

DATABASE

Roof Daylight Systems

PV as art

Architectural Engineering

TU Delft . Studio 2016

tutors

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Marcel Bilow

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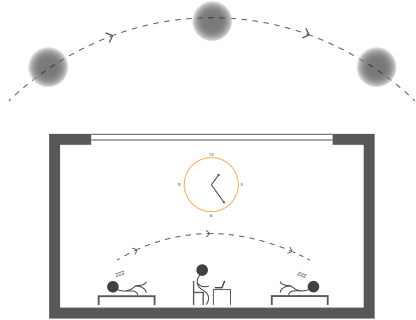
F.C.J.E.Sanders@student.tudelft.nl

references

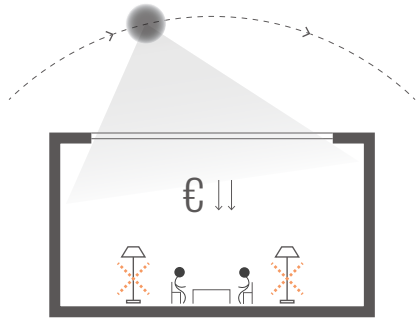
The sections in this database are own illustrations

The photographs are extracted from <http://www.archdaily.com>

ADVANTAGES
roof daylight

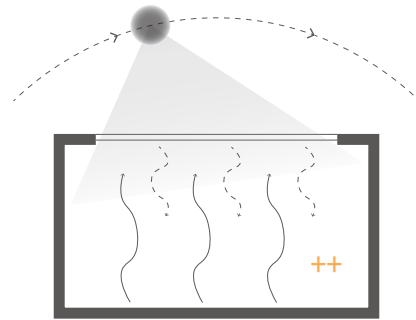


stimulate biorhythm of users

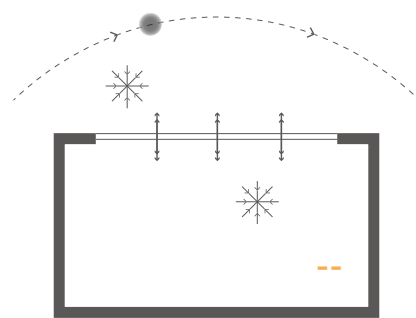


decrease in lighting / electricity costs

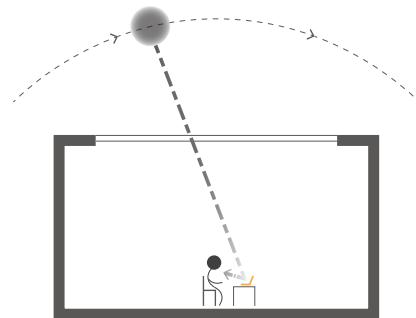
DISADVANTAGES
roof daylight



summer: overheated by greenhouse effect



winter: high heat losses through glass



sun glare on screens

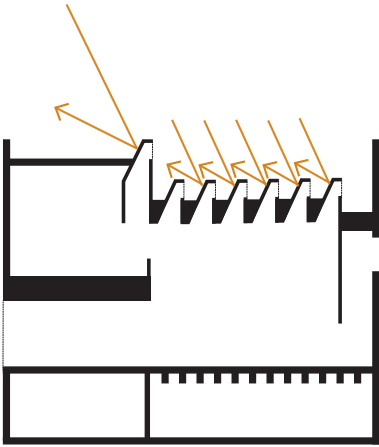
SOLUTION

=

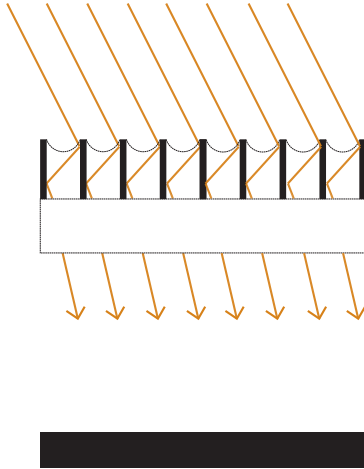
ROOF DAYLIGHT SYSTEM

yes < diffuse radiation (D)
no < beam/direct radiation (B)

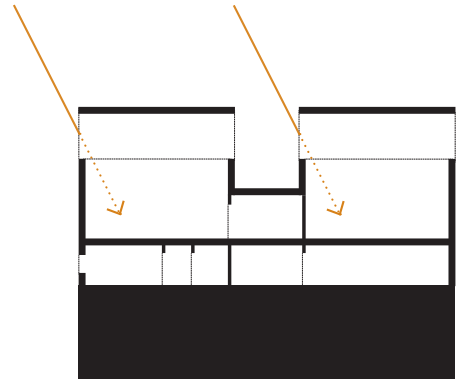
6



rebound



reflection

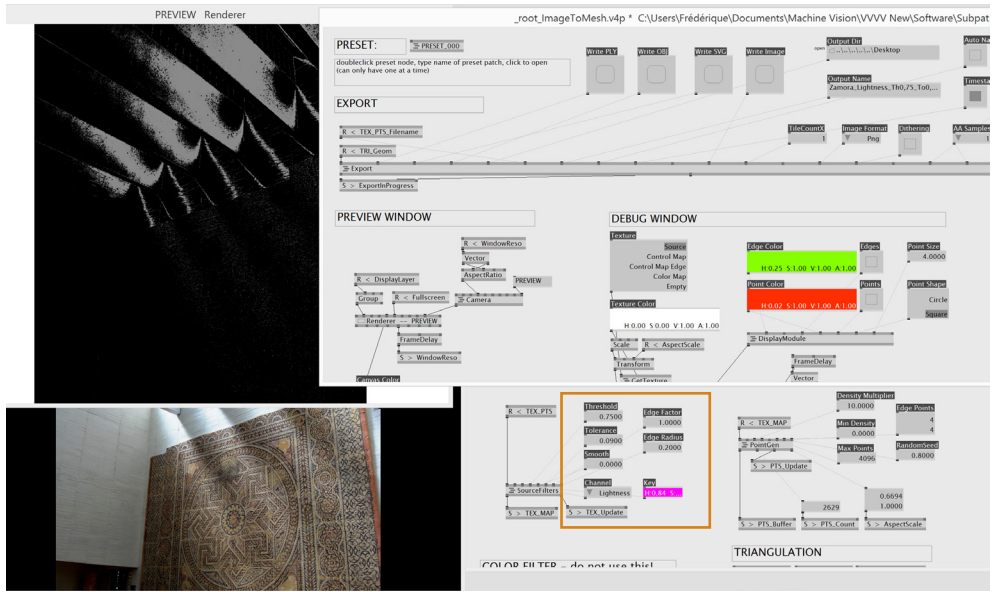


filtration

CLASSIFICATION

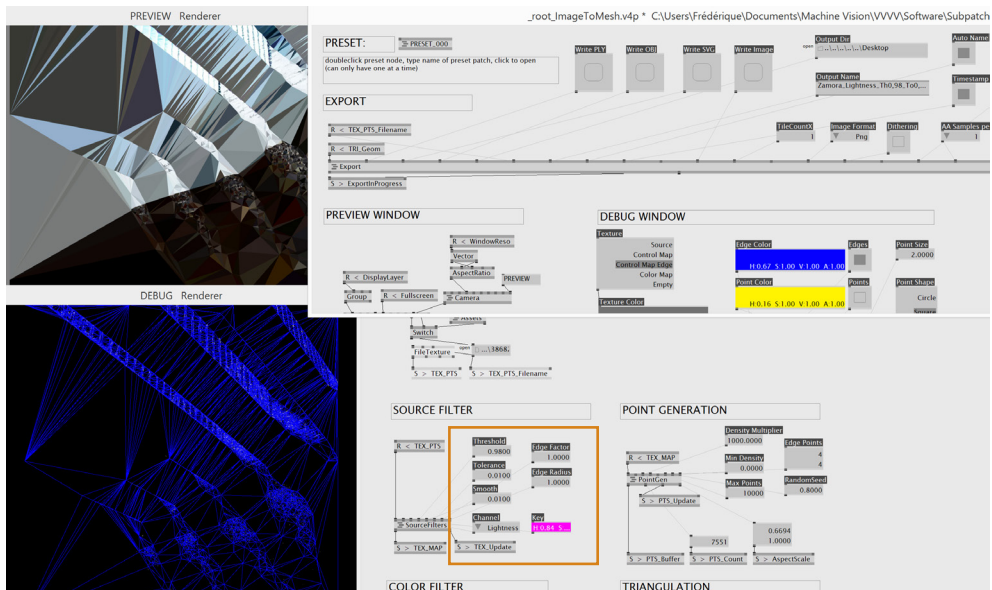
Function of roof daylight / sunshading systems: transform *beam/direct radiation (B)* in *diffuse radiation (D)*. The different projects in this database are arranged in three groups:

1. **Rebound**
Direct light not admitted / openings towards the North
2. **Reflection**
Direct light bounced back and forth
3. **Filtration**
Direct light transmitted through different material layers



VVV-1 analysis software < points

8



VVV-2 analysis software < connections

ANALYSIS METHOD

In order to compare the 26 different daylight projects, of each project a representative interior photo will be subjected to the VVVV-1 and VVVV-2 analysis software. This is a computational reinterpretation program based on procedural digital workflows. With this software the light intensity in the building can be measured.

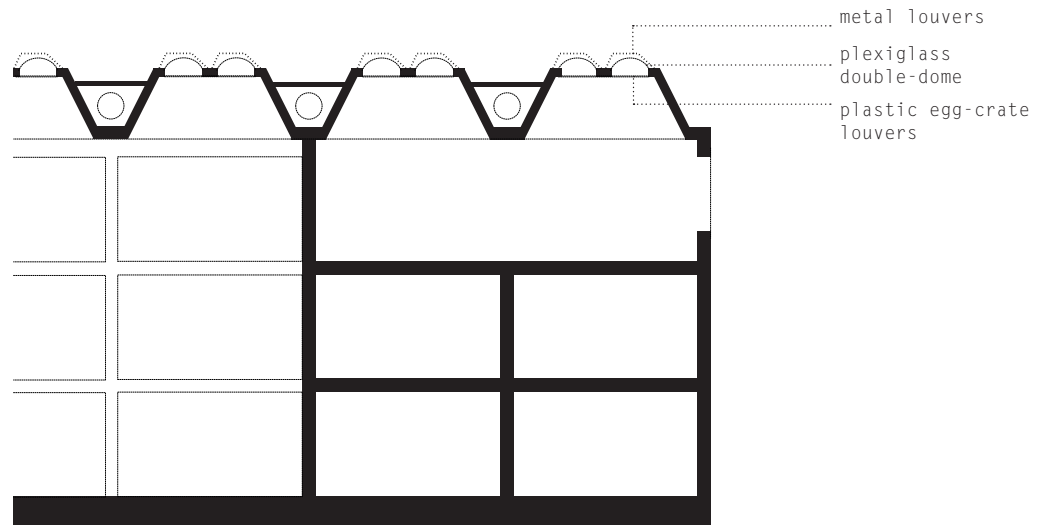
The VVVV-1 analysis software focuses on the points of lightness; the VVVV-2 analysis software on the connections in lightness. **The higher the Threshold and lower the Tolerance of the output, the higher is the light intensity in the building.**

Yale Center for British Art

Function: Museum / history institute

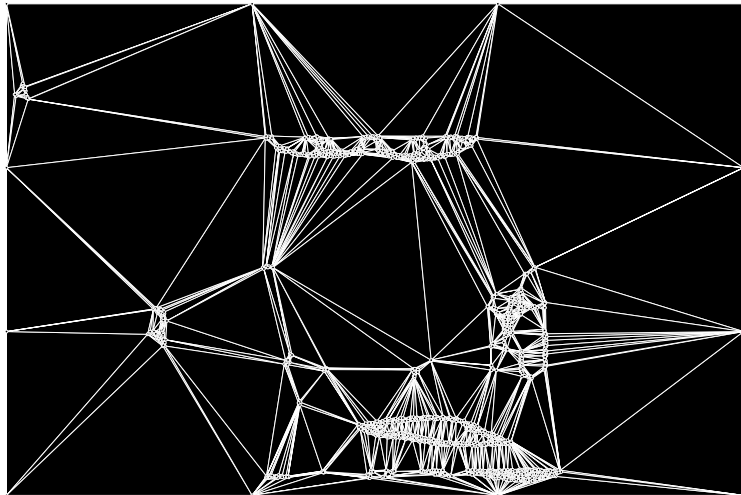
Architect: Louis Kahn

Connecticut, United States - 1974





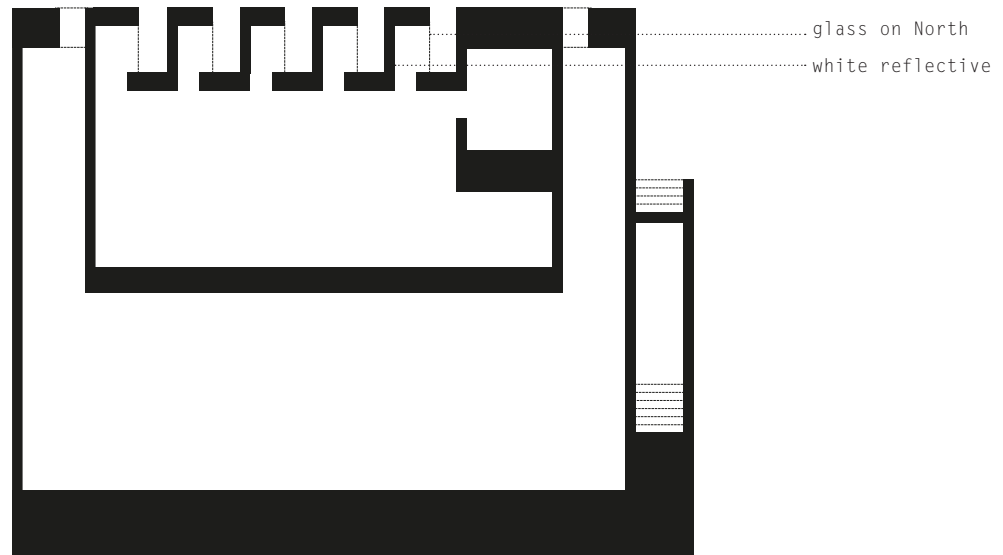




Focused on Lightness
0.75 Threshold - 0.03 Tolerance

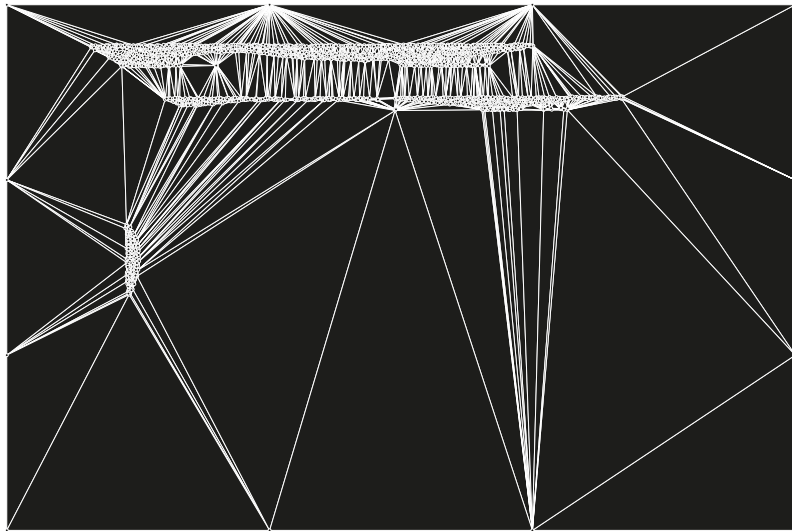
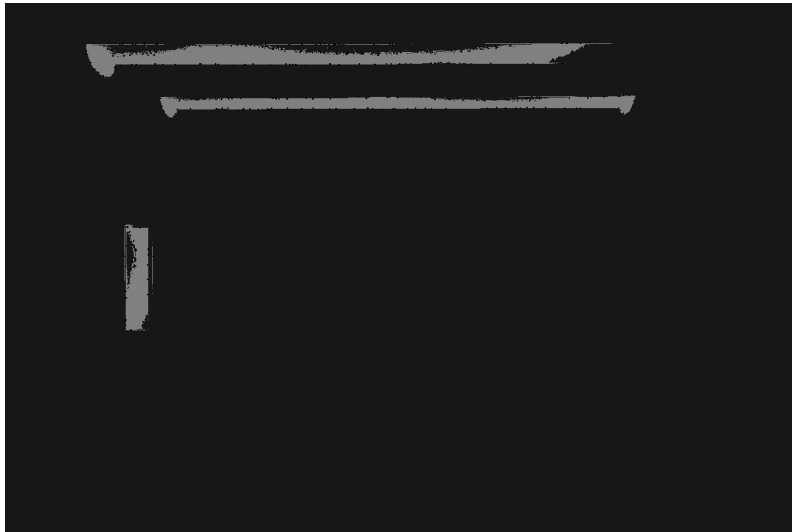
Centro das Artes Casa das Mudas

