GELCLAD *VETURE kit*. Optimizing thermal bridges

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Introduction

The GELCLAD project intends to develop a versatile, easy to install, eco-friendly and highly performing external wall prefabricated insulation solution based in the *VETURE kit* concept. A prefabricated *VETURE kit* comprises an external skin, an insulating layer (**Figure 1**) and is installed onsite by bonding and/or fixings devices.

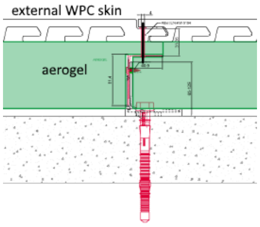

Figure 1 Illustration of one fixing concept (example) of GELCLAD *VETURE kit* panels (cross section).

The insulating material of the GELCLAD *kit* is a nano-silica aerogel targeted to reach very low design thermal conductivity (λ) values and able to be co-extruded with the *kit*'s skin (eco-WPC extruded profiles). Active Aerogels (GELCLAD partner) produced two aerogel batches which, under reference test conditions, reached λ values in the order of 0.027 W/(m.K) and 0.015 W/(m.K).

However, the *VETURE kit* GELCLAD panel must be fixed to a real wall and thermal bridges must be minimized in order not to significantly decrease its overall thermal performance. Depending on the characteristics of this surface and of the wall itself (concrete, bricks), different fixing solutions must be envisaged.

In this work it is shown how alternative fixing solutions may influence the thermal performance of the GELCLAD panel based in three-dimensional steady-state heat transfer simulations.

Fixings and thermal bridges evaluation

Considering the satisfactory internal cohesive strength of the aerogel (σ_{mt} = ~80 kPa) adhesive bonding is a possibility if the wall surface is sound and clean and an adequate adhesive is chosen. This would be the preferable solution as it does not create thermal bridges and, therefore, no reduction of the U-value (thermal transmittance) of the GELCLAD insulated wall element has to be considered. Nevertheless, due o different practical and real life performance constraints, some mechanical fixing is desirable and in some cases even mandatory. Steel point (anchor) or profile fixing are common solutions in *VETURE kits*.

In order to evaluate and quantify the influence of fixings in the reduction of the thermal performance of the GELCLAD panel, computer simulations have been performed using a three-dimensional transient and steady-state heat transfer program (HEAT 3)*.

The width of the GELCLAD panel elements was assumed (targeted) to be 500 mm. The thickness of the aerogel insulating layer considered in the simulations was 100 mm (λ = 0.027 W/(m.K) or λ = 0.015 W/(m.K)). Dynamic heat transfer simulations under real climatic conditions showed that 50/60 mm and 100/120 mm would be quite satisfactory aerogel thicknesses, for buildings located in regions, respectively, of mild climate (southern Europe) or cold climate (northern Europe).

Two basic reference, but optimized, conceptual fixing options have been considered: steel anchors (**Figure 2**), diameter 6 mm or 8 mm (4 anchors/m^2) and a vertical steel profile (**Figure 3**) discontinuously fixed (2 short L fixing/m^2) to the wall substrate. The vertical L shaped profile is embedded in the GELCLAD panel which in turn is also point anchored (4 steel fixings/m^2, diameter 4 mm) to the vertical L profile.

Results and discussion

Table 1 presents the U-values corresponding to each fixing option and the % increase of the GELCLAD kit insulated wall U-value, as compared to a simply bonded solution (no mechanical fixings).

***Table 1** GELCLAD kit U values. Influence of aerogel lambda value and fixing options*

Fixing options	$\lambda_{aerogel}$ = **0,015** W/(m.K)		$\lambda_{aerogel}$ = **0,027** W/(m.K)	
	U W/(m^2.K)	***% U increase***	**U** W/(m^2.K)	***% U increase***
GELCLAD kit bonded, no mechanical fixings	0.133	*reference*	0.218	*reference*
GELCLAD kit, bonded + (4/m^2) anchor fixings (diam. = 6 mm)	0.153	*15%*	0.236	*8%*
GELCLAD kit, bonded + (4/m^2) anchor fixings (diam. = 8 mm)	0.156	*17%*	0.240	*10%*
GELCLAD kit with embedded fixing profiles	0.158	*19%*	0.249	*14%*

Table 1 shows that departing from an *ideal* U value of 0.13 W/m^2. K ($\lambda_{aerogel}$ = 0.015 W/m.K, no mechanical fixings) this value may almost be doubled when aerogel λ value increases to 0.027 W/(m.K) and a better (profile) fixing is required. The lower the λ value the higher the percentage increase due to the fixings, but it also may be recognized that an optimized linear embedded profile fixing may not be significantly worse than point fixings.

