether any foot pressure has been applied to cause the blister to crack and form a passage for water penetration. One of the most common defects is that no provision has been made for ventilation and a vapor barrier.

4. **Gutters and drainpipe obstructed or precarious**

![Figure 13 and 14 Gutters and drainpipes](image)

Unstable gutters may fall down for the weight of snow and can cause holes and cracks in the roofing. Furthermore, obstructed gutters and drainpipe can compromise the proper down flow of rainwater and cause flooding or water leakage through the roof.
5. Electric cables exposed

Figure 15 and 16 disposed electric cables

Leaving electric cables on the roof without protection from the atmospheric agents can cause problems for the whole building’s electrical system and can cause fire and injury to people on the roof.

6. Corrosion of pipes and chimneys

Figure 18 Corrosion stains

Corrosion is an electrochemical process. In one part of the process metal ions and electrons are released, in another part the electron are consumed. Water functions as an electrolyte in the corrosion process. Corrosion leads to the formation of cracks in the steel and this may cause infiltration of water in the roof and the damage of the eaves.

7. Damages in the insulating layer

In some areas of the ceiling, the insulating materials appears damaged and falling down through the beams. This may be due to the old age of the insulating material or to the presence of water in the layer, which compromises its strength and tightness. Damages in the insulation layer cause thermal bridges and waste of energy.

There will be heat escaping the building and the heating systems need to make up for this.

However, care should be taken to ensure that there is adequate ventilation in the roof space to counteract
the probable effects of condensation. It is very necessary in roof spaces to keep the metal fixings from becoming damp and the moisture content of the timbers at a low level. Condensation is normally due to the lack of ventilation when the insulation material is packed tightly into the eaves at plate level.

**BASIC RENOVATION:**

The most basic renovation you can do is cleaning the roof. For example removing the plants that are growing on it and clean the gutters and drainpipes so that the water can easily flow away. On some place the gutters are really loose. On those spots one needs to replace the gutters. The bitumen layer is in such a bad shape that there are a lot of cracks and gaps in it. These should at least be closed that there won’t be any water flowing in towards the isolation layer. The lowest part of the ceiling is made from gypsum fiber plates. A lot of those plates have molt stain or damp patches on them as you can see in the figures 8, 9 and 10. These gypsum fiber plates should be replaced as well.

**INTERMEDIATE RENOVATION:**

To reach completely new quality and improve safety of the whole building under described roof, present bituminous felt should be replaced by tested and reliable waterproofing system dedicated for flat roofs. Our suggestion of intermediate renovation is:

- Application of new external waterproofing surface without insulation replacement by removing present finishing layer and substituting it with green roof layers show on Fig.20
- Assembly of new gutters and chimneys in the places where the old and corroded are located
- Hiding and fastening electric cables which are apparently freely moving on the roof surface
- Partial replacement of internal tiles (only these which are affected by moist)
- Installation of vapor barrier to protect roof elements from the moist coming from the pool

Flat roofs are challenging in matter of waterproofing and its resistance on external and physical factors. Typical bituminous felt is sensitive on external damages, especially when the surface of the roof is very hot during the summer. Even stepping on bituminous membrane once its temperature is very high may cause damages and weaken water resistance of whole system.

As an alternative to present external surface - the green roof may be introduced. Thanks to vegetation, the problem with high temperature on underlying waterproof components could be minimized (dimension changing, air blisters). Another advantage is higher resistance on physical impact as well as elimination of UV degradation. It also reduces costs of heating in the winter.

Since the water vapor in this case contains chlorine which may cause corrosion of the roof elements, vapor barrier should be installed after the first internal finishing layer.
DE LUXE RENOVATION

For the high performance renovation is necessary a complete remake of the outer layer of the roof and the ceiling, paying attention to not compromise the concrete supporting structure of the roof. The deluxe renovation develops on four main directions:

- Remove the entire bituminous felt and replace it with a new one, paying attention to use materials with a low environmental impact that can be recycled in the future.
- Increase the pitch of the roof in order to prevent leaks caused by poor drainage.
- Improve the insulating layer and install a new vapour barrier to prevent the diffusion of the moisture through the roof.
- Change the wooden clagging of the ceiling with a damp proof material and replace the gypsum fibre plates with new others more eco-friendly.

For a complete high performance renovation, the first thing to do is remove all the old bituminous layers and all the gutters and drainpipes. The bituminous felt can be recycled into a resource for new roofing felts. This resource can be used to actually produce new roofing felts by mixing it with a virgin bitumen and using this mix in the regular production process. This choice will reduce the environmental impact of the new bituminous layer and increase the environmental sustainability of the building.

Once this operation will be completed, the pitch of the roof will be increased with the installation of rigid foam panels with various tapers and thicknesses.

This solution permits to increase the slope of the roof, facilitating the drainage of rainwater and preventing flooding, and at the same time improve the insulating layer, reducing heat loss.

In the picture below, the reader can see an example of how the new roof will appear and he can understand the double utility of the added fibre insulation: it allows to increase the roof pitch and to improve the thermal isolation of the building.

Furthermore, tubes can be inserted in the extra insulating layer for the passage of electrical cables, solving in this way the problem of the exposed electric cables seeing during the swimming pool inspection.

With this system is also possible to build a better-ventilated roof, as the picture shows. The installation of a ventilated roof allows, above all, an increase in the energy performance of the building. During the winter months, ventilated roof prevents condensation of moisture, guaranteeing a greater degree of energy conservation and durability of the entire roof. In the summer months, instead, the ventilated roof facilitates the airflow, which contributes to avoid an excess of overheating of material and environments. The ventilated roof greatly reduces over-heating in the roof and it ensures greater durability of the insulati

*Figure 21: insulation system*
After completing the installation of the extra inner layer the following step will be the installation of a new bituminous felt over the top of the roof, paying particular attention to the laying of the membrane near vertical walls and chimneys.

![Diagram of bituminous felt installation](image1)

**Figure 22 – how to install the bituminous membrane properly near chimneys and vertical walls.**

In most of buildings, chimneys and vertical walls are the spots where the roofing can be easily damaged, so the figure 20 describes the correct way of installing the bituminous membrane. A correct installation will prevent the entry of microorganisms in the roof and the infiltration of water.

