

Optimization of GELCLAD VETURE kit' thermal performance.

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Abstract *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. 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)[1].*

In order to evaluate the GELCLAD kit thermal performance, computer simulations have been performed using three-dimensional steady-state and transient heat transfer programs (HEAT 3).

This paper shows how alternative fixation solutions can influence the thermal performance of the GELCLAD kit and evaluate the influence of thermal insulation thickness on its thermal performance, for the different climatic conditions of the project partners (Portugal, Spain, Germany, United Kingdom and Slovenia).

1. 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.

The insulating material of the GELCLAD kit is a nano-silica aerogel targeted to reach very low design thermal conductivity ($\lambda=0,015$ W/(m.K)) values and able to be co-extruded with the kit's skin (eco-WPC extruded profiles)[1].

A prefabricated *VETURE kit* comprises an external skin, an insulating layer (Figure 1) and is installed onsite by bonding or fixings devices.

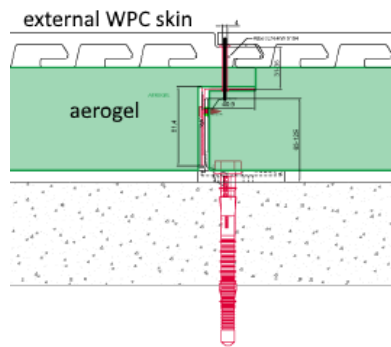


Figure 1 Illustration of one fixing concept of GELCLAD VETURE kit panels (cross section) [2].

Depending on the characteristics of the wall (concrete, bricks), different fixing solutions must be envisaged. These fixing solutions induce thermal bridges that must be minimized in order not to significantly decrease GELCLAD kit overall thermal performance.

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 (HEAT 3).

Knowing that diverse climatic conditions request different thermal insulation level, thermal simulations were performed using transient heat transfer program HEAT 3, to evaluate the influence of thermal insulation thickness (50 mm and 100 mm of aerogel) on GELCLAD kit thermal performance.

The evaluation was carried out using countries' climatic data of the project partners (Portugal, Spain, Germany, United Kingdom and Slovenia). The thermal simulations, based on heat flux results, allowed estimating the heating demands in winter season.

2. THERMAL SIMULATIONS INPUTS

In order to evaluate the GELCLAD kit thermal performance, computer simulations have been performed using three-dimensional steady-state and transient heat transfer programs (HEAT 3).

2.1. Fixings and thermal bridges evaluation

Considering thermal bridges, the preferable situation is the adhesive bonding of GELCLAD panel to the wall surface (reference solution), if it is sound and clean and the adhesive is adequate. In this case no thermal bridges exist and, therefore, no reduction of the U-value (thermal transmittance) of the GELCLAD kit has to be considered.

Nevertheless, usually 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 these simulations was 100 mm ($\lambda = 0.015 \text{ W/(m.K)}$) and the support wall was made of lightweight concrete (0.25 m).

Three basic reference, but optimized, conceptual fixing options have been considered: steel anchors, diameter 8 mm (4 anchors/m²) (Figure 2), a vertical steel profile (Figure 3) discontinuously fixed (2 short L fixing/m²) 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/m², diameter 4 mm) to the vertical L profile. The last fixing option is equal of the past one but with a PVC foam layer (100 mm) located between the 2 short L and the wall.

2.2. Thermal insulation thickness influence

To assess the influence of thermal insulation thickness on GELCLAD kit thermal performance in function of weather, locations of countries' project partners (Portugal, Spain, Germany, United Kingdom and Slovenia) were taken in consideration for 1 month in winter season (February).

The selected cities were, respectively: Lisbon, Malaga, Hamburg, London and Ljubljana, due to their geographical locations and availability of data [3].

Thermal simulations were performed using HEAT 3 in dynamic mode.

Calculation was realized considering a family house (150 m²) built with GELCLAD kit, and two alternative thicknesses of aerogel; 50 mm and 100 mm. Like for previous simulations a lightweight concrete wall, with 0.25 m thickness, was considered.

