Fire resistance in a sunshading element

as an alternative design solution for fire retardant glazing

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AR3B025

Graduation presentation
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TU Delft

0. Introductie

Op welke manier is het mogelijk om zonwering te gebruiken als een brandwerend element, zodat het functioneert als een alternatieve ontwerpoplossing voor brandwerende beglazing in openbare gebouwen in Nederland?

- Het begin

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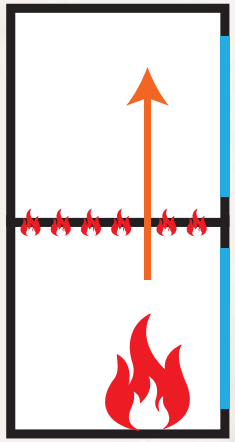
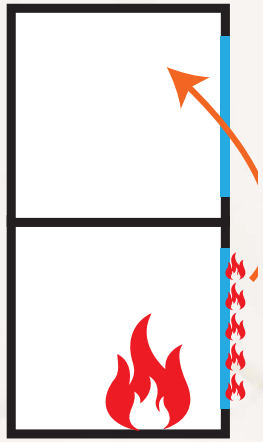
- Het begin
- Waarom?
  - branddoorslag (fire penetration)
  - brandoverslag (flash-over)



Fire penetration



Flash-over

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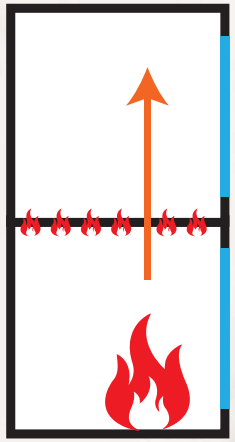
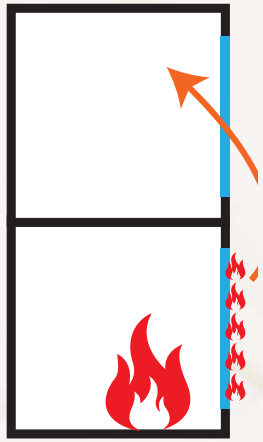
Op welke manier is het mogelijk om zonwering te gebruiken als een brandwerend element, zodat het functioneert als een alternatieve ontwerpoplossing voor brandwerende beglazing in openbare gebouwen in Nederland?

- Het begin
- Waarom?
  - branddoorslag (fire penetration)
  - brandoverslag (flash-over)
- Hoe?
  - kennis brandveiligheid & zonwering
  - simulaties
  - prototypes
  - metingen



Fire penetration



Flash-over

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Introduction

1. Posed problem & relevance

- Gap of fire safety knowledge

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- Lack of integration of fire safety and design

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- Gap of fire safety knowledge
- Lack of integration of fire safety and design
- More glass in buildings

  - more sunshading
  - more fire resistant glass

    - expensive
    - not fit into i.e. monuments

2. Research questions

In which way is it possible to use sunshading as a fire retardant element, such that it will be an alternative design solution for fire retardant glazing in public buildings in Holland?

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What are the criteria and specifications of the fire retardant element?

- What are the current rules in Holland regarding fire resistance of windows?
- What are the current criteria for fire retardant glazing and how does it work?
- What criteria should the fire retardant sunshading element meet?
- What is the influence of the distance between the element and the window?
- What is the critical time in which the system has to close in order to prevent the window from breaking?
- How to ensure that the system will close automatically in case of fire?
- How to ensure natural ventilation via the window and what will be the influence during fire?

2. Research questions

In which way is it possible to use sunshading as a fire retardant element, such that it will be an alternative design solution for fire retardant glazing in public buildings in Holland?

Which materials will be used?

- What kind of materials is best to use for the sunshading?
- What kind of materials is best to use for the fire resistance?
- What will be the influence of UV over time?

2. Research questions

In which way is it possible to use sunshading as a fire retardant element, such that it will be an alternative design solution for fire retardant glazing in public buildings in Holland?

What will be the durability of the element?

- How is the price in relation to current fire retardant glazing and sunshading?
- How to prevent malfunction, possible damage and wearing?
- What will be the performance of the sunshading element in relation to thermal comfort?

2. Research questions

In which way is it possible to use sunshading as a fire retardant element, such that it will be an alternative design solution for fire retardant glazing in public buildings in Holland?

What will be the influence of a fire retardant sunshading element on a fire and what will be the consequence for the fire fighters?

3. Method & time planning

P1

- Contact the Dutch Institute of Physical Safety & the fire department
- Subject & relevance
- Research questions
- Theoretical framework

3. Method & time planning

P1	P2
• Contact the Dutch Institute of Physical Safety & the fire department • Subject & relevance • Research questions • Theoretical framework	• Theoretical frame-work - sunshading - fire safety - products & materials - mechanism • Simulations • Program of requirements • Efectis fire lab

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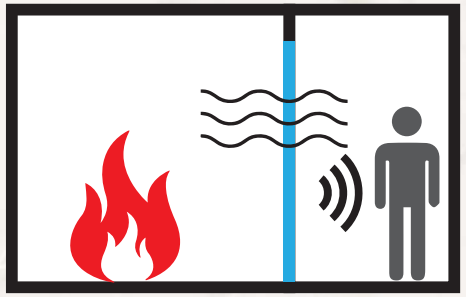
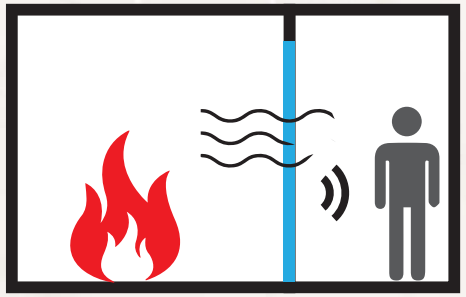
Theoretical framework

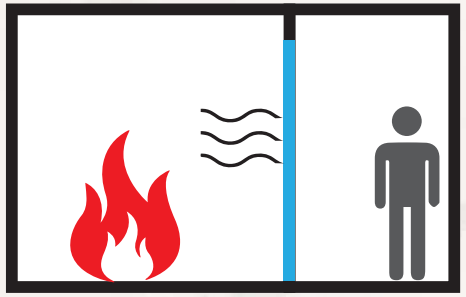
4. Theoretical framework - fire



E: closed for flames



EW: radiation



EI: temperature

- Specifications of fire retardant glazing
  - E
  - EW
  - EI

- Different types of fire retardant glazing
  - Safety wired glass (E)
  - Full tempered glass (E)
  - Full tempered glass with coating (EW)
  - Full tempered glass with an epoxy resin interlayer (EW)
  - Fire resistant glass with intumescent interlayers (EW/EI)

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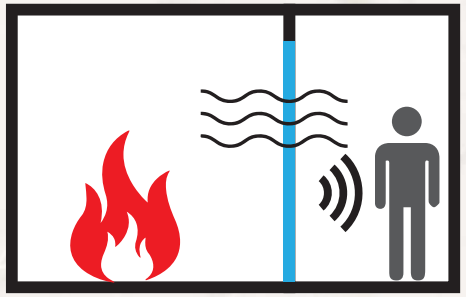

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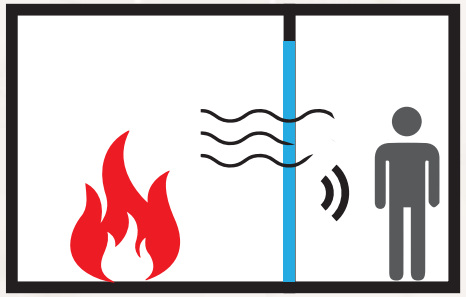

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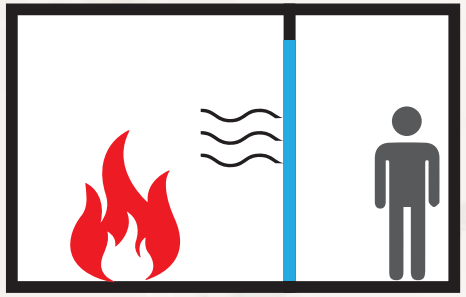

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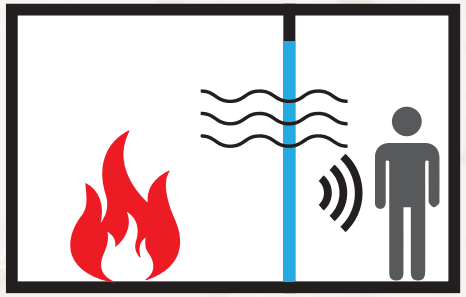

