Sustainable colour design in architecture: materials, technologies and products

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When should we consider the colour of a building as a sustainable feature? In contemporary architecture, old and new materials, technologies and products are complying with the new rules of sustainability by providing the architectural project the means to adapt to the new challenges of contemporary innovation. Of course, colour seems to play a strategic role in this scenario, adapting to the choices of the different points of view – sometimes ideological – of contemporary architecture. The paper describes the results of a recent research conducted in the “Eterotopie” Research Centre by the authors, with the valuable contributions of V. Brustolon, A. Dehò, C. Gregoris, A. Martini, and P. Zennaro [1]. The researchers, dealing with various specialisms, studied chromatic use in the architectural design of 12 families of materials, technologies and products with the aim of assessing their real impact on the environment and possible solutions based on a scientific and rational approach.

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Introduction

Colour is often overshadowed in research on the environmental sustainability of buildings. As we well know, however, colour plays a strategic role not only from an expressive point of view, but also in the control of the internal and external environmental quality of buildings and also for their microclimate. Indeed, we can think about the colour of the surfaces of the building as a tool for the integration with landscape and for the environmental quality or as a tool for controlling the heating of the surfaces irradiated by the sunlight. This survey, carried out within the Eterotopie Research Centre, a spin-off of the Research Unit "Colour and Light in Architecture" of Iuav University of Venice, tried to go further.

The research started with a question that we probably could define as very complex: when should we consider innovation in architecture as a sustainable feature? First it is necessary to clarify that the term innovation here is focused on materials, technologies and products used in contemporary constructions. “Sustainability is often regarded by the lay community as something that can only be beneficial” [2]. The different visions we may find in contemporary literature are generally “grounded in ideological claims that need to be better understood before one builds an architectural foundation on them. Saving the World is important, but if the choice is between a future of noble managers, conservative ethicists, or eco-determinists then sustainability still has some important lesson to learn” [2]. We need a more pragmatic point of view. Trying to answer this question, we decided to consider the entire life cycle of twelve large families of materials, technologies and products, without neglecting lessons from the culture of building. The analysis of the entire life cycle of products or processes (Life Cycle Assessment), often known by the acronym LCA, is regulated by standards ISO 14040, 14041 etc. Applied to materials, products or technologies it enables an overall view of their impact on the environment from the extraction of raw materials through to the "end of life" which may result in the disposal, reuse, recycling, incineration, and so on. But what does colour have to do with all these things?

Obviously materials, technology and products have a strategic role when they form the external walls of buildings. Each "family" of materials, technologies and products is characterized by a more or less extended colour range: for “natural” materials the colour range will likely be smaller compared to the infinite possibilities of contemporary paints. Every surface, exposed to the weather, is then subject to decay that has different time periods in relation to the intrinsic characteristics of the materials and technologies used. Therefore, also the colour fastness (for example of textiles) becomes a very important aspect. But when should we consider the colour of a building to be “sustainable”?

To assess the sustainability of a material or a product we must be aware of the period after which it fails to provide the required performance. In a sense, the colour fastness can be an indicator of the health status of the material. When we deal with colour, however, this aspect cannot be separated from broader considerations of the colour of architectural surfaces in a relationship of harmony or contrast with the surrounding environment. Therefore we consider colour as a design tool to achieve certain effects that influence the perception of the building in its context. The colour of architectural surfaces will be more "sustainable" when it will succeed in time to maintain or positively change the relationships with the environment so that the project idea will keep its full effectiveness.

In order to simplify the synthesis of the research we propose a reading that separates, at least virtually, the so-called “natural materials from the artificial ones that dominate the contemporary world of construction” [3], knowing well that this distinction is now very unstable given the continuous hybridisation of the various materials used in buildings and the related technologies. In this article, we describe the results obtained from this research in relation to the chromatic aspects of materials, products and technologies that we have analysed.

Methodology

As stated before, we have chosen to compare international LCA researches on materials, technologies and products to understand their real environmental impacts (eutrophication, acidification of water, global warming etc.). For convenience, we used the classic distinction between natural and artificial materials [3]. Within these categories we find the twelve families of materials, technologies and products listed in Table 1.

Natural / naturalised materials	Artificial materials
1. Clay	5. Ceramics
2. Vegetation	6. Concrete
3. Wood	7. Metals
4. Stone	8. Glass
	9. Plastics
	10. Textiles
	11. Composites
	12. Smart

Table 1: Twelve families of materials, technologies and products considered for the research.

