

Glass facade of Elbphilharmonie Hamburg

Glass tuning forks and
curved glass panes



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The Elbphilharmonie already draws scores of visitors to the construction site of the new Hamburg landmark. Its trademark is the glass façade with dynamic curved panes and the loggias in the form of tuning forks made of glass fibre reinforced polymer and glass. By the beginning of 2011, 850 of the approx. 1.100 façade units have already been installed to the 110 meter high building in the Hamburg harbour. Each of the glass units, up to 5 meters high with special printing and coating applications, is unique to this project. Some of the units are curved both inwardly and outwardly. The 21.500 square meter glass façade reflects the sky and the water thereby creating singular images and effects.



Swiss architects Herzog & de Meuron placed extreme technical challenges on the façade. For instance, multifunctional double glazing curved along only one edge did not exist prior to this construction. Never before have glass panes been successively printed, coated and precisely curved at 600 degree celsius. Josef Gartner GmbH, together with internal and external experts, industry partners as well as universities, developed new processes and products which push the limits of current technical feasibility. At the factory in Gundelfingen the new facades were subjected to extensive testing, for example climate, thermal, tightness and performance testing. Logistically, Gartner also adopted a totally new approach. The individual façade elements are marked with an RFID (Radio Frequency Identification) chip which contains information on the exact position of the unit within the construction and exact glass details etc. This makes installation easier and is an integral part of the required quality assurance.

Glass ship in the Hamburg harbour

The Elbphilharmonie is emerging directly on the Elbe at the peak of the harbour above the historical Kaispeicher A in which tea and cocoa sacks were stored right up until the 90s. The new building with its curved glass facades sweeps up above the gutted red clinker Kaispeicher and takes on the appearance of a huge glass ship. An 82 meter long escalator leads up to the public plaza on the roof of the old Kaispeicher at a height of 37 meters, where visitors are rewarded with a fascinating view of the harbour and city. The heart of the building is the large concert hall with 2,150 seats, which is set to become one of the best in the world. The concert hall rests on large spiral springs and will be acoustically uncoupled from the rest of the building. In addition, the building will also house a smaller concert hall with around 550 seats, a 5 star hotel with around 250 rooms, 45 apartments as well as restaurants and bars. The Elbphilharmonie is the cultural highlight of the new HafenCity area and is likely to become the centre of the city of music, Hamburg. The 26 floors offer a gross floor area of 120.000 square meters. The client is ReGe Hamburg Projekt-Realisierungsgesellschaft mbH and the main contractor is Hochtief.

Extreme technical requirements on the facade

Herzog & de Meuron defined extreme technical requirements for the single skin unitized glass facade. The glass had to be geometrically deformed in order to create differing images through surface reflection dependant upon location, weather and perspective. Also certain rooms had to be naturally ventilated by oval shaped vertical tilt windows located at the protruding edges of the glass units.

The architects together with curtain wall manufacturer Gartner similarly clad a shopping paradise for the fashion label Prada in the Aoyama district of Tokyo with a glass facade likewise consisting of three dimensionally curved glass units. The building, which opened in 2004, has become an architectural icon. The spherically curved glass units for the Elbphilharmonie had to be more acutely curved, this included at the edges. Plus its geometry had to be even more complex. For building physics and architectural reasons the glass panes had to receive different coatings e.g. a complex dotted chrome layer.

In order to meet the various technical requirements Gartner first of all put together an internal development team of engineers, structural engineers, building physicists, architects etc. who presented the initial solutions for the facade. Thereafter, industry partners were sought to develop first prototypes e.g. for the curved glass panes through gravitational deformation. For the insulated glass units the bending furnaces had to be specially outfitted and the precise temperatures for heating and cooling had to be determined.

Subsequently, the first panes, components and facade mock-ups had to be thoroughly tested. In further trials together with the laboratory for steel and light metal structures of the University of Applied Sciences in Munich, the load capacity and long-term durability and serviceability of the spherically curved facade glass units were established. In addition, a climate chamber was erected at the Gartner Gundelfingen premises in order to investigate the heat transfer coefficient and the total energy transmission as well as climate impacts on the facade such as thermal shock resistance and the effects of solar radiation.

Using pendulum impact tests at the Gundelfingen testing facility glass strength and fall protection were also thoroughly tested. Gartner carried out dynamic facade tests with their own 2.200 HP strong aircraft engine, which generates strong winds of up to 150 km/h and a dynamic wind pressure of 600 Pa. By means of a spray rack, the facade was sprayed with water at a rate of 2.0 litres per minute and per square meter in order to ensure resistance to driving rain and joint tightness. Through the application of positive and negative static pressure the load capacity of

the façade units against wind suction and wind pressure was investigated. The quality of the new components as well as the constructability and long term performance of the Gartner developed facades could be reassuringly verified with these tests that were complete in regard to every detail and underpinned with expert reports.

