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# L'ORANGERIE – A new generation of earth building in Lyon

01 Outer shell of L'Orangerie in context (© F. Fouillet)

As part of the second phase of Lyon's new "La Confluence" neighbourhood in the inner city, a novel loadbearing rammed earth structure is being built in the heart of an urban block. Enclosed by tall rounded arches made of exposed rammed earth, it is due for completion in late 2020. The architecture of the new building, which will contain offices, breaks with the convention of solid walls perforated by windows and represents a contemporary revival of the rich tradition of rammed earth construction in the Rhône-Alpes region of France.

**The history**

Our intention with the building was to demonstrate and inspire: to carry forward the history of earth building in the Lyon region and to inspire other architects and builders to pick up the thread and spin it forward – a challenging task if ever there was one!

We also wanted to show that earth building belongs back in the city centre, as was once the case in Lyon. Today, the River Rhône has been contained and the flooding that destroyed many earth buildings in Lyon in the 19th century is no longer a problem. Most of Lyon's earth buildings fell victim to the great flood of 1856 and the ensuing demolition of much of the lower-lying quarters.

Earth buildings can still be found today in the higher parts of the city, in the Croix-Rousse or Saint-Just quarters, or a little further away from the city centre in Vaise or Tassin, although the earthen structure is almost always concealed beneath rendered facades. In the surrounding regions to the east and northeast of Lyon, however, earth buildings can be found everywhere, and entire villages of the Dauphiné region are made of rammed earth with impressive overhanging roofs.

02 The "La Confluence" quarter in Lyon (© CVA)

We wanted to bring earth construction back from its rural niche and showcase its use in a new urban quarter where high-rise residential blocks, mostly made of concrete, rise some 50 metres into the sky.

Resource-efficient construction is all too often just a declaration of intent, but not here. At Clément Vergély Architectes, we would not class ourselves as eco-pirates, but we are enthusiastic about solid construction, clear floor plans, enduring structures, good detailing and exposed materials, as well as about buildings that are typical for their location and that pick up local characteristics.

**The competition**

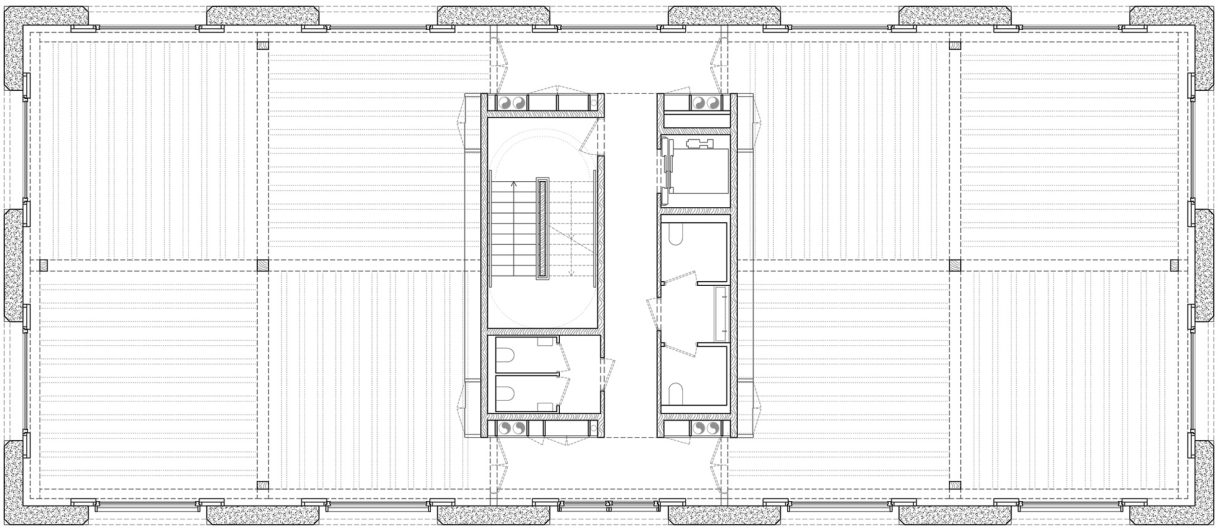
"L'ORANGERIE" is part of the Îlot B2 development in the new Confluence 2 district being built on the former alluvial land between the Rhône and the Saône rivers. Herzog & de Meuron's master plan for the new neighbourhood at the confluence of the two rivers proposed a typology of three-storey buildings for each block – on the one hand a carry-over from the scale of the "Marché gare", the former wholesale market in Lyon, and on the other an invitation to experiment and realise unusual and surprising solutions at a smaller scale.

The site comprises a total of five buildings, the result of a competition winning entry submitted together with Diener & Diener Architekten from Basel.

