AR0532
Smart & Bioclimatic Design Theory

Controlling the elements
A search for smart sustainability

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1. Introduction

As designers we are always looking for better and newer ways of creating buildings. When we approach a existing building there is always a conscious thought process towards the how and what of the building. In the coming article I will discuss an existing project and find a way to make it better suited for the time we are living in now, and for the coming decades.

During the course of Smart & Bioclimatic Design Theory a presentation was given by Doepel Strijkers Architects. In their presentation they discussed a project that they worked on out of their own initiative. In this project the research focused on bioclimatic skins. They created different kinds of eternal sun shading typologies in order to lower the energy consumption of the building. In the same lecture they discussed a project for the NAi in Rotterdam. The project consisted of redesigning the building and surrounding area. The main focus was to disconnect the rainwater system of the building from the municipal sewage system, and design the building like a sponge to absorb peak rainfall.

I am a frequent visitor of the NAi library and study hall. When I visit the NAi, the glass volume where the offices and library are placed, are very hot. This occurs in winter and in summer time. When I started interviewing the people that work in the offices and work in the study hall most of them complained about the temperature inside. The temperatures inside can reach up to 30°C in summer time, and even hotter adjacent to the curtainwall façade. This fact has been on my mind for a long time now and when I saw the project passing by in Doepel Strijker Architects presentation I got triggered.

This report for Smart & Bioclimatic Design Theory was set up to be linked together with a design studio. For me this presented a problem, seeing that I am not in a design studio at the moment. I am following this course in advance for my SADD design studio coming semester. I shaped this problem into an opportunity to re-design a building fragment of the NAi. In a previous building technology studio I already made some analyses of the NAi, this provided me with the opportunity to extend my research for the NAi.
2. The main problem

When visiting the NAI to see her collections you are lead through the refectory/entrance building and than on to the exposition building. When you are a visitor that wants to perform architectural research you will probably be lead to the office/library building. This volume consists of a glass curtain wall as main envelop. The offices and library are placed in this glass volume. When you are inside this glass volume you experience a great deal of heat. The working temperatures for a library and office in summer time are around 22°C and in winter around 20°C. The observed temperature on several occasions in summer time were 30°C or even higher, especially in the area adjacent to the façade. The temperature in winter time is also higher than normal. Also the problem in winter time is the cold downfall adjacent to the facades. The high temperature in the library building, almost during the whole year, causes the building to use a large amount of energy. The building uses a large amount of energy to cool itself in summer time, and even in sunny winter periods.

2.1 A question

In the day and age that we find ourselves in we must embrace the fact that we have to conserve energy and reduce it wherever we can. We as designers have to try to incorporate sustainable building elements into the designs that we make. Herein lies the opportunity to develop new ways in constructing buildings and the use of buildings. The idea of manipulating and using the elements that approach a building from the outside, like sun, wind and rain, and transforming them into usable climatic components is something that has been around since the Mayan temples. Therefore is will use the Nai as a case study for this research. And see if there are possible solutions in improving the current building without reconstructing the building. Therefore, can we develop a addition to a building that makes use of the existing building components and transforms a building into a more sustainable and usable machine. And can we do this in line with our sustainable way of thinking and in a way that is esthetically pleasing.
3. Making a framework

In order to perform a specific research it is necessary to create boundaries, a framework. Within this framework you can conduct a more clear and less broad research. The first step in making the framework already has been done in the previous chapter. I mentioned that the focus will be on reducing the internal heat gain to create a more comfortable interior environment for its users. I also mentioned that we would like to accomplish this without reconstructing the building.

From the afore mentioned we can derive two main subject. Firstly it is important to know what a indoor climate means and what the different elements are. And secondly it is important to understand in what way we can reduce the heat gain in the building.

3.1 Comfort

Different building types pose different demands on the level of comfort. The important aspects for the comfort in a building are thermal, hygienic and acoustic comfort. The issue with the comfort of a building is that users of a building are not identical. So when specifying comfort-related factors such as air movement, temperature, light intensity and humidity we have to provide some guideline values. The assumption that each individual user perceives the values differently provides us with the opportunity to give the unique user the possibility to control his / her environment. In this case I will focus on office buildings because my case revolves around the office / library part of the NAi.