For the bituminous layer, in order to increase the environmental sustainability of the swimming pool, can be used Icopal Noxite Air-purifying Roofing Membrane. Noxite® is a smart sustainable construction material that reverses NOx particulate air pollution and provides a cleaner, healthier environment around the building. For commercial builders, it can also have an immediate effect on reducing the environmental impact of a building over its lifetime in a way that is socially and economically responsible and environmentally sustainable. Noxite® torch-on roofing membranes use the radiation of the sun to produce an autocatalytic reaction that turns harmful nitrous oxides into benign nitrates. The resulting depolluting effect is permanent, throughout the life of the waterproofing membrane.

![Diagram of Noxite Air-purifying Roofing Membrane](image2)

Also a vapour barrier will be installed during the renovation. In a large part of buildings in the Northern Europe where winter heating conditions predominate, vapour barrier will be placed toward the interior heated side of insulation in the assembly. A vapour barrier will prevent the diffusion of moisture from the swimming poll through the roof, avoiding the development of air blisters under the roofing.

![Diagram of vapour barrier installation](image3)

In the end, all the wooden ceiling and the gypsum fiber plates will be replaced. The new wooden ceiling will be made with wood fiber panels coupling on the back with calcium-silicate panels. The wood fiber corrects the reverberation of noises accented by water, the panel silicate protects the structure from fire.
Inspection of Entrance of Västertorp Indoor Swimming Pool Building

AF2403 Building Damages

Group 6

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1. Introduction

The background to this report is a site visit to the Indoor Swimming Pool Building of Västertorp in Stockholm, Sweden. This is a public building in south Stockholm, containing a 25-meters long swimming pool, a gym, and some other training facilities. There, the entrance of the building was inspected. This inspection was mainly performed through looking around in the entrance, but also by talking to the receptionist of the building, and taking some photos to be further examined later.

This report focuses on the two main problem areas that we could find for the building entrance – dirt being brought in and accumulating, and the energy consumption. These problem areas are discussed in separate parts and in for every problem area some suggestions are made as to how renovation can be done. The renovation suggestions are for each problem area divided into three potential “packages of action taken”, called A, B and C, being respectively basic, intermediate and high performance renovation. Finally, there is some discussion of the two problem areas and the suggestions for renovation.
2. Dirt in entrance

2.1 About dirt in entrances

Except for being in contact with the public space and giving the building an identity, the entrance also has an important role to keep the dirt outside. 80% of the dirt that enters the building comes with the people entering the building (3M, 2015). Which means that with a well-designed building money can be saved from a lower maintenance cost. A person entering brings on average 0.58 gram of dirt, and the cost to clean up 1 kg is about 10 500 SEK. That means if we approximate that there are 150 guests a day in the swimming hall the cost of cleaning up the dirt is 328 000 SEK per year (3M, 2015).

In Swedish Working Environments Authorities’ regulations, AFS 2009:2 42 §, there are some rules regarding the design of floor: “…Floors, walls and ceilings shall be made such that they can, without problems, be cleaned to the extent required considering the function of the building… It is particularly important that the floors can easily be cleaned” (Arbetsmiljöverket, 2013).

2.2 Inventory of the building

Just outside the entrance doors, there is asphalt and the asphalted area is about 2 m or closer to the entrance does not have any slope, which can cause problems if there is heavy rain. Asphalt is also a sticky material which means that asphalt particles can be stuck under shoes and precipitated indoors. The doors also have a small threshold which stops dirt and, because of the height of the threshold is low, make it easier to clean compared to if there had been a taller threshold.

The entrance doors themselves are made of metal and have an upper part of glass. This is an optimal solution because the windows are harder to clean than the metallic material, but you still want to have the window to avoid people colliding when they are opening the doors. The windows are of course also working as an inlet of daylight. A handle made of metal also secures that dirt and marks from peoples hand do not sets on the window surface (Björk. F., 2007).

The first thing in the swimming hall entrance which primary purpose is to stop dirt is the rubber carpet which scrapes of some dirt from the guests’ shoes and is also there if the guests want to scrape off their shoes more actively than just walking over it. The carpet is permeable which means that water from the shoes can infiltrate down in the carpet. In the lock there was also a shoe brush for more coarse dirt.

The next step to take care of dirt was that they had placed out some ordinary carpets strategically to match with people’s normal walking paths. The task for these ordinary carpets is to suck up the water that guests are bringing with them on a rainy/snowy day.
2.3 Renovation proposals

2.3.1 Optimal design of an entrance
An optimal design of the entrance can be divided into three zones: the first zone is outside or just after the first door where you want the heavy dirt and rain/snow to stay. This is met by having a rough carpet or a scraper. On a rainy or snowy day there can be a lot of water so it is important that the water can be lead away, i.e. through a well. An important property of the carpet or scraper is that it is easy to clean.

The second and next zone is a carpet that both collect dirt and water. This zone can be combined with zone number one if the entrance does not have enough space for more than two separate zones.

The last zone is made to soak the rest of the water and should therefore be made of a highly absorptive material. For every zone to be efficient it is recommended that each zone is two to three steps long (Duri, 2014).

2.3.2 A – Basic renovation
Install a loose scraper just before the first doors. These scrapers will take away the heaviest dirt or snow that is stuck under the shoes. This leads to that the same dirt stays outside and the entrance does not have to take care of all the wetness from shoes.

Always have the second door closed so people will have to open it to enter. Because the door is outgoing it will mean that people will have to take an extra step backwards and therefore more dirt will be scraped off.
Risks: Since the scraper isn’t at the same level as the ground people will probably avoid stepping on it because you have to take an extra high step and you also have to stop your walking and stand there to scrape off your shoes which is probably not what you prefer to do.

When the scraper is loose they also need to be taken in every day so it does not get stolen. It will also be an obstacle for people in wheelchairs or walkers.

2.3.3 B – Intermediate renovation

Install permanent scrapers just before the first door. These scrapers are lowered down in the ground so that the scrapers’ surface is at the same level as the ground. The scraper should be water permeable and underneath there should be a well that leads all the water away to a storm water pipe.

Another proposal is to install an entrance roof. Since they only use 1 of 3 doors they could just install an entrance roof above the door that is being used. The roof helps the ground underneath stay dry so less water and dirt enters the building.

Risks: If the scraper isn’t cleaned frequently, leaves and dirt can clog the well and water will overflow.

It should be checked if the roof construction can take the additional load from that comes with installation of entrance roof. If the construction can’t take the load, the cost for installing the roof can quickly add up to be an expensive investment.

2.3.4 C – High performance renovation

Except for the renovations given in B some solution for a better entrance regarding the dirt is to change the asphalt to concrete. The asphalt is stickier than concrete which means that the asphalt will sully the shoes instead of helping to scrape the shoes which concrete can do.

