

REFLECTION PAPER

Frédérique Sanders . TU Delft . AE Studio 2016

PV as art:

integration of roof-mounted solar energy and daylight systems

RELATIONSHIP RESEARCH AND DESIGN

The Architectural Engineering studio is divided into two periods: the research and the design. In real these two focus points are not consecutively but are intertwined in an iterative process. By designing solutions based on research for a problem, new problems occur. The long graduation time period of one full year, makes that this iterative process can be based on more depth research.

The scheme below (ill. 1) gives a general overview of the topics I researched in order to answer my overall design question: “*In which aesthetic and eco-efficient way, solar energy and daylight can be integrated in a roof-mounted system, using an existing building on the Marineterrein in Amsterdam as a test subject?*”. As seen in the scheme I divided my thematic research questions in two themes: daylight and solar energy. By this clear division, I could do deep research separately into both topics, without intertwining them already. This intertwining of the daylight and solar energy topics came along in my Research Paper.

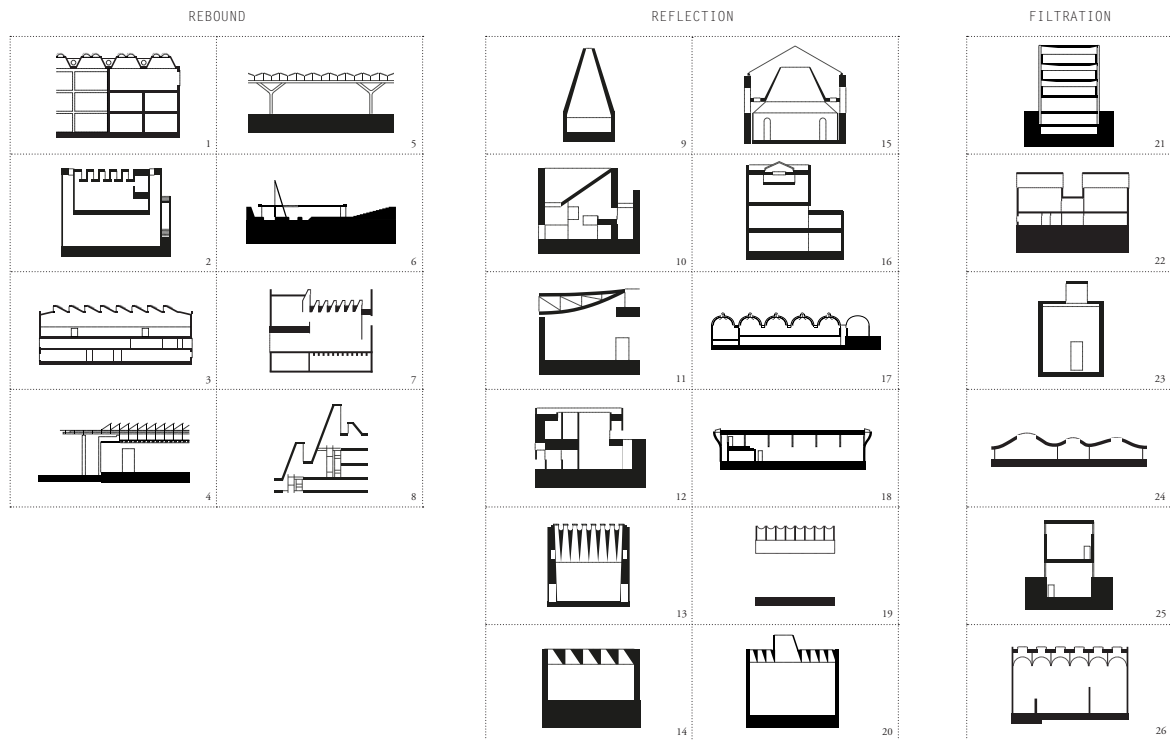
111. 1



An important section of the Research Paper is the roof daylight database. This database - explaining 26 different roof daylight systems all around the world (*ill. 2*) - indicated for me three important design recommendations. Firstly the database shows that the difference in reflective surfaces has more influence on the light intensity in a building, than the difference in type of sunshading system (rebound, reflection or filtration). Secondly it says that reflective walls have more effect on the light intensity than a reflective floor. This suggests to me as the designer: keep the walls as light in color as possible and use the floor surface for deep colors or character-giving patterns. As last the database shows that to create an interesting interior with a pleasant light intensity, the sunshading system has to be composed of several different integrated layers. These recommendations based on research helped me in the design process for the Heros daylight-school on the Marineterrein in Amsterdam.

