interview

"Social and demographic changes... are creating a stimulating context for finding new solutions"

In preamble to our conference dedicated to architecture, "Building, construction and infrastructure: fast, economic and lasting solutions", which will take place on 13 March 2019 as part of the upcoming JEC World show, we approached Christelle Chalumeaux , Architect and Teacher-Researcher, who kindly answered our questions.
Christelle Chalumeaux, who is familiar with composite materials, is one of the conference partners.

interview

Christelle Chalumeaux,
architect, lecturer-researcher
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JEC Composites Magazine: You organized the seminar "Building with composites for architecture, what is the state of affairs today ?" that took place in November 2017 at the Ecole Nationale Supērieure d'Architecture in Nancy, France. Could you tell us more about your connection to composite materials?

Christelle Chalumeaux : I have a threefold link to composite materials. First of all, through my architectural practice: in collaboration with Luc Boulais from the "*Artificial Architecture*" agency, I experiment with different structural and morphological typologies and different qualities of function and space through various architectural designs built from composites.
At the same time, I have initiated architectural, historical and prospective research on the structural use of composites, in the inter-laboratory Lhac-Map-Crai platform at the Ecole Nationale Supérieure d'Architecture in Nancy (the platform links hard science and the humanities). The Navier Laboratory at the Ecole des Ponts Paris Tech is the partner for the environmental component.
This research is directly motivated by the issues raised during my architectural practice. The 2018-2022 "*Building with compos-*

House interior, Colombes, France, 2009.
Arch. C. Chalumeaux, Acme Industrie.
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ites for architecture" cycle that opened with the above-mentioned seminar is organized around these. And third, I am working to set up specific courses on composites at the Ecole Nationale Supérieure d'Architecture in Nancy.

There are very few courses on these materials in architectural schools. What brought you to composites?

C. C.: I studied during the 1990s and start teaching during the 2010s in France, Porto (Portugal) and Istanbul without running into composites – neither in history courses nor in construction courses. I did discover them while I was still a student in 1997, when my curiosity took me to my first JEC tradeshow.

It was fabulous to plunge into this industrial world there were foams with skins, ultra-lightweight gas bottles, wovens, peel plies, 3D meshes, filters, plane fragments, bicycles, etc., and people from every continent. I went from stand to stand and tried to understand this industry, the vocabulary, the processes a whole astonishing world that I'd never heard about in school or out. Then, later, when I was a young architect, Luc Boulais from Artificial Architecture took me to see one of his composite creations, the Chomel School footbridge in the 7th arrondissement in Paris.

In 2010, you were nominated in the "First Work" category of the Equerre d'Argent architectural award. Can you tell us something about this project and the role of composites in it?

C. C.: Above all, this experimental project was an adventure involving a manufacturer, an architect, an engineer, a developer, and a city around a small project. I was using composites for the first time, and they played a crucial role. The project involved the extension and renovation of a villa in a heavily urban area in France. The City of Colombes authorized the extension under a "floor area ratio" bonus given for energy performance achieved. There were many constraints during the operation. The owner requested that the construction and renovation be completed within seven months on a tight budget, and that the most living space possible be created, with an energy consumption target of under 40kWh/m^2/year. The requirements for the bonus included walls with a thermal resistance of 5m^{2}K/W. At the time, creating a maximum living space and achieving high thermal performance were almost mutually exclusive, because urban regulations at the time established a method of computing the surface area that calculated the floor surface taken up by the thickness of the envelope, structure and insulation included. There were heavy constraints linked to the site as well: very limited constructible area (a 1.9 x 9 metre strip), very low weight-bearing capacity of the floor, and the site was listed in the flood risk management plan. In addition, the owners/future inhabitants wanted to live in a fluid architectural space on three levels where each could cohabit and work, feeling the presence of the other without being in the same area. Various building solutions were considered at the drawing stage – wood frame, cross-laminated timber (CLT) panels, shuttered reinforced concrete, monomur bricks. I discovered the Chomel footbridge then, and so composites entered into the preliminary design studies and the numerical modelling, and in a hands-on way for everyone involved, in the form of samples, prototypes, printed and life-sized mockups, with visits to the footbridge, which was an hour away from the site. You see, for this "new" material, it was also necessary to "provoke" a physical connection – in the phenomenological sense – and to emphasize the footbridge's own semiotics and symbolism. We worked specifically with the future inhabitants on the basics of these materials, since the notions of a 5-cm-thick translucent structural wall, or of a translucent slab without a structural projection, or of the particular resonance and touch of the material, do not enter into the standard architectural vocabulary. We also had to rapidly find a manufacturer willing to change application areas to work on a small, unique project and to leave the shop to install on site and rub shoulders with a traditional business. Acme Industrie, a company under the direction of Thomas Brant that was located in the same area, accepted the challenge to work outside of its comfort zone. The design and engineering office was incorporated into the company, and Luc Boulais came in as a consultant. The project developed as the possibilities offered by the manufacturer's skills and tooling were weighed and matched to the customer's specifications. The choice leaned towards an all-composite construction, entirely prefabricated in the shop. At the site, the urban electric cables made any crane operation impossible, and neither the schedule nor the budget would allow installing them underground (private road). This led us to a semi-prefabricated solution to minimize any on-site work. The use of polypropylene honeycomb sandwich panels laminated on both sides with glass-fibre-reinforced polyester resin (without skins) for the walls, slabs, stairs and railings resulted in a structural translucence, eliminating the need for artificial lighting. It also fulfilled the inhabitants' desire for shared, yet independent living by "filtering" the presence of the oth-