The research was focused exclusively on the architectural envelope of buildings (façade, roofing). Within the LCA researches there was a lack of information on the chromatic characteristics of materials. So we decided to integrate the framework with a further investigation into the chromatic variations of the materials used, in particular, in the realisation of the façades of buildings. For this purpose we have collected a significant sample of about 30 case studies of buildings. Where possible a physical colour survey was performed using a colour detection instrument: the NCS Colourpin II [4]. The Natural Colour System (NCS) is the Swedish standard for colour notation. Today, NCS is one of the most widely used systems of colour notation for practical purposes (colour plans, architecture, industrial design etc.). Since in most cases it was not possible to detect physically the colours of the buildings, we used a photographic sample provided directly by the designers. The images were processed using the Adobe Photoshop software provided with NCS Swatches [5]. It is not possible to convert RGB display colours into NCS colours, because the NCS palette contains only 1950 colours instead of RGB's 16.7 million colours. So we used a conversion tool from e-paint.co.uk [6] for identifying the NCS value closest to the RGB Hex Colour value provided by the colour picker tool in Adobe Photoshop. The same operation can be done with the software NCS Navigator 2.0 Premium.

The buildings we have analysed were built in a relatively recent timeframe: 2004–2013. The survey was carried out in the period 2013–2014 (we had recent images of the buildings as well as images of the construction period). So the maximum time period between the realisation of any building and the survey was 10 years. Chromatic variations due to different natural lighting conditions, artificial lights, reflections and other environmental factors have not been taken into account. For the digital images we used mainly pictures taken at noon.

In the following sections, the results obtained for each family of materials are discussed. Each section contains images of some of the case studies analysed. On the left we have highlighted the main colours detected from the picture and obtained through the palettisation process, which is performed with an Adobe Photoshop filter and approximates an image to a few principal colours. The chromatic scale on the right shows the chromatic variation identified from the realisation of the building till 2014. The tables give the range of the detected colour variation of all cases of that specific family of materials and products for façades, expressed by the NCS notation. The position of the two scales is switched in artificial materials.

Results for natural and naturalised materials

Among the first materials used in construction are those most easily found in nature which, in the past, needed relatively few processes: wood, stone and even clay. Wood and stone have a very important tradition in architecture: it seems useless to enumerate the countless number of buildings, from the ancient world to the present, built with the technologies related to these materials. "Clay was used mainly in vernacular construction" [7]. The term "naturalisation" means "to realise the process of human elements and procedures existing in nature in addition to the techniques acquired by man and used in the action of urbanisation" [8]. It means a natural camouflage or ecological makeup that sometimes becomes "ornamental hypertrophy to hide the otherness of the architectural object" [9], which is well identified with "green architecture". Examples are the green walls built by Jean Nouvel and Patrick Blanc for the Quai Branly Museum in Paris (2006) and the "vertical forest" by Stefano Boeri in Milan (2014).

Clay

Green building and certain ideological sectors of the construction industry are supporting the recovery of certain traditions of the past such as those related to the use of clay. The colour palette on earthen buildings, now mostly made with compressed blocks or rammed earth, is closely linked to the colours of the materials available on the construction site, rich in clay and aggregates, ranging from red ochre to warm grey (Figure 1 and Table 2). These surfaces are subject to erosion and weathering of time, so to preserve the original appearance of the building as long as possible, they need strong projections of roofs to limit the negative action of the rain. Surfaces are often "naked", sometimes covered with plaster made of lime or earth. In the latter case the colour may vary from that listed above. Today, clay can be integrated with smart materials to improve the performance of the thermal insulation of walls. However, they do not affect the colour of the material. Apart from these innovative aspects, the critical aspect of such buildings seems to be the necessary maintenance during their operative life. Researches on LCA we have analysed seem to indicate high maintenance costs that affect embodied energy throughout the life cycle of the product. Earthy colours can be obtained also with other natural and artificial materials: a masterpiece of this kind is Frank Lloyd Wright's Taliesin West (1937–59) (Arizona). In the cinema-theatre "all the main structures were covered by canvas panels stretched within an exposed framework of dark-brown stained, rough-sawn redwood trusses" [10]. In 1955 he also developed a line of home products specifically for people who didn't live in one of his houses. It also included a selection of 36 paint colours from the Martin-Senour paint company.