Function: Art centre
Architect: Paulo David
Madeira, Portugal - 2004





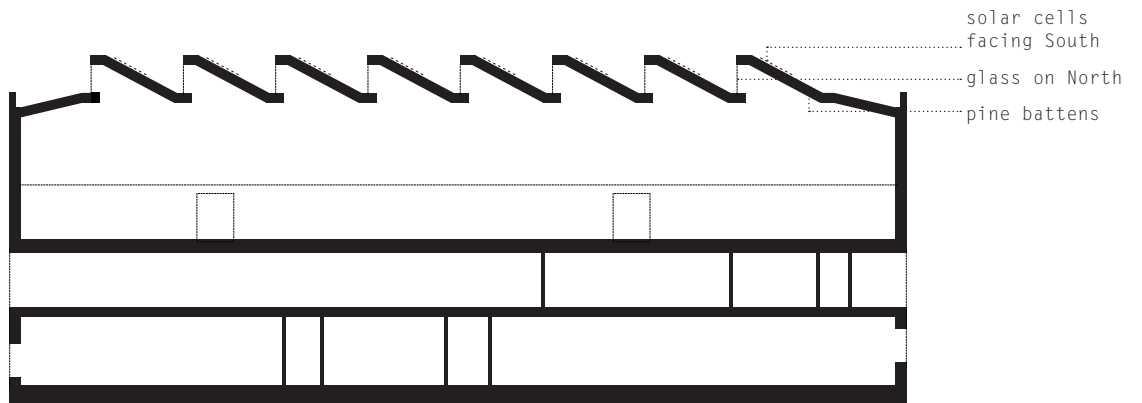




Focused on Lightness
0.93 Threshold - 0.07 Tolerance

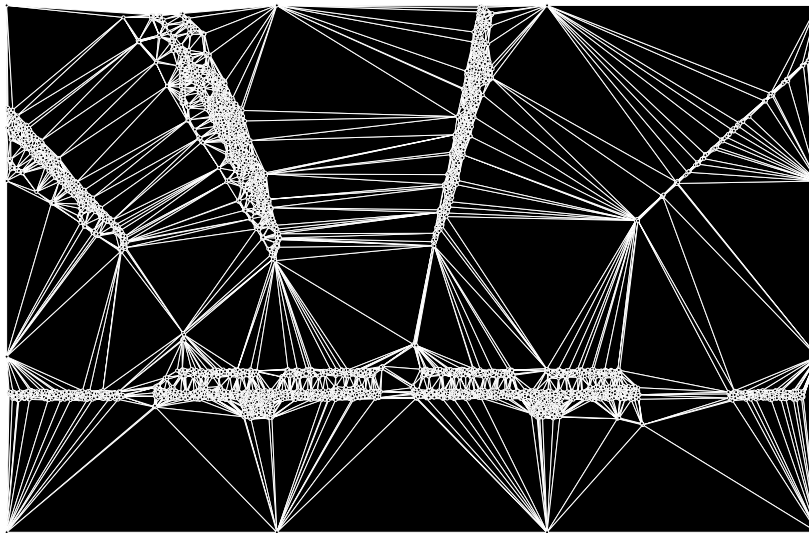
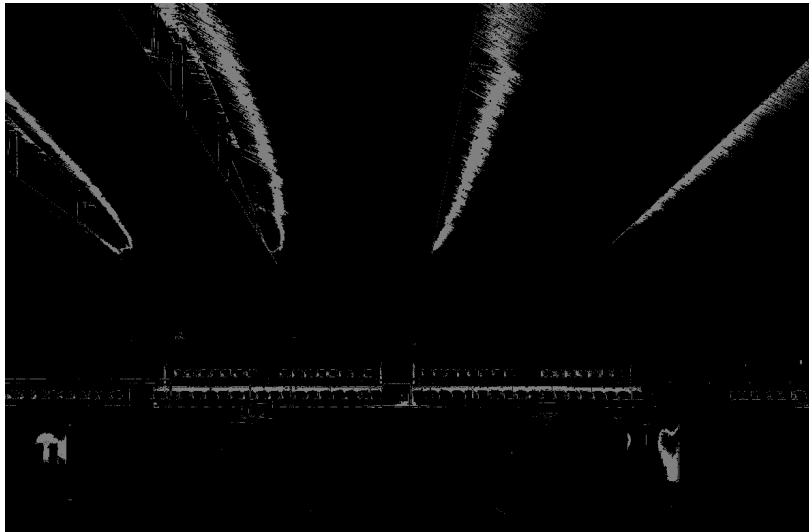
Pajol Sports Centre

Function: Sports centre
Architect: Brisac Gonzalez
Paris, France - 2012





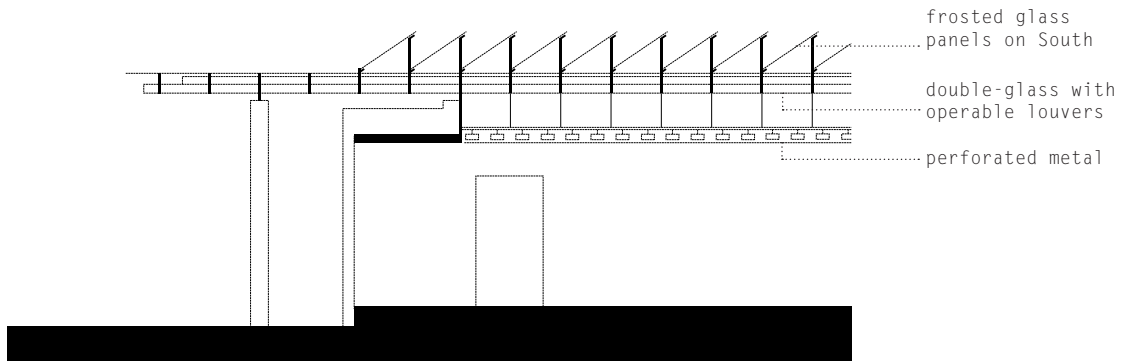




Focused on Lightness
0.74 Threshold - 0.08 Tolerance

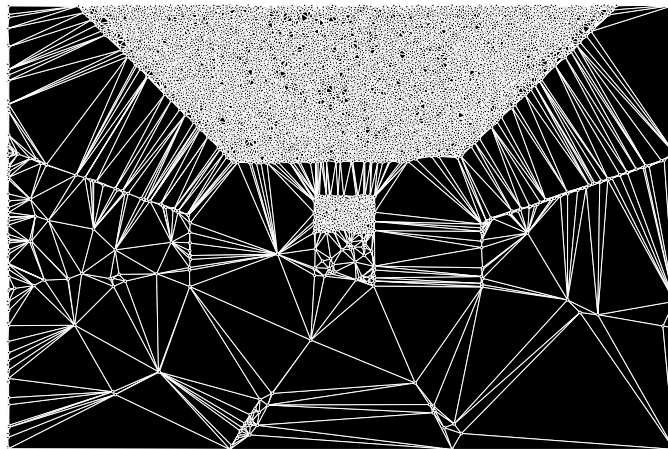
Beyeler Foundation

Function: Museum
Architect: Renzo Piano
Riehen, Switzerland - 1982







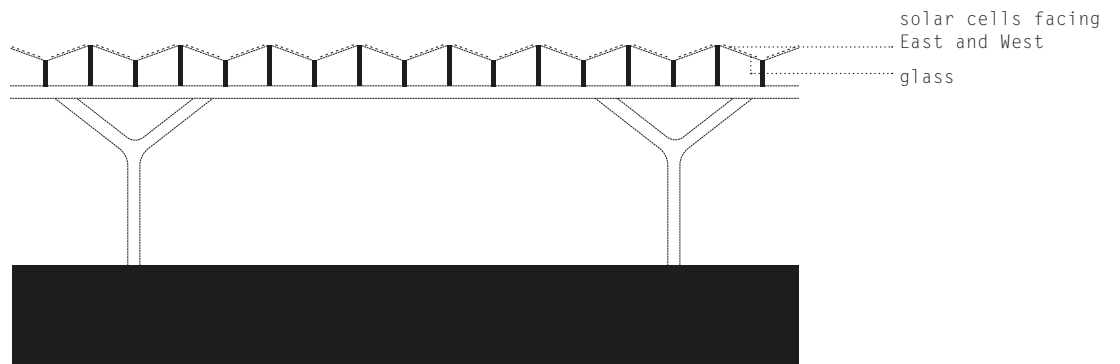


Focused on Lightness
0.88 Threshold - 0.02 Tolerance

Rotterdam Central Station

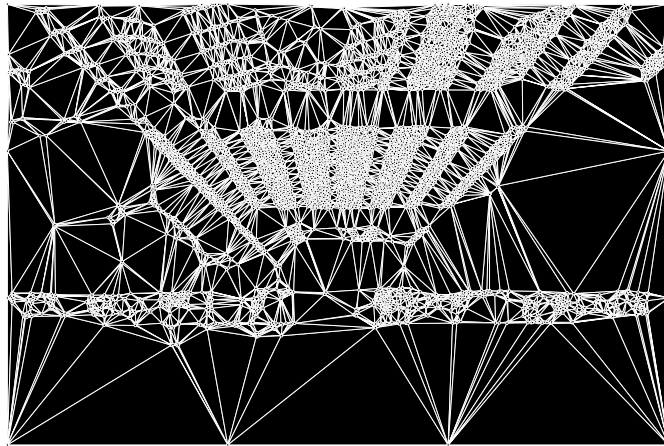
Function: Public transport station

Architect: Team CS (Bentham Crouwel Architects + MVSA Architects + West 8)
Rotterdam, The Netherlands - 2014







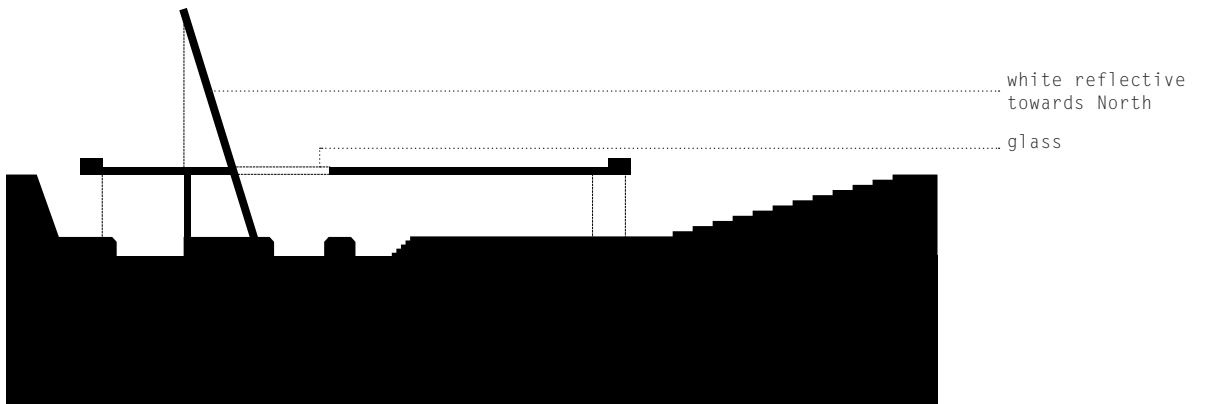


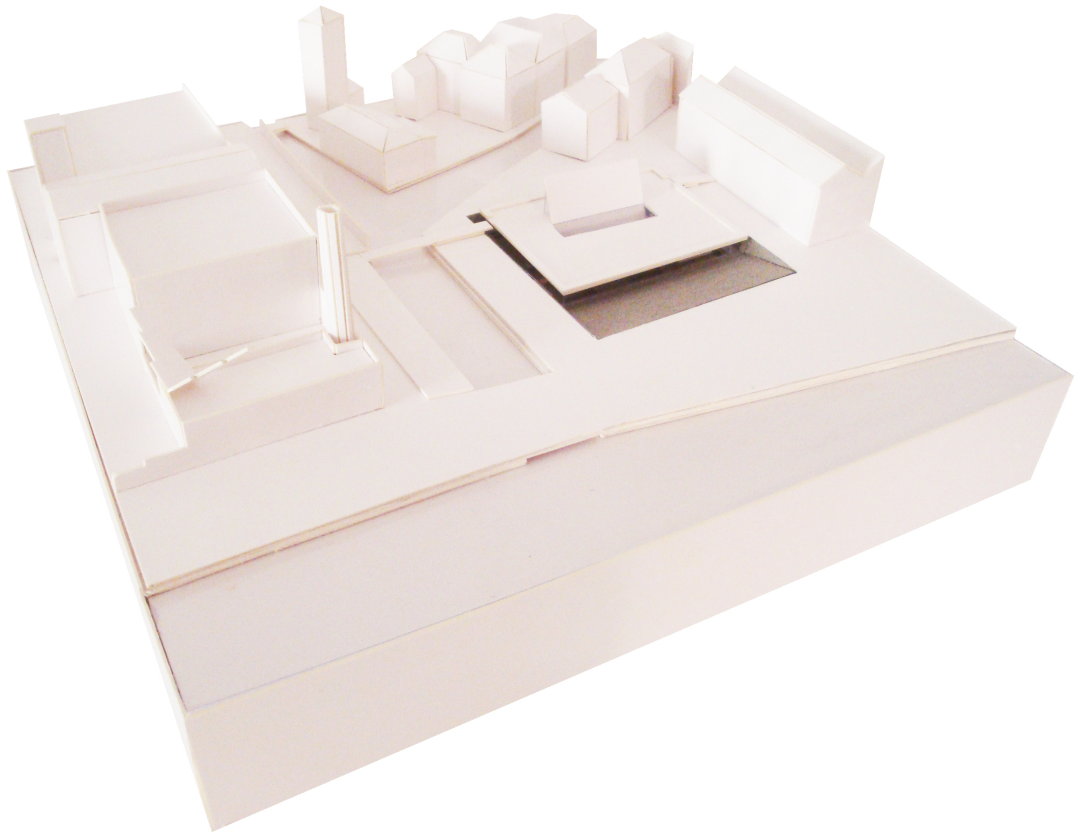
Focused on Lightness
0.88 Threshold - 0.07 Tolerance

Museo dei Maestri IUAV . Sala Aldo Rossi

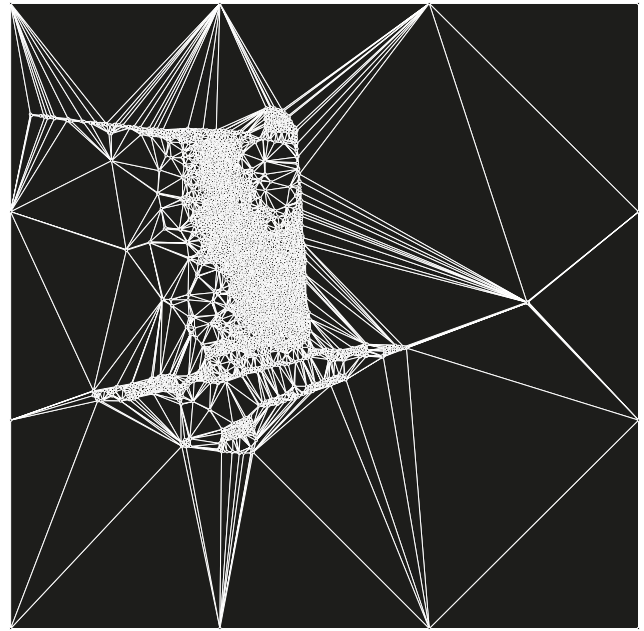
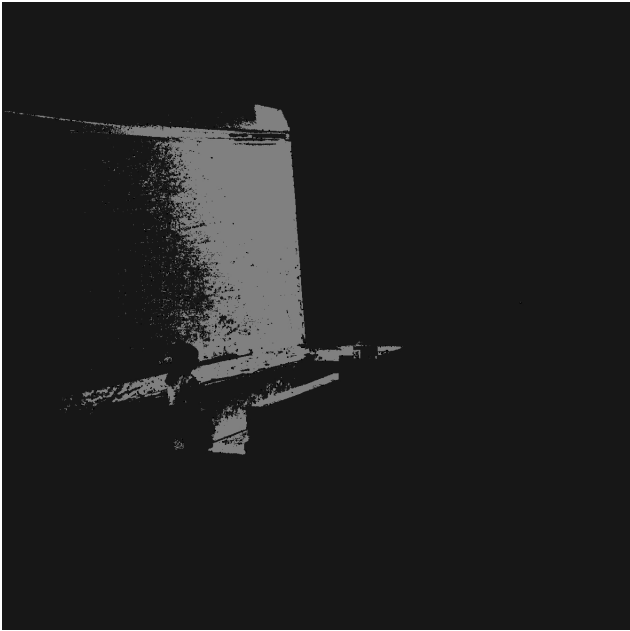
Function: Museum
Architect: own work
Venice, Italy - 2013 (unbuilt)

