QING DAO NEW RAILWAY STATION, SHANDONG - CHINA

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Located on the east coast of China, the city of Qing Dao is one of the country's biggest ports. In the 19th century it was colonised by Germany and was officially ceded to it by the Manchu administration in 1898 for a period of 99 years, but was taken back by China in 1922 following the war with Japan.

In 2008, Qing Dao hosted the Olympic sailing events.

Its new mainline station, which faces the sea, almost self-evidently seeks its inspiration in the symbolism of ports and seafaring birds with large wingspans. It was this self-evident symbolism that was unanimously acclaimed by the competition judges in December 2007.

As in most Chinese stations built on this scale, the arrivals and departures lines are covered over with a "departures hall" – a full-blown bridging structure built over the tracks, from which passengers descend to their departure platforms.

For passenger arrivals, and to minimise the pressures of large numbers and dense flows of passengers, travellers go down a level towards the metro, taxi rank and passenger car pick-up areas. This ensures that departing and arriving passengers never mingle.

The main area of the “Departures Hall” and the seemingly complex shape of the roof can be guessed at from the repetition of a single structural module, which only varies as a function of its spatial positioning. The programme is therefore, in view of its scale, an apparently complex formal programme, but because it is modular it is economical and easy to implement.

Structure of the project

The roof structure is composed by 10 identical frames parallel to the tracks called “arches”, reaching a maximum span of 140 meters. The arches support main roof transverse beams every 22 m with inclined columns called “brackets”. The brackets, the arches and the transverse roof beams are braced together in order to form rigid triangles.

The beams and the arches are offset to form the curvature of the roof, and rotated in a vertical plan perpendicular to the arrival. In the middle of the station, the space is narrower, but higher.

In the longitudinal section, the structure is composed by “V” columns supporting the transverse beams. In the central section of the station, the V brackets are connected to each other, and create a very stiff double-W system to resist horizontal forces perpendicular to the tracks while enabling the structure to expand under thermal variation.

The system of beams and the arches are connected longitudinally at the top of the structure by a central ridge beam. This beam has a triangular section of 5 m x 3.80 m.

All three facets of webs of the triangular box beam are pierced with rectangular holes to reduce its weight. This beam is designed as a 3-dimensional Vierendeel truss, reinforced with diagonals where shear forces must be counteracted.

The use of many identical frames made standardization possible, and thus allowed to develop complex details such as cable-reinforced brackets.

The brackets are stiffened by a self-balanced system that stabilises them against buckling while increasing the slenderness ratio of each member to reduce the weight and cost of construction.

The brackets are connected to the arch through pin connection plates.

The arches, “V” branches, and “V” columns supporting the waiting room structure are connected on a single foundation, formed as a concrete buttress.

In China, structures spanning more than 120 m, and those with a maximum dimension longer than 300 m must submit to the “National Commission of Structure Seismic Design Beyond Code Limits.

In compliance with this commission’s requirement, the roof structure must resist wind pressure up to 700 kg/sqm on the cantilevered sections, due to its vicinity to the sea.

The utilization of folded plate technology allows the creation of original structural forms through the dense deformation of plate steel sheets. With many densely-packed folding axes the production of conical shapes are possible. The technique was initially developed and utilized successfully on the Shanghai South Station, a project we completed in 2006. The entire steel structure was fabricated in Nanjing and shipped to the building site.

The arch is built with 20 mm bent plates in order to form a cylindrical shell stiffened every 5.500 m by interior plates.

The roof transversal beam comprises 1 upper flange of 400 mm x 30 mm, and a lower chord designed as an elliptic cylindrical shell.

10.8 km of cables (diameter varying between 50 and 120 mm) are used to stabilize the brackets connecting transversal beams and arches against buckling. 5.5 km of cables are used for the diagonal bracing.