Osmotic fabrics for historical building external surfaces protection

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Abstract

The analysis of historical building behaviour demonstrates that control of external wall performance is very important because the chain environment–building–degradation depends on its efficiency. In fact traditional wall behaviour is very similar to the human skin, that works as an osmotic filter between body and environment. Moreover, the high complexity of traditional buildings usually produces irregular shapes and surfaces. In that context the main features required for the new facing system were: waterproofness, air permeability, chemical compatibility to the support material, morphological and geometrical compatibility to the support and reversibility. The prototype has been obtained by a sort of hybridisation process of different kinds of materials in a composite system that can be customized depending on surface conditions. It is mainly characterized by the use of osmotic performance fabric, combined with a selection of special glues and joined up with specifically designed devices. A large number of laboratory and on-site tests demonstrated that the wall-facing system prototyped supply good transpiration and waterproof performances, improving durability and reliability of the external surfaces of traditional buildings. A strong protection is assured, also in hard environmental conditions.

1 Introduction

This contribution reports the outcomes of a research aimed to design, realize and validate a prototype of panelling system for existing buildings external protection. Achieved goal is an effective industrial product for protective intervention of traditional building’s external surfaces, for which reliability and persistence in performance levels are guaranteed through industrial quality controls.

Nowadays, quality control represents one of most interesting subjects for research related to building production, also because of the arising
consciousness of financial value of traditional and historical building estate. This economical aspects leads to the increasing of requests related to reliability guarantees. Besides, in rehabilitation field quality matters are the main issue of design process, because project is based on consistency between current needs and offered performances by existing buildings. On the other hand, the rehabilitation design is strongly influenced by the purpose to respect characteristics and identity of existing estate, that are not unimportant values in estate evaluation. Then, the permanence of material and environmental characteristics is one more quality aspect in rehabilitation intervention, and materials take on a great role in expressing more evident and visible qualities of traditional architecture. The specific case of intervention on external surfaces introduces further problems, concerning aesthetic issues and performances control of wall wrapping in relation to environment, building and degradation.

If we consider the external objects surface as the human epidermis, we can observe that perceived image lets us overcome the abstract idea of quality, to achieve the sensorial conscience of the world through all these qualitative and emotional characteristics, stimulating perceptive processes. Therefore, the architectural image is represented by means of the external appearance, as well as the assessment on quality evaluation is just formed through its façade. This means that at the first sight buildings are what they appear, independently from actual offered performances, and the external appearance is the filter between people and building. Material’s external surfaces and their spatial configuration are the convey to grasp architecture’s language and identity. Besides, traditional building’s wrapping works as a flows regulating membrane and playing the role of interface between building and environment. In this way, building wrapping is like human skin, aging as selection and protection element.

Therefore, wrapping materials are in charge of making effective all these mechanisms, mediating relations between environmental components and internal microclimate. Because of this role, external surface is the first receiver of physical and chemical agents having impact on buildings; at the same time, external surface is able to strongly influence functioning of building organism, from sensorial quality related to appearance and acceptability to technical performances, concerning energetic exchanges between building and environment. For this role, similar to an osmotic membrane, external surface has a character mainly dynamic, and because its behaviour, surface is the first site where transformations of surfaces appear. These visible and invisible transformations produce the lowering of surface’s performance levels.

2 Methodology

The focused methodological path to individuate panelling system’s requirements for buildings covering in historical centres is based on the central role of traditional buildings behaviour. In fact, to quit classical approach for “new” buildings, we need to know the dynamics marking existing buildings, and define different goals of intervention. Following this
point of view, a preliminary study of these behaviours has been done, in order to find out building's bonds and vocation.

Research activity launched a progressive revealing of quality of external wall covering, also depending from both knowledge about traditional building behaviour and understanding of covering role for the whole building. In presented research, building is not meant as an idle object on which operate a control without considering its inner working properties; instead, it is considered as an active organism, establishing adaptation processes with environment. Intervention on existing buildings, whether aimed to the integral conservation, whether aimed to the performance improvement or integration, is a transformation that activates some processes influencing the whole building behaviour. These processes aren't the outcome of a direct and univocal operation, because of the complex character of building organism, expressing a system of multifaceted and interdependent relations.

The identification of many possible sceneries of intervention, related to the innovation for panelling system, a survey on industrial products for wall finish and on other products not designed for building field, leaded to the concept of a new product idea, suitable to satisfy expected requirements of conservation, aesthetics, protection and durability.