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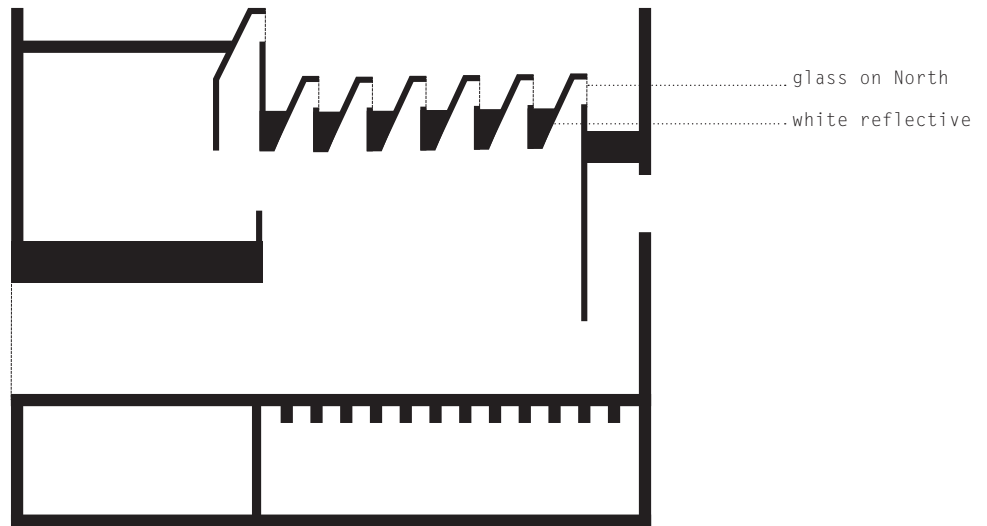
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Focused on Lightness
0.89 Threshold - 0.05 Tolerance

Museo Provincial de Zamora

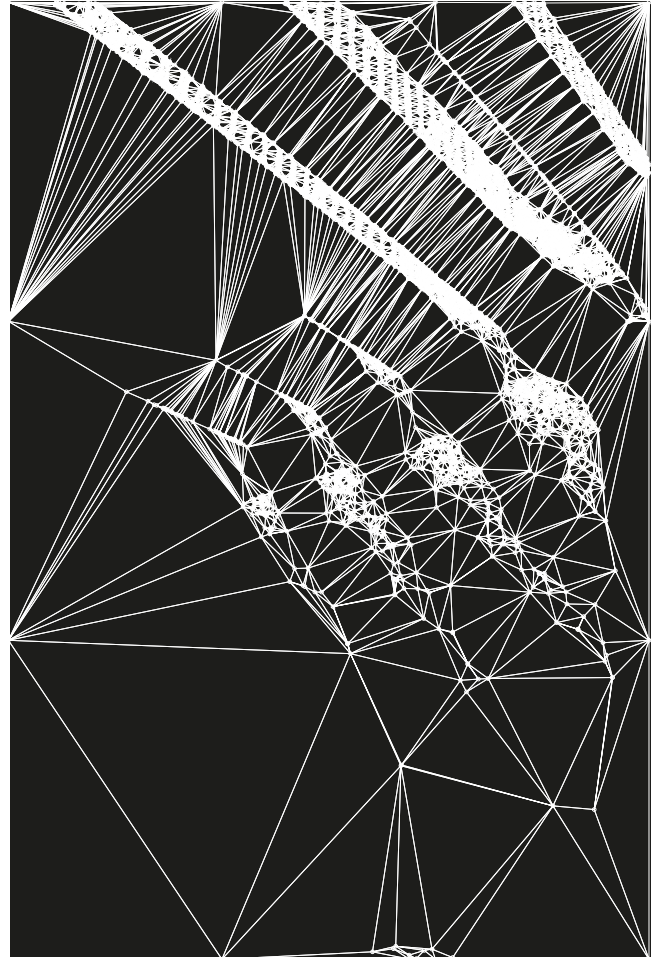
Function: Museum

Architect: Luis Moreno Mansilla and Emilio Tuñón
Zamora, Spain - 1996









Focused on Lightness
0.75 Threshold - 0.09 Tolerance

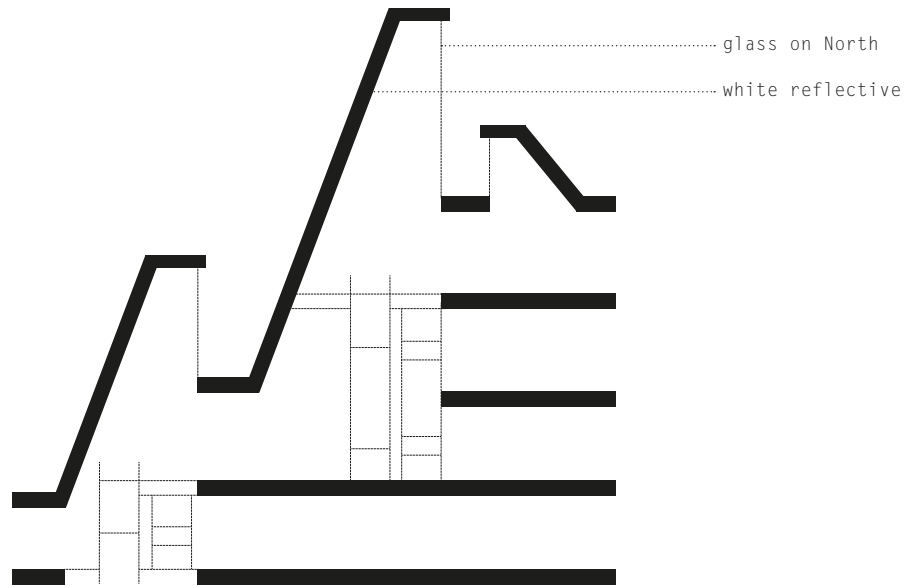
Congress Centre of Aragón . Expo 2008

Function: Congress centre / auditorium

Architect: Nieto Sobejano Arquitectos

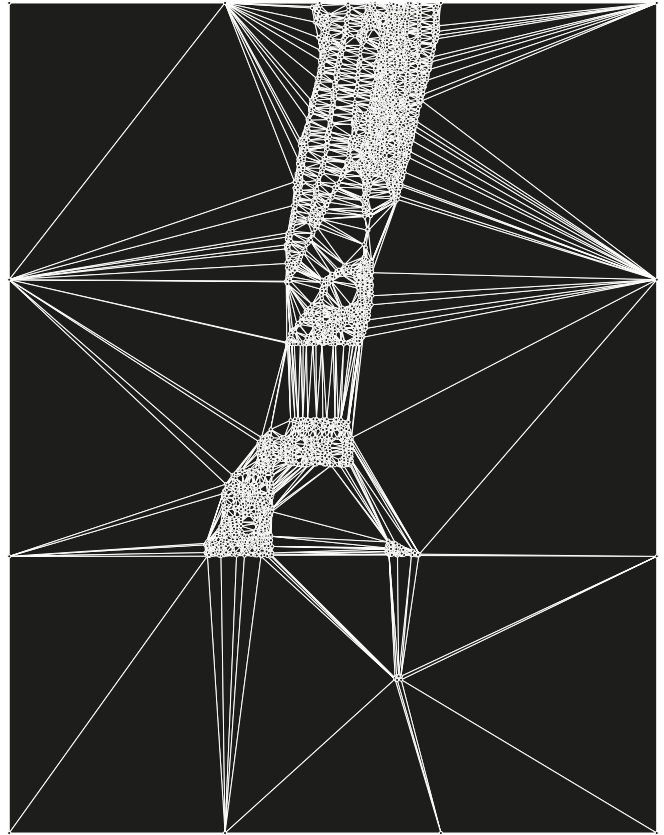
Zaragoza, Spain - 2008

40





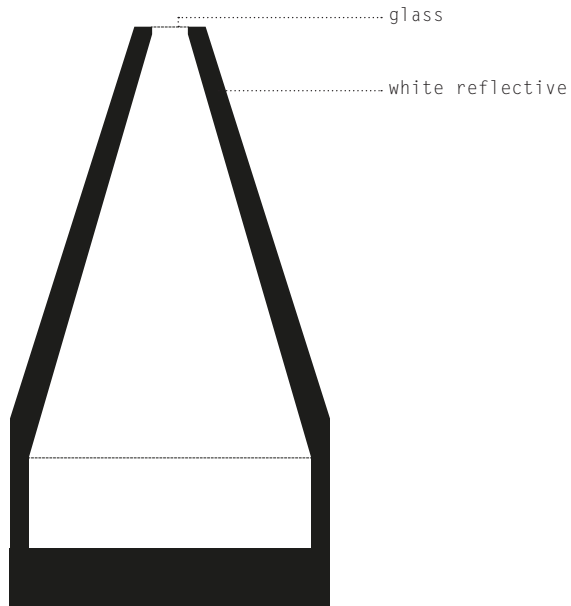




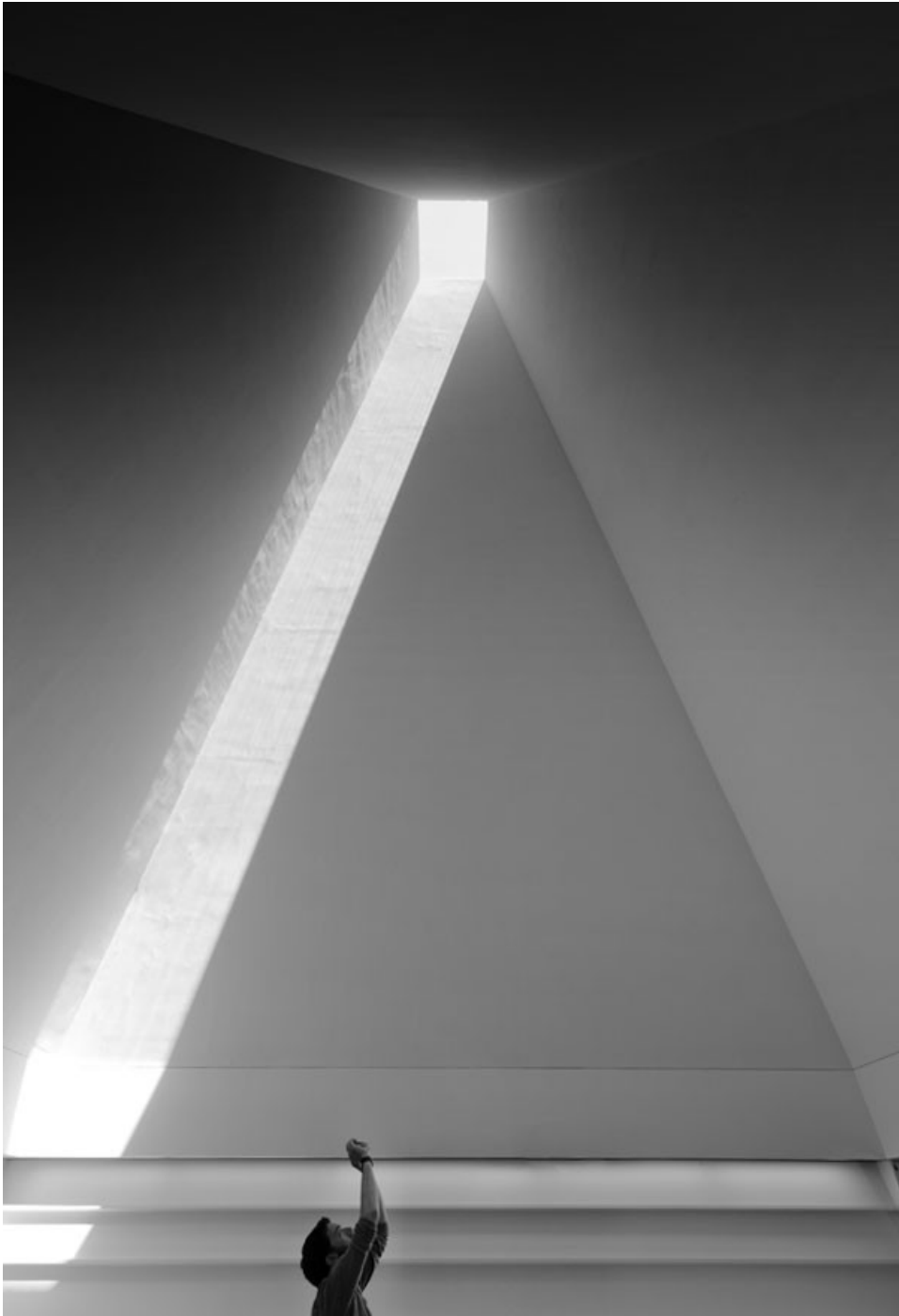
Focused on Lightness
0.82 Threshold - 0.06 Tolerance