Besides this design guidance, the database shows that only two of the 26 projects combine sunshading with solar energy. These two projects (*number 3 and 5 in ill. 2*) are representative for the currently only two existing types. In the first type the solar cells are facing towards the South (positioned at an angle of 36°) and the vertical glass faces the North; the second type is indicated by solar cells which are facing East and West and placed parallel to the glass. The disadvantage of these systems is that the amount of produced energy is not constant and in the second type also clear shadows of the solar cells will appear. The conclusion of this research is that a solution can be found in designing a new roof system that even allows comfortable, diffuse daylight as prevents a high energy peak at noon. For this innovation a tracking system is an essential part. My objective is that the integration of this tracking system improves both the solar energy production (more constant) as the indoor daylight qualities (reflecting direct sunlight).

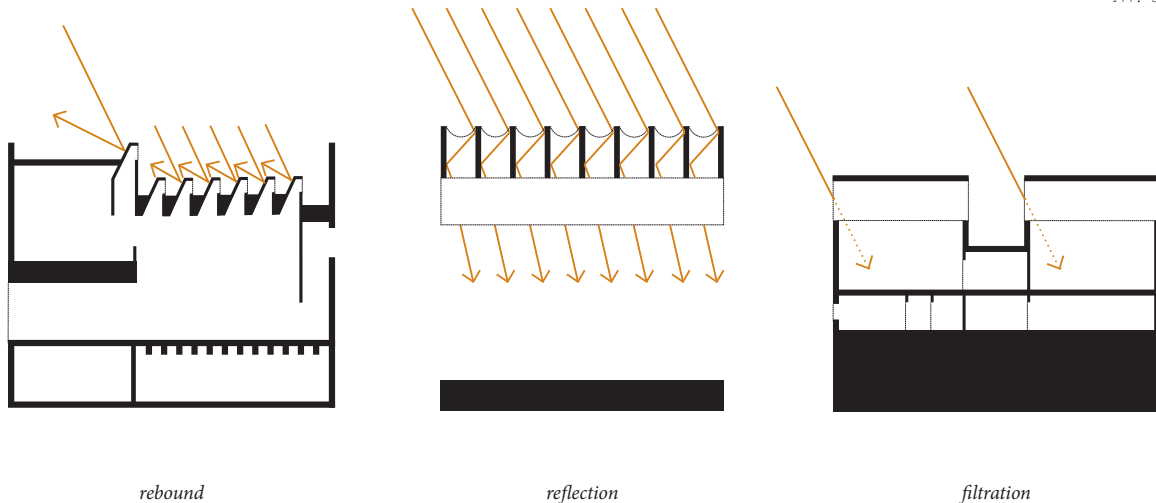
111. 2



The function of the 26 roof daylight systems is to transform beam/direct radiation (B) in diffuse radiation (D). I arranged the different projects in three groups (*ill. 3*): *rebound* (direct light not admitted / openings towards the North), *reflection* (direct light bounced back and forth) and *filtration* (direct light transmitted through different material layers). This division was done to make a classification of the different projects in the database; the purpose was on base of the research. But while transforming building #039 on the Marineterrein into the Heros school, the same classification was an useful tool to explore the daylight concept. The rotating solar/daylight roof system in my design represents the ‘rebound-effect’ to get only diffuse radiation in the building while the beam radiation will be focused on the solar cells (constant solar energy production). The milk-glass façade of the added elevation is based on the filtration of direct light. In this way the knowledge from the research to the different daylight concepts in the database, helped me to form the daylight concept of the Heros school.

To close the circle, I applied the same research method I did for the database, on my own design. For this I used a section model. This model shows the building design cut out into 36 sections. Every section is engraved with a code based on the rebound, reflection and filtration principle. In this way the model can give the daylight-type information for every part of the building. In conclusion one could state that the research and design helped each other in an iterative process to shape the daylight concept for the Heros school.

