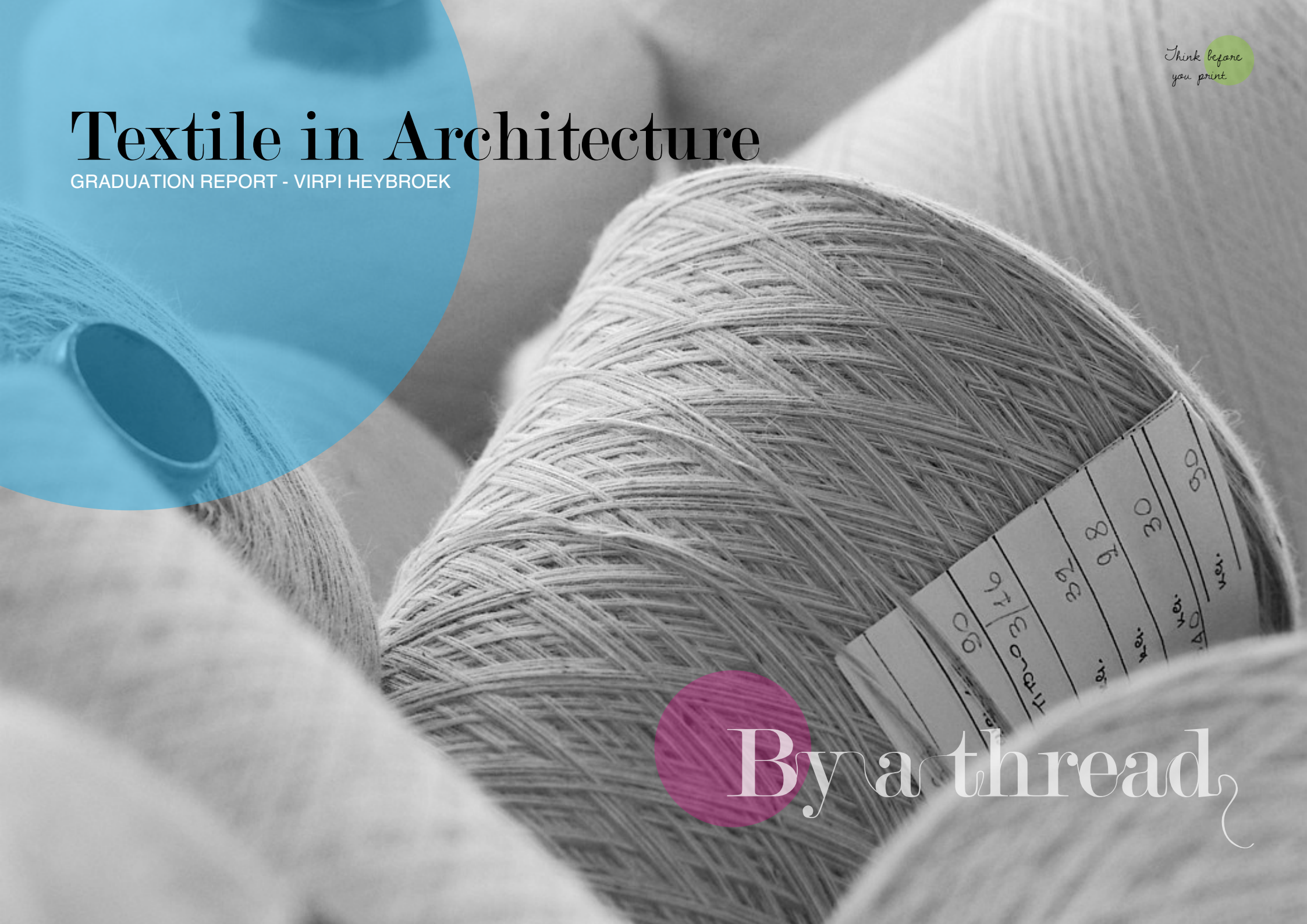

Textile in Architecture

GRADUATION REPORT - VIRPI HEYBROEK

Think before you print

By a thread

Graduation Report

Virpi Heybroek ©
1352636
Master Architecture - Graduation Explore Lab
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By a thread

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00._ Preface

Textile is my fascination and is something that has been a part of my life for a really long time. From the age of 5 I spent a lot of time behind my mother's sewing machine. I made all type of things, clothing for my dolls, cushions and so on. Even in high school my subsidiary subject was 'Textile'. In this course we made bags, textile posters and clothing.

For me, the most exciting part is the material itself and designing with it. Designing was the subject I wanted to study, that's why Architecture is my chosen study. In my architecture study there are multiple courses where I included textile in my architectural assignments. In my minor a colleague and I designed a house where you could easily change the textile façade depending on the climate of that season, so you could dress the house differently throughout the year. In technology in BSc semester six another colleague and I designed the Dutch pavilion for the World Expo. We included a textile moveable roof representing the sailing country the Netherlands is. It also had a climate aspect: the moving roof produced wind and the roof generated shade, so it would not get so hot in the pavilion.

This research is part of my graduation project at Explore Lab for the Master Architecture at the Technical University in Delft. Explore Lab is a graduation studio for students with a unique fascination. There is an election process to select students with interesting fascinations that cannot be explored in any other thesis labs. Textile in Architecture was such a subject. I am very glad that the subject of my graduation project is so personal.

I see textile as a lost building material and I want to discover what the possibilities are to improve the indoor climate with the use of textile. In this research I am searching for ways how textile can be used in more advanced ways. The tension constructions of textile in architecture is a proven method and I find it less interesting to do extensive research on that subject. That is why I want to approach my subject from the angle of smart climate systems, because there is a lot to gain at that point.

To connect this subject with a building program I included another fascination of mine to the project, the Dutch fashion industry. The social and environmental impact of the garment industry increased in the last couple of years. And the sustainable issues are asking for changes.

When starting this graduation project I did not know where it would end up. On 24 April 2013 the Rana Plaza in Bangladesh collapsed. 1127 people were killed, 2438 made it out alive. After this moment, the world looked a bit different to the garment industry. And my research subject shifted. Who was to blame for this disaster? In the end couldn't we blame everybody?
In a research to those questions I found that the fashion industry is spilt between Haute Couture and the Brands that copy them, getting those styles in store for 10% of the price of Haute Couture and much faster than any Luxury department store can have the clothes hanging on there racks. Fast Fashion is becoming a problem instead of a marketing strategy. The price gap between Haute Couture and ordinary fashion brands is getting too big. And the fashion styles become too similar. Fast fashion is not about quality, that is why cheap clothes end up in the trash bin ever soon.
To improve the status of fashion, a building is designed for the Dutch Fashion Industry. That needs to bring the public and the Fashion designers closer together. In this design textile is an important building material and it is used to make a smarter indoor climate. To really present what the fashion industry is standing for.

My graduation project is a combination of three subjects; Textile in Architecture, Fashion Industry and Sustainability. The research that lies before you is about Textile in Architecture. This research consists of 35 case studies and two types of analyses about those case studies: the reason for choosing textile in the specific projects and what kind of material is chosen.
I conclude my research with my vision on how to design with textile in architecture, the way I approach my design for the building for the Dutch Fashion Industry.

1 ROSSUM, M. van. 2012. *Goedkope mode bestaat niet*. NRC Handelsblad, 14 december.
Photo © Abir Abdullah (http://www.newyorker.com/online/blogs/photobooth/2013/05/slide-show-abir-abdullahs-photographs-of-tragedy-in-bangladesh.htm?slide_ss_0=10)

01._ By a thread

Aim of the Design

To better understand the scope of this research, the aim of the design, which is a large part of the graduation project, is explained here. In the preface the problems of the fashion industry are described, about the competition between fast fashion and fashion designer brands. ***This design can make a start for the public's reassessment of the Dutch Fashion Industry.*** To provide clear guidance to the design four qualities are characterized.

Attract
The building should put a spotlight on the Dutch Fashion Industry, making AFW the fifth of the 'Big Four of Fashion-weeks', so Amsterdam becomes the international fashion and design capital it deserves to be. The building should attract attention from international architectural magazines and national newspapers.

Seduce
The building need to seduce the public to go and visit. It should seduce the public to think differently about the fashion industry and sustainability. The building needs to be a place were sustainable fashion can be shown and inspires young fashion designers to think differently about textile and fashion. The building needs be sustainable to inspire fashion designers and public that sustainable can be beautiful as well as good for you and the world.

Climate smart
To be a sustainable building the climate should be as smart and self-regulating as possible. Installations are band as much as possible.

Adaptable
It needs to have a good adaptable indoor climate with the use of textiles. And if the Fashion Week is held in the building, it needs to get dressed for the fashion-shows. Because the building can not take the space needed for the fashion week all year around. And than the media and the public sees when the shows are held, so it can get more attention.

Objectives of the Research

The following objectives are derived from preceding problem definitions and form the motivation for his research.

1 Showing how and why textile can by used in architecture.
2 Creating new concepts for the combination of sustainability and the use of textile in architecture.

Research Questions

Sub-questions

What is the history of textile and architecture? - Literature
When and why choose textile above other materials? - Case studies
How can textile be used in Architecture in a sustainable way? – Literature & Case studies
How to choose a architectural textile? – Literature & Case studies

Main question

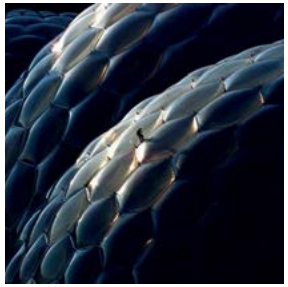
How can the use of textile optimize the indoor climate for a building in Amsterdam with both temporary and contemporary program?



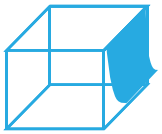








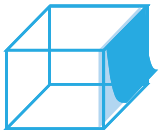

- Type of textile use



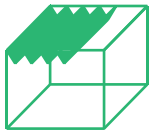
Exterior Curtain

Canopy

Tent

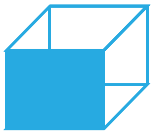


Exterior double façade



Retractable Roof

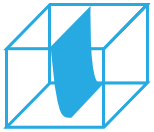
Pneumatic Tent



Interior double façade

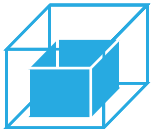
Umbrella

Pneumatic Façade



Partition

Pneumatic Construction



Room in Room

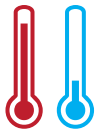
- Reason for use of Textile

Temporality

Weight

Adaptability / Movement

Transparency / Lighting



Indoor Climate

Atmosphere

Acoustics

02.01 Introduction

The word Tent will not be associated with architecture and design by most people. Tents have a negative name. Its seen as a last resort, nobody wants to live in a tent. On holiday maybe, be only because than we have the freedom to move were ever and when ever we want.

So what is considered architecture? Primarily permanent buildings made out of wood, stone, concrete, steel and glass are classed on the name of architecture. In the terminology of Louise Kahn *"Architecture is thoughtful making of space"*[1] material is not set in stone. That can change in time and through innovation.

The history of textile in architecture is very old. With the history of human nomad cultures portable dwelling was a key to survival. Tents are a prime example of vernacular architecture. Light structures are a big part of this. Tents are the first type of dwellings using textile as a cover. The valued qualities of this contemporary architecture are the lightness, flexibility, contemporaneity and portability. When the nomadic live style grows smaller more solid dwellings arose. And the use of textile decreases as a façade. It became a second-class material.[2]

In historical use of the textile architecture, man worked with the nature the profited shelter and a liveable indoor climate. Permanent en solid buildings arose, when mankind learned to use the climate and land. They are so durable that nowadays very old buildings are still in use. Over time buildings were build without any sense of the climate they were in. Installation began to "fix" the defects of the indoor climate. Contemporary architects are trying more and more to work with nature again, instead of against. Those architects understand that dependence on installations, isn't the future. Sustainability becomes more important.

Important countries in the textile architecture are Germany, America, but it were the Japanese who were most at ease with membranes, they see the beauty of the fleeting character and are not afraid of impermanence.

Now more high performance textile are available new functions and different applications of textile in architecture arise. In different climate also different methods of using textile are applied. In this report case studies are collected to show an overview of the contemporary use of textile in architecture.

The case studies are categorised on the construction and function of the textile, showing in the icons on the left of the page. Furthermore, the reason for using textile is analysed and also iconic displayed on the right side of the page. At the end the analyses the reasoning are described per category.

Textile is defined in this projects as a material that keeps its flexibility, while combined with a stiff construction it can be a very strong material. Categories on the construction and function of the use of textile:

Textile can be used as a roof, a wall or an overall tent construction, so first it is divided in the different functions; vertical, horizontal or three-dimensional definer. These categories can be divided by their constructions or place.

00.00 The Tubaloon in Kongsberg, with a pneumatic construction

Vertical Space Definer:
Exterior Curtain is the use of textile as an outside façade in a vertical direction. A lot like the Exterior Curtain is the *Exterior Double Façade*, which contains of textile used outside in a vertical direction to partially or entirely covering the building façades, as an example is could be a lighter version of the glass double skin façade. The term Curtain wall refers to textile poisoned behind large-area glass-façades, providing light and visual protection. *Partition* is a term used for curtains how divide a space, those curtains can create different spatial situations. *Room in Room* is a variant of the partition but in this term it can be used to create an entire room.

Horizontal Space Definer:
Canopy is a textile construction protecting us against the sun and the rain. *Retractable Roof* is the movable version of the canopy roof. The classical term *Umbrella* is also representation in this report, consisting of a central mast with moveable extra construction with the textile attached above.

Three-Dimensional Definer:
The *Tent* consists of the basic elements of a frame and a cover. To avoid the extra frame a possibility is using air as the constructing element, which is called a *Pneumatic structure*. The pneumatic structures are divided in three categories. The tent is airtight and blown *as a whole*. Only the double-layered *façade* is blown-up. Or *the construction* is as the structure can be blown-up.

1 FREDERICK, M. 2007. *101 things I learned in architecture school*, Cambridge, MA: MIT Press.
2 DREW, P. 2008. *New Tent Architecture*, London, Thames & Hudson Ltd.

