

Ductal® Solutions

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bringing materials to *life*™

EDITORIAL

Ductal® in evidence

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Pont du Diable footbridge
Architect: Rudy Ricciotti

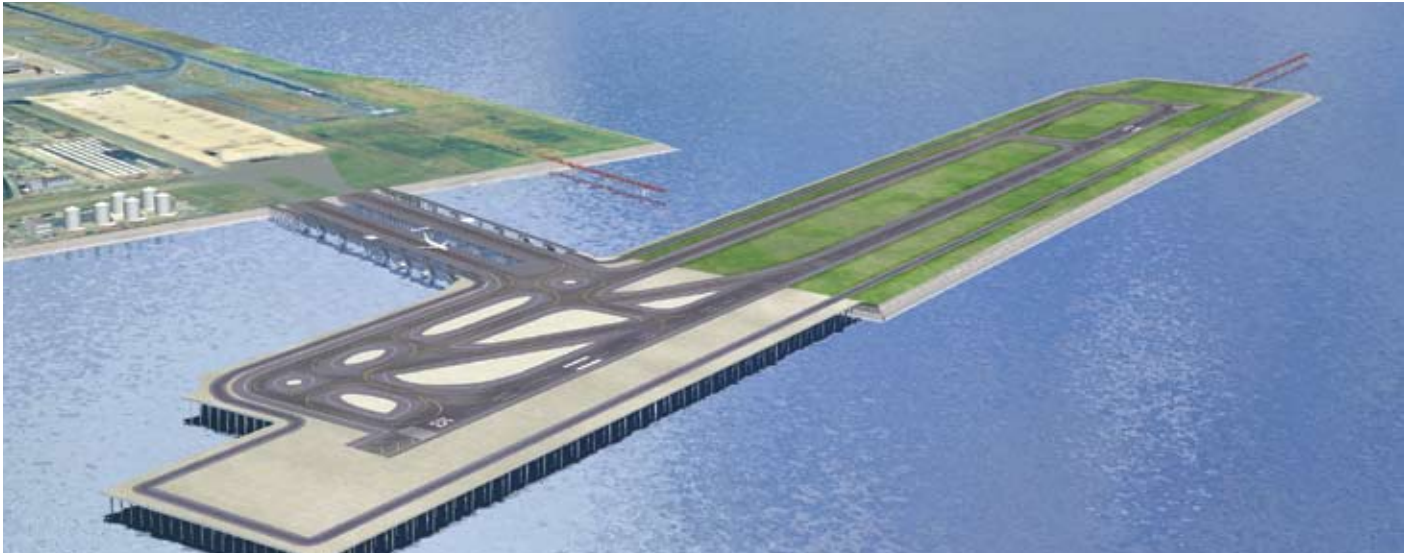
Over the years, architects, engineers and pre-casters have experimented with the capabilities of Ductal®, becoming more precise and creative with each new experience. More than any other past issue, this edition of Ductal® Solutions reveals this spirit of research and innovation. A footbridge in France, four bridges in North America and an airport runway in Japan; all demonstrate the structural performances of this revolutionary concrete, continuing to validate the

material's superior durability, strength and aesthetic properties. Together, these accomplishments will lead us to a future in which Ductal® will become the material of choice for builders of remarkable structures that are durable, attractive and economically viable.

Jean-François Batoz
Ductal® Development Director
Precast Marketing Director

Haneda Airport (Tokyo)

Blurring the borders between sea and sky



The new runway for international flights:
520,000 sq m over the sea

The unusual feature of the new runway at Japan's Haneda Airport, is that it is built on the sea. The pier providing the base for the fourth runway, built exclusively for international flights, is made of Ductal® slabs secured onto steel girders. To understand the scale of the project, we spoke to Akio Otake, Vice Project Manager for construction firm Taisei Corporation and Akihiko Kodama, Manager of Taiheiyo Cement Corporation (Ductal® supplier in Japan).

What are the issues at stake in this project?

Akio Otake: By the end of 2010, Haneda will boast a new take-off and landing runway, emerging out of the sea. The pier will stretch out over a massive 520,000 sq m area over the sea, and will feature two structures: an underwater part, consisting of steel pillars and their coatings, going down to a depth of 70 m, and a concrete area of 192,000 sq m secured onto steel girders.

