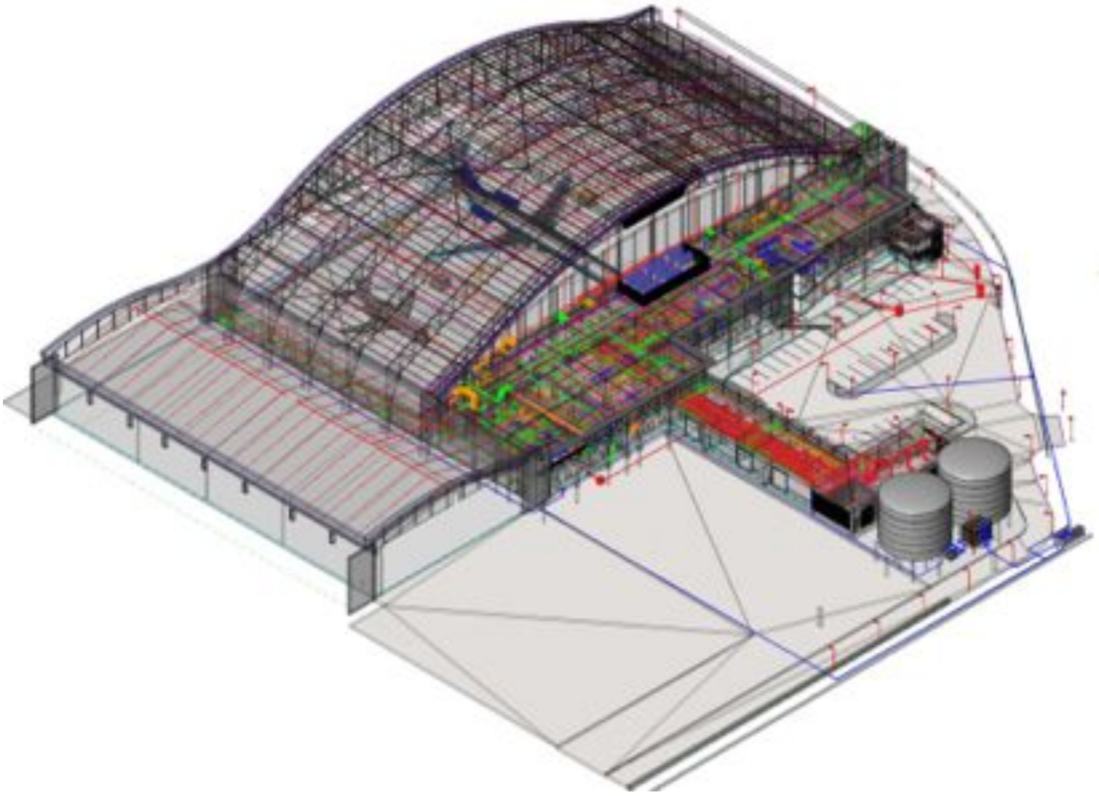

BIM AWARD 2013

Jet Aviation Maintenance Hangar

Singapore

July 2013

Mott MacDonald

Mott MacDonald BIM Award Entry

Jet Aviation Maintenance Hangar, Singapore

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Contents

1. Synopsis

Mott MacDonald is the Engineer for a 5000m^2, 100m span maintenance hangar for Jet Aviation in Singapore. The detailed design, using a MM-led BIM model, integrated Architectural, Geotechnical, Civil, Structure, Fire, Mechanical, Electrical and Public Health.

The teams utilised BIM to provide a complete and unique perspective allowing the engineers and architect to manage design risks prevalent in traditional 2D designs.

Engineering services were rapidly rationalised, modelling the stressed arch superstructure, cost-effective and safe solutions for incorporating the fire suppression system in the roof before being lifted into its final position were completed.

The team demonstrated the power and efficiency of BIM that enabled MM to maintain a fast track design programme to the satisfaction of the client. Successful review of outputs of the BIM model by HMM led to achieve Accredited Checker and Authority approvals.

The model is used to demonstrate our BIM capability and the benefits it can bring to future clients resulting in new project appointments.

MM Singapore has, with MMHK's assistance and experience, broken into a new market. By winning this aviation project, which is the first hangar in Singapore designed using BIM, it demonstrates how BIM maximised our extensive skillset across the globe, representing commitment to further improve our business.

2. Introduction

In July 2011 Mott MacDonald were appointed by Jet Aviation for the design of a new 6000m^2, 120m span maintenance hangar at Seletar Private Airport in Singapore. The Switzerland based company (owned by General Dynamics, producer of Gulfstream Jets) provides aviation support services around the world.

The hangar was designed to provide state-of-the-art maintenance services safely and efficiently for the new generation of Boeing Business Jet and Gulfstream G650 and other private aircraft types. These Jets are partially fuelled within the hangar.

As part of the brief the initial design was modular such that the facility could be replicated across other airports in SE Asia.

The 120m span concept design was completed in early 2012. Due to constraints, an area of 5000m^2 and 100m span hangar was approved by Jet Aviation Zurich to be delivered via Design and Build contract.

A good relationship had been established with Jet Aviation in Zurich and Singapore whilst assisting them with the re-design. As a consequence, Jet Zurich instructed Aircraft Services Industries (ASI), the Design and Build contractor, to employ Mott Macdonald as the Engineer.

Mott MacDonald started the fast track detailed design in October 2012 and The hangar is due to be operational in time for the Singapore Air show in February 2014.