Case Study number

Titel, city, opening year

Material
PVC/PES Type 2 Acrylic Lacquer (20,000 m², Verseidag)[1]
Desinger
Wilkinson Eyre Architects & KSS Design Group

1_.01 The façade of the basketball stadium

Category:
Type of Textile use

Analyses:
Reason for using textile

Project description

The London Olympic Games of 2012 wanted to by the most sustainable Games ever organised. They set high goals for the design-teams of all venues. This state-of-the-art temporary stadium is the biggest temporary sport venue ever erected for the Olympic Games. Design for dismantling was the design mantra in this project, but it would still provide elegance and visual drama. It was built within planning and budget, many useful lessons emerge from the design process. Now this stadium can be packed and moved to a new Olympic Games all over the world. After profound research PVC was selected as the best cladding material.[2]

1_.02 Section over the façade

1_.03 Overview of the Olympic park, London 2013

1_.04 Pattron of the tensile façade

Reference list

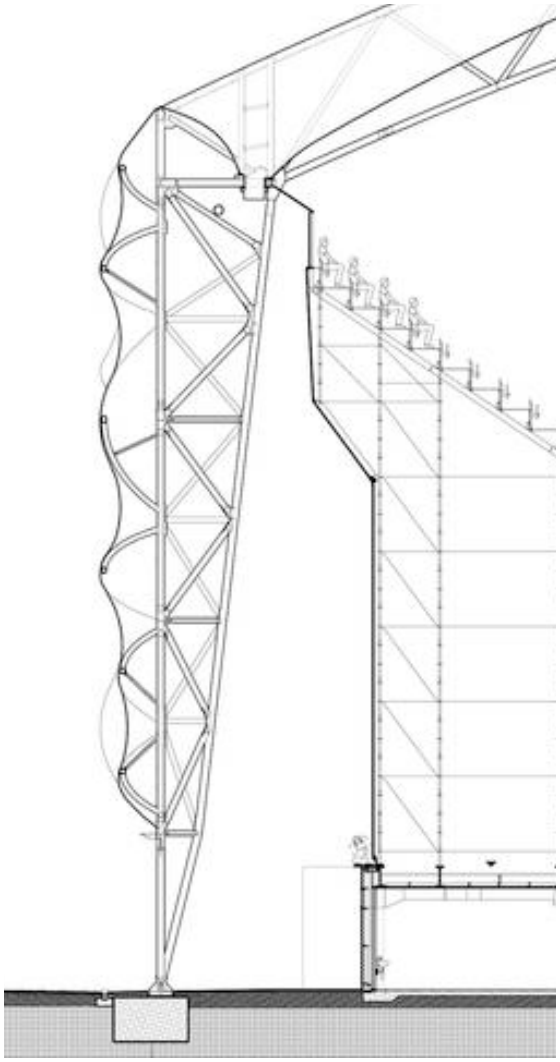
1 RIDDLE, M. 2011. *Temporary basketball arena for the London 2012 Olympics* [Online]. Fabric Architecture. Available: http://fabricarchitecturemag.com/articles/1111_f3_basketball_arena.html [Accessed 29 August 2013].
2 HARTMAN, H. 2012. *London 2012 Sustainable de- ... Legacy*, London, Wiley.

Olympic Basketball Stadium, London 2012

Material: PVC/PES Type 2 Acrylic Lacquer (20,000 m², Verseidag)[1]
Designed by Wilkinson Eyre Architects & KSS Design Group

1.01 The façade of the basketball stadium

The London Olympic Games of 2012 wanted to by the most sustainable Games ever organised. They set high goals for the design-teams of all venues. This state-of-the-art temporary stadium is the biggest temporary sport venue ever erected for the Olympic Games. Design for dismantling was the design mantra in this project, but it would still provide elegance and visual drama. It was built within planning and budget, many useful lessons emerge from the design process. Now this stadium can be packed and moved to a new Olympic Games all over the world. After profound research PVC was selected as the best cladding material.[2]



1.02 Section over the façade

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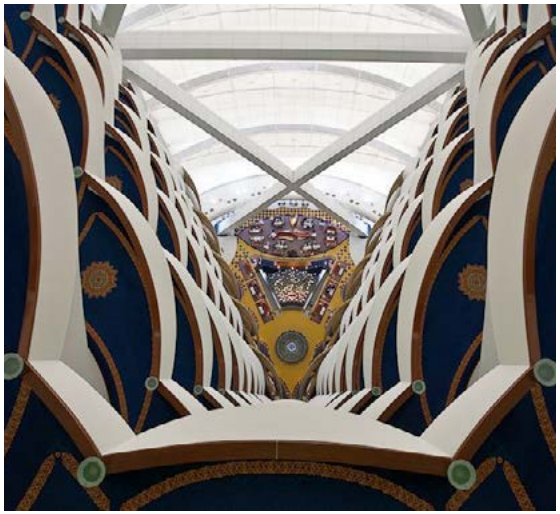
1 RIDDLE, M. 2011. *Temporary basketball arena for the London 2012 Olympics* [Online]. Fabric Architecture. Available: http://fabricarchitecturemag.com/articles/1111_f3_basketball_arena.html [Accessed 29 August 2013].
2 HARTMAN, H. 2012. *London 2012 Sustainable design, Delivering a Games Legacy*, London, Wiley.

Burj al Arab Hotel, Dubai 1999

Material: Double-layered glass fabric coated with Dyneon™ PTFE and Fluorthermoplastic (7,500 m², Verseidag-Indutex)[1]
Designed by Tom Wright of Atkins

2.01 View on the Burj al Arab Hotel

The brief of the design was to create an icon for Dubai, such as the Eiffel tower for Paris and the Opera House for Sydney. This "seven star" hotel is built on its own artificial island, 280 metre out of the coast. The design is inspired by the sail of a dhow, a type of Arab vessel. The open V shaped plan gives space to a very large atrium. The double white PTFE coated glass fibre fabric covers the 180 metres tall atrium. 7,500 m² membrane was required for this façade. From the outside the atrium looks closed but on the inside the translucent façade gives a light sense. The PTFE membranes are UV-resistant, non-combustible and self-cleaning every time it rains.[1]



2.02 View on the atrium for one of the upper levels

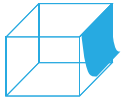
2.03 View on the atrium during construction time; giving a sense of the size of the atrium and its textile façade

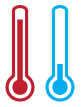
2.04 Atrium from ground level, giving a sense of the light conditions

1 2002. *Freestyle Membrane Architecture*. In: DYNEON (ed.). Oakdale: Dyneon.
2 DREW, P. 2008. *New Tent Architecture*, London, Thames & Hudson Ltd.

Curtain Wall House, Tokyo 1995

Designed by Shigeru Ban





3.01 The façade in summertime

The client for this house lived in a traditional Japanese-style house; Ban designed a contemporary reinterpretation of the client's old house on the same spot. This three-story house is divided in stacked living space and serves rooms, like the bathrooms and stairs. The serves rooms are closed off while the living spaces are opened to the street. The sliding glass doors and a two-story-high curtain can be closed to control temperature, light and privacy, mostly used during winter. Closing the curtain gives a cocoonlike environment to the living spaces. The thin curtain takes the place of the traditional translucent Japanese Paper screens and doors.[1]

"Mies invented the glass curtain wall, but I just used a curtain". (Shigeru Ban in Designboom 2010)

3.02 View from inside when curtains are closed

3.03 The façade in wintertime

3.04 The façade with beautiful moving curtains, curtains not connected to construction

1 MCQUAID, M. 2003. Curtain wall house. *Shigeru Ban*. London: Phaidon Press Limited, p. 192-197.

Haus mit Alelier, Wißgoldingen 2008

Material: scaffolding fabric [1]
Designed by C18 Architects

4.01 The façade in summertime

This house with jewellery workshop in the German Alps is located on a sloop with an incredible view. You enter this white glazed tiled house at the second floor. To the street this home looks very closed of, with only two doors and a single window showing. But to the amazing view there are floor to ceiling windows with thin aluminium window-frames. In villas, like this, curtain rails are a clincher. In this design the curtains a take outside, also covering the pool or the balcony, in order not to interfere with the sleek detailing. The silvery, glittering material of the curtains was originally developed for the investiture of scaffolding. The curtains give more privacy to the house.[1]

4.02 Combination from curtains and pool, and inside and view

4.03 The façade in detail, silvery scafholding material

4.04 The façade with open curtains

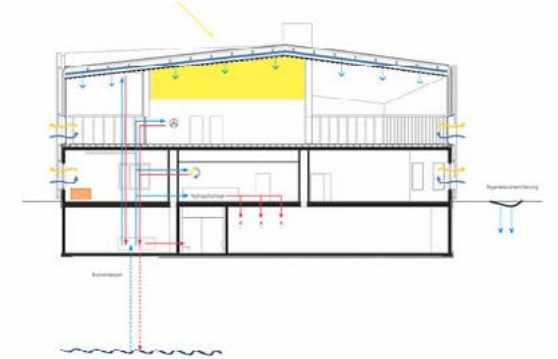
1 HOLL, C. 2008. *Haus mit Atelier.* Stuttgart: kaestle ocker roeder Architekten BDA.

Forschung Sedus Stoll AG, Dogern 2010

Material: silicone-coated, glass fibre fabric
Designed by ludloff + ludloff Architekten

5.01 View on the building

This research office for the furniture company Sedus Stoll AG has a double façade. The outer façade is made of silicone-coated, glass fibre fabric; this translucent membrane protects the building from sun and rain and is ideal for rear ventilation. So this façade is lowering the energy bill. Twelve metres high aluminium profiles attach the fabric to the steel tubing frames. Springs in the holding profiles will maintain the tightness in the fabric as the construction changed due to temperature fluctuations.[1]



5.02 Climate scheme

5.03 Inner façade is showing during constriution

5.04 Detail from the outer façade

5.05-07 The façade during sunset

1 SCHITTICH, C. 2013. Research and Developmetn Centre in Dongern. *Detail*, 53. #1/2 p 32-37.

Westraven, Utrecht 2007

Material: Duraskin® B18971 - Glass Fibre EC 6, PTFE (Verseidag-Indutex)[1]
Designed by Cepezed (renovation)

6.01 Overview of the Westraven building

The Dutch Department of Public Works (RWS) has high regard for sustainability and innovation. The architects from Cepezed were up for the challenge to make the new RWS building a combination of technical innovation and functional beauty. After thorough consideration and calculation, between a new building and renovation of the old building with sick building syndrome, RWS concluded that renovation was the best option. The construction of the high-rise is built in the early seventies and had a limited spatial experience. Multiple voids and a new double skin façade give a new expression to the tower. An extension is constructed in the form of the light and special low-rise.

The second skin façade of the tower is all glass on the north side of the building, to block out the noise pollution. On the remaining façades the second skin is made of an alternation of glass; a lighter and cheaper openweave membrane. The open-weave structure offers allround protection against the wind and makes it possibl;e to work with open windows even on the top floors. The material is tested on all the technical and functional requirements.[2]

6.02 3D section of the façade principle

6.03 The westraven before the renovation

6.04 The façade of the westraven

1 2010. *Duraskin® B18909.* In: VERSEIDAG-INDUTEX (ed.). Kerfeld: Verseidag-Indutex.
2 CRONE, J. 2008. Innovatieve waterstaatsarchitectuur. *Bouwwereld*, #4, p. 46-55.

Wrapping Reichstag, Berlin 1995

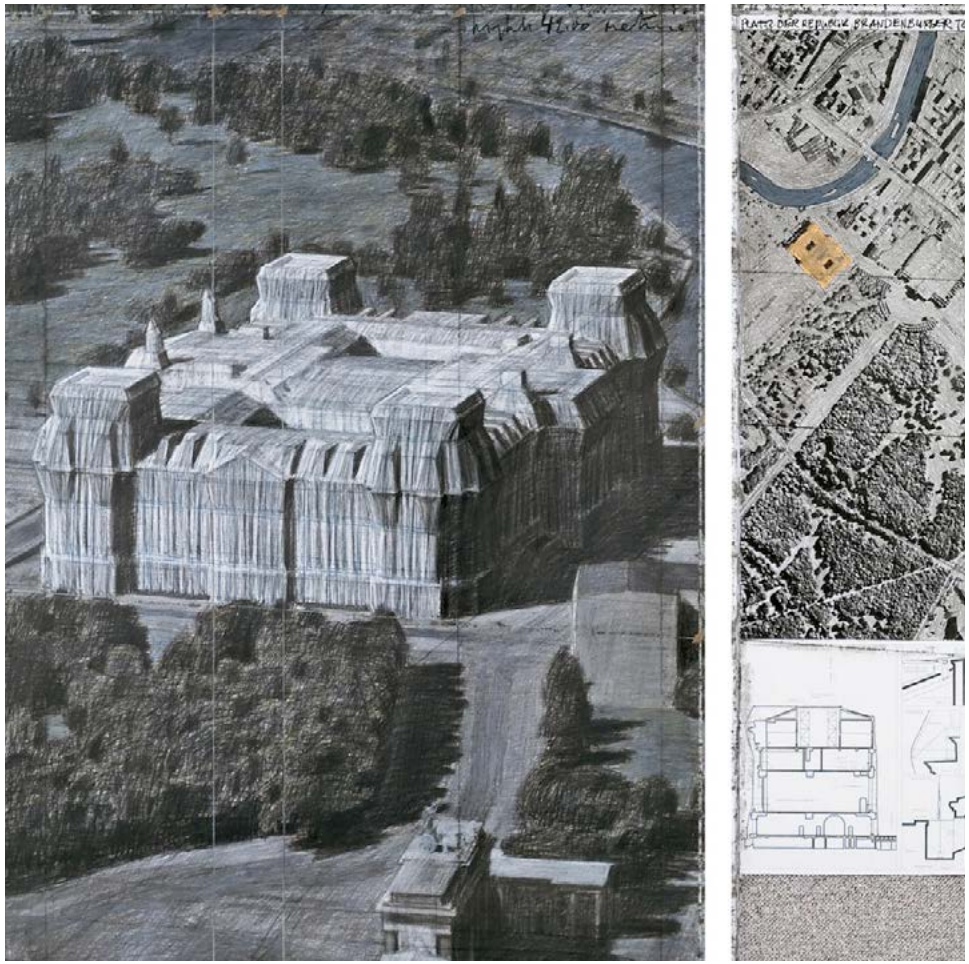
Material: thick woven polypropylene fabric (100,000 m²)
Designed by Christo and Jean-Claude

7.01 Wrapped Reikstag

The Reichstag is built in 1894 and has always been a symbol of Democracy in Germany. For 24 years Christo and Jean-Claude worked on the project which was financed by selling studies, drawing, collages and scale models of the projects. In June 1995 the work of 90 professional climbers and 120 installation workers was done. For 14 days the Reichstag was covered by 100,000 square metres of thick woven polypropylene fabric, specially weaved for this project. This is twice as much as the surface of the building and kept in place by 15,6 kilometres of blue polypropylene rope. The use and forms of fabric always fascinated Christo and Jean-Claude. Fixing fabric-forming folds, pleats and draperies is a significant part of their work. The use of fabric on the Reichstag follows the classical tradition. Fabric, like clothing or skin, is fragile; it translates the unique quality of impermanence. The richness of the silvery fabric, shaped by the blue ropes, created a sumptuous flow of vertical folds highlighting the features and proportionsof the imposing structure, revealing the essence of the Reichstag. The Reichstag remained wrapped for 14 days and all materials were recycled.[1]

7.02 Workers a wrapping the Reikstag

7.03 Model of a wrapped Reikstag



7.04 Design drawings of Wrapping Reikstag, sold to pay for there work

1 CHURCH, J. 2013. *Wrapped Reichstag* [Online]. New York: Christo and Jeanne-Claude. Available: http://christojeanneclaude.net/projects/wrapped-reichstag#.UjcHDeB6NfR [Accessed 29 August 2013].