The key issues specified by the engineers for this project are durability, strength and low maintenance costs. Ductal® was selected for its salt resistance (a hundred times superior to ordinary concrete) and a very low permeability coefficient, far exceeding the values for ordinary concrete. The cement company Taiheiyo undertook to supply the airport construction site with Ductal® at an extremely high pace.

What is the current status of this project ?

Akihiko Kodama: The Ministry of Land, Infrastructure and Transport recently announced that the new runway for international flights would be in service by October 2010.

The supply of Ductal® slabs, to form the whole area surrounding the runway itself, is a major challenge for our Ductal® business. We had to produce 1,100 m³ of Ductal® every month – imagine the scale of the undertaking! We will complete the manufacture of the Ductal® slabs by August 2009. Out of the 6,139 slabs required, 3,000 have already been produced.

We have faced a whole range of new challenges, with regard to the scale of the project, securing the raw materials, producing the premix and transporting the materials. However, we have found the right answers for all the technical issues, enabling us to acquire very extensive experience.

What features does Ductal® have that makes it particularly well-suited to this type of construction?

Akihiko Kodama: Costs are significantly reduced for this unprecedented structure due to the durability and surprisingly lightweight design of the Ductal® slabs. Given the characteristics of the material, the weight of the slabs can be reduced, as can the cost of the steel casing and the piles.

Akio Otake: Many studies were carried out in order to reach the conclusion that Ductal® was the most reliable solution, with respect to the specific nature of the site and the scale of the project. This product, more than any other, also ensures the highest level of homogeneity across such a large number of slabs. Its durability guarantees low maintenance costs over the long term.

Building Bridges

Innovative Ductal® bridge solutions continue to pave the way in North America with recent completion of four unique bridge projects, each validating the material's ability to create strong, durable and cost-effective alternative solutions for low maintenance structures that are built to last.



Jakway Park Bridge
Iowa (United States)



Hawk Lake Bridge
Ontario (Canada)



Country Hills Pedestrian Overpass
Alberta (Canada)



Cat Point Creek Bridge
Virginia (United States)

The **Jakway Park Bridge** in Buchanan County, Iowa has three, 51-ft Ductal® pi-girders (produced by Lafarge Precast/Winnipeg). Designed by the Office of Bridges and Structures at the Iowa Department of Transportation and the Bridge Engineering Center at Iowa State University, it is the first highway bridge in North America built with a new generation of Ductal® pi-girders, the first North American highway bridge project to incorporate batching of Ductal® in a ready-mix truck, and the second highway bridge project in Iowa and North America to be built with UHPC girders.

In Kenora, Ontario, the **Hawk Lake Bridge** utilized the Ductal® "JS1000" Joint Fill solution. The photo at left shows the deck panel joints being covered after a Ductal® pour to provide curing. By utilizing the material's superior properties in conjunction with precast deck panels, engineers can create optimized solutions for advanced precast bridge deck systems with simplified fabrication and installation processes. This solution paves the way for future full-depth waffle deck panels with Ductal® field cast joints!

In Calgary, Alberta the **Country Hills Pedestrian Overpass** has a 110-ft Ductal® drop-in girder, produced and installed by Lafarge's Alberta Precast team. Spanning over 6 lanes of traffic, this 160-ft clear span pedestrian bridge now provides the two adjacent communities with an aesthetically pleasing and durable curved-linear link.

The **Cat Point Creek Bridge** in Virginia has five, 80-ft Ductal® girders, produced by Bayshore Concrete Products for the Virginia Department of Transportation (VDOT) and the Federal Highway Administration (FHWA). This bulb-tee girder bridge with conventional cast-in-place deck demonstrates the ability of Ductal® to provide long bridge girders (without rebar or stirrups for shear) with reduced weight and improved durability.

The new \$5.13 million structure replaces a 70-year-old bridge. VDOT closed the old structure last spring, after a routine inspection revealed extensive corrosion and deterioration of the steel beams. The closure resulted in a 5.5 mile detour for several months. Abernathy Construction Corporation of Glen Allen, VA began construction of the new two lane bridge, which is more than 800 feet in length, in the spring of 2007. They delivered the project on time and on budget.

