THE QATAR FACULTY OF ISLAMIC STUDIES

Constantine Emmanouil Migiakis
Civil Engineer MSc DIC
Technical Manager
AKTOR S.A
Doha, Qatar
Email: cmigiakis@adcc.com.qa

ABSTRACT

The Qatar Faculty of Islamic Studies is a 45,000 m^2 building which is intended to be a landmark for Doha, the capital city of Qatar, due to its unique architecture. It consists of the library, the faculty area, a conference auditorium hall, the mosque and the inclined minarets.

The lower floors are reinforced concrete frames with shear walls. For the mosque slab a number of large post-tensioned beams have been used in order to minimize long term creep deflection.

The roof is constructed from a system of primary and secondary beams supported by a mixture of vertical and inclined steel columns. Primary beams are typically curved plate girders and are made up of a number of sections joined on site. The steel work will form the main framework for the elevation of the library and faculty area and the variable height curved surface of the mosque. Total weight of structural steel is 3200t.

The most non-conventional structures are the two minarets which stand cantilevered at a height of 75m, consisting of built-up steel plate girders, curved and tapered. The aerodynamic stability of the minarets relies upon the performance of its viscous dampers.

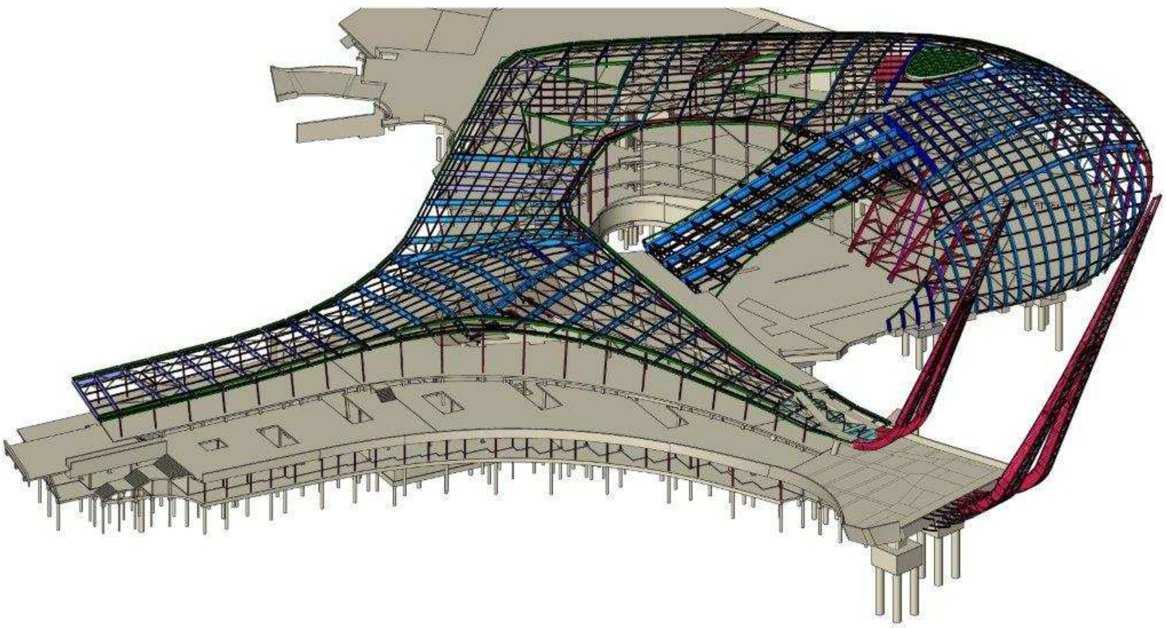

Fig 1: Overall view of the Structural System

INTRODUCTION

The Qatar Faculty of Islamic Studies is located in the new Education City development in Doha. The building houses a Mosque, a faculty and academic area, a library and two minarets. The proposed structure, despite its complex geometry has been designed so that most elements can be built using conventional methods of construction and erection.

PILING

For the majority of the columns either a single pile or pair of piles is proposed to support the loads. These piles have therefore been designed to account for the moments and shears caused by the piles and the columns being 100mm eccentric (75mm for pile tolerance and 25mm for column tolerance). The columns which are supported on 3 or more piles are designed assuming that the pilecap distributes any out of tolerance into the piles and therefore the piles are only designed for a nominal horizontal load of 15kN.

