

opusC

Architecture & Design with Concrete

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Industriestraße 180 | D-50999 Köln

Zaha Hadid Architects

Zaha's Signature

Changsha Meixihu International Culture & Arts Center

Zaha Hadid Architects clads the organic, flowing main structure of the Changsha Meixihu International Culture & Arts Center with a white panel pattern made of GRC. Eight galleries on a total of 10,000 m² space, gathering around an atrium designed for large-scale installations, are part of the Museum of Contemporary Art (MICA), while a theater with 1,800 seats and a multi-purpose hall with flexible seating capacity make the rest of the cultural program.



For all those familiar with the work of Zaha Hadid, who died in 2016, it shouldn't be difficult to recognize the characteristic style of the architect from the Changsha Meixihu International Culture & Arts Center. The project was first conceived in 2011 and has now been opened at the end of last year. 2019 was a big year for Zaha Hadid Architects in China. In addition to the Changsha Meixihu International Culture & Arts Center, the office has completed Daxing International Airport and Leeza Soho in Beijing, as well as a new luxury hotel in the Nanjing International Youth Culture Center.

The organic architectural language of the new cultural and art center in Changsha is defined by pedestrian paths that meander through the sites and connect to the neighboring streets. This ensemble of three separate cultural facilities provides a view from the city to the adjacent Meixi Lake, offers access to the parks and hiking trails on the festival island of the lake and creates outdoor courtyards where pedestrian paths for outdoor events and sculpture exhibitions cross. The largest and most versatile cultural center in Hunan Province is direct-

ly connected to station of line 2 of the new Changsha metro system. The cultural and art center is the new landmark of Hunan Province. Located on the historic trade routes through China, the city of Changsha continues its tradition as an important communication center and one of the country's leading media hubs, with the center's Grand Theater hosting a popular program of performances and television productions. The Grand Theater, which is designed for the widest variety of performing arts, opened in 2017 and offers full functions such as lobbies, bars and hospitality suites, as well as the necessary ancillary functional rooms such as administration offices, rehearsal studios, backstage logistics, cloakroom and dressing rooms.

With eight adjacent exhibition galleries totaling 10,000 m², which are grouped around an atrium for large installations and events, the MICA art museum also includes dedicated spaces for community workshops, a lecture theater, a café and a museum shop.

The Small Theater is characterized by its flexibility. This multi-purpose hall with a seating capacity of



All photos (unless otherwise stated): ZHA / Virgile Simon Bertrand

The Changsha Meixihu International Cultural and Art Center is divided into three separate buildings that are located around pedestrian paths that cross the site.

Photo: ZHA/Seven7Panda

The art museum is 10,000 square meters and consists of eight galleries, which are located around a large Skylit atrium that can be used for large installations and events.



500 can be transformed into different configurations to enable a wide range of functions and performances, spanning from small plays, fashion shows and music performances to banquets and commercial events. These three civic facilities with a total area of 115,000 m² are uniquely defined and separate from, yet complement each other with different opening times and thus create vitality throughout the day and evening. The theater becomes active when the art museum concludes its day-time operation, while the variety of events in the smaller theater ensures it will be constantly used. As the largest cultural center in Hunan Province, the project consolidates the position of Changsha City as one of the country's leading cultural and media hubs. The Changsha Meixihu International Culture & Arts Center opens with its debut, "Flowing Eternity" by MOTSE, a group of 40 artists and researchers from Shenzhen.

GRC elements

The architectural appearance of this project continues the "Zaha's signature" with a new and unique shape and creates a noble and elegant shape of "hibiscus flower", which reflects the special construction of the building. The form of the supporting structure is a reinforced concrete shear wall construction. The peripheral steel structure

has a unique shape, which is entirely composed of 22,000 tons of curved and twisted steel components. The outer facade has a surface area of approximately 100,000 m², which consists of 74,000 randomly curved GRC panels (glass fiber concrete). The inner area is divided by irregular hyperbolic GRC panels.

Nanjing BEILIDA New Material System Engineering, as the main manufacturer of GRC panels for the project, spent a total of 3 years with this masterpiece, whereby 2 years were spent only on the design optimization and on the innovative, patented GRC assembly system, which is particularly suitable for non-linear architectures.

There were enormous construction difficulties hiding behind the complicated and progressive design of the "Zaha style". First of all, there are 11,353 individually curved GRC panels, the production and assembly of which are extremely complicated. These irregular hyperbolic GRC panels created by random curving do not follow any rules. The connecting angle between each GRC panel and the main structure varies from plane to plane. The standard general connecting pieces cannot meet the technical requirements. The theoretical space between the main steel structure and the GRC facade is only 1 meter. Since it's not feasible to maintain the internal piping and the watertight layer

by setting access gates in the later operation and maintenance phase, the construction faces a bottleneck. To meet the requirement of high durability, this project required high performance GRC with higher compactness and better strength. The traditional method could not meet the shaping requirements of the hyperbolic GRC panels of this project. Secondly, a hyperbolic, single-layer steel structure with large volume and wide span must be precisely installed. The steel structure of the roof is made of a specially shaped, hyperbolic, single-layer lattice shell. The dimension of the overall structure is quite large and there are no structural connections and no regular changes. The simulation analysis of the temperature and residual welding stress of the whole structure during closing is quite complex and there are no relevant technologies or cases that could serve as a reference. The entire architecture is 58 m long from south to north, 43 m wide from east to west and the maximum inclination angle is over 40 degrees. Under the combined effect of various force systems such as bending, shearing, compression, tension and torsion, the distribution of the force flow is extremely complex.