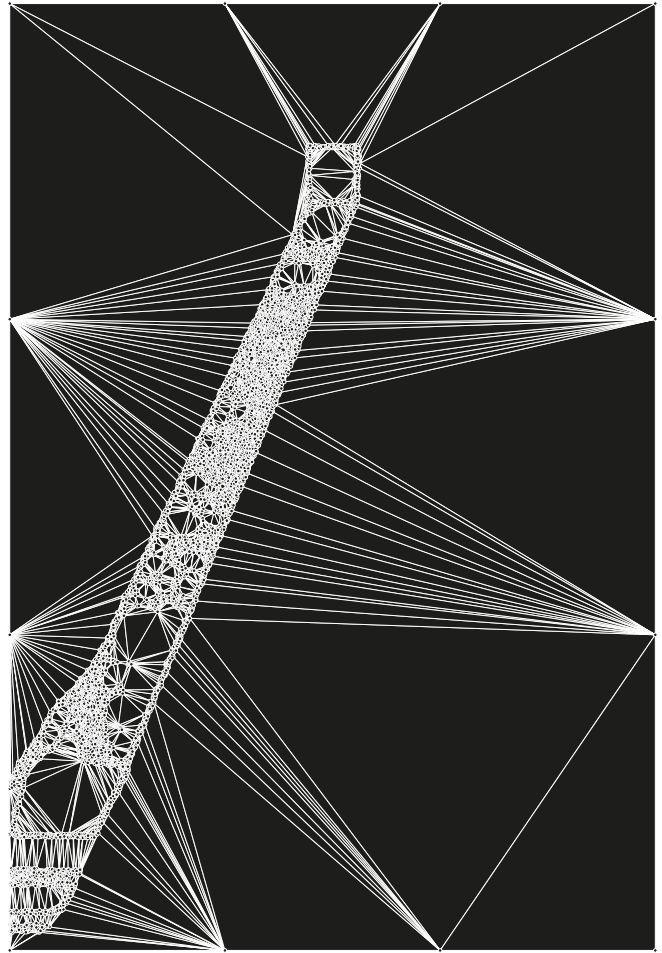
Casa das Histórias Paula Rego

Function: Museum
Architect: Eduardo Souto de Moura
Cascais, Portugal - 2009





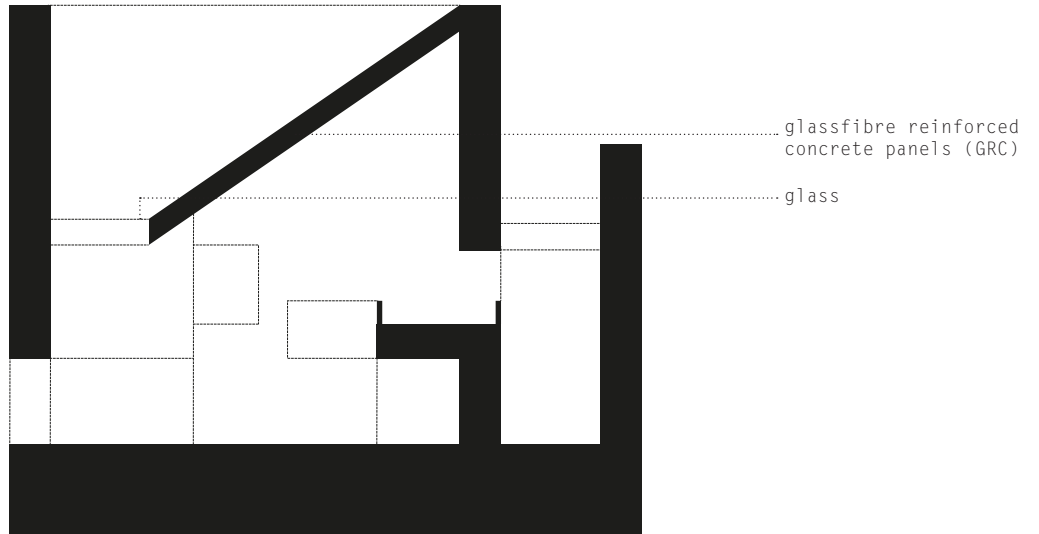




Focused on Lightness
0.86 Threshold - 0.04 Tolerance

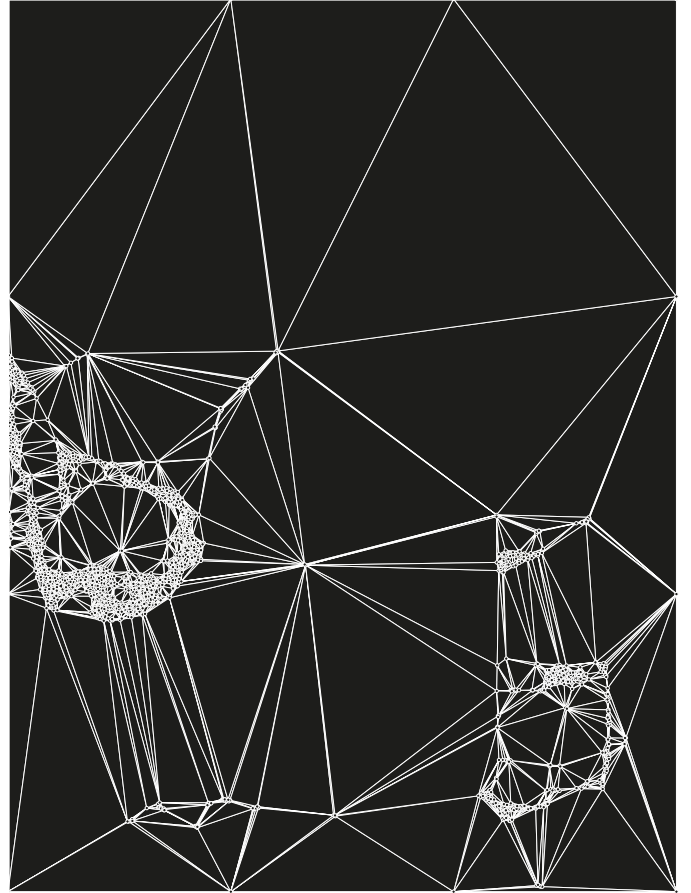
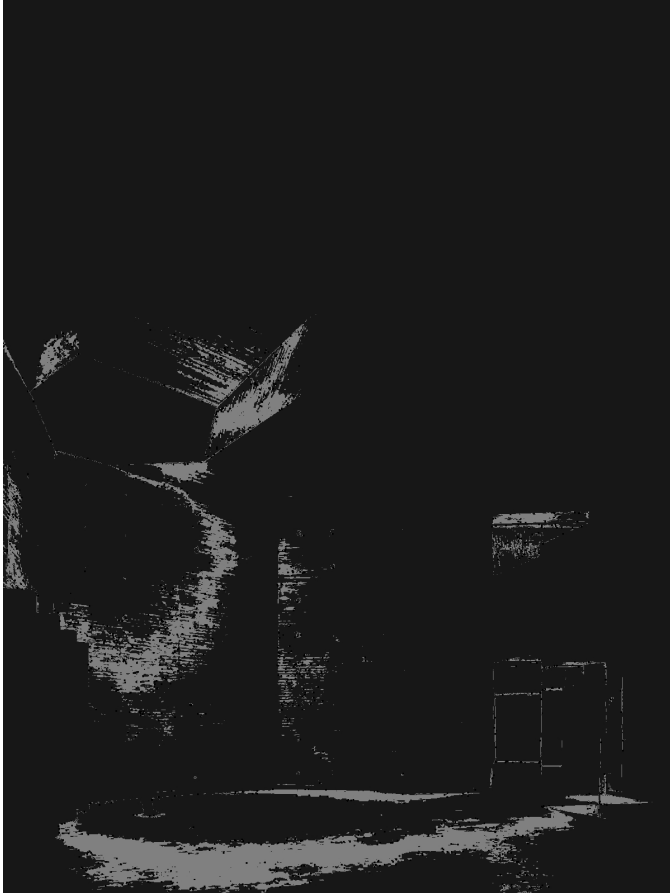
Contemporary Art Centre

Function: Art centre
Architect: Nieto Sobejano Arquitectos
Córdoba, Spain - 2013





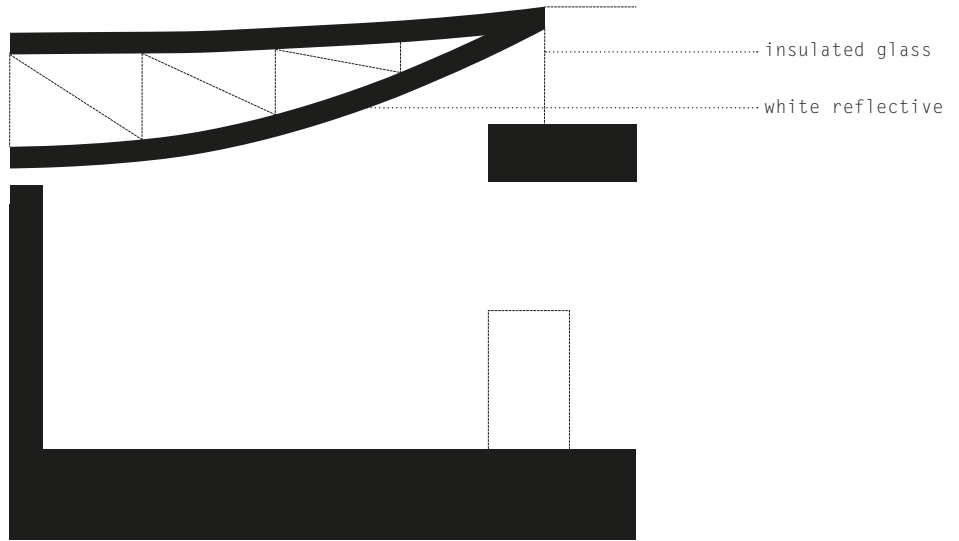




Focused on Lightness
0.68 Threshold - 0.06 Tolerance

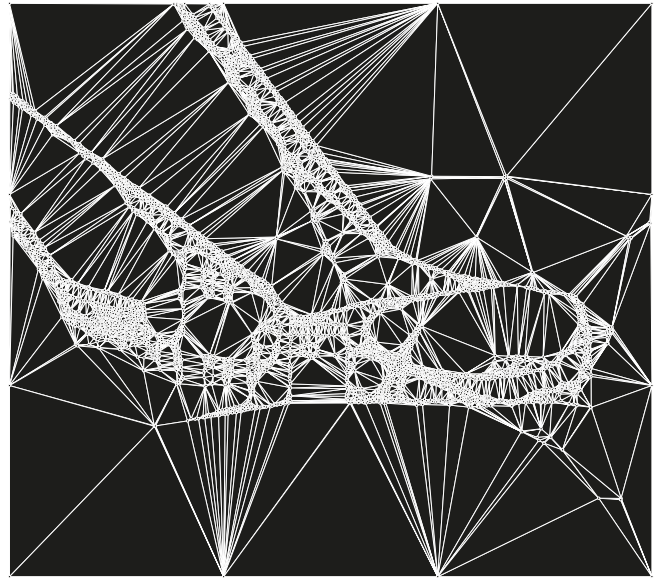
Herning Museum of Contemporary Art

Function: Art centre
Architect: Steven Holl
Herning, Denmark - 2009





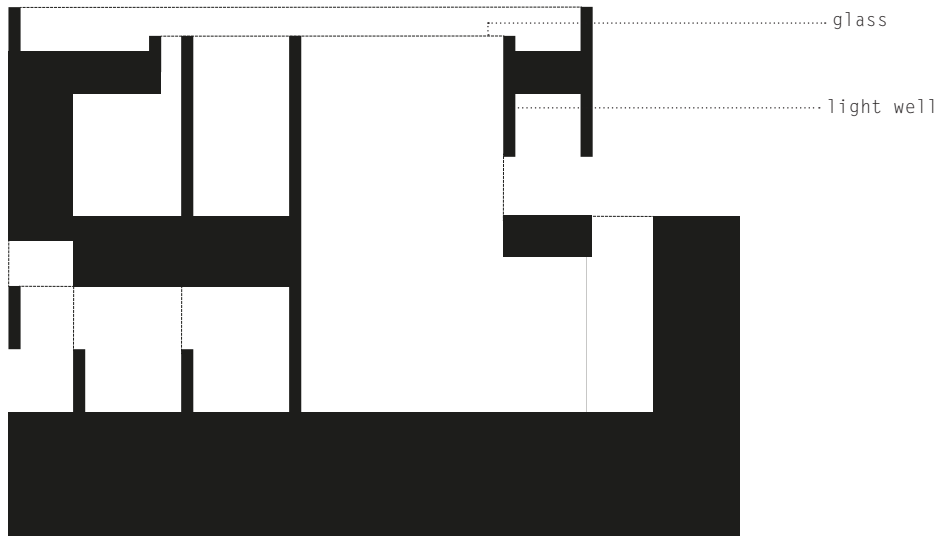




Focused on Lightness
0.86 Threshold - 0.03 Tolerance

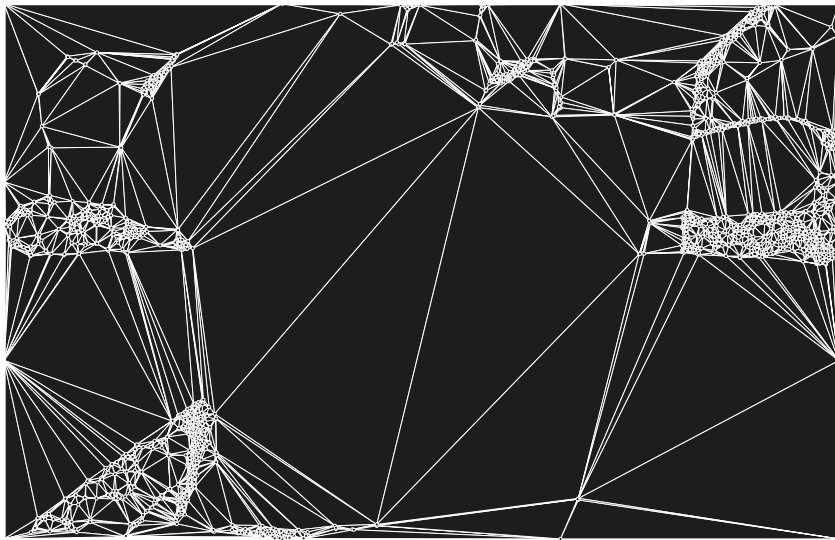
Fernando Botero Library Park

Function: Library / theatre
Architect: G Ateliers Architecture
Medellín, Colombia - 2009





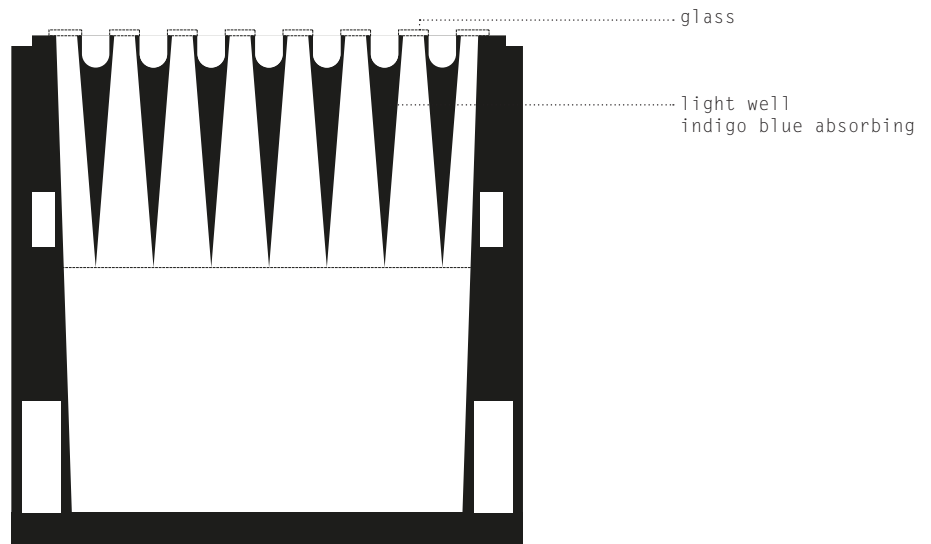


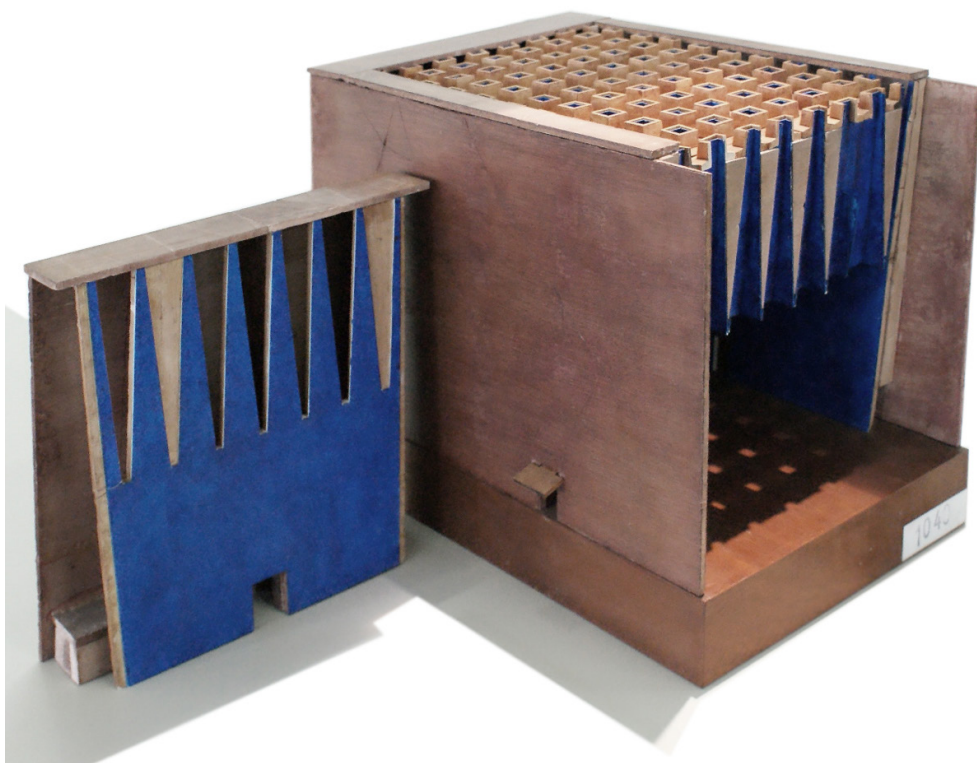


Focused on Lightness
0.65 Threshold - 0.06 Tolerance

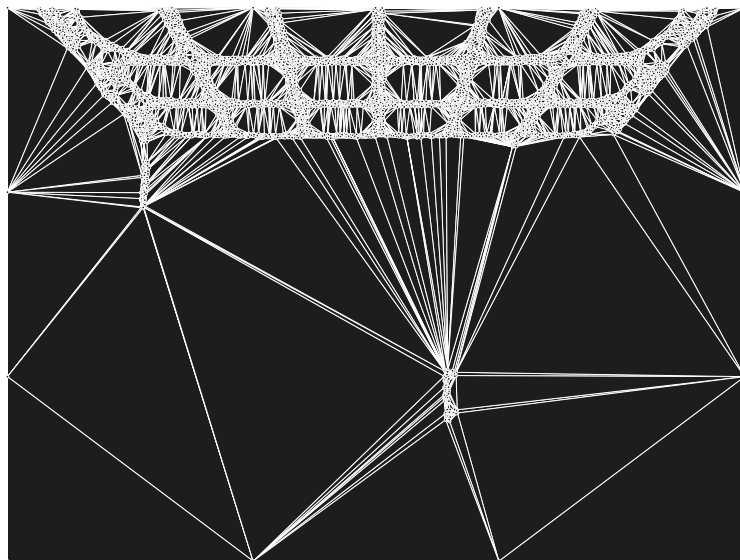
Herz Jesu Kirche

Function: Church
Architect: Peter Zumthor
Munich, Germany - 1996 (*unbuilt*)







