THE DUCTAL® RAINSCREEN CLADDING SOLUTION IN EUROPE

Laura Fernandez (1)

(1) Ductal® -LafargeHolcim, Paris, France

Abstract

The Ductal® rainscreen cladding solution is a new development designed to meet the specific requirements needed for a variety of different buildings. In order to validate a technical assessment in France for a rainscreen cladding panel, several tests and calculations have to be done on the complete system (fastening and panel) by the CSTB: seismic test, shock test, wind resistance test, fire test and a calculation of the seismic influence on the anchors. For example, the mechanical performance of Ductal® UHPC gives the panels a good strength and impact resistance. With a specific constructive design, the panels and fastening can withstand until 400J with a soft body and 10J with a hard body. This paper discusses the development of the new Ductal® rainscreen cladding solution, how it can be integrated in an External Thermal Insulation system and the tests done for technical assessment in France.

Résumé

La solution panneau de bardage en Ductal® est un nouveau développement destiné à répondre aux besoins spécifiques d'une grande variété de bâtiments. Afin d'obtenir une certification technique en France pour un panneau de bardage, plusieurs tests et calculs doivent être réalisés sur le système complet (fixations et panneau) par le CSTB : essais sismiques, essais de résistance aux chocs, essais de résistance aux effets du vent, essais feu et calcul des sollicitations sismiques dans les chevilles de fixation. Par exemple, les performances mécaniques du BFUP Ductal® confèrent aux panneaux une bonne résistance aux chocs. Le système panneau et fixations peut résister à un choc jusqu'à 400 J avec un corps mou et jusqu'à 10 J avec un corps dur. L'article parle du développement de la nouvelle solution de bardage en Ductal®, comment cette dernière peut être intégrée dans un système d'Isolation Thermique par l'Extérieur (ITE) et des tests réalisés afin d'obtenir la certification technique en France.

1. INTRODUCTION

The combination of high mechanical strength, excellent durability, ductility and aesthetics makes Ductal® an innovative construction material used, for example, for perforated panels with a high open space (Fig. 1) or roofs with significant cantilever (Fig. 2).

LafargeHolcim has developed, in collaboration with partners specializing in prefabrication, a new rainscreen cladding product made of Ductal®. These rainscreen panels are made through a highly effective production process specially developed for the creation of thin cladding panels (Fig. 3). They can be used alone or as part of an External Wall Insulation System (EWIS). An EWIS uses superimposed cladding to create an envelope of insulation around a building. This envelope enhances numerous aspects of the structure: it improves the building's visual appearance, its heat insulation and soundproofing, its impact strength, airtightness and impermeability, and transfers the external load burden onto the central structure.

To be classified as a traditional cladding system, it is mandatory in France to obtain a Technical Assessment or ATEx Type A certification issued by the French Scientific and Technical Centre for Building (CSTB). To obtain this certification a product must meet various requirements, involving tests on the material making up the panels, tests on the complete system (both fastenings and rainscreen panels), and a series of other computations. Once this process is completed, certification is issued for the system as a whole [1] [2].

Figure 1: Ductal® lattice work panels- Vente Privée office, Saint-Denis (France) (©Atelier d"Architecture E. Nebout, ©photo Pierre Schwartz)

Figure 2: Ductal® canopy- Cinema, Rodez (France) (©Atelier d'Architecture E. Nebout, ©photo Pierre Schwartz)

Figure 3: Ductal® rainscreen cladding panels, collective housing rehabilitation, Paris (France) (©LafargeHolcim Ductal®, © Philippon-Kalt architectes Urbanistes,© photo M. Panaget)

2. RAINSCREEN CLADDING PANELS WITH EXTERNAL THERMAL INSULATION

For any architect taking on a new project or seeking to renovate an existing building, high-performance energy insulation is a priority. Both public authorities and private organisms have introduced an increasing number of environmental certificates, such as LEED, BREEAM and HQE. External Wall Insulation Systems (EWIS) are therefore designed to meet the required heat insulation performance criteria (involving in France, for example, obtaining certification under the 2012 Thermal Regulations).

