SOLABS: Development of a Novel Solar Thermal Facade Cladding System

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Abstract

Within the European project SOLABS (Development of unglazed coloured solar absorbers) a novel performing unglazed metal collector has been developed, using a coloured absorber and with special focus on the architectural integration of the solar system.

The paper first describes the criteria leading the architectural integration quality, as recorded by a large European survey. It describes the design methodology applied to develop a collector facilitating the building integration, satisfying the aesthetic expectations of the users, but also responding to energy production needs and to cost requirements.

An analysis of the formal characteristics of the resulting collector design is presented, in relation to the integration criteria and to the specific users' wishes recorded by the survey.

Finally, two simulations of collector integration in existing buildings are presented and compared to the original solar system integrations.

Keywords: building integration, thermal collector, unglazed, colour, SOLABS.

1. Introduction

The EU project SOLABS (Feb 2003- Dec 2006) is developing a novel unglazed solar thermal collector for building façade, resorting to coloured selective coatings on steel material. In a context were the lack of solar design is considered to be one of the main reasons of the slow spread of solar thermal technologies (even when the technology is already efficient and cost effective), the project intends to produce a novel collector conceived as a *multifunctional construction element,* to *ease the architectural integration* (both in new buildings and in renovations), and able to *meet the users' aesthetics expectations.*[6][7][8]

2. Project phases

To be able to produce a new collector meeting the above described goals, the architectural integration issues were articulated into 4 phases:

- Identification of the general architectural criteria defining the integration quality.
- Selection of potential collector concepts.
- Exploration of users' wishes and preferences for the proposed options.
- Development of the final collector combining users' expectations and technical needs.

3. Integration criteria

A large survey over the way(s) European architects and engineers perceive the integration quality of Building Integrated Solar Thermal (BIST) was designed and conducted at the beginning of the project (170 fully completed questionnaires). [1]

The questioned were asked to rate the global integration quality of ten selected examples of existing BIST. A detailed evaluation of the module sizes, shapes and colours in relation to the

integration context was also proposed, to help clarify the bases of the global judgment.
The architects' votes were remarkably consistent, confirming the existence of general criteria defining quality in architectural integration of BIST *(see detailed criteria description in ref 1)*. They can be summarized in 2 points:

- System size and position, module size and shape, jointing type, collector surface texture and material are characterizing integrations as much as does the absorber colour. Each of these characteristics has to be coherent with the whole building design logic for the integration to be considered successful.

- The use of the energy system as a multifunctional construction element (façade cladding, roof covering etc…) can greatly ease the integration design work. Building design logic is in fact easier to follow when the architect has to balance fewer elements.

Unfortunately the formal characteristics of most products proposed by the market are just issued directly from the energetic optimisation of the technology, without the due awareness of the architectural impact their integration may have on a building.

4. Design methodology

Any new collector design has to be defined within the formal limits imposed by its specific solar thermal technology *(see methodology description in ref 1).*

In this specific case the SOLABS team had to explore the formal possibilities offered by the *unglazed – hydraulic* - *flat plates* - collector technology, with the further constraint to use steel material for the absorber.

As unglazed thermal collectors for façades are de facto façade metal claddings, the original approach was to select options directly inspired by existing façade metal claddings (already developed to respond to building needs), rather than from existing solar collectors.

For evaluation, these claddings were divided into three families:

- *Profiled sheets*: very large non modular metal sheets providing a homogeneous covering, thanks to the absence of visible jointing between the cladding sheets.
- *Cassettes modules*: modular elements of geometrical proportions varying from 1:1 to 1:4, with visible jointing, well-suited for cladding of large wall surfaces. Due to the visible jointing, the careful choice of the module dimensions is the key to a successful cladding.
- *Panel planks*: cut to length modules with a width ranging from 20cm to 40cm. The maximum length of individual planks is usually 4.00m. The variable width of the reveals (from 0 to 30mm) makes the use of even standard modular element more flexible, so that the panel-planks can be used for the cladding of numerous architectural objects.

As only cladding types able to support a hydraulic system could be taken into account, profiled sheets were skipped, being hardly adaptable from the technical point of view.
Cassette modules and panel plank were both considered realistic options.
Then possible module *shapes*, *sizes*, *jointing*, surface *texture*, *finishing*, *colours* options were pre-evaluated within the SOLABS team to propose realistic options in a new questionnaire.