Thirdly, due to the complex technical modeling and the large number of manufacturers involved, it is difficult to deepen the design and coordination of

BIM for all main areas. From planning, manufacturing, installation to operation and maintenance, the data transmission must be appropriate and accurate, so it was urgently imperative to develop an information management system for the GRC panels for claddings.

Fourthly, the acoustic control of the auditorium is very difficult with an asymmetrically curved surface. The auditorium of the large theatre is asymmetrical and has a large number of streamlined, inner, concave light slits on its surface, which can easily create an uneven sound field, resulting in focusing of the sound in several areas or the absence of side-reflected sound, uneven frequency absorption and difficult reverberation time control. For all these difficulties and requirements, the precast company Beilida developed suitable solutions: A relevant construction technology of the hyperbolic GRC facade was to be developed to realize a high-precision, fully screwed, adjustable, removable and specially shaped GRC facade. Furthermore, a digital hyperbolic shape production technology to implement the parametric design of the GRC shape and to control its machining precision by combining the digitization and numerical control had to be invented. A three-dimensionally adjustable connection and installation component to realize the flexibility

In the three buildings of the center, there is a museum for contemporary art, a large theater and a small theater.





of the connection between the rear steel frame and the main structure also had to be developed, as well as an equipment for spraying high-performance GRC to realize high-strength concrete, and a device for installing and removing the facade panel, which can complete the installation and removal of the GRC panel by one simple operation. The whole structure has been divided into several independent systems by setting sealing joints. They are installed in each area accordingly to solve the technical problem of installing a large hyperbolic single-layer steel structure.

In combination with companies and related test laboratories, various acoustic calculation software, true-to-scale model measurements, experiments and other technical means were used to optimize the overall shape, structure and materials of the building as a whole in order to achieve a perfect combination of sound quality and architectural modeling.

Through continuous research, uniform standard nodes have been developed to meet the requirements of 10,000 different types of GRC panel. They are adjustable in six directions, i.e. XYZ three-way rotation, three-way positive and negative movement, and their position is fixed by non-slip washers and nuts. The mechanical calculation was carried out in cooperation with Tongji University to ensure the safety of the project.

The realization of the hyperbolic GRC facade with high durability, high precision, all screw connections, adjustable and removable openings through the bottleneck of the original GRC facade sets a new milestone in the development of the architectural facade. The application of BIM technology has enabled the data sharing in design, manufacturing, installation, operation and maintenance. It has also highlighted the organic integration of BIM, IoT, Big Data and further information technologies with advanced construction technology, reflecting the innovation and reform of the construction industry. The research results have filled the gaps in the field of large-area hyperbolic, single-layer steel structure and hyperbolic GRC facade in the country and abroad, which have won 38 patents, a software copyright and 13 provincial science and technology awards.

White cement for GRC

PW 52.5 Aalborg White portland cement, produced at Cementir's plant in Anqing, Anhui, China, was the exclusively specified white cement for the production of GRC products for this project. Thanks to the



Photos [2]: ZHA/Seven7Panda



very high purity and stability of the white cements, manufacturers of GRC cements can provide high performance and color stability in their end products for the end customers. Highly pure and stable white cement is the key to products of all colors - even architectural products with the grey cement basis are often based on white cement to achieve a constant surface color. The chemical stability of cement plays an important role in the quality of the end concrete product. Cement is combined worldwide with many types of chemical additives for almost all applications. These additives have become increasingly efficient over the years and have an enormous influence on the concrete industry, which has further increased the need for qualified workforce. And at the manufacturer's plant, advanced quality control systems have to be implemented. A sprayed GRC must generally be very robust in order to maintain its integrity, since it is mixed at high speed, stored "stationary" in the feed tank, pumped, sprayed and troweled. The qualified employees of Beilida New Material System Engineering - a member of the International Glass-fiber Reinforced Concrete Association (GRCA) - have

fully exploited all the properties of white cement in order to realize this magnificent structure.

Architecture

Zaha Hadid Architects, UK-London EC1R 0BQ
www.zaha-hadid.com

GRC-Manufacturer

Nanjing BeiLiDa New Material Co., Ltd.
www.beilida.com

White cement

Aalborg Portland (Anqing) Co., Ltd.
www.aalborgwhite.com

The Grand Theatre offers 1,800 seats and has an impressive wooden interior.