Figure 1: Tucson Mountain Retreat, Arizona, 2012, designed by Dust (Photos © Bill Timmerman).

Darkest colour	Lightest colour
NCS S 7020-Y50R	NCS S 1005-Y20R

Table 2: Detected colour range for rammed earth façades.

Vegetation

Vegetation as a wall cladding for buildings, once conceived almost exclusively as roof garden or climbing plants (ivy, jasmine, etc.), is now identifiable in green roofs or green walls. Despite Le Corbusier's toit-terrasse, the "greens" of vegetation, the main colours of green-architecture, reappeared in buildings after the birth of slums, the poorer suburbs of the globalised world, where the people try to recreate in their own terrace that portion of green that concrete and asphalt have taken away. "In the vision of green, people find a new psycho-physical well-being" [11]: at least this is what is claimed by the botanist Patrick Blanc in explaining the birth of his idea of vertical garden. In these technological solutions vegetation grows in harsh conditions with little earth or even in felt pockets attached to PVC panels fed through a system of artificial irrigation.

Vegetation proliferates as it can, but to keep alive its colour, which is closely linked to its health, it requires constant maintenance. This is demonstrated by many contemporary architectures where the colour of the surfaces is affected by the presence of water: not only the vegetation must be taken care of in order to proliferate the best, but also the other surfaces should be kept clean and dry. The colour of non-evergreen vegetation (e.g. hydrangea, used in Trussardi Café, Figure 2) changes during the seasons, mainly from dark green to yellow. The natural decay of vegetation, if not constantly maintained, seems to undermine the whole building that loses the basic features of the original design (see again Figure 2 and Table 3). So many doubts remain about the alleged benefits of green vegetation in architectural surfaces especially as regards the cost of maintenance of manufactured products covered by these "new" technologies.

Figure 2: Trussardi Cafè, Milan, 2008, designed by Carlo Ratti e Associati (Photos © Arianna Cester).

Darkest colour	Lightest colour
NCS S 5030-G10Y	NCS S 4050-G80Y

Table 3: Detected colour range for green façades.

Wood

Wood remains one of the most popular materials used in the construction industry, even though in many applications it has been replaced by artificial materials. Timber is conceived as a renewable resource, therefore, in certain sectors of contemporary building it is regarded as a highly sustainable material. However it is essential not to forget the devastating exploitation of this resource, even in these days.

Wood is a highly expressive material: the colour range includes, among others, “the yellow honey of fir, the grey stone of the oak, the copper black of chestnut, the light red of cherry, the ivory white of pear, the velvety black of ebony” [12]. Wood is well preserved when protected inside buildings, but it has a relatively rapid decay when exposed to the weather. Rough fir, for example, has a yellow colour that soon turns to grey, even after the usual treatment in an autoclave (see Figure 3 and Table 4). In the worst conditions it rots and therefore it must be treated with resins and varnishes and maintenance must be performed by the periodic repainting of the artefact at more or less constant intervals of time.

Cross-laminated timber (CLT), used today as a construction system, is generally coated with other materials. In any case it is made with fir or spruce and has the same problem stated before. The use of coatings and varnishes turns wood into an artificial material. Exotic woods, generally denser and darker, longer retain their natural colour. As part of the LCA the use of timber, its colours and its treatment have to be evaluated from time to time in relation to the context in which the building is placed. It should not be forgotten what is most important: wooden architecture belongs to the tradition of some places (alpine sites for example) but not to others (urban centres and Mediterranean climate). Wood is used in contexts where its use is part of the local culture. In this sense, the colours of the wooden architectural surfaces become sustainable only when used in the appropriate places.

*Figure 3: Ecomuseum of Rennes, F, 2010, designed by Guinée*Potin Architects (Photos © Stephane Chalmeau).*

Darkest colour	Lightest colour
NCS S 6030-Y70R	NCS S 2000-N

Table 4: Detected colour range for wooden façades.

Stone

Stone is the material of eternity. Stone has many variations in colour, from white to black. There are stones of every colour and shade. Today stone is essentially a cladding material. To save the resource, which is not inexhaustible, slabs of increasingly small thickness are employed, sometimes only a few millimetres glued onto a metal or fibre-reinforced support.