Aichinger Haus, Kronstorf 2010

Designed by Hertl Architecten

8.01 Façade of the Aichinger house

It used to be a restaurant with two bars, but it was reinvented a multi-story apartment building consisting of two flats. The grey draping's are more than decorative object, wrapping it around all of the two-story façade. It is reducing solar gain and deflecting daylight. In the evening the atmosphere of the building changes by letting indoor light shine trough the curtains.

Hertl Architekten explains the thought behind the textile: *"A light grey curtain covers the solitaire, the abstract form is disguised by a soft texture. The element, also used for shadowing, can be moved apart the windows. A decorative element, normally used indoor, is building an irritating and at the same time fascinating facade."*[1]

8.02 View from the inside

8.03 Windowopening, by a pulled curtain

8.04 The entrance of the appartment building, with inside light shining through

1 HERTL, G. 2011. *hertl architekten: aichinger house* [Online]. milan: designboom. Available: http://www.designboom.com/architecture/hertl-architekten-aichinger-house/ [Accessed 10 September 2013].

Casa da Musica, Porto 2005

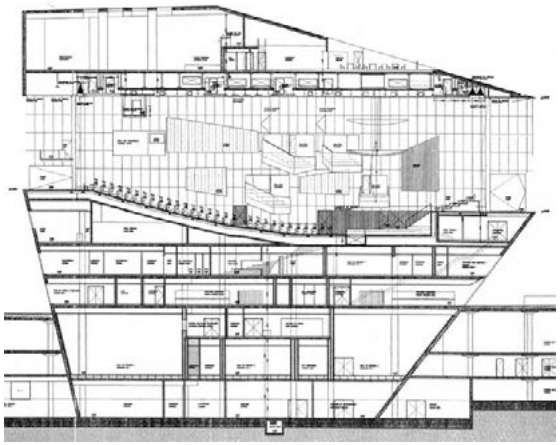
Designed by OMA & Inside Outside

9.01 Casa da Musica in the city of Porto

On the design of OMA, Casa da Musica Inside Outside was consulting the interior design.

"Rem Koolhaas wanted a 'view filter' on each side of the hall. The term 'view filter' felt totally obvious yet also very vague: a view filter to what degree, with what purpose? To filter out, to tone down, spread light, obscure, fade, bluer what is visible behind it? Or to envelope the room, create an aesthetic backdrop for the orchestra, allowing the gaze to sense the outside, to see sky, trees, sculpture and city?" *(Blaisse, 2007, p. 374)*

The design of Petra Blaisse consists of 11 curtains with a variation from 22 by 15 metres to 65 by 8 metres. The curtains are controlled by silence motors can be stored in cavities in the wall or ceiling. The curtains influence the light and sound in the concert halls.[1]



9.02 Section of Casa da Musica over the major music hall

9.03 The entrance of Casa da musica

9.04 Petra Blaisse with the curtain for Casa da Musica

9.05 The curtain for Casa da Musica

9.06 Difference between two curtains and no curtain in the major music hall

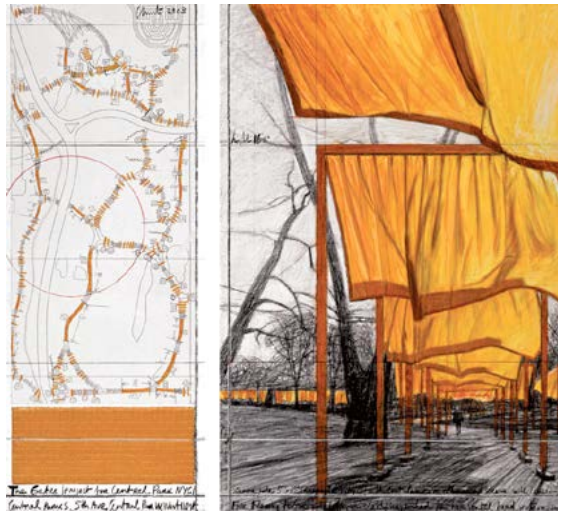
1 BLAISSE, P. & OTA, K. 2007. *Inside Outside*, Rotterdam, NAi Publishers.

The Gates, New York 2005

Material: Saffron coloured vinyl
Designed by Christo and Jean-Claude

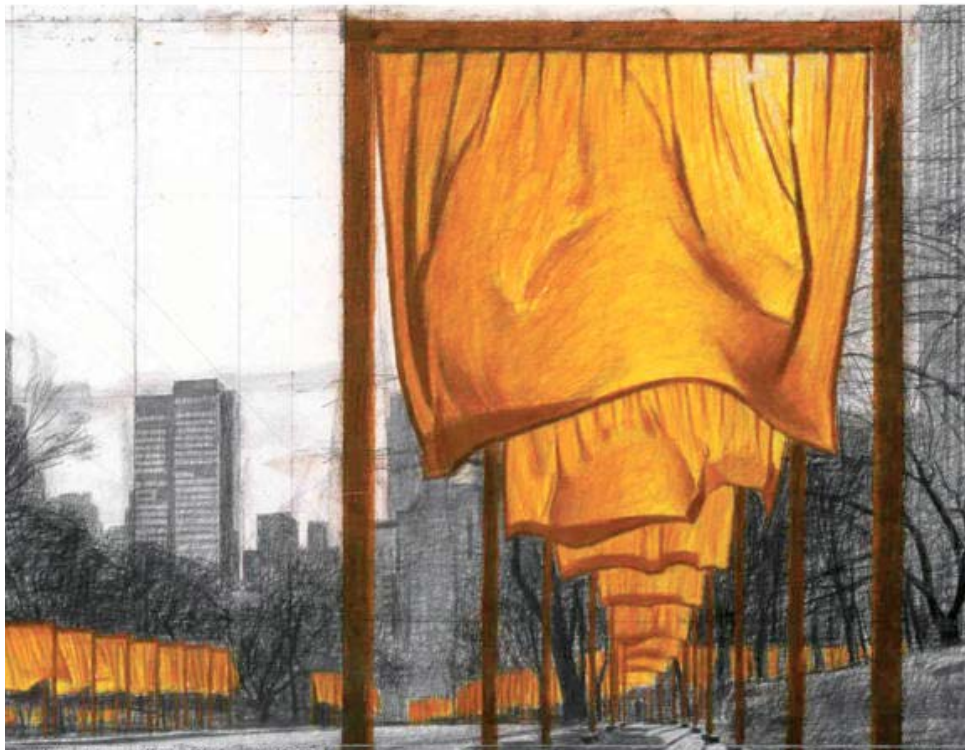
10.01 a Gate, seeing the beautiful shadow of the trees

This installation was in Central Park for 16 days in Februari of 2005, designed and financed by Christo and Jeanne-Claude. The installation consisted of 7503 gates and a total of 96,5 km saffron coloured vinyl. After its removed all the materials where recycled. The block-like city structure was shown in the rectangular structures, while the serpentine design of the walkways and the organic forms of the bare branches of the trees were reflected in the sensual movements of the free-flowing canvases in the wind. Walking on the walkways trough the park the saffron vinyl creates warm shadow in the cold winter, but viewing central park from the skyscrapers surrounding, it looked like golden rivers were crossing the park.[1]



10.02 Design drawings

10.03 Overview on Central Park, giving a view on the route

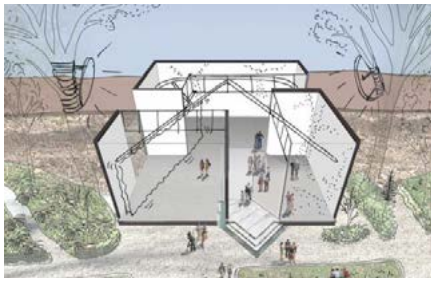


10.04 Design drawings of The Gates, sold to pay for there work

1 DAVENPORT, J. 2013. *The Gates* [Online]. New york: Christo and Jeanne-Claude. Available: http://christojeanneclaude.net/projects/the-gates?view=info [Accessed 29 August 2013].

Re-set, Venice 2012

Designed by Petra Blaisse - Inside Outside



11.01 Design drawing

In 2012 Petra Blaisse designed the Dutch Pavilion for the International Architecture Exhibition in Venice, in the existing Rietveld pavilion of 1953. Petra Blaisse designed an installation of multiple curtains on a rail moved by a motor that changes every 5 minutes supported by different sounds while moving.

Petra Blaisse: *"We are not going to hang Objets d'Art, exhibit works or stage events. We are responding to the vacant architecture itself. One single mobile object occupies the space for three months and emphasises the building's unique qualities. This object will flow through the interior, re-configure its organisation and create new rooms along the way. Through relatively simple interventions the experience of light, sound and space will be manipulated so that new perspectives emerge."*[1]

11.02 Visitor of the Dutch pavilion on the 2012 Bienale

11.03 Rietveld's Pavilion for the Venice Bienale from 1953

11.04/05 Different moments from the same point of view

1. BLAISSE, P. 2012. PRESS RELEASE JUNE 5: RE-SET; New wings for architecture [Online]. Rotterdam: NAi Available: http://en.nai.nl/toolbar/international/venice_biennale/_rp_kolom2-1_elementId/1_1252750 [Accessed 29 September 2013].

Video link: http://vimeo.com/62580631

"Samt und Seide" Café, Berlin 1927

Material: Dyed silk [1]
Designed by Ludwig Meis van der Rohe & Lilly Reich

12.01 "Samt und Seide" Café overview

Commissioned by the German silk industry Ludwig Mies von den Rowe and his partner Lilly Reich designed the interior of the café for the Fashion exhibition in Berlin of 1927 "Mode der Dame". The Café needed to represent the silk industry of Germany. The exhibition was held in the exhibition space of the Berlin Radio Tower.[2] He used different coloured silk and velvet curtains to seperate the café from the exhibition and creating private areas and protected spatial situation. He used colours as black, red, orange, yellow as well as gold and silver.[3] The velvet was introduced as a counterpart to the semi-translucent silk.[1]


12.02 Lay-out of the Café


12.03 Different high are used for the composition


12.04 Atmosphere of the "Samt und Seide" Café

12.05 Colour study of the "Samt und Seide" Café

1 COLOMÉS, E. & MOUZE, G. 2004. Mies, Café de Terciopelo y Seda, Madrid, Editorial Rueze S.L.

2 LANGE, C. 2011. *„Café Samt & Seide", Die Mode der Dame, Berlin 1927* [Online]. Krefeld: Projekt MIK. Available: http://projektmik.com/contact_en.php?SID=SQnleHdk57cx [Accessed 26 September 2013].

3 KRÜGER, S. 2009. *Textile Architecture*, Berlin, Jovis Verlag, p. 65

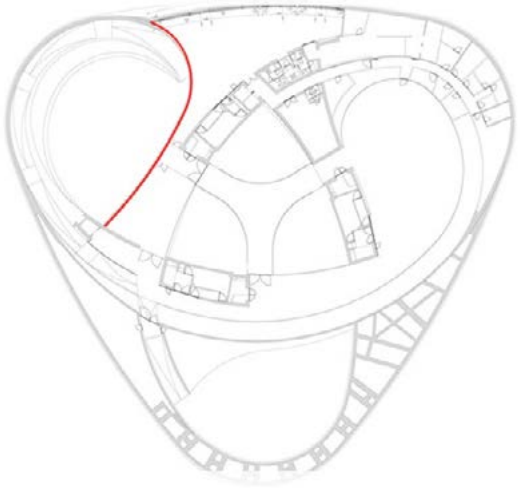
Mercedes Benz museum, Stuttgart 2006

Designed by UNstudio & Inside Outside

13.01 Outside of the Mercedes Benz Museum

The Mercedes Benz museum is an unique cloverleaf concept using three overlapping circles with the center removed to form a triangular atrium. An elevator brings the museum guest to the top floor where they can pick one of the two routes downwards. These spiralling route are situated around a central atrium. On different points throughout the routes their can by switched between the expositions. The museum has no straight walls or corners. Walls and ceilings merge into each other.[1]

Petra Blaisse and her team were asked to design curtains on multiple places throughout the museum. One of those curtains was meant for the Espresso Bar on the ground floor. The concave brush wall acts as a back drop to the concrete walls. The brushes scatters the sound-waves, giving the Bar a better acoustic.[2]



13.02 Seventh floor with restaurant

13.03 The groundfloor with Espresso bar

13.04/05 Restaurant and lounge defider from the atrium / detail of the wall

13.06/07 Brush wall in the espresso bar / detail of the wall

1 KÜHNLE, N. 2006. Mercedes-Benz museum [Online]. Amsterdam: UNstudio. Available: http://www.unstudio.com/projects/mercedes-benz-museum [Accessed 29 September 2013].

2 BLAISSE, P. & OTA, K. 2007. *Inside Outside*, Rotterdam, NAi Publishers.

Danish Cultural Ministry, Copenhagen 2005

Designed by Louise Campbell & Marianne Britt Jorgensen

14.01 Outside of Ministry building

This monument-protected building houses the Danish cultural ministry office. To give space for the seven staff members the entrance to the minister's office was used. To close the offices of the staff members from the passageway, without harming the building, five steel cubes frames were built. Hand-dyed curtains on two sides of these frames act as variable sun protection towards the window front and separate the working area from the passageway by creating a concentrated working atmosphere.[1]

14.02 Two desks in there new office

14.03 The office in use

14.04 Overview of the new office

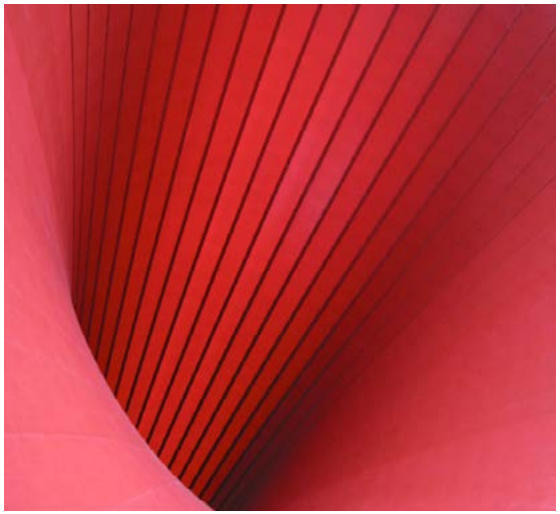
1 KRÜGER, S. 2009. Textile Architecture, Berlin, Jovis Verlag, p. 64.

