

Reinforced Polyester Roofs and Natural Cooling Strategies

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ABSTRACT: Under tropical conditions, heat exchanges troughs the roof are significant if compared with other envelope components. In many cases commercial and industrial buildings require to solve both ventilation and natural lighting needs, so the roof becomes the main cooling device.

In the other hand manufacture roof process requires to develop a cost / benefit structure able to solve at the same time the user needs , bioclimatic and commercial requirements.

The purpose of this paper is to show improvements on design, manufacturing and marketing process of reinforced transparent polyester roofs in order to assure an adequate bioclimatic response at affordable prices. This is essential to assure a sustainable approach under developing tropical areas like Colombia.

Bioclimatic features: transparent roofs could be used at the same time as a ventilation and lighting device. This requires the search of specific thermal and lightning standards according to industrial and commercial conditions: light : 100 LUX , SC : 0.20. Heat average gain / m² : 35 W/m² , ventilation rate to heat discharge an removal hygienic air by stack effect : 16 to 20 volumetric air changes.

Keywords: Natural cooling, comfort , bioclimatic roofs

1. INTRODUCTION

In Urban contexts under tropical conditions, the efficiency of natural ventilation systems based on stack effect depends strongly on the roof design. In order to assure at the same times adequate solar gain control, hot air exhaust, and natural lighting conditions at affordable prices, *Exiplast* developed the first research step of “*cool transparent sheets* “. Improved roofing FRP sheets were developed in accordance with an integrated cooling strategy which is a high efficient

ventilated skylight and a good thermal transparent insulation roof[1]. To evaluate a better solar gain control device, three samples were tested in a comparative way using direct measurements under real conditions of a typical tropical area of Colombia. In the other hand to know the response of transparent sheets to assure maximum ventilation rates, *Urbvent* [2] ventilation model and mathematical calculation were undertaken out.

In accordance to the above goals, this paper shows in a first step, a comparative analysis between commercial sheets and the

thermal requirements. At a second stage the paper shows the test results focused on the diminution of the SC factor, and the stack improvement (increase in air exhaust rates) using transparent polyester ventilated skylights.

In conclusion the paper stresses some guidelines to the design of an appropriate industrial product, application possibilities and cost benefice balance.

2. COMPARATIVE ANALYSIS

2.1 Thermal requirements:

The comparison between existing sheets is based on the performance of “sensible” thermal indexes” according to the tropical the climate needs. The Figure 1. shows the comparison in U coefficient index [W/m²oC] LT index [% light transmission index] and CS [% Shadow coefficient index].

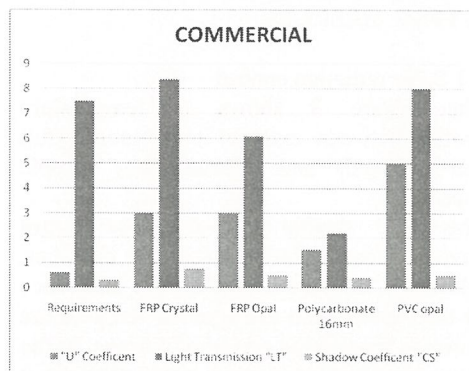
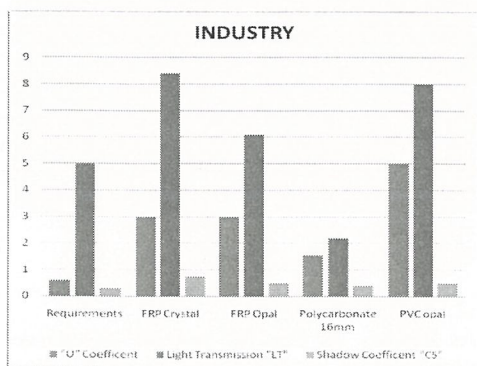


Figure 1: Requirements vs performance

The Figure 2, shows the response of a ventilated skylight in comparison with the air flow requirements under tropical conditions.