Building on these four examples involves extensive, ongoing research by various universities and the FHWA. Today, there are several Ductal® bridge projects under construction or in the planning stages. Ductal® bridge development is currently ongoing in the states of New York, Iowa, Florida, Virginia, Georgia, and the provinces of Ontario and Alberta.

Why use Ductal® for bridges?

- Improved durability
- Ductility
- Flexural strength
- Superior freeze/thaw resistance
- Resistance to continuous flexing across joints (from truck loads)
- Reduced traffic disruption & risk during construction
- Longer, thinner spans
- Increased usage life
- Impact & abrasion resistance
- Dimensional stability
- Low chloride ion diffusion
- Faster construction
- Reduced maintenance
- Extremely low porosity

FOCUS

Which Ductal® product is right for your project?

The choice of material to use in projects is key to fulfilling architectural and engineering requirements.

Two types of fibers can be used to make Ductal® products: high carbon metallic or organic, poly-vinyl alcohol (PVA) fibers. When choosing which fiber to use, determining factors include strength and rheology requirements, exposure to corrosive agents, desired aesthetics and exposure to human contact.

Ductal® is not incompatible with reinforcement - quite the contrary. When metallic fibers are used, Ductal® does not systematically undergo heat treatment, but it does stabilize the material, enabling it to achieve higher strengths faster. Additionally, the choice of material and the way it is used has an impact on the finished aesthetics, therefore prototype testing and validation is required during the preparatory phases.

Some projects do not leave much room for choice. For the Pont du Diable footbridge, Ductal® with metallic fibers (heat treated) was used in order to meet the structural requirements and the Ductal® façade and mesh panels were produced with organic fibers in order to meet aesthetic and colour requirements. The choice is less obvious for some other projects such as stairs, slabs on supports, shelters/roofs. Where Ductal® with metallic fibers (without heat treatment) or reinforced Ductal® with organic fibers are applicable.

Whatever your project, the Ductal® team is available, to help you make the best choices. For contact information, see: www.ductal-lafarge.com



Pont du Diable footbridge: From utopia to reality

“The paradox between high-level technological assertion and physical disappearance assumes its full value and meaning in an exceptional landscape.”

Rudy Ricciotti

Listed by Unesco as part of a World Heritage site, the Pont du Diable footbridge, designed by architect Rudy Ricciotti and engineer Romain Ricciotti, constitutes a first for Europe. A 70 meter-long, muscular girder provides discretion and lightness, thanks to the exceptional prestressing resistance of Ductal®.



A material that withstands very high levels of pre-stressing

The design called for an attractive, single span, 69 m footbridge with no other bearings, minimal elevation and no arches or stays.

Two parallel, isostatic beams (produced with Ductal® with metallic fibers) form the railings. Ductal®, is frequently referred to as “Ultra-high performance, fiber reinforced concrete” (UHPFRC) and withstands very high pre-stressing levels, due to its high resistance to compression. The two bone-shaped beams are optimized to limit the impact of the structure, with an ultra-high slenderness ratio and static height of 1.80 m. A width of 1.88 m between the two beams provides a usable space for pedestrians and cyclists.

The slenderness ratio of the footbridge, unlike conventional structures, requires the use of mass dampers to limit the effects of vibratory coupling between the wind and the footbridge.

The colour of the concrete and its organic section (100% of the material is structural) reduce the print of the bridge in the landscape. Construction was carried out by Freyssinet and Bonna Sabla, who perfectly mastered the use of UHPFRC; a material that shortens and simplifies the work, minimizes the impact on site, and improves working and safety conditions. (This 144-ton bridge was built by a team of 6 workers.)

Welcoming nearly 600,000 visitors every year, the gorges de l'Hérault in the south of France, reveals stunning landscape, classified sites, historical monuments, a protected biotope and a state biological reserve. At the heart of this popular tourist attraction, the Pont du Diable footbridge accommodates up to 250,000 pedestrians and cyclists every year. With these excessive numbers in mind, developing the landscape and restoring natural spaces were at the core of the grand site project's design, with high emphasis on the organization of walking trails.

As an essential element of the development project, the Pont du Diable footbridge opened in the summer of 2008, allows pedestrians to explore the area and discover its richness at an easy pace. The structure, at 70 meters long and 1.80 meters wide, is according to Romain Ricciotti “neither an arch, nor even a suspended footbridge, but a simple beam set on two supports: the two banks, to cross the gorge”.