The use of stone cannot be separated from preservation of the areas from which it is extracted (quarries), remembering that, for certain applications, whole mountains have been dismantled. Some stones are consumed over time, whereas others remain almost unchanged. The colour fastness is threatened primarily by air pollution. The dark dust deposited on the porous surfaces of some types of stone, especially sandstone and limestone, needs to be thoroughly cleaned off to return the surface to its original condition. Today we might consider more “sustainable” stone surfaces designed to be self-cleaning and therefore require virtually no maintenance.

As for clay, the traditional use of stone is linked to the availability of on-site material. Therefore, the more sustainable colours will be those of the typical stones of the place where the building is located (there is a link to the local culture yet) (see Figure 4 and Table 5). In Italy, for example, many regions are characterised by the presence of stones with typical colours (i.e. Travertino of Rome, Red Marble of Verona, White “P” of Carrara etc.).

Figure 4: Bajo Martin County Seat, Hijar, 2011, designed by Magén Arquitectos (Photos © Magén Arquitectos).

Darkest colour	Lightest colour
NCS S 8502-B	NCS S 0502-Y50R

Table 5: Detected colour range for stone clad façades.

Results for artificial materials

The term artificial is derived from Latin “artificialis” from “artificium”: obtained with art, as opposed to what is by nature. The colour of artificial materials thus derives from one or more transformations brought about by man. Among the materials we define here as artificial are colours that arise from the nature of the base component, and colours obtained by several processes. Ceramic tiles are often glazed and then coated with a protective vitreous layer of any colour; the colour of conglomerates is derived from the base material prevalent in the dough; metals may have a detectable colour in nature or a colour obtained by different finishing processes; glass may be translucent, transparent or coloured depending on additives; textile materials, composites and smart materials have the most disparate colours obtained by the use of endless chromatic ranges of synthetic pigments and lighting systems. These are the materials in which research and refinement of techniques related to the colour appearance play a strategic role.

Ceramics

Ceramic materials have been used in buildings since ancient times: bricks, tiles, terracotta, etc. Their colour can derive from the clay used and from the level of baking (temperatures reached, cooking time, number of firings, etc.). For example, the bricks used in Italy have a reddish colour while those of the

Nordic countries have a colour tending to black (clinker bricks). Ceramic tiles can be glazed to produce any colour. The current production techniques are the evolution of the traditional ones: today with the use of metal oxides and other components we can obtain mirror finishes, dichroic finishes and other appearances not achievable in the past. With digital printing on ceramics any other material can be imitated.

The excellent state of preservation of some artefacts of the past demonstrates the durability of glazed ceramics in many environmental conditions. Today's production techniques and posing allow further improvements in the durability of the material. So the colour is very stable in time.

Since ceramics are also traditional materials, often linked to particular places (e.g. in certain regions of Spain), it seems important for the sustainability of the intervention to produce a chromatic analysis of the colours of the place in order to harmonise those of the project. In this case we can talk about colour sustainability as the harmonisation of the building within its context.

Concrete

Concrete will last for approximately one hundred years. Its base colour, light grey, can vary over time due to pollution, dirt, mould and erosion to which it is subject. For added protection from the elements special paints may be used. Surface paint treatments can decay in a few years (see Figure 5 and Table 6). Concrete can also be coloured using dough additives. Today we have a lot of innovations in colour related to this widely used material: aerated concrete, fibre reinforced concrete, translucent concrete, light concrete, stamped concrete, photo-etched concrete, and so on. The research is moving towards a progressive increase of recycled materials in the production of the binder "because the production of the binder seems to generate the greatest environmental impact" [13]. In any case, in order to preserve it efficiently over time, even concrete must be periodically cleaned, checked and possibly patched or repainted, if necessary. The use of concrete is now widespread in all cultures. Its grey colour characterises most of the anthropic environments of our globalised world: the grey of the suburbs, slums, etc. Although in many situations we cannot avoid the use of concrete, a meditation is needed on the use of grey and the influence of this material on urban greyness.

