Colour design of textile architectural envelopes: an initial study

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ABSTRACT

Textile materials are now widely used in the construction of architectural envelopes. Even if a wide range of colours is available today, only few of them seem to be preferred by the designers. A better understanding of this phenomena could be achieved through the study of the use of colour in relation to these architectural artefacts. In order to do so, the paper aims to show some of the interactions between the colour of textile architectural installations and some of the components that affect their design, in particular: form, function, lighting technologies and the context. The methodology of the research is based on a selected sample of buildings. These buildings have been investigated according to their surface colours and a set of other criteria. The results showed that white is the most widespread colour for this type of buildings. White seems to be strategic for enhancing complex and irregular forms and as a background for light projections, especially when the building needs to be highlighted in the context. Multi-coloured surfaces seem to be preferred in temporary installations as well as in suburban or rural contexts. In general, the expected lifespan of these buildings and of their materials seems to be very important for the colour choice. This initial study is dedicated to architectural designers interested in the use of textile materials for the building envelope.

KEYWORDS Textile Architecture, Textile Materials, Colour Design, Architectural Design

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1. Introduction

In the last decades textile materials, due to the evolution of textile composites, are more widely utilised in architectural applications (Fritz 2011). Current textile composites are used for the design of the whole building envelope, as well as for canopies, tensile structures, claddings and solar shading devices. The colour of architectural textile materials has always had an important role in different cultures (Gasparini and Zennaro 2007). Without going too far back in time, in modern Western society, we may say that high-tech textiles architectures (Chilton 2010) are mainly characterized by whitish colours. Even today, a simple Google search with the keyword 'textile architecture' will produce a predominant number of whitish installations (Fig. 1). However, since textiles are filters for the daylight, white is the colour that allows a good diffused light into the building (Schock 2001).

In the last years, like for many other types of architectural claddings (Zennaro 2014), we have seen an increasing use of highly coloured architectural textile surfaces. These 'new' colours could be permanent (e.g. with high saturation) or temporary (e.g. light projected, light emitted), as for some types of textiles (Ritter 2013). The choice of colour could be made according to the function of the textile object and other criteria (Premier 2012). The investigation sought to better understand and discuss the use of colour in relation to some of the features of the architectural design of buildings, especially when colours other than white and grey are used.

Fig. 1. China Corporate United Pavilion of Expo Milano 2015 in Italy, designed by the Architectural Design and Research Institute of Tongji University Ltd. A typical example of whitish textile surface. Photo © Alessandro Premier.

2. Research background

Textile materials are often used in temporary installations where colour is strategic for visual impact (Fig. 2), but they are also used in claddings and shading devices with the same purposes (Fig. 1, Table 1). The colour is strongly influenced by the form of the object, that can be regular or irregular (Trautz 2009). Regular forms (based on primary solids or their combinations) or irregular forms (free-forms, parametric, hypersurfaces) (Oosterhuis 2012) can produce different interactions with colour. A typical example is the *chiaroscuro* effect played by white or greyish volumes. Another important aspect is the function of the object: building envelopes, claddings, solar shadings and canopies have all different needs when dealing with colour design, especially if we consider the intended use of the artefact. The functions of a textile envelope can be: cladding, shading and shelter (Chilton 2010). Surface texture quality can be an additional element of complexity. The colour of textiles can also be affected by the integration of lighting technologies. Often, the object becomes a screen for night-light projections and this can be strongly related to the temporary nature of the object itself (e.g., designed for a specific event) or to the use of textiles as a screen (Fig. 2). Another important criterion is the chromatic relationship between the object and the surrounding environment. Colour can be used to merge the object into the context or to highlight it. For instance, urban areas can be affected by saturated colours (Fig. 3) as well as suburban areas, where the greyscale predominates (Premier 2012). Three different types of context have been identified: urban, suburban and rural (Nguyen and Teller 2016) and two different strategies have been associated to them: to blend or to highlight the building into the context.