When we asked the employees if it usually gets wet in the entrance they said that on a snowy or rainy day there can a lot of water on the floor and they have to bring forth their cleaning machine to soak up the water. One way to deal with this is to make the current first zone longer so you have to take 2-3 steps instead of 1-2 as it is today. This will make the zone to soak up more water.

Another way to deal with the water problem can be to install ground heat on the outside. This will heat the ground so there will be less snow and water coming in to the building.

Risks: The loads on the ground will change which means that the ground can settle if the soil and geotechnical conditions are not examined before.
3. Energy Consumption

3.1 Components ensuring the thermal insulation

Another technical function of an entrance is to maintain in the room a temperature inside the “comfort zone” (i.e. around 23°C) in spite of the energy losses due to the entrance door. To ensure this function, the swimming pool entrance has several components.

Firstly, people have to go through a lock to come into the building, not a single door. This system’s goal is to reduce the energy losses when someone opens the entrance door. Indeed, thanks to the lock the air entering the room when a person comes in or out will be warmer than the outside air.

Secondly, all windows and doors are double-glazed, which is much more efficient than single-glazed windows.

Finally, the swimming pool owners had heaters installed all along the walls, to offset the energy losses occurring through the windows.

3.2 Risks and drawbacks related to the current components

Each of the components listed before may incur several risks or not fulfill their function in an optimal way.

Regarding the lock, we noticed that the inside door is absolutely not tight, which reduces considerably the protective effect of the lock. Indeed, the outdoor air can easily reach the entrance when the main door is opened, cooling down the room in winter or warming it up in summer. There is also a risk of bringing in too much dampness when the weather is rainy, causing inconveniences such as mold or condensation inside the building.

Moreover, the windows are a critical zone for energy losses. Indeed, their frame is made of wood, a material that is exposed to decay and rot. These phenomena reduce the thermal resistance of the frame, resulting in more energy losses. Furthermore, the decay is making the wood weaker, threatening the air-sealing qualities of the building. We can already see that the window frames are not air-proof at all, as there is a lot of dust and even spider webs between the glasses. It can come from the failure of the joint or the beginning of the wood decay in some parts.

Eventually, the room is facing the east direction, which means it will get a lot of sunrays during summer, but few in winter. Therefore, it is not a good idea to put a lot of window on this side of the building, as the temperature might go too high in summer and too low in winter. There are currently 12 windows in the entrance, which is according to us far too many. Indeed, the receptionist confirmed that the room gets too hot in summer and cold in winter.
3.3 Renovation proposals

3.3.1 A - Basic renovation

A basic and not expensive type of renovation for the entrance could be the replacement of all the joints around the windows and the doors.

Indeed, we noticed that the doors are not tight enough, causing air leakage and energy losses. Replacing the current joints and adding some around the inside door will reduce these problems, and the same thing applies to the windows.

However, this solution is not durable, as the joints’ lifespan is not very long. Therefore, someone will have to regularly check them and replace them if needed. Moreover, this solution does not solve other problems in this room. For example, there is still a risk that the wooden frames of the windows will decay or expand, resulting in air leakage, dampness rising and maybe respiratory illness if the problem is not treated.

3.3.2. B - Intermediate renovation

The swimming pool owners may consider spending more money for renovations of better quality and efficiency, in addition to the previous solution.

One of them is to replace all the windows of the entrance. The wooden frames need to be replaced by PVC frames. Indeed, PVC is a material that requires less maintenance than timber, as it is not exposed to decay or insect risks. Moreover, it presents a far better thermal resistance, as wood’s weaker durability affects its performances over the time.

In addition, the number of windows will be reduced, as the room is exposed east. It will result in less heat losses in winter and a lower indoor temperature during summer.

The main risk the room would be facing is insufficient ventilation. Indeed, this renovation aims at making the room the most air-proof possible to minimize the energy losses. Therefore, there might not be enough fresh air coming in, unless the ventilation works efficiently, which was not the case when we visited the building. Indeed, we noticed that no new air was brought by the ventilation system. If nothing is done to solve that, it may result in some discomfort for the users, due to the bad quality of the indoor air.
3.3.3 C - High performance renovation

This last proposal will enable the room to optimize its energy consumption, but at the cost of higher spending.

Indeed, the insulation material inside the wall could be replaced by a high performance material such as polyurethane foam, which is currently one of the best insulation foams. Associated with the previous proposals, we may say that the energy losses would considerably drop compared to the current situation.

Moreover, the ventilation system could be improved by using a double-flow system. This system is using the exiting air to heat up the new fresh air before entering the room in winter, or cooling it down in summer. The use of a heat exchanger would decrease significantly the energy consumption.

Figure 2. Double-flow ventilation principle
4. Discussion

In this report, suggestions were made as how to improve two aspects of the entrance. These adjustments can be made independent of each other.

Renovations made to lessen the energy consumption do not affect the problems associated with dirt, and vice versa. The basic renovation suggestion for the problem of dirt needs not affect the operation of the building very much, while the more advanced options might need operation to change during the process of renovation. During this time, a provisory entrance can possibly be made, so that the building can remain in operation.

The renovations to solve the dirt problems might be done independent of renovations of the remaining part of the building. Were the high performance renovation for the energy consumption reduction to be performed, this would likely need to be coordinated with adjustments of other parts of the building’s HVAC systems made at the same time, for the HVAC system to remain in balance. For all renovation measures apply that it might be most efficient to combine them with similar renovation measures in other rooms, to gain the advantage of changing things at greater scale and possibly reduced unit cost, e. g. cost per single fixed window.
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Renovation Manual

Repairing Scheme of the Water Treatment Section

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1. Technical functions of water treatment section in the swimming facility

In the water treatment section, used water from the swimming pool is pumped, treated and later reinjected to the swimming pool. There are two main procedures; chemical treatment and mechanical treatment. In the chemical treatment process, chlorine will be added in the used water from the dosage chemicals room in order to remove most of the microorganism, i.e. Escherichia coli. Chlorine will continue to perform in the whole treatment procedure. As for the mechanical treatment, the suspended solids, human hair and scurf will be flocculated in the flocculation pool and finally stuck in the two gravity sand filters, which are indicated in the figure 1 as 7 & 8. Some of the water is used to fill the flushing tank, and the rest is stocked in the clear water tank before being used to supply the swimming pool. The water from the flushing tank is used to backwash the filters once a week in order to guarantee the designed efficiency of the sand filter* (information provided by the staff in the swimming facility). During this process the flush water goes into the sewage. This also helps to evacuate a part of the water out of the circuit, doing so some water can be discharged and replaced by fresh water from the municipality. Because in a closed circuit with the same water all the time, hygienic problems may arise.