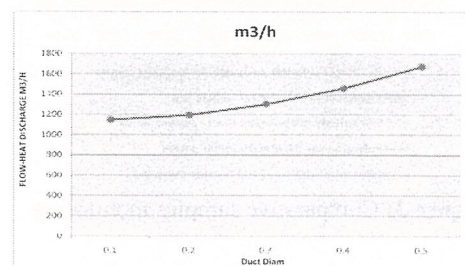
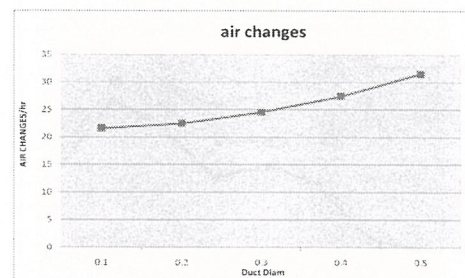
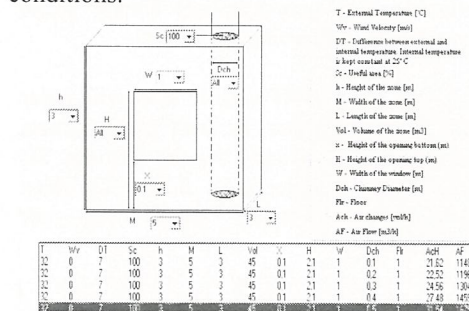


Figure 2: Urbvent simulation

3. TEST RESULTS

3.1 Solar radiation control

The Figure 3 shows the temperature profile between external temperature (full sun exposed) and internal face sample sheets.

The FRP double skin with solar control devices located into a 5 cm air chamber, allows the maximum temperature difference of 8oC lower than the external temperature during a monitoring period of 4 hours. In the other hand both aluminium single FRP sheet and FR double skin allows a temperature decrease between 3oC – 5oC. Ice polycarbonate 10mm panel could decrease about 2oC the maximum external temperature. Other test carried shows that reflective grey polycarbonate 10mm panel decreases the temperature in 3oC.

In any case the FRP double skin with solar control devices, has the best performance, according to predicted results [3] the SC factor will be reduced to 0.25-0.32 index (translucent reflective glass with air chamber).

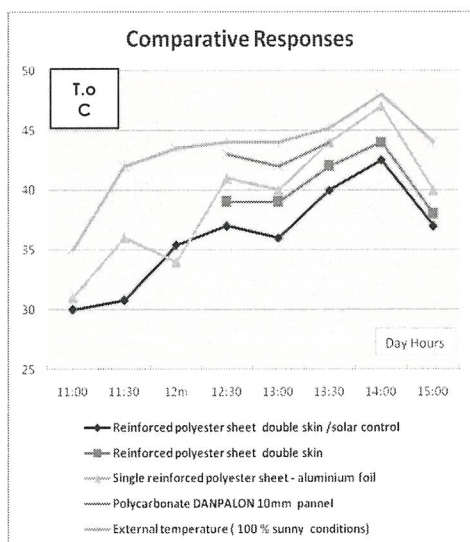
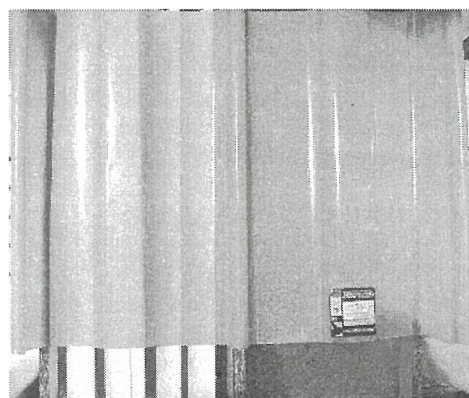
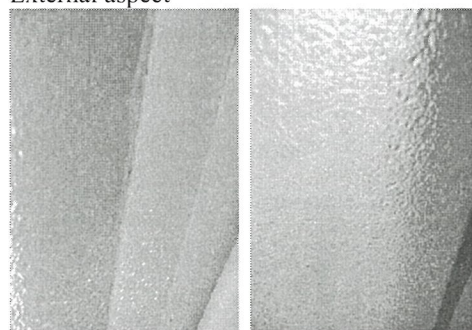


Figure 3: Comparative samples monitoring

The Figure 4 illustrates the tested samples. Nevertheless the LT factor of the FRP double skin with solar control becomes lower than the other tested samples.