SUPERSTRUCTURE

The structural frame is typically reinforced concrete columns, slabs, beams and core walls. The inclined concrete columns will impose horizontal loads on the structure due to self weight, finishes and live loads. Therefore the sequence of construction must be considered so that the stability system is in place prior to the application of these horizontal loads.

The building is divided into a number of stability zones by the introduction of movement joints. These are formed either with the introduction of double structure (pairs of columns or walls either side of the joint) or by halving joints in the slabs and beams, such that the slabs and beams on one side of the movement joint support those on the other side. In the case of the halving joint detail, the sequence of construction should be such that the slab and beams on the supporting side should be cast first.

The mosque bottom slab includes a number of large post-tensioned beams in order to offset the self-weight deflection and minimize the long term creep deflection. The design assumption is that the live ends will be located on the inner end of the beams and the dead ends will be at the cantilever end of the beams. This is due to the need to integrate a steelwork connection detail at the cantilever end where the main roof steel of the Mosque is supported.

ROOF

The roof is constructed from a system of primary and secondary beams supported by a mixture of vertical and inclined steel columns. Connections are typically pinned site bolted, although there are bolted moment connections for cantilever spans and splices within primary beams. Primary beams are typically curved plate girders, and are made up of a number of arch sections joined on site. Knee bracing is required in some locations to restrain the beam flanges from buckling, and at some connections.

Stability is achieved by plan bracing within the roof plane, and connection to the concrete lift and stair cores. There are five movement joints within the roof steelwork, typically marching the movement joints in the building.

The structural metal decking spans approximately 3m between the secondary beams, and has not been designed to restrain the secondary beams against lateral torsional buckling. In the flatter areas of roof decking is multiple span, where the roof becomes more curved than a radius of 120m, the decking will need to be single span. Steel columns typically have nominally pinned base plate connections with four holding down bolts.

ERECTION

The erection of the steel beams will generally be as with a conventional steel roof. The primary beams would be erected first, followed by the secondary beams and bracing, then the roof decking will be fixed in place. The main plate girders over the Mosque and Mosque canopy are up to 50m in span, and therefore temporary support trestles may be required.