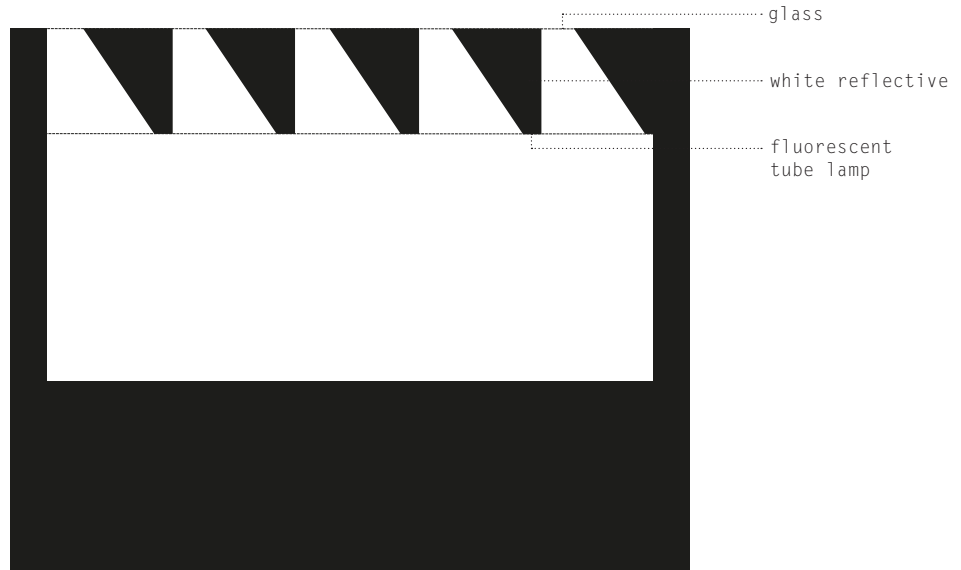


Focused on Lightness
0.65 Threshold - 0.06 Tolerance

Nottingham Contemporary

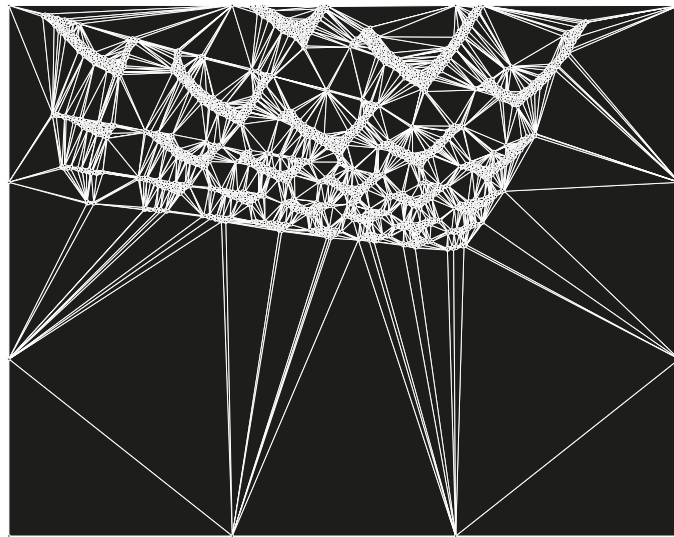
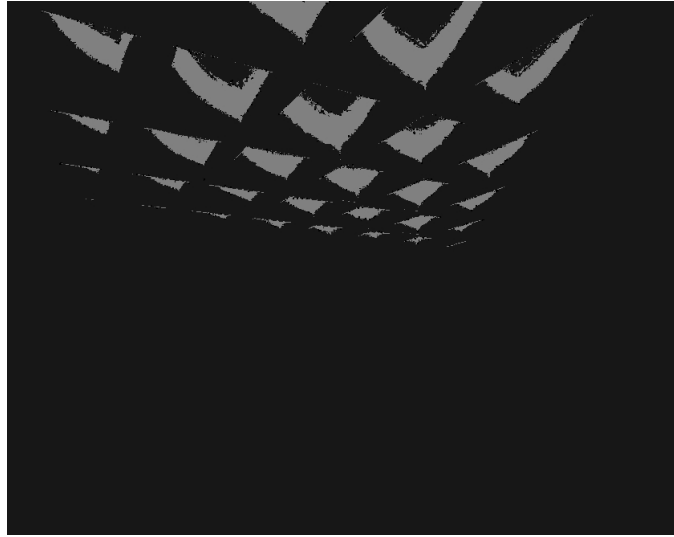
Function: Museum

Architect: Caruso St. John Architects
Nottingham, Great Britain - 2009





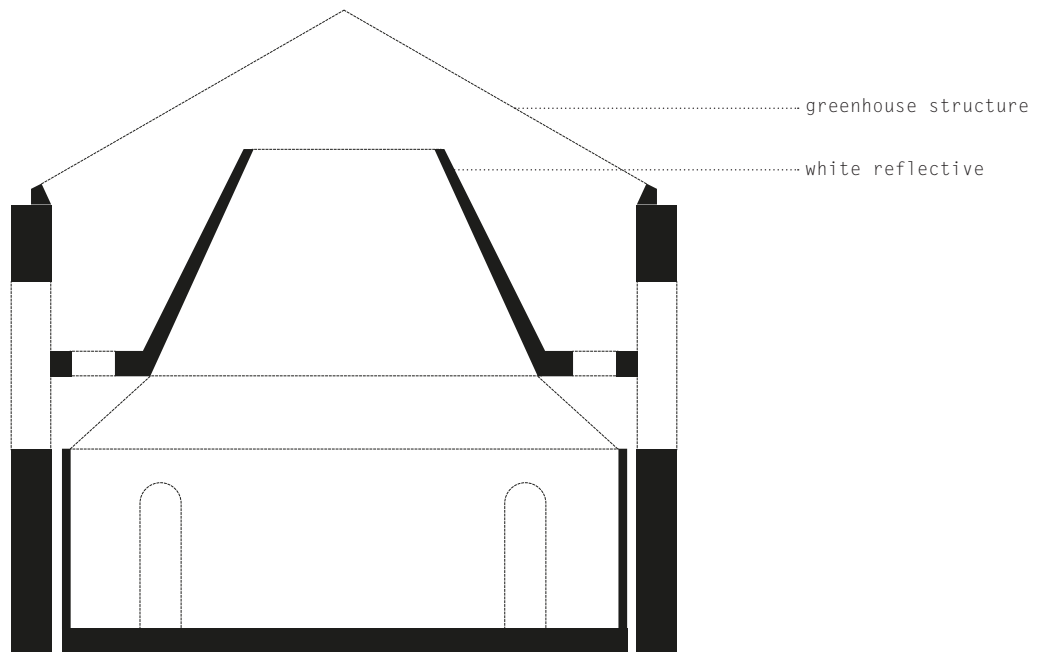




Focused on Lightness
0.95 Threshold - 0.04 Tolerance

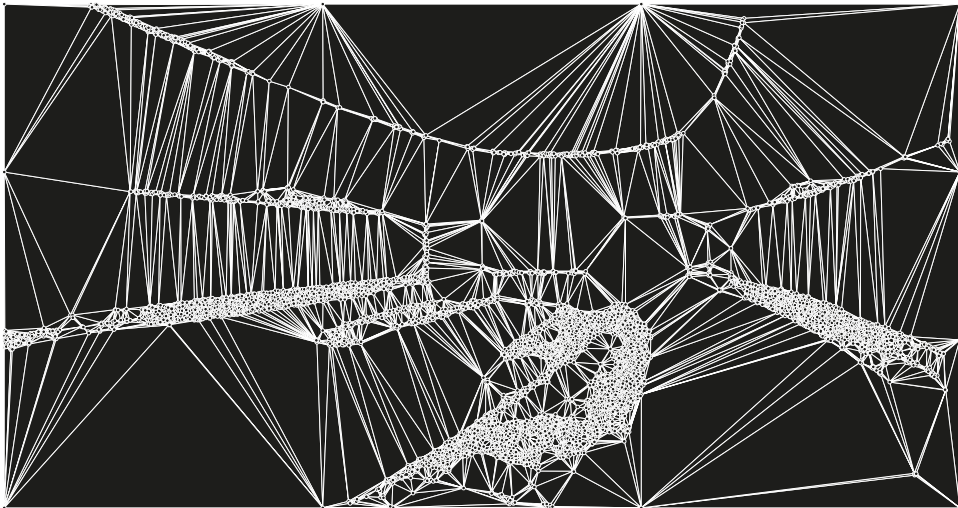
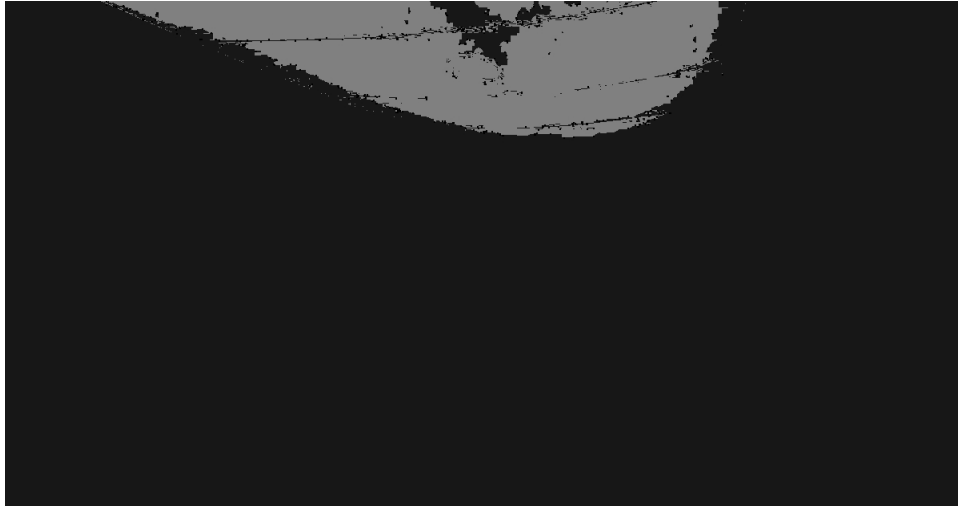
Musée de l'Orangerie

Function: Museum
Architect: Olivier Brochet
Paris, France - 2006 (renovation)





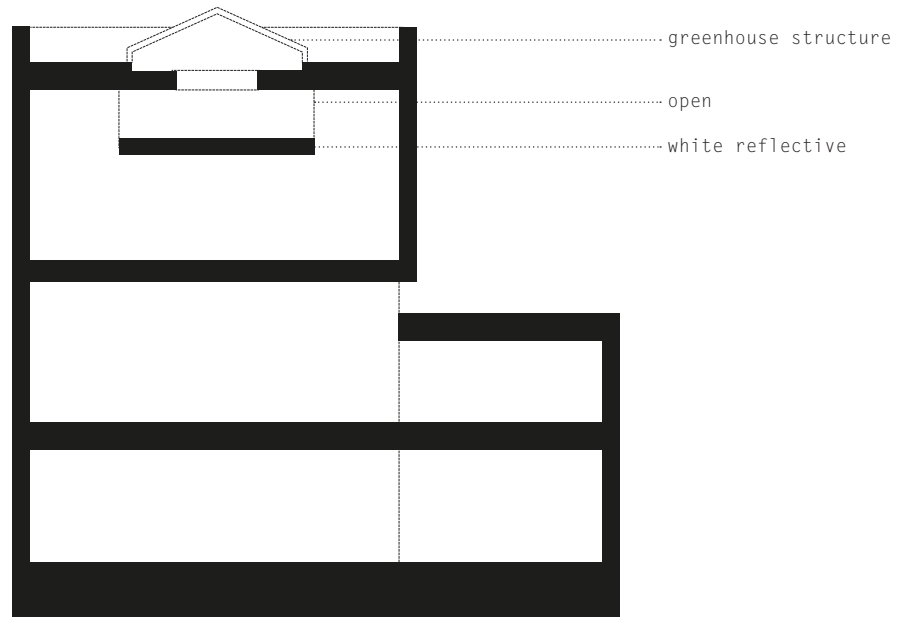




Focused on Lightness
0.95 Threshold - 0.04 Tolerance

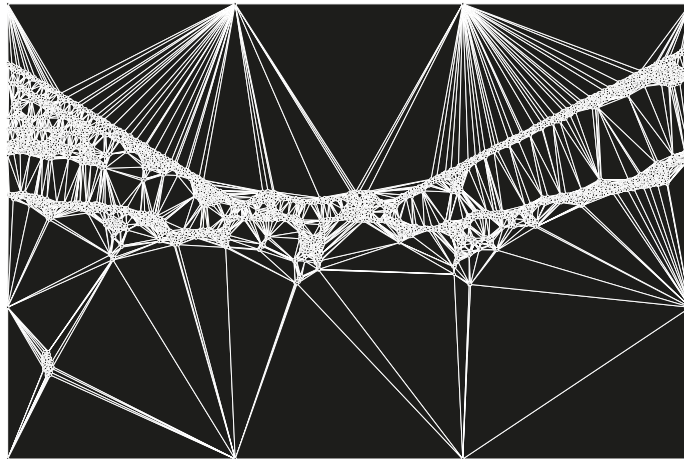
CGAC . Centro Galego de Arte Contemporânea

Function: Museum
Architect: Álvaro Siza
Santiago de Compostela, Spain - 1993







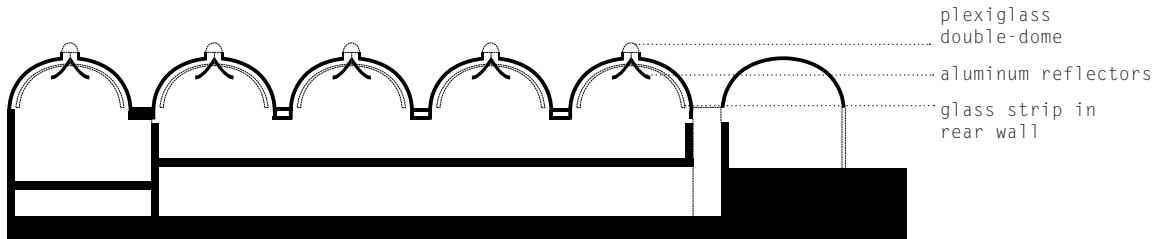


Focused on Lightness
0.87 Threshold - 0.05 Tolerance

Kimbell Art Museum

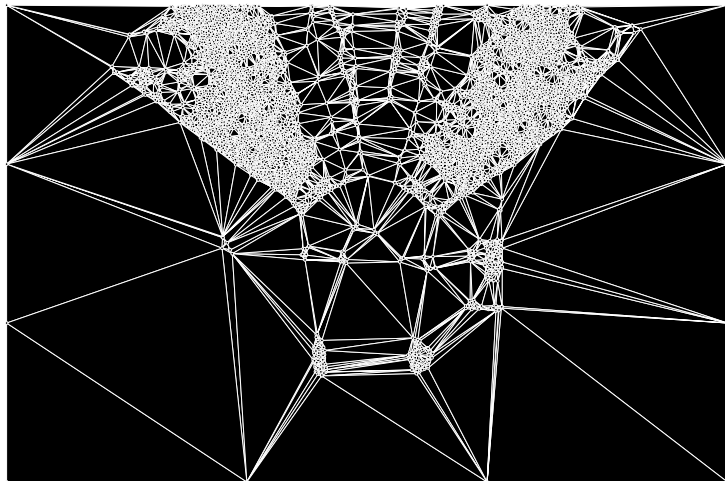
Function: Museum
Architect: Louis Kahn
Texas, United States - 1972

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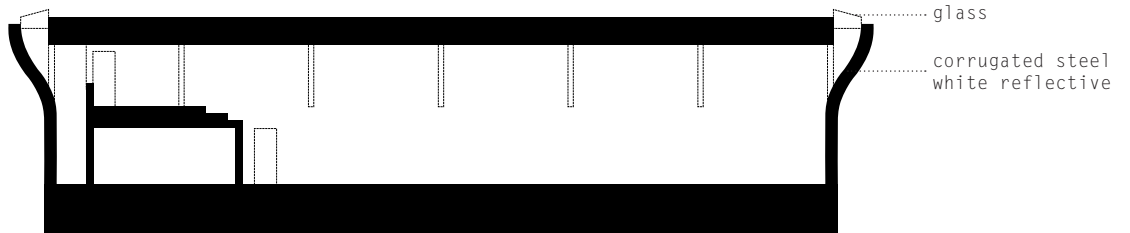


