Sharm El Sheikh Airport Terminal Roofs

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(The following paper will be delivered with additional graphics to further illustrate the issues presented here and others – if additional information is required contact Joseph Dean, Wade Consulting Group, joseph@wadeconsult.com)

Introduction

The Sharm el Sheikh Airport Terminal building roof in north east Egypt constitutes a landmark tensioned fabric structure. It is believed to be the first project in Egypt to use a two layer architectural membrane roof.

Birdair were successful in winning the contract to provide the membrane roof, steel support framing and aluminium and glass skylight system. Wade Consulting Group was commissioned by Birdair in February 2005 to provide engineering final design and drawings for the steel framing and assistance with patterning and scheduling for the fabric, cables and fittings.

The contract value for our services was between $150k and $200k which represents approximately 2.5% of the roof contract. This fee included performance and optimization bonuses.

The time allowed for the bulk of the engineering design was approx four months. Apart from a slight delay in approvals coming back this was essentially achieved and we received a performance bonus on this basis.

Project Details

Project Name: Sharm el Sheikh International Airport
Location: Sharm El Sheikh, Egypt
Owner: The Egyptian Company for Airports
Architect: dar al–handassah
Roof Fabricator: Birdair
General Contractor: Saudi Binladen Group

Total cover area: 15,700 m2 (168,993 sqf)
Fabric area: 33,000 m2 (355,209 sqf)

Year of completion: 2006

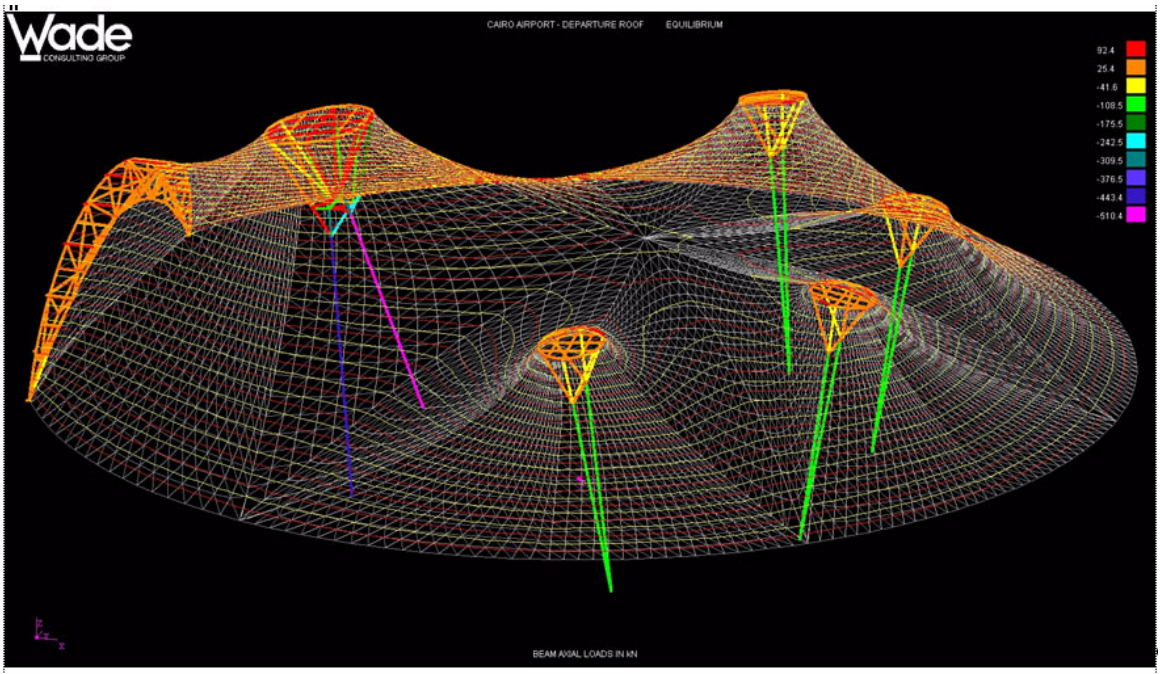
Membrane type: Outer Layer PTFE Sheerfill I
Liner Fabrasorb I

The terminal building comprises a central link building and arrival and departure halls. The central link building or ”boat” structure is concrete as are the perimeter ring beams and columns for the arrival and departure halls. The roofs of the arrival and departure halls have an outer layer of Sheerfill I and a Fabrasorb I liner separated by approximately 400 mm. The two layers of PTFE fabric are supported by steel and cable framing and aluminium extrusion at the perimeter are the subject of this discussion. The two halls are essentially 100 metres in diameter, the arrival hall is framed with arched steel trusses on columns while the departure hall features five steel rings supported by branching columns.