Based on results of heat fluxes through external walls, heating demands (kWh) were estimated for one month, considering an inside temperature of 21°C.

3. RESULTS AND DISCUSSION

3.1. Fixings and thermal bridges evaluation

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), showing the influence of thermal bridges on thermal performance (U-Value).

Table 1 GELCLAD kit U values. Influence of the fixing options

Thermal performance	Fixing options			
	GELCLAD kit bonded, no mechanical fixings	GELCLAD kit, bonded + (4/m²) anchor fixings (diam. = 8 mm)	GELCLAD kit with embedded fixing profiles	GELCLAD kit with embedded fixing profiles + PVC foam
U W/(m ² .K)	0.117	0.129	0.137	0.130
% U <i>increase</i>	<i>reference</i>	<i>10%</i>	<i>17%</i>	<i>11%</i>

Table 1 shows that departing from an *ideal* U value of 0.12 W/m². K (no mechanical fixings) this value may increase 17% when a better (embedded profile) fixing is required. If a layer of PVC foam is added, % of U decrease to 11%, similar value of 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.

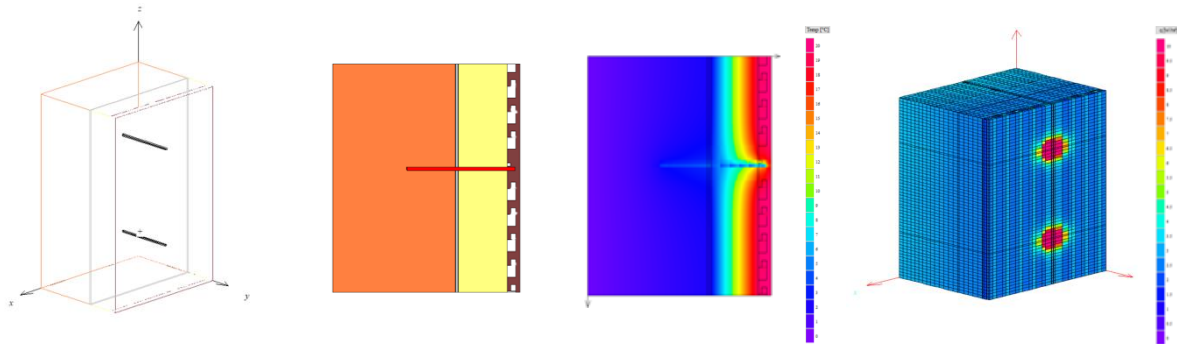


Figure 2 GELCLAD panel with point fixings. Geometry, temperature (cross section) and heat flux distribution

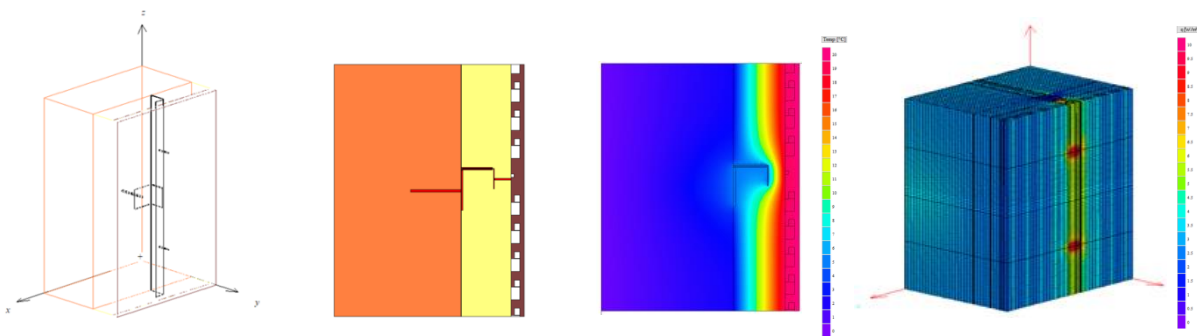


Figure 3 GELCLAD panel with embedded linear profile fixings. Geometry, temperature (cross section) and heat flux distribution

3.2. Thermal insulation thickness influence

Table 2 shows heating demands (kWh) estimated for one month of winter (February), considering an inside temperature of 21°C, based on results of heat fluxes through GELCLAD Kit, with 50 and 10 mm of thermal insulation (aerogel).