Pink House, Colombes, France, 2009.
Arch. C. Chalumeaux, Acme Industrie.

Feature Construction

er, and of course it drastically reduced the structural bulk by 70% to create the most living space possible. Other advantages: the complete absence of thermal bridges, optimized cost and lead times, less need for interaction between the different trades, lower deferred costs, easily handled components, etc.
The solution also enabled us to respect deadlines and build at only 60% of the cost of a wood construction, while creating a quality space. The extension weighs only 15% of the weight of a standard building of the same size and it saves about 80% on materials, compensating for much of the embodied energy required to make all of these materials.
Highly constrained by the operational and production conditions, this project utilized only a few of the possibilities offered by composites when they are used for structural purposes, but it introduced more composite materials into everyday life. With Luc Boulais (Artificial Architecture), we are developing various structural typologies, programmes and scales: theatre, habitat, school, daycare centres, furniture; and use in urban densification, suspended floor construction, grafts, extensions. One specific line of research concerns summer heat transfer technology, in which we develop a situational approach, meshing/modelling the building layout, the typology, and some elementary systems to exploit the low inertia of composites. We are seeking to develop projects that use composites as tailor-made materials, and not by optimizing marginally. This approach, which is also championed by Jean-François Caron (Laboratoire Navier, Enpc), who makes use of the flexibility of composites, forces us to think in another language that is specific to composites. It also enables a "typological" opening of the construction and of the architectural space that involves physical perceptions and a symbolic and cultural dimension.

Do you think that composites could be used more in the building/civil engineering sector?

C. C.: Yes, composites now are well positioned alongside other materials. It would certainly be worthwhile for project owners, contractors and architects to learn more about them and their strong potential. There are many applications in finishing and structural-reinforcement work. As JEC's 2017 book The Future of Building clearly shows, many finished/semi-finished products (especially pultruded) and construction systems exist and are being developed. The joinery sector also has potential. In France, for example, the low thermal conductivity required for doorframes by the new thermal regulation (the RT 2020) will make composites almost indispensable. And let's not forget the low-maintenance advantage associated with these materials. These days, a number of architectural constructions are benefitting from recent R&D in civil engineering. Due to their specific mechanical, thermal and air-/watertight properties, their low weight and their low maintenance cost, composites are high performing and competitive as materials for architectural production purposes. Furthermore, there are new prospects for structural composite applications in architecture, thanks to things like current research results on composites (recyclability, advances in thermoplastic research, environmental assessment), the advances made in forming and manufacturing processes, improvements in design, characterization and NDT (non-destructive testing) tools, and the development of metacomposites. Composites have definite advantages for structural applications. As seen above, they work well in dense, constrained urban environments due to their

Composites House Hormazabal, Noisy-le-Sec, France, 2013.
Arch. Artificial Architecture, C. Chalumeaux, Acme Industrie.

low weight (low impact on foundations, easier handling and crane operations), low structural bulk, speed of implementation (greatly reducing cost), and functional integration (reducing need for interaction between trades). Job-shop production also provides optimum inspection conditions and minimizes on-site assembly operations. Finally, and especially, the technological breakthroughs in robotics and digital manufacturing have made it possible to produce non-standard objects in series, which is particularly adapted to architecture. And in a way, architecture produces "unique prototypes" on an ongoing basis for each operation. The series production of different articles provides an economy of scale, but not of design. However, design can still be optimized via optimum project management, using building information modelling (BIM), for example. The paradigm change linked to this breakthrough has made it possible to look at productivity differently. Robotics has made it possible to break free of the constraints of tooling and mould investment costs, of the logics of scale as described by architect Arthur Quarmby during the 1970s.
Social and demographic changes, urban densification, energy transition issues and environmental performance are creating a stimulating context for finding new solutions. This area of activity is potentially very competitive if it is called upon to help architects develop structural solutions that favour the quality of use and the durability of buildings.

What are the main obstacles to the large-scale use of the composites you identify?