2. Components and materials

The structures of the water treatment section are mainly built with reinforced concrete, for instance the control room for engineers, the gravity filters tanks and the different water tanks. Reinforced concrete is a material composed of concrete cast around and inside of steel reinforcements. It works well with tensile stress but is sensitive to some external factors i.e. humidity, acidity. The external factors will cause series of problems, especially the corrosion of the steel reinforcement that cause the concrete to crack. Since this is a water treatment section, pressure pipelines are installed to connect different components in the water treatment process. Most of the pipes are made of iron, some of them are made of stainless steel and some are plastic pipes. Steel pipes are sensitive to corrosion. There is an inspection and control stage between the sand filter and the flushing water reservoir which is made of iron frame. There are also a set of switch box for engineers to control the working procedure of the pumps during the treatment process.
3. Possible damages

After the visit of the swimming facility, and inventory of all possible damages which has been figured out has been made and is listed below.

3.1 Exposed steel bars in the sand filter tank. (Figures 1-2-3)

3.1.1 Description:

Acid moisture, mostly chlorine, penetrated into the concrete surface started reacting with the steel bars, during the chemical reaction, red-colored oxide iron are formed and the volume of the steel bars expended. And this is regarded as the main reason for the cracked edge of the filter tank. In a long term, the steel bars will be totally rusted and lose their structural functions. Then the tank can no longer hold tensions from the water pressure, there would be risk of failure of the filter tank which will cause serious problems in further steps. The reason why this problem occurred is insufficient thickness of coating of the reinforcement bars. If the reinforcement is not deep enough into the concrete, there is more possibility of the reinforcement being attacked by moisture. In this environment with high humidity, extra coating thickness should probably have been implemented.

Same kind of problem at the outer surface of the clear water excavation (Figures 6-11), there is also a risk of structure failure if no further measurements are made. The original painting on the surface has already been partly peeled off, as can be seen from the shape and outlook of the remaining painting. This may be caused by the overflow from the clear water excavation. Other reasons like damage during construction and improper storage of chemical doses should also be considered. Since there are not enough information for these reasons, these two will not be illustrated into details from this report.

3.1.2 Remedies and renovation

From the figure which shows the exposed reinforcement bars conclusion can be made that the concrete cover is not thick enough to protect the steel bars.

The recommended value of thickness of concrete cover in Eurocode 2 is defined as below:

\[ C_{\text{nom}} = C_{\text{min}} + \Delta C_{\text{dev}} \]

Where,
- \( C_{\text{nom}} \): Nominal cover thickness in mm;
- \( C_{\text{min}} \): Minimum cover thickness in mm;
- \( \Delta C_{\text{dev}} \): Allowance thickness in mm, recommended value 10mm.
The environment which the sand filter tank is exposed to is classified as XD according to EN206-1*, which indicates a risk of chloride-induced corrosion. And furthermore in the further specifications of main exposures in subclass, case for swimming pool is classified as XD2.

Recommendations for Cmin,dur.
The final choice of Cmin,dur can be modified from Table 4.4N in accordance with EN 10080*.
Since the information of the sand filter is not comprehensive, so the structure is preliminary defined as Class 4 (with a service life of 50 years) which requires a thickness of 40 mm. [1]

3.1.2.1 Sand filter repairing scheme

For basic level, neat epoxy mortar is recommended for small spalls by Texas department of transportation in Concrete Repair Manual. Epoxy specialized for concrete repair has very tenacious bond and performs well in thin applications [2]. Although this kind of method cannot stop the corrosions where a small amount of reinforcement bars are exposed, it provides a perfect waterproof barrier and significantly slows down the rate of corrosion if it is properly applied [2]. It is the most economical solution in a short term. If the repair work need to be performed in a deeper level, for immediate actions, regular inspections of the broken concrete cover are recommended to be carried out to prevent deterioration. Especially further attentions to cracks parallel to the arrangement of the reinforcement.

But in a long term, it is recommended that the owner of the swimming facility should excavate the concrete to investigate how the reinforcement bars are rusted and decide whether to perform rust removal actions or replace the reinforcement. And finally recast sufficient thickness of concrete to cover them. Since the swimming facility is operated by the municipality, summer break is always a good time for the repair work.

If the funding from the municipality is sufficient, then the renovation can be carried out in a high performance way. Since gravity sand filters are old fashioned, a new pressure filtration system is recommended for the final renovation. From the odor in the swimming facility, is can be judged easily that the air contains lots of chloride, which could cause corrosion problems for the metal works. The smell actually comes from tri-nitrogen chloride which is produced by the reaction between chlorine and ammonium under acidic conditions in the water. When the pH in the swimming pool is normally between 6.8 and 7.6, the surface of the biofilm formed by the bacteria will be acidic. The surface will be the place where the tri-nitrogen chloride is produced.

When tri-nitrogen chloride forms, with the help of high damp concentration in the indoor air, metal work inside the building could be corrupted under some certain conditions. Actually, the largest area in a swimming facility is neither the surface of the swimming pool nor the surface of the pipes, it is the surface of the sand. The reason for this is because one metric tons of sand has a surface area of approximately 3000 square meters, and for a standard 25 meter pool, amount to 60000 square meters [2]. In this case, huge amount of bacteria will form a biofilm and escape from chlorine.
One possible solution is from a company called DRYDEN AQUA, that a kind of filtration media called Active Filter Media (AFM) could solve this kind of problem effectively by reducing the amount of bacteria in the system then reducing the production of tri-nitrogen chloride. So applying the pressure filtration system would benefit in several aspects.

3.2 Corrosion of metal elements in the room (Figures 5-6-7-8-9-10)

3.2.1 Description

Corrosion of metal elements in the room (pipes, metal elements in structures, water pumps)

Rust is present on almost all the metal parts in the water treatment room. The pipes are usually a bit rusty and one of them is heavily rusted (see picture 5 and 6). Several water pumps are also corroded (see picture 4) as well as different metal parts of the structures (metal profile supporting the inspection gateway, screws and bars holding the pipes or the pipes from the heating system). This corrosion of the steel elements in the room is due to the damp environment rich in chlorine. Some of the elements in the room are made of stainless steel, those have not been as much attacked as the steel elements. The elements made in steel usually have paintings to protect them from corrosion, but this does not seem to behave efficiently enough. Even if the stainless steel elements have resisted much better that the other part, some small traces of corrosion could be found on them, and the bottom of the profile supporting the inspection gateway is heavily attacked. The service environment of the water treatment section of a swimming pool belongs to the highest group of corrosion hazard, in those conditions a normal stainless steel can also be corroded.