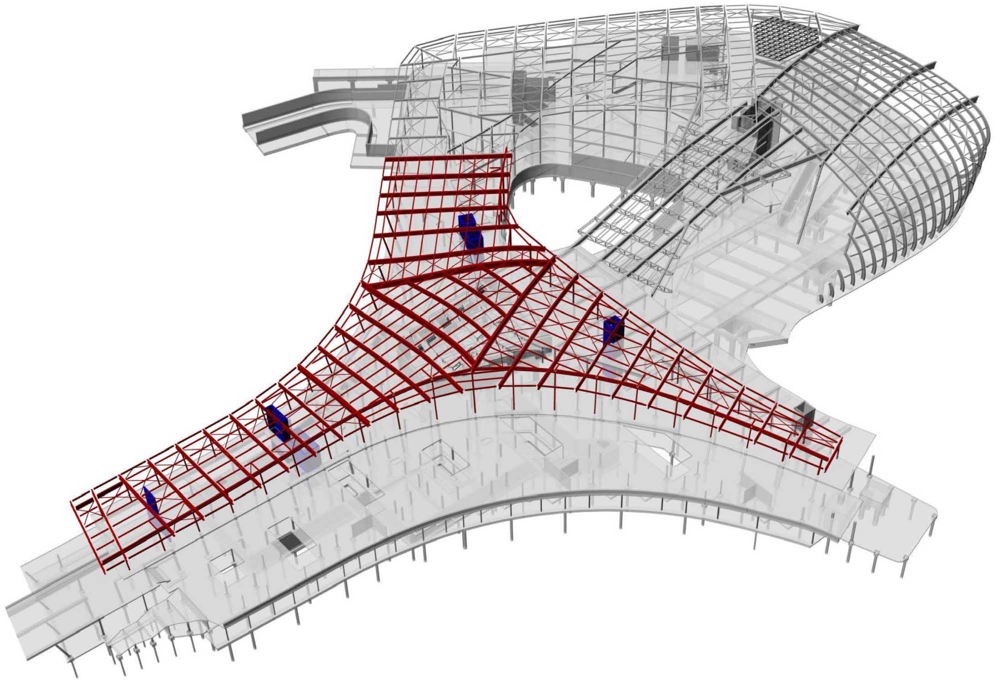

Fig. 2: Roof Steelwork – Library Area

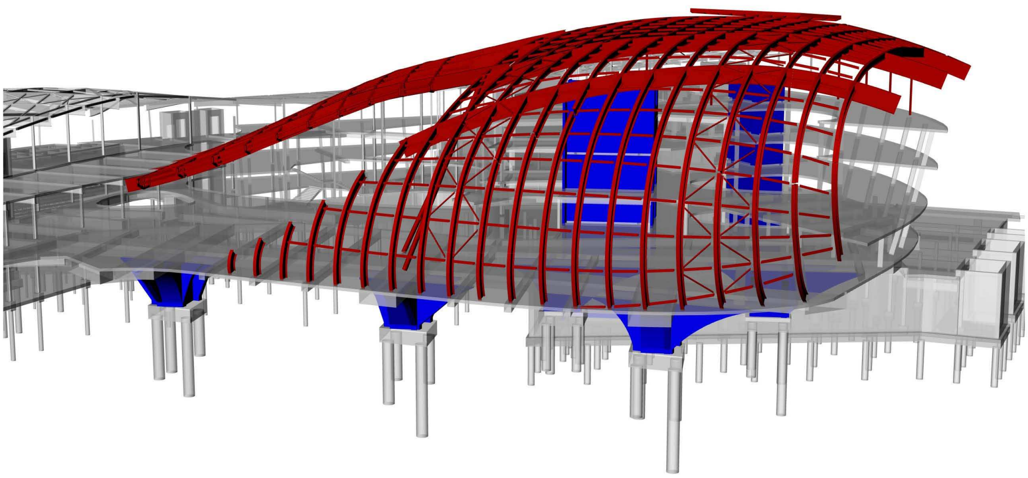

Fig. 3: Roof Steelwork – Mosque Area

The base of the Mosque West façade (where the roof becomes almost vertical) forms a truss spanning between the primary reinforced concrete beams within the lower slab level. To this end of the lower sections of the curved plate girders will all have to be erected, including purlin and bracing members before the remaining sections can be erected.

MINARET

The minaret structures are inclined 25 degrees to the vertical. Both the large and the small minarets will be cantilevered structures formed using tapering steel plate girders. The larger minaret, Minaret 1 will rise approximately 80m above the ground level with a structural depth of 2.5m at the root, tapering to 0.47m deep at the tip. The smaller minaret, Minaret 2 rises approximately 69m above ground level tapering from 1.5m deep to 0,25m at the top.

The fabrication and erection of the Minaret is the most non-conventional aspect of the building. However, the design has been developed with erection as follows:

- The individual beam elements will be limited in size based on their length (maximum 10 to 12m) and their weight (maximum of 20t)
- The individual beam elements are either single curved tapering beams parallel to each other or straight tapering beams not parallel to each other. This means that none of the members are doubly curved.
- High Strength Friction Grip Bolted connections will be used rather than site welding due to access restrictions and the need for a fatigue resistant design.

The erection of the Minaret steelwork will be pre-set to account for the self-weight deflection of the Minaret including the cladding self-weight. The offset geometry is achieved by cranking the Minaret plate girders each side of their splice positions. The rotation provided at each crank point generates the pre-camber geometry. The connection of the Minaret primary steel plate girders to the concrete deck beams has been developed in order that tolerances and alignment can be achieved prior to fixing in place.

VISCOUS DAMPERS

The aerodynamic stability of the Minaret relies upon the performance of two viscous dampers in each Minaret. Each viscous damper is connected to a damping cantilever member. Two plate girders in each minaret are not connected to the adjacent structure along their length and are connected via a viscous damper at their tip. This damping arrangement controls the wind induced motions of the structure.

Each damper is to be supplied with spherical bearings, fixing brackets and fixing bolts. The viscous dampers will need to be installed in the Minaret prior to the cladding being applied, in order that there is not a temporary situation where the aerodynamic stability can occur before the viscous dampers are operational.