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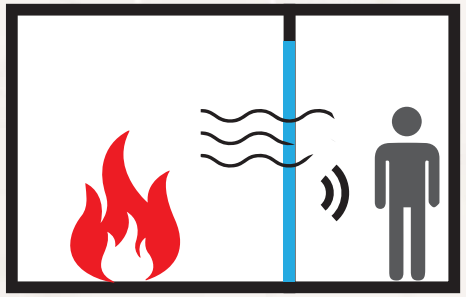

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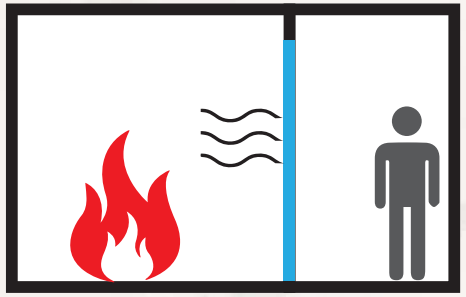

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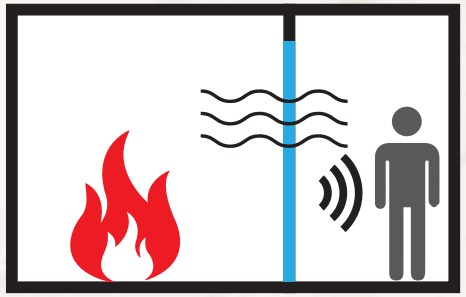

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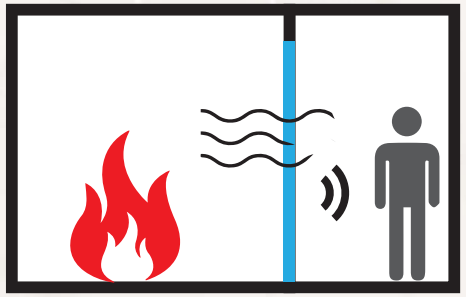

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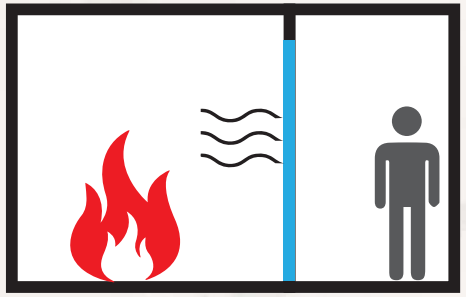

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- Influence of the breaking of the glass of a window during a fire
- Price of glazing
- Relation between radation and distance to the heat source

5. Theoretical framework - sunshading

Markies

Folding arm awnings

Markisolette

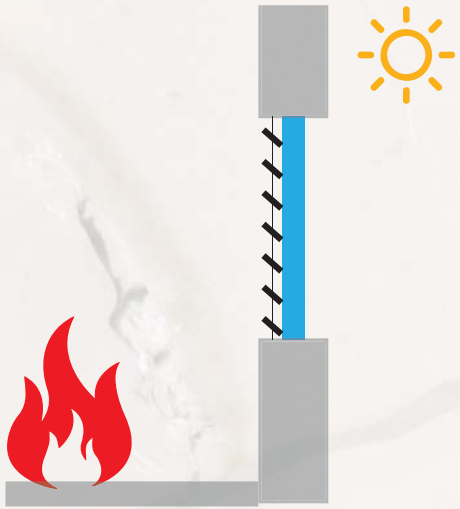
Roller shutters

Shading between glass

Overhang

5. Theoretical framework - sunshading

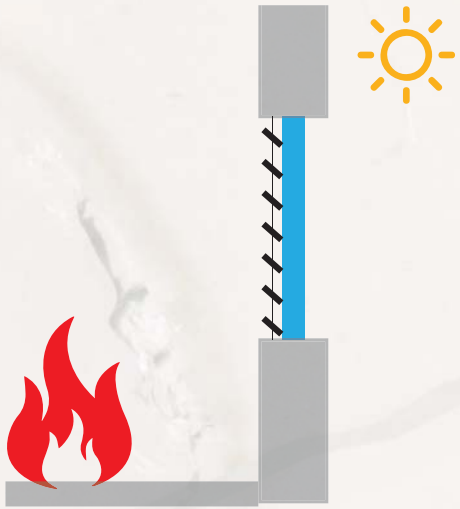
Venetian blinds



+ 1 side of the lamellae UV coating
+ 1 side of the lamellae fire retardant coating
+ Window is not breaking
+ Different positions of the shading
+ Easier maintainance
+ Less damage, wear and vandalism

5. Theoretical framework - sunshading

Venetian blinds



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- Sunshading on the inside
- Dust & cleaning

Design research

Venetian blinds

Fire intumescent coating

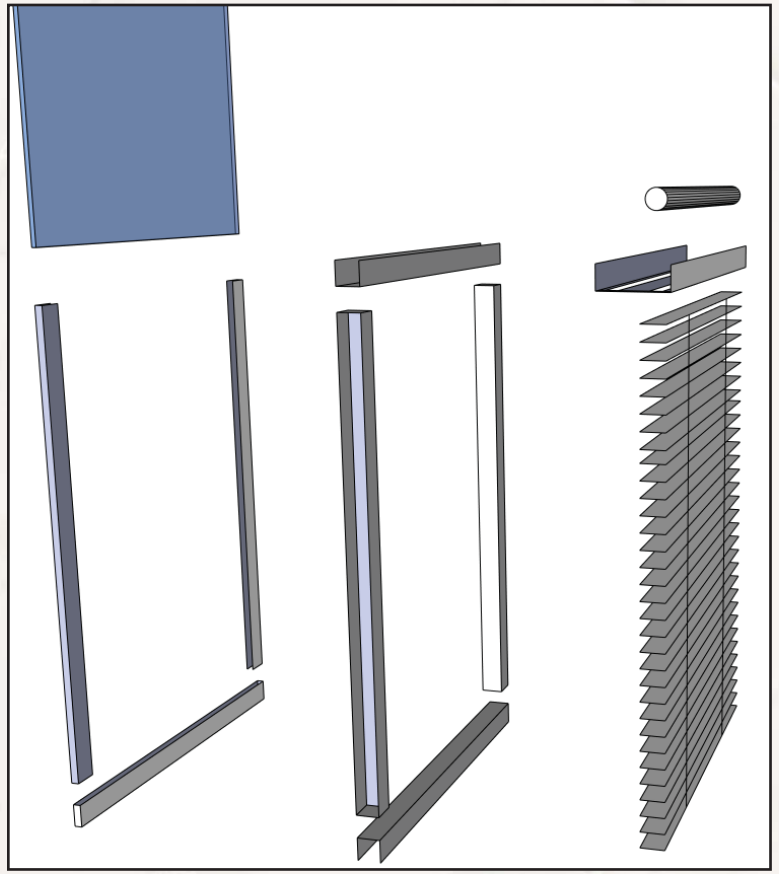
Design assignment

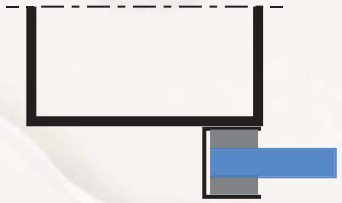
A concept for a sun shading element which also functions as an alternative design solution for fire retardant glazing.

Program of requirements:

- Integrity
- Stop radation
- Insulation
- Fire retardant materials
- UV & fire retardant coating
- Self closing mechanism
- Costs of element < 250- 550 euro
- Sunshading
- Esthetical
- HR++ Glass 4-16-4 or 6-16-6 mm
- Optimal distance between element and window
- Minimum loss of space
- Element on the inside of the window
- Fire intumescent coating

