Case Studies

Crystal and cloud shapes in steel and glass

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Musee de Confluences in Lyon,
a New Science Center and Urban meeting point
Wolf D. Prix Coop Himmelb(l)au

A new Science Centre with an urban recreation area has been developed on the confluence of the Rhone and Saone in Lyon. According to its mixed use the spectaculous Musée des Confluences combines two contrary building shapes: a crystal and a cloud. These free shapes and the resulting structural and building physical queries have placed extreme demands on the Josef Gartner GmbH steel construction and glass façade.

The entrance area in form of a crystal consists for example of 32 differently inclined part areas and of the "Puit de Gravité". This 36 metre high funnel of steel and glass has been manufactured partly from spherically bent glass panes. Sub-segments of the primary and the secondary steel stucture were connected by means of screws included in the profiles. The partly highly bent spherical glass units are horizontally supported only via the structural glazing. In order to realise some of the free geometric shapes they had to be optimised with a three-dimensional computer model in

cooperation with the architect of the façade manufacturer. For this reason more than 160 nodes, where the individual steel trusses of the funnel meet, had to be designed individually. In order to avoid gaping joints with steel profiles Gartner had to develop new connection and installation techniques.

Musée des Confluences shall create flows of new knowledge

The Musée des Confluence shall combine mixed uses but also different fields of knowledge like technology, biology and ethics. Social future-questions should be dealt with in permanent and temporary exhibitions. Above and beyond the presentation in a museum context visitors should be inspired to find new relationships using our contemporary knowledge. The museum was built on a headland where also an urban recreation area is to be developed. The rivers Rhone and Saone come together at this place and form a sharp angle. An urban highway separates the region of the old harbour in Lyon where an inner-city office and residential area is being developed at present.

The 2001 competition for the new Museum constructed by the Departement du Rhone was won by Viennese architects Coop Himmelb(l) au. The floor plan of the design by Wolf D. Prix is based on an elongated triangle which reflects the special shape of the headland. The museum constructed on 20,974 square metres of land was built on stilts and is virtually rising up from the peninsula. The building which is 190 metres long, 90 metres wide and up to 41 metres high connects in a complex way two building parts: the natural light-flooded crystal as entrance hall on the city side and the adjoining cloud. The transparent entrance hall and the closed cloud stand on a common plinth facing each other like the open present and the hidden future.

The museum which is scheduled to open in November 2014 has a useful floor space of 29,700 square metres and a gross floor area of 46,476 square metres. Its architecture mirrors aspects like penetration and variability which are characteristic for the concept of the museum. Visitors can move between closed and open exhibition areas like in a meandering course of a river. Passing numerous passages, ramps and plains they are able to gain flows of new knowledge.

Realising Free-Form Geometries

The architectural design of Coop Himmelb(l) au has confronted Gartner with considerable problems at first. A complex structural system was required due to the extremely soft overall structure of the building. The free-form roof geometry and the 36 metre high funnel in the entrance lobby descending diagonally downwards into the building were rather challenging. The steel construction called for strong curvatures and extremely tight radii. During the development phase Gartner therefore suggested to adjust the roof shape in some places and to avoid extreme curves, however, without changing the design concept.

Gartner has specially optimised the node points of the steel construction for the funnel in cooperation with the architects. The architects and Gartner experts have designed each of the 160 tricky node points individually on a three-dimensional computer model. Always six steel trusses made of rectangular hollow sections meet in the nodes. Direction and gridline of the splice plates had to be established on the computer for each node in order to enable the cutting of the hollow sections and to give the nodes a more elegant design.

Crystal with 32 inclined sub-areas and a 36 metre high glass funnel

The steel construction of the entrance lobby with its 32 differently inclined sub-areas was manufactured of around 650 tons of steel. Both primary and secondary steel structure are characterised by concealed screw joints with head plates. A panel-to-panel connection as usually used would have resulted in gaping joints due to the complex geometry. Gartner has therefore developed an elegant new solution. The screws are now inserted in the steel tube. The head plate was recessed by a few milimeters and welded into the tube. The steel components are firmly connected only via the pipe wall which also transfers the high pressure. A strictly controlled pretensioning sequence of maximum eight screws ensures a homogeneous stress distribution in the cross section of the pipe at the butt joint. If the pipe walls are subsequently overpainted the joints are no longer visible on the completed building structure.