The design of the viscous dampers allows for the temporary removal of one damper in each Minaret without any adverse effect on the structure. This is due to the fact that the damping system has been designed to provide additional damping 0.6% to the structure, effectively 0.3% per viscous damper/damping cantilever system.

However, in the calculations of structural performance, the inherent damping of the structure (without the viscous dampers) has been ignored. This is estimated at a minimum value of approximately 0.3%.

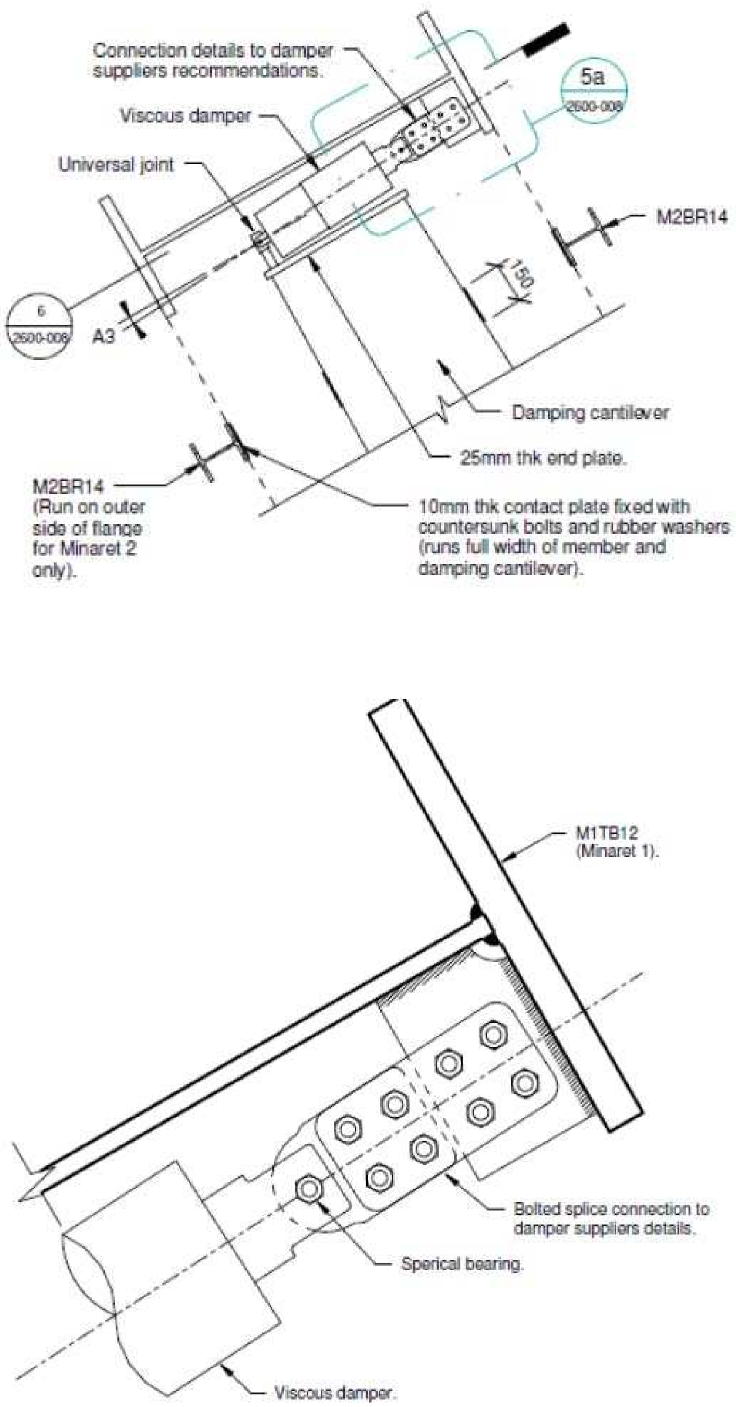

Fig. 4: Viscous damper details

Therefore, in the case when one damper is temporarily removed for maintenance, the combined inherent structural damping and the remaining viscous damper/damping cantilever system will provide sufficient damping to avoid aerodynamic instability.