5. Users wishes

This new questionnaire was designed to explore the users' statistical preferences (mainly addressed to architects, but also to engineers and façade manufacturers) for collector appearance.
Each above mentioned collector characteristic was investigated in terms of aesthetic criteria and desired freedom/standardization *(see detailed results in ref.2)*.

5.1 Module shape, size, jointing

5.1.1 The cassette option.

Starting with the analysis of the cassette option, a definition of the level of acceptable module standardisation was asked.
The majority of the questioned architects selected as minimum requirement a cut to length module to have at least the freedom in one dimension. Moreover almost one third of the architects said that a made to measure module is a prerequisite.
For the jointing, the profile free solution (negative jointing) is the most appreciated. Frame jointing is well behind, even though it is still considered acceptable.

5.1.2 The plank option.

The analysis of the panel-plank starts with the most suitable panel width, as the plank length freedom is already characterizing this kind of cladding. The ideal size satisfying most of the interviewees is around 30 cm.
A variable width reveal is considered a suitable jointing technique by all the interviewees, architects and engineers, in order to have a flexible panel plank solar element in both dimensions.

All interviewees considered both the cassette and the plank to be valid solutions for the SOLABS unglazed collector, with a slightly better rating for the plank.

5.2 Surface colours, textures and finishing

5.2.1 Surface colours.

The wishes concerning the number of colours to be provided in the SOLABS palette brought a definitive challenge. Two thirds of the interviewees wish a palette made of more then ten colours and forty per cent of the architects suggest a palette with more than 20 colours. Moreover, for two thirds of the questioned architects the possibility to freely choose a custom colour is considered to be an essential requisite.
To help define in which direction the SOLABS colour development was to be pushed further, we asked to select three colours (out of 24) which should definitely be included in the SOLABS palette. Architects' most demanded colours are by far the greys, no matter if they come from the North, the Centre or the South of Europe. Blues and reds are also selected options while greens, browns and yellows are less popular.

5.2.2 Surface texture and finishing.

As expected the preferences of both architects and engineers have gone to the most traditional surface textures proposed: flat and slightly profiled. The also proposed embossed and lenticular perforated surfaces are considered not appropriate for façade use, even though they seem to interest a few people.
The question about surface finishing leaves no doubts: 90% of the interviewees think it should be matt rather than polished.

6. The resulting collector

A careful balancing work between defined users' wishes (aesthetic preferences and need for freedom), production feasibility, cost requirements and energy performances was then conducted.

The joint efforts of SOLABS engineers and architects, starting from the clear identification of the problems to be solved and the knowledge of users' wishes, made possible the design of a product that should respond to building needs and to the market demand.

6.1 Module shape and size

Considering the high level of freedom in module size requested by the users for that option, the cassette was abandoned and the development was focused on the plank.
The resulting product is a cut to length plank collector of 29 cm width, with variable negative jointing from 0 to 2 cm, very similar to the largely available planks modules proposed by the façade metal cladding market (fig. 2).

The hydraulic system is glued to the back of the collector to ensure both an optimal heat transfer and a perfectly smooth front surface. The horizontal piping system is designed to be compatible with the cut to length dimension of the modules. Similarly, the hydraulic junction between the planks, ensured by a brass manifold, is designed to be compatible with the variable width of the horizontal jointing (Fig. 1).

To extend the range of possible integration solutions, the decision was taken to additionally offer dummies elements, giving the possibility to apply a homogeneous cladding also in non-optimally exposed surfaces or on small areas.

6.1 Surface colour, texture, finishing

The surface of the absorber is flat with a matt finish, as wished by 90% of the interviewees. Considering the users' desire of large colour freedom, the decision was taken to use a selective coloured painting to be applied to the already formed collector preferably to coloured coil coated metal sheets to make the collector absorber. With this option, the production of a specific colour is not limited by the need to produce significant quantities as for coil coating, and a large colour palette can be proposed. As the paint can be produced in small quantities and in short time, customers will also have the possibility to ask for a specific colour on demand.

The coloured selective paintings used in the project were developed by the National Institute of Chemistry of Slovenia, a SOLABS partner. Different absorptance and emittance values (α and ε) characterize the various colours of the palette, and the architects will have to select the paint balancing aesthetics and energy efficiency.