Focused on Lightness
0.86 Threshold - 0.05 Tolerance

Gym Hall TNW

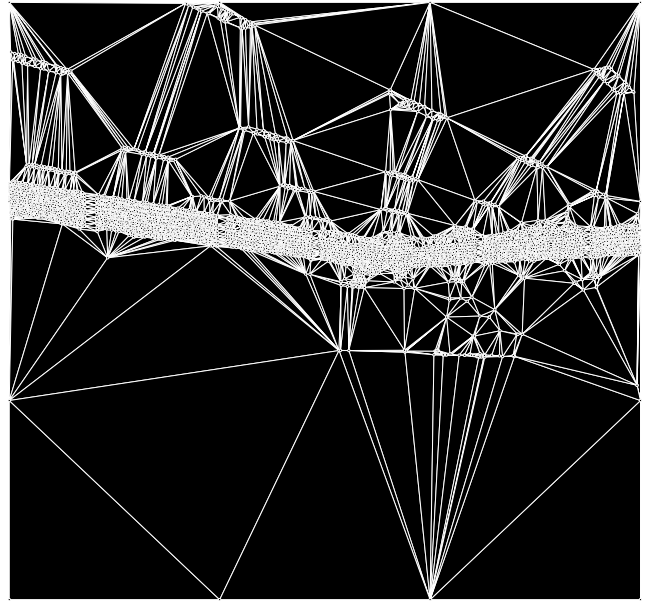
Function: Gymnastics hall
Architect: NL Architects
Utrecht, The Netherlands - 2011

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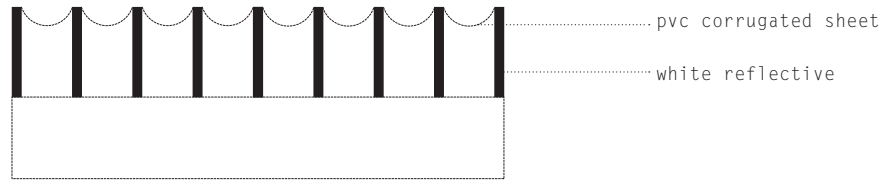




Focused on Lightness
0.93 Threshold - 0.07 Tolerance

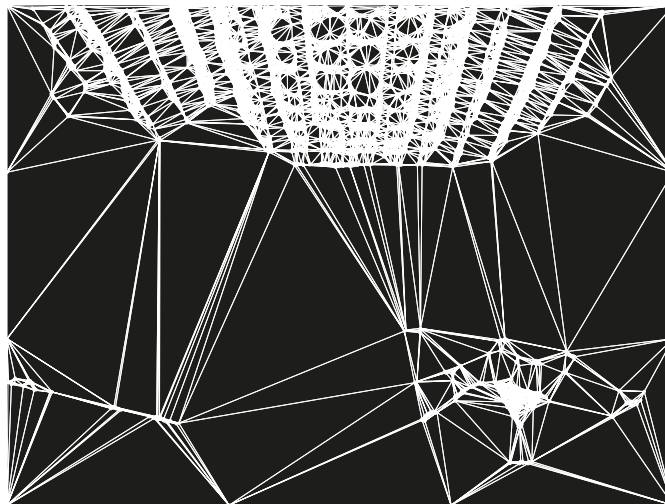
Nordic Pavilion Venice Biennale

Function: Pavilion Biennale
Architect: Sverre Fehn
Venice, Italy - 1962





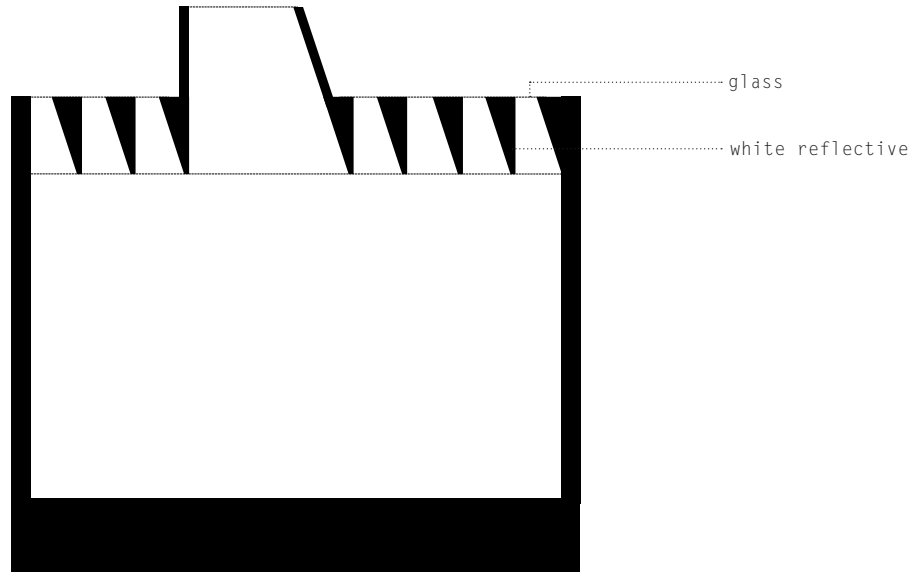


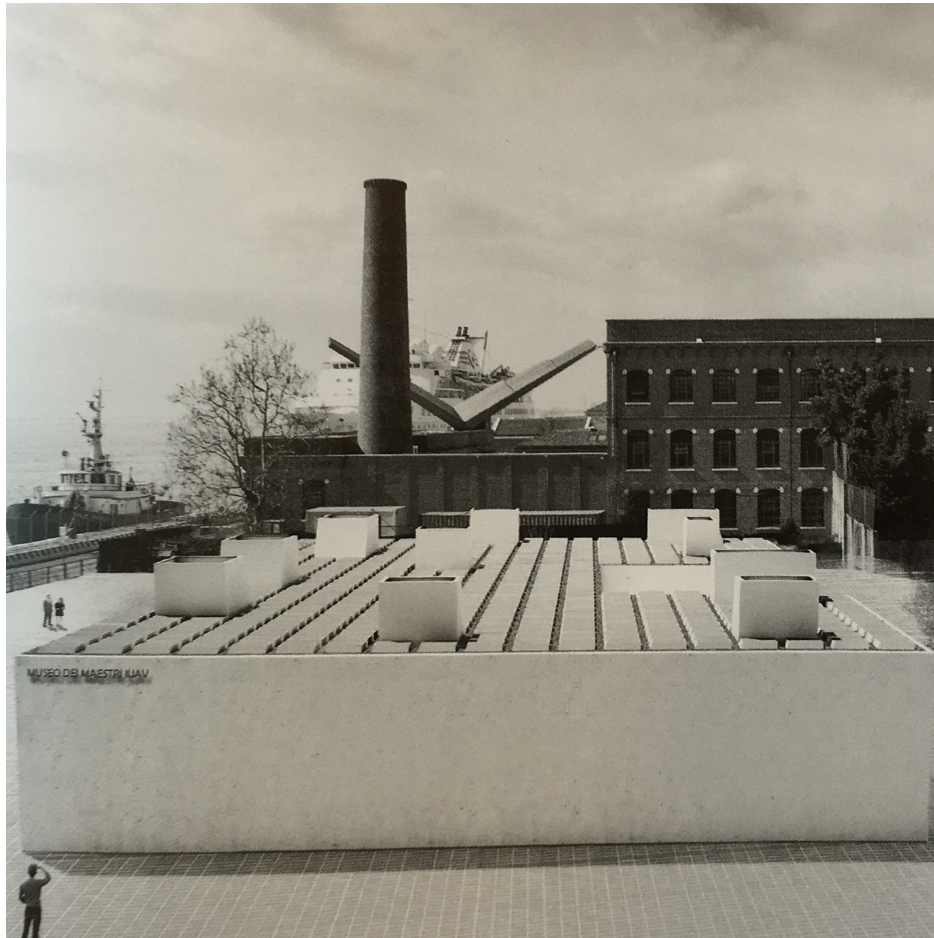


Focused on Lightness
0.75 Threshold - 0.04 Tolerance

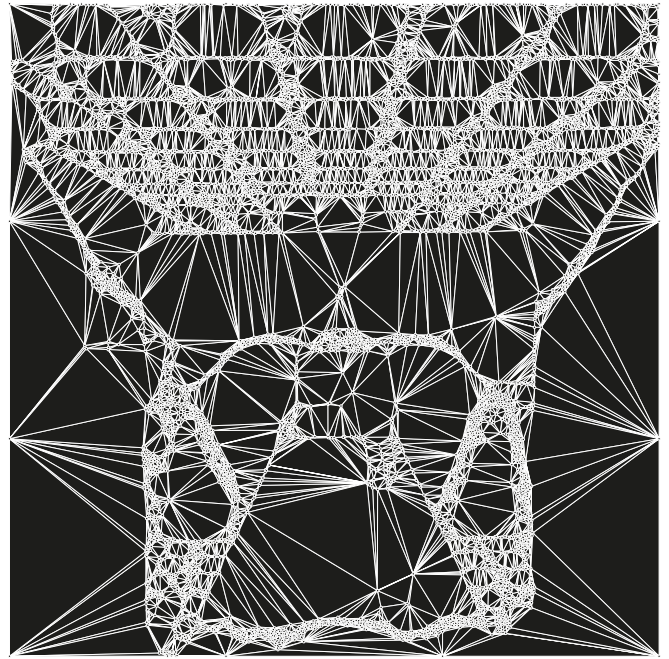
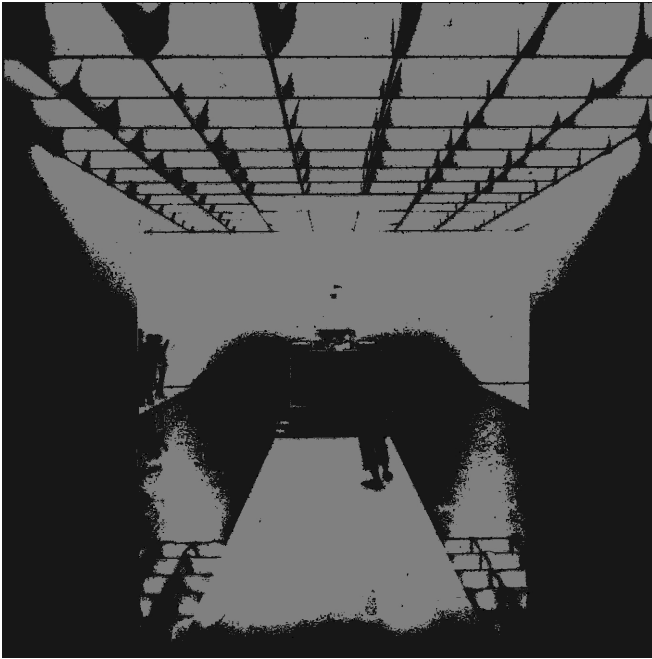
Museo dei Maestri IUAV . Sala Aldo Rossi

Function: Museum
Architect: Niki Maragkoudaki
Venice, Italy - 2013 (unbuilt)





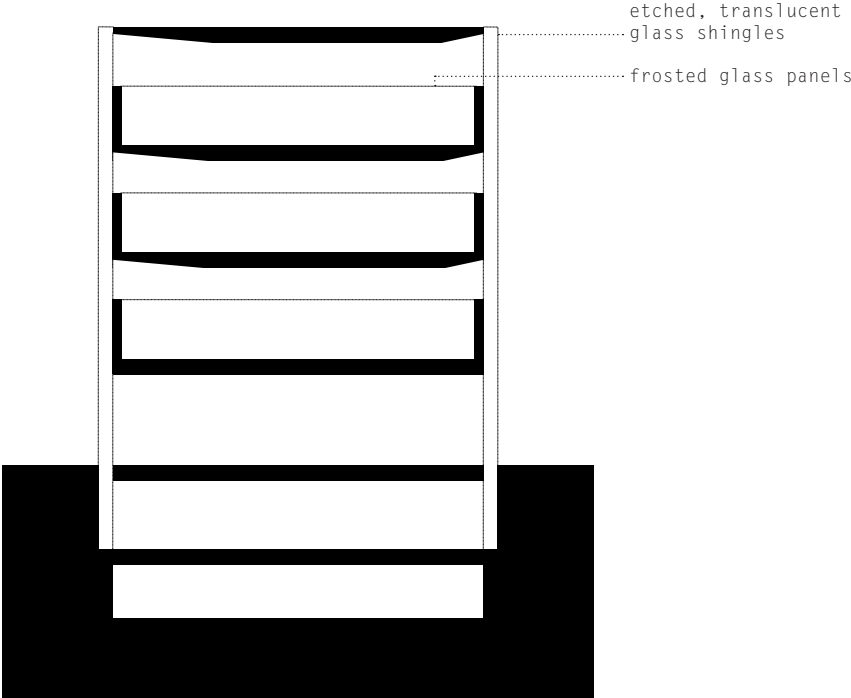




Focused on Lightness
0.98 Threshold - 0.02 Tolerance

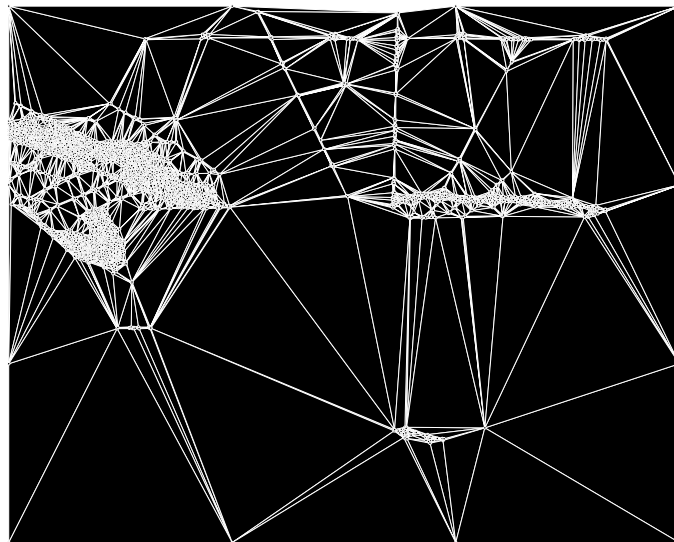
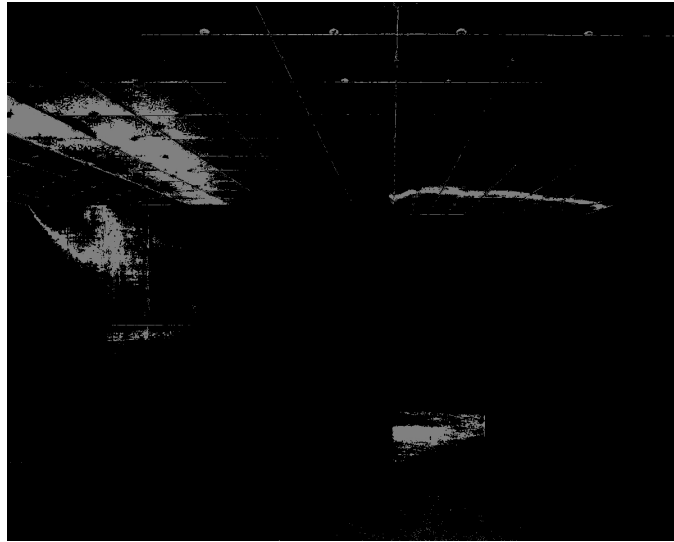
KunsthauB Bregenz

Function: Museum
Architect: Peter Zumthor
Bregenz, Austria - 1997









Focused on Lightness
0.75 Threshold - 0.06 Tolerance

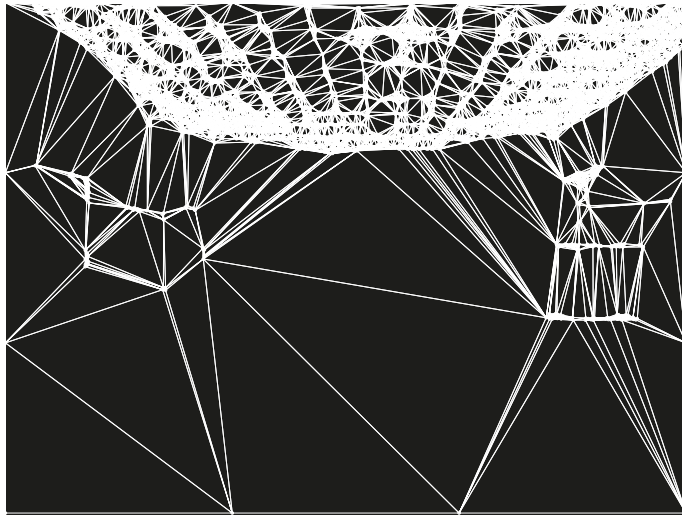
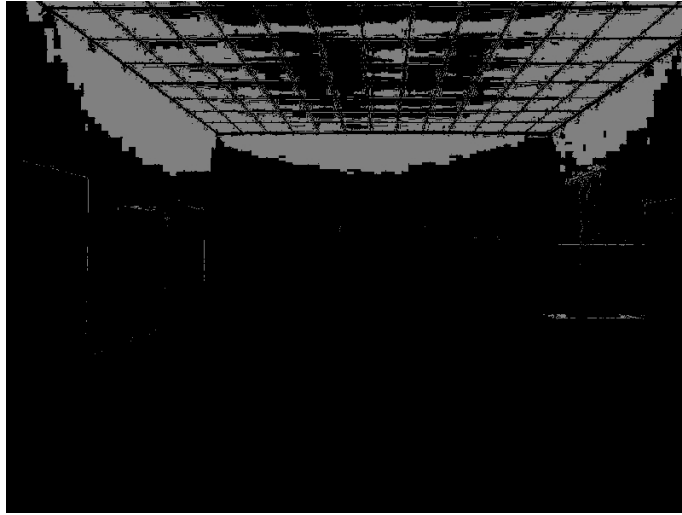
Kirchner Museum Davos

