

SMART SHADING: SURFACE FINISH FOR REQUALIFICATION, REGENERATION AND VALORIZATION OF THE BUILDING ENVELOPE

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Abstract

The research called “Smart Shading” aimed to show how an intervention on the last finishing layer of the exterior walls can lead to a significant increase in the value of the whole building in terms of environmental quality and improvement of thermal insulation performance. The project has been developed by Iuav University of Venice, “Color and Light in Architecture” Research Unit, Veneto Region, Materis Paints Italia SpA and CERT Treviso Tecnologia (now T2i).

In the first part, the paper aims to show a summary of the goals of the research for the development of “Smart Shading” facade finishing. In the second part it aims to deal with the possible applications of the finish. In particular we want to show the importance of these tools for the requalification, regeneration and valorization of the architectural envelope of buildings, realized in the second half of the twentieth century, that are worthy to receive interventions for improvement.

Keywords: Sustainable coatings, smart technologies, environmental quality

Introduction

The research “Smart Shading” was founded with the goal of identifying new technological solutions for the protection of the external walls of the buildings from the summer sunshine, possibly through the application of innovative materials and technologies. Smart Shading project was developed in collaboration between Iuav University of Venice and the operating partner Materis Paints Italia SpA between March 2012 and March 2013. Materis Paints Italia SpA, with its brand “Settef”, is a global leader in the Italian market of paintings for buildings. The strength of Settef production are the finishing solutions for exterior “overcoat” insulating systems.

As part of the PRIN 2008 research “Requalification, regeneration and valorization of high-intensity social housing built in suburban areas in the second half of the '900” the results of the work conducted by the Research Unit of Iuav University of Venice, composed by Pietro Zennaro, Katia Gasparini and Alessandro Premier, have shown that the ultimate physic layer of buildings, that is, their outer coating layer, plays a strategic role for the enhancement of the entire building complex. The importance of what is often called “the ultimate sacrifice layer” mainly revolves around the following aspects (Zennaro, Gasparini, Premier, 2012):

- a. Better protection of the underlying layers;
- b. Redefining the appearance of the building;
- c. Increased thermal insulation performance.

These issues involve the following effects on the whole building:

- Increase the useful life of the building (a);
- Increase in the value of the property (b, c);
- Increased environmental quality (b, c);
- Improved micro-climatic comfort (c).

The Research

The goal of "Smart Shading" research was therefore to develop, in collaboration with the operative partner, a finishing system suitable to be applied on the panels used for thermal insulation (i.e. EPS, XPS, PE etc...) but also on other substrates (bricks, plaster etc.), providing adequate protection to the underlying layers from the sunshine overheating (external walls).

To achieve its goals the first phase of the research has focused mainly on two fronts:

1. The identification of solutions for the façade finishing made with smart materials (already on the market or in the testing phase) with the aim of improving the thermal insulation performance of the walls;
2. The identification of protective solutions from sunshine overheating able to lower the surface temperature of the external walls of the buildings through the use of chromatic technologies.

Even in a cost-benefit perspective the first phase of the research has shown that, to achieve the desired results (reduction of the surface temperature of the finish), it was necessary to work in two directions:

- Increase the surface reflectance of the coating system (note that the reflectance measures the ability of a surface to reflect light);
- Identify a three-dimensional configuration of the finish, able to decrease the surface irradiated by the sun (smart shading effect).

The research, which concentrated on these two aspects, has considered various possible solutions, identifying the use of pearlescent pigments the most suitable solution for increasing the reflectance of the surface finish. Pearlescent pigments are made essentially of micaceous iron oxide, highly reflective, inserted into a stucco able to provide the requested performances. As regards the three-dimensional configuration of the finish we made a detailed analysis on the progress of the height of the sun during the day and the different months of the year (sun path). As it is well known, the height of the sun in the sky above the horizon, measured in degrees, determines the angle of incidence of solar radiation on the earth surface. As a result also determines the angle at which sunlight strikes the surface of the exterior walls of buildings. Since the Smart Shading finish works on increasing the reflectivity of the surface, we decided to act on its morphology to ensure that a portion of the incident radiation could be easily reflected and part of the wall could be shaded, reducing its total surface temperature. To achieve this effect we tried different solutions, identifying at least an "hacksaw" design for the stucco with an average slope of the "teeth" adapted to different latitudes. This section, similar to the inclined blades of a sunshade, allows to have a wall portion (one below the inclined part) that is shaded for a rather prolonged time.

