

# Structural design and erection of the Khalifa Stadium

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## Abstract

Renovation of Khalifa Stadium is changing of existing Asian Game Stadium with 50,000 seats for 2022 FIFA World cup to 68,000 seats. There are two compression rings, tension and suspension cables with PTFE membrane for new Khalifa Stadium. This paper consists structural review, dismantle and erection work for Renovation of Khalifa Stadium conducted during the bidding process.

**Keywords:** roof structural system, cable structure, membrane structure, erection

## 1. Introduction

Khalifa Stadium in Doha, Qatar is a sports stadium which was constructed in 1976 and was for the 2006 Asian Games with 50,000 seats.

Qatar is the host state of the 2022 FIFA World Cup and has a plan that builds the new ten stadiums for football. The Khalifa Stadium will be extend to 68,000 seats according to the plan. C·S Structural Engineering (CSSE) participated in tender stage for bidding studied with roof structure system, and erection method.

## 2. Roof structure system

The existing stadium consists of the west stand which is 220 meters long with 50 meters width PTFE membrane resisted by cables and the east stand without roof only with the lighting arch structure, 265 meters long and 15 meters high (Figure 1).



Figure 1: Overview of the Khalifa Stadium (before changing)

According to the renovation plan the membrane and cables of the west stand and the lighting tower of the east stand will be dismantled. The extension of the east stand and the new compression ring truss above the east stand and the strengthening of the west stand will be followed for the membrane roof (Figure 2).

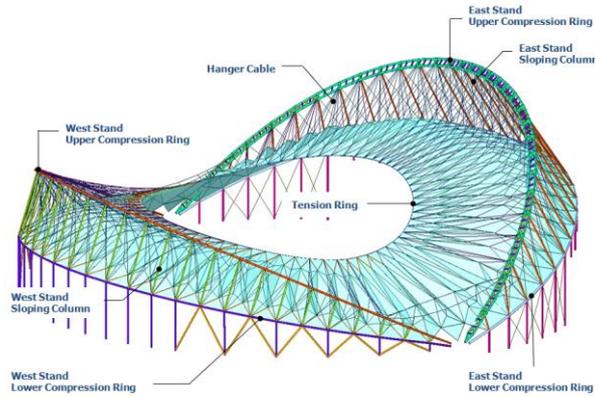


Figure 2: Structure system of the Khalifa Stadium (after changing)

The membrane roof covered the whole seats is stabilized with the inner tension ring and hanging cables from the east and west upper compression rings (Figure 3, Figure 4).

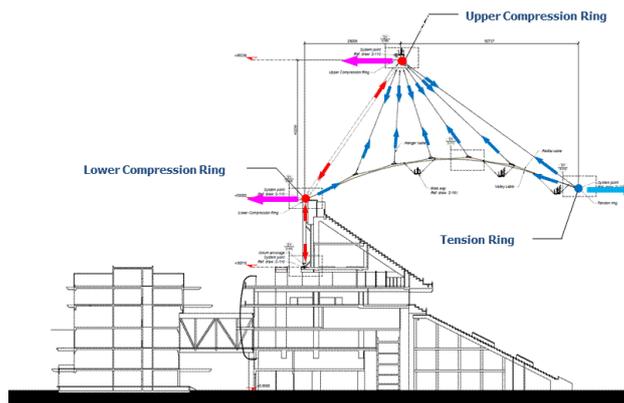


Figure 3: General section describing system stability

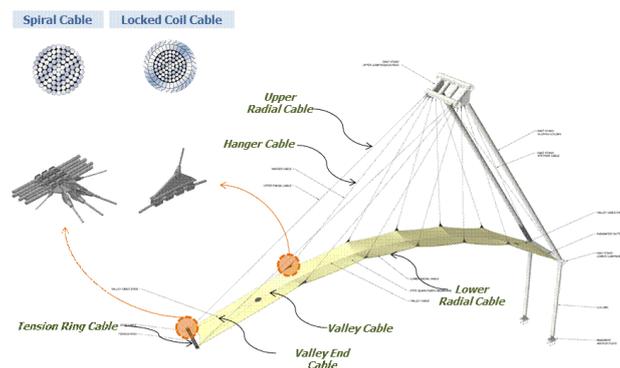


Figure 4: Cable structure system

The west upper compression ring will be strengthened the existing structure by replacing and additional members (Figure 5).