3.2.2 Remedies and renovation

Remedies for the rusting problem are of two kinds. The first one is trying to make the environment of the room less aggressive for the steel and the second one is making the steel with better antirust ability or better protected against the aggressive environment. The two main factors in the air that sustain the development of rust is humidity and chlorine. A better ventilation of the water treatment sections could help diminishing the damp and chlorine level. Also the replacement of the filtration system, currently two gravity sand filters, by a pressure filtration system could help diminishing the chlorine level in the air and so reducing rusting of steel elements in the room as mentioned in the repairing scheme of the sand filter. Anyway, as the rusting process is already far for some elements, a repair work of the rusted elements cannot be avoided.

In a basic renovation, the rust should be removed from the rusty elements and a anti corrosion painting should be applied to all of the metal elements that are not in stainless steel. The painting should be checked regularly and painting work should be carried on every now and then to prevent any rust from appearing again.
A more complete renovation would be the replacement of all the elements in metal by elements in stainless steel. Moreover the quality of the stainless steel should be high enough, indeed in this environment with high corrosion hazard even stainless steel can corrode (see source). As recommended by the German guidelines for the design and fabrication of stainless steel structures [4], the following quality of stainless steel should be used in this kind of environment: X1NiCrMoCuN 25-20-7 (1.4529), X1CrNiMoCuN 20-18-7 or X1NiCrMoCu 25-20-5 (1.4539) acc. to PN-EN 10088-1:1998 [5].

3.3 Falling insulation panel. (Figure 14)

The falling insulation panel is only partly attached to the ceiling, it could fell down into the water at any time. It does not fulfill its role as insulation panel any more as it is no longer at the right position. The reason for this could be the failure of the metal connector or the expansion of the neighbor panel due to dampness in the atmosphere. Narrow space and water in the tank will add difficulties in inspecting and fixing this problem. In this case, the reason for the dropping of the panel should be investigated when the flushing tank is empty. Then the insulation panel should be replaced or re-attached in the right position.

3.4 Damaged painting and reinforcement bars exposed in the clear water tank. (Figure 12-13)

There seems to be a painting inside of the clear water tank that could protect the concrete from the water if the painting is water proof. But probably the painting should have been renewed regularly because it is a protection mean that is not really lasting. As can be seen on the picture the painting peeled is off at certain points. Such that it did not protect the concrete from moisture and eventually lead to corrosion of the reinforcement bars.

The clear water tank should be repainted to insure the functions of the painting.
4. Appendix

4.1 Figures

Figure 1: Plan of water treatment section in the swimming facility

Figure 2: Corrosion of the embedded metal of the sand filter tanks.
Figure 3: Corrosion of the embedded metal of sand filters tank

Figure 4: Corrosion of embedded metal on the exterior surface of the clean water tank.
Figure 5: Corrosion of the heating system pipes

Figure 6: Corrosion of the steel pipe, and small stain of corrosion on the stainless steel pipe.
Figure 7: Corrosion of a steel pipe.

Figure 8: Corrosion of the feet of stainless inspection gateway
Figure 9: Corrosion of the water pumps

Figure 10: Corrosion of bolts and steel structures
Figure 11: Insulation material falling from the ceiling of the flushing tank.

Figure 12: Decaying painting and rust of metal reinforcement in the clear water tank.
Figure 13: Decaying of the paint in the clear water tank
4.2 Reference


Renovation manual for air handling system in a swimming pool building
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Renovation manual

Introduction

The aim of this report is to produce a renovation manual focusing on the air handling system for the public swimming pool building of Västertorp.

We carried out an inspection of this building on the 14th of September, and the renovation manual will be established based on this investigation.

Technical functions of the air handling system

To begin with, we will briefly describe the technical functions of the air handling system of the swimming pool.

This unit has to maintain a fixed temperature of 27-28°C inside the building and also to provide fresh air for the users. To do it, a main pipe located in one corner of the swimming pool dispatches the fresh, preheated air by the air handling system. Afterwards, the dampness and the exhaust air have to be evacuated from the building with the help of some ventilation nozzles.
In the same time, undesirable odor is removed and the CO$_2$ level is controlled which assures good air quality.

**Inventory of the building**

The building consists of the followings:

1. Large swimming pool: 25 x 13 m
2. Small swimming pool: 13 x 6.6 m
3. Gym
4. Showers and changing rooms
5. Water treatment section
6. Air handling system:
   a. fresh air handling systems;
   b. exhaust air system;
   - both consisting of air filters, air dampers, pumps, humidity sensors and frost protection sensor.

Define the problems

- **Air- and water temperature control**
  
  In order to reduce evaporation from the pool, the temperature of the air should be 2°C above water temperature. During the inspection, we noticed that this condition was not fulfilled.

- **Air-flow control**
  
  Improper placement of the air intake and outlets. Although

- **Humidity control**
  
  No device indicating the humidity of the air but fungi could be noticed on the ceiling, which indicates a problem of dampness.

- **Control of air contamination with chlorine:**
  
  No chlorine smell was noticed during inspection

Inventory of possible damages

- **on health:** exaggeratedly high moisture level harbors fungus, molds and dust mites which has several negative effects on people, ex.: headache, nausea, nasal- and chest congestion, eye problems, fatigue, dry skin etc.

- **on building:** unpleasant sight of mold on the ceiling, rusty steel elements

Figure 5 Ceiling
Further analysis

- **Mechanism of the damages**
  
  The problems start with the improper placement of the air intake and outlets. This causes bad air circulation; probably it doesn’t even circulate in the whole building. The humid air is the result of the evaporation of the water from the swimming pool. We know that moist air is lighter than dry air, which makes this layer of air to rise until the ceiling. There the damp air gets in the structure of the soft material of the ceiling causing mold. The closeness of the windows affect the ceiling as well, heating up the water on its surface, providing an even more habitable life for fungi to spread.

- **Remedy**
  
  We cannot do any remediation until we don’t know for sure the source and location of the problem. Even after some kind of remedy was done, if the right source of the moisture is not found, mold will appear anyway later. The goals of remediation are to remove or clean the contaminated materials, preventing fungi from entering the occupied area again and preventing it from reappearance. Most of the times the main provocative of the mold in buildings is the air handling unit. Even if the system is new, it is obligatory to make periodical inspections to assure its proper functionality. Thus the most important step to be taken in cleaning a building from mold is to clean the HVAC system. This involves several other steps like turning the HVAC system off. Then, while wearing protecting suit replace filters and any wet insulation, use wet vacuums to clean out any standing water and use disinfectant to clean non porous surfaces like ducts, coils and pans of mold and mildew.