Pursued goal has been to realise an industrial product offering protection performances that are adequate to the wall support, performing reliability and durability higher than which-ones performed by plaster, and not denying those historical and aesthetical expectancies, allowing intervention acceptability especially for historical buildings.

Research methodology has been articulated in six steps, as explained below.

a) environmental behaviour analyse of traditional brickwork, understanding of external covering role in wall wrapping protection and its representation in urban scene;

b) panelling requirements definition and outlining of technical performances, based on the selection of materials to be used and their performances, with special reference to air permeability, water resistance and morphological conformability;

c) panel design through outlining of constituting elements, definition of production process, laying up system and prototype realisation;

d) panelling system validation through on site and laboratory tests

e) cost/performance evaluation;

f) check of the possibility to industrialize production process of prototyped panelling system.

The study on bonds systems had the aim to define which are the specific bonds related to a traditional building covering system; defined bonds are: perceptive and cultural ones, morphological ones, constructive and material ones. From these bonds the panel's requirements system has been focused, giving main relevance to durability, wall support protection, compleatability and production, as requirements referring to product; appearance, safety, environment safeguard, health, well-being and management are identified requirements referred to users. Then, main defined technical requirements are: wind resistance, air permeability, water resistance, geometrical and morphological compatibility wit different part of wall support,
morphological conformability and chemical and physical compatibility with the support.
To select suitable materials, many production fields have been investigated, heading for technical and performance characteristics of a wide range of materials. Survey results indicated as more suitable osmotic materials. This kind of material is not currently used in building industry, nor in buildings renewal and rehabilitation, therefore some appropriate adjustment had to be focused, in order to compare new panel performances to plaster's ones.
The outcome of previous step was the conception of a new covering system as a whole of elements, which are able to specialize their performances in relation to specific needs of each intervention on existing buildings. Selected materials are all industrial product not destined to building industry, and their use to realise the prototype of panel required new assembly methods. Prototype has been realized by a PTFE osmotic membrane, different glue types and auxiliary devices.
Durability, external agents' resistance, completability and appearance panelling system's characteristics were tested on site and in ICITE – CNR laboratory.
Because of the innovation of prototyped product and the consequent reference standards lack, laboratory testing activity had to develop specific testing protocols for panelling system. Considered standards are these ones referred to waterproof membranes, adhesive joints and/or frames. Prototype usage effectiveness was tested for a wide range of wall support (traditional and new ones), different kinds of degradation, different product set and fastening systems.
On site testing was finalised to check actual assembly time and easiness, the influence of whether conditions, sun exposure, façade position, surfaces and wall support characteristics and decay/degradation. Tests were effectuated in Salerno, on the Santa Maria dell'Addolorata church; screen test analysis, and not-destructive analysis were done. Screen test analysis was finalized to define support type, constituting layers, panel adhesion, water contents and chemical and biological compatibility. Not-destructive analysis consisted in a thermograph survey in order to evaluate homogenous adhesion, air bubbles presence, effectiveness of point-system adhesion and degradation stopping effects of panel application.
Cost analysis looked upon elements that determine production and installation cost; some competitors company (offering similar performing products) provided their data to compare available products and new panelling system's technical performances. All-in evaluation of project goals and achieved results has been done through a multicriteria method (Analytic Hierarchy Process) applied to information acquired in previous phases.
The possibility to transfer production process to the industrial scale has been checked, as well as the potentiality of an industrial approach to historical building rehabilitation. The type of company able to engineer and produce the panelling system, needed industrial resources, organisational aspects and market outcomes has been identified. Moreover, actual innovation offered by developed system has been evaluated, also in relation to building rehabilitation practices and criteria.
Fig. 1: Model for panel technical requirements identification
3 Results

The prototype of panelling system “SKIN” is characterised by excellent reliability and durability performances, and proved to be an effective product for external covering of buildings situated in historical centres. It is constituted by semi-rigid panel in composite materials, with osmotic behaviour, applied using adhesives with different performances and finished with a perspiring wall painting. System is composed by a triple layer laminate panel, adhering to the wall support through different kind of glue and some auxiliary devices. Many products combination (nine) has been selected, in order to make the covering system suitable to many different context (intervention goals, expected lasting, historical value, etc.). Below details about the set of used materials are itemised:

**Panel**

a) triple layer laminate fabric, performing high perspirability and impermeability. It is constituted by a expansate PTFE nucleus, with 0,2 μm microcellules and an external polyester covering (thickness 0.5mm, weight 450 +/−20g/m²);

