

# GRC production for the Venetian Hotel in Macau

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## Summary

This paper outlines the scope of the work to supply 20,000 m<sup>2</sup> of glassfibre-reinforced concrete (GRC) elements in the construction of the Venetian resort in Macau, and the challenges involved in a very demanding project. In terms of size, commercial risk, intricacy of design, timescale and quality requirements the project set new limits, such that the company termed it a 'scary' project. The particular problems and their solution, leading to a successful conclusion to the construction, are explained.

Keywords: Venetian, Macau, QC, GRC products.

The artistic value and the number of glassfibre-reinforced concrete (GRC) products used on the Venetian Hotel in Macau may break world records. Allow me to introduce Nanjing Beilida and share our experience of this project.

The prototype of this project is in Las Vegas. Compared to the Venetian Hotel in Las Vegas, more innovation in concept, design, material and technique were brought to the Venetian Hotel in Macau. At the same time there were more challenges to face. In order to fulfil this plan, the Venetian developers gathered top architects, designers, engineers and entrepreneurs from all over the world to form their special team. Many specialists also considered it a 'scary' project; even one of our American clients told us that we should quit this project when he got the news that we would tender for it. As the project developed, the reasons for our apprehension became increasingly apparent.

Reason one is that there was risk in the tender. According to the drawing and the specification of the tender, it was the tenderer who would shoulder all the responsibility, including any imperfections in the tender document. A tiny mistake could cost millions, perhaps tens of millions. Even a deviation in the number of precast bolts would result in a cost overrun amounting to millions.

Reason two is that there was risk at the start of the project. Prior to formal production, the Venetian management team would organise three inspections of the manufacturer. The first would be to inspect the scale, organisation, equipment, technique and QC systems of the factory. The second would be to see if the factory could organise the production process and produce a quality product. The third would be to inspect the productive capability. All these processes would take five months. Consequently, the company would risk losing millions of RMB, because if it failed to pass the inspections, it would have to take all the responsibility and bear all the cost. It was required that all the factories be exclusive to the Venetian Hotel, and specialise in the GRC products. Fortunately, the company passed the three inspections in only one attempt. Success was due to a combination of mutual trust, cooperation and understanding. Thanks are due to the specialists for their patient help and guidance. We were determined to succeed.

Reason three is that it was a very urgent project. It took seven years to complete the Venetian Hotel in Las Vegas, but planning time for the Venetian Hotel in Macau was limited to just two years. We could imagine what time meant to a man who earns US\$1000 an hour. So we made every effort to do the work. Everything was prepared before we received the formal production orders from the owner. We had built the workshop, had increased the amount of equipment, and had assembled more than 250 workmen. At the owner's request, 55% of our workers had to be approved by Nanjing Beilida, and have working experience of more than five years. As a result of our huge investment and careful preparation, we finally won the contract. We are the first manufacturer to achieve the GRC surface effect that was required by the Venetian project, and we have now become a benchmark for all other manufacturers. We were also the first to build a digital control management system, and have batch production. We were highly praised by the owner and specialists for our effort and achievement.

Reason four is that we had to bear the risk of precision of installation. The standard of the GRC project for the Venetian Hotel in Macau was way above standards for all other countries, and because there are large numbers of point-to-point installations, any deviation would have meant rejection of the product. Take for example a product in the aisle of the Venetian Hotel, namely a sculpture with an internal steel frame. This presented us with two requirements: one that we needed to use a recessed steel frame as support, and the relevant product needed to be hollow; second that we needed to consider the wind load of the area. How to design the structural supportive strength posed a difficult problem. We needed to consider the questions of line of curvature and other arch decorative panels. We had to devise a method of inserting the steel frame inside the GRC without compromising shape. It was imperative that we obtained precise orientation and direction. In the first tranche of the Venetian Hotel project we had produced more than 20 thousand square metres of GRC, representing more than 24 thousand products in total, nearly 80 thousand precast joints, and more than 2600 kinds of complicated shapes. Bearing in mind that on average each shape is composed of ten separate elements, it can be appreciated that this was a difficult project.

The fifth reason to be concerned was the risk in fulfilling the technical standards required. Internal GRC projects in China tend to follow UK national standards; however, Macau has its own building standards. American investors required that the construction of the project comply with ASTM standards, but that all of the GRC tests be carried out according to European standards (BS EN). The variations and transformations of these standards meant that we had to exercise particular caution in selecting a definitive production standard. Thus, we established our testing lab according to BS EN standards, produced our QA/QC plan according to PCI standards, and established our GRC production control system according to ISO standards. The quality of GRC can be ensured by means of systematically organising production and controlling the quality of products.

The sixth reason 'to be scared' was the risk of a large number of rejected products which could result from the onerous checking and inspection required. Our overall process of GRC production was continually under inspection by the Venetian organisation, the management company and the professional team of the general contractor, all of whom had strict standards. All the related parties set up their own office within our factory. We were able to ensure the quality of the products through a strict quality control system. Units of measurement were as follows: working procedure control was gauged in seconds; weight control in grams; and the variation of size was controlled within 1–2 mm. Temperature, humidity, water/cement ratio, sand diameter, mixing time, batching of materials, sequence of materials, angle of spraying, all had to comply with the strict specification and requirements. The products also had to pass not only our own inspections but also those of other bodies including professional institutions, client representatives based in the factory, the site superintendent and sometimes Venetian Personnel. As well as the conventional inspection of parameters, we also checked the appearance, the pull-out of the cast-in products, and the delamination of the structure, all of which were carried out by the Hong Kong QCC company who selected samples in our factory. If there was one factor that did not comply with the requirement, then the QCC company would then choose twice as many samples and repeat the tests. If the samples were still unacceptable then all products would be rejected. The supply schedule and quality guarantee of original materials was also a challenge for us. The materials were imported from five different countries, and each batch of materials had to be checked by the Hong Kong QCC, and we would not use them unless they proved acceptable. In order to successfully pass every inspection, all Beilida employees had to abide by the honesty principle, comply with the requirement and guidance from experts, and carry out their work carefully and conscientiously.

We are a professional enterprise which has specialised in GRC production for 14 years, and we have set up branches in Beijing, Nanjing and Shanghai. We have been involved in more than 800 projects, including 11 GRC projects totalling an area of 30–50 thousand square metres on the mainland. The work includes such areas as design, mock-up fabrication, moulds, GRC products and project installation. There are 22 construction managers who possess the national qualification in our company, and we have completed three national technical innovation projects for the National Construction Department in five years. We have carried out various kinds of projects, and now the Venetian Hotel, a project which is guided and managed by a professional team. It improves our experience and promotes our capability yet further. Under the assistance and guidance of international experts, we met the requirements of the Venetian project in the shortest time. Our early success provides other manufacturers with a benchmark. At the same time, we also clearly recognise that our success marks only the beginning, and that more difficult and challenging jobs await us.

Thanks go to the friends and colleagues who have helped us, to those who have brought us to the international stage, and to those who have given us the chance to exhibit successfully. They have helped us enormously, just like Prometheus, bringing fire and sunshine to humankind and illuminating our road!