Marsyas, London 2002

Material: Précontraint® 1002 fabric - PVDF (4,000 m², Serge Ferrari)[1]
Designed by Anish Kapoor

15.01 The Marsyas with light from the roof

Anish Kapoor was the third designer in The Unilever Series for the Turbine Hall at Tate Modern. Anish Kapoor is renowned for his enigmatic sculptural forms that permeate physical and psychological space. For the Turbine Hall at Tate Modern he takes up the whole space with three steel rings joined together by a single span of PVC membrane. Marsyas is a satyr in Greek mythology, the invertor of a wind instrument with two pipes, in contrast with Apollo, with his string instrument. Anish Kapoor wanted to make a body into skin.Because of its size you cannot see at the sculptural as a whole, from every place in the room you can see something new in 'Marsyas'. [2]



15.02 Detailed photo of the fabric

15.03 The horizontal ring in the middle

15.04 The vertical rings with visible lines from the fabric

1 2011. SPECIAL ISSUE MONUMENTA; Leviathan; Anish Kapoor. Serge Ferrari news WorLdWIdE, #6.

2 2002. The Unilever Series: Anish Kapoor: Marsyas [Online]. London: Tate Modern. Available: http://www.tate.org.uk/whats-on/tate-modern/exhibition/unilever-series-anish-kapoor-marsyas [Accessed 25 September 2013].

myThread pavilion, New York 2012

Material: solar-activated, reflective and photoluminscent threads of Nike FlyKnit [1]
Designed by Jenny Sabin & Ben Shaffer


16.01 The pavilion from the outside

Nike Inc. resealed a new technology for their running shoes, FlyKnit Collection, knitting fabric for the shoe as one piece. To launch this collection Nike Inc. quested six artists to design different pavilions all over the worth. For the New York City department in the Bowery Stadium Nike Inc. Jenna Sabin was quested. In collaboration with FlyKnit designer Ben Shaffer she organized two workshops to come to a form and a technic. Working with the new knitting techniques of the FlyKnit a lot of round 'tubes' are made, connecting them, creating a open, but 'thick' wall, forming a half a round space.[1]


16.02 Ben Shaffer in the illuminating pavilion


16.03 Jenna Sabin looking at different samples for the pavilion


16.04 Nike FlyKnit in the myThread pavilion

1 HIEMSTRA, G. 2012. myThread Pavilion [Online]. New York: Captain Lucas inc. Available: http://www.coolhunting.com/design/nike-mythread-pavilion.php [Accessed 27 September 2013].

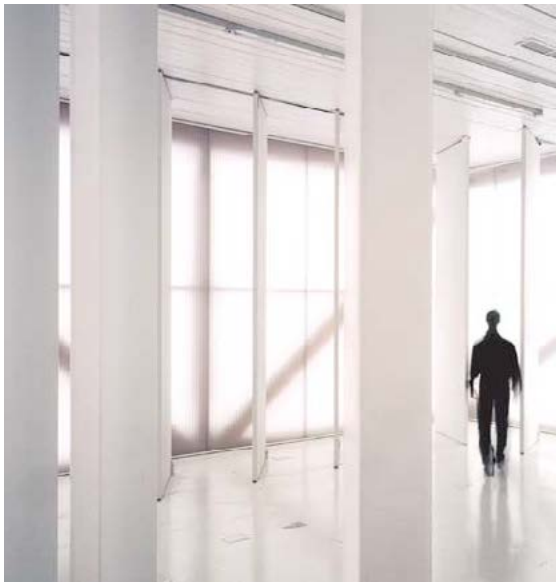
Video Link: http://www.youtube.com/watch?v=zU-pal6TyS5E

Swiss pavilion, Madrid 2003

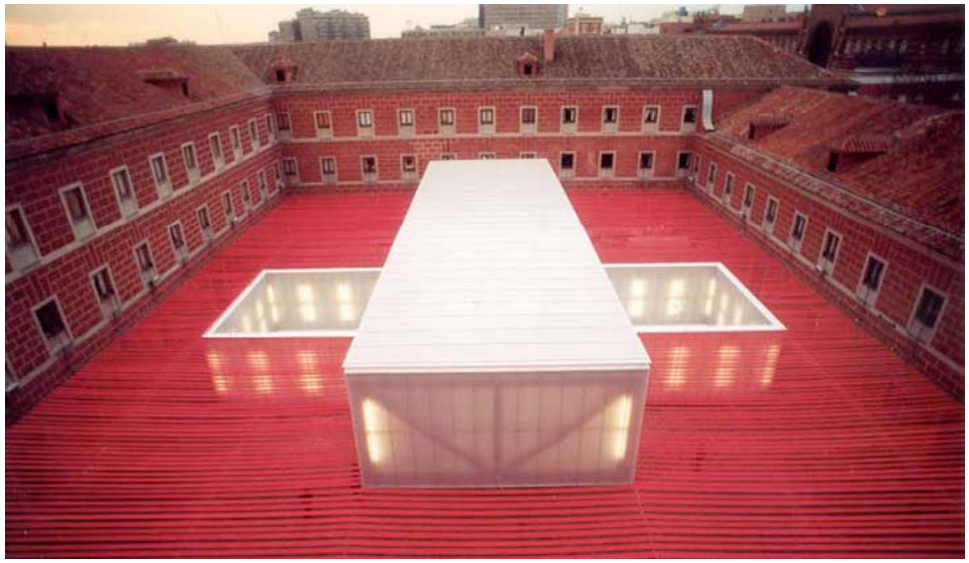
Material: Canvas[1]
Designed by 2b architectes


17.01 Bird's eye view on the Swiss pavilion

2b architects developed an exhibition pavilion for Switzerland for the international Arco art fair in Madrid in the courtyard of the Conde Duque cultural centre. Two containers stacked on top of another rotated a quarter turn forming the national symbol the 'Swiss cross'. The containers have a translucent white outer skin, making the interior very neutral. During the night the 'Swiss box' illuminated the courtyard. On bird's eye view the pavilion is a Swiss flag, red canvas bands connected from the boxes to the Conde Duque create the red colour. The bands give the inner courtyard a closed of feeling and a beautiful shading patron on the floor. Canvas and acryllic glass are the two basic materials for this project.[1]


17.02 The inside of one of the containers


17.03 The pavilion from the upper floor of the existing building

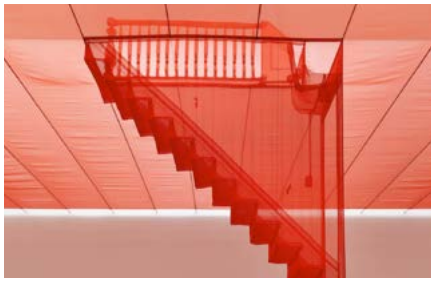

17.04 The pavilion from above, looking into the white spaces inside the container


17.05 The Canvas ribbons are hanging by steel threads

1 KRÜGER, S. 2009. Textile Architecture, Berlin, Jovis Verlag.

Staircase-III, London 2011

Material: Red transparent nylon[1]
Designed by Do Ho Suh



18.01 Staircase III in Tate modern

Do Hu Suh made this one to one scale model of the narrow staircase that leads for his apartment to the apartment of his landlord.[1] It took him six years to dare to go up this staircase. He takes architectural elements out of there context. The public can see it in a different light, normally there is no attention for these places. Staircases, bridges, doorways are special to him, in a video interview he explained; *"I'm more interested in transitional spaces [staircases, bridges, doorways] rather than destinations," Suh says. "They connect to different spaces, but at the same time they separate the spaces. I truly believe that life is a passageway."*[2]

18.02 Do Hu Suh while installing Staircase III

18.03 Textile outlet with a lot of detailing

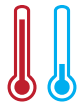
18.04 The textile staircase, including every detail

1 *TateShots: Do Ho Suh - Staircase-III*, 2011. New York: Tate Modern. (video)
2 *Staircase*, 2009. Directed by SUH, D. H. Londonish: Helsinki Films. (video)

Video link: http://vimeo.com/2985253#

Arium, Hannover 2003

Material: Polyamide sail [1]
Designed by J. Mayer H. architects



19.01 The courtyard during the event

The Designers World Conference was held in the former Erst-August-Karrée. The glass-roofed courtyard of this building was the meeting place of the event. The installation of J. Mayers H. transformed the courtyard into an intimate landscape for informal conversations and relaxation.[1] On a height of 4 meters a fabric roof of 30 meters long to 10 meter wide covers the courtyard. The space, covered by the sail, sewn together from different lenghts of material in yellow, green, and blue tones, provided a contemplative alternative to the hectic congress. By blocking direct sunlight the meeting place is kept cool.[2]

19.02 The contra shaped seat cushions

19.03 Light blocked by the installation

19.05 From above you can see the construction of the installation

1 NORDISKA, N. 2003. *ARIUM - ISCID* [Online]. Berlin: J. Mayer H. . Available: http://www.jmayerh.de/63-0-Arium.html [Accessed 27 September 2013].
2 KRÜGER, S. 2009. Textile Architecture, Berlin, Jovis Verlag.

Centre Pompidou, Metz 2010

Material: PTFE-coated fiberglass with TiO_2 Coating (8020 m^2, Taiyo Europa)[1]
Designed by Shigeru Ban & Jean de Gastines


20.01 Centre Pompidou in Metz

Shigeru Ban ones bought a Chinese hat in Paris, when he started to work on the Centre Pompidou in Metz he used this hat as a concept for the design. The wooden construction is a benchmark concept in the construction world and represents the bamboo hat. The membrane façade keeps the interior light and makes the museum an icon at night. The large overhanging roof protects the facades from the weather in winter and provides shade in summer.[2]


20.02 Detail of the wooden beams on the steel construction


20.03 The wooden roof construction

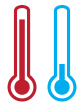

20.04 At night you can see the construction trought the illuminating façade

1 2011, *Taiyo Reference List* [Online]. München: Taiyo Europe GmbH, Available: http://www.taiyo-europe.com/downloads-overview [Accessed 30 September 2013].

2 ETHERINGTON, R. 2010. Centre Pompidou-Metz by Shigeru Ban [Online]. dezeen Magazine. Available: http://www.dezeen.com/2010/02/17/centre-pompidou-metz-by-shigeru-ban/ [Accessed 30 September 2013].

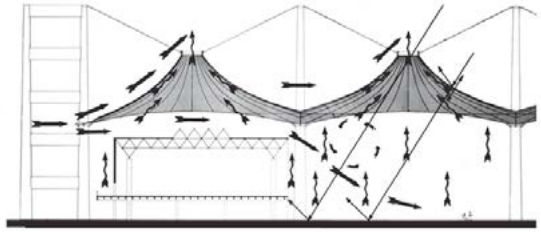
Hajj Terminal, Saudi Arabia 1981

Material: PTFE with a Teflon®-coated fiberglass membrane (43,000 m², Birdair Structures)[1]
Designed by SOM & Horst Berger



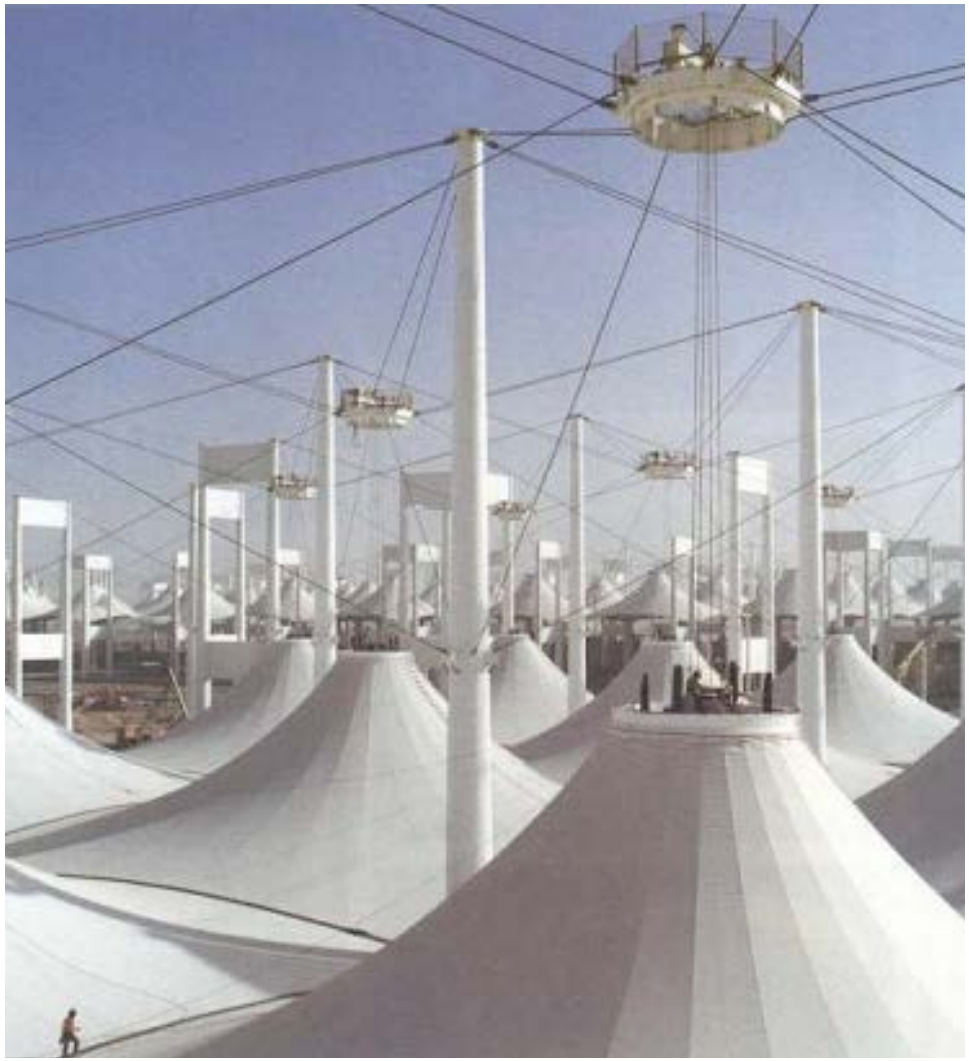
21.01 The terminal in use

On the Jeddah airport during the holy month of the Hajj an enormous number of pilgrims arriving, they're on their way to Mecca. One hundred jumbo-jets arrive on any day during this month. In 1977 Skidmore Owens & Merril was asked to design a new terminal structure. Because of its temporary function and situated in the desert, indoor climate was an imported design aspect. A conventional, enclosed building with air-conditioning was not an option. Lighting and the mass of a solid roof would increase the temperature in the terminal. A fabric tensile structure roof was a good option, with a size of 13 Astrodome stadiums this was a turning point for tensile structures. By reflecting most of the sun's head the temperature will not rise as much. Because of the translucency of Teflon-coated glass-fibre it is unnecessary to use artificial light during the day. The shape of the roof elements has the ideal shape for natural ventilation. And because the roof is light less money and time would be necessary to built it. Birdair Structure was the company that was responsible for the coated fabric.[1]



21.02 Climate Scheme of the terminal

21.03 Pelgrims inside of the terminal



21.04 The roof with all its construction

1 BERGER, H. 1996. Light Structures Structures of Light; The Art and Engineering of Tensile Architecture, Bazel, Birkäuser.