External Wall Insulation Systems (EWIS) position insulating materials outside existing walls and line them with an external façade that makes the building weatherproof. EWIS systems have four principal characteristics: a reduction in the number of thermal bridges in the structure of a building; increased protection and weatherproofing thanks to the lining of the external façade; optimum heat insulation comfort in both summer and winter; and a double function as both insulation and decoration.

Our Ductal® cladding system can be integrated into an EWIS-type ventilated cladding system so as to provide an elegant and durable solution that protects buildings (Fig. 4).

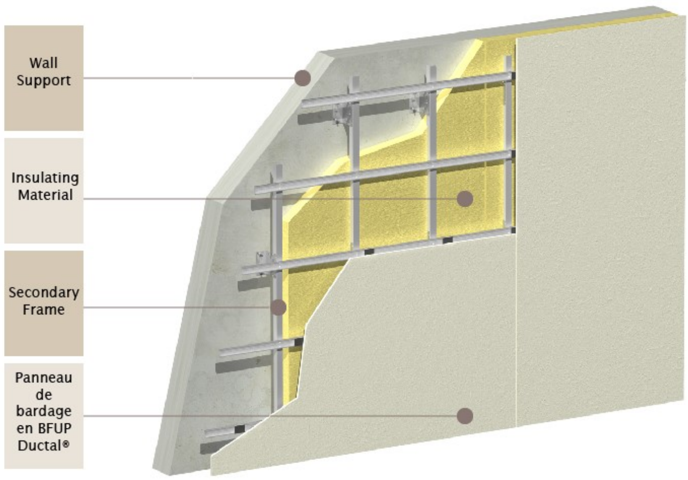
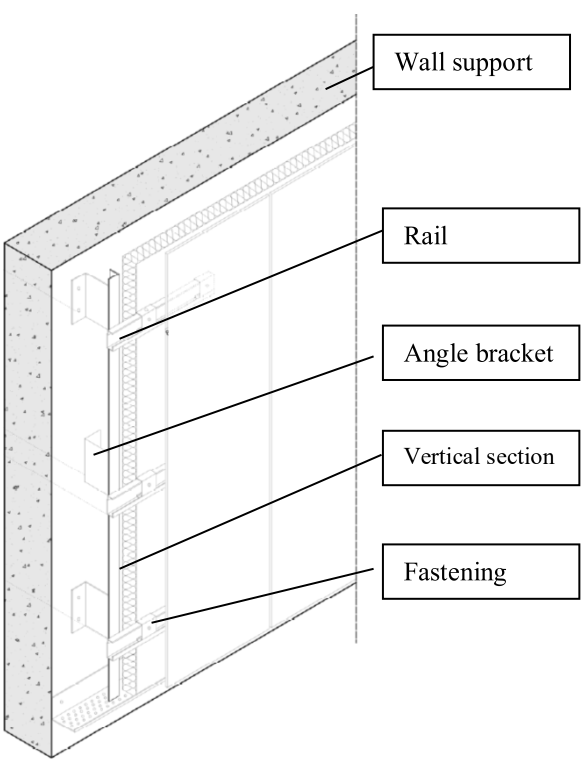


Figure 4: Principle of External Thermal Insulation with rainscreen cladding panels

Ductal® rainscreen cladding panels, made from UHPFRC using organic fibres, are 16 mm thick and available in 3 standard sizes (1.2 m x 1.2 m; 1.2 m x 2.4 m; and 1.2 m x 3.6 m). The choice of any sub-format matching these standard sizes is also possible. A number of colours and textures are available.