Figures 2 and **3** show the influence of fixings both in terms of temperature distribution (interstitial condensation risk and fixings corrosion) and surface heat fluxes.

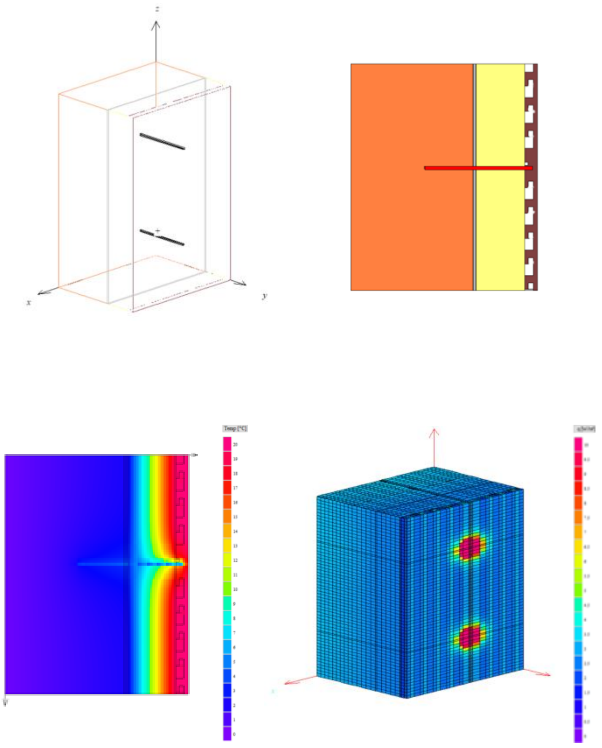

***Figure 2** GELCAD panel with point fixings. Geometry, temperature (cross section) and heat flux distribution*

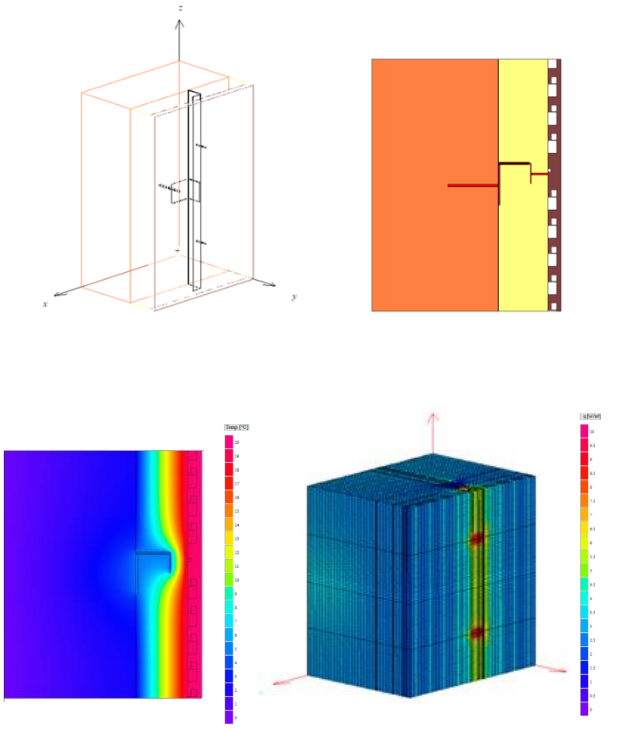

***Figure 3** GELCAD panel with embedded linear profile fixings. Geometry, temperature (cross section) and heat flux distribution*

Conclusions

In summary, simulations carried out over two alternative conceptual mechanical fixing alternatives (steel point and profile) for the GELCLAD *VETURE kit* panel (100 mm aerogel) showed that it is possible to produce an optimized solution with very low U-values (U < 0.25 W/m^2.K) minimizing thermal performance reduction. As WPC and aerogel (co-)extrusion difficulties may arise due to intrinsic material properties and extrusion process, narrower GELCLAD panels (< 500 mm) may be required. This will either negatively influence the overall thermal performance of the kit or require improved fixings design. The disadvantages derived from increased fixings density and associated condensation risks are issues that must also be studied.

* - HEAT 3 is a PC-program for three-dimensional transient and steady-state heat transfer. Blocon AB, Lund, Sweden. www.blocon.se