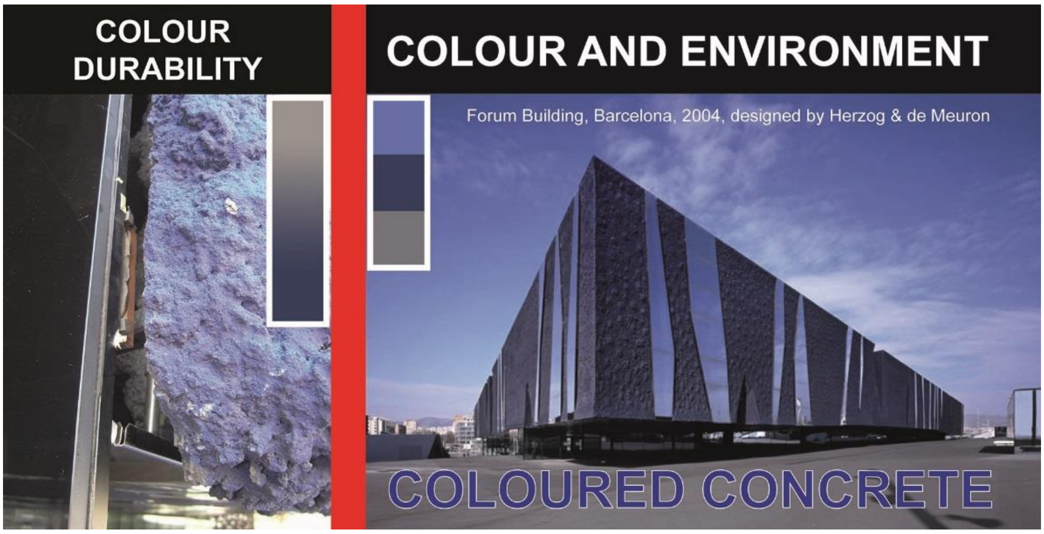

Figure 5: Forum Building, Barcelona, 2004, designed by Herzog & de Meuron (Photos © Katia Gasparini).

Darkest colour	**Lightest colour**
NCS S-9000N	NCS S 0502-Y50R

Table 6: Detected colour range for concrete façades.

Metals

For nearly one hundred years metals have been used, in addition to roofing, on façade claddings. The colour of metals can vary in time due to the phenomenon known as oxidation (see Figure 6 and Table 7). Some materials may even completely degrade due to corrosion. The oxidised copper, green in colour, can last for over a hundred years; zinc alloys remain almost unchanged over time in their light grey colour; steel oxidises to red rust; “stainless steel instead has a durability that can exceed one hundred years without maintenance” [14]. Today, through processes of artificial oxidation we can get multiple colours (as well as those we may find in nature) of the alloys of copper and zinc. Stainless steel and aluminium can be electro-coloured for interference effects. Steel and aluminium can be painted with dichroic and iridescent paints. The most important issue is, as always, the design of the building and the correct choice of materials for the context in which it is inserted. Context and design features lead to a greater or lesser durability of the colour of the material. For example there are metals that are not suitable for salty environments (e.g. cor-ten steel). In addition, attention must be paid to dark colours and highly refractive surfaces that can cause the phenomenon of “urban heat island”.

Figure 6: Private House, Arosio, CH, 2007, designed by Lands Architetture (Photos © Michele Nastasi).

Darkest colour	Lightest colour
NCS S-9000N	NCS S 0502-Y50R

Table 7: Detected colour range for metal façades.

Glass

Glass is considered to be the material of transparency and translucency. Glass also has a surface full of reflections of the surrounding environment (see Figure 7 and Table 8). Such as metals or ceramics, glass can be coloured with any other colour: by dough or by means of films and coatings with various pigments, metal oxides or other. Glass can change colour through the use of specific chemicals in double-glazing and turn also into an opaque material. If it is not damaged or scratched, glass can be almost eternal. It can also be recycled with relative ease. Glass is one of the most significant contemporary materials. Although it can be used in any colour, glass is fundamental in architecture for its visual lightness. In fact, glass can be used to dematerialise the building envelope. Attention must be paid to concave surfaces that can cause the “Archimede’s mirror” burning effect (e.g. the infamous “Walkie Talkie” building at 20 Fenchurch Street in the City of London).