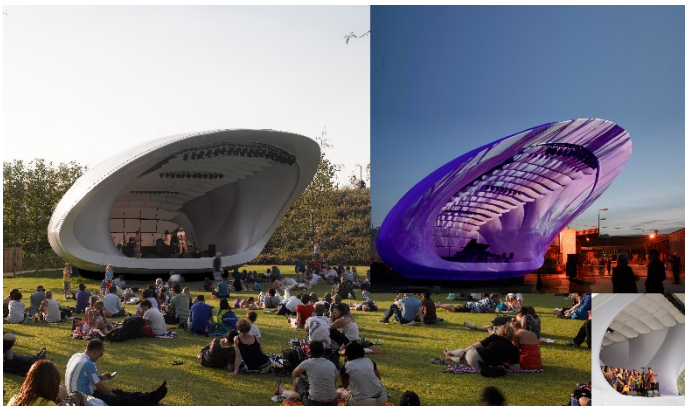

Fig. 2. Soundforms Pavilion, Olympic Park, London, 2012. The white cladding becomes a surface for light projections. Photo © Nick Guttridge (Courtesy of ES Global Ltd).

Fig. 3. SelgasCano Pavilion, Bruges, Contemporary Art and Architecture Triennial, 2018. A temporary installation with a 'one colour' envelope. Design by Lucía Cano, José Selgas. Photo © Iwan Baan (Courtesy of SelgasCano).

3. Objectives

The aim of this paper is to discuss some of the interactions between the colour of textile architectural installations and some features of their design. In particular, the research is targeting the relationships between colour and form, function, temporary lighting technologies and context. This without neglecting other important criteria as location, lifespan and materials that will be the subjects of further investigations. This study could be useful for designers interested in the chromatic design of textile surfaces for architecture, to identify under what circumstances and with which modalities is possible to use certain colour strategies in order to obtain specific results. In particular, this study aims to question some of the reasons that may underlie the choice of colours or colour combinations that are different from the white or grey scale.

4. Method

The research is based on a sample of buildings built between the years 2000 and 2018. The information on these buildings was collected from 2009 to 2019 for a series of more than thirty articles developed for the Italian magazines Tenda In & Out, and Tenda International (Tenda in & out 2018). A final limited selection of twenty-eight textile architectures and shading skins has been identified according to the objectives of the research. The buildings have been studied according to their surface colour, the form of the building, the function of the textile material, the implementation of light projections and the colour strategy for the context. A comparison between the materials of the fibres' coating has been added. The goal was to identify a set of relationships between the surface colour and the criteria shown in Table 1, in order to better identify the colour strategies adopted for environmental design.

BUILDINGS	**Colour category**	Whitish One colour Multiple colours
	Form	Regular Irregular
	Function	Cladding Shading Shelter
	Fibres coating	PVC PTFE GFRP PVDF Other
	Lifespan	Permanent Temporary
	Lighting technology	Yes No
	Context	Urban Suburban Rural
	Context strategy	To merge To highlight

Table 1. The criteria of the research.

The study of the surface colours was developed using the database of pictures provided by the designers of the case studies. The images were processed using Adobe Photoshop: RBG values were sampled and the colours were sorted using the closest NCS colour codes (Arbab et al. 2018) (Table 2). This process allowed us to identify three colour categories for these textile surfaces: whitish, one colour, multiple colours.

	Building	Function	Colour category	RGBs	Lighting	Context
1	Chanel Mobile Art Pavilion	Cladding	Whitish		NO	Urban
2	Burnham Pavilion	Cladding	Whitish		YES	Urban
3	Gardens by the Bay	Shading	Whitish		NO	Urban
7	Soundforms	Cladding	Whitish		YES	Urban
8	Zurich Headquarters	Shading	Whitish		NO	Urban
11	Outdoor Room	Shelter	Whitish		NO	Suburban
13	Expo 2015 China CCUP Pavilion	Cladding	Whitish		NO	Suburban
21	2018 Bruges Triennale Pavilion	Shelter	One colour		NO	Urban
22	Le Albere	Shading	One colour		NO	Suburban
23	Ark Nova	Shelter	One colour		NO	Rural
28	Cressy School	Shading	Multiple colours		NO	Suburban

Table 2. Buildings: excerpt from the synoptic table.