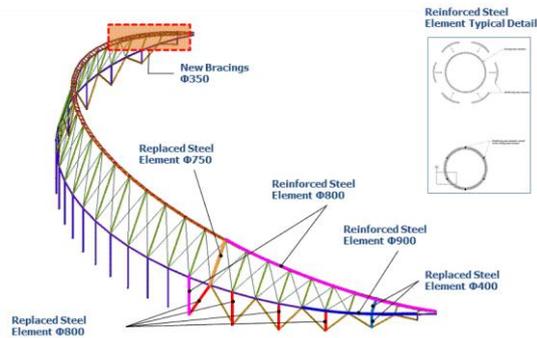


Figure 5: West side steel structure – Strengthen of steel structure

The east upper compression ring erected after the removal of the lighting tower will be build up by the lower compressing ring, sloping columns and bracings (Figure 6).

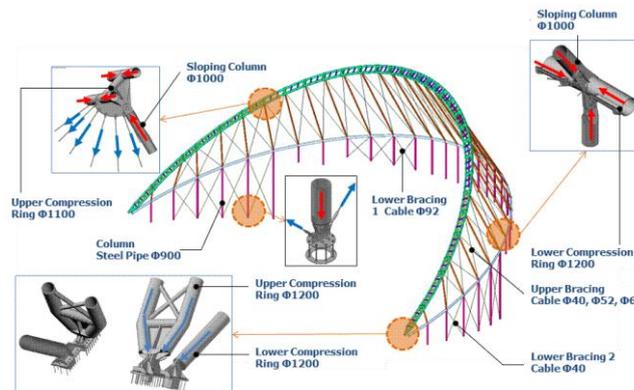


Figure 6: East side steel structure – Installation of new steel structure

### 3. Erection engineering

#### 3.1 Erection of the east compression ring

For the build of the east compression ring the lifting method using hydraulic jacks is suggested instead of stack up segment method by tower crane. The two supports of the ring will be used as the pivot hinges during lifting up the ring by the hydraulic jacks at the far side.

##### 3.1.1 Lifting sequence of the compression ring

- Stage 1) Fabrication of temporary supports and upper compression ring
- Stage 2) Lifting of upper compression ring
- Stage 3) Fabrication of lower compression ring
- Stage 4) Fabrication of sloping columns and braces
- Stage 5) Lifting of lower compression ring fabricated with upper compression ring, columns and braces
- Stage 6) Lower columns and braces to be fabricated to lower compression ring and base plates on the floors
- Stage 7) Dismantle of temporary supports

#### 3.2 Erection of cables

The erection method of cables is adopted the lifting and tensioning process using hydraulic jacks without temporary towers.

The construction stage analysis of cables is used by backward analysis from complete cables to beginning stage of cables using geometry nonlinear deconstruction analysis.

### 3.2.1 Cable erection sequence

Stage 1) Tension ring cables are laid out and connected on the ground.

Stage 2) Laid out lower radial and hanging cables. Clamping tension ring to radial and hanging cables

Stage 3) Installing hydraulic jacks, winches and construction cables

Stage 4) Tensioning and lifting

Stage 5) Complete cable erection and fixing hanging and radial cables

Stage 6) Tension and geometry check often installing membranes

## 4. Conclusion

The erection engineering for finding the optimum solution of the combined structure, the flexible structure of cables and the rigid structure of the ring was worthwhile.

## References

- [1] *Total Renovation, Construction, Completion and Maintenance of Khalifa Stadium and Museum at Aspire Zone*, Aspire Zone, 2013.
- [2] Tristram C., Jane N. and Peter M., Khalifa Stadium, Doha, Qatar, *The Arup Journal*, 2006; **2**; 44-50.