After the phase of theoretical research we passed to the stage of experimental research. Parallel to the factory production of the stucco finishing, there was a research aimed to identify the optimal solution for the application of the stucco using a tool capable of imparting the desired three-dimensional configuration. The research was carried out on two fronts: the study of a tool specially designed for the goal and the identification of ready-made tools available on the market. The second solution was preferable because it allowed a significant cost savings.

Once the stucco was ready, we tried its application with a special trowel, specially designed, which reported on its base the negative of the three-dimensional design to be imprinted on the finish. We used in a normal wood trowel (size 40x14cm) with applied on the bottom a specially micro-milled panel of Plexiglas®. After the application fails (the trowel on the plaster could not give a sufficiently uniform section and deep), we have tried different solutions on the market. The choice fell on different types of metal spatulas for glue (or spatulas for coachbuilders) who reported a "teeth" design similar to that of the project (Fig. 1). Parallel to the tests for the application of the stucco with various types of spatula, Materis Paints technicians better calibrated the thixotropy of the stucco, increasing it to get a product sufficiently dense as not to "fall" too much during the drying phase. The excessive lowering of the height of the section involved the loss of the shading effect on the part of the teeth. In the end we identified a suitable notched metal spatula originally designed for the application of adhesives.

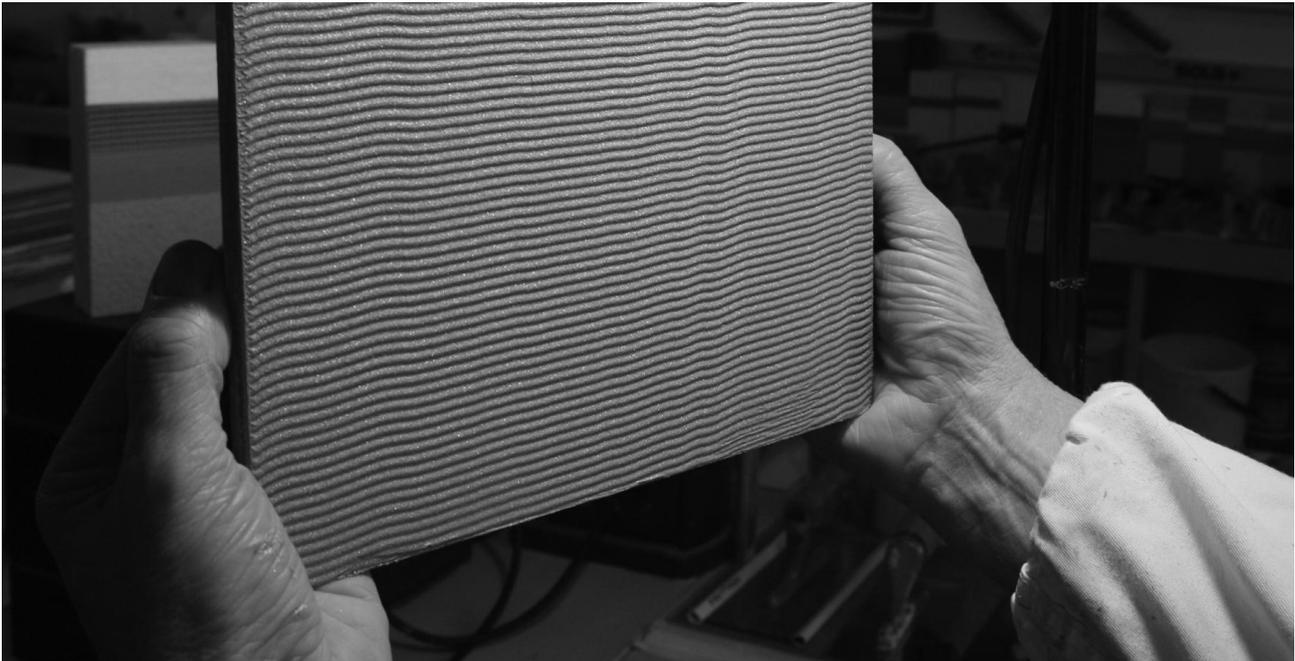


Fig.1 *Application tests of the new finish.* Photo © Alessandro Premier

After the of the new stucco was ready, we asked the “network partner” Treviso Tecnologia (now T2i) to carry out tests on samples of panels treated with the new finish. T2i - former Special Agency for Innovation of the Chamber of Commerce of Treviso - is a certification company that deals with innovation and technology transfer, training specialist and managerial as well as providing services for the enterprise and the protection of industrial property. The research has made use of the services provided by the internal structure called CERT. CERT, offers, through its laboratories, knowledge and services in order to promote the qualification and recognition of the products of the companies on the Italian and international market (CE marking of building products, certification of fire resistance, etc ...). CERT Workshops were part of the SIL network of university laboratories of the Galileo Science Park in Padova and the network of laboratories of the Italian Chambers of Commerce (see www.t2i.it).