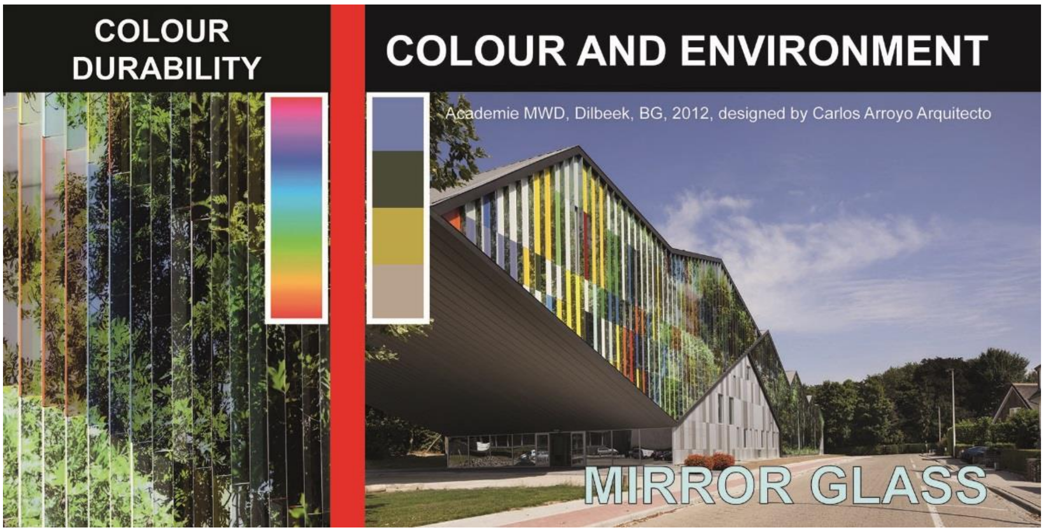

Figure 7: Academie MWD, Dilbeek, BG, 2012, designed by Carlos Arroyo (Photos © Miguel de Guzmán).

Darkest colour	**Lightest colour**
NCS S 8502-B	NCS-S 0502-B

Table 8: Detected colour range for glass façades.

Plastics

Plastics can adapt to any shape and have an almost inexhaustible range of colours. The prevailing derivation from petroleum has relegated them, for a long time, among the symbols of the environmental pollution. Today, most plastics have probably the highest degree of recyclability and reuse capability. Their fusion requires, contrary to metals, relatively low temperatures.

One of the main factors of degradation of polymeric materials is the photo-oxidation (yellowing due to UV exposure that occurs normally in PVC, polystyrene and in many other materials) and "which can be braked by the introduction of antioxidants, UV absorbers or external protection" [15 p34]. PMMA instead retains for a long time the original colour and the original degree of transparency so that many companies offer a 30 years warranty on the product.

Plastics can be considered highly sustainable materials from the point of view of their durability and recyclability. Attention must be paid to fire resistance of certain plastics, however, especially when used in composites with aluminium for exterior cladding (e.g. Grenfell Tower fire in London). From the point of view of colour we should analyse the colour durability of a single product (see Figure 8). The extremely wide range of colours instead requires a very careful study of the chromatic harmonies or contrasts with the surrounding environment that will result, from time to time, from the goals of the project.

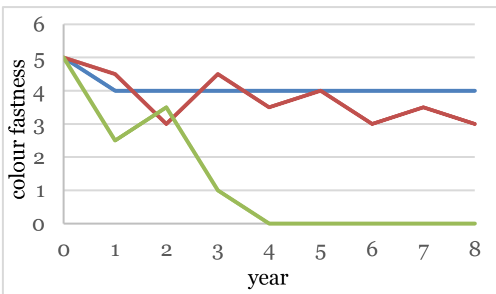

Figure 8: Colour fastness on white PVC windows in different environments. The colour fastness is represented according to the grey scale (CG) of DIN 54001 [15 p32].

Textiles

When we talk about fabrics, colour plays a central role. In architecture fabrics have mostly a decorative and protective function (sun shades, awnings, curtains, membranes and façade claddings). Colour fastness has always been an important issue for the fabrics used outside buildings, forced to suffer the negative effects of weathering and pollution and mould. Currently we have technical fabrics made of synthetic fibres that meet high technical and quality requirements (mechanical and thermal performance, durability, fire resistance, etc.). Polyester, PVC, glass fibre, and metal wires are guaranteed for many years of lasting colour, and with a micro-perforated screen excellent trade-offs can be obtained between matte surface shielding, privacy and permeability of sight.