Qatar Showcase, Doha, 2010

Material; Multiple layer, PVC and ETFE.[1]
Designed by Arup Associates

22.01 The solar installation of the stadium

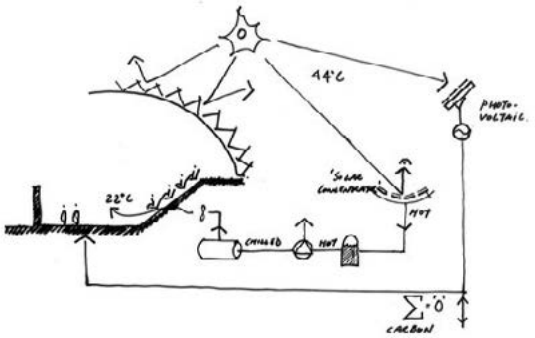
Arup Associates designed world's most sustainable stadium for the 2022 FIFA World Cup, the Qatar Showcase. The starting point of the original design brief was a simple pavilion demonstrating some cooling performance and setting a standard for the stadium for the 2022 FIFA World cup. Designed in 8 weeks and built in 4,5 months. The five-a-side football stadium includes amongst others fixed seating for 500 spectators as well as air-conditioning to spectator seats and area (max. 28˚ C pitch tempearature at much higher outside temperature up to 48˚ C).

The Revolving Canopy Roof revolves, in 14-and-a-half minutes, to provide cooling shade within the building and insulated against the hot sun in summer. The multi-skinned roof structure is clad with permeable screens of triangulated PVC fabric with a low emissivity coating supported on a secondary steel frame, with an inner cladding of triangulated 'pillows' of translucent ETFE (Ethylene Tetrafluroethylene) membrane, providing both thermal performance and light transmittance, keeping radiant and conductive heat out and allowing natural lighting into the arena.[1]

1 2011 Qatar showcase. World Buildings Directory, [online accessed: 30 September 2013] http://www.worldbuildingsdirectory.com/project.cfm?id=3187

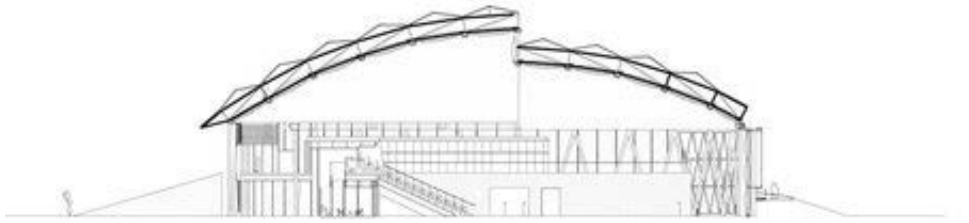
22.02 Inside of the roof clading

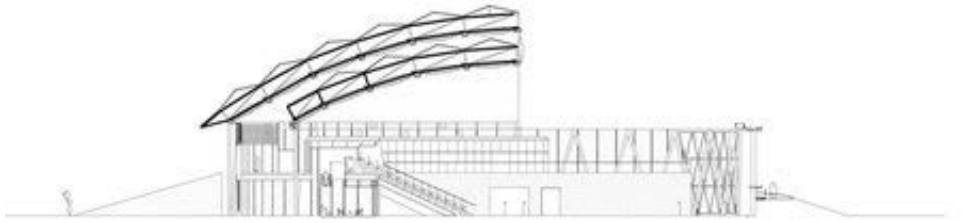
22.03 Roof openings are seen at night



22.04 Climate scheme of the stadium

22.05 The roof in the shape of a cochlea

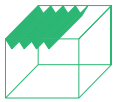




22.06 Two the same sections, opened and closed roof.

Rothenbaum tennis stadium, Hamburg 1997

Material: PVC-coated Polyester (3,000 m², Koch Hightex)[1]
Designed by Schweger & Partners



23.01 Closed tenniscourt during a game

This tennis stadium consists of a retractable roof, where play can continue regardless of weather conditions.The free-span structure is a typical ring-stadium type, with fixed, radially cable support. The 63m-diameter inner roof is asymmetrical to avoid casting shadows over the court. The fixed outer roof is made from the same material as the retractable roof, translucent white, self-cleaning PVC-coated polyester membrane. In retractable state the inner roof is covered protecting the folded fabric from rotting and tearing. Sensors automatically control the movements of the inner roof. The unfolding of the roof takes place with maximum speeed because the fabric needs continually tension.[1]

1 DREW, P. 2008. Rothenbaum Tennis Stadium. *New Tent Architecture*. London: Thames & Hudson Ltd.

23.02 Bird's eye view on the tenniscourt with open roof

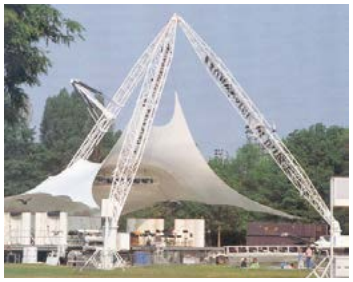
23.03 Nice weather during a tennis match

23.04 Open roof

23.05 The roof is folded

Carlos Moseley Music Pavilion, New York 1991

Material: Précontraint 1002S - PVC-coated polyester fabric (339 m², Serge Ferrari)[1]
Designed by FTL Architects plc

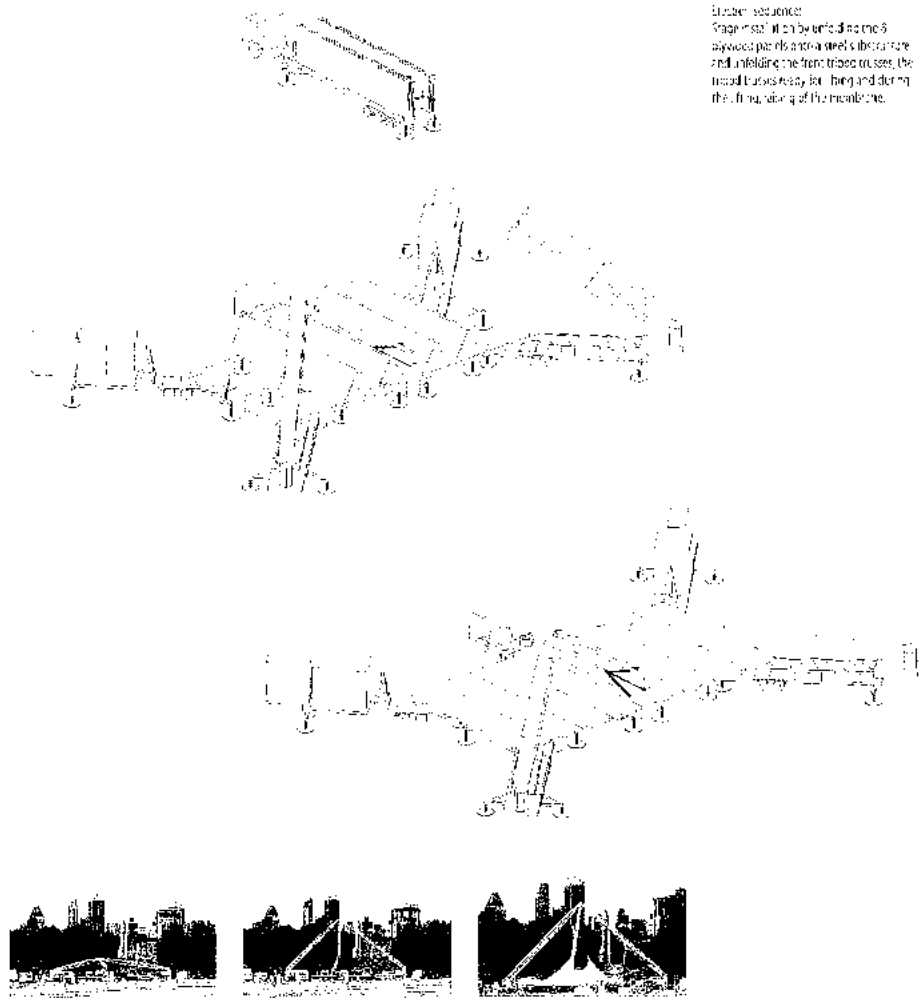


24.01 Pavilion in use

From 1965 the New York Philharmonic gives every summer free concerts in the Park. In 1991 FTL Architects designed a Mobile bandstand that can be built in only six hours. The stage is erected from five semi-trucks and two trucks. In first summer 30 concerts were held in 16 different parks. The same trucks that moved the pavilion from location to location were used as the basic foundation of the pavilion.[1]

24.02 Technical drawings of the Music Pavilion

24.03 Connection detail



24.04 The construction principle of the Music Pavilion

1 H. Berger, 1996, Mobile Bandstand, New York, USA, *Light Structures; Structures of Light,* Birkhäuser, Basel, Boston, Berlin.

Folding Umbrellas, Madinah 1992

Material: SEFAR® Architecture TENARA® Fabric - ePTFE (4T40HF *)
Designed by SL-Rasch and Dr. Kamal Ismail

25.01 Umbrellas blocking the sun

The folding Umbrellas are built on the courtyard of the Prophet's Holy Mosque to regulate the climate. In summer the unfolded umbrellas keep the sun from heating up the marble floor. At night when the umbrellas are folding in, the sky cools the courtyard. In december the cycle turns, letting the marble floor heats during the day and traps heat with the opening of folding umbrellas at night.
The detailing at the pillars are made along the minimal surfaces' lines of stress add a blue lines as ornamentation. This way the umbrellas gain in plasticity and merge fully with the mosque.[1]

25.02 Unfolding Umbrellas

25.04 Beaulifily detailed, combining construction and decoration

25.04-06 Umbrellas in three steps closed, unfolding and open

1 HOLZAPFEL, R. 1993. Folding Umbrella [Online]. Leinfelden-Echterdingen: SL Rasch. Available: http://www.sl-rasch.com/p_048.html [Accessed 20 October 2013].

Video link:
http://www.youtube.com/watch?v=PvCngVZqGNY

* Comparable contemporary project of the same manufacturer

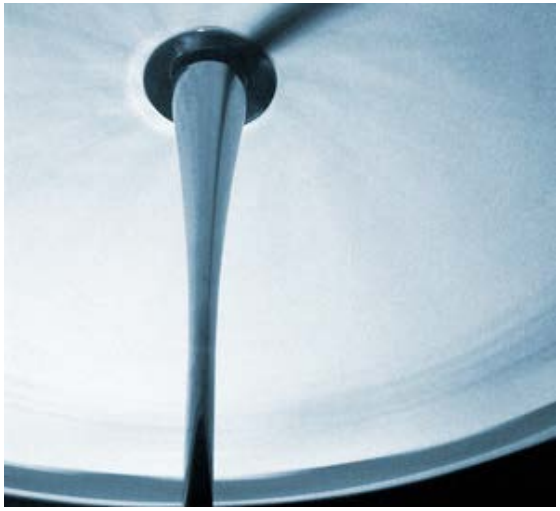
Rotating Umbrella, Stuttgart 2003

Designed by Werner Sobek

26.01 Rotating umbrellas in different steps

This spoke-less umbrella gets it shape from a rotating electro motor in the rod. The fabric is light reinforced in the hub area. The lightly curved edge improves the aerodynamic stability even further.[1]

26.02 Standing still



26.04 Rotating

1 SOBEK, W. 2003. Rotating Umbrella [Online]. Stuttgart: Werner Sobek. Available: http://www.wernersobek.de/index.php?page=67&modaction=detail&modid=580 [Accessed 30 September 2013].

The Umbrella, Ibaraki and California 1991

Designed by Christo and Jean-Claude

27.01 Umbrellas in a valley in California

In December 1990 the construction of the umbrellas began. On October 9 in 1991 1,760 workers began the installation of the 3,100 yellow umbrellas in Bakersfield, California and the 1,340 blue umbrellas on the other side of the Ocean in Japan. Each umbrella measures 6 meters high in height and 8.66 meters in diameter. This 26 million temporary installation reflected the similarities and differences in the ways of live and the use of land in the two inland valleys. 18 days later the removal started and all materials used in this project were recycled when it was taken down.[1]

27.02 Design drawings for the blue umbrellas

27.03 The valley in Japan

27.04 Installing one umbrella askes for a lot of manpower

27.05 The valley in California

1 DAVENPORT, J. 2013. The Umbrellas [Online]. New york: Christo and Jeanne-Claude. Available: http://christojeanneclaude.net/projects/the-umbrellas [Accessed 3 September 2013].

Off Stage, Versailles 2006

Designed by Shigeru Ban

28.01 When the music starts it is still closed

"This temporary project was a kind of music box, at the beginning the structure was down with the musicians inside and just after the scissors columns lift the veil from a music stage inside the garden of the Château de Versailles."[1]

This temporary stageis inspiring because of its simplicity and elegance. An example were basic elements together form a beautiful stage.[1]

28.02 The stage during a show

28.03 Pussing the curtain up, instead of pulling it up

1 BLANCHE, N. 2006. *VERSAILLES OFF STAGE - Versailles, France, 2006* [Online]. Tokyo: Shigeru Ban Architects. Available: http://www.shigerubanarchitects.com/works/2006_versailles-off-stage/index.html [Accessed 30 September 2013].