  Since we don’t have a vast knowledge in fixing air handling units we try to come up with other ideas which can be taken into consideration to fix the problems caused by the improper function of the ventilation system. In the coming paragraph a set of remedies are presented based on the three renovation levels, which differ from each other mostly based on the amount of money used to do the renovation.

  ➢ **Basic:**
    - Changing the filters
    - Clean the mold from the surfaces and repaint them
    - Open windows for a better air circulation
  ➢ **Intermediate:**
    - Remove the fans from the ceiling. The fans may distribute the moisture in the air even better so they increase the risk of mold appearance on the whole ceiling which we could observe
    - Instead of the fans, install air extractors directly on the ceiling thus the moist air can leave the building the easiest way. This way the appearance of mold, fungi can be prevented even more because, by having an air extractor and not an air circulator the moisture is not diffused in the whole building but evacuated as soon as possible.
High performance:

- Currently the air intake and the outlet are functioning on the same wall, which is not effective enough in serving its purpose which is to change and/or circulate the air continuously. By separating them from the same wall and installing the air outlet on the opposite wall from where the intake is put, the air can circulate before it is extracted from the building.

- A more advanced solution would be to install ventilation pipes around the building, under the windows. This could help to prevent the appearance of condensation on the windows by extracting the moist air evaporating from the pool before it would get in contact with the windows.
References:

- Mold growth, assessment, and remediation
  https://en.wikipedia.org/wiki/Mold_growth,_assessment,_and_remediation#Remediation

- Mold: A common HVAC complaint that is easy to deal with

- Lecture notes
- Pictures from the swimming pool visit
Renovation Manual - Västertorpshallen

A building renovation manual of Västertorpshallens changing rooms

Group: Group number 8
Members: Erik Wetterbrandt
         Lorenzo Zaccaro
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Presentation

Västertorpshallen is a facility located south of Stockholm in Hägersten. Construction started in 1968 and the building was finished in 1971. The drawings however are from the 1950’s. Every year the facility has around 200 000 visitors (Reference 2). Some parts of the facility is in great need of renovation due to poor maintenance and high number of visitors.

The facility have a sports hall, coffee shop and a swimming hall. The sports hall have three different areas for activity: a big hall, small hall and an endurance exercise room. They offers all kinds of activities such as basketball, table tennis, football, handball, disabled sports, floorball and school sports. The Swimming hall has one swimming pool with a length of 25 meters, a coffee shop, diving tower, sauna and a gym.

Facts

Address: Personnevägen 90
129 49 Hägersten
Sweden
Building year: 1968-1971
Owners: Stockholms Stad
Number of visitors: ~ 200 000 visitors / year

Assignment

The assignment is to analyze and describe the technical functions of the building parts in the dressing rooms, showers, toilets and saunas. Furthermore we are to describe the components that give these functions and the material of the components. When that is done we then have to describe indications and mechanisms for some typical damage to the construction. Lastly we are to suggest remedies for these damages and propose three different levels of renovation: basic, intermediate and high performance.

Working progress

First of all, on monday the 14 of september 2015, a study visit was made at the swimming facility with the purpose of documenting and making an inventory list of the building\(^1\). With the drawings, notes and pictures of the building as it looks today at hand, we can make a first analysis of the data. When we have evaluated the building parts technical design and material, we then propose 3 types of remedies to the different construction parts and finally come to a conclusion of what needs to be done.

\(^1\) Note that because this is a school project and the activities in the swimming hall have to be open for business during the whole study visit, we couldn’t inspect the women's dressing rooms. For that reason, this article will only refer to the inspections of the men's dressing rooms.
Inventory

As we mentioned in the presentation, a study visit was made at the swimming hall on the 14 of september 2015. We took 53 pictures of different construction parts, lifted the ceiling tiles to see the construction above and inspected the joints were different materials met. All in all, we inspected the sauna, toilet, showers and dressing rooms. The inspection lasted about an hour.

Changing rooms

Technical functions of the building part

This part of the building must be designed to assure the comfort of the customers, including the air quality, the cleaning, the absence of moisture or dampness that could increase the risk of asthmatic and allergic symptoms, not to mention the risk of slipping and hurting yourself.

Components that gives these functions

The ventilation system should be designed to decrease the moisture production by carrying away the high moisture content air from the changing rooms. On the floor the pvc carpets main functions is to keep the floor clean and and stable (not slippery) and, mabie most important for the construction, keep it waterproof. The false ceiling is designed to dampen the volume and cover up the installations so that staying in the dressing rooms is as comfortable as possible.

Materials in the components

PVC, ceramic, false ceiling

Observed damages

The damages we can observe in the dressing rooms largely consist of wear and tear of the building. For more information, please look at appendix 2 and the inventory Excel spreadsheet.

Showers

Technical functions of the building part

The showers should be constructed with hygienic and easy to clean materials. The floor must not be slick. Water must not stagnate. The steam/moisture must be removed in order
to maintain a good humidity level. The water supply system must provide hot and cold water without too great heat losses.

Components that gives these functions

The floors and walls has ceramic tiles with hygienic, waterproof and non slippery properties. The floor is designed with a slight slope so that the drainage system is assure to remove the water coming from the showers. The ventilation system is designed to control the humidity level of the showers. Finally the false ceiling should be designed to prevent moisture of passing through into the construction.

Materials in the components

Ceramic, mineral wool

Observed damages

We refer to the Excel spreadsheet in appendix 2 for a complete description of the observed damages.

Saunas

The sauna is divided into two rooms. The first one you enter is on the drawings called eftersvettnings which, if you translate it directly from swedish, means “after sweating”. The room has a higher temperature (~40°C) than normal indoor temperature (20-23°C) and its function is to act as a relaxation area before and after you enter the sauna. The sauna itself is a so called dry sauna and has a temperature around 80-100°C. Dry sauna means that it doesn’t have any added steam (more than if you pour a scoop of water on the heating unit) unlike a steam sauna (steam room?) where the steam is heated to the desired temperature (Reference 3).

Technical functions of the building part

The sauna should uppermost be designed to retain heat to make sure the energy consumption doesn’t gets too high. Of course it’s also important that the visitors have a comfortable stay in the sauna.