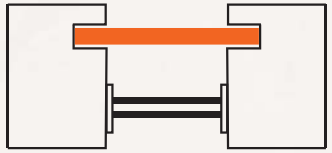
6. Design research - overview



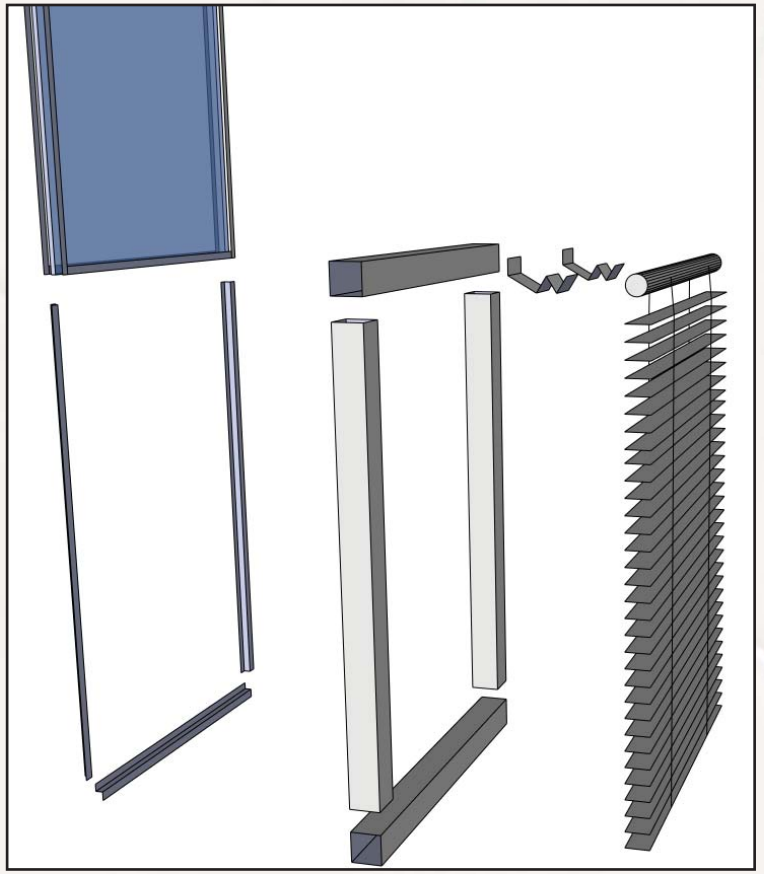


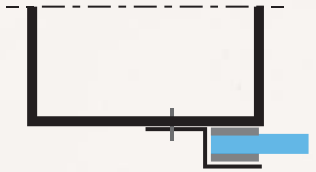
U-profile

Mounting principle



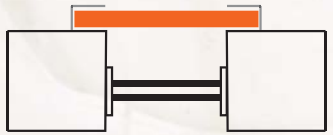
Sealing principle





Z-profile

Mounting principle



Sealing principle

6. Design research - mechanism

1. Wire & fire

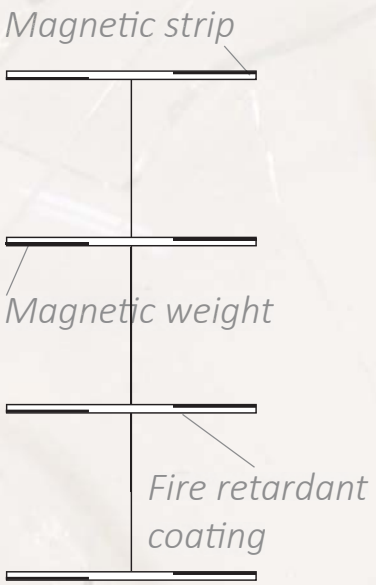
6. Design research - mechanism

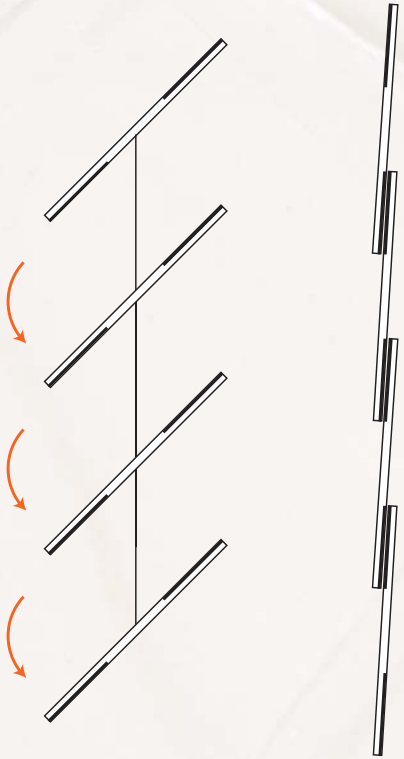
2. Burning wire

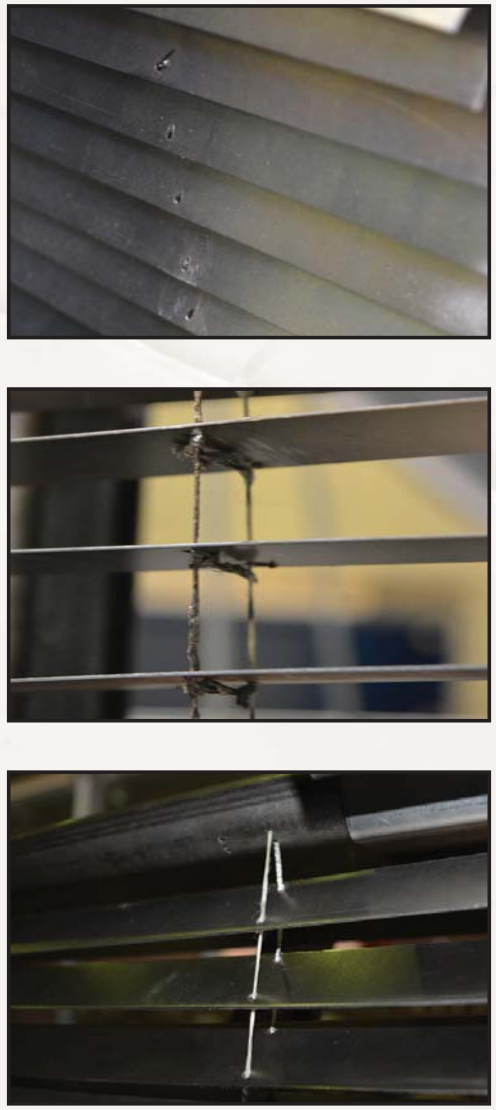
6. Design research - mechanism

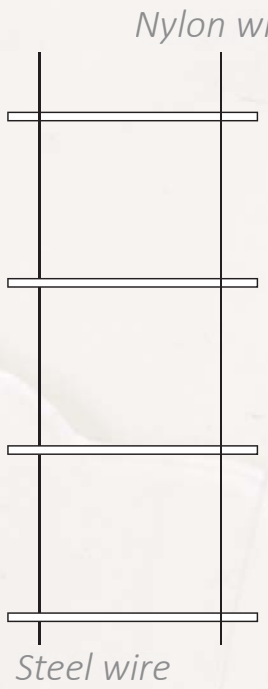
3. Breaking wire

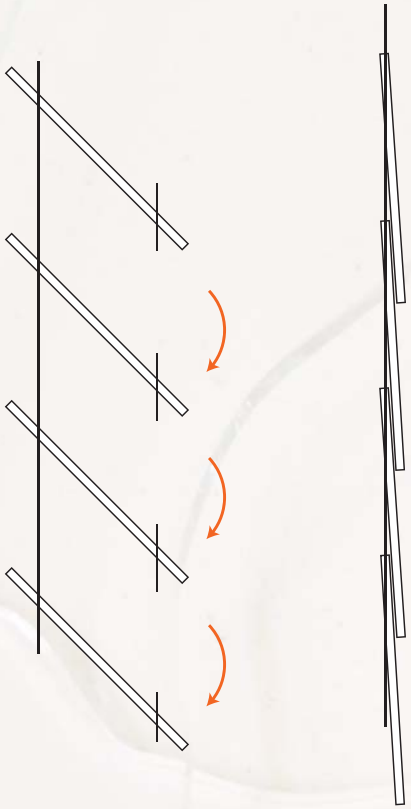
6. Design research - mechanism



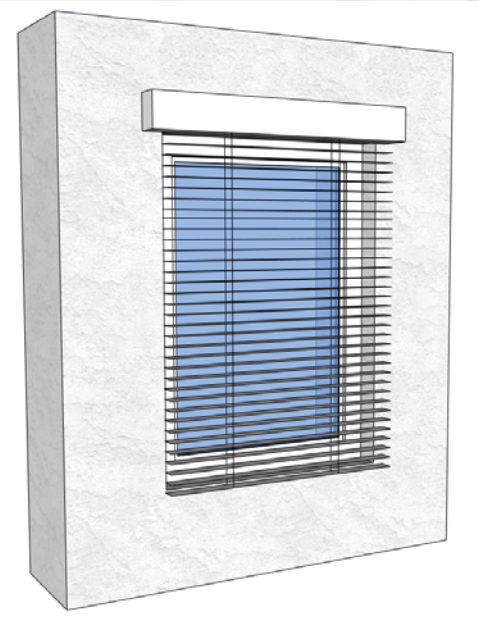








6. Design research - design

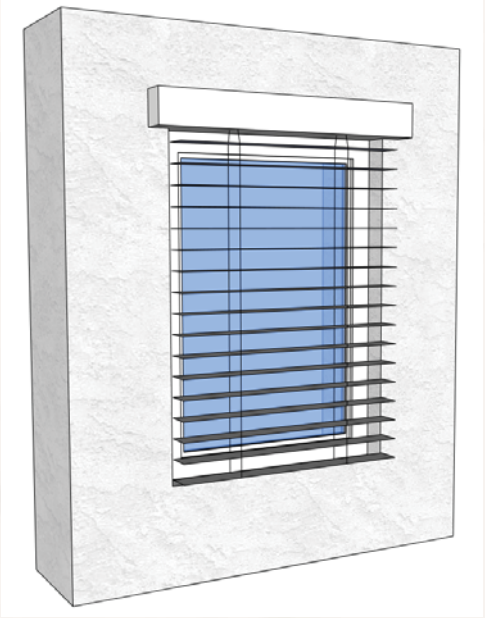


Normal sunshading