CLADDING

Exterior wall facades including:

a) Composite Metal Panel Fascia
b) Glass façade and curtain walls
c) Insulated Core Metal Wall panels, including coping and flashing
d) Natural stone cladding panels of various materials, finishes and sizes.
e) GRC (Glass Reinforced Concrete) cladding panels of various patterns and sizes
f) Aluminum/stainless steel fixing and support systems, thermal insulation, waterproofing coating and vapor barriers for all types of panels listed above
g) Minaret Metal Cladding
h) Calligraphy Embossed Coating

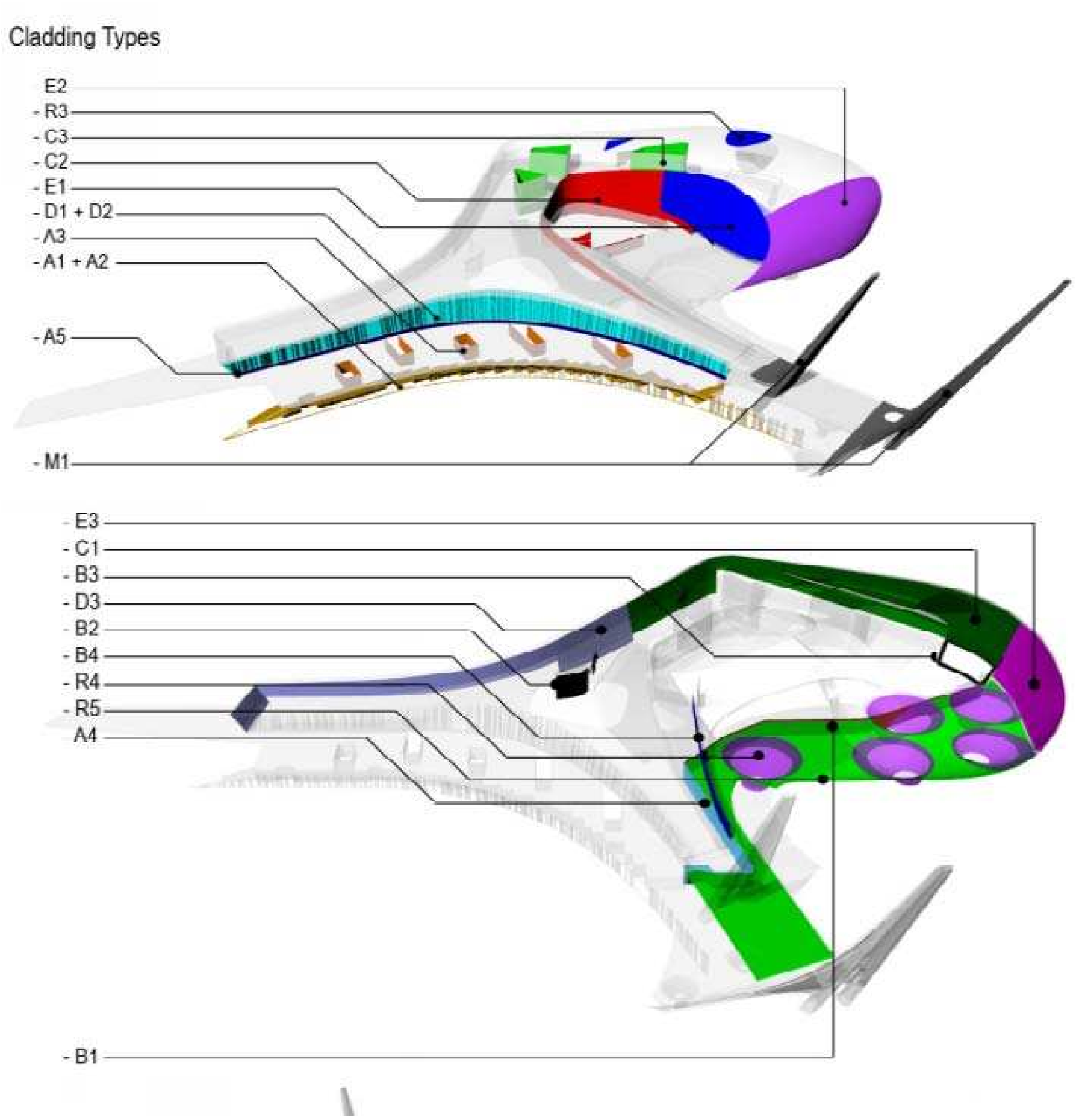

Fig. 5: Cladding types

The text of the calligraphy will be laser cut from a 10mm stainless steel plate and will contain parts from the Quran. It will be applied on the Mosque columns and roof.