When we are talking about the comfort level we can specify different elements. 3

- Thermal;
- Visual;
- hygienic;
- acoustic;
- ventilation;

Figure 3- Indoor Comfort; acoustic, thermal, ventilation, visual comfort
The comfortable temperature for an office building for light indoor work should be between 21°C and 26°C max. For visual comfort the user should be able to easily grasp the surroundings and receive a clear impression of the space. Also an important aspect of visual comfort is that the space is provided with sufficient natural light.

Hygienic comfort manifests in the way that a space is ventilated, heated and cooled. It is perceived in factors like outside air quality, room furnishings, dust, gases, CO2, odor substance, viruses and bacteria.

When we think about acoustic comfort, we think about sounds transferred from the outside, sounds from the inside and from person to person sounds. The last one we can describe as the resonant response.

Ventilation is also a vital element. It regulates the space temperature as well as the relative humidity. Exhaust air is removed and replaced by fresh clean air. With the air replacement harmful and odorous substances are also removed. Ventilation is regulated by different methods, natural and mechanical, or a hybrid of natural and mechanical. 4

**How do you feel ?**

+3 Hot
+2 Warm
+1 Slightly warm
0 Neutral
-1 Slightly cool
-2 Cool
-3 Cold

**Figure 4- Comfort zone**

**Comfort - temperature and humidity**

Temperate climate zone
Indoor clothing
Light work

**Figure 5- Comfort zone taken**
Heat gain in a building primarily comes from solar radiation. When a building isn’t sufficiently protected from the solar radiation it can provide heat gain problems in the interior climate. A façade acts as an intermediate layer between the interior climate and the exterior climate. Fresh air and heat can be dispatched by and through the façade. In many occasions the façade in itself cannot provide the user with a comfortable enough environment. In order to achieve the functional requirement additional components have to be added into the façade or next to the façade. The façade and its technical additions have an interaction with each other. The more efficient these systems work with each other, the more we can take advantage of the surrounding climate. The system that I will focus on within the parameters of this research will be the sun shading systems. The choice for this system is made because of my personal interest in sun shading systems. And because the case project, the NAi, heats up primarily due to solar radiation.

3. Sun shading Façade Typologies
Shading controls the amount of heat and light admitted into a building. By doing so, solar shading devices contribute to saving energy in various areas. They can reduce the need for heating or air conditioning by maintaining a more even temperature despite varying climatic conditions. They can also cut the amount of energy required for lighting, by admitting more light during overcast conditions for example. Besides the thermal and energy aspects, solar shading leads to better visual comfort. Glare reduction can improve working conditions in offices, reduce sick leave, increase productivity and contribute to health and safety at work.

According to B. L. H. Hasselaar’s PhD Research on Delft University of Technology (Department of Building Technology, Chair of Building Physics, 2005-2009), based on extensive case study research 5 “almost any modern façade that claims to be ‘adaptable’, ‘intelligent’ or ‘responsive’ can be categorized to one of five different types of solar control devices”, 6 7 8 as demonstrated in the diagram below. 9

![Diagram of five types of solar control devices: external, integrated, internal, double skin, and ventilated cavity.

Figure 6- Image source; Climate Adaptive Skins: towards the new energy-efficient façade
3.1 External Solar control devices
External solar control devices reflect and emit the heat absorbed from solar radiation outside the building itself, reducing the need for cooling in summer. The outdoor elements are exposed to the elements resulting in higher costs for maintenance and cleaning. External devices can be fixed or movable (fabric blinds or screens, slatted or metal louver blinds). Less common are sliding façade units such as panels, screening grids and light-deflecting elements.

3.2 Integrated solar control devices
Integrated solar shading systems are usually positioned between the main façade elements and an external second skin façade, usually glass. These systems are used in order to either fully reflect or partially reflect/redirect solar rays, in order to prevent interior temperature rise/ adjust the interior light conditions respectively. Integrated solar control devices are relatively uncommon. Cleaning costs are relatively low. Maintenance costs however can be much higher, especially in cases where the electric motors are also incorporated in the cavity between the panes.