**Adhesives**

b) monocomponent adhesive, water based, containing acrylic and natural resins, with high initial adhesivity (grip time 2-8 hour, weight 1.2 g/cm³);

c) polychloroprene monocomponent adhesive, with performance set situated between epoxy and monocomponent adhesive; rather elastic, characterised by an excellent fluidity and good strain characteristics, that allow the compatibility with wall dilatation and joining up by glue spots (grip time 8 minutes, weight 0.83 g/lit);

d) epoxy and ammine bi-component adhesive, peeling resistant, high use flexibility and good strain characteristics (grip time 90 minutes, weight 1.33+1.26 Kg/lit);

**Finishing**

e) hydro-painting for wall, washable, high cover power, micro-porous structure, with high perspiring performances, tixotropic (drying time 4-5 hour, weight 1,450 Kg/lit);

**Auxiliary devices**

f) fabric in polyamide net, (thickness 0.330mm, weight 0.91 g/cm³);

g) transparent vinyl film (polyethylene), with acrylic adhesive, pierced for 40% of total surfaces and used as stencil for glue application;

h) polyester net for geological interventions (thickness 5 mm).

The adhesion phase is very important for good working of panelling system, in fact the osmotic fabric’s low rigidity requires a carefully dissemination of adhesive under panel surface without reducing perspiring performances. Identified techniques for adhesion allow good panels holding and high perspiration thank to a “spot gluing” strategy and very high air permeability of osmotic fabric. Focused techniques are two: the first one uses a disposable stencil, made with the pierced adhesive film, on which glue is spread and fabric is fixed; the second one uses the polyamide net that is first soaked with glue, then squeezed, fixed on the support and covered with the fabric.
The panelling system "SKIN" realises a sort of skin on building organism, assuring air permeability and water resistance levels higher than any plaster. External brickworks where SKIN is applied are allowed to keep the natural perspiration flow, benefiting of the effective protective action of panelling system. Degradation and decay process are stopped by SKIN use, because the contact between stone surfaces and aggressive agents is interrupted by chemical SKIN's stability; moreover the new panelling system is characterised by chemical inertia to wall support.

SKIN is reversible: it is characterised by easy removability and taking away of unimportant quantity of support's material.

Thickness and consistency features make the panelling system suitable for a wide range of applications, corresponding to the variability and complexity of intervention cases in historical centres. In fact, SKIN is able to adapt to volume articulation and erratic morphology of traditional buildings.
Panels joints conceal through three layers of covering wall painting, chromatic uniformity and final texture offered by painting layers, give to the wall a plastered surface appearance, assuring the respect of historical and aesthetic needs.

SKIN can be used on plastered surfaces, both smooth and dusty or rough; on degraded surfaces: mouldy, cracked, detached, etc.; besides, it can be used on unclear surfaces (i.e. brick walls). It is very useful in presence of "plaster gap", thank to variability of dimension, thickness features, high performance of morphological conformability and application flexibility. In these cases, the panelling system allows the effective integration of plaster lack, guaranteeing the historical architecture respect.

Considerable application cases refer to a very wide range, including historical monuments, buildings in historical centres or in relevant environmental contexts and ordinary buildings. System acceptability varies depending on guardianship bonds. In strict safeguard scenery, SKIN is suitable for plaster gap integration or partial plaster substitution, giving a consolidation contribution also; panel use is advisable for monument protection in case of environmental/human stressing conditions, putting into effect provisional, but not precarious, interventions for temporary protection (happenings, concerts, etc.). Common buildings will be benefit by SKIN use because of its quick and easy application, high durability and stability.

4 Conclusions

Achieved result is an industrial product offering adequate performances of support protection, durability and reliability higher than performances offered by plasters. At the same time, SKIN panel is respectful of aesthetical values that characterise intervention acceptability, especially on historical buildings.

Proposed panelling system is a very dynamic system, whose composite character makes it reproducible in many version, specifically suitable to many different intervention cases; moreover, components interchanging role allows the control of performances/costs ratio

SKIN system presents high innovativeness considering two points of view. The first one is related to the transfer of high performance materials in building rehabilitation field; the second one is referred to the use of some industrial products in building rehabilitation in a not-invasive way, pursuing the goals to create a new product fully compatible with existing building, thank to its behaviour, similar to the external surfaces one, and able to improve and do not modify traditional walls working.

References


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