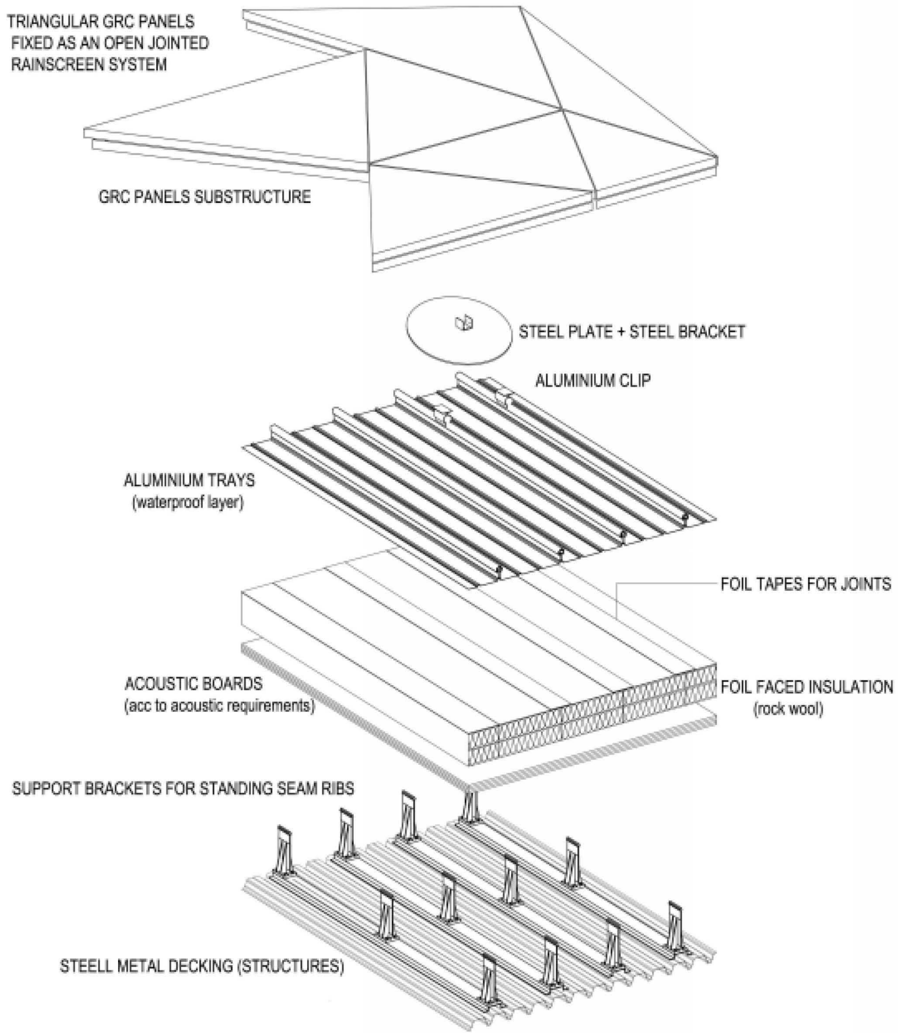

Fig. 6: Roof system with GRC panels

CONCLUSIONS

This complex geometry building is another example of excellent use of structural steel in order to achieve unique shapes for facades, and to combine and provide supporting system for various types of architectural cladding and roofing materials. Glass and Cladding specialist subcontractors will provide solutions for fast erection, installation as well as structural and architectural detailing. Challenge will be the proper co-ordination between different trades and particularly cladding/steelwork at the interfaces.