The designer must pay attention to light colours on certain textiles in polluted environments: the colour may vary from white to dark grey (see Figure 9 and Table 9). Furthermore, fabrics can be integrated with other technologies such as photovoltaic, LED and other lighting devices. The durability of the colours of textiles must be also related to their use in the low-cost ephemeral constructions (shields, marquees, pavilions, etc.) where the cost of the intervention and the possibility of dismantling and quickly moving, make these technological solutions (and thus colours) sustainable. In an ephemeral textile structure with a scheduled duration, we can use highly saturated colours that contrast sharply with the surrounding environment, since the intervention will modify the context for only a limited time. For structures whose expected duration is longer white or grey colours are preferred.

Figure 9: Zurich Headquarters, Milan, 2009, designed by Scandurra Studio (Photos © Model System Italia).

Darkest colour	Lightest colour
NCS S 8502-B	NCS-S 0502-B

Table 9: Detected colour range for textile façades.

Composites

Composite materials are one of the leading solutions in the research for highly sustainable products. These employ mostly recycled materials, combined to exploit the best characteristics of the individual components. They are high performance and durable materials (e.g. Corian®, GRC, etc.). In this case, the availability of colours is virtually unlimited and the fastness of the colour over time is specially designed to offer security guarantees. In multilayer composites (e.g. Alucobond®, honeycomb panels, etc.) the durability of the cladding, and hence the colour is entrusted to the outer surface (metal, stone etc.). As for other contemporary materials the chromatic sustainability of the intervention depends on the relationships that the building has with its environment. Composite materials can reproduce the effects of many other materials like glass, metals, stone, wood etc. So they can be used to obtain the same range of effects: camouflage, mimesis with the environment, strong contrast, visual shock, and so on.

Smart

Smart materials and smart technologies are the outcomes of cutting edge research in innovation in the field of materials and products for the construction industry. They are mainly designed to consume very little energy, or even zero energy, in their use (e.g. shape memory alloys or shape memory polymer), to reduce the energy consumption of certain technical elements (e.g. phase change materials), or to produce energy (e.g. photovoltaics). As in many previous cases, the colour rendering of these materials is variable. “If you introduce materials that change colour (photo-chromic, thermo-chromic etc.) and some lighting technologies, the colour range reaches millions of colours” [16].

While these materials can provide high performance solutions (dynamic sun shadings systems, coatings with high insulation, etc.), however, given their recent introduction on the market, we cannot have reliable data on their colour fastness. Therefore, their use should be calibrated according to specific needs, taking into account the maximum yield defined by the project. It seems quite difficult to identify the colour range of smart materials. We might have said something more specific about photovoltaic (PV) devices, which generally have a colour range that varies from black to dark blue, but now we have also semi-transparent and coloured PV cells (DSC, Grätzel cells). Generally we may say that the most used colours for smart materials are grey and white. With regard to the chromatic integration with the context (and thus the chromatic sustainability of the intervention) various colour relationships that exist between the elements of the building envelope and the possible variants (artificial lighting, movement of components etc.) should be analysed, taking into account the many possible goals of the project.

Conclusions

From the situation that emerges from this study, we may say that the colour of materials, products and technologies used in contemporary architecture is probably one of the most effective parameters for assessing the sustainability of an intervention. The colour cannot be the only test of the state of health of a material or a product (colour fastness, ageing, durability), although we can state that some contemporary materials seem to have an extremely accelerated ageing. The sustainability of colour (and materials) cannot be separated by the architectural project as a whole and it is intimately linked to cultural factors (location, traditions, etc.). This seems to be true especially for traditional materials (wood, clay, stone, wall paintings, etc.). In fact we have seen that “natural materials” have wide but limited colour ranges (the earthy colours of clay, the shades of green of vegetation, the shades of brown of natural wooden surfaces, the range of colours of marbles).

For artificial materials and innovative technologies, more complex factors are involved (changing colours, dynamic surfaces, lighting technologies, etc.). We have seen in the results that the colour range of artificial materials is virtually infinite. For this reason, a more complex study of the colour relationships that the building establishes with the context is needed: contrast, harmony, shock, dematerialisation, etc. Maybe colour will become much more sustainable, as it will be able to provide the benefits for which it was designed. There is also a cultural factor concerning the understanding by the client that some materials naturally change colour over time. A planned useful life (e.g. ephemeral architecture) could help to understand better the chromatic effects on the environment of contemporary artefacts and to calibrate accordingly the use of these technologies, in order to have the least impact on the environment.

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