Function: Museum
Architect: Annette Gigon and Mike Guyer
Davos, Austria - 1992





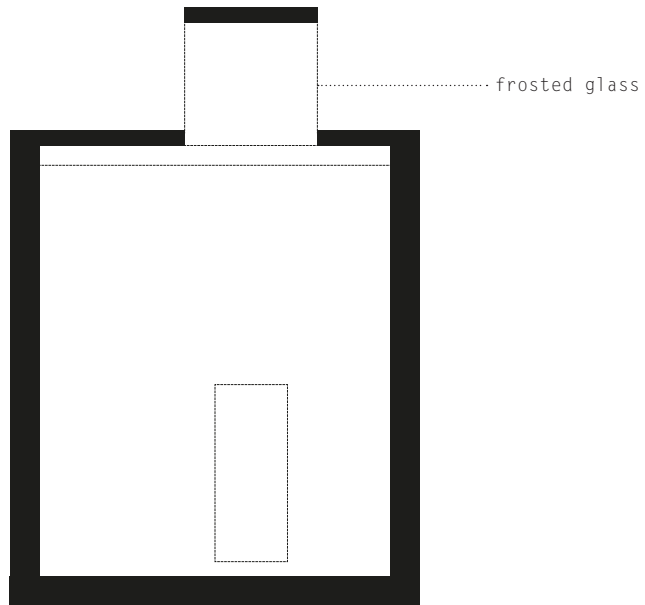




Focused on Lightness
0.89 Threshold - 0.05 Tolerance

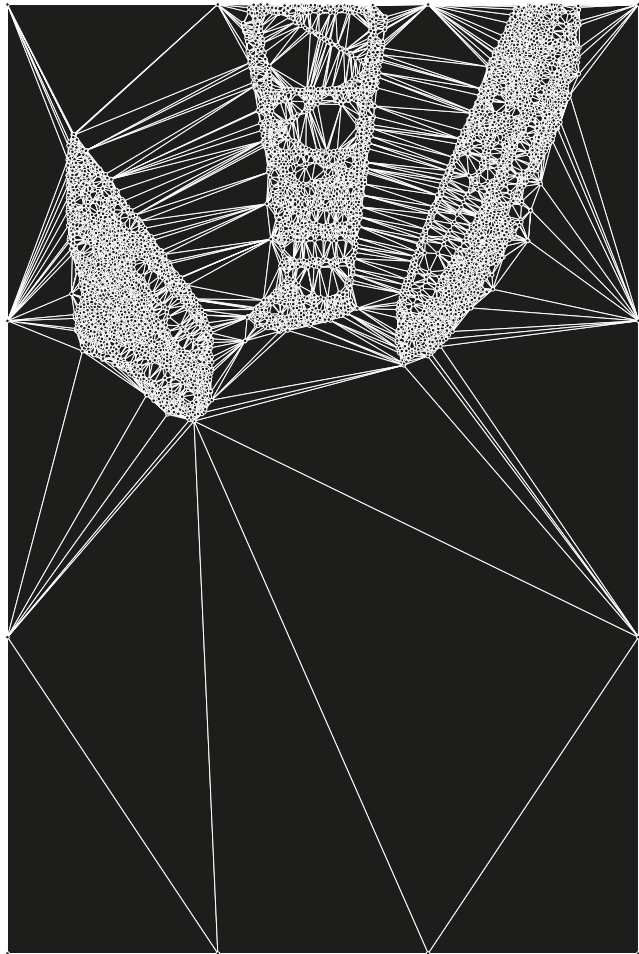
Museum La Congiunta

Function: Museum
Architect: Peter Märkli
Giornico, Switzerland - 1992







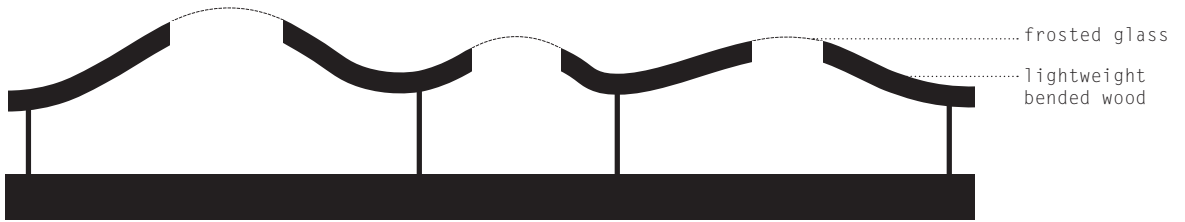


Focused on Lightness
0.70 Threshold - 0.04 Tolerance

Guggenheim Helsinki Design Competition

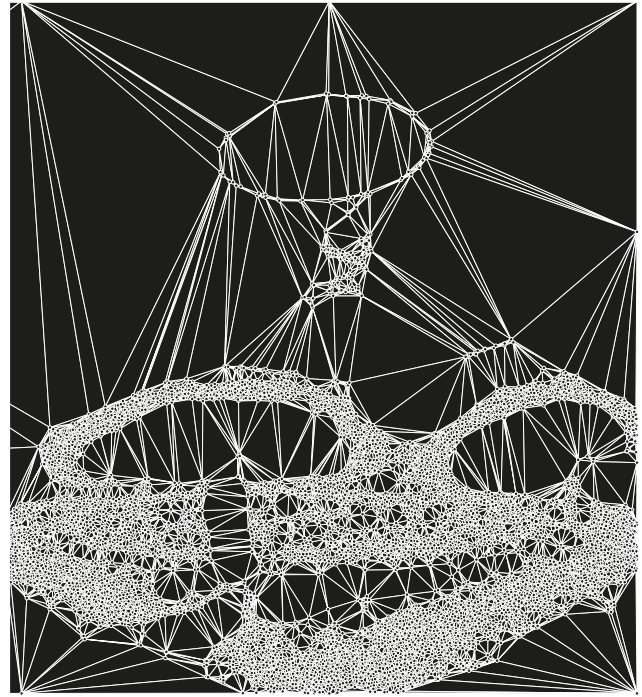
Function: Museum
Architect: Karol Zurawski
Helsinki, Finland - 2014 (*unbuilt*)

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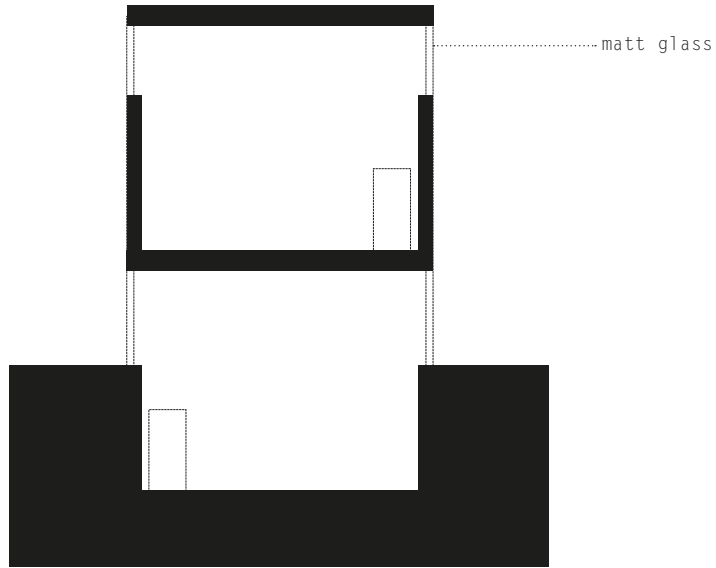




Focused on Lightness
0.78 Threshold - 0.04 Tolerance

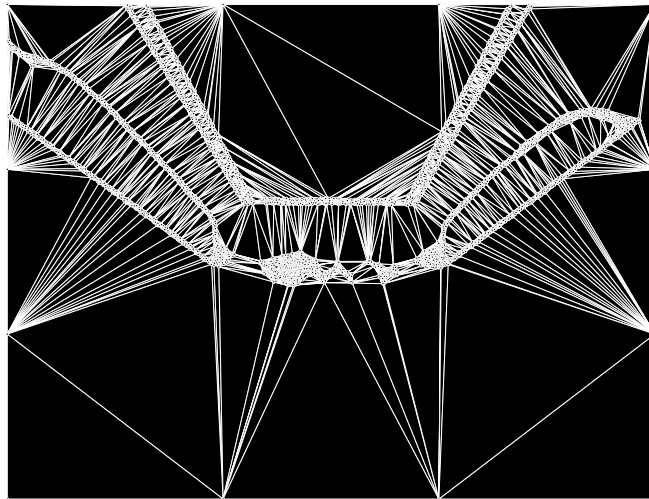
Sammlung Goetz

Function: Museum
Architect: Herzog & de Meuron
Munich, Germany - 1992





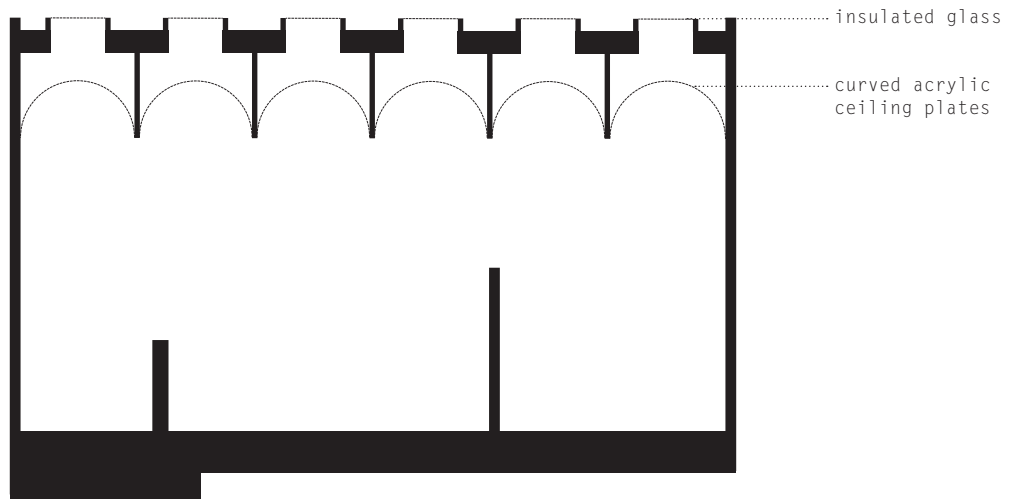




Focused on Lightness
0.93 Threshold - 0.08 Tolerance

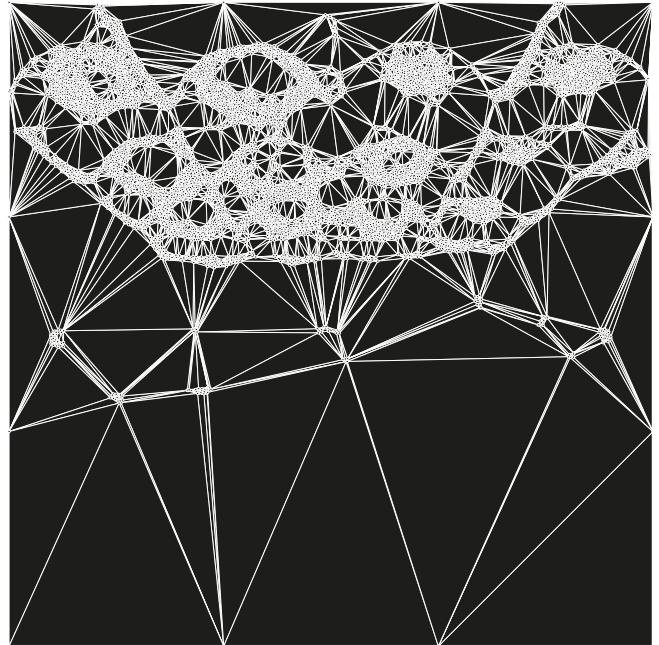
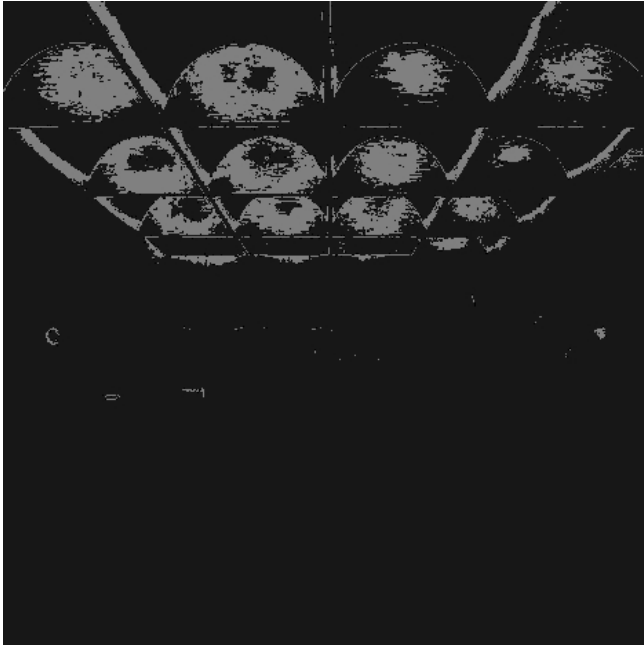
Daylight House

Function: Residential house
Architect: Takeshi Hosaka
Yokohama, Japan - 2011









Focused on Lightness
0.80 Threshold - 0.05 Tolerance

rebound

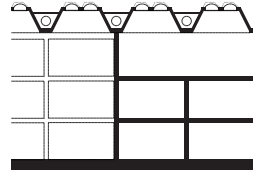
- 1 *Yale Center for British Art*
Connecticut, United States
TH: 0.75 - TO: 0.03
- 2 *Centro das Artes Casa das Mudas*
Madeira, Portugal
TH: 0.93 - TO: 0.07
- 3 *Pajol Sports Centre*
Paris, France
TH: 0.74 - TO: 0.08
- 4 *Beyeler Foundation*
Riehen, Switzerland
TH: 0.88 - TO: 0.02
- 5 *Rotterdam Central Station*
Rotterdam, The Netherlands
TH: 0.88 - TO: 0.07
- 6 *Museo dei Maestri IUAV Sala Aldo Rossi*
Venice, Italy
TH: 0.89 - TO: 0.05
- 7 *Museo Provincial de Zamora*
Zamora, Spain
TH: 0.75 - TO: 0.09
- 8 *Congress Centre of Aragón Expo 2008*
Zaragoza, Spain
TH: 0.82 - TO: 0.06

reflection

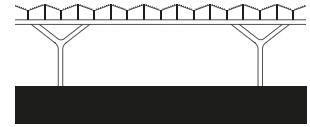
- 9 *Casa das Histórias Paula Rego*
Cascais, Portugal
TH: 0.86 - TO: 0.04
- 10 *Contemporary Art Centre*
Córdoba, Spain
TH: 0.68 - TO: 0.06
- 11 *Herning Museum of Contemporary Art*
Herning, Denmark
TH: 0.86 - TO: 0.03
- 12 *Fernando Botero Library Park*
Medellín, Colombia
TH: 0.65 - TO: 0.06
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- 16 *CGAC - Centro Galego de Arte Contemporânea*
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- 19 *Nordic Pavilion Venice Biennale*
Venice, Italy
TH: 0.75 - TO: 0.04
- 20 *Museo dei Maestri IUAV Sala Aldo Rossi*
Venice, Italy
TH: 0.98 - TO: 0.02

filtration

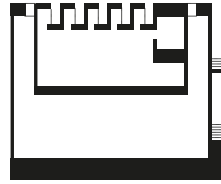
- 21 *Kunsthau Bregenz*
Bregenz, Austria
TH: 0.75 - TO: 0.06
- 22 *Kirchner Museum Davos*
Davos, Austria
TH: 0.89 - TO: 0.05
- 23 *Museum La Congiunta*
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- 25 *Sammlung Goetz*
Munich, Germany
TH: 0.93 - TO: 0.08
- 26 *Daylight House*
Yokohama, Japan
TH: 0.80 - TO: 0.05