There is a choice of attachment systems between invisible and visible (Figs. 5-6). The invisible attachment system involves a secondary aluminium framework of rails and a primary framework also made of aluminium and consisting of angle brackets and vertical sections. Thanks to the Keil anchoring system (Fig. 7), fastenings inserted in the rear of the rainscreen panels are then attached to the rails. The visible attachment system involves an aluminium primary framework consisting of angle brackets and vertical sections to which the rainscreen panels are attached by means of screws.

The primary framework consists of vertical sections made of aluminum alloy 6060T5 extrusion of a minimum thickness of 2.5 mm. The angle-plates are also made of aluminum alloy 6060T5, of a minimum thickness of 3 mm. The center-to-center distance between the angle-plates will be calculated on the basis of the mechanical characteristics of the uprights and of the positive or negative pressure in accordance with the modified NV 65 regulations, but without exceeding 1.35 m, in compliance with CSTB 3194 [3] specifications.



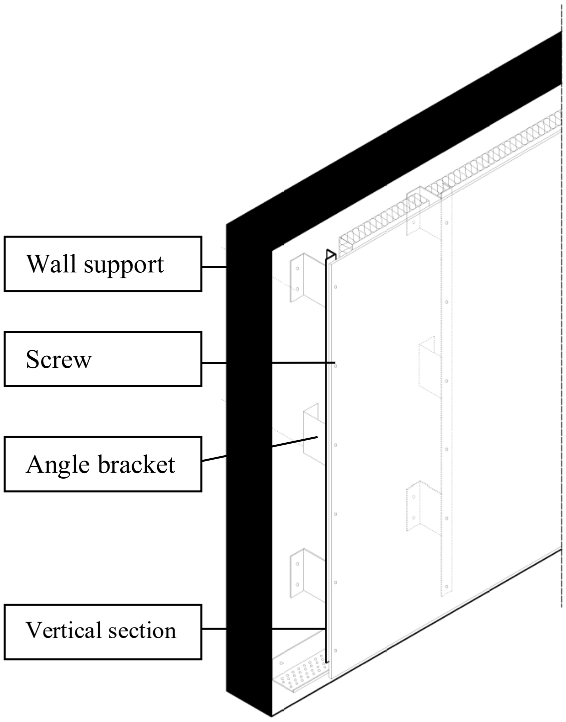


Figure 5 (on the left): Schematic diagram - Invisible attachment
Figure 6 (on the right): Schematic diagram - Visible attachment

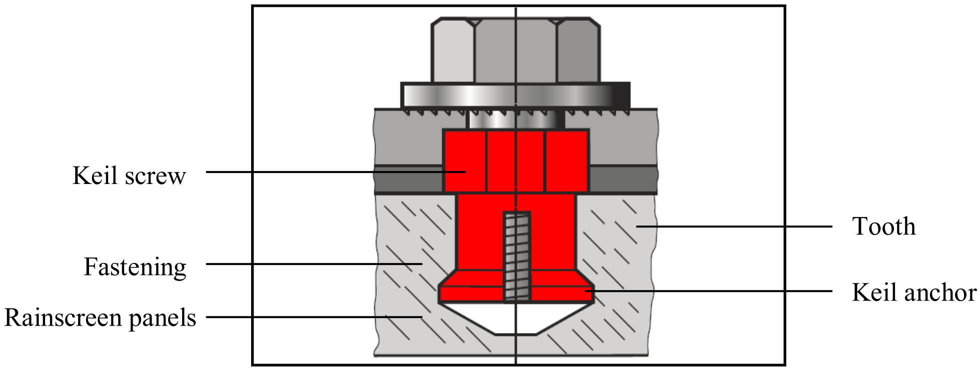


Figure 7: Schematic diagram - Keil anchors

3. TECHNICAL ASSESSMENT

To be classified as a traditional cladding system, it is obligatory in France to obtain a Technical Assessment or ATEx Type A certification, both issued by the CSTB. The entire system (both fastenings and panels) is tested and then approved. The system is validated exclusively by testing: wind resistance tests, fatigue tests followed by wind resistance tests, impact strength tests, seismic tests, durability tests on the material, and fire tests. Only two calculation sheets are required: a calculation of the seismic stresses on the anchor pins forming the attachment to the support structure, and a calculation of the extrapolation of the formats concerned to earthquake zones.