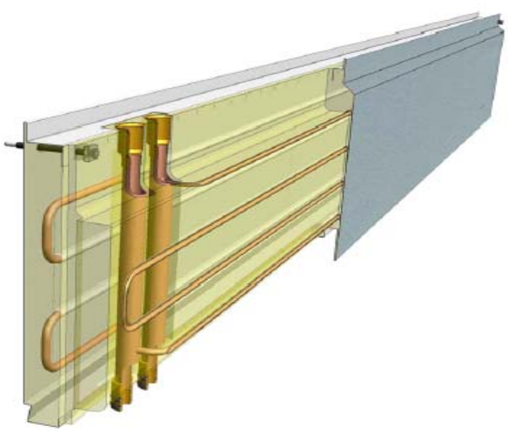

Fig.1. SOLABS plank hydraulic system (Clipsol SA)   Fig. 2.Demonstration stand at Demosite-EPFL

7. Integration simulations

A few integration simulations (Photoshop) have been proposed to test the formal possibilities offered by the SOLABS collector in relation to the previously described integration criteria.

As a base for the first simulations we have chosen two buildings already proposed in the first part of the questionnaire (case 3, fig 3-a, and case 4, fig. 4-a) whose original integrations were rated respectively unsatisfactory and just acceptable by the respondent architects (Fig 3-b and 4-b). (*See detailed analysis of architects' rating in Ref. [1]*)

The existing solar systems have been "removed" to restore the appearance of the buildings before the integration, and to better understand the logic regulating the original design (Fig.3-c, and 4-c). Then a new integration, following the whole building design logic, has been proposed using the SOLABS plank (Fig.3-d and 4-d). The flexibility of the new collector made it possible and even easy to stay within the pre-existing buildings design logic.

8. Conclusion

The true understanding of the characteristics affecting the integration quality of the collector confirmed the importance of conceiving the novel collector as a multifunctional construction element, and underlined that it had to be flexible enough to adapt to different buildings and contexts.
Consulting the users was fundamental to specify in which direction focus the research to ensure that the new collector will meet a real market.
The broad range of complementary competences brought in by the different partners of the consortium led to original solutions able to balance architectural quality, energy performances, production and cost constraints.
The relatively small width of the plank, the flexibility in both dimensions, the availability of dummy elements together with the large choice of surface colours makes the novel collector a versatile cladding easy to integrate both in new building and renovations.

Fig. 3-a. Single family house, existing integration

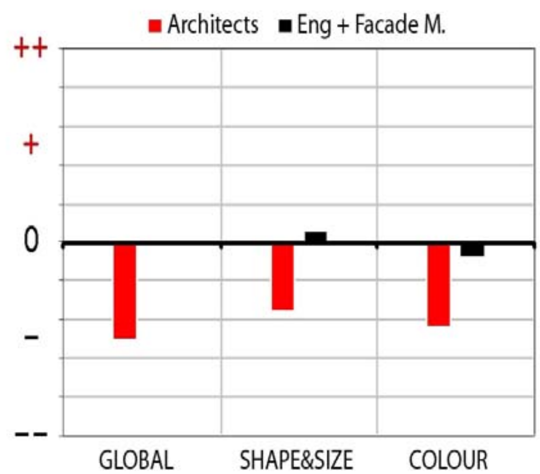

Fig. 3-b. Rating given to the existing integration.

Fig. 3-c.The building before the integration

Fig. 3-d. New integration using the SOLABS plank

Fig. 4-a. Youth hostel renovation (existing integr.)

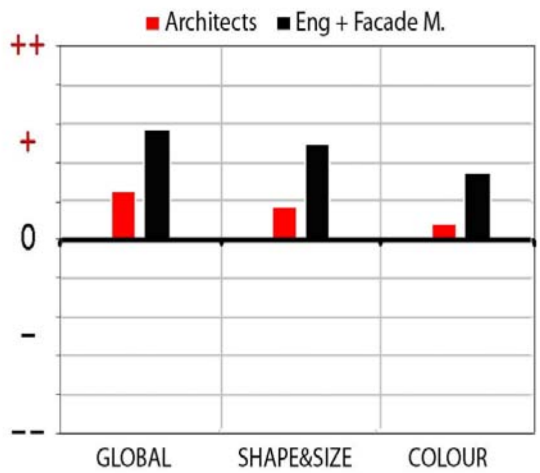

Fig. 4-b. Rating given to the existing integration

Fig. 4-c. The building before the integration

Fig. 4-d. New integration using the SOLABS plank

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