The "Orangerie" stands on the south side of a courtyard and garden designed by Michel Desvigne landscape architects and is, so to speak, the garden house of the block. Its height of just under 11 metres allows sunlight to shine directly into the courtyard with its lush vegetation.

When we initially proposed constructing a loadbearing earth building clearly set apart from its neighbours,

03 Aerial rendering of the Îlot B2-Ydeal Confluence site (© CVA)



04 Floor plan, 2nd floor (© CVA)

we weren't entirely sure what we were letting ourselves in for. In hindsight, however, our comparative naivety was also an asset: without it we would never have progressed so far. Since then, our enthusiasm for this building material has grown steadily, although the process has at times been somewhat sobering.

The typology of the "Orangerie" with its bright, sunlit working platforms and tall rounded arches draws inspiration from the orangery in the "Le Parc de la Tête d'Or", Lyon's largest and most beautiful park. As the mayor often has the last word in competitions in France, a sprinkling of local patriotism can work wonders.

Last but not least, we were able to draw on the knowledge and expertise (research, teaching, product development and earth building craftsmanship) already available in the Lyon region and to test them under real market conditions.

Finally, without the conviction of the private property developer OGIC, the orangery would not have been built. While funding was still tightly monitored, the construction costs of approx. 2100 € per $m^2$ of usable space (approx. 1000 $m^2$) are in the upper average range. The earth construction itself cost approx. 570,000 € (before VAT).

**The plan**

The building has a rectangular ground plan of 14 × 32 m comprised of two wings either side of a central access and service core. The floor plan is kept deliberately simple, with the complexity arising in the elevation and section:

- Staggered wall thicknesses: 80 cm on the ground floor, 65 cm on the first floor and 50 cm on the second floor. The blocks are flush on the outside so that each floor level extends out 15 cm further. The wall is therefore tapered, reducing its weight and structural load accordingly.
- Wide curved arches: the arched openings are 4.75 m wide at their base and follow the line of an inverted catenary line as an ideal structural form, concluding with an arched lintel at their apex.

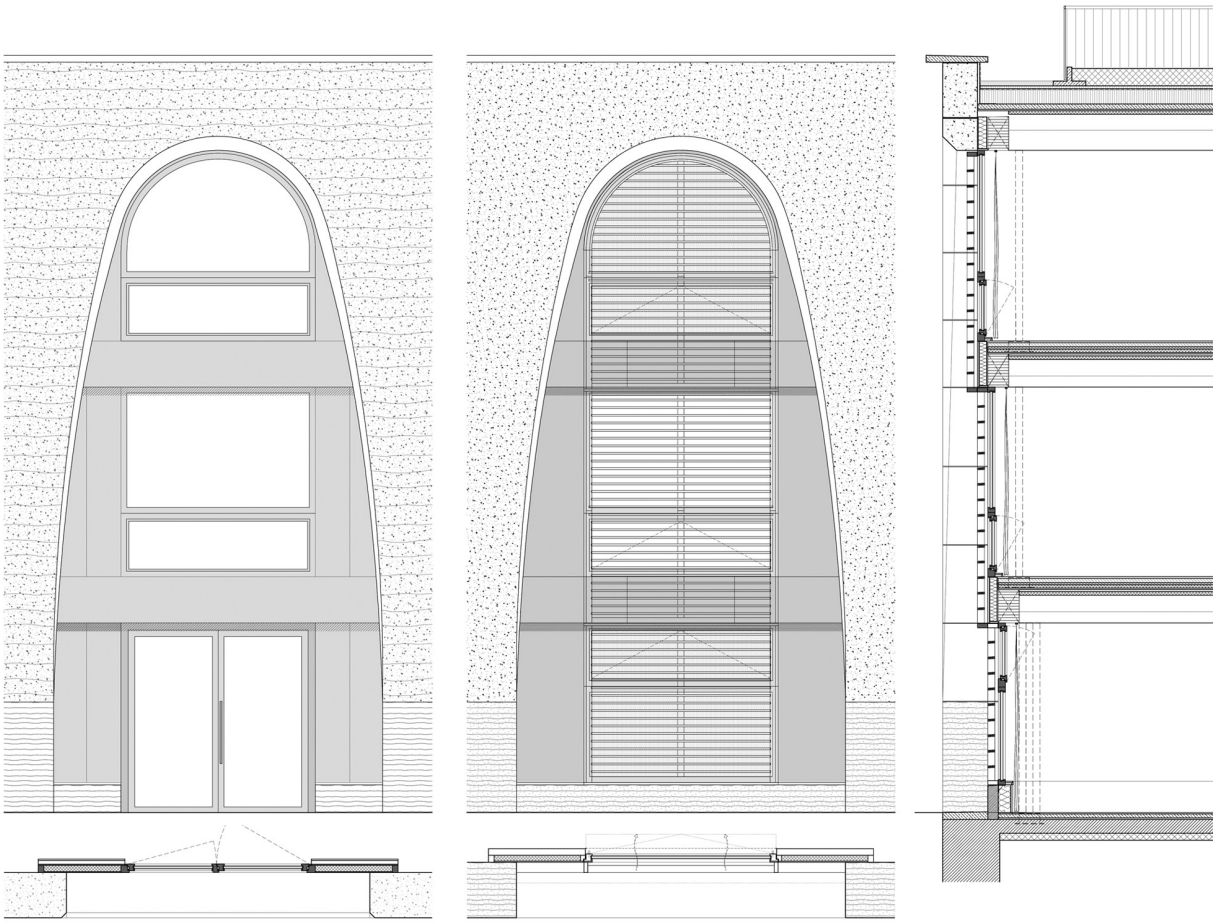
The building design presented an opportunity to test two hypotheses:

- Modern prefabricated earth construction and ambitious design solutions are not mutually exclusive and indeed condition one another
- Loadbearing non-stabilised/additive-free rammed earth can be used for walls with significant openings

The arched openings account for 40% of the wall's surface area, putting the material's structural properties to the test. Rammed earth structures can only sustain compressive forces, which is the case here. Horizontal forces are absorbed by the rigid stair core which is connected to the earth walls via the ceiling slabs.

**The construction**

The walls with their 14 uniform rounded arches – 5 on each long side, 2 on each short side – were



05 Elevation and section of the facade (© CVA)

constructed floor by floor with the timber structure erected within it shortly after.

The building design was conceived from the outset as a resource-efficient timber and earth structure, echoing its historical predecessors: earth serves as an external loadbearing shell, while wood is used for the ceilings and internal loadbearing elements. The timber beam ceiling rests directly on metal anchor plates embedded in the earth blocks that transfer the loads evenly. This also illustrates the principle of a pragmatic rather than historical-nostalgic approach to realising an efficient and compact solution for the connecting element.

**The material**

To meet the ecological principles of the "WWF sustainable city" initiative which the "La Confluence" urban district should conform to, and to minimise the carbon footprint, the material needed to be procured – as far as possible – from the surrounding area.

The plinth and the wall crown are of natural stone (Pierre de Hauteville bicolore) sourced from a quarry some 80 km away. The flat roof is greened and can be used by the building's occupants as an additional rooftop garden.

The massive stone blocks of the plinth have the same format as the earth blocks, which can be seen in the pattern of joints. The stone slabs around the eaves at the crown of the walls have an interlocking edge profile for optimum protection against moisture ingress.

The solid timber structural elements (Binderholz system) are factory produced and originate from France (Vosges) and Austria.

The earth from the site was, unfortunately, unsuitable for using for the rammed earth walls. It consisted primarily of backfilled material from the 19th century wholesale market that occupied much of the La Confluence site and was partially polluted.

06 Three materials: wood, stone and rammed earth (© F. Fouillet)

07 Pierre de Hauteville quarry (© CVA)

08 Scale model of the prefabrication principle (© M. Valcarce)

Instead, 380 tons of so-called "red earth" was sourced from a construction site just 30 km away in Saint-Quentin-Fallavier. As excavation material, it was available for free and only the transport costs needed to be paid.

The characteristics of the raw material was tested by the material testing specialist Antonin Fabbri at the public institute ENTPE L'école de l'aménagement durable des territoires (College for sustainable spatial planning).

To begin with, three to four earth samples from different locations were tested and assessed for their potential: Sieve analysis, density, moisture absorption, cracking, compressive strength, colour and above all the volume of material available – everything had to be right.

The work could then begin: the chosen construction method of prefabricating on site made it possible to precisely monitor the necessary drying periods of the specific loadbearing components. The controlled drying process also made it possible to anticipate the material-specific, but negligible shrinkage. In addition, sufficient space was also available to store the prefabricated elements prior to installation over a period of two years.

During the planning and detailing phase, the facade was divided into 286 individual blocks, which were constructed using standardised metal formwork and are of a transportable size. The construction principle bears similarities to that of earth brick production, which is currently also experiencing a renaissance.

An advantage of this method was the ability to meticulously control the quality and optimise the homogeneity of the prefabricated rammed earth blocks, including determining the moisture level of the earth mix and recording the geometry of each individual block. The fabrication of the rammed earth blocks took place on site from April to the end of October when the climatic conditions were most favourable.

09 Storage and drying of the earth blocks (© M. Valcarce)

To join the blocks, an earth mortar was used: here too, it was important to avoid the use of inappropriate materials. Additional weathering retarders, like those often seen in historical buildings, were not inserted. Instead of including lime or stone chippings, the edges were simply progressively chamfered. This lends the edges of the building and of the arches a specific delineation that anticipates their future weathering and maintains the overall monolithic impression of the structure.