The other criteria of the research were collected in a synoptic table and studied using a MS Excel sheet. Year and location of the buildings have been considered. A comparison between the identified colours and the other criteria has been carried out. The data have been collected in charts in order to study these relationships.

5. Results and discussion

As predicted, the majority of the case studies had whitish surfaces (from white to light grey). This is the most widespread colour range of textile membranes for architecture. There were seventeen case studies with a whitish coloured envelope. Six case studies used a single colour surface (not in the greyscale) and a further five demonstrated the use of multi-coloured combinations.

5.1. *Colour and form*

The comparison between the three colour categories and the form of the buildings has shown that whitish surfaces seem to be the most frequent solution for complex and irregular forms. The *chiaroscuro* play of volumes and shapes is certainly enhanced by a 'one colour' surface, and above all, white. This is also connected to the wide use of whitish surfaces in Modernist architecture (Klinkhammer 2004). The combination of form and whitish surfaces is also related to the fact that these buildings maintain lower surface temperatures in hot climates, thus allowing better indoor performances. In regard to the location, twenty-one case studies were in Europe, four in Asia, two in the US and one in Africa. Wide literature is dedicated to the use of light/cool colours and coatings in warm climates (Synnefa et al. 2007).

The use of white, like the use of other colours, might be related to communication purposes. For instance, if we consider the CCUP Pavilion at Milan 2015 Expo (Fig. 1), the choice of the whitish envelope might be related to the symbolic objective of the design. The pavilion was called 'Seeds of China' and drawing on the symbolism of the seed, it interpreted the idea of a group of Chinese companies that wanted to show their 'values' of conservation of natural resources and food security. The image of power that arises from the breaking of ground to the sprouting of seeds has inspired the design of form and colour of the CCUP Pavilion (Wang 2015).

5.2. *Colour and function*

The study of the relationships between colour and function of the textile surface shows that, although whitish colours are the most widespread for all the three functions, there seems to be a strong preference for their use in claddings. In the cladding category there are no 'one colour' surfaces. In addition, the substantial balance of the three colour categories for the shading function seems to be relevant. In the design of shading devices, greyish and dark surfaces allow a higher performance of the combination window-shading device (Carlo Giovanardi & C. snc 2017). This could be a motivation behind the colour choices for the 'shading' function. Three out of four case studies with 'multiple colours' surfaces had shading devices. An example of a façade with multi-coloured shading is the School Centre in Cressy (Fig. 4).

Fig. 4. School Centre in Cressy (CH) (2002–2006) designed by dl-a (designlab-architecture). An example of a façade with multiple colours. Photo © Fausto Pluchinotta (Courtesy of Serge Ferrari).

The building is characterized by a double skin glass façade that guarantees a rational management of the heat exchange between building and environment. The outer skin is configured as a structural glass cladding (spider-glass façade). The façade is coloured by the presence of vertical awnings installed in the cavity between the two skins. The façade is thus defined by the vertical bands marked by the different colours of the awnings. The fabric used is a Soltis 92 by Serge Ferrari suitable for façade applications (Serge Ferrari SAS 2012). The chromatic alternation of vertical bands plays a contrast between cold and warm colours: green, yellow, orange, light blue, beige (Fig. 4). At night, the double skin lights up depending on the energy accumulated during the day. The light filtered by the coloured shading devices is reflected on the internal walls of the building, creating a complex play of colours (Premier 2012). This is allowed by the function of the building (an early childhood centre) where colour has a strategic importance for learning (Zennaro 2015). On the contrary: whitish surfaces allow a diffused daylight into the building and the light is not affected by any coloured filter. This use of whitish colours for shading is essential where high accuracy on colour rendering is needed. For instance,

in museums (to appreciate paintings and other artworks), in libraries (to facilitate reading) and in offices (especially where people work with images).