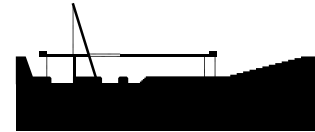
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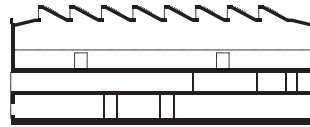
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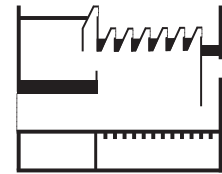
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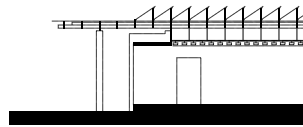
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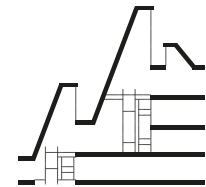
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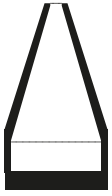


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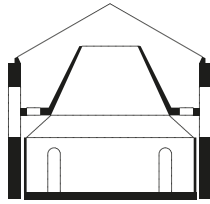


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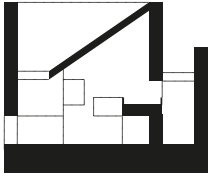
REFLECTION



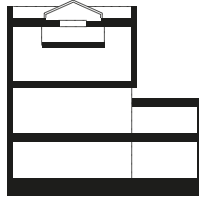
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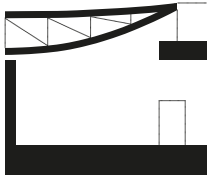
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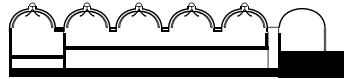
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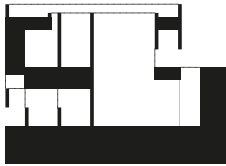
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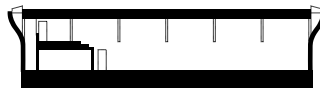
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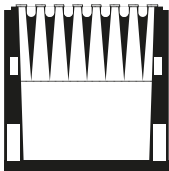
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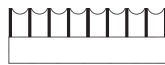
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18



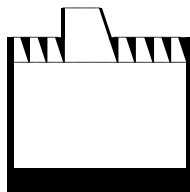
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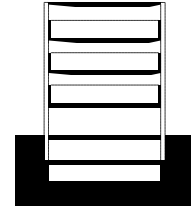


14



20

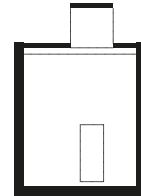
FILTRATION



21



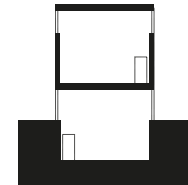
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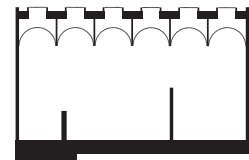
23



24



25



26

rebound

- 1 *Yale Center for British Art*
Connecticut, United States
TH: 0.75 - TO: 0.03
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Zamora, Spain
TH: 0.75 - TO: 0.09
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Zaragoza, Spain
TH: 0.82 - TO: 0.06

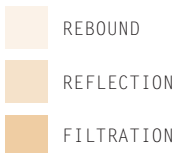
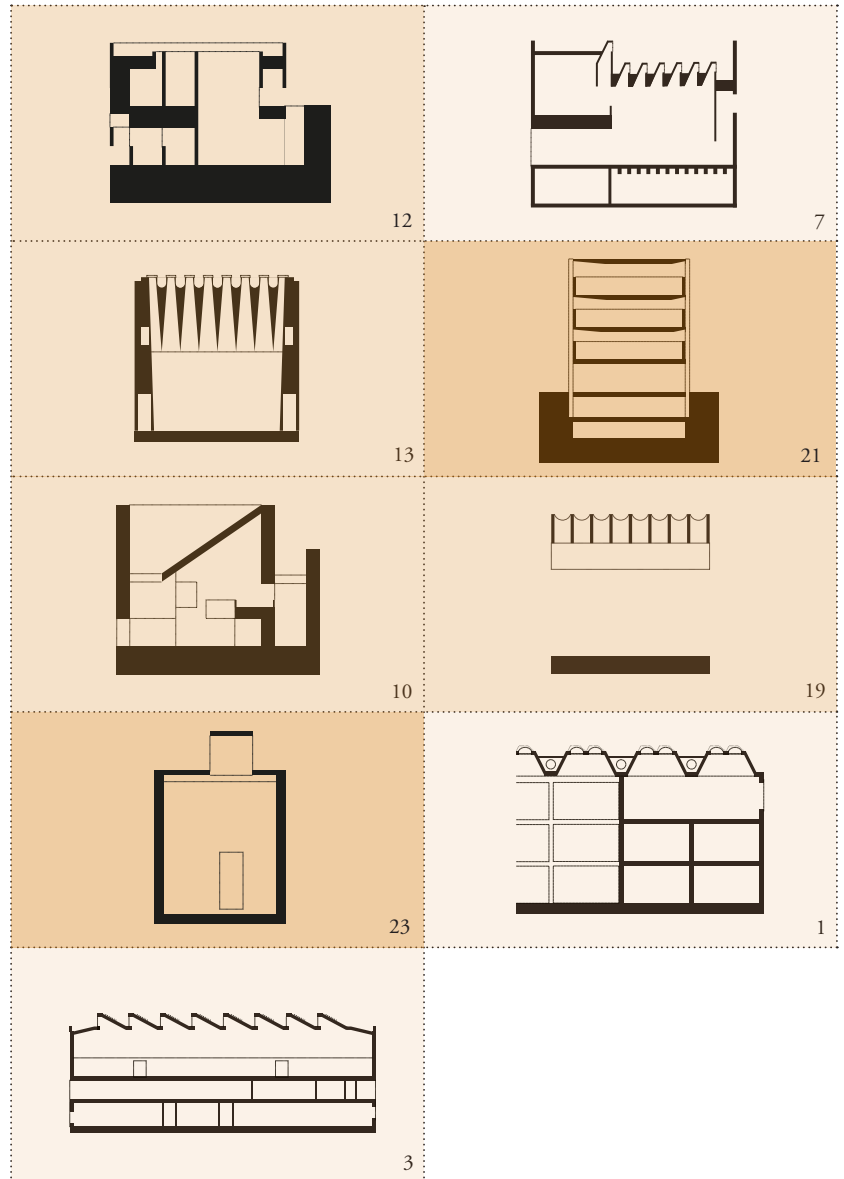
reflection

- 9 *Casa das Histórias Paula Rego*
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filtration

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Yokohama, Japan
TH: 0.80 - TO: 0.05

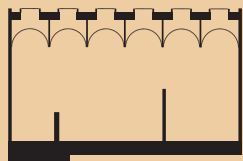


TH MEDIUM [0.76-0.86] ; TO MEDIUM [HIGH-LOW]

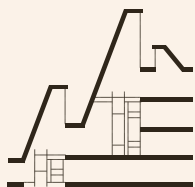
TH HIGH [0.87-1.00] ; TO LOW [HIGH-LOW]



24



26



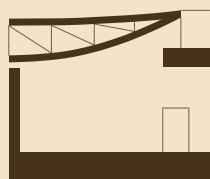
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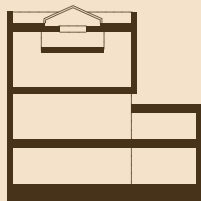
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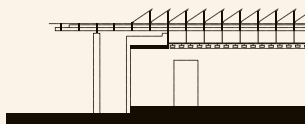
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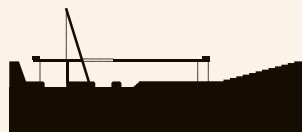
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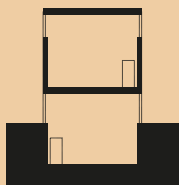
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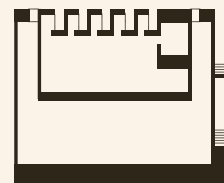
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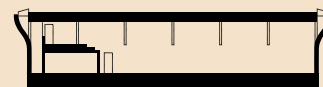
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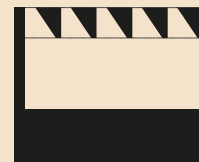
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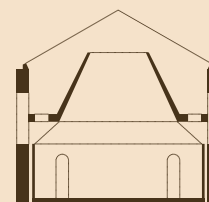
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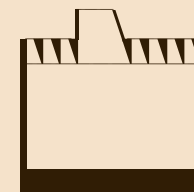
18



14



15



20

125

rebound

- 1 *Yale Center for British Art*
Connecticut, United States
TH: 0.75 - TO: 0.03
- 2 *Centro das Artes Casa das Mudas*
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Zaragoza, Spain
TH: 0.82 - TO: 0.06

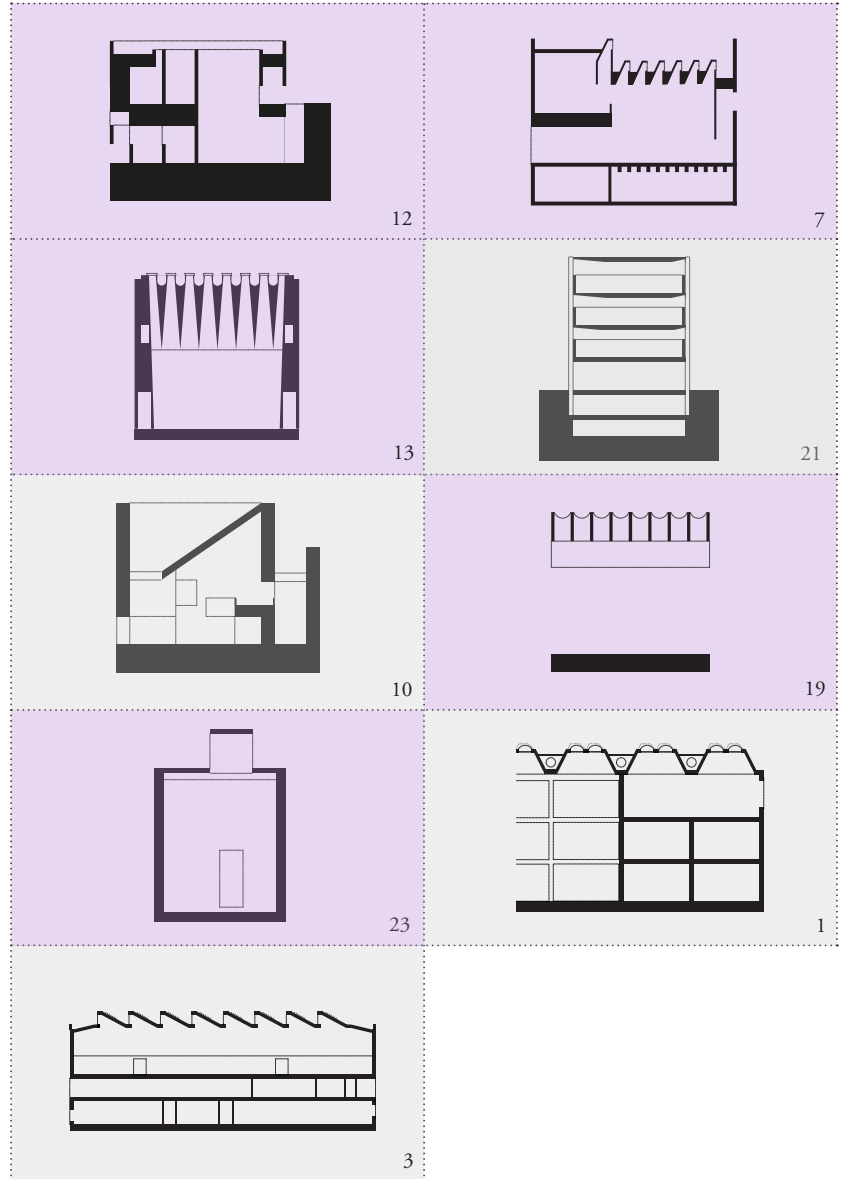
reflection

- 9 *Casa das Histórias Paula Rego*
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Venice, Italy
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filtration

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- 26 *Daylight House*
Yokohama, Japan
TH: 0.80 - TO: 0.05



REFLECTIVE CEILING

REFLECTIVE FLOOR

REFLECTIVE WALLS

REFLECTIVE CEILING + WALLS

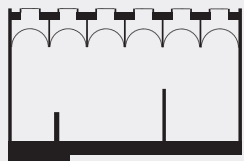
REFLECTIVE CEILING + WALLS + FLOOR

TH MEDIUM [0.76-0.86] ; TO MEDIUM [HIGH-LOW]

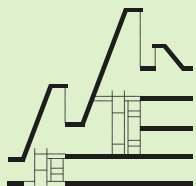
TH HIGH [0.87-1.00] ; TO LOW [HIGH-LOW]



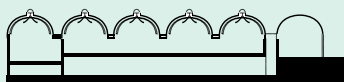
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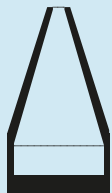
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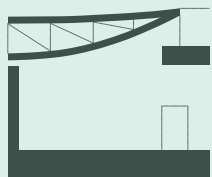
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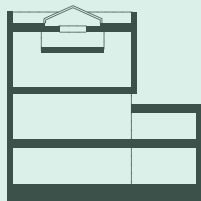
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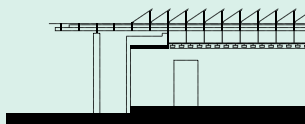
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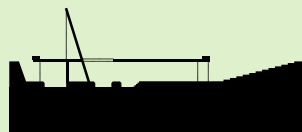
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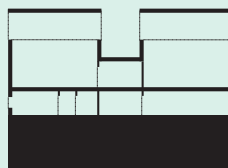
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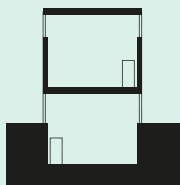
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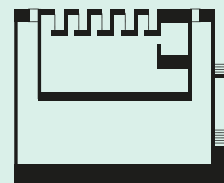
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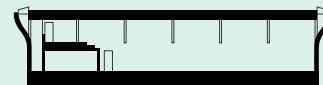
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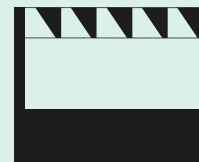
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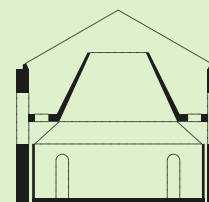
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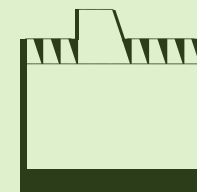
18



14



15



20

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	TH LOW TO HIGH	TH MEDIUM TO MEDIUM	TH HIGH TO LOW
REBOUND	$3/8 = 9/24$	$1/8 = 3/24$	$4/8 = 12/24$
REFLECTION	$4/12 = 8/24$	$3/12 = 6/24$	$5/12 = 10/24$
FILTRATION	$2/6 = 8/24$	$2/6 = 8/24$	$2/6 = 8/24$
	↓ <i>most rebound</i>	↓ <i>most filtration</i>	↓ <i>most rebound</i>

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	TH LOW TO HIGH	TH MEDIUM TO MEDIUM	TH HIGH TO LOW
REFLECTIVE CEILING	$5/5 = 20/20$	$0/5 = 0/20$	$0/5 = 0/20$
REFLECTIVE FLOOR	$4/5 = 16/20$	$1/5 = 4/20$	$0/5 = 0/20$
REFLECTIVE WALLS	$0/2 = 0/20$	$2/2 = 20/20$	$0/2 = 0/20$
REFLECTIVE CEILING + WALLS	$0/10 = 0/20$	$2/10 = 4/20$	$8/10 = 16/20$
REFLECTIVE CEILING + WALLS + FLOOR	$0/4 = 0/20$	$1/4 = 5/20$	$3/4 = 15/20$
	↓ <i>most reflection ceiling</i>	↓ <i>most reflection walls</i>	↓ <i>most reflection ceiling + walls</i>

CONCLUSION

The different sunshading projects are placed in order of the intensity of light in the building (*based on an interior photograph representing the project*). The light intensity is higher when the Threshold is higher and the Tolerance lower.

Linking this order to the characteristics of the different projects, it becomes visible that it doesn't matter if the sunshading system is based on a ***rebound, reflection or filtration system***. The filtration system is with the same number (8/24) represented in the "TH low - TO high", "TH medium - TO medium" and "TH high - TO low" groups. The differences of amount in these groups of the rebound and reflection systems are negligible.

By contrast the effects of ***various reflective surfaces*** in the projects are much more noticeable. The table shows that the combination of reflective ceiling, walls and floor, is the most important in controlling the daylight coming into the space. Beside the table shows that reflective walls have more effect on the light intensity than a reflective floor.

Three important design recommendations can be extracted from this database:

1. **The difference in reflective surfaces has more influence on the light intensity in the building, than the difference in type of sunshading system (rebound, reflection or filtration);**
2. **Reflective walls have more effect on the light intensity than a reflective floor. This indicates to the designer: keep the walls as light in color as possible and use the floor surface for deep colors or character-giving patterns;**
3. **To create an interesting interior with a pleasant light intensity, the sunshading system has to be composed of several different layers.**