6. Design research - design

Normal sunshading

Less lamellae used



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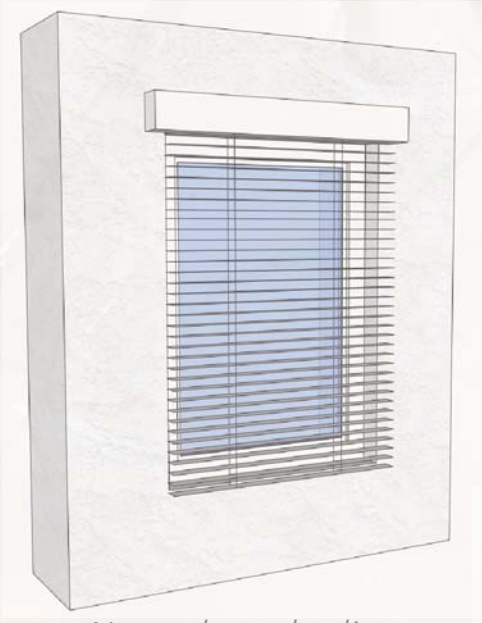

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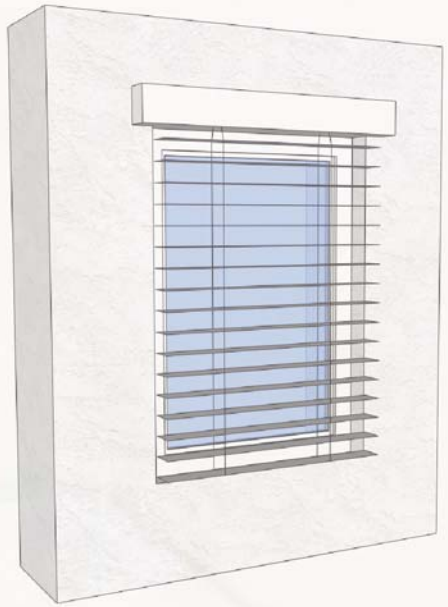

Closed element with the mounting principle

6. Design research - design

Normal sunshading

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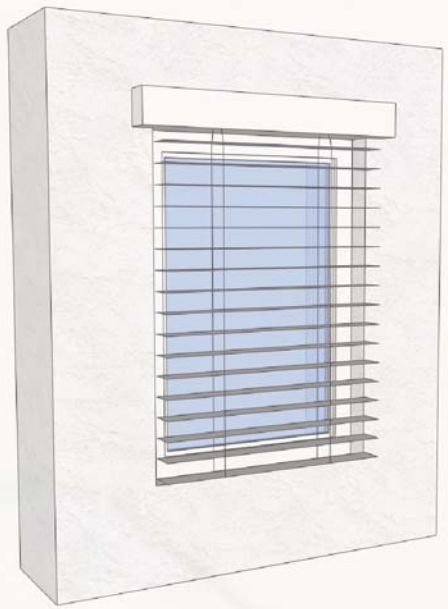
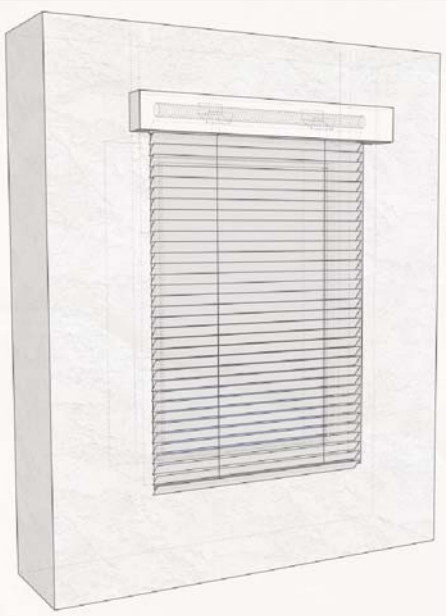
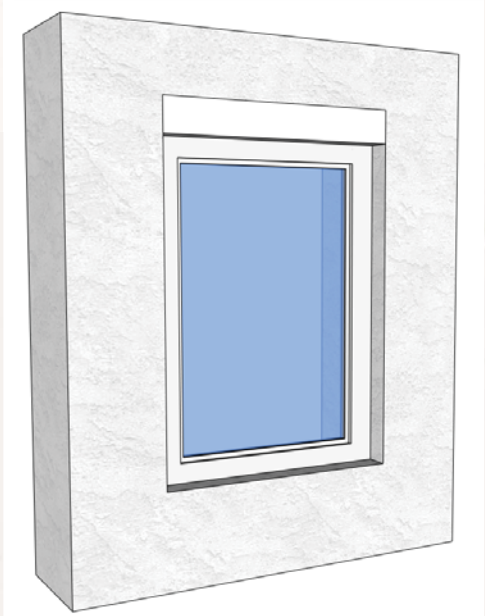




Closed element with the mounting principle

The element is taken out



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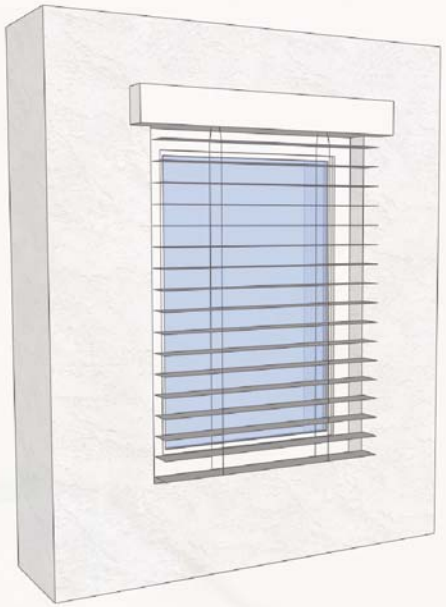

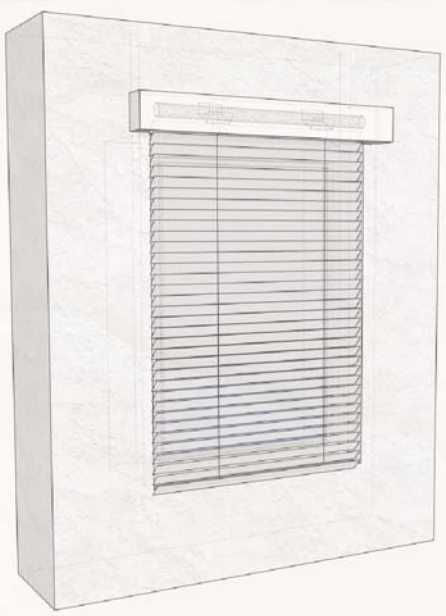

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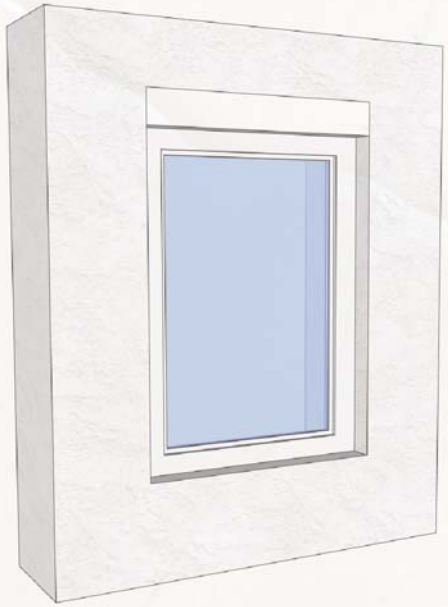