External aspect



Light transmission

Figure 4: Tested samples Photo

3.2 Ventilation test

As shown in Fig. 5, the air discharge depends more on the improved stack effect with a 100% effective outlet area than a wind capacity which is not available under tropical conditions and suitable for the operation of an eolic turbine.

The mathematical expression which is useful in this case is done by [4]:

$$Q = \text{Area} \times k \times \sqrt{\Delta H} \times (T_i - T_o)^{3/2}$$

$$Q = \text{Volume of heat to be removed}$$

$$A = \text{opening area}$$

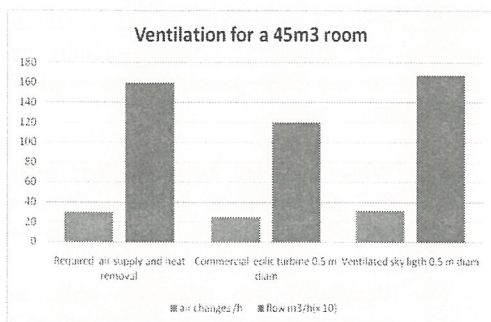


Figure 5. Comparative air flow response

4. CONCLUSIONS

Actually for cooling purposes, PFRP and PVC sheets are not able to control enough solar heat gain even if finishing mates as opal /ice are added.

Nevertheless lightening performance of translucent polyester sheets is better than other commercial sheets as polycarbonate panels.

So, the tested new alternative FRP double skin with solar control assures a good performance against solar transmission. The decreases of maximum external temperatures are desirable for internal comfort, but it does not help the stack effect. The following figure Fig 6 shows how to achieve a good and economical balance between thermal features, lighting and ventilation features.

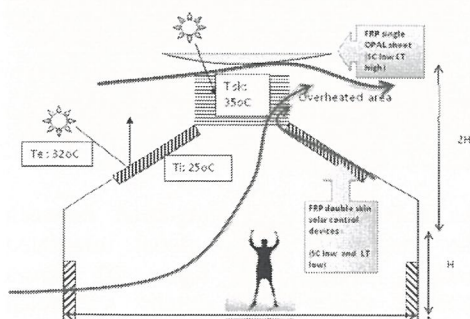


Figure 6: Appropriate integrated solar control and ventilation device using improved FRP.

A cost benefit result is illustrated in Figure 7, taking into comparison the cost /m2 of the *Exiplast Cool Transparent Sheet*, single transparent sheets and high standard polycarbonate sheets, for a similar SC value. Is clear the need to choose adequate roof depending on the bioclimatic requirement.

In this case, lower CS factor sheets are suitable for roofing even if the LT factor is also lower than the required. In the other hand sheets with higher CS and LT factor responses effectively to the air movement done by an improved stack effect, and lighting requirements. Regarding costs, the lower CS factor sheets are cheaper than higher CS sheets, manufactured with two transparent skins.