Material able to withstand very high pre-stressing

“A performance that could be achieved by dividing the structure into 15 monolithic segments, cast from a single mold, which are placed on the scaffolding. No casting is carried out on site, everything was previously cast in the factory and then placed on the scaffolding.

Within these sectors, space was reserved for the cables that were tensioned to place the segments under compression (up to a tenth of a millimetre of tolerance*) thereby forming the beam. This ultimately produced a “flat vault”; a conventional pre-stressing technique, which is enhanced by the performances of Ductal®. Thanks to this material, it is no longer necessary to reinforce the concrete with steel as previously the case. Therefore it is possible to build a structure with a deck just 4 cm thick. The resulting visual expression is a static height of 1.80 m for a span of 70 m.”

For its designer, Rudy Ricciotti, the footbridge shows “that the difference between utopia and action is this reality of implementation. The paradox between high-level technological assertion and physical disappearance assumes its full value and meaning in an exceptional landscape. It means believing in the material and what we can get it to say. And asking one's self whether the structure's mathematical reasoning belongs to the person reasoning or whether it is already part of the material itself?”

* A performance due to the quality of the mold and Bonna Sabla's pre-caster.



Visual expression:
the priority

Ductal® cladding restores an old hotel to its original beauty



Hotel Rialto
terracotta replacement

The transformation of the Hotel Rialto in Victoria, BC, Canada has marked a significant step towards the revitalization of the city's downtown core. Built in 1911, this five-storey, Edwardian style hotel (once considered "upscale") was formerly known as the Prince George Hotel, and the Hotel Douglas (since 1918) until its most recent makeover in 2007 and 2008.

With its proximity to City Hall, the building's period design elements including brick cladding, terracotta columns and cornice and dentil moldings, established the hotel as historically significant and led to its designation as a municipal heritage site in 2005. The original façade comprised 11 columns in two sizes, clad with white glazed terracotta tiles. Years of use and several renovations during the 1970s and 1980s left the façade unrecognizable and much of the terracotta damaged beyond repair.

As the owners sought options to restore the façade to its original appearance, they consulted restoration specialists from local pre-caster (and Ductal® sublicensee), Szolyd Development Corporation. Szolyd's team recommended cladding the existing columns with Ductal® because it provided a strong, durable alternative to the difficult to find and costly terracotta tile. Because of its design flexibility and superior moldability, Ductal® was ideally suited to replicate the color, texture and form of the original tilework of the columns.

Szolyd's team meticulously fabricated custom moulds to replicate the original columns which included intricate details in the polyurethane liners to match the mortar lines and texture of the original glazed terracotta tiles. The moulds were used to cast one inch thick skins designed to cover existing concrete substructural columns. Structural engineers developed a mortar free installation method for the columns using hidden mechanical fasteners. These fasteners were cast into the columns and married to fasteners that were imbedded in the substructural columns.

Szolyd's solution for the columns addressed not only the façade's aesthetic requirements but also the owner's concern about long term maintenance costs and overall durability. The columns' color is integral, eliminating ongoing maintenance costs associated with coating.

Because of the hotel's downtown street-level location, the building is prone to graffiti and vandalism, therefore an anti-graffiti coating was applied so that spray paint and felt markers could be easily removed with an industrial cleaner.

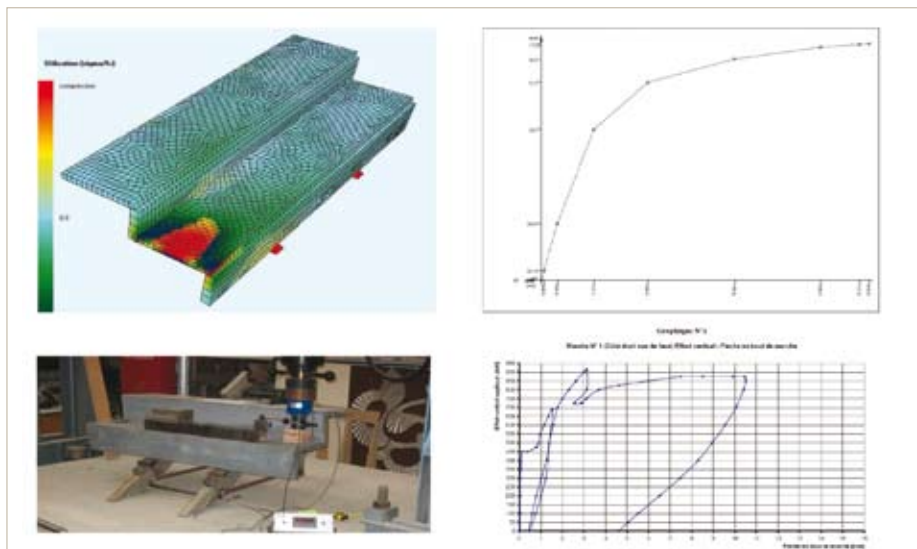
During the course of the renovation, several other restoration pieces were needed for completion of the façade construction. To meet these needs, Szolyd manufactured plinths and curbs for the base of the columns from a traditional concrete mix. These were cast from custom moulds to match the original granite skirting tiles for the building.