Among the shelters there is a clear prevalence of 'one colour' solutions. Examples of non-whitish 'one-colour' shelters are the water pavilion by SelgasCano (Fig. 3) and the Ark Nova pavilion by Arata Isozaki and Anish Kapoor (Fig. 5).

Fig. 5. Lucerne Festival Ark Nova. 2015 Installation in Fukushima. Design by Arata Isozaki and Anish Kapoor. Photo © Yu Terayama (Courtesy of Lucerne Festival Ark Nova).

5.3. *Colour and lighting technology*

The comparison between the colours and the presence of lighting technologies shows that only whitish surfaces are used as screens for night-light projections (Fig. 2). It is evident that a whitish colour, or a neutral light grey, is better suited as a screen for bright chromatic projections. In fact, with these technologies and with smart-textile technologies almost any colour is achievable and it is possible to use these colours only when it is needed (Gasparini 2017). At certain times or in a specific place (e.g. if we talk about temporary architectures) it might not be appropriate to have a brightly coloured cladding and with these on-off technologies the problem is easily manageable. It goes without saying that highly saturated surfaces are not the best option for colour rendering in light projections.

5.4. *Colour and context*

The data regarding the context in which the buildings were located show that in urban areas, as city centres or historical centres, there are only 'whitish' and 'one colour' surfaces, while in the other contexts the other colour strategies are quite well distributed, even if there is a higher percentage of whitish surfaces. This data can be related to the fact that in city centres, 'multiple colours' surfaces are often not allowed for preservation reasons, while in other areas this is possible.

An example of 'one colour' surface in an historical context is the water pavilion designed by SelgasCano (Fig. 3). The water pavilion was built for the Bruges 2018 Triennale in Belgium. Launched in 2015, in its second edition (2018) it focused on the topic of the 'Liquid City', with reference to the Bruges watercourse network and according to the famous concept of liquid modernity (Bauman 2000). The pavilion, located in the canal called Coupure, was a temporary floating installation and served mainly as a platform for bathing and sunbathing. The installation consisted of a structure composed of steel bars covered with a fluorescent pink-orange vinyl membrane. The waterproof cladding was mounted on a floating wooden platform painted in yellow in order to stand out against the dark water of the canal (Premier 2019). Natural light passed through the skin of the pavilion creating a surprising and unsettling atmosphere that changed the usual perception of the old city. The structure had two irregularly shaped openings at the ends and curved around a void in the centre of the platform to form a tunnel through which visitors could move freely. The Spanish architects José Selgas and Lucía Cano are mainly known for the 2015 Serpentine Pavilion in London (Premier 2018). Their work is characterized by the use of polymer-derived materials and highly saturated colours.

5.5. *Context strategy*

The general result of the context strategy was a balance between the buildings designed to stand out from their context and buildings designed to merge into the context: fifteen buildings were considered 'highlighted', while thirteen buildings were considered 'merged' into their context. These results should be compared with the surface colour, the building form and the presence of lighting technologies. It was found that colour is not the only strategy used by designers to achieve one of the two objectives. For instance, amongst the whitish surfaces, ten buildings out of seventeen were designed to be highlighted in the context. This result was achieved mainly through unusual and irregular forms; an example being the Chanel Mobile Art Pavilion designed by Zaha Hadid. Some of these buildings were highlighted in the context only by the use of lighting technologies: for example, is the envelope of the Luanda Multisports Pavilion in Angola with its sandy colour during the day and the coloured lights during the night (Fig. 6). On the contrary, amongst the 'one colour' surfaces four out of six buildings were designed to merge into the context. This was achieved by the use of unsaturated or brownish colours.

Fig. 6. Luanda Multisports Pavilion by Berger Arquitectos. Photo © Berger Arquitectos.

5.6. *Coating and lifespan*

Amongst the case studies, twenty buildings (71%) involved PVC coated textiles; only three involved PTFE coatings; individual case studies involved PTE, PVDF, ETFE, GFRP and aluminium mesh. The results did not show any evident relationship between the colour and the coating of the fibres. Likewise, permanent and temporary buildings were equally distributed amongst the three colour categories. However, many considerations can be made on the use of these materials, their colour and the lifespan of the object.