PROJECT DATA

Client: Qatar Foundation / Qatar Petroleum
Consultant: ARUP
Architects: MANGERA YVARS / RHWL
Contractor: To be appointed (Project at Tender Stage)
Project Duration: 25 Months

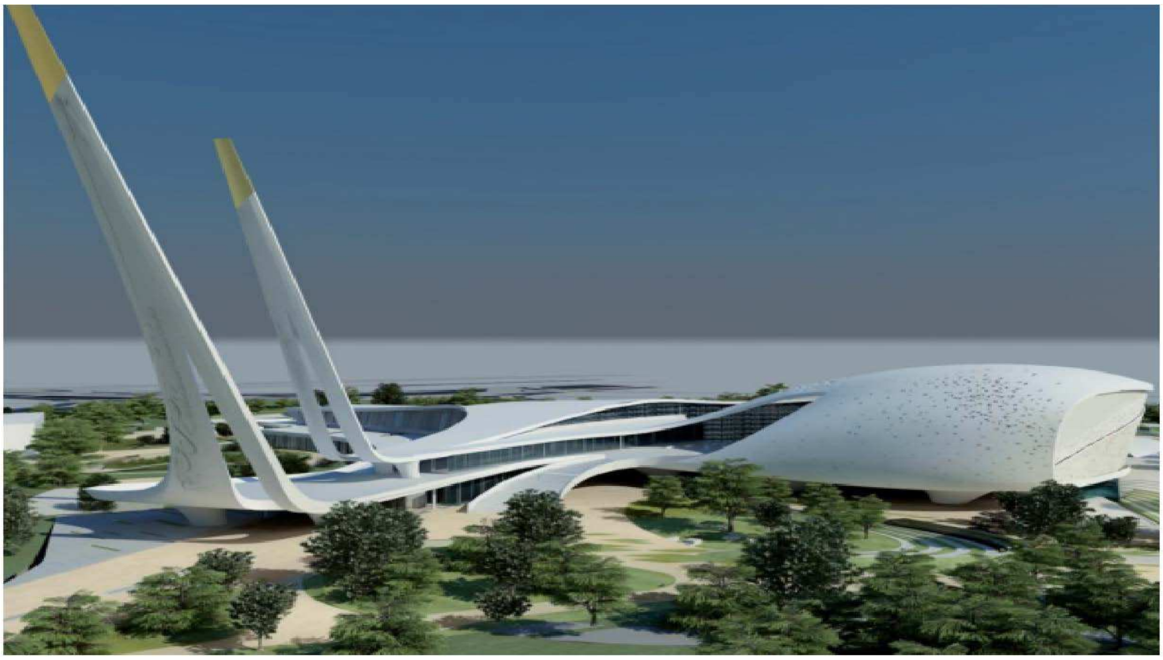

Fig 7: Overall view of the project – Completed (Image)

ΠΕΡΙΛΗΨΗ

Το Κέντρο Ισλαμικών Σπουδών στο Qatar είναι ένα κτίριο συνολικής επιφάνειας 45,000 m^2 και βρίσκεται στην πρωτεύουσα του κρατιδίου, την Doha. Αποτελείται από τη βιβλιοθήκη, το χώρο του Πανεπιστημίου (αίθουσες διδασκαλίας), την αίθουσα συνεδρίων και διαλέξεων, το τζαμί και τους επικλινείς μιναρέδες

Οι τυπικοί όροφοι είναι πλαίσια Ο.Σ με τοιχεία ενώ η οροφή είναι μεταλλική και αποτελείται από ένα σύστημα κυρίων και δευτερευουσών δοκών στηριζόμενη σε υποστυλώματα κάποια από τα οποία είναι επικλινή. Η μεταλλική κατασκευή έχει συνολικό βάρος 3200τ και αποτελεί τμήμα της όψης της βιβλιοθήκης και του Πανεπιστημίου, καθώς και του μεταβλητού ύψους τζαμιού.

Το περισσότερο ασυνήθιστο και δύσκολο τμήμα του έργου είναι οι δύο επικλινείς μιναρέδες οι οποίοι είναι πρόβολοι σε γωνία επίκλισης 25 μοιρών και μέγιστου ύψος 80 μ. Αποτελούνται από συγκολλητές διατομές μεταβλητού στατικού ύψους και η αεροδυναμική συμπεριφορά τους καθορίζεται από αποσβεστήρες, οι οποίοι τοποθετούνται κατά το μήκος τους.

Επίσης ενδιαφέρον έχουν οι διαφορετικοί τύποι επικαλύψεων για τις όψεις και την οροφή όπως τα πανέλα υαλοπλισμένου σκυροδέματος σε ειδικά σχήματα (τρίγωνα ή ρόμβοι) και διάταξη.