Components that gives these functions

The after sweating room is dressed with wood planks on the walls and ceiling. It has wooden benches along its walls and the floor is covered with small tiles. The sauna itself has tile floor and walls with wooden panels only in the ceiling. In one of the corners of the sauna they have placed the heating unit and around it covered the walls with bricks rather than tiles or wood.
Materials in the components

For starters: because we don’t have access to the detailed drawings showing the cross section of the walls, floors and ceilings of the building, we don’t know for sure how these surfaces are structured. From what we can tell the building framework mostly consists of lightweight concrete whereupon the different surface layers has been cast/built. How good this construction is at retaining heat, we have no information.

Observed damages

The sauna has more or less the same damages to its tile surfaces as the shower. The seals are loose and damaged and some of the tiles are cracked. However, these damages may have appeared for slightly different reasons in the sauna than in the showers. Because of the big temperature differences in the sauna (the sauna is for instance most likely turned off at night to save energy, whereby the temperature plummets from ~100°C to ~20°C) the mortar/seals have to endure great stresses and strains to keep the tiles in place.

If we instead look at the wood panels, they too have to endure great expansions and contractions because of the temperature difference. Because of this we can see big cracks in many parts of the wooden panel.

The points where the different materials meet (for example seals between the door frame and the tile walls or the brick wall near the heating unit and the surrounding tiles) the seals have to be designed to stick to both the tiles and the wood/brick. Because wood, brick and tile all contract and expand at different rates with the temperature difference, the seals around the frame have completely loosen from the wood and the brick.

For a more detailed description of the damages please look at appendix 2.

Toilets

Technical functions of the building part

The toilets should be constructed with hygienic and easy to clean materials. Particular attention must be given to maintain the environment dry. If not, germs and bacteria have a higher risk of growing in the wet environment. It’s important that the piping system that provide hot and cold water do this without no risk of leakage. All couplings need to be visible.

Components that gives these functions

The ceramic tiles needs to have hygienic properties. The drainage system must be effective at removing the water on the floor. The ventilation system must be able to control the humidity level.
Materials in the components
Ceramic

Observed damages
For our observed damages, please look at the Excel spreadsheet in appendix 2.

Observed damages - summary
Indication and mechanism of a typical damage

Rot and condensation
Mould will appear when RH is above 75%. There is a risk of rot when the moisture ratio is below 20%. Although, the risk is small. The ideal level for fungi is somewhere around 25 to 30% moisture ratio with optimal temperature is around 21-32°C (These humidity and temperature conditions are typical of a swimming pool, therefore the risk of rot is high).

Causes
Moisture which condenses on internal surfaces is derived from the internal air and is generally produced by the occupant's activities (especially in a wet environment like the swimming pool). Condensation will occur when the warm air is cooled to a temperature known as its 'dew-point' temperature, either by being brought into contact with the cold surfaces of the structure (as could happen on the windows) or by passage into a cooler part of the building (that is the case of the gap between the ceiling and the false ceiling). Condensation will also occur on absorbent surfaces, but will not always show until the surface is very damp. In such cases mould growth will appear consisting of green or black patches which will cause deterioration of decorative finishings.

Diagnosis
The gypsum plaster being denser and colder doesn’t have the power to absorb moisture. However, this problem has largely been overcome by the introduction of vapour check thermal boards and lightweight retarded hemihydrate plasters. ‘Cold bridges’ formed by cavity wall ties can produce small discoloured patches of mould on wall plaster. Openings in cavity walls sealed with slates in cement mortar can also cause a similar condition on the wall plaster. Metal windows have a high thermal conductivity which can cause similar conditions when built direct to brick openings that provide a cold bridge between the exterior and interior. A considerable amount of double glazing has been carried out during the past twenty-five years which no doubt reduces the risk of condensation. Natural ventilation is the cheapest form of remedial work and is nearly always beneficial in reducing condensation.
Conclusion

From what we have observed at Västertorps swimming pool facility, the building is in grave need of restoration. Many of the surface layers we’ve been looking at are supposed to be watertight to ensure that no damage will come to the construction. Today, that’s not the case. Some damages are small and others are bigger. However, the main thing is that the facility needs restoration immediately. In the end it’s (as always) a matter of cost. Hopefully our suggestions can be of some use for the upcoming work at hand.

References

1. [http://www.stockholm.se/-/Serviceenhetsdetaljer/?enhet=7a72c4082ec04c82b6c4fa3b51ffe41c&acceptcookies=true](http://www.stockholm.se/-/Serviceenhetsdetaljer/?enhet=7a72c4082ec04c82b6c4fa3b51ffe41c&acceptcookies=true)
Appendix

Drawings

Inventory excel spreadsheet
När den har ritningen skannades så var skärmönster har ovan 10 cm.
Ritningen är skannad i 400 dpi.
The red writings are insecure (sometimes are just hypotheses about some problems that could occur)

The three levels of renovations have been assigned depending on the gravity of the problem and how much money the intervention requires to be done

**PVC**

<table>
<thead>
<tr>
<th>NOTES</th>
<th>DAMAGES</th>
<th>CAUSES</th>
<th>RENOVATIONS</th>
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<tbody>
<tr>
<td><strong>IT'S OK FOR</strong></td>
<td><strong>POSSIBLE DAMAGES</strong></td>
<td><strong>IF THE PVC IS LAYED ON A CEMENT AND SAND SCREED IT MUST BE BONDED TO IT</strong></td>
<td><strong>BASIC</strong></td>
</tr>
<tr>
<td><strong>GREATERT MOISTURE STABILITY</strong></td>
<td><strong>CRACKING AND LIFTING</strong></td>
<td><strong>THE COVED SKIRTING IS WELL DESIGNED. THE ONLY MISSING THING IS THE CAPPING STRIP WHICH IS IMPORTANT TO AVOID THE WATER INFILTRATING THE WALL (SEE IMAGE)</strong></td>
<td><strong>INTERMEDIATE</strong></td>
</tr>
<tr>
<td><strong>A DAMP-PROOF MEMBRANE IS ESSENTIAL</strong></td>
<td><strong>PVC WILL LIFT AT THE EDGES</strong></td>
<td><strong>THE Coved skirting is well designed. The only missing thing is the capping strip which is important to avoid the water infiltrating the wall (see image)</strong></td>
<td><strong>DE LUXE</strong></td>
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**FALSE CEILING**