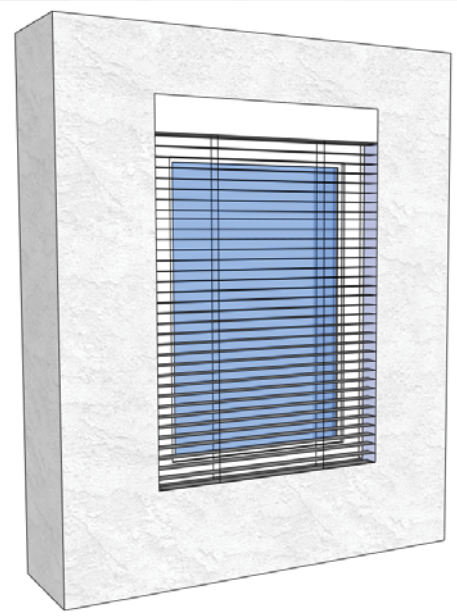

Integrated element

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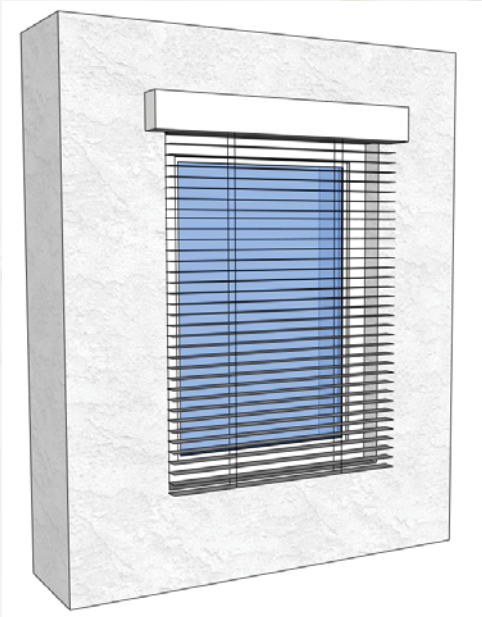
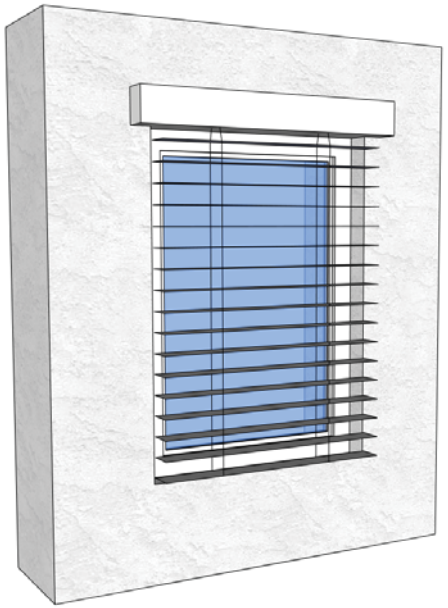
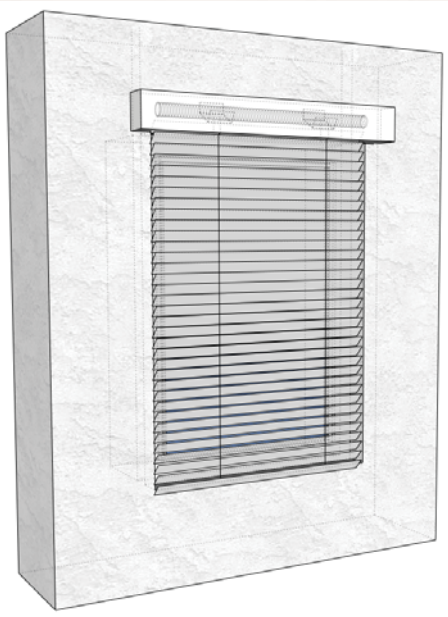


Normal sunshading

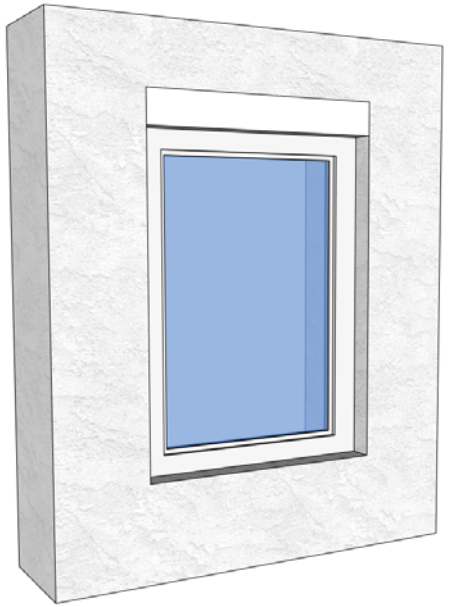
Less lamellae used

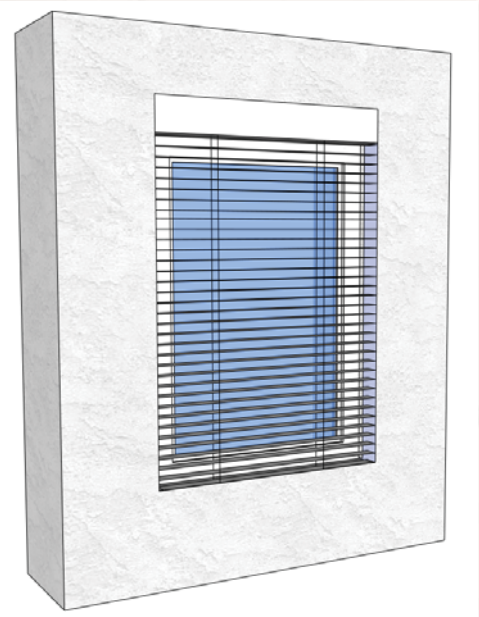




Closed element with the mounting principle

The element is taken out





Integrated element

6. Design research - durability

Possible damage and wear

- Nylon wire with UV coating
- Element on the inside
- Check

6. Design research - durability

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- Nylon wire with UV coating
- Element on the inside
- Check regularly

Price

- Fire retardant glazing : 250 till 550 euro per m^2
- Sunshading: 20 till 150 euro
- HR+++ glass: 120 euro per m^2
- Facilities for fire resistance: 50 euro
- Fire retardant sunshading element: 190 till 310 euro

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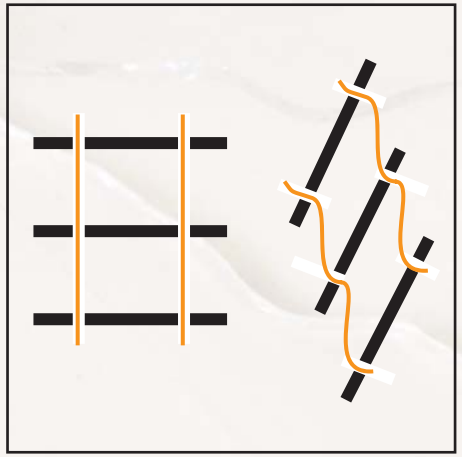
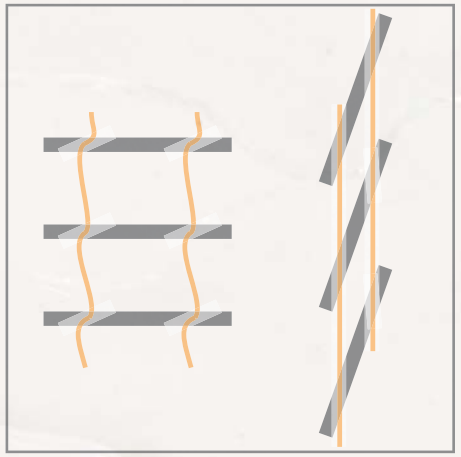
-
-

Influence for the fire fighters

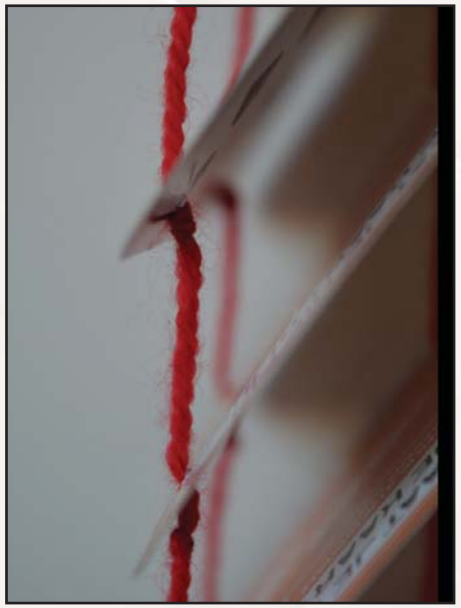
- Temperature increase
- Less oxygen supply
- No flash-over