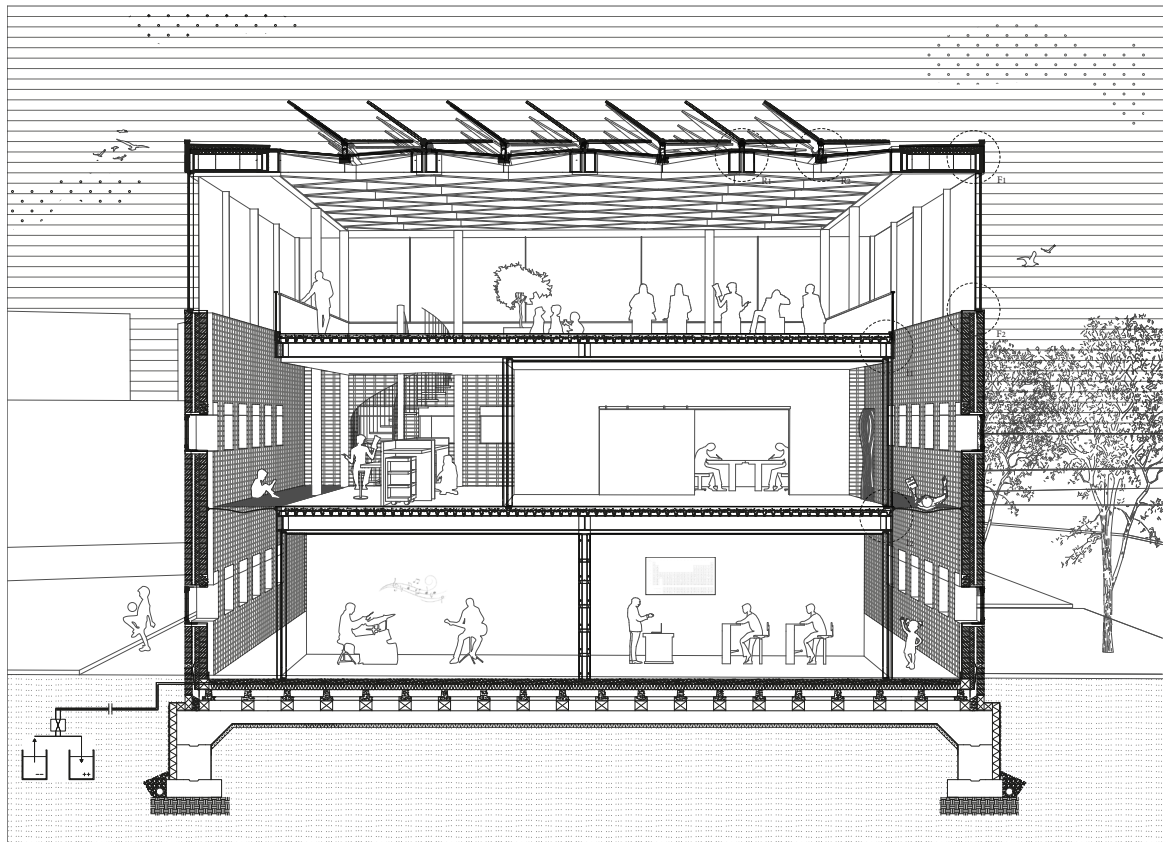
III. 3



RELATIONSHIP GRADUATION LAB AND SUBJECT

During my time at the TU Delft I was given the opportunity to study abroad; one time in la bella Venezia and another time in London. I discovered that there are several different ways of approaching the architectural field and that there exists a gap between the more aesthetic and narrative approach of architecture and the technical method. This 'grey area' where architecture and engineering come together interests me a lot. I believe that the level of integration of those two can determine the quality and sustainability of a design. For that reason I chose the Architectural Engineering Studio where a lot of attention is paid to the integration of architecture/aesthetics and engineering/technics. The tutors helped me to explore this level of integration. The biggest challenge in this project was for me to make the rotating solar/daylight roof system (*ill. 4*) as an integrated oneness, instead of an assembly of different layers.