Initially we thought to be able to carry out tests in the hot box owned by Iuav University of Venice in use at CERT. The hot box is a device, made according to the UNI EN ISO 8990: 1999, consisting of two air-conditioned rooms (a hot one and a cold one) between which is placed, on a suitable support structure, a sample (wall or window frame) on which estimate the thermal transmittance. The two rooms simulate different environmental conditions relatively to the outside/inside ratio of a building. This measurement is carried out using thermocouples (temperature sensors) placed at various points in the rooms and also on the analyzed sample. The hot box would be modified using lamps as radiators with an emission spectrum close to the sunlight. Heating the surface of the stucco with the lamps was a necessary condition for two reasons: because the tests were to be carried out during the winter and then in a closed environment; and because the Smart Shading finish acts just with the solar radiation. At a later stage, for economic reasons, we decided to build a special hot box drawing inspiration from a device made by a well known international manufacturer of façade systems for testing the thermal transmittance of aluminum doors and windows. The device consists of a steel chamber, completely open on one side. Inside the chamber we put lamps able to simulate daytime solar radiation. In a first step we have assumed the use of UV lamps such as those used for terrariums or for rearing chicks. Thanks to the advice of prof. Marina Vio, lighting expert and former university professor of Applied Physics, we opted for a cinema lighthouse with an incandescent lamp with a power around 1000 watts. The choice fell on reflectors for photo studio, the Ianiro: 800 Watt halogen lamps fitted with 3200 K color temperature (very close to that of the sun in the atmosphere: 4000 K) supplied by Iuav University photographic laboratory of the former Faculty of Arts and Design.

The goal of the room specially created was to provide data needed to identify the thermal conductivity of panels for exterior "overcoat" insulating systems treated with Smart Shading finish. To make the tests were therefore needed, in addition to the tools described above, the heat-flow meters, devices that are commonly used for measuring "quantitative" exact thermal insulation of a wall.

In parallel to the preparation of the devices for the test, Materis Paints technicians worked on the samples of finish to be tested. A comparison between the data obtained from the samples with the new finish and samples of commonly used standard finish was necessary to be able to determine the differences in performance. The technicians therefore prepared panels of white polystyrene foam (EPS-100 type), size 100x50cm, in different thickness: 3cm, 4cm, 6cm, 8cm, 10cm. The panels were equipped with three different finishes: finish type "Cortina Cap Medium" white, finish "Cortina Cap Medium" yellow (Viero, code: BY 6004) and the new finish "Smart Shading" light gray pearl. "Cortina Cap Medium" is a protective acrylic coating with a rustic look product under Settef brand. For "standard" panels we have chosen two colors very often used: white and pastel yellow. For the new finish we opted for a light gray since white would have resulted in an advantageous choice too. White in fact, as it is well known, allows the surfaces to accumulate less heat than the other colors because it offers a high proportion of diffuse reflection. Each panel was composed by the following stratigraphy: adhesive layer with "Bonding 11"; application on the adhesive layer of a glass fiber mesh; subsequent leveling of "Bonding 11" stucco; application of the finish. "Bonding 11" is a standard adhesive and leveling for applying finishes over insulating panels (product of Settef brand).

The tests performed on the samples was supervised by engineers of Treviso Tecnologia who sealed the special hot box with the panels to be tested, keeping the external environment at a standard temperature of 20 ° C. The lamps were inclined at about 60 degrees to simulate the angle of sunlight during the summer at our latitudes. The maximum surface temperature on the panels was set at 60 ° C, extreme condition that can only be reached during the summer. The panels with the new Smart Shading finish, in all the performed tests, showed a difference of surface temperature greater than the standard panels. In fact, the new finish thanks to the special three-dimensional configuration seems to behave as a passive heat sink similar to those used in electronics. With the same wall surface, the new finish increases the surface/volume ratio that enhances heat dissipation. The heat is dissipated by the thermal conductivity of the material and by the convection currents that are generated by the temperature difference in the air around the heat sink. Some of the heat is also transferred to the surrounding environment through the phenomenon of irradiation. In fact, a body that has a temperature higher than the zero Kelvin emits energy in the form of electromagnetic radiation, thereby reducing its temperature.