First, in permanent buildings greyish surfaces could be preferred because they show less stains and dirt, while white surfaces highlight the stains and dirt more. Discoloration of PVC coatings is also a well-known issue (Yousif and Hasan 2015), thus white can be generally favourable also for this reason. Another reason that could be related to the choice of whitish or greyish surfaces is the cost: higher request/quantity means lower prices according to economy of scale (Azcarate 2014). Thus, if white is the most utilised colour, this is likely also to happen in the future.

PVC is the most frequent coating material. The PVC coated polyester fabric is a common material in tensile structures. Its durability is guaranteed for ten years. It is presented in a wide variety of colours and is suitable for digital printing. Texyloop® technology has been developed to recycle these types of fabric. (Serge Ferrari SAS 2019). The PVC coating contains UV stabilizers against yellowing and fading, fireproof and anti-fungicide additives (Serge Ferrari SAS 2017).

6. Conclusions

This project is a small part of a wider research endeavour, focussed on solar shading devices, started by the author twelve years ago. The limited number of twenty-eight selected buildings is due to the specific features necessary for the study: textile materials and additional functions (claddings and shelters). The number of buildings will be extended in the future to develop all the topics that emerged from this initial study. The goal of this study was to highlight and discuss some of the interactions between the colour of textile architectural installations and some features of their design. In particular, the research targeted the relationships between colour, form, function, lighting technologies and context. Three colour categories were identified: whitish surfaces, ‘one colour’ surfaces and ‘multiple colours’ surfaces. The whitish surfaces were the most widespread for all types of applications: some considerations on the reasons for the choice of this color have been presented. The three colour categories were then compared with the other criteria of the research (Table 1). Some results are summarized below.

Colour and form. White seems to be more used for irregular forms: in those situations, form (not colour) is the main tool to highlight the building in the context.

Colour and function. There is a fairly regular distribution of the three colour categories for shadings. In shadings, multi-coloured solutions seem to be more frequent, but this strategy can be adopted only for some types of buildings.

Colour and lighting technologies. Whitish surfaces are better suited to the integration with lighting technologies and light projections. In those situations, temporary colours are used to highlight the building, but only at night. The building might merge into the context during the day.

Colour and context strategy. Multi-coloured surfaces seem to be not particularly common in urban centres, but they can be easily integrated in other contexts.

Colour and lifespan. In temporary buildings the colour choice can be adapted to a wider range of chromatic schemes. The lifespan of the material is also very important for the colour choice. Generally, whitish and greyish colours are more durable than others.

This paper voluntarily omits some aspects related to the history and culture of colour of textile materials presented by the author in other publications. Further research can be carried out on the choice of colour in relation to the performances of these materials in specific climate zone.

7. Conflict of interest declaration

The author declares that he has no conflicts of interest.

8. Funding source declaration

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10. Short biography of the author

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References

Arbab, S., Brindle, J. A., Matusiak, B. S. and Klöckner, C. A. (2018) 'Categorisation of Colour Terms Using New Validation Tools: A Case Study and Implications'. I-Perception, 9(2). doi.org/10.1177/2041669518760043.

Azcarate Aguerre, J. F. (2014) Façades as a Product-Service System The potential of new business-to-client relations in the façade industry. Thesis in Master of Science and Building Technology. TU Delft. https://repository.tudelft.nl/islandora/object/uuid:0aca38e7-81ae-4ca7-9b1f-ffcf0f2e33fc?collection=education

Bauman, Z. (2000) Liquid modernity. Cambridge, UK: Polity Press.

Carlo Giovanardi & C. snc. (2017) Screen SG 989.

Chilton, J. (2010) 'Tensile structures – textiles for architecture and design'. Textiles, Polymers and Composites for Buildings, Pohl G. (ed.) Cambridge, UK: Woodhead Publishing, pp. 229–257. doi.org/10.1533/9780845699994.2.229.