Design

The drawings we received indicated that a preliminary design for tender drawings had been done by Tensys Consultants and Tony Hogg Design. A tender pricing design check had also been undertaken by Birdair. This meant that much of the design work was fairly routine, confirming member sizes and further detailing the substantial connections.

The roof structures were modelled and analysed using dedicated membrane and cable net finite element modelling software MCM / MCAP written by Martin Brown. Other in–house post processing software was used to refine the design. Some aspects of the steel framing were also modelled and checked in SpaceGass.

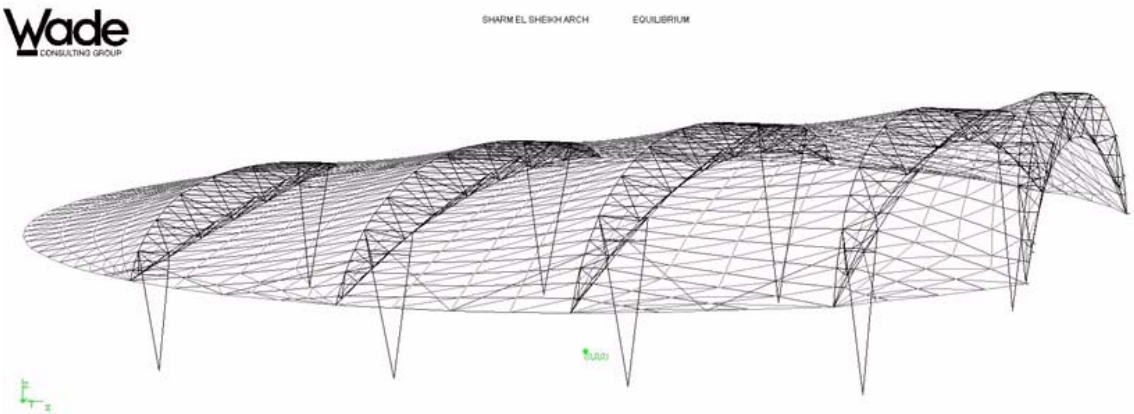


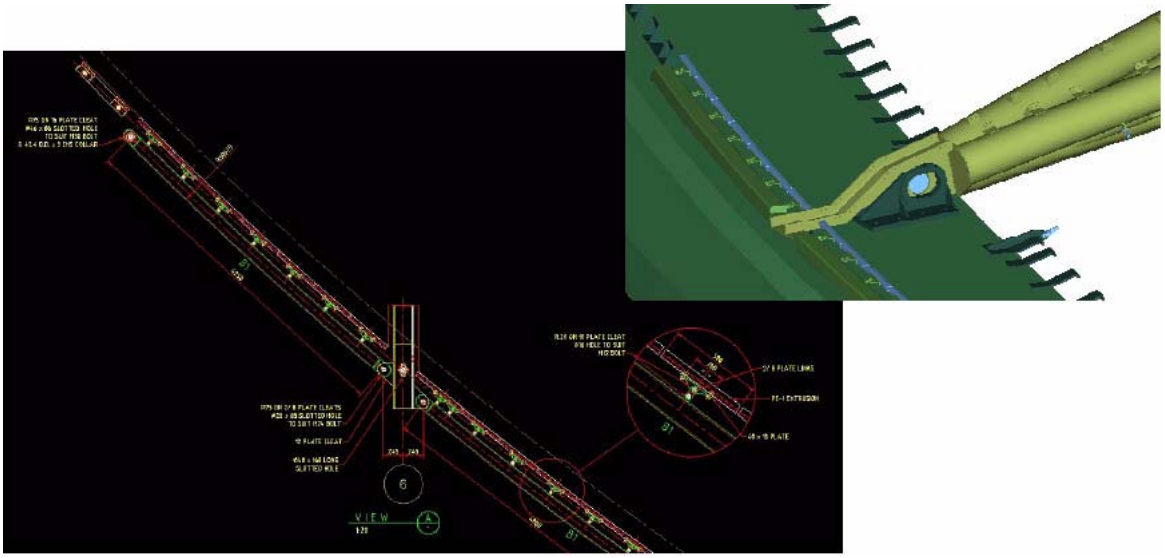
Reactions to the footings and perimeter ring beam were determined and provided to allow checking of the perimeter frame and footing design by the local concrete designer. Design work on the roof structures was carried out by us from April to August 2005.

Design Challenges

A significant design constraint imposed by the concrete support frame designers was that the arches for the arrivals hall were to impose no significant lateral thrust on the perimeter ring beam. To achieve this, a slotted hole was provided at the arch truss anchor points to allow this point to move horizontally in line with the truss.