In 2008, Szolyd successfully completed the manufacture and installation of a series of unique Ductal® architectural precast cladding elements, garnering fast appreciation from the local residents who are more than pleased to see the evolving beautification and fitting restoration of this former run-down, historic landmark.

www.szolyd.com

Sofistik : How to master complex structures in Ductal®?

Sofistik is a digital calculation software that allows you to model the behaviour of complex structures. A powerful tool for architects and engineering departments wanting to initiate Ductal® structures that have not yet been utilized.



Punching test of a step
Comparing computer simulation and live testing

The core of its calculation program integrates powerful non-linear calculation algorithms, taking account of the intrinsic laws of material behaviour and the effects of large deformations. These features are particularly adapted to calculating Ductal® structures.

In fact, Ductal® design calculations, according to the French guidelines of SETRA* and AFGC*, require the use of a non-linear law of behaviour, that is elastoplastic in tensile state, both for Service Boundary Conditions and Final Boundary Conditions. Most of the Finite Element software on the market is based on non iterative linear elastic calculation. This type of calculation cannot be used to model the real effects of load redistribution by hyperstaticity. Yet, as its name implies, Ductal® has ductile behaviour, allowing graduated load redistribution more apparent in structures with a high degree of hyperstaticity.

Furthermore, the thin layers permitted by the material require large deformation testing to take account of instability phenomena, previously seen in metal construction. Sofistik lets you make this type of doubly non-linear, large deformation calculation. These large deformations, initially caused by mate-

rial non linearities, are themselves sources of geometrical non linearities leading to large displacements and unstable behaviour in the neighbourhood of the rupture. You can also calibrate calculation imperfections based on the preponderant buckling modes and run calculations for an imperfect structure to best simulate the manufacturing faults and tolerance. Aside from these possibilities for a fine assessment of the mode of rupture, Sofistik contains varied and integrated modules in the same platform, such as the module for calculating pre-stressed concrete structures developed with the firm VSL or "form finding" modules to calculate deformations of the 3rd order.

Based on all the above statements, a collaboration was set up between Sofistik, C&E Engineering and the Lafarge Ductal® team in order to develop a module designed for Ductal® in generalist Sofistik software. Over a period of two years, a series of test cases will be run to calibrate the module to a series of "standard" cases already performed.

Integrating a law of behaviour for Ductal® into the selection of materials will be the first step in this joint development phase. To provide the best possible support for structural engineers

ZOOM

The complete Ductal® kitchen

With a specialty in the production of decorative concrete elements, the Italian firm, Il Cantiere caused a sensation at the Milan Furniture Fair last April. Capitalizing on their expertise in countertops, Il Cantiere worked in collaboration with kitchen designer Comprex and Siemens, to produce an attractive, functional kitchen module that is entirely made of Ductal®.

"We started out with the idea of making the countertop and back of the kitchen module in Ductal®" explains Gigi Rossi, designer and co-founder of Il Cantiere. "But the technical characteristics and performances of the Ductal® product urged us on to pick up the unlikely challenge of building the whole kitchen in concrete, with doors that are lighter than Corian and even lacquered glass. Beyond this lightness, which has now been achieved, the resistance drew the attention of not only kitchen designers, but also architects and designers present at the fair."

An innovation to watch.

www.ilcantieresrl.it



in advanced calculations, training seminars will be regularly held by Lafarge with the Sofistik development teams. Whatever the engineering approach, the tool however will not substitute a fine understanding of the physical phenomena, which only experience and the sharing of knowledge can guarantee.

