BESIX

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Prize of the Jury

BESIX Group is the largest Belgian construction group, a conglomerate of companies active in the construction, engineering, environmental, real estate and concession sectors.

In 1909, Jacques-Marie and Charles Stulemeijer see potential in prestigious construction projects in Belgium and set up the Société Belge des Bétons (SBB). They immediately earn their reward with the rebuilding of Belgian ports and canals, in the aftermath of the war and soon the activities expand in France and Spain.

In 1947 SBB recognizes the extraordinary market potential in former Belgian Congo and, together with the Belgian Group Empain, creates a common subsidiary Auxeltra-Béton.

Large projects in the Middle East demand a new organization from 1966. The six companies of the SBB Group form Six Construct. The success in this new region becomes considerable.

Since then, the group has known impressive and regular growth with the acquisition of new companies such as Entreprises Jacques Delens in Brussels, Etablissements Jean Wust in Wallonia and Vanhout in Flanders and, more recently, Van Britsom (Oostkamp), Verheye (Diksmuide), GRWestkust (Diksmuide) (50%), Socogetra (Awenne) and Cobelba (Naninne).

In the meantime, the company has entered the Egyptian and Libyan markets, it has also becomes an important player in France and the Netherland and has realized impressive projects in India, Russia, Poland, the Czech Republic, Slovakia, Algeria, Morocco and many other countries.

In 2004, thirteen managers of BESIX and its subsidiaries, together with Orascom Construction Industries, execute a management buy-out. SBB becomes BESIX Group, firmly anchored in Belgium.

Today, BESIX and its subsidiaries cover practically all fields of the construction industry and are operating in Western Europe, in Central and Eastern Europe, North and Central Africa, in the Middle East, in Central Asia and in the Caribbean. The Group realized a turnover of approximately 1.6 billion Euros and employs over 20.000 people worldwide.

The Group intends to be a leading international player, serving Western and Central European markets from its home country Belgium, and covering the Middle-East from the United Arab Emirates.

The success of the group is the result of:

- A commitment of upholding the highest standards of quality, reliability, professionalism and performance.
- The permanent seek of innovative ways to increase its expertise and enhance its performance.
- Providing a safe work environment
- A particular care for the teamwork spirit and the respect of individuals
- Taking new challenges that will strengthen the reputation and open new horizons.

Short Description

The Tornado, Doha

The QIPCO Office Tower, also known as the Tornado is since December 2008 one of the major and striking landmarks that define the ever-expanding Doha. Situated in the heart of the City behind the Corniche, it has transformed, once and for all, the skyline through its unique shape and character.
The client for this project is QIPCO Holding with Six Construct-Midmac JV appointed as General Contractor. The Tower has a height of 202 m and consists of 3 basements and 51 floors with a total office area of 83,148 m². It comes with its own private helicopter platform at the very top on level 52.
The building has a cylindrical shape with a variable radius which thins out at mid height (28.8 m / 19.3 m / 27.8 m). Its main feature is the outer diagrid arrangement of diagonal columns and beams which give the building a unique diamond shape pattern of the cladding.

Project Information

Owner: Qipco Holding
Architect: Cico / Siat
General Contractor: Six Construct / Midmac
Engineering Office: Meinhardt Singapore

Construction Start: 20/07/2006
Construction End: 26/12/2008
Location: Doha, Qatar

Quote of the Jury

It is an impressive structure, well presented and with a lot of highly technical aspects. The steel and concrete connections were carefully designed. This project is a good example how interoperability with other software can be used. The seismic and dynamic analysis as well as accommodating the difference in settlements between the core and the adjacent structure was a great technical challenge.

Project Description

The project is located behind the Doha Corniche and consists of a 52 storey office tower and a three level basement car park. The tower is a 202 m tall circular building with a total office area of 83,148 m² and a helipad at level 52.