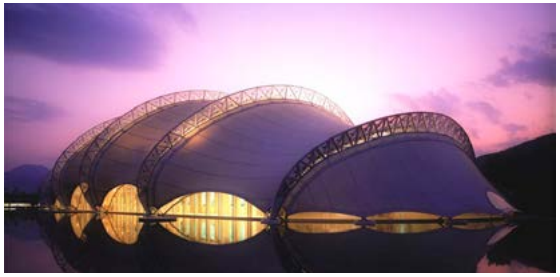
Laboratorium M&G Ricerche, Venafro 1991

Material: PVC-coated polyester fabric
Designed by Philippe Samyn & Partners

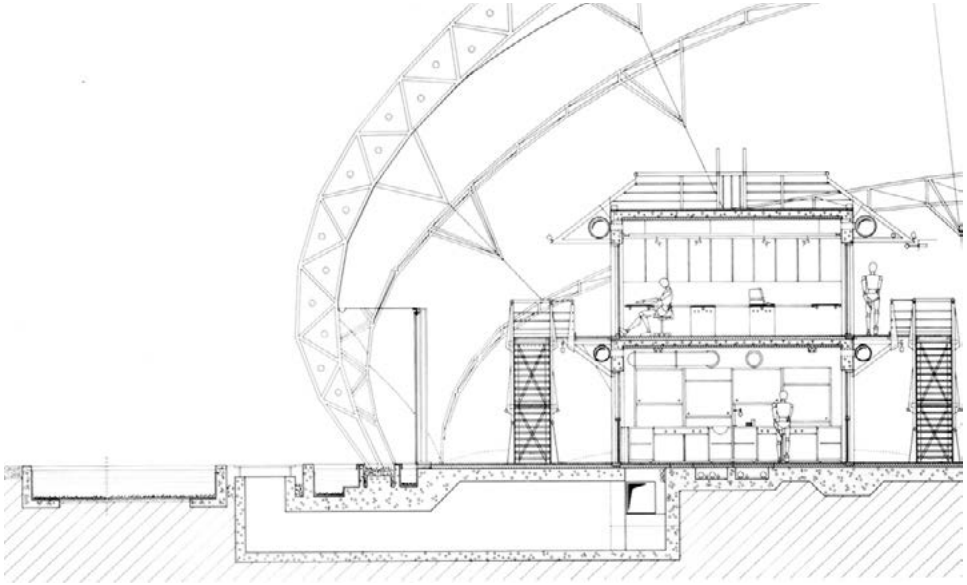
29.01 Model

This fabric structures is suitable for the function because of natural light and the big span gives lots of flexibility to the ground floor. The program of this research centre can be divided in two parts; a technical area with pilot plans for the development of production and processing methods, and a chemical-physical area with labs for synthesis and analysis of chemical products. The program asked for a minimal high of 15 meter and a controlled environment. The design team find the fabric structure suitable because of its flexibility and natural daylight. For functional and safety reasons the large air volume under the membrane roof must be airtight. The tensile structure is in this case supported by six triangulated arches. Transparent PVC-coated polyester fabric covers the arches. The roof is made of translucent PVC-coated polyester fabric.[1]

29.02 The roof connection to the ground



29.03 The building at night



29.04 Section of the façade and the workspaces

29.05 Inside it has a light atmosphere

1 DREW, P. 2008. New Tent Architecture, London, Thames & Hudson Ltd.

Prada transformer, Seoul 2009

Material: Cocoon Mothballing System (Cocoon Holland)
Designed by OMA/Rem Koolhaas

30.01 The Prada Transformer in its context

Prada and OMA work together since 2000 in the time they have formed an opinion of interaction of applied arts; *fashion is in architecture, architecture is in fashion; art is in fashion, art is in architecture*. The concept is a result of the program; the pavilion is made to hosts four different events. The events hosted were a PRADA fashion exhibition, a cinema, a fashion show, and an art collection exhibition. The Prada Transformer has one of four different apparent shapes, depending on the function of the building that is needed at the moment. The pavilions' shape is that of a tetrahedron; a tetrahedron is a polyhedron composed of four triangular faces, three of which meet at each vertex. The tetrahedron sort is of a pyramid, which is a polyhedron with a flat polygon base and triangular faces connecting the base to a common point. Cranes have been used throughout the event to lift the building and rotate it so that the tetrahedron levels with the ground on one side and therefore change the building's form and function while it leaves the remaining three shapes to compose the ever-changing building form.[1]

1 ARGYRIADES, M. 2009. A Deeper view inside PRADA Transformer in Seoul [Online]. Yatzer. Available: http://www.yatzer.com/A-Deeper-view-inside-PRADA-Transformer-in-Seoul [Accessed 31 September 2013].

30.02 Illumunating Prada Transformer

30.03 Transformation of the Prada Transformer

30.04 Fashion exposition in the Prada Transformer

30.05 The constrution inside the Transformer

Leviathan, Paris 2011

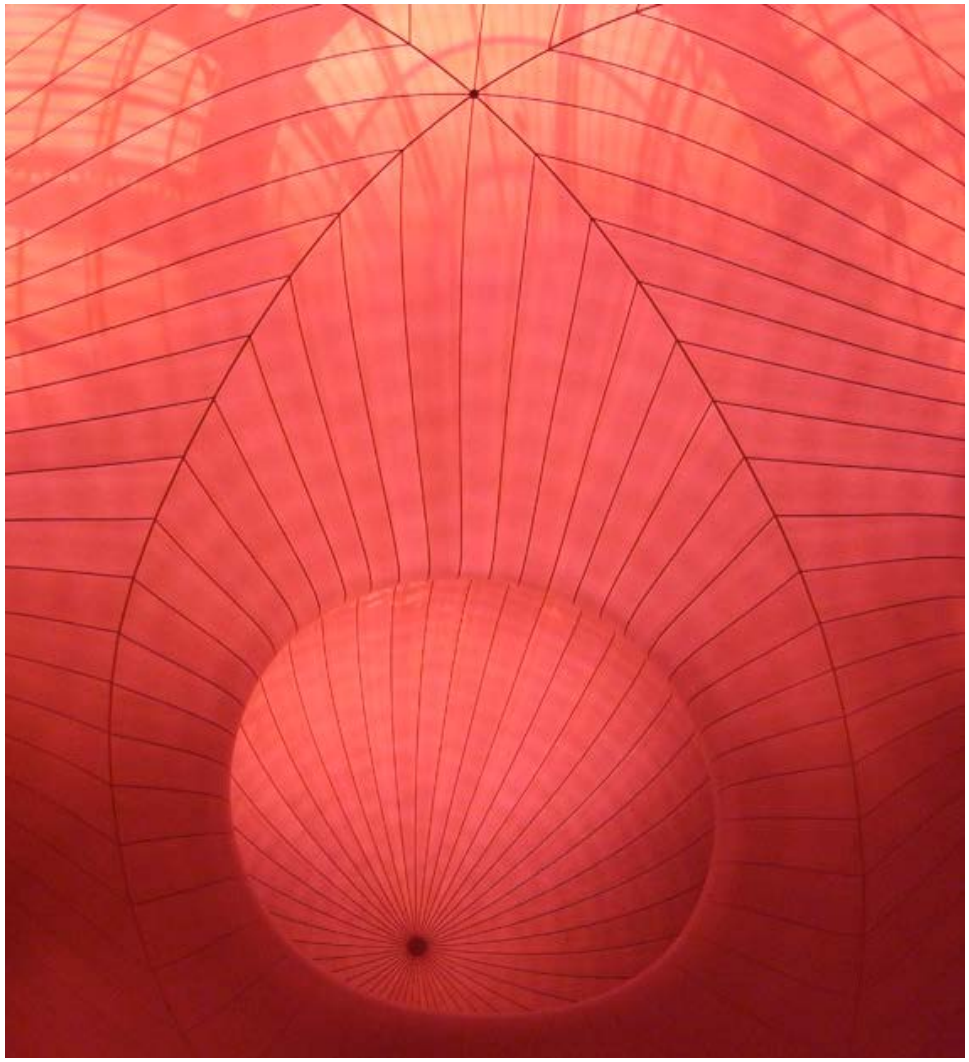
Material: Précontraint® 1002 fabric - PVDF (72,000 m², Serge Ferrari) [1]
Designed by Anish Kapoor

31.01 Leviathan, the bull in a china shop

Previous collaboration between Anish Kapoor, Hightex, Tensys and Serge Ferrari in 'Marsyas' in Tate Modern was proven to be fruitful. Eight years later a different new artwork is designed by this group, with this project they can take it a step further. No big steel structures is carrying this sculpture, but air keeps the structure in place. Leviathan is a monster with a body that is too big; it gives a feeling of a bull in a China shop. Inside the sculpture it gives the sense of being inside the body of this monster, the dark red colour resembles blood. From inside the beautiful steel structure of the Grand Palais can be seen troughout the fabric, while from outside it looks like a non translucent membrane.[1]

31.02 Under the installation, look at his size

31.03 Inside the body of Laviathan



31.04 From inside you can see the construction of the Grand Palais

1 2011. SPECIAL ISSUE MONUMENTA; Leviathan; Anish Kapoor. Serge Ferrari news WorLdWIdE, #6.

Video link: http://www.youtube.com/watch?v=12Ni0c4D27Y

Video link: http://en.sergeferrari.com/lightweight-architecture/interview-with-francoise-fournier-serge-ferraris-architecture-market-manager/

Inflatable Tea House, Frankfurt am Main 2007

Material: Gore® Tenara 3T40 - ePTFE fiber base (fabricated by Canobbio S.p.A.) [1]
Designed by Kengo Kuma


32.01 The inflatable Teahouse

This Teahouse is given by Japanese companies to the 'Museum für Angewandte Kunst', to complement the Japanese fine arts collection. This temporary pavilion can be built up and be taken down and carried away on a trolley by four people.
The double skin pavilion is like an air mattress with an oversized blower. The blower is capable to inflate the single camber of the Teahouse in 10 minutes. Polyester coupling cables keep the two layers together, in a diamond pattern. The air-filled wall is in the top 1-meter thick. With an air pressure of 1000 Pa the Teahouse is standing and with 1500 Pa it can withstand a storm.
The pavilion has two entrances that can be closed by air-tied zippers. The LED-lighting illuminates the Teahouse at night. The LED-lighting can also be used as heating for the inner-room.[1]


32.02 From inside the teahouse, the trees are giving lightshow


32.03 Illuminating teahouse at night


32.04 Taking your shoes of while visiting the teahouse

1 SCHMID, G. 2011. The Modern Teahouse – a contemporary nomadic building. Steel Construction Design and Research, Volume 4, 121-126.

Eden Project, Cornwall 2001

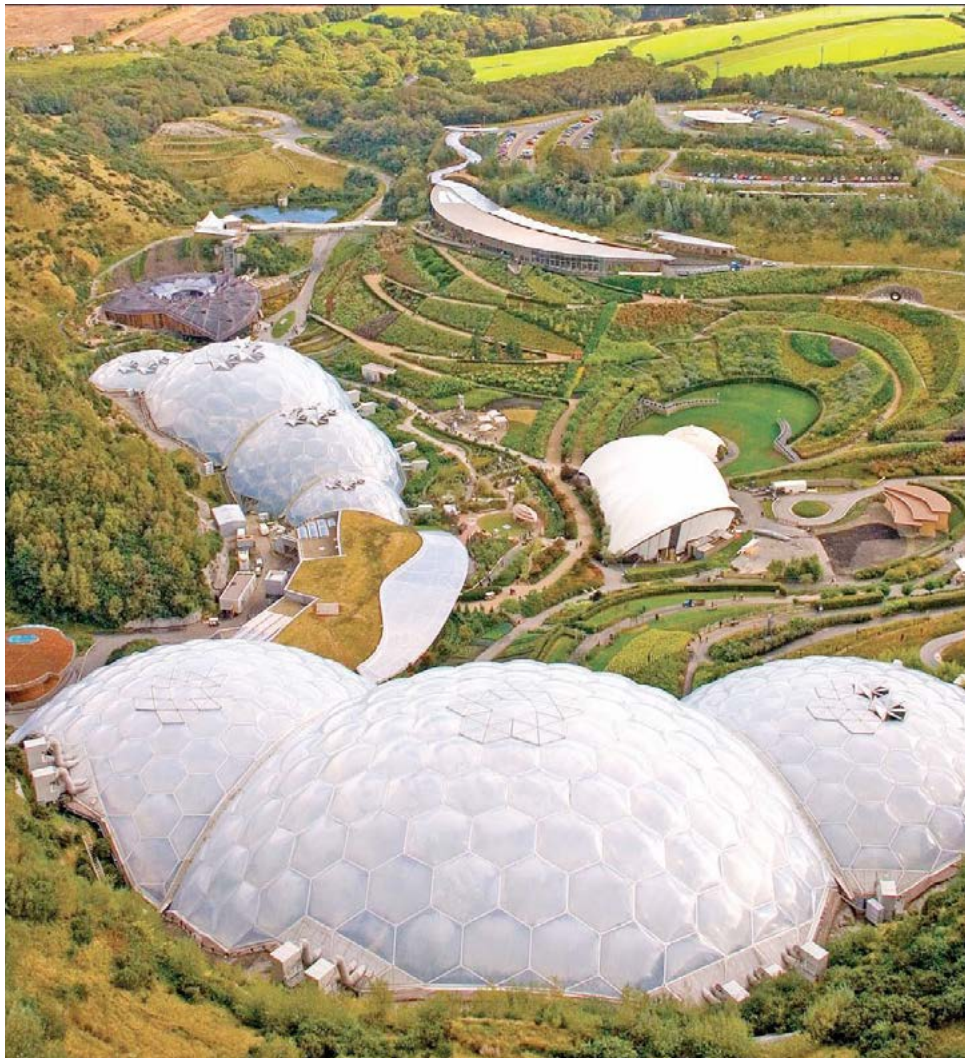
Material: Texlon® ETFE foil (30,000 M², Vector Foiltec)[1]
Designed by Nicholas Grimshaw

33.01 Eight domes from the Eden Project

The Eden project consists of two biomes in eight interconnected geodesic domes. One of the biomes is a humid climate; the other is can be altered into its garden inside. The every dome is cladded with a different size of three-layered ETFE-pillows with steel structure. An other reason for choosing ETFE-pillows is that ETFE-foil is 100 times as light as glass, thereby the steel construction can be smaller, that is why more light and heat can be collected. The Eden project has been build as climate change awareness by the Millennium Commission. Cornwall's economy hits it hard went mining and the fishing industry declined. The Eden project can be considered as a successfull project each year thanks to 2 million visitors.[1]

33.02 The domes are creating a climate for the tropical plants

33.03 The whole construction is on the inside of the domes



33.04 From up the hill you can see the whole Eden Project and his ouside gardens

1 2001. *Project: Eden Project* [Online]. London: Vector Foiltec Ltd. Available: http://www.vector-foiltec.com/en/projects/pages/gb-cornwall-eden.html [Accessed 30 September 2013].