**The earth builder: Nicolas Meunier**

We were fortunate to have a pre-eminent French earth builder in our team and on our side, not to mention the only "extremist". Nicolas Meunier rams the earth "as found" without any additives. The most he does is to sieve out stones that are too large.

He learned his craft in Africa in Mali and Morocco and his first earth building was realised in 1988. In 1995, he realised a three-storey residential building not far from Saint Etienne that is still in active use today. Over the past two decades, he has continually perfected his mobile semi-automatic atelier: At the end of a conveyer belt, four suspended weights of 20 kg each are lifted by compressed air and allowed to fall freely, always with the same intensity, onto the earth mix, which is periodically filled into the form in layers. This apparatus also has a social and humane component: the labour-intensive work of filling and compaction that was originally undertaken by hand is now performed by the machine, relieving the employees of the toil of manual labour and in turn protecting their health.

The storage and natural drying of the earth blocks was undertaken on an area adjacent to the construction site. Lightweight mobile construction cranes allow the blocks, which weigh up to 4 tonnes, to be set down easily and precisely down to the millimetre.

The structural engineering office BATISERF (Philippe Clément + Thibault Vialetton), the Institute ENTPE (Antonin Fabbri) as well as the University of Coventry (Jean-Claude Morel) proved to be indispensable partners and were a driving force for the project.

**The climate**

To make optimum use of the indoor climate regulating properties of earth building materials, especially during the increasingly extreme periods of intense heat in summer in France, we were able to dispense entirely with thermal insulation in the earth wall without violating the French thermal protection regulations (RT 2012).

Consequently, the rammed earth walls are exposed on the inside and outside so that they can act as a climate regulator for the room. Openable air vents provide natural ventilation and serve at night along with simple ceiling fans as a means of cooling. As a result, air conditioning is not needed. Room heating in winter is provided by underfloor heating coils.

The materials have been left exposed and unfinished and all technical installations have been kept as simple as possible.

Permanent brise-soleil elements to protect against overheating have only been installed on the south side, which is most exposed to the sun. Most of the other facades are shaded by the surrounding buildings, and in these cases internal curtains with a special coating are sufficient.

**The building standard**

Earth building is still classified as a "non-traditional" (i.e. unconventional) construction method in France, although it could hardly be more emblematic of traditional building methods in France.

Despite the high quality of production and craftsmanship now prevalent in earth building, the lack of a building standard means that in the eyes of the law, each building is an "experimental" building that requires case-by-case building approval (ATEx type b – Appréciation Technique d'Expérimentation, CSTB). Normally, this is required only for high-tech constructions in order to obtain the requisite building insurance.

Back to the future then: whether due to ignorance, inexperience or, as some maintain, the strong concrete lobby, we were unable to convince the expert commission of the viability of our solution, despite backing up our arguments with a 750-page document by the ATEx (a work that in its size and quality would rival a doctoral thesis). Consequently, the commission stipulated an absurdly high safety coefficient of over 3.5.

Here we can see the scepticism with which this traditional but promising material is still seen. What followed was a period of almost two years of arduous negotiations with the national inspection engineers who, although highly regarded, are it seems out of their depth in this case. If earth building is to be more than mere decoration, considerable persistence and persuasion is required. Public commissioning bodies could step into the breach here and demonstrate greater courage in future.

At the end of the day, our building has been built and the walls stand freely under load. We have, however, been instructed to insert additional non-loadbearing emergency supports. Their purpose, one suspects, is more to appease the authorities.

10 Prototype of the arch chamfer (© M. Valcarce)

11 Setting the first blocks (© M. Valcarce)

In contrast to industrially standardised products such as bricks, the assumption is that each earth block implies a risk that is hard to quantify. In our case, the opposite is true: rigorous monitoring and a consistent, dependable production process have resulted in a product of optimum uniformity and consistency. Monitoring the weight and humidity of each block and visual inspection during production serve as an additional means of quality assurance. Test specimens from different batches were also sent for laboratory testing to ensure blocks of insufficient quality were returned and not used for construction.

Finally, trust is also important: trust in the professionalism and expertise of our team, and trust in the decades of experience of our earth builder. This is a person who can anticipate laboratory testing results by testing the raw material earth with his bare hands; a person who, with his team, places the earth blocks along the entire length of the building with only 3 mm deviation; a person who in his "spare time" organises some 30 guided tours for 700 interested visitors and teaches children to tamp clay.

As such, our hope remains that this project will inspire others to build with earth.

**Project participants**

Property developer and client: Ogic Lyon Rhône-Alpes
Architects: Clément Vergély Architectes + Diener & Diener Architekten
Landscape architects: Michel Desvigne Paysagiste
Rammed earth construction: Le Pisé (Nicolas Meunier)
Structural engineer: BET BATISERF with Jean-Claude Morel (University of Coventry) & Antonin Fabbri (ENTPE)

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12 Completed rounded arches (© F. Fouillet)