Challenges

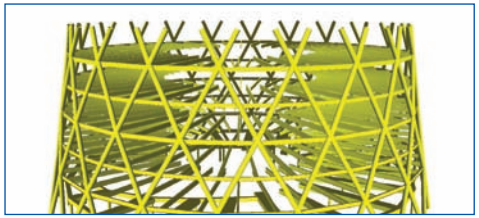
The building had to be designed and constructed in a period of 30 months between July 2006 and December 2008. The challenge faced by the designers was to produce a state of the art design in a very tide schedule. The design was made that much more complicated by the fact that the perimeter and radial steel beams were subjected to significant tensile loads resulting from the shape of the building. The floor slabs were designed to act as membranes bracing the diagrid to the central core by tensile action. Connection design both between steel-to-steel and steel-to-concrete were the subject of very careful and systematic analysis of the structural models. This resulted in a very refined and detailed 3D modelling with the primary purpose of ensuring that the final layout and geometry of the connections safeguarded the overall stability of the building without impacting on the aesthetic and visual effects projected by the architects.

Tower Geometry and structural system

The tower consists of a 23.8 m diameter central concrete core and a perimeter steel diagrid. The design was based on BS Standards. The building is cylindrical with variable radius (maximum 28.8 m at ground floor; minimum 19.3 m at level 28.

The structural system consists of the following:

- Central Core – 300 mm thick RC walls of constant thickness. Floor-to-floor height is 3.8 m.



Used software: ESA-Prima Win

- Perimeter Diagrid – Diagonal Steel columns and peripheral steel beams
- Floor slabs – Composite radial steel beams + 180 mm thick concrete slab on metal deck.

The building fundamental period was T1 = 4.2 sec

Design Software

The structural design of the basements and tower was by Meinhardt (Singapore) using ETABS. The BESIX Engineering Department in Dubai was appointed to carry out a third party independent check. BESIX used ESA-Prima Win for full 3D modelling. CICO, the client's engineer and architect, carried out a separate check by modelling the building in STAAD PRO.

Foundations

The geology of the Qatar peninsula consists mainly of extensive carbonate sediments overlying basement rocks up to 10 km in thickness. The tower is founded on Simsima Limestone.

The foundation system consists of a 2.7 m central raft and perimeter pile caps interconnected by a series of radial ground beams 2500 W x 750 H. The raft itself is supported on bored RC piles as follows:

- 1200 mm DIA – 14 m long – 129 Nos
- 900 mm DIA – 8 m long – 20 Nos

Seismic loads

Seismic design was based on Uniform Building Code 1997 and seismic Zone 1 (Z = 0.075). Earthquake base shear was calculated as 8555 kN, less than 1% of the tower gravity loads.

Wind loads

Theoretical wind loads were calculated using CP3 and with Vb = 41.67 m and were verified by wind tunnel testing. The loads calculated from the wind tunnel results were 5% lower than the theoretical values:

- Wind Base Shear = 14,846 kN
- Base Bending Moment = 1,628,212 kN.m

Structural 3D Modelling

BESIX developed two separate 3D models of the tower for the purposes of checking the design.
Model A – Core walls modeled as FE plates and beams and columns using member properties. Slabs were introduced as dead weight to the beams.
Model B – Same as model A but slabs were modeled as FE plates. Floor beams where given vertical eccentricity to replicate the actual situation on site
The geometry of the diagrid was exported from the architectural AutoCAD files in ESA in DXF format. This saved considerable time in creating the non-linear geometry of the external diagrid system.
The load distribution between central core and diagrid is 75% to 25% respectively. Total gravity load is 999,000 kN.

Designing with ESA-Prima Win

Model A was used to check and verify the overall stability of the building and to confirm its natural frequency. The time required to solve the model was generally less than 10 min and this afforded the designer the possibility to test different layout arrangements in order to obtain the most optimal in terms of economy.
Model B was used to investigate the effects of radial in-plane forces transferred from the diagrid nodes to the core walls through the slab plates. The running time of the full dynamic model was approximately 2 hrs and was therefore used in final detailed design.
The following points are considered to represent the main advantages afforded by ESA-Prima Win to BESIX designers:

1. Relatively short time required to run the basic models when compared to other commonly used software in the Gulf.
2. Use of the dynamic module for obtaining the lowest significant Eigen frequencies of the structure
3. Ability to run quickly and effectively sensitivity studies including the influence of elastic shortening of the central core under different values of Young's Modulus, in order to determine the effect of load transfer between core walls and diagrid columns
4. Use of concrete design module to verify RC quantities
5. Use of structural steel module to verify the diagrid columns and beams

Conclusion

The Tornado has been successfully completed and has become a major landmark in the Doha Corniche. With its unique shape and character it has changed the City's skyline ones and for all.