6. Design research - Prototype playingcards



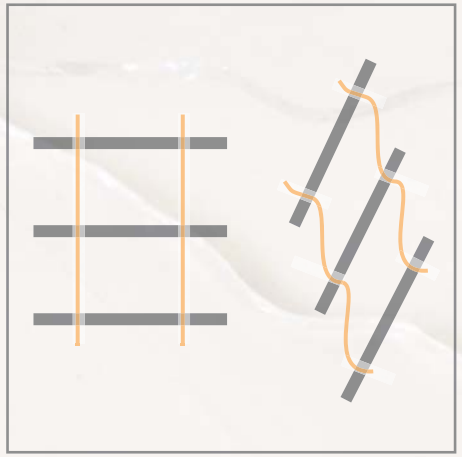


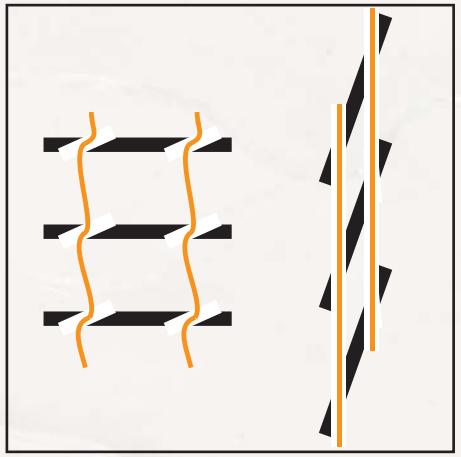
Before



After

6. Design research - Prototype playingcards

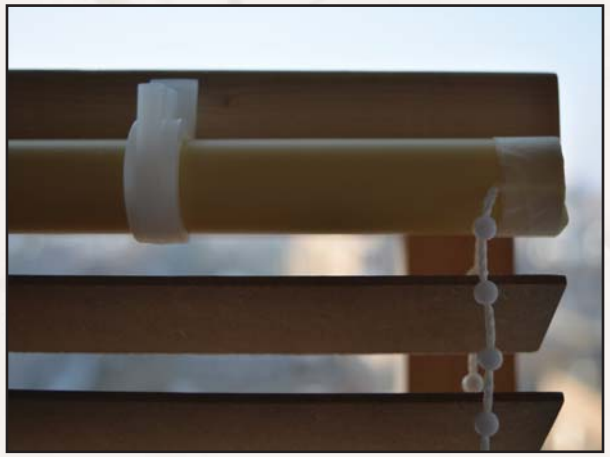


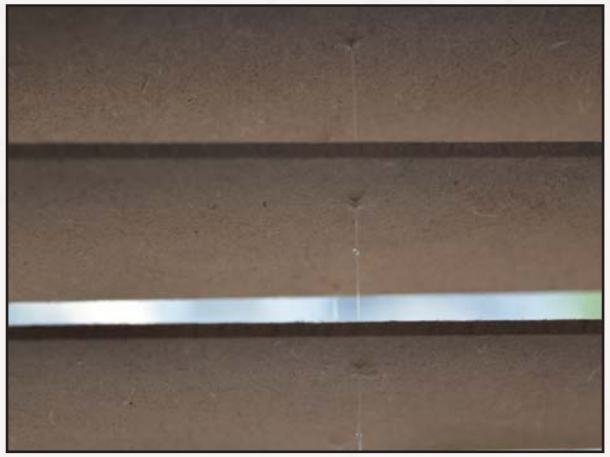


Before

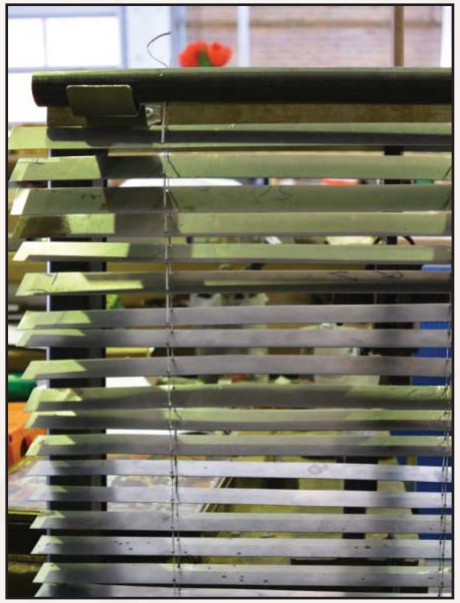
After

6. Design research - Prototype wood





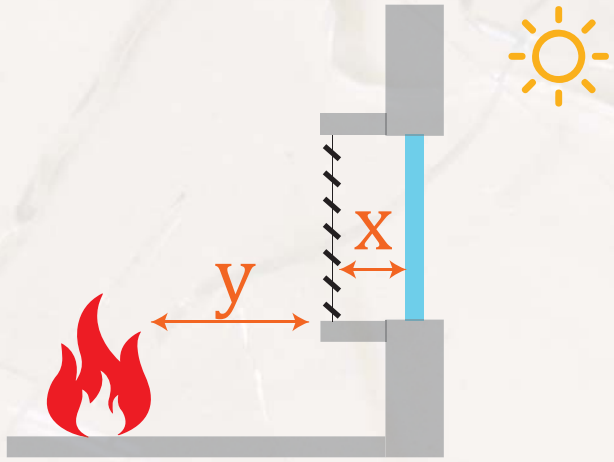
6. Design research - Prototype steel



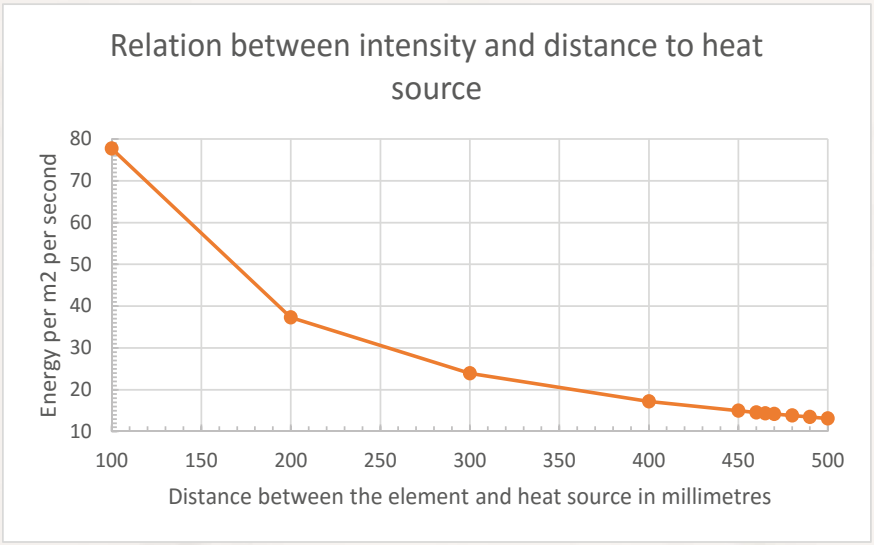
- Distances of 75 and 100 mm
- Steel wire and nylon wire
- Handles

Simulations

7. Simulations



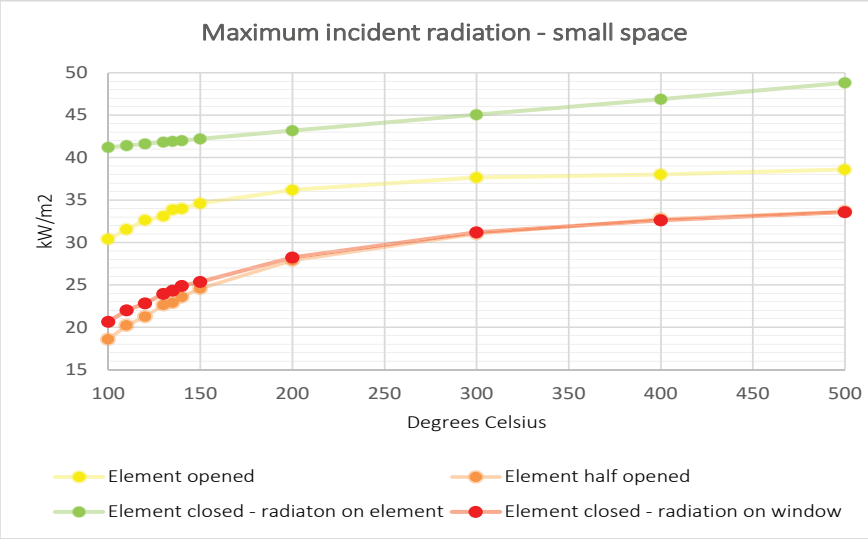
Optimal distance



The results of the simulations should determine the following variables:

- Incident radiation on the glass & shading element
- Temperature of the glass during the simulation
- Temperature of the element during the simulation
- The optimal distance between the window and the element in relation to heat
- Results of the simulation with the same distances as used in the measurements in order to compare them

7. Simulations - results



- Element more closed- smaller optimal distance
- The temperature of the glass is around the same value for each distance in all positions
- When the distance between the element and the window is bigger the temperature on the window will be lower- but radiation on the element is higher
- New simulations with the same distances as the measurements

7. Simulations - conclusions

- Different glass thickness hardly had any effect in the simulation
- Relation between distance and heat source
- No comparsion to the measurements, because of the different scale, different radius to the heat source

Measurements

8. Measurements

Measurements:

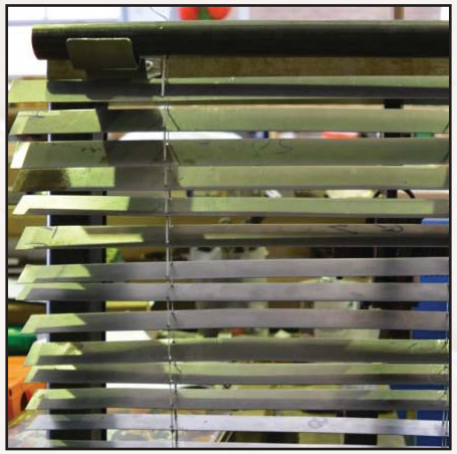
- [x] 4 mm / without an element
- [x] 4 mm / open element / 75 mm distance
- [x] 4 mm / open element / 100 mm distance
- [x] 4 mm / closed element / 75 mm distance
- [x] 4 mm / closed element / 100 mm distance
- [x] 4 mm / open or closed element / 75 mm distance / fire retardant coating
- [x] 6 mm / without an element
- [x] 6 mm / open element / 75 mm distance
- [x] 6 mm / open element / 100 mm distance
- [x] 6 mm / closed element / 75 mm distance
- [x] 6 mm / closed element / 100 mm distance
- [ ] 6 mm / open or closed element / 75 mm distance / fire retardant coating

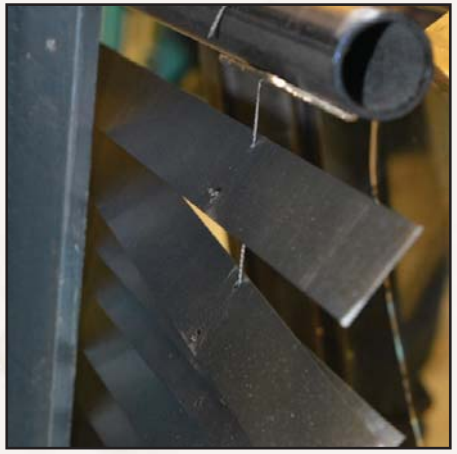
8. Measurements

Materials:

- Steel plate: 28 steel lamellae of 458 x 30 x 0.8 mm
- Fire retardant coating for steel (Tangit FP800 is used)
- Steel wire
- Nylon wire
- Steel frame with mounting options for the element
- Steel pipe for mounting the element
- 4 mm glass 6 panes: 400 x 625 mm
- 6 mm glass 6 panes: 400 x 625 mm
- Stopwatch
- Infra-red measurement tool
- Heat resistant suits
- Bricks to absorb and radiate the heat
- Fire extinguisher or other safety measures

8. Measurements





- The mechanism worked
- Handles
- Re-use of frame, lamellae and metal wire

8. Measurements - method

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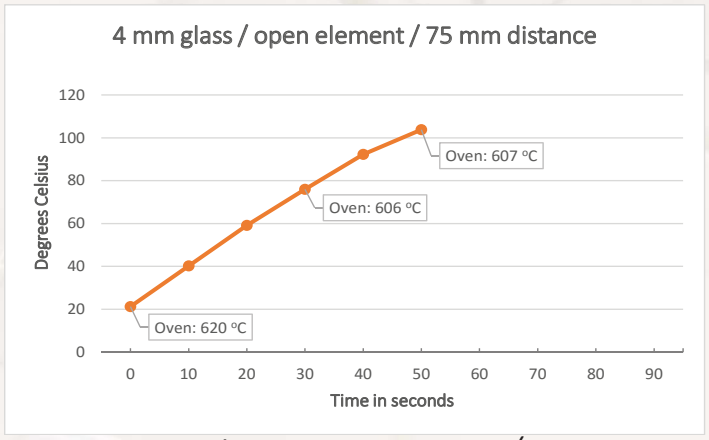
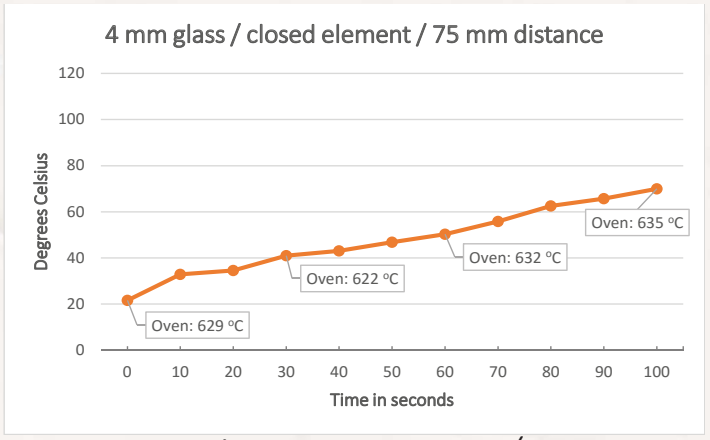
8. Measurements - results 4 mm glass



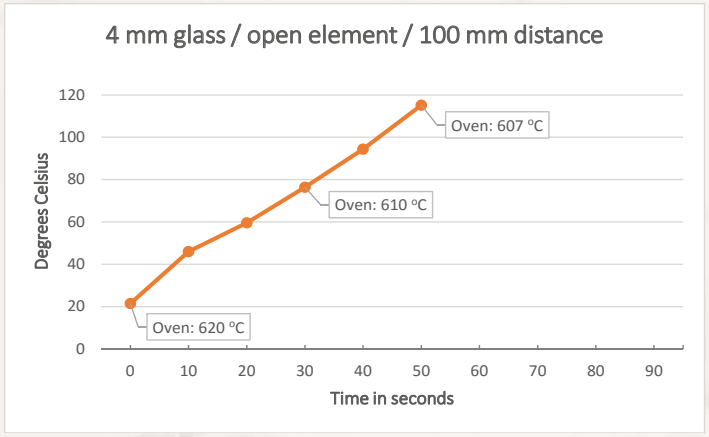
Temperature increse rate 1.7 °C/s



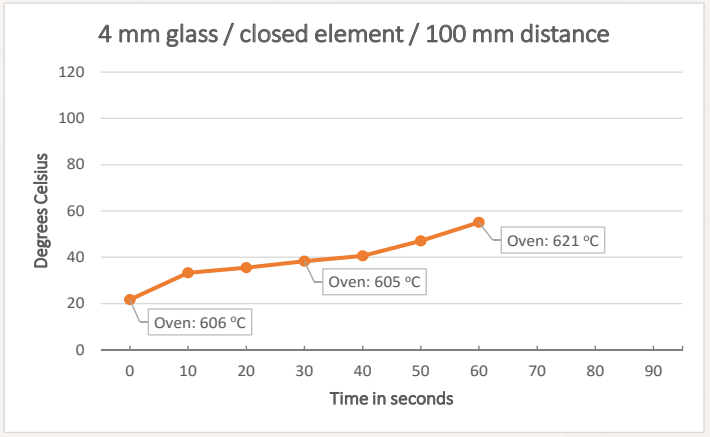
Temperature increse rate 0.5 °C/s

- Temperature increase rate
- 4 mm glass breaks faster, but at higher temperatures