Only the wind resistance and impact strength tests conducted on the rainscreen cladding system with visible attachments will be detailed below. In all tests, the complete system is tested, including the rainscreen panels, Keil anchors, fastenings, rails, vertical sections and angle brackets.

3.1 First dimension calculation

The two most important parameters for defining a Ductal® flat panel solution are the thickness of the sheets and the center-to-center distance of the fastenings (as a hyperstatic system). A first dimension calculation was conducted by applying a permissible stress equivalent in linear elasticity in tension, with σeq ≥4 MPa for SLS loads. The withstanding of a maximum normal pressure of 1.6 kN/m² was taken into consideration (resistance V3 in the reVETIR [4] classification). Thus by only taking into consideration the relevant wind loads, the first results gave a panel thickness of 16 mm and a center-to-center distance between fastenings of 800 mm for both dimensions.

Impact loads are difficult to model in terms of finite factors, as is also the case for seismic stresses. However, a 16 mm rainscreen panel with a center-to-center distance of 800 mm in each direction apparently cannot withstand the largest impact loads. A center-to-center distance of 300mm x 300mm, and still maintaining a thickness of 16 mm, was chosen as a configuration to withstand the biggest shocks (see 3.4)

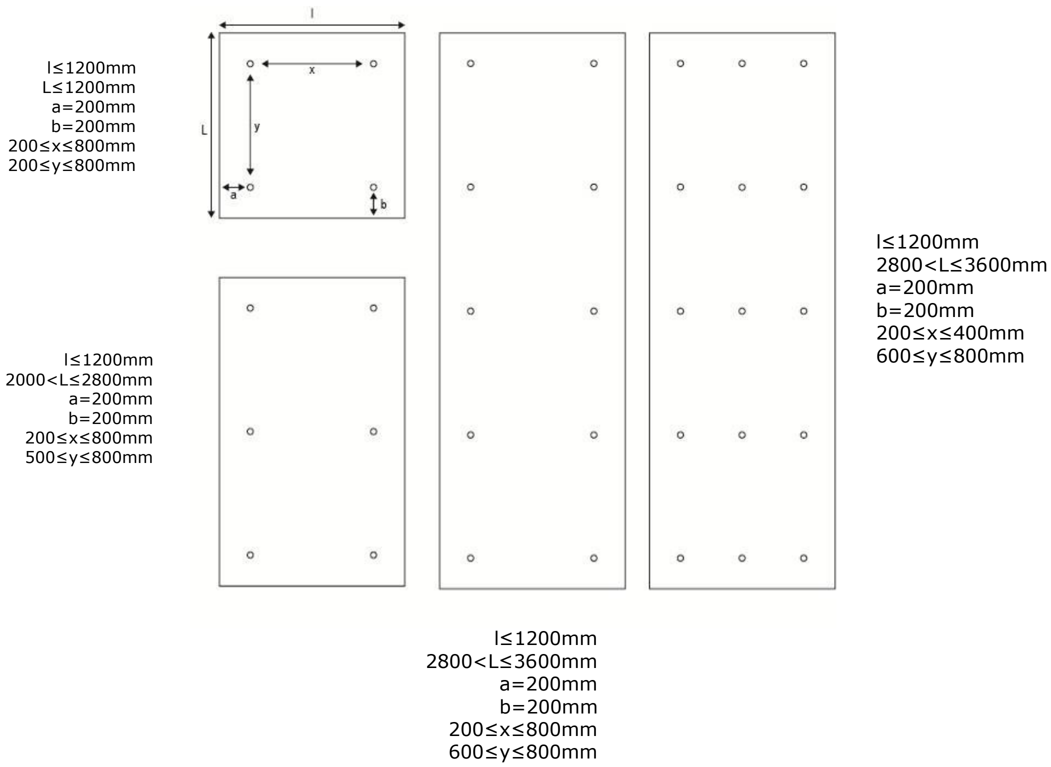


Figure 8: Example of the positioning of fastenings by size of the panels

3.2 Wind resistance tests

The test set consists of the following:

- a frame to which the test body is attached;
- a device serving to apply positive and negative controlled test pressure to the test body;
- a device serving to obtain a rapid, controlled variation in positive and negative test pressure within pre-defined limits;
- a device serving to measure the positive and negative test pressures exerted, continuously or intermittently.

Successive sequences of positive and negative pressure were applied to the test body while measuring the displacements at each stage. For the static pressure test, after subjecting the test body to three pulsations of air pressure at 300 Pa for at least 3 seconds, all the measurement devices are reset to zero. The test body is then subjected to specific pressures; by stages of 250 Pa for duration of 15 seconds ±5 seconds until deterioration is observed in an element of the test body (this deterioration may take form either in the fastenings or in the panel). The frontal displacements are measured at each stage of pressure and the frontal deflections are determined. The same operating method is used to carry out the test with negative pressure [5]. A safety coefficient is applied to the value established: 3.5 if the deterioration appears in the panel and 5 if it appears in the fastenings. The test values must be cross-checked with calculation values. The calculation takes into account the maximum pressure value in terms of deflection criteria and criteria of the anchor's resistance.

In our case, a 16 mm panel was tested with a center-to-center distance of 800 mm in both directions. Various configurations were tested: 2 x 2 fastenings and 2 x 3 fastenings (see Figure 5). Following our first dimension calculation, we expected to obtain a value of around 1600 Pa. During the test, the deterioration of our panel appeared in relation to the anchor (resulting in the anchor being wrenched out). The maximum admissible load that a Ductal® panel can withstand in normal wind conditions is 888 Pa (see Table 1), with a center-to-center distance of 800 mm (this value includes the safety coefficient).

Figure 9: Test assembly with panels and fastenings before the test

Table 1: Admissible loads in normal wind conditions in Pa
in compliance with modified NV 65 regulations

Number of fastenings (H* V)	Admissible loads in normal wind conditions (Pa) Horizontal center-to-center distance between fastenings : 800 mm Vertical center-to-center distance between fastenings (mm)					
	≤300	≤400	≤500	≤600	≤700	≤800
2*2	1523	1333	1185	1066	969	888
2*n (n>3)	1422	1066	853	711	609	533
n * 2 (n>3)	914	800	711	640	581	533
3*n n*3 (n>3)	854	641	512	427	366	320

3.3 Fatigue tests followed by wind resistance tests

In order to verify that the system is not sensitive to fatigue, the same wind test, in terms of positive and negative pressure, was conducted on a test body subjected to fatigue. [5]. The test specimen (Fig. 10) is tested following the cycle given in Table 2 and illustrated Fig. 11. Q is the wind load fixed as the admissible load under normal wind for the panel, defined by the rules NV 65.

Figure 10: specimen to be tested

Table 2: Pressure cycles

Number of the cycle	Number of pulsation in succession	Load on the panel (Pa)	
		Maximum	Minimum
1	83 600	2*Q/7	2*Q*0.35/7
2	10 720	3*Q/7	3*Q*0.35/7
3	3 800	4*Q/7	4*Q*0.35/7
4	560	5*Q/7	5*Q*0.35/7
5	280	6*Q/7	6*Q*0.35/7
6	720	Q	Q* 0.35