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<tr>
<th>NOTES</th>
<th>DAMAGES</th>
<th>CAUSES</th>
<th>RENOVATIONS</th>
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<tbody>
<tr>
<td><strong>SEE “ROT AND CONDENSATION” IN SEC. OBSERVE DAMAGES</strong></td>
<td><strong>SPOTS OR MOISTURE, ROT IN THE WOODEN CEILING</strong></td>
<td><strong>HIGHER MOISTURE CONTENT</strong></td>
<td><strong>BASIC</strong></td>
</tr>
<tr>
<td><strong>HIGH CONCENTRATION OF BACTERIA IN A WET ENVIRONMENT, INSUFFICIENT VENTILATION. DAMP CAN PASS THROUGH THE FALSE CEILING</strong></td>
<td><strong>LACK OF ADHESION OF MORTAR TO TILES</strong></td>
<td><strong>IMPROVE VENTILATION BETWEEN FALSE CEILING AND CEILING (IMPROVE THE CURRENT VENTILATION SYSTEM OR CHANGE TO NATURAL VENTILATION)</strong></td>
<td><strong>INTERMEDIATE</strong></td>
</tr>
<tr>
<td><strong>DIFFERENTIAL MOVEMENT BETWEEN THE SCREED AND THE TILES, CLAY AND CONCRETE HAVE DIFFERENT COEFFICIENTS OF THERMAL EXPANSION WHICH CAUSES DIFFERENT MOVEMENTS WITH TEMPERATURE CHANGES</strong></td>
<td><strong>FAILURE TO PROPERLY ADJUST THE SUCTION OF THE TILES BEFORE APPLYING THE MORTAR. WALL TILES HAVE A VERY HIGH SUCTION WHICH IS REDUCED BY WETTING, BUT IF THE TILES ARE SATURATED, THIS WILL AGAIN RESULT IN LACK OF ADHESION</strong></td>
<td><strong>CHANGE THE VENTILATION SYSTEM AND REPLACE THE FALSE CEILING WITH A FIXED CEILING MADE OF A WATERPROOF GYPSUM LAYER</strong></td>
<td><strong>DE LUXE</strong></td>
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</table>

**CLAY TILES**

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<tr>
<th>NOTES</th>
<th>DAMAGES</th>
<th>CAUSES</th>
<th>RENOVATIONS</th>
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<tbody>
<tr>
<td><strong>ALL THESE FINISHES ARE USUALLY APPLIED TO CEMENT AND SAND SCREENS</strong></td>
<td><strong>LACK OF ADHESION OF MORTAR TO TILES</strong></td>
<td><strong>NEW MASTIC ADHESIVES PROVIDE A MORE RESILIENT BEDDING AND OBLITERATE ALL THESE SHRINKAGE PROBLEMS</strong></td>
<td><strong>BASIC</strong></td>
</tr>
<tr>
<td><strong>MOISTURE PENETRATION PASSING THROUGH THE SCREED. THE MOISTURE CONTAINS ALKALIS DERIVED FROM THE CONCRETE SCREED</strong></td>
<td><strong>DIFFERENTIAL MOVEMENT BETWEEN THE SCREED AND THE TILES, CLAY AND CONCRETE HAVE DIFFERENT COEFFICIENTS OF THERMAL EXPANSION WHICH CAUSES DIFFERENT MOVEMENTS WITH TEMPERATURE CHANGES</strong></td>
<td><strong>INSTALLATION OF A WATERPROOF LAYER BETWEEN THE CEILING AND THE BACKING MATERIAL</strong></td>
<td><strong>INTERMEDIATE</strong></td>
</tr>
<tr>
<td><strong>FAILURE TO PROPERLY ADJUST THE SUCTION OF THE TILES BEFORE APPLYING THE MORTAR. WALL TILES HAVE A VERY HIGH SUCTION WHICH IS REDUCED BY WETTING, BUT IF THE TILES ARE SATURATED, THIS WILL AGAIN RESULT IN LACK OF ADHESION</strong></td>
<td><strong>THE USE OF UNSUITABLE SANDS IN THE RENDERING OF THE INNER WALL SURFACE TENDS TO INCREASE DRYING SHRINKAGE</strong></td>
<td><strong>INSTALLATION OF A WINDING JOINT AROUND THE PERIMETER OF THE TILES</strong></td>
<td><strong>DE LUXE</strong></td>
</tr>
<tr>
<td><strong>FAILURE OF ADHESION IN OLD WALL TILING OR OPACITY GLASS IS ALSO CAUSED BY THE HIGH TEMPERATURE FROM HEATING SYSTEMS CAUSING SHRINKAGE BETWEEN BEDDING MORTAR AND THE BACKING MATERIAL</strong></td>
<td><strong>FAILURE OF ADHESION IN OLD WALL TILING OR OPACITY GLASS IS ALSO CAUSED BY THE HIGH TEMPERATURE FROM HEATING SYSTEMS CAUSING SHRINKAGE BETWEEN BEDDING MORTAR AND THE BACKING MATERIAL</strong></td>
<td><strong>INSTALLATION OF A WATERPROOF LAYER BETWEEN THE CEILING AND THE BACKING MATERIAL</strong></td>
<td><strong>DE LUXE</strong></td>
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<tr>
<td><strong>FAILURE CAN ALSO OCCUR WHEN TILING IS APPLIED TO BRICK WALLS SUBJECT TO MOISTURE PENETRATION. PENETRATING WATER CARRYING SULPHATE SALTS IN SOLUTION TO THE CEMENT MORTAR BACKING SULPHATE SALTS IN SOLUTION TO THE CEMENT MORTAR BACKING</strong></td>
<td><strong>THE PRESENT WALL OF THE TOILET HAS THIS STRATIGRAPHY: CONCRETE BRICK - GLU - CERAMICS TILES. IT WOULD BE BETTER TO HAVE A WATERPROOF LAYER MADE AS SHOWN IN THE FIGURE</strong></td>
<td><strong>INSTALLATION OF A WINDING JOINT AROUND THE PERIMETER OF THE TILES</strong></td>
<td><strong>DE LUXE</strong></td>
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<tr>
<td>PLASTERWALL</td>
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<tr>
<td><strong>NOTES</strong></td>
<td><strong>DAMAGES</strong></td>
<td><strong>CAUSES</strong></td>
<td><strong>RENOVATIONS</strong></td>
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<tr>
<td></td>
<td>Fine hair cracks</td>
<td>Use of loamy sand if the work is in gypsum plaster or excess lime in the finishing coat</td>
<td>Paint it again (it is just a temporary solution; it requires continuous maintenance)</td>
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<tr>
<th>DOORS</th>
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<td><strong>NOTES</strong></td>
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<tr>
<td>Not just for the doors, but for every kind of wooden sheets, found in the toilets and in the sauna</td>
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<th>WINDOW</th>
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