As screw connections like these were not common to date and had been realised for the first time in France with the Musée des Confluences, several independent institutes had to be involved and also the European Committee for Standardisation. In the meantime this kind of technique has been mentioned in a commentary on EN 1090, which is the currently valid European standard for the execution of steel structures.

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Newly developed flush ventilation windows and natural smoke and heat exhaust ventilators (type NRWG)
For the first time also flush ventilation windows and natural smoke and heat exhaust ventilators (type NRWG) were developed. Over 200 flush ventilation windows with sizes of 2.6 x 1.5 metres were manufactured by Josef Gartner in Gundelfingen, Bavaria and tested regarding permanent functionality, air and water tightness. In addition all fire protection tests were carried out which were necessary to achieve the European approval as NRWG-ventilators. These were manufactured in eleven different geometries from the parallelogram to the triangle.

The primary and secondary steel structure has a total glass area of 3,500 square metres and consists of double laminated safety glass with 1.52 mm PVB interlayer. Depending on size and wind load the thickness of the individual heat strengthened (TVG) glass panes varies between 8, 10 and 12 mm. The double curved glass in the cone consist of 2 x 8 mm float with 1.52 mm PVB interlayer and adhesive SG profiles for fixing to the steelwork by others. An intermediate cover made of heated glass ensures the quick defrosting of snow accumulated within the funnel. The heated glass consists of 15 + 6 + 19 + 19 mm toughened glass and a 1.52 mm PVB interlayer. The heating coating with a total of six different heating circuits is applied on the 6 mm thick glass pane.

Spherically curved glass with a radius of only 500 mm
Spherically curved glass panes had to be manufactured for the crystal with curves approaching the limits of what is technically feasible. Each pane is bent in two axes. The four lower funnel panes in the crystal had to be manufactured with radii below 500 mm which is a curving similar to a cockpit window of a jet plane. For this purpose the extra-large panes with an edge length of up to 4.5 metres had to be manufactured, formed and hot bent multiple times. Only then the edges could be ground and cut to their exact dimensions so that they fit with milimetre precision.

The spherically curved glass panes in the lower area of the funnel are only held in position horizontally by means of silicone adhesive (structural glazing). These panes have to withstand wind loads of up to 0.6 kN/m^2 in the entrance lobby.