Fritz, S. (2011) 'The very fabric of architecture: textile use in construction'. Architonic, 20 August 2011. Available at: https://www.architonic.com/en/story/susanne-fritz-the-very-fabric-of-architecture-textile-use-in-construction/7000625 (Accessed: 28 April 2019).

Gasparini, K. (2017) 'Media-surface design for urban regeneration: the role of colour and light for public space usability'. Journal of the International Colour Association, 17, pp. 38–49.

Gasparini, K. and Zennaro, P. (2007) 'Colore e design nella produzione di schermature solari tessili'. Il colore nella produzione di architettura, Zennaro, P. (ed.) Verona: Ipertesto Edizioni.

Klinkhammer, B. (2004) 'Creation of the Myth: “White” Modernism'. 92nd ACSA Annual Meeting, Miami, FL, pp. 429–434.

Nguyen, N. L., and Teller, J. (2016) Colour in the urban environment: a tool for the chromatic analysis of spatial coherence. Liège: University of Liège. https://orbi.uliege.be/handle/2268/20175.

Oosterhuis, K. (2012) 'Simply complex, toward a new kind of building'. Frontiers of Architectural Research, 1(4), pp. 411–420. doi.org/10.1016/J.FOAR.2012.08.003.

Premier, A. (2012) Superfici dinamiche: le schermature mobili nel progetto di architettura: innovazione tecnologica, architectural design, sostenibilità. Milan: Franco Angeli.

Premier, A. (2018) 'Outdoor textile design: manufatti leggeri e materiali innovativi'. Tenda in & out, 2, pp. 40–49.

Premier, A. (2019) 'Architetture tessili per eventi culturali'. Tenda in & out, 1, pp. 80–87.

Ritter, A. (2013) 'Architectural applications of smart textiles'. Multidisciplinary Know-How for Smart-Textiles Developers, Kirstein, T. (ed.) Cambridge, UK: Woodhead Publishing, pp. 468–488. doi.org/10.1533/9780857093530.3.468.

Schock, H.-J. (2001) Atlante delle tensostrutture. Milan: Utet Scienze Tecniche.

Serge Ferrari SAS (2012) Soltis 92.

Serge Ferrari SAS (2017) Precontraint 702 S2 & 702 Fluotop T2.

Serge Ferrari SAS (2019) Soltis Horizon 86. Transparency and Natural Light.

Synnefa, A., Santamouris, M. and Apostolakis, K. (2007) 'On the development, optical properties and thermal performance of cool colored coatings for the urban environment'. Solar Energy, 81(4), pp. 488–497. doi.org/10.1016/j.solener.2006.08.005.

Tenda in & out (2018) Tenda International–Tendain. Available at: Maggioli: http://www.tendain.it/rivista-international/ (Accessed: 20 July 2019).

Trautz, M. (2009) 'The application of folded plate principles on spatial structures with regular, irregular and free-form geometries'. Proceedings of the International Association for Shell and Spatial Structures (IASS) Symposium 2009, Evolution and Trends in Design, Analysis and Construction of Shell and Spatial Structures, Domingo A. and Lazaro C. (eds.), Valencia: Universidad Politecnica de Valencia, pp. 1019–1031.

Wang, J. (2015) Seeds of China. Exploring the Design of China Corporate United Pavilion Expo 2015. Available at: http://finance.cnr.cn/zt/mlsb/gd/20151228/t20151228_520955141.shtml (Accessed: 8 October 2019).

Yousif, E. and Hasan, A. (2015) 'Photostabilization of poly(vinyl chloride) – Still on the run'. Journal of Taibah University for Science, *9*(4), pp. 421–448. doi.org/10.1016/j.jtusci.2014.09.007.

Zennaro, P. (2014) 'Il ruolo del colore nella costruzione'. Archi: Rivista Svizzera Di Architettura, 2, pp. 45–49.

Zennaro, P. (2015) Il colore delle scuole. Rimini: Maggioli.