2 DREW, P. 2008. The Eden project: Phase 2, The Biomes, *New Tent Architecture*, London, Thames & Hudson Ltd, p. 184.

Allianz Arena, Munich 2005

Material: ETFE foil (Koch Membranen)
Designed by Tim Hupe of Herzog & de Meuron


34.01 Allainz Arena is opening for a game

This stadium is a prominent landmark on the northern edge of Munich. The stadium housed two different football clubs. The façade consists of 2,760 ETFE-foil air panels, filled with dry-air. All the pillows are individually adjustable to meet the changing loads from wind. The transparency of the panels varies, some are transparent and others have a lot of small white dots on the surface, but they appear to be white. The panels can be illuminated in red, white or blue light, it depends on the respective home team. Every diamond-shaped pillow has a surface of 35-m2 and the ETFE-foil is 0,2 mm thick. The choice for ETFE-foil has been made, due to the fact that it doesn't burn without a supporting heat source, even a cigarette can not burn a hole in the panels. Because of the size of this project solutions could be extensively been tested. Next to the large number of air-pillow the lighting was also a big issue, because of the location next to the highway bright light was not allowed.[1]

34.02 Allianz Arena in a neutral state

34.03 TSV 1860 München is playing a home match


34.04 Bayern Munich played a home match, there home colour is red

1 ZEH, M. *2010. Herzog & de Meuron's Allianz Arena 10+ yrs; The Allianz Arena in retrospect.* [Online]. Munich: Fabric Architecture Available: http://fabricarchitecturemag.com/articles/0910_f2_allianz_arena.html [Accessed 21 September 2013].

The Tubaloon, Kongsberg 2006

Material: Précontraint 1002 S - PVDF coated PVC fabric (Serge Ferrari) [1]
Designed by: Snohetta AS

35.01 The Tubaloon

The Norwegian architecture firm Snøhetta designed the main stage for the annual Kongsberg Jazz Festival, which takes place the town three weeks a year. The rest of the year the membrane structure is stored in standard containers. The geometry of this pneumatic structure is suggestive of natural acoustic forms such as the inner ear. Acoustically the Tubaloon is a dynamic and tunable venue, the PVC fabric is nearly transparent to sound during amplified performances. The structure type is hybrid; it combines pneumatic perimeter tubes and an inner steel skeleton. The pneumatic perimeter tubes and the tension membrane structure together give a uniquely shape. The designers for Snøhetta Architects describe the main stage as an biological organism rather than just a skin.[1]

35.02 The installation of the Tubaloon

35.03 The Tubaloon from a visitors point of view

35.04 The back side of the Tubaloon

1 SLYNGSTAD, S. 2006. *Kongsberg Jazz Festival Norway* [Online]. Olso: Shøhetta. Available: http://www.e-architect.co.uk/norway/kongsberg_jazz_festival_pavilion.htm [Accessed 29 August 2013].

03.01 Introduction of the Analyses

Textiles *"are soft, sensuous, feminine, touchable, adaptable, compact, easily dismantled and relocated, an convenient."*[1] And in the case studies shown those qualities are used to there fullest advantage, there was always one, two or three qualities most important for a project.

In the picture of the curtain wall house you can see more than one reason why textile was pick over a more common building material. It is strong, but movable, translucent and light. Textile has in itself no straight angles and because of this softness it invites to be touched, it gives an other atmosphere. In this analyses only one main reason is pick per project to categories the reasoning of this case studies.

The reasons that were selected are Temporarily, Weight, Adaptability/Moveability, Translucency/Lighting, Indoor Climate, Atmosphere, Acoustics. The projects are collected on one of those reasons. After that they are being analysed on that point.

As a second analyses the materials are analysed. What are the reasons for picking a particular membrane in stead of an other.

The pictures in the analyses all come form the case studies in this research, the numbers are kept the same, because than it is easy to find the original pages for that particular case study and it so you can find the reference in the Illustration credits list. In the analyses the number of the project talked about are put behind it.

3.04 Curtain wall house

1 DREW, P. 2008. *New Tent Architecture*, London, Thames & Hudson Ltd. p 6.

03.02.01 Temporarily

There are a lot of temporary projects if you look at textile projects. Because of this lightness, easiness to dismantle, movability and nowadays is relatively simple to reuse or recycle textile membranes. Temporary project can be divided in three categories;

The first type has more than one temporary locations and the design concept is based on *build to dismantle* and *movable* in smaller parts. In the work two examples are give of this type; The Olympic Basketball Stadium in London 2012 [1] and the Carlos Moseley Music Pavilion [24]. The basketball stadium was built to be sold to the Olympic Games of Brazil.
The Carlos Moseley Music Pavilion was designed with the knowledge that the pavilion need to be moved by trucks, so they were included in the design as construction. The pavilion was moved 16 times during one summer, the music pavilion was the stage during 30 concerts held by the New York Philharmonic.

The designs that only are used or shown *once* as part of an event used textile to show some qualities only textile has. Such as Wrapping Reikstag [7], Christo made use of textile for the property of the way it fold. The artist Anish Kapoor used textile because of the span he could reach with it in the Tate Modern hall [15]. With the myThread pavilion [16] the material was the starting point of the design, because Nike wanted a pavilion to celebrate the new FlyKnit technology. So in this category there is always a second reason why textile is used.

Recurring use can describe annual events pavilions, that do not want take up the space all year around. The inflatable tea house [32] of Kengo Kuma has this quality, because the structure is filled with air as it is in use. The total volume of the structure without air is small. The pavilion can be built or dismantled by four people and be stored on a trolley.
Another example is the pavilion for the annual Norwegian Jazz Festival [35], every year the city of Kongsberg the Tubaloon is rebuilds on there public square. The pavilion is designed to fit in regular containers throughout the year.


1.01 Olympic Basketball Stadium - 'Movable'


7.01 Wrapping Reikstag - 'Once event'


15.01 Marsyas, Tate Modern - 'Once event'


16.01 myThread pavilion - 'Once event'


17.01 Swiss Pavilion Madrid - 'Once event'


24.01 Carlos Moseley Music Pavilion - 'Movable'


32.01 Inflatable Tea House - 'Recurring use'


35.01 The Tubaloon - 'Annual recurring use'

03.02.02 Weight

When large areas on a building need to be covered with a waterproof and translucent material, the lightest choice is a textile. Subsequently the construction can be built less heavily to coop with the same forces. Less building material are needed. The same is truth for climate installations. After glass sunlight heads the air in the room, because no sunlight is reflected. In the cause of a solid building material the thermal mass would store the solar head, keeping the temperature constant, but in some climates this is not desired. A solid façade also asks for lighting inside and that costs energy. When properly designed the use of a textile façade or roof makes the building more sustainable, lowering the environmental impact.

The Atrium of the Burj al Arab Hotel [2] has a 7,500 m^2 façade, if this would be made of glass the indoor climate of the atrium would be over-headed very quickly. The translucent membrane reflex most of the sunlight, limiting the head transfer. This is also true for the membrane roof of the Centre Pompidou in Metz [20].
Because the Prada transformer [30] needs to be turned by cranes, the lighter the pavilion was, the small the cranes and there contra-weight could be and how smaller site needed to be.

2.01/04 Burj al Arab Hotel - From outside and inside

20.01 Centre Pompidou in Metz

30.01 The Prada Transformer - outside and inside

03.02.03 Adaptability / Movement

Flexibility is the most particular quality determining the definition of textile or membranes. In most of the shown projects this has influenced the chooses for the building material. In the four projects you see on the right his it the main reason. Moving curtains really show the lightness of the material. In my eyes a moving curtain is poetic, it shown the influences of wind and nature, without changing there qualities. The Gates [10] of Christo explore this effect in Central Park in New York. In a snow-white surrounding the safraan coloured curtains move on the choreography of the wind. In the remaining projects the movements are electronically controlled.

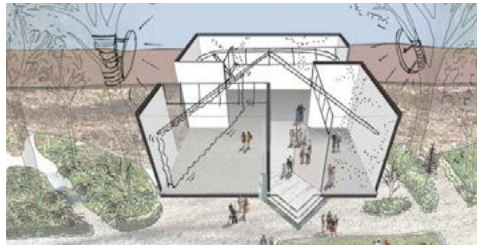
Because of the building industry crisis in the Netherlands, the budget for the new pavilion Architecture Biennale in Venice of 2012 was reduced. Renovation is put on the architectural agenda more and more, so that is what the pavilion [11] needed to shown. Petra Blaisse re-designed the interior of the Rietvelt pavilion from 1954. The ever changing interior consists of different curtains on a rail made of bicycle chains attached to a small, silence motor. The sounds the movements make are bells and whistles attached to the chain.

For the roof of the Rothenbaun tennis court [23] is designed so the weather does not ruin a tennis match.

In this case movement is important, but also the most vulnerable position the fabric can be in. The transforming process of de-folding needs to happen at a certain speed, so it does not harm the fabric to much.

The rotating umbrellas [26] get there shape for the movement, without extra structure it gets it shape from the centrifugal force principle.

10.01/03 The Gates - seeing the beautiful shadow of the trees through the fabric, it is like a river trough the park.



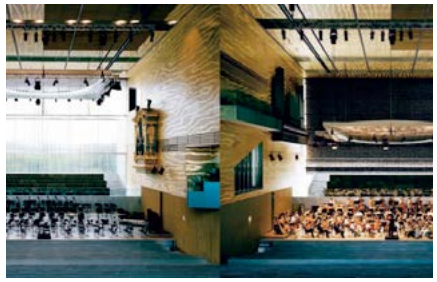
11.01/05 Re-Set - Design drawing , re-set during the Biennale of Venice in 2012

23.05/04 Rothenbaun tennis-court - The roof is folded and de-folded

26.01 Rotating umbrellas - in different steps

03.02.04 Transparency / Lighting

Most textile membranes used, are translucent, blocking most of the solar radiation but still let some light through. In most case studies designers use this to there advantage. In some projects this is the decisive reason for choosing textile. On the right some of those projects are shown.
The architects of OMA designed the large concert hall of Casa da Musica [9] in Porto with two walls completely from glass, in a performance hall this is very odd. To have more control over the light intensity in the room, they let Inside Outside design a three layers curtain. In this way the room has four different lighting options, without using a lot of energy.
The Staircase [18] of Do Ho Suh, exhibits a normally very solid architectural element in a transparent material, so the public sees the element in a new light. The transparency is contradicting the normally closed of function of this staircase and door.
Shigeru Ban used a translucent fabric to transform this Ancient stage in a simple way into a modern music-box [28], as the music starts it opens through moving the element up by the supporting cranes.
The M&G Laboratory [29] is a big tent with a very artificial indoor climate, because everything needs to be controlled. The translucent façade give a diffuse light in the indoor space.
Anish Kapoor shows in the Leviathan [31] a body, where from the outside you can not look through. But from the inside the colour of the material changed and you can see a glimpse of the surrounding.
The Allianz Arena uses there transparent and translucent façade to transform the stadium into an icon of two different soccer club easily with a turn of a switch.

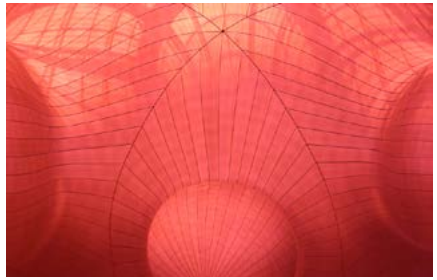


9.06 Casa da Musica - Difference between two curtains and no curtain in the major music hall

18.01 Staircase III in Tate modern

28.01 Off Stage - When the music starts it is still closed

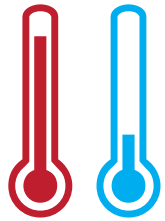
29.05 Laboratory M&G - Inside it has a light atmosphere



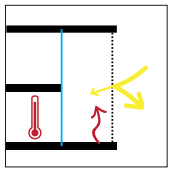
31.04 Leviathan - From inside you can see the construction of the Grand Palais

34.04 Allianz Arena - Bayern Munich played a home match, there home colour is red

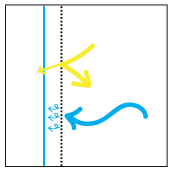
03.02.05 Indoor Climate



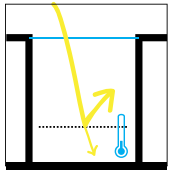
If a textile wall, façade of roof is properly designed it can have a lot of influence on the climate system. And it can make the building more sustainable. The projects shown on the right will be explain with schemes and additional texts. The textiles can have influences on solar radiation, ventilation and the inside temperature.



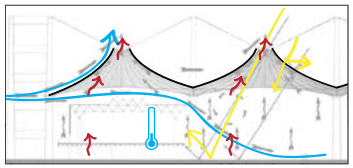
The first project is the Curtain Wall House [3], were the curtains enclose the balcony of the residential house. When the curtains are closed a sort of double façade is created, keeping the inside warmer. Because of the transparency of the fabric still some warmed of the solar radiation is collected.



The next scheme demonstrates the climate principle of two projects, the research office for the furniture company Sedus Stoll [5] and the Westraven building in Utrecht [6]. The textile façades are lowering the solar radiation inside the offices. And the façade breaks the wind into smaller air flows. So ventilation can be created trough opening a window, even on higher levels, without the disturbing drafts.



If textile is use indoors to block the sun lighter colours need to be used to prevent extra warmed is collected in the fabric. In the Arium [18] project light colours protect the courtyard from overheating and creating a calm atmosphere.



The Hajj terminal [21] is only used a month a year, there for a passive climate system can really weight against an all installation controlled indoor climate. The shape of the roof elements is perfect to release the head and increase natural ventilation. The fabric is translucent and through the openings comes enough light that during the day no artificial lighting is needed.

3.04 Cutrain Wall House - The façade with beautiful moving curtains, not connected to construction

6.01 Overview of the Westraven building

21.01 The terminal in use

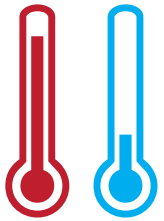
25.01 Umbrellas blocking the sun

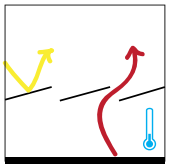
5.01 View on the building

19.01 The courtyard during the event

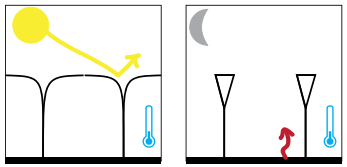
22.01 The solar installation of the stadium

33.01 Eight domes from the Eden Project

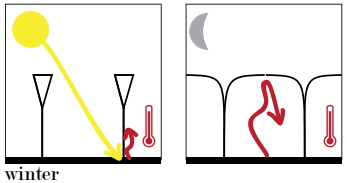




The Qatar showcase [22] wanted to be the most sustainable and completely self-supporting stadium. In a climate with an average temperature of 44˚C cooling is the most important climate aspect. With a moving roof blocking the sun through a double layer textile façade the stadium warms as least as possible. The rest is cooled through a cooling installation, powered on solar energy.