3.3 Internal solar control devices
Internal solar control devices are less effective, as the light passing through glass is transformed into heat by the shading device, which is trapped by the glass and emitted into the room. Cleaning and maintaining these devices is considerably easier than exterior and integrated ones, as they can easily be reached. Readily available systems include Venetian blinds and textile materials such as vertical blinds, roller blinds or fabric screens.
3.4 Double skin façades
Double skin façades have an extra (usually) glass sheet on the outer space of a building, posing in front of the actual building façade. An “intermediate” climate is achieved in the cavity between the two façades, hence the term “double skin”. Solar control devices are placed in the cavity between these two skins, which protects them from the influences of weather and air pollution. Heat absorbed by the solar shading is re-radiated and emitted into the intermediate cavity, creating a natural stack effect which causes the air to rise, removing additional heat with the upward flow.

3.5 Ventilated cavity façades
Ventilated cavity façades have an additional single glass sheet on the inside of an interior solar control device. Furthermore, the cavity is mechanically ventilated. Lower pressure in the cavity draws part of the exhaust air from the room into this space where the air warms up, taking most of the heat from the solar control devices, and finally it is driven out of the cavity. The air is extracted on each floor separately, either flowing upwards or downwards in the cavity.

At this moment we have a clear overview of which typologies exist and what characteristics they poses. The typology that sounds most suitable to implement on the design of the NAI is external solar control devices. The reasoning for this is quite simple. We don’t want to reduce the floor space of the building by introducing a typology that needs a large amount of extra floor space. And we want to keep it a basic as possible. That is why we will focus on a external sun shading system.
In order to understand a bit more about external sun shading systems we need to find and examine a built case study.

4. Council House 2, Melbourne, Australia

- **Project:** Council House 2, Melbourne, Australia
- **Architect:** DesignInc
- **Size:** gross floor area (GFA) 12,500 m²
- **Client:** City of Melbourne
- **Completion:** 2006
- **Building cost:** € 40,000,000

**4.1 General**
The Sun shining on the west façade can have a significant effect on commercial building in Melbourne, heating up the interior space and creating glare in the offices. For these reasons, CH2 has a louver system covering the western façade, with the louvers able to move and track the sun, responding to the internal light and temperature conditions. CH2’s western façade features a system of responsive recycled timber shutters that protect the building from the late afternoon sun while enabling views out of the building and natural light to enter the building. The shutters are open when the sun is in the eastern or northern sky, closing only when the sun is in the west.

The shutters are slated to maximize the amount of daylight that can be admitted while still performing their protective function. In summer, the shutters fully close fairly quickly and, when the sun is nearly square-on to the building, they then open slightly to stop the sun from penetrating through the slats. In winter, the shutters close more slowly and do not need to close completely as the sun does not get square-on to the building. In winter, the main purpose of the shutters is to protect staff from the glare of the sun’s rays.

**4.2 Controlling system**
The western elevation is bio-climatically responsive to the direct sunlight falling on the façade. The façade is controlled by the Building Management System informed by a solar clock and the weather station on the roof. The facade movement is controlled by the Building Management System with a software program set to the sun’s movement throughout the year, i.e. a solar clock.
This automated system provides the ability to optimize the lighting/cooling balance, including dealing with difficult low sun angles in winter.

The system planned for CH2 comprises a weather station that measures the amount of sun falling on the façade, wind direction and rain, and a solar clock to inform the BMS when to open and close the system. Further it was the intention that the solar photovoltaic array on the roof would produce enough power to offset the energy required to open and close the louvers.

4.3 Concept diagrams

The wooden louvers are opened in winter to provide filtered light and vertical air movement. In the summer the shutters track the movement of the sun to provide the best shading and thermal protection (Figure 12).

The operable vertical timber shutters provide complete summer shading. The spacing between the independent parts of the shutters provides sufficient daylight and views for the users (Figure 13).

The cavity created between the façade and the louvers create a insulating and cooling layer. Through convection a draft is created behind the louvers that can help cool down the building in summer time. In winter time the draft can be minimalized in order to create a air pocket that provides a insulation layer in between.
5. The goal
The goal for this report is to conduct appropriate independent research and implement this into a design. In my case I want to implement my research results into an existing building. In order to do this I have to perform some research on the building that I am using.