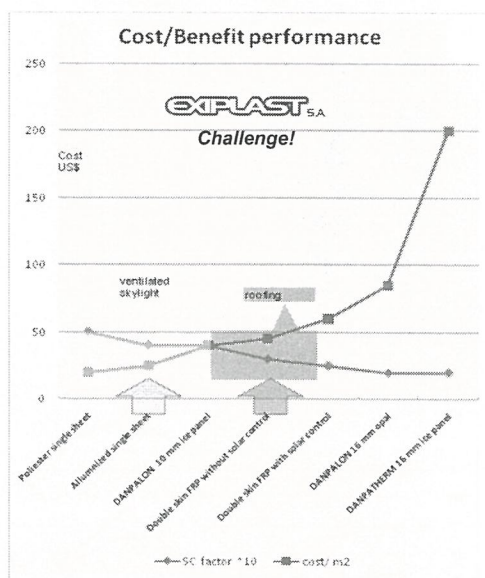


Figure 7: SC factor and cost performance between different transparent sheets.

For commercial purposes especially into industrial buildings, the aluminised single sheet offers a balanced performance at low prices. The Figures 7-7A illustrates monitoring results.

Finally we can suggest that the performance of improved FRP is related closely to the entire architectural design, and this has a direct impact on the lower price of the roof. This is an appropriate technology for the tropical countries around the world especially those on development, located in Asia, Africa and of course South America.

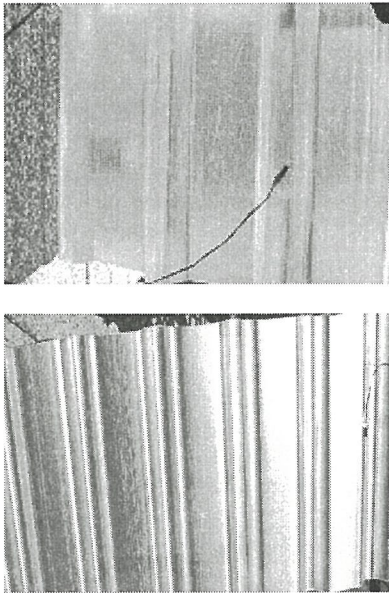


Figure 8: Internal face – External face

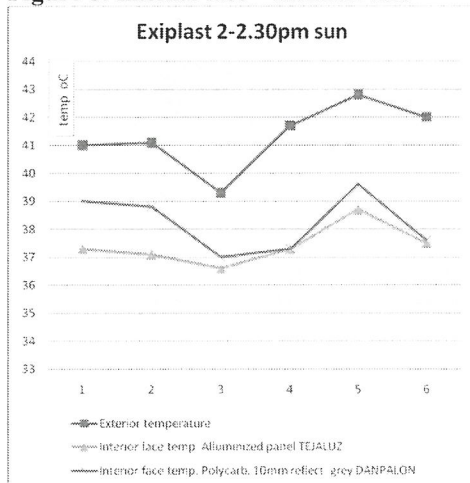
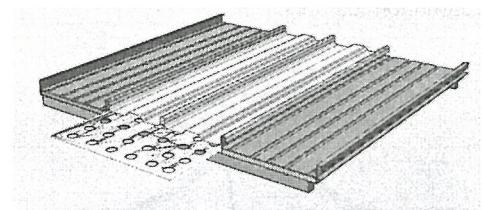


Figure 8A- Comparative performance

Summarizing the related basic research results, the following criterion could be stressed to use FRP panels under tropical conditions:

- White external color applied over the sun control blades plays a significant role in decrease of maximum temperatures.
- Ventilated air chamber help to decreases the U factor ($W/m^2 \cdot ^\circ C$) and could increase stack effect on tilted roofs coupled to a ventilated skylight
- A LT factor of 50 % (adequate for commercial/industrial spaces) could be achieved using combinations of clear FRP single sheets (placed at the top of the skylight) and FRP double skin sheets on the roof (20% floor area) area.
- Alternative aluminumized sheet could be place on the tilted roof, allowing 40% LT factor. In this case the performance in the heat control is lower than the FRP double skin sheet.

As an example of this guidelines the figure 9 shows a model with a better performance to be developed after the first basic model research.



As an example of the integration between the “cool roof” with a global integrated cooling strategy, the figure 10 shows thermal results of a naturally ventilated commercial mall located in a humid tropical area of Colombia. [1].



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