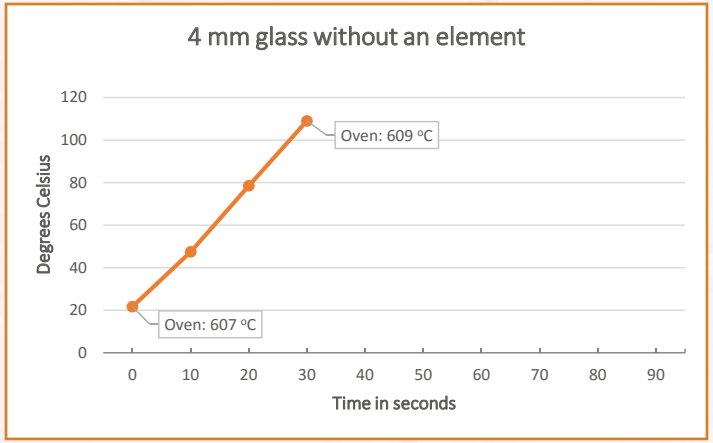
Temperature increse rate 1.7 °C/s



Temperature increse rate 0.4 °C/s

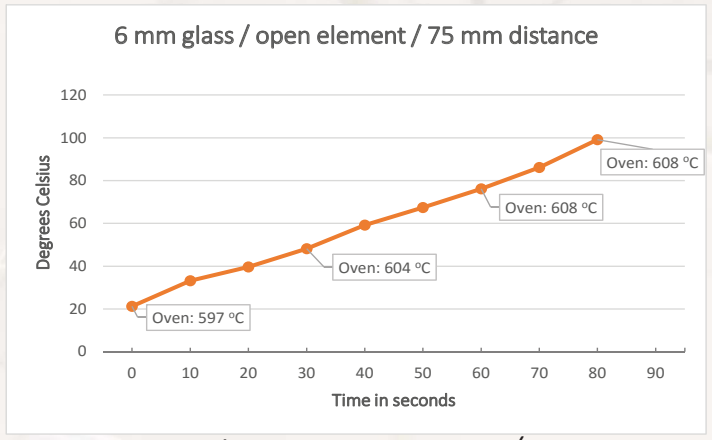


Temperature increse rate 2.2 °C/s

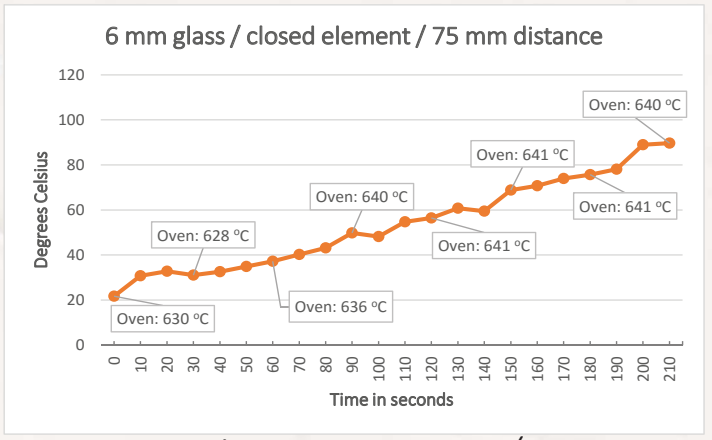


Closing element after 8 seconds

8. Measurements - results 6 mm glass



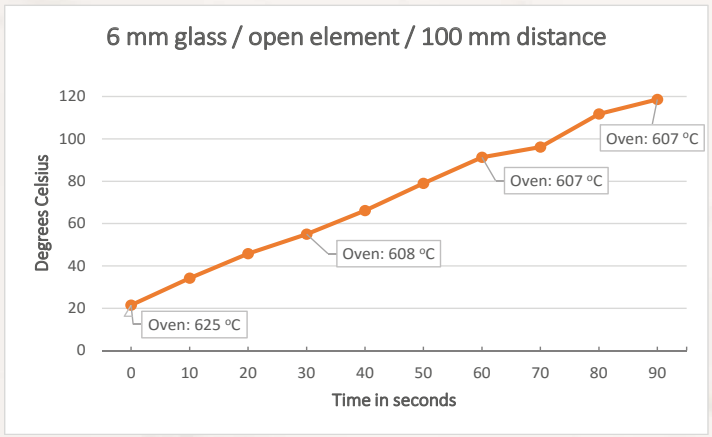
Temperature increse rate 1.0 °C/s



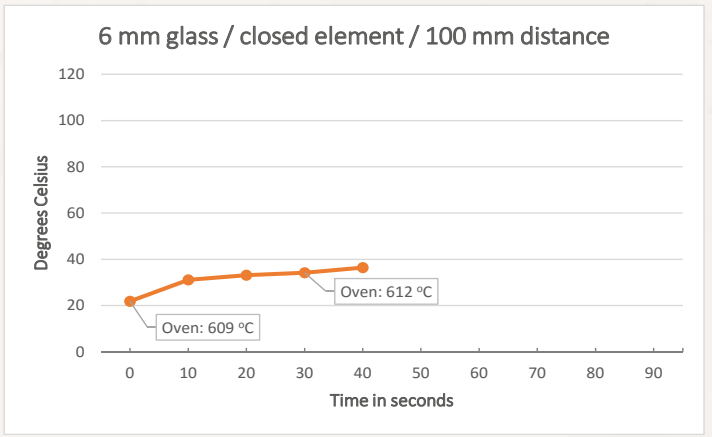
Temperature increse rate 0.3 °C/s

- Not always the same spot measured
- Closed element 100 mm distance, variant result

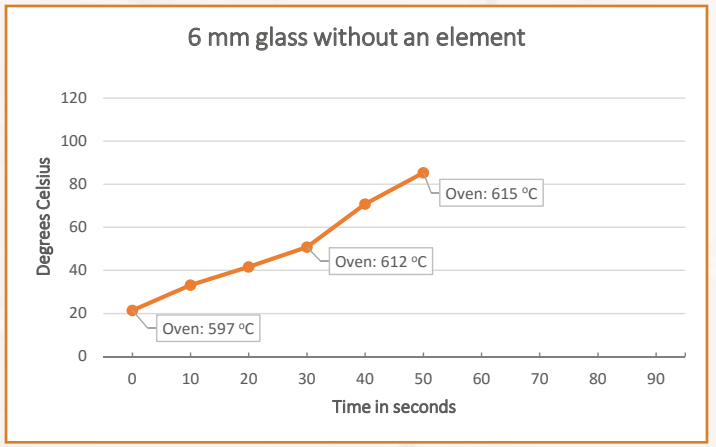
Temperature increse rate 1.0 °C/s



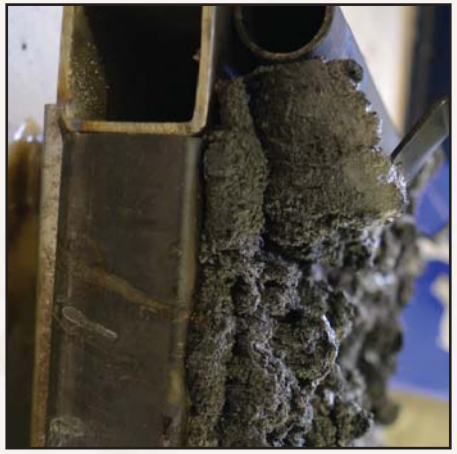
Temperature increse rate 0.3 °C/s



Temperature increse rate 1.3 °C/s



8. Measurements - results fire retardant coating



- Fire retardant coating on the inside
- Expanded
- No flash-over
- Not a remarkable result
  - insulation
  - time
- Only 1 measurement done
  - not safe enough
  - safety report

8. Measurements - photos












8. Measurements - conclusions

- 4 mm glass can withstand higher temperatures but breaks faster.
- When the element is closed the temperature when the glass breaks is lower than when the element is open, because there was less exposure to the heat source.
- With the element at a distance of 75 mm from the glass it takes longer for the glass to break in comparison to a distance of 100 mm.
- The temperature rise of the glass fluctuates.

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- The temperature rise of the glass fluctuates.

Simulation vs. measurements:

- Different scale / distances
- Closer to the heat source, higher radiation on the element

Discussion

9. Discussion & recommendation

Simulation:

- Program

- Room temperature
- Scale and size
- Smoke

Recommendation

Other program like Brando i.e.
More refined grid

First know the measurements
Other simulations

9. Discussion & recommendation

Simulation:

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- Scale and size
- Smoke

Measurements:

- Method

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First know the measurements
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Conform NEN/Dutch Building Decree
Measuring on the same spot and at more places

9. Discussion & recommendation

Recommendation

Simulation:

- Program

Other program like Brando i.e.
More refined grid

- Room temperature
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First know the measurements
Other simulations

Measurements:

- Method

Conform NEN/Dutch Building Decree
Measuring on the same spot and at more places

Design:

- Pull up of the lamellae

9. Discussion & recommendation

Simulation:
- Program

- Room temperature
- Scale and size
- Smoke

Measurements:
- Method

Design:
- Pull up of the lamellae

- **Further measurements:**
- Thinner lamellae thickness
- Other glass thickness
- Other coatings

Recommendation

Other program like Brando i.e.
More refined grid

First know the measurements
Other simulations

Conform NEN/Dutch Building Decree
Measuring on the same spot and at more places

Conclusion

10. Conclusions

In which way is it possible to use sunshading as a fire retardant element, such that it will be an alternative design solution for fire retardant glazing in public buildings in Holland?

What are the criteria and specifications of the fire retardant element?

- ☐ Sunshading
- ☐ Fire retardant
- ☐ Manually adjustable
- ☐ Different colours and designs
- ☐ Self-closing mechanism
- ☐ Heat-flux < 15 kW/m^2 at 1 meter distance
- ☐ Lower costs than fire retardant glazing
- ☐ Alternative design solution

10. Conclusions

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What are the criteria and specifications of the fire retardant element?

- [x] Sunshading
- [x] Fire retardant and prevent flash-over
- [x] Manually adjustable
- [x] Different colours and designs
- [x] Self-closing mechanism
- [ ] Heat-flux < 15 kW/m^2 at 1 meter distance
- [x] Lower costs than fire retardant glazing
- [x] Alternative design solution

10. Conclusions

- Influence of the distance between the element and the heat source
- System closes automatically in case of fire
- Natural ventilation
- Influence during a fire
- Consequence for the fire fighters

Thank you! Questions?