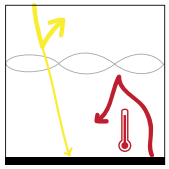


summer



winter

The folding umbrellas [25] create a passive climate for the mosque plazas, used in many different places. In the middle east the climate has extreme difference between day and night. This umbrellas make good use of that fact. If it is to hot during the day, the umbrellas block the sun, keeping the marble ground cool. In the cold night, the ground cools the head that was collected.
On colder periods it is reversed, during the day the marble floors store head in there thermal mass. In the cold nights the umbrellas protect the floors from the cold sky, saving the head for the next day.



In the Eden project [33] two tropical gardens are created on the ETFE-pillow-façade. The transparent ETFE-pillows are not resistant against solar radiation, the pillows work as insulation because of the inner layers that keep the air set in the pillows. So head comes in and stays inside. The indoor climate is warmer than the outside temperature.

03.02.06 Atmosphere

Like put down in a earlier analyses textile has something poetic, not only through movement, be in other ways as well. It gives another atmosphere than solid materials, because of its softness and the way it can flow and fold. In some cases it feels like a baby blanket, it can give a senses of privacy and security. Two examples demonstrated this aspect, Haus mit Atelier [4] and Aichinger Haus [8]. In both project curtains are taking outside, giving them more importance.
In the “Samt und Seide” Café [12] the curtains form smaller spaces in the large exhibition hall, making it more intimate.


4.02/04 Haus mit Atelier - Combination from curtains and pool, and inside and view


8.02/04 Aichinger Haus - View from the inside - light shining through

12.04 Atmosphere of the “Samt und Seide” Café

27.01 ‘Umbrellas’ in a valley in California

03.02.07 Acoustics

When a three-dimensional fabric is created it can absorb sounds, by breaking the sound waves. Like the brush-wall in the espresso-bar of the Mercedes-Benz museum [13]. The concave brush wall acts as a back drop to the concrete walls. The brushes scatters the sound-waves, giving the bar a better acoustic. In the restaurant the curtains block a small part of the sounds from the museum. In a museum were a rooms are connected by an atrium, sound can be a problem. The same applies to an open office, were the passageway is in the same room. In the Danish Cultural Ministry office [14] this is the case. The carpet mute the sounds of walking people. And the curtains give more privacy to the employees.

13.04/05 Mercedes Benz Museum - Restaurant and lounge divider from the atrium / detail of the wall

13.06/07 Mercedes Benz Museum - Brush wall in the espresso bar / detail of the wall

14.04 Danish Cultural Ministry - Overview of the new office

03.03 Architectural textile membranes - Analyses

This chapter gives an inside on the different types of Architectural membranes and will make the choice of membrane a little bit easier. To show what for membranes the case studies were made and why the architects choose that material, gives you a sense of the chooses that are out there. Because when you go an architectural textile membrane manufacturer, they will find a material and production method that will meet with the requirements you need.

Membranes

The term membrane finds it origin from the Latin word *membrana*, that can be translated to skin. It describes a flexible material that is very thin relative to its surface area. In biology the skin has a separating function. In the building industry textiles woven materials and also polymer foils and sheet metals can all be classed as membranes. In this study the parameter that is keeps an amount of flexibility classifieds a material as a textile membrane. So it could be rolled or folded. Membranes starts with fibres made into fabrics. In this chapter we start with the different fibres, then go to the way they can be made into fabrics. Than most architectural textile membranes need a coating. Most of the information in chapter 4.03 is abstracted for the book of Birkhäuser on Polymers and Membranes.

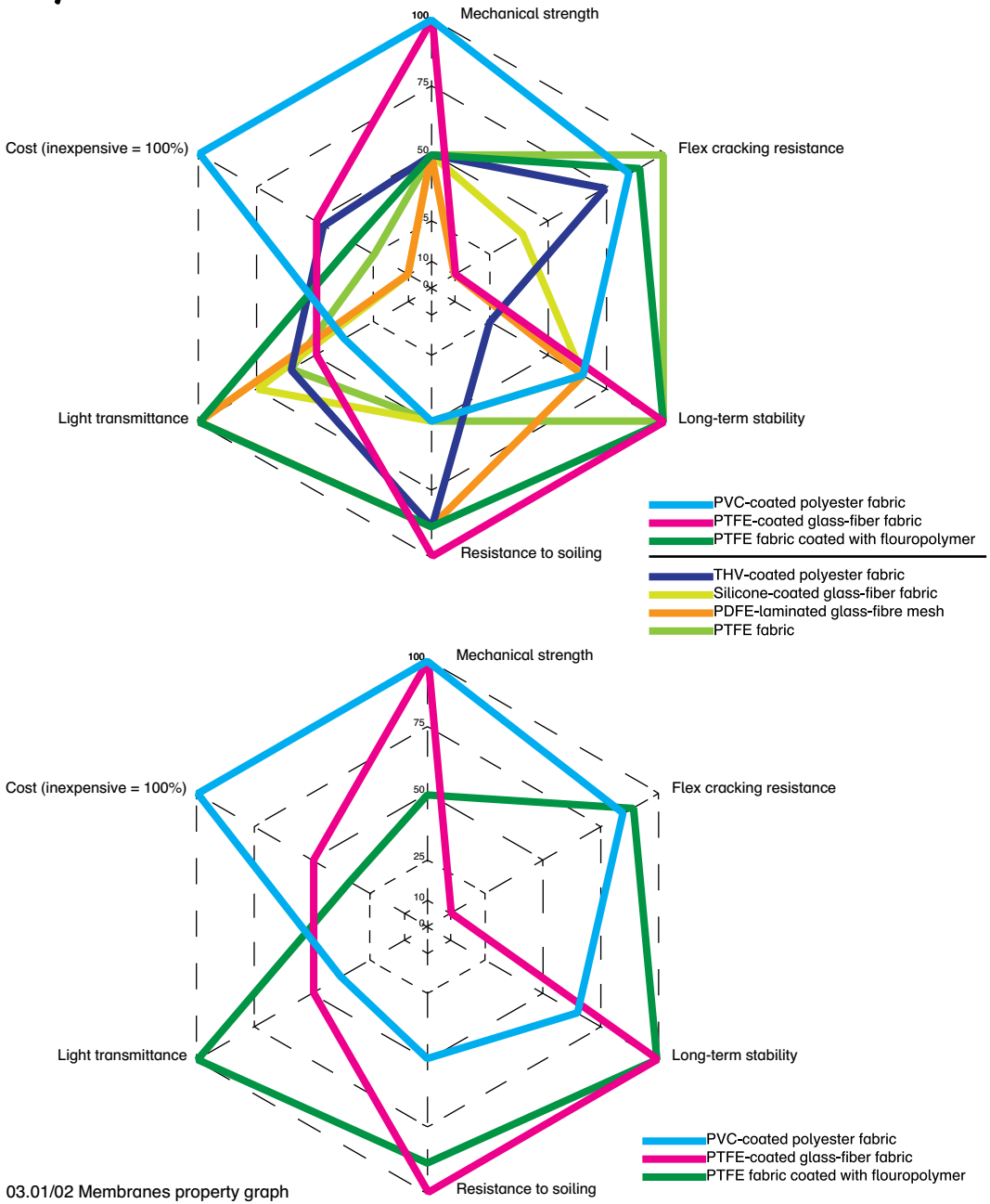
Properties

In the figures on the right side of the page 7 of the most common architectural textiles are plot in a graph. There is not one material that satisfy all the properties completely, so a choose of fabric need to be made due to the demands of the design.

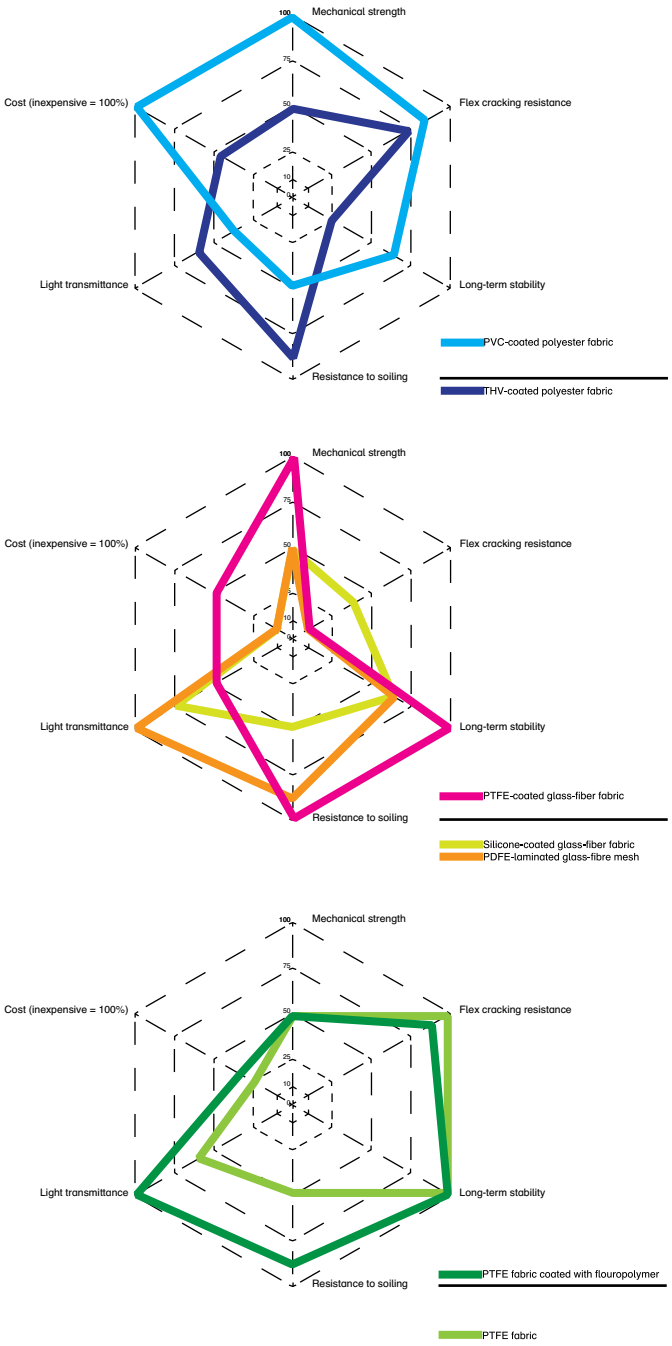
The raw materials of fibres

A textile always consists of a lot of thin filament fibres made be different steps into a fabric. Filament fibres has a very small cross-section in relation to their length.

Organic synthetic fibres are fibres how are based on carbon compounds, also called polymer fibres. The typical properties of polymers are being extensible, they then to creep and are combustible. During the production process of the fibres much better mechanical properties can



03.01/02 Membranes property graph



03.03-05 Membranes property graph, same membranes with different coatings

be enabled. Polymer fibres have usually an abbreviation, here are a couple; AFRP (Aramid fibres reinforced polymer), PE (Polyethylene fibres), PA (Polyamide fibres), PET (Polyester / Polyethylene terephthalate fibres), PTFE (Polytetrafluoroethylene fibres)

Inorganic fibres exhibit very little creep. They absorb very little moisture, but still tend to corrode when exposed to the weather, therefore it must be coated or embedded in polymer. The most common used are glass and carbon fibre, that is way those two are explained here.

Melted glass is drawn into threads to produce *glass fibre*. Glass fibres is mostly used in when it is reinforced with polymers (GFRP)

E-glass (E = electric) most common used
AR-glass (AR = alkaline-resistant)

Used in the building industry;
C-glass (C = corrosion) good for chemical resistance
R-glass (R = resistance)
S-glass (S = Strength)

The last two are high-strength and have a high heat and fatigue resistance. One big advantage of glass fibre is that is it does not burn, Permanent temperatures up to 250˚C have no effect on the mechanical properties of the fibres. Glass fibres are transparent, but usually appear white. In combination with a transparent polymer coating it becomes translucent.

Carbon fibres have the highest elastic modulus of all the fibres. The mechanical properties of carbon fibres can easily be varied, because of the way it is been produced. They can be described in three forms; with high tensile strength (HT), with high material stiffness (high modulus, HM) or intermediate modulus (IM) with moderate tensile and material stiffness. Carbon substances are black. Because of the production cost of carbon fibres it is not common to use it in the building industry.

Natural fibres can be divided in three groups; animal, vegetable or mineral fibres. Only vegetable is interesting for the building industry.

Coatings
In the figures 03.03-05 you can see the difference in properties of textiles when they have different coatings. For instance in 03.04 you can see that fibre glass has different qualities when different coatings are applied.

Case study analyse
The conclusion that can drawn for the collection of 35 examples of textile in Architecture is that the type of materials that are pick are very different. The possibilities are endless. But for outside textile façades not a lot of different basic fabrics are chosen.

The most common is PVC-coated polyester fibres, from the 35, 8 were made of that membrane. 4 were made of PTFE-coated glass fibres, 1 of silicone-coated glass fibre. Two are made of different coated PTFE-fibres. Three from the combility transparent ETFE-foil. And 18 of the 35 were all sort of fabrics, but

most of them are interior projects or very temporary projects. The most special of the 18 is Prada transformer, from OMA. They used a fabric that is mostly used to project machinery during transport, this is a very stretching fabric. So the different shapes of the construction are really seen.

Some project that have chosen PVC-coated polyester fabric (the light blue line) are the basketball stadium of the London Olympics [1], Rothenbaum tennis court [23], Carlos Mosely Music Pavilion [24] and Laboratory of M&G [29]. Those projects all consist of a roof. In the stadium and the laboratory the roof and the façade are one. The most important advantages of PVC-coated polyester is that it is inexpensive with reference to a good mechanical strength.

Burj al Arab Hotel [2] and Olympic Basketball Stadium of London [1] have both two different membranes. The biggest difference between the properties is that the atrium of the Burj al Arab hotel needs to be light through the textile façade and the stadium gets to hot if sun transmittance warm the sport-hall with the audience. Fibre glass gives more light transmittance, so the choose is very understandable. Also the Centre Pompidou [20] and Hajj Terminal [21] are made from fibre glass, to profit from the light transmittance, to use less energy for lighting than a solid façade and less energy for cooling to compensate for the hit transmittance that caused by a glass façade.

04._ Conclusions

This research tries to make the step towards using textile in architecture a little bit smaller. It shows in the case studies what the possibilities are and that textile is a serious architectural building material. The possibilities are endless, that makes designing with it, some what more difficult. And it always needs a secondary material to give it stiffness and body. Most common in the case studies are steel and air.

The design will give an answer to the main research question;

How can the use of textile optimize the indoor climate for a building in Amsterdam with both temporary and contemporary program?

But this research is a guideline on how to approach the design takes. Seen in the indoor climate analyses, but in most cases the textile had a great influence on the climate system. Textile is a material that is light, soft, touchable and convenient. Textile really works with the outdoor climate instead of only being a protection to it. After the design is really, the real conclusion can be drawn in the reflection to concluded this research.

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