111. 4



RELATIONSHIP WITH THE METHODOICAL LINE OF APPROACH OF THE GRADUATION LAB

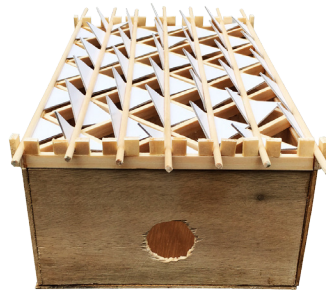
The methodical line of approach of the graduation track starts with proposing a thematic fascination, whereafter a tutor experienced in this topic will be connected to you. In my case the fascination was based on the hypocrisy of the sustainable arguments which are used for placing solar panels on roofs all over the world. In my opinion the increasing number of solar panels on itself is of course a good development; but from an aesthetic and eco-efficient point of view it can be done much better. The many time that was given to us to focus only on research, gave me the opportunity to explore a lot and go deeper before starting with the design process.

An example of this explore tour is shown in *illustration 5*: three viewing boxes for comparing the daylight effect of different roof systems on the interior space. In a playful and effective manner I could see what the advantages or disadvantages of the different conceptual tracking systems were. An other example can be seen on the next page in *illustration 6*. This is the section model where the building design is cut out into 36 sections as described before. In addition to the more analytical function of the model - each section is engraved with a code based on the rebound, reflection and filtration principle - the model can shape the visitor experience on a white wall by using the generated shadows. It shows that the visitor of the Heros daylight-school experiences a constantly changing architecture that has the ability to alter our understanding of space and place, as well as calling attention to the enduring relationship between architecture and the environment. This kind of experiments I enjoyed very much and were possible because the methodical line of the studio is very free and in that way it stimulated to me to walk my own exploring path.