C. C.: For the most part, architecture involves a project that is "situated", and each building is a unique prototype. There is very little series work. With the changing population, you can't say that there is a very low volume, but on the other hand, there is not much reproducibility. Digital manufacturing that is free of moulds and tooling investment is a major advantage that will bring composites into the building industry. Structurally speaking, those involved in construction are scattered and very diverse. There is a full range of regulations and standards that varies from one operation to another, depending on the programme and the location. Circomstantially, contractors and developers lack detailed knowledge about these materials, and there can be confusion about the meaning of terms. All this can be solved through information, e.g. that distributed by JEC and by the unions. There is also a lack of dedicated training and educational courses on composite materials, processes, and jobs, and of dedicated Construction journals like there were in the 1950-70s. In France, Nancy is in a good position to develop courses that include the history and building practices for composites, besides other materials. I don't know of any other schools. There was Marseille during the 1970s, and then Grenoble, where Luc Boulais opened up a Composites curriculum in 2004, which was replaced in 2010 by one on wood. In Nantes, there is the Naval Architecture programme.

From composites side, structurally speaking, a composite is not a material, but a concept that is 3,000 years old. There are various semi-finished or finished products, and there are a lot of potential composites and processes. All this complicates things, but also constitutes the power of these tailor-made materials. As a designer, you have to think two ways: delving down into the substance to decide which matrix and reinforcement to use to produce one's material, and at the same time thinking forward to choose the forming process. It would be a shame if standardization limited choice, as it did in the past for concrete (also a composite, with a ceramic matrix) and the associated processes – although fortunately, that is changing today. Concerning the circomstantial brakes, there is progress on fire and smoke behaviour issues. The value chain for architecture is not in place yet, due to social and economic obstacles. The absence of a business/scientific network that is organized for architectural production using composites is an obstacle to the diffusion of knowledge and to the development of new practices. And practically speaking, it is difficult for an architect these days to estimate the cost and lead times for a composite project; it is difficult to designate the producers and installers in advance. Engineering firms are more rare, and you sometimes have to use a broker for the insurance. It is a real obstacle course.

However, architecture is lucky enough to benefit from advances made in other fields – civil engineering, and aerospace. Manufacturers, including those in the energy field, were very present in the history of the some 270 architectural achievements by the architects and engineers who pioneered in composites from the 1940s to the 1980s. Manufacturer, architect and engineer formed a trio that was crucial for the success of these experiments. We might mention, for example, Matti Surronen and Oyl Polykem in Finland; Komatsu Plastic Industry in Japan; Arthur Quamby and the railway company in England; and in France, Ionel Schein and the coal-mining enterprises Charbonnages de France and Houillères du Nord, Jena Benjamin Maneval and the Société Nouvelle des Pétroles d'Aquitaine (today Elf Aquitaine), and Jean Prouvé with Saint Gobain in 1965, then with Matra's Division Industrie Plastique. It is essential to find common ground again that unites architects, researchers and manufacturers. And we can't neglect the response from the public and users, either – users are the main ones concerned, but are often forgotten.

You are a teacher and a researcher. What must be done to make the students aware of all the potential of composites?

C. C.: To do that, it seems essential to me to avoid what is often done with other materials, i.e. considering them merely as future specifiers who sell semi-finished or finished products to replace other materials because they are stronger, more durable, lighter and cheaper, or because they come in ready-made building systems. With composites, there is the extraordinary challenge of completely reinventing the design and being able to use the strict minimum of a tailor-made material. Designing with composites means thinking in another language. This has been very stimulating for the students I've already been able to work with in Nancy. They are very focused on material savings, on the quality of the space constructed, and on the social and environmental ecology involved. The architectural students of today are comfortable with and interested in both craftsmanship and digital construction; they are also at ease with complex shapes, manual, numerical and BIM methods, and are interested in robotics. This is all very compatible with composite construction, which makes it possible to build in true 3D. I feel that we must give priority to a theoretical and practical teaching that provides hands-on exploration of the materials, processes and creations, and which includes a historical yet also forward-looking dimension. It seems very important that the students get a taste of the industrial world and all the composite-related jobs from raw materials to processing, and that they be aware of the industrial challenges. These jobs have their origin in fields other than building & construction – like shipbuilding, aerospace and automotive. Both sides need to assimilate new ideas. This is what we are trying to do at the Nancy School of Architecture, where its director, Lorenzo Diez, has created a competitive cluster for regional architecture to develop, organize and accelerate the synergies between training courses, research and businesses. Architectural and town-planning research, along with agile, innovative, project-oriented teaching, takes place in close cooperation with the communities and the socio-economic environment. To raise student awareness of all the possibilities offered by composites, an industrial-research-teaching partnership seems to me to be a must. □

More information :
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