*SETRA = French authorities of civil engineering structure design and control

*AFGC = French association of civil engineering

www.sofistik.com



Fire objects by Ora-ïto and Climart: when design rhymes with environment

As a specialist in high-end fire objects that burn natural plant alcohol, Climart invites top designers to rethink the universe of fire. The famous designers – Philippe Starck, Somnuk Thao or Ora-ïto – have chosen the brand to display their creativity. No chimney, smokeless and dust-free, the creative possibilities of these fire objects inspire designers, especially as they can take advantage of materials like Ductal® to create veritable sculptures of light and fire. Like the creation of designer Ora-ïto, who produced a particularly refined and elegant outdoor series, using all the potential for ductility and finish offered by Ductal®. The partnership between Climart and the prototype engineering and pre-caster Cogitech, resulted in the design of a piece that is light and very high quality. “Specialized in develop-



ing and producing high-end pieces in limited series, we went on to imagine a shell in two parts made by compression molding and assembled with no visible joints,” explains Sylvain Quidant from Cogitech.

“The thickness of Ductal® was redefined to produce an object weighing barely 25 kg, integrating ceramic insulation to favour thermal conductivity.” A safety aspect that is important for Climart which is developing a range to meet all the required standards. The company was, moreover, one of the members behind the French Standards project Norme Française D 35-586: “Domestic appliances for intermittent use, burning an ethanol-based fuel”, and is part of the committee responsible for drafting this NF (French standard) project. As a precursor to a booming trend in decoration, Climart pays careful attention to the plant alcohol it distributes.

www.cheminees-bio.com

Taporo: the creative freedom of concrete...



In Paris, Philippe Tissot has created the Taporo Workshop; a unique design studio where he and other designers can work together to create and build innovative concrete furnishings. This Workshop has produced a wealth of original creations, essentially devoted to the many creative possibilities offered by Ductal®.

Meditation tables, futuristic libraries, decorative panels, outdoor tables combining concrete and steel... all created by the Workshop participants, are the fruit of its vocation to welcome artists and designers from different backgrounds to a permanent place for exchange and creation in the domain of concrete. “Modern concrete is actually a pleasant, silky material that is sufficient in its own right”, according to Tissot. “The undeniable advantage of ultra-high performance concretes is the gain in elasticity that is made possible due to their compo-

sition, as well as an amazing capacity to reproduce impressions.

The new performances offered by Ductal® allow the crafting of exceptionally fine furniture. The lines are fluid and light. Hand polishing the surfaces produces finishes ranging from mat to ultra-brilliant.” The success of this initiative also depends on Tissot’s own creations, on display in his gallery on the famous Boulevard Saint-Germain.

Specialised in furniture, the Workshop produces stunning pieces like a curvaceous desk with invisible jointing. Limited series or exclusive items such as coffee tables, dining tables, fireplaces, decorative wall panels or lamps, which share the elegance of the sublimated raw material, smooth or structured textures, capturing patterns that only the properties of Ductal® will allow.

www.taporo.com

Editorial team:

Jean-François Batoz - Laurence Jacques - Lisa Birnie - Anne-Sophie Fenart

Editor: Philippe Billon

Credits: Photothèque Lafarge

Design/production: Agence All Write 01 53 59 83 83

Printing: Imprimerie BM

Allo Lafarge : 0 820 385 385

www.ductal-lafarge.com

ZOOM

Ductal® lights up

Topos Environment, producers of furniture and design, is once again extending the creative scope of Ductal®.

Developed as part of its Senso range, the light table was a popular feature at the “Equip’Hôtel” (international exhibition for restaurants, hotels, bars etc.) held in Paris at the end of 2008.

A tabletop made with Ductal® in which Topos Environment placed a solar sensor, linked to an optical fiber and LEDs network. When night falls, the light table shines for around 5 hours (a 220 V or low voltage electrical system is also available for indoor use). Soft and smooth, resistant to stains, abuse and fire, weather resistant, solid yet manageable, extremely stable on outside floors, the light table gives free reign to the originality, imagination and sentiments of the user. This truly opens up a new area of innovation for indoor and outdoor furniture.

www.topos-environnement.com