5.1 A quick scan of the NAi
The NAi consists of four main building volumes. We can best divide these volumes based on their main function. The archive, the exposition space, the offices/library, the refectory/entrance building.
These four buildings have their own load bearing principle and their own façade material. The archive building is a building with a load bearing structure that consists of prefabricated concrete elements. The façade of the archive building is built up with insulated steel profiled façade plating.
The exposition space and the refectory/entrance building are built up with the use of an insitu-concrete structure with a structure of load bearing facades, columns and beams. The façade of the exposition building is made out brickwork that is hung onto the concrete structure. The façade of the refectory building is made out of an insitu cavity wall.
Finally the office/library building is built up with prefabricated concrete floors that are hung onto an exxo skeleton of columns and beams. The façade is made out of a glass curtain wall mounted onto aluminum window framing system. The overall climate system consist of a balanced ventilation and heating system that is regulated separately for each volume.

Figure 12 – sketch of the main building volumes of the NAi
6. The main focus

I have mentioned a couple of times before that I will focus on the library/office building of the NAi, the large floating glass volume in the center of the NAi.

The climate system in the glass volume consists of a balanced ventilation system together with liquid based heating through radiators. The main protection against the sun is provided by internal solar shading. The shading system consists of curtains, bookshelves, roller blinds and vertical plastic louvers. The glass that is used in the curtain wall is of a, comparing to nowadays, very low quality insulating value. The floor and the roof are also insulated with outdated low insulating insulation material.

The office/library building consist of four functional layers. The lower two are for the library and the upper two for the offices. De load bearing structure consists an exxo skeleton of eight steel frames. The steel frames have a hart measurement of 6,5 m. Each steel frame has three floor beams HE 900 A spanning between them. The floors are made out of a ribbed sectional floor.

The façade of the NAi is built up with a glass curtain wall. This glass curtain wall consists of a glazing type standard for 1988. This glazing type has a U-Value of 3,2 K/W.m². if we compare this to our standard glazing nowadays has a value of 1,2 K/W.m² this provides almost 300 % more insulation for a standard glazing type. The roof and the ground floor are insulated with insulating materials with a capacity of Rc 2,0 m²/KW. Nowadays we aim to reach a minimal value of Rc 3,0 m²/KW, this is an improvement of 150 %.

The glazing system consist of a aluminum window framing. These aluminum window framings are uncoated and natural on the inside. Outside the window framings are finished with black coated click frames. The corners styles, the upper and lower edge all have a aluminum colored finish. The window frames are set up in a grid of 3,54 m x 1,25 m. This being the measurements of the double glass panels. The whole window system is a self load bearing system. This means that the whole height 13,5 m and width 11,16 m is supported by the aluminum framing system.

This part of the NAi provides a opportunity to redevelop the façade zone of the glass volume in such a way that it helps to provide a user pleasant working space. The possibilities in this day and age with new materials and different approaches are plentiful. With improved insights in sun protection and insulation we can achieve a better and more sustainable building.
The exxo skeleton can for example provide a perfect load bearing structure for outside sun shading. The current glazing in the façade is very dated, we saw that in the U-values and the roof and ground floor easily could be packed with a higher insulating insulation.

7. A structural analyses

At this time we are looking at the glass volume of the NAI and the possibilities that lie within its elements. Like we said before the exxo skeleton can provide an excellent bearing structure for a outside sun shading system and the roof and lowest floor lend themselves for additional insulation. The bearing structure of the curtainwall also provides us with renewal possibilities.

![Figure 14 – sketch of the load bearing structure of the office / library volume of the NAI](image)

But first things first, lets look a little bit closer at the elements of the glass volume. We can divide the elements into three parts. The load bearing structure, the floors and the façade.

7.1 Load bearing structure

The load bearing structure is built up with steel tube columns filled with concrete and reinforcing bars. These columns have a diameter of Ø 609.6 mm and a wall thickness of 20 mm. Onto these columns steel consoles are welded made from a HE 900 A profile. The HE 900 A beams spanning between the steel tube columns are mounted onto the steel consoles through bolted rigged steel plate connections.

![Figure 15 – detail of the exxo skeleton of the NAI](image)  
![Figure 16 – detail of the Floor beams of the NAI](image)
7.2 Floor and roof structure
The roof and floor structure consists of prefabricated concrete ribbed elements with a thickness of 85 mm. On top of the floor a pressure layer is poured with a thickness of 50 mm. The concrete shells around the HE 900 A beams that provide the bearing surface are also filled with concrete to create a rigged and whole floor plate. Around the edges of the floor a ring beam is made insitu to take up the lateral forces. The roof is insulated with 80 mm of insulation with a insulating value of Rc 2,0 m²/KW.