The preliminary design intent was that the fabric was to be fixed by bolt rope and extrusion to both the arch trusses and the concrete ring beam. The potential movement of the trusses relative to the concrete ring beam created a situation in the corner where the fabric could be very highly stressed by this relative movement. The solution we settled upon to overcome this difficulty was to provide a pivoting clamp beam approximately 4 metres long on either side of the truss end. This beam provided a transition zone for the fixed edge of the fabric between the movement at the end of the truss and the concrete edge beam.





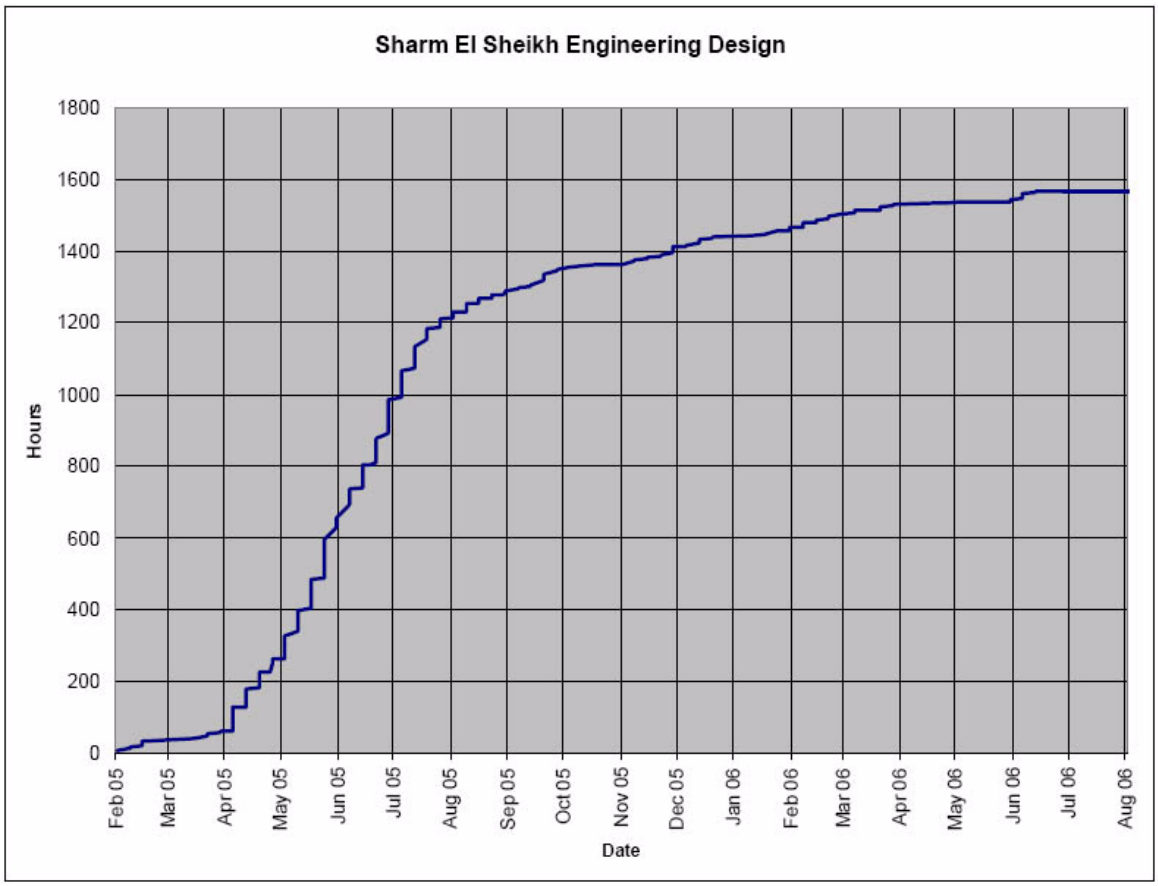
Extra Engineering Support

The fabric is attached relatively symmetrically to each side of the arches trusses. The design of the top face of these trusses did not require fully triangulated truss action therefore no diagonals were included in the design. The fabricator chose to build these trusses on the side so when it came time to lift the trusses into place it was found that significant deflections would occur.

We were asked to provide details and strengths of temporary rigging required to allow for safe lifting of the trusses. Analysis of the lift cases for single trusses were carried out and temporary diagonal chains, cables and steel were specified to allow the lift to take place safely. The lift to vertical was achieved by three cranes and the final positioning by one very large site crane.

Further Comments

While our design phase was targeted for four months the graph of hours spent on the job shows that the subsequent phases and unforseen assistance like support during erection etc added significantly to the cost of the engineering design. These elements should not be under estimated and we were fortunate to have a client in this case who valued good engineering support.



Wade Consulting Team

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Lead Drafter – Mark Bovill

From our company point of view this represents a landmark project which we carried out quickly and to the complete satisfaction of our client.