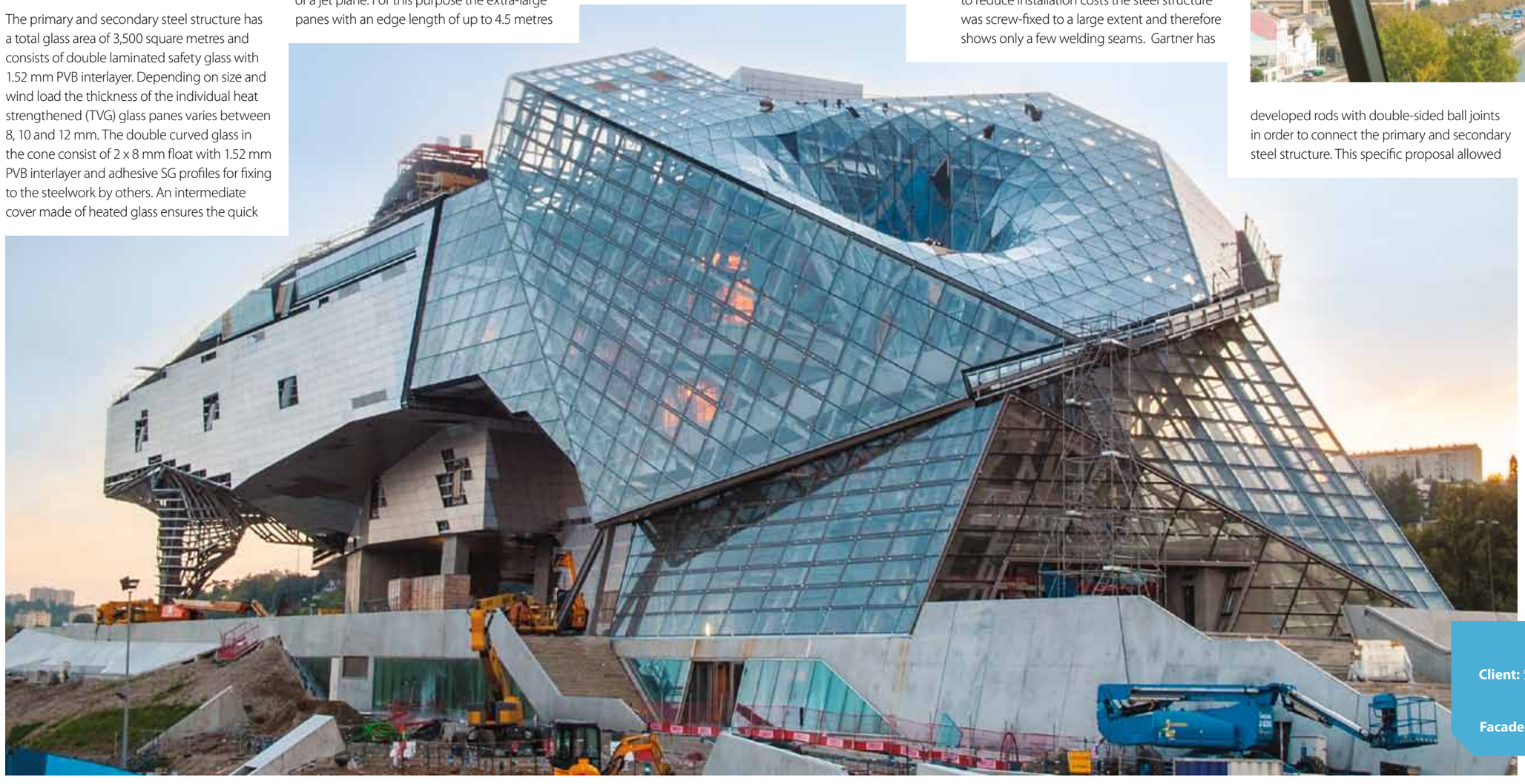
A cloud made of stainless steel and argon filled panes
Eleven sub-areas of the stainless steel-clad cloud are glazed and provide natural daylight in the museum rooms. Also these glass areas had to fulfill special acoustic requirements all panes were made of laminated glass with argon filling and a Stopray Clearvision coating.

Brasserie, boutique and the „Salle de Reception" are situated below and on the cloud. The three glazed lounges consist of a steel-glass construction with an area of 1,000 square metres and partly highly inclined sub-areas. All double glazed units are provided with argon filling and a Planibel Energy coating.

Installation with ball joints and preassembly in the factory
In order to accelerate the installation on site and to reduce installation costs the steel structure was screw-fixed to a large extent and therefore shows only a few welding seams. Gartner has developed rods with double-sided ball joints in order to connect the primary and secondary steel structure. This specific proposal allowed that installation tolerances could be adjusted in all directions. Without this solution, which was not included in the tender, the complex construction would not have been feasible.

The complete structure of the crystal including the 36 metre high funnel in the entrance area has already been preassembled in the factory. This means that there were no steel connections that had not been tested and assembled in the factory prior to delivery to the building site in Lyon. This ensured that the connection fits and the installation on site could be carried out more quickly. Permasteelisa France, a company of the Permasteelisa-Group which is the parent company of Gartner, was responsible for the installation on site. Permasteelisa France has also been acting as the main contractor for Musée des Confluences.

Numerous special transports were necessary for the transportation to site as the largest steel units were up to 4.5 metres wide and 20 metres long. The preassembled glass units were stored temporarily in a warehouse in Lyon and then collected sectionwise for the installation on site.



Owner: Département du Rhône
Client: SERL, Société d'Equipment du Rhône et de Lyon
Project Architect: Coop Himmelb(l)au, Wien
Main Contractor: Vinci Construction France
Facade: Josef Gartner GmbH, Gundelfingen / Germany