![Figure 17 – detail of the roof edge of the NAi](image)

Figure 17 – detail of the roof edge of the NAi

Figure 18 – detail of the curtainwall of the NAi

7.3 Façade structure
The façade structure is built up from aluminum profiles that support the window frames and are mounted between the concrete floor and roof. The window frames are mounted onto the aluminum bearing structure. Like we said before the aluminum column profiles have a hart measurement of 3,54 m and a length of 13,5 m. The horizontal profiles have a hart measurement of 1,25 m. The aluminum profile used is a i-profile of 130 mm x 65 mm x 10 mm. The mounted window frames have a dimension of 50 mm x 32,5 mm.

8. A concept for the NAi
When dealing with the problem of excessive heat gain and solar glare we can think of different approaches for reducing this. In this design process we have taken it upon us to work with as much elements of the excising context as possible.

External solar shading is the most suitable and effective way to control the internal conditions of a building. Radiation from the sun is transmitted, absorbed and reflected by the louvers. As a result, solar heat gain is prevented from passing into the building, minimizing ventilation requirements and reducing the cooling loads. If a controllable system is installed, adjustable blades can track the movement of the sun, thereby reducing the number of days when the building overheats. Equally, in winter the louvers may be adjusted in such a way that the building benefits from the heat of the sun, and the louvers can be closed at night reducing the heat loss.

![Figure 19 – diagram of the concept for the NAi](image)

Figure 19 – diagram of the concept for the NAi

Figure 20 – diagram of the louver concept for the NAi
The intention of creating an external solar shading is to reduce the energy use of the building. If we extend this thought process it’s a logical step to think in terms of a shading system that has a low energy consuming impact on the environment. This is why we want to incorporate the use of wood as main bearing system and as main louver system.

Using wood as building product assures us that we are approaching a sustainable way of building. Wood is a renewable building material and its production is sustainable. The type of wood used in this design will be Accoya wood. Accoya wood is a wood type with performance properties that match or exceed those of the best tropical hardwoods. Accoya wood has a class 1 durability label, very good dimensional stability, the quality is reliable and consistent, has a high resistance to UV degradation, the paint or coating will last up to four times longer because of the low shrinking and swelling, it’s non toxic and 100% recyclable. Because of the acetylation process the wood becomes almost resistant to swelling and shrinking. This in its turn is perfect for the use as load bearing system and as a louver system.

<table>
<thead>
<tr>
<th>the Forest</th>
<th>the Wood</th>
</tr>
</thead>
<tbody>
<tr>
<td>- essential for humans</td>
<td>- renewable material</td>
</tr>
<tr>
<td>- part of the ecosystem</td>
<td>- infinite possibilities</td>
</tr>
<tr>
<td>- production of oxygen</td>
<td>- practical</td>
</tr>
<tr>
<td>- storage of CO2</td>
<td>- versatile</td>
</tr>
<tr>
<td></td>
<td>- beautiful</td>
</tr>
</tbody>
</table>

Now we have created a way to keep out most of the heat by blocking the solar radiation from the outside, but we can also improve the way that we insulate the building. If we take a look at the floors, the roof and the curtain wall, we can establish that the materials that were used at the time, can’t live up to the quality we want to reach nowadays. We’ve seen the statistics of the used materials and the standard of the current building laws. Now we take a step higher, if not the highest.
The concept for insulating the floor and the roof came with the limitation that lied in the projects dimensions. The ground floor could easily be insulated from the bottom down, we have enough space there. But the problem was the roof, I did not want to make a thick roof edge, that would conflict with the original design. So I came up with a very high insulating material, that was thin enough to place in the current building dimensions. This material, from isobouw, is PolyFortPro. The thickness of the material is 144 mm and has a Rc 5,0 m²/KW value, this compared to the current Rc 2,0 m²/KW is a improvement of 250%. By replacing the old insulation with this new insulation we keep the heat out in summer and keep the heat in, in winter.

The same exercise will be preformed on the curtain wall. The current glazing can easily be removed from it’s framing and be replaced by a glazing type that has higher insulating properties. The current glazing has a U-value of 3,2 K/W.m² which creates a great deal of heat los and gain, the new glazing has a U-value of 0,5 K/W.m² which keeps in the cool / hot air and respectively keeps out the cool / hot air depending on the season.