Crystal made of curved, coated and printed glass

Both standard curtain wall units developed for the Elbphilharmonie comprise two modules each, 4,30 m wide, and 3,35 m high as well as 5,00 m wide and 3,35 m high. Of the 2.184 glass units used, 601 are spherically curved and 1.583 are flat glass, both made of low iron glass (extra white glass) which is especially transparent. Both unit sizes are outwardly curved but also inwardly with an offset of 350 mm to the inside. An oval vertical tilt window which can be used for ventilation purposes has been fitted in the orthogonal area to the curved glass edge. The standard units with a size of 5,00 x 3,35 meters weigh approx. 1.500 kg. Each of the facade units has an additional dot matrix print as sun protection. However, the small reflective chrome dots vary in diameter and degree of print density, all according to the architect's specifications and the intended room usage, so that each unit represents a different unique print. The unique print frames the view and creates a mesh network over the entire outer facade. In the residential areas the curved glass units have been less frequently used as in the hotel area. In addition to solar and low E coating the g-values of the glazing were optimised by around 25 percent through the grey dot print and the dot matrix chrome mirror coating. On the west and south west side of the building the facade dampens reflective radar waves from passing ships. At the transition from facade to the wave-like roof of the Elbphilharmonie, every glass unit runs parallel to the roof edge and has its own unique shape.

The storey high plaza facades, with a total area of approx. 3.500 square meters are recessed and manufactured as special steel constructions up to a maximum height of 8 meters. The plaza is situated directly on the upper edge of the 8th floor, above which the unitized facades from Gartner start. The 2.000 sqm void facades form light shafts open towards the roof.

The aluminium profiles have a black Duraflon coating in RAL 9005. The vertical facade





members of the spherically curved units in the Philharmonic area have been partly covered with a mirror polished high gloss sheeting made of stainless steel. The approximately 370 mirror polished, manually operated vertical tilt windows were also tailor-made for the Elbphilharmonie and serve the individual fresh air supply. The glass composition of the double glazing consists of an outer 2 x 8 mm laminated safety glass pane with chrome dots, solar control coating and grey screen printed dots in RAL 7012, a cavity of 16 mm as well as a 2 x 6 mm laminated inner pane with low E coating.

Glass fibre reinforced polymer tuning forks

The horseshoe shaped cut out glass balconies in the residential areas resemble a tuning fork. Gartner manufactured a very special type of facade for this loggia area. The approx. 100 „tuning forks“ made of glass fibre reinforced polymer (GRP) are outwardly curved and in addition have to support the loggia glazing.

The foyer facade comprises unit sizes of up to 5 meters in height and 4,30 meters in width with two glass panes, as well as six large elements in the form of a big tuning fork with a height of 5 meters and a width of 6,45 meters. These elements weigh almost 2.000 kg and were installed in October and November 2010.

In addition to the glass fibre reinforced polymer (GRP), which facilitates the creation of free forms, the large tuning fork curtain wall units consist of three spherically curved glass panes. The pre-elements out of GRP comply with Fire Protection Classification B1 and were manufactured and coated brilliant white by the Chemnitz company Fiber-Tech Products GmbH. Gartner fitted these pre-elements with inner stainless steel reinforcements to support the structure as well as the three centimetre thick, double curved laminated triple glazing.

The large loggia tuning forks were installed between the 12th and 17th floors of the Elbphilharmonie at a height of 55 to 75 meters. In front of the concert hall there is an open area which concert goers can step out onto, like a balcony. The tuning forks are suspended at the top ends whereas the bottom ends rest on two spring axis operating in opposite directions. The large tuning forks were transported from Gundelfingen to Hamburg on a 20 meter long special transporter. Using this special hydraulic inclined loader the 6,45 x 5m large elements



could be placed in different positions in order to meet requirements for maximum height and width. By means of hydraulic adjustment all bridges and construction sites could be passed without the need for police escorts.

RFID chips for quality assurance

The fact that every single facade unit is an original and has to be installed at an specifically defined position posed special challenges to logistics and installation. Gartner provided each facade unit with an RFID chip, which was attached to the facade profile and is not visible from the outside. Each facade unit received a

number which can be read anywhere. In this way an overview is always available of where the individual facade units are located and in which order or in which location they are to be installed. The installation process can therefore be accelerated and above all is made safer. The RFID chips are also an important part of quality assurance. The chips contain all the essential information about the unit. On comparison with the data base it can immediately be clarified when and where the glass unit was manufactured or which tests and quality assurance reports are available. Later, should damages or any other problems

occur to individual components, the user can identify the unit with his reading device and in conjunction with the data base solve problems and promptly carry out the necessary repairs.

In the quality assurance process RFID chips complement the extensive tests and expert reports during the development phase of the façade. While undergoing the tests, the properties of the component itself are determined. Using RFID technology, the specific features of the individual components are quality assured.