Requalification, Regeneration and Valorization of the Building Envelope

Our urban centers, as well as most of our suburbs, are characterized by a large number of buildings especially of the second half of the twentieth century. These buildings often are located next to other ancient buildings. I think, for example, about the town of Treviso, whose historic center was razed to 80% by Allied bombing on 7 April 1944, and subsequently rebuilt. Much of this building heritage, which has not yet reached the age of 70 provided in the Decree Law 70/2011, is worthy of being retrained as an expression of the most advanced instances of design research at the time, often interpreted by leading designers.

The research described above fits exactly in this area. This kind of buildings in fact, while requiring special care and attention in the interventions, has no special constraints and allows the adoption of a very wide range of technology solutions which include the redesign of the outer skin of the building itself. The new finish "Smart Shading" is designed precisely for this kind of building. Its use, considering also the high reflectance of the pigments used, can be calibrated to certain parts of the building so as not to create annoying glare effects. "The tendency to use light materials or metal, both for fashion and to prevent overheating of the external surfaces, collides with effects that, if not controlled can have even worse consequences. For example the Walt Disney Concert Hall by Gehry, opened in 2003, characterized by curved surfaces and polished stainless steel (at least partially), immediately after the completion of the building had problems of rising temperatures inside the surrounding buildings and glare and raising the temperature of the pavement of the surrounding spaces. Some measures have found that in summer the surface temperature of the pavement was around 60° C, while the areas reached by the radiation reflected from the building of Gehry came to values of 150-170 ° C" (Dessì, 2007).

Recently in Milan the light reflected from the windows of the new building of the Lombardy Region has melted the plastic venetian blinds of an adjacent building. As became clear during the research that led to the publication of the book *L'involucro rivestito* (published by Maggioli, Rimini, 2012) conducted by Pietro Zennaro, Katia Gasparini and Alessandro Premier within the Research Unit "Color and Light in Architecture" of Iuav University of Venice, a solution widely practiced in the requalification of buildings in Italy involves the use of coatings with panels covered with leveling compound or other material (Zennaro, Gasparini, Premier, 2012). "Smart Shading" finish, designed for this type of technological solutions, has a look that, for reflectance and surface texture, approaches to metallic materials, which are also much used today in the interventions of over-cladding of buildings. Over-cladding is a process according to which the existing cladding of the building is left in place and used as a basis for the new one (Zennaro, Gasparini, Premier, 2012). For these reasons Smart Shading represents, from the point of view of the "look" performance, a viable alternative to metals, especially on the economic level. In any case, the use of reflective particles in the plaster is not a recent invention. There are well known plasters containing particles of glass or marble, documented in Venice since at least the sixteenth century. For example you may think about the various types of Venetian "marmorino" plaster. Also Vitruvius (1st Century BCE) in his *De Architectura* deals with polished plasters made with lime, sand and marble dust.

Taking into account these factors, the research has provided guidelines for the design of the facades coated with the "Smart Shading" finish. They are based primarily on the use of color. As it is well known, to prevent the overheating of the walls of a building during the summer period (in the northern hemisphere), it would be appropriate that the walls facing south were painted with light colors. For the opposite reason, those exposed to the north, less sunny, should be painted with darker colors to increase the absorption factor and thus retain heat in winter. Since the angle of the "toothing" of the new surface finish increases the light reflection upwards, avoiding overheating of the horizontal surfaces, it is possible to use it in the higher parts of the building where any overhangs can protect the surrounding buildings against an excess of reflection. It is however evident that in the design phase the solutions to be adopted should be calibrated to each specific situation.

Another important aspect to be evaluated in the design phase concerns the support for finishing. Although the operation of over-cladding materials such as EPS is now widespread, it is still a solution that has some critical points: the expanded polystyrene foam, while not burning in flames, softens at around 95 ° C, and also has very low an impact resistance, so it can be easily damaged. You will then need to identify alternative solutions that provide additional protection of the material, thus avoiding the exclusive application with final smoothing. This last aspect will certainly be one of the future developments of the research.

Conclusions

The results of the research have shown one more time that the coating layer of the outer walls plays a strategic role for the enhancement of the entire building. They also have confirmed that the color of these surfaces can be strategic not only from a perceptive point of view but also for improving the environmental quality of the building through an effective contribution to the reduction of summer overheating of the walls. It is therefore necessary to try these new materials in applications on the built environment, also through simulations that are able to reproduce the effects on a large scale, such as the implementation in the context of a district. At the moment the adopted color palette provides colors that are close to the colors of metals: silver gray, red copper, green copper and golden yellow. We have tried, however, to prefer light colors. These colors are certainly suitable for industrial buildings but they need to be tested above all on the requalification of residential buildings. However, the results of the research have provided yet another confirmation that the color and the quality of the surfaces of the buildings are one of the most important features of the design of a single building as well as of the design of an entire district.

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