We will adjust the existing climate system in order to create a better working environment. We propose to use the air from under the building in summer time. This gives us cooler air. And use the air from in between the louvers and the building in winter time, this provides us with warmer air.

9. Implementation of the design

The redesign consists of two main elements. The outside solar protection and the improvement of the building insulation. And we can define a smaller third element, which is the climate.

The outside solar protection is made up form a laminated wooden bearing structure together with wooden louvers. The wood type that we use is Accoya, for it’s outstanding performances. We talked about this earlier on. The bearing structure will be attached onto the exxo skeleton of the NAI.

They method of attaching the bearing structure is by using a bracket system that clamps onto the excising bearing structure. First a steel bracket will be fixed (welded) that will serve as adjustment rings. The main steel bracket will then be mounted onto the adjustment rings. The brackets consist of two parts that will be bolted together around the steel tube columns. Attached on the steel bracket parts consoles are mounted, this can be done by forehand in a factory. The consoles will function as a bearing surface for the wooden beams.
The main bearing beams are laminated and made up from 23 pieces of 180 x 40 mm and glued with thermally hardening glue. For outside use we will apply resorcinolformaldehyde glue. For the best rigidity of the beams we will place the individual pieces in a horizontal direction. Onto these beams we will place the laminated bearing columns made up from 12 pieces of 180 x 40 mm and a center piece of 180 x 20 mm. The same glue will be used as in the beams. We now have a window frame with which we can use to place the wooden louvers.

The wooden louvers are also made out of Accoya wood. The louvers consist of two pieces of 300 x 25 mm rounded on one side. The louvers will have an aluminum core that will strengthen the louvers and give it a turning axis. The heads of the louvers will be fixed with steel end parts of 320 x 120 x 10 mm into which the louvers will fit. The steel ends will in their turn be fixed onto a conductor that controls the angle of the louvers. The controlling element is very important because it will rotate the louvers in their right position according to the angle of the sun and the temperature of the cavity between the louvers and the building.

Earlier on we were talking about improving the insulation of the building. For the roof we intend to use PolyFortPro with a Rc 5,0 m²/KW. First we need to remove the old roofing material until we reach the pressure layer of the concrete roof. When we cleaned of all the old roofing material we can start building up. Then we need to create a new roof edge, this is done by attaching a steel corner profile 150 x 100 mm onto the concrete floor and making a timber framework to fix on the corner steel profile. When this has been done we can cover the whole roof with the new insulation.
and top the insulation of with EPDM roofing. For the finishing element we cover the timber framework with steel plating typesetting.

The procedure for the floor is quite similar, remove the old and attach the new. The biggest difference is that we hang the new structure on the bottom of the floor with timber framework.

The idea for the climate of the building will primarily be controlled by the outside louvers, because they determine how much solar energy will infiltrate the building skin. The louvers of the facades will be bio-climatically responsive to the direct sunlight falling on the façade. This system is controlled by a Building Management System. This system is informed by a solar clock and by a weather station on the roof. The movement of the louvers are controlled by the B.M.S. system with a software program set to the sun’s movement throughout the year. This automated system will provide the building with an optimal light and cooling balance. The open and closed way of the louvers also provide the cavity space between the louvers and the curtainwall façade with a draft, which will get rid of the hot air in summer, and can function as a buffer zone in winter.
10. conclusion

When setting upon a journey it is never clear to us what the endpoint will be. Discovering the problems with the heat in the library of the NAI and the way that this heat gain results in a higher energy consumption. We've seen that the way the sunshine was being handled in the current situation, by inside solar projection, only made the problem worse.

The intervention that followed from the problem at the NAI is a special one to say the least. We have harnessed the theoretical knowledge in an attempt to create a possible solution. The exciting bearing structure gave us the opportunity to add a extra layer that would regulate the buildings climate. By using the climate in a smart way we are able to work with the environment instead of against the environment.

We saw in the chosen case studies what possible ways we could imply in our own design and how this was executed.

What I set out to do, creating a addition that would allow the building to operate better and to make working inside better, I think I achieved. The building now has a better insulating quality with the addition of one of the highest insulating glazing types and insulation materials. The louvers give the building a natural outside double skin in which the air flows to create a buffer zone for hot and cold air.

The way that the wooden structure is incorporated inside the steel structure gives us a fulfilling end result. We again have a sustainable intervention onto a timeless building that can go on to operate for another fifty years.
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