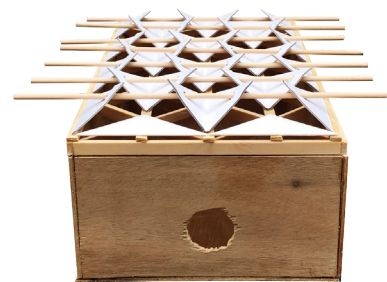
111. 5



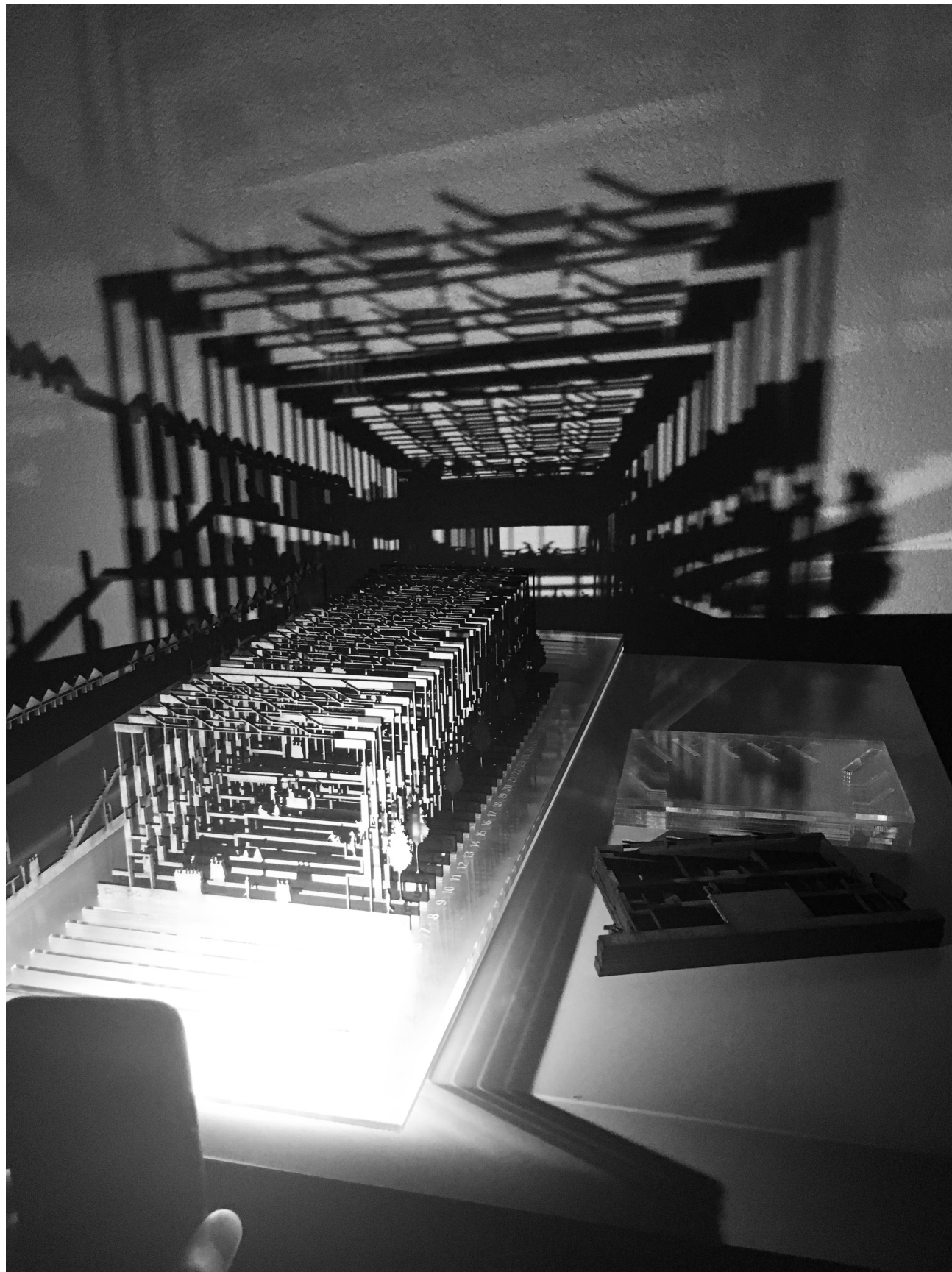
SUNFLOWER MOTION
horizontal grid



SUNFLOWER MOTION
diagonal grid



LOTUS MOTION
diagonal grid



RELATIONSHIP BETWEEN THE PROJECT AND THE WIDER SOCIAL CONTEXT

Keeping in mind the European Parliament mandate for all new buildings constructed in Europe after 2020 to be nearly carbon-neutral, it is generally expected that in this century photovoltaics will become a substantially contribution to the mainstream power production of buildings. This increasing number of solar panels mounted on roofs all over the world is a good development, but not fed by an architectural approach. The solar panels are an addition to the - by Koolhaas so-called - "*Junkspace*".

Beside somehow during the 1960s, we forgot everything we knew about the art and science of daylighting; cheap energy and air conditioning did us in (*Evans, 1981*). Recent research has proved that daylight provides an array of health and comfort benefits that make it essential for buildings' occupants. By origin humans have a natural attraction and need for daylight, but the reality is that we spend 90% of our time indoors. The light that is important to our circadian rhythm (our 24-hour daily rhythm) is different from the light that is important to our visual system. In that way the variation in the light spectrum of natural daylight is unmatched by any constructed light source. Using daylight is beside these human benefits, also an important parameter of an energy-efficient design. It does not only replace electric light during daytime - reducing the electric energy use with 50-60% -, it also influences both the heating and cooling loads (*Galasiu, 2007*).

The use of roof windows and skylights deliver significantly more light and a larger variation of light levels than vertical and dormer windows. The best formation of these roof windows is to avoid direct light and allow diffuse light which is comfortable due the fact that the solar intensity is consistent and less clear shadows appear. A daylight system ensures that the beam/direct radiation (B) will be reflected and that the diffuse radiation (D) will be transmitted to the inside. In this way a daylight system avoids the disadvantages of roof daylight, like overheating in the summer and sun glare. The interesting thing is, that in contrast to this, solar panels require the direct light.

In this way, a golden combination is found. It is important that there will be innovation towards a roof-mounted sunshading system which not combines, but integrates daylight and solar energy. A system that even allows comfortable, diffuse daylight as prevents a high energy peak at noon. For this innovation a tracking system is an essential part. With my design for the Heros School on the Marineterrein in Amsterdam I would like to give an example how this integration of daylight and solar energy can be done in an aesthetic and eco-efficient way.