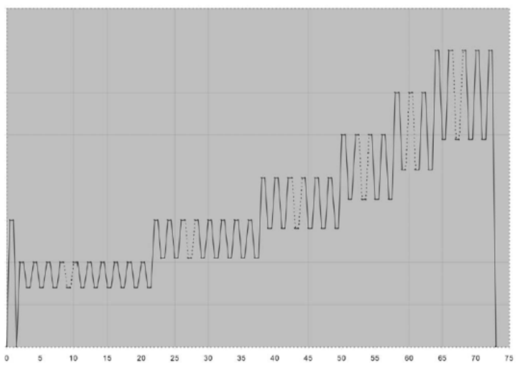


Figure 11: Pressure (Pa) according to the time of the cycle (s)

No deterioration was observed after the fatigue test. A wind test (see 3.2) was then conducted on the test body. The value after the fatigue test was similar to that obtained without the fatigue test. The Ductal® rainscreen cladding panels are therefore not sensitive to fatigue.

3.4 Impact strength tests

Depending on the environment surrounding the structure and the location of the panels on the façade, different impact strength values may be required: from Q1 (the least resistant) to Q4 [6].

All the impact bodies are released with a pendulum movement. The resistance criteria are satisfied if the external walls do not undergo deterioration that brings into question their performance, durability or appearance. There are two soft bodies: a spherical/conical bag with a mass of 50.0 ± 0.5 kg, and a spherical ball with a mass of 3.00 kg ± 0.03 kg. There are also two small hard bodies: a steel ball with Ø 63 mm and a mass of (1.00 ± 0.001) kg, and a steel ball with Ø 50 mm and a mass of (500 ± 5) g. In order to be classified as Q4, the panel must resist an energy of 400 J with the spherical/conical bag of a mass of 50 kg, 60 J with the spherical ball of a mass of 3 kg, and at 10 J with the steel ball with Ø 63 mm and a mass of 1 kg [7]. Following our first dimension calculation, a 16 mm panel with a center-to-center distance of 800 mm in both directions was tested so as to produce a resistance of Q1, and a 16 mm panel with a center-to-center distance of 300 mm in both directions was tested so as to produce a resistance of Q4.

Following the tests (Fig. 12), the Ductal® rainscreen cladding panel indeed produced resistance to the Q4 impact with a center-to-center distance of 300 mm in both directions and a thickness of 16 mm.

Figure 12: Panels after the various shock tests

4. CONCLUSIONS

The following tests and calculation sheets conducted on the Ductal® cladding system have not been described in this paper: seismic tests, durability tests on the material, fire tests, calculation sheets on the seismic stresses on the anchor pins forming the attachment to the support structure, and the extrapolation of the formats to earthquake areas. The ATEX Type A certification obtained for this system is an advance in the industrial production of Ductal® [8]. This certification has been obtained after around 18 months. Indeed, by obtaining it, the Ductal® rainscreen cladding panel has become a standard solution in France in the range of cladding panels, grouping together all types of materials (composite, fiber-cement, metal, etc). In order to develop this solution also in United-Kingdom and Germany, the same process of certification has to done in these two countries, with almost the same time of obtaining.

For any architect, energy efficient insulation is a priority. City governments and private organizations are looking increasingly to buildings that respond to environmental norms such as LEED, BREEAM or ABCD+. External Thermal Insulation (ETI) systems answer that call by being designed to meet thermal performance requirements like 2012TR (France) as well as future demands for zero net energy and positive energy construction. External Thermal Insulation (ETI) systems (also known as External Wall Insulation systems) place isolative material on the exterior of existing walls, with a finished, textured facade added to weatherproof and complete the solution. ETI systems maintain the following four characteristics: reduction in the number of thermal bridges, increase the resistance a protection through exterior, optimal thermal comfort in winter and summer and insulation and aesthetics in one package. The Ductal® rainscreen cladding panel fits into ETI systems and is differentiated from other options (composite, fiber-cement, metal etc.) by its durability, its impact strength and its mineral aesthetics.

ACKNOWLEDGEMENTS

The author would like to thank all the members of the Ductal® team who have contributed to the development of this solution, together with our partners specializing in prefabrication, without whom this would not have been possible.

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