Table 2 Heating demands for 100 and 50 mm (% increased) thickness of thermal insulation

Aerogel thickness (mm)	Energy demand (kWh/month)				
	Portugal	Spain	Germany	UK	Slovenia
100	308	284	486	571	693
50	488 (+55%)	423 (+50%)	790 (+63%)	934 (+64%)	1126 (+63%)

Like expected, energy demands in countries of mild climate, with location in southern Europe (Portugal and Spain) are lower (approximately half a part) than correspondent energy demands in cold climate of northern Europe (Germany, UK and Slovenia).

The reduction of thermal insulation thickness in GELCLAD Kit induce an increasing of about 50% of energy demand, for southern countries and about 65% for northern countries.

Figure 4 shows heat flux evolution during a winter' month for Portugal and Slovenia climatic conditions and evidence the considerations done above.

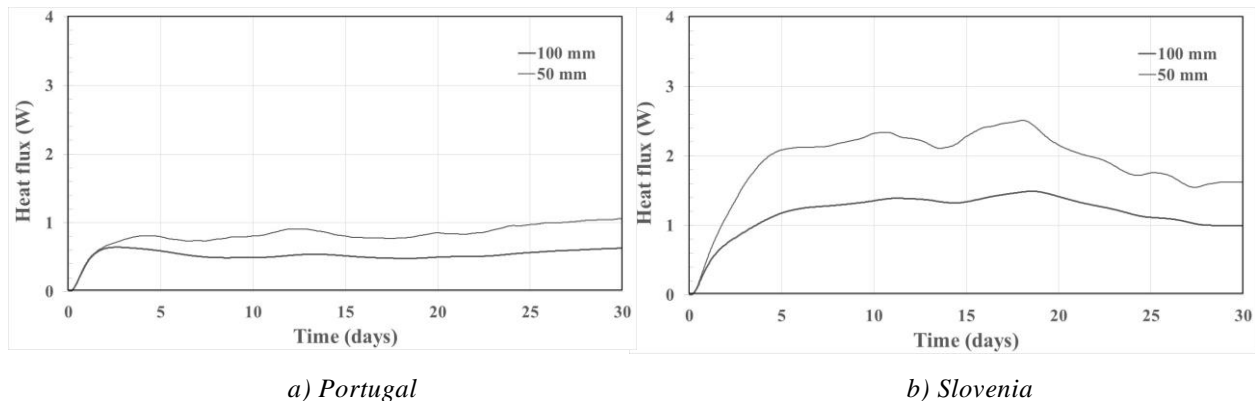


Figure 4 Heat flux through GELCLAD Kit with two thicknesses of aerogel (50 mm and 100 mm). Winter climatic conditions of Portugal (a) and Slovenia (b).

4. CONCLUSIONS

Thermal simulations carried out over three alternative conceptual mechanical fixing alternatives (steel point, profile and profile with PVC) for the GELCLAD *VETURE kit* panel (100 mm aerogel) showed that it is possible to produce an optimized solution with very low U-values ($U < 0.14 \text{ W/m}^2\cdot\text{K}$) minimizing thermal performance reduction (11%).

The influence of moisture and thermal bridges are issues that also have been studied [4].

Dynamic thermal simulations performed for locations of project partners (Portugal, Spain, Germany, United Kingdom and Slovenia) show that energy demands in southern Europe countries (Portugal and Spain) are about half a part of energy demands in countries of northern Europe (Germany, UK and Slovenia). Results also evidence that the increase of thermal insulation thickness is more important and significant in cold climate zones.

ACKNOWLEDGMENTS

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