3. Mott MacDonald Design Team

3.1 Design Team - APNA, SEA, Singapore

Gregory Cox	Project Director
Abdul Rahman Wahab	Project Manager and Structural Lead
Tay Khye Lam	BIM Lead
Jonathan McCallum	Geotechnical Lead
Thomas Tan	Structural
Joanne Lim	BIM
Hwei Gjin Ow	Mechanical Lead and Coordination
Alina Remez	Mechanical
Govinda Muthu	Electrical Lead
Kelvin Tay	Electrical
Aditya Santoso	Fire Lead
Jerome B Custodio	Fire
Damian Izzard	Risk and Legal

3.2 Reviewers - APNA, SEA, Singapore

Soon Won Moi	Civil and Structural
Ong ThiamGuan	Mechanical
Soh KaiYea	Electrical

Region, Unit	EUNA, BNI, London
Justin Garman	Fire

Region, Division	MESA, Dubai
Kim Hunt	Public Health

3.3 Peer Reviewers - NASA

Hatch Mott MacDonald	CAMIS / USMBL
Christopher Solecki	Aviation Practice Leader
Alex Van Groenewoud	Aviation Deputy Practice Leader

4. Collaboration

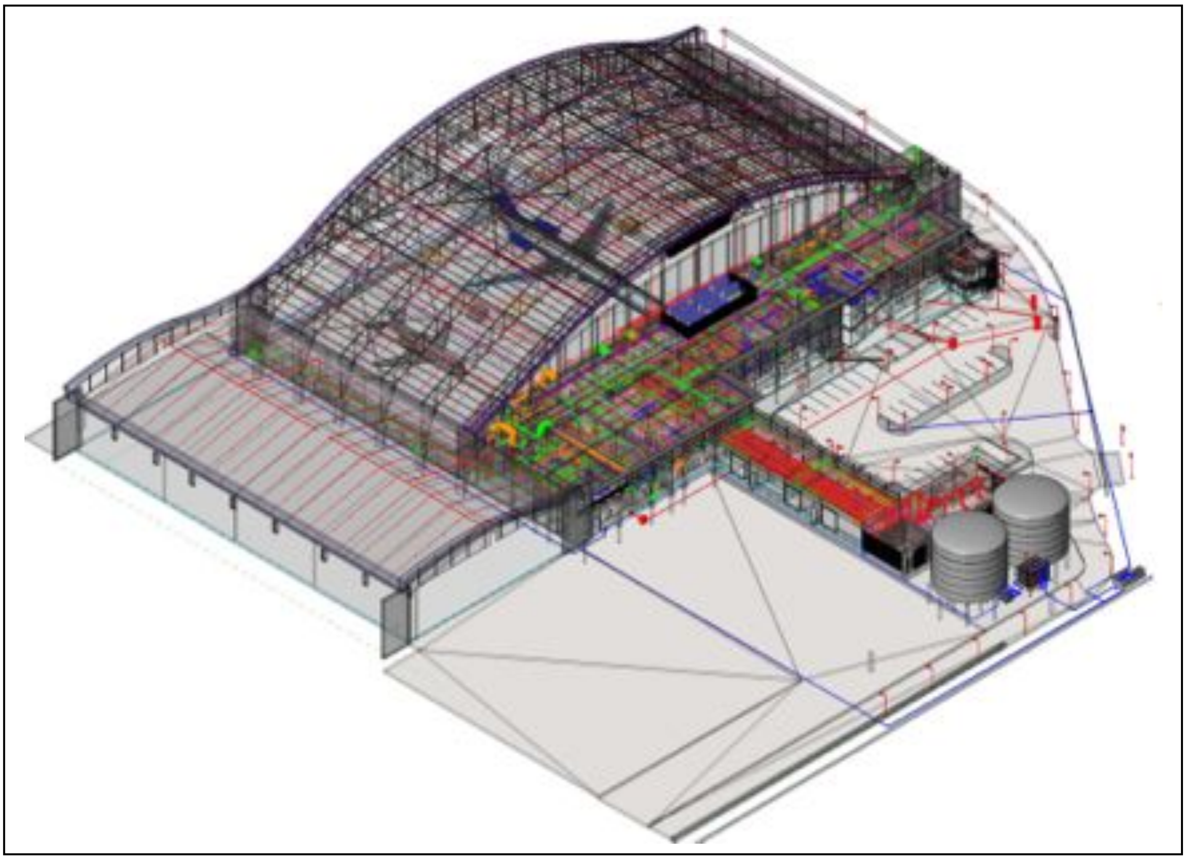

Fig 1 Hangar Model (Mott MacDonald)

Designing the hangar was a true collaborative effort involving:

- The design, review and peer review teams in five Mott MacDonald offices across all four regions
- Lu and Wo architects in Singapore (BIM Partner),
- Jet Aviation Singapore/Zurich (Maintenance team to understand areas and preferred ways of improvement of safe working and efficiency),
- Main contractor (ASI)
- Holmes Consulting Group in New Zealand (Stressed arch designer, to understand the erection methodology so the foundation system could be designed for the most onerous design case, frame geometry concept),
- Manufacturers of key components (e.g. aircraft services pits, deluge flow control valves, generator fire pumps, foam injection systems, linear and beam fire detection, fire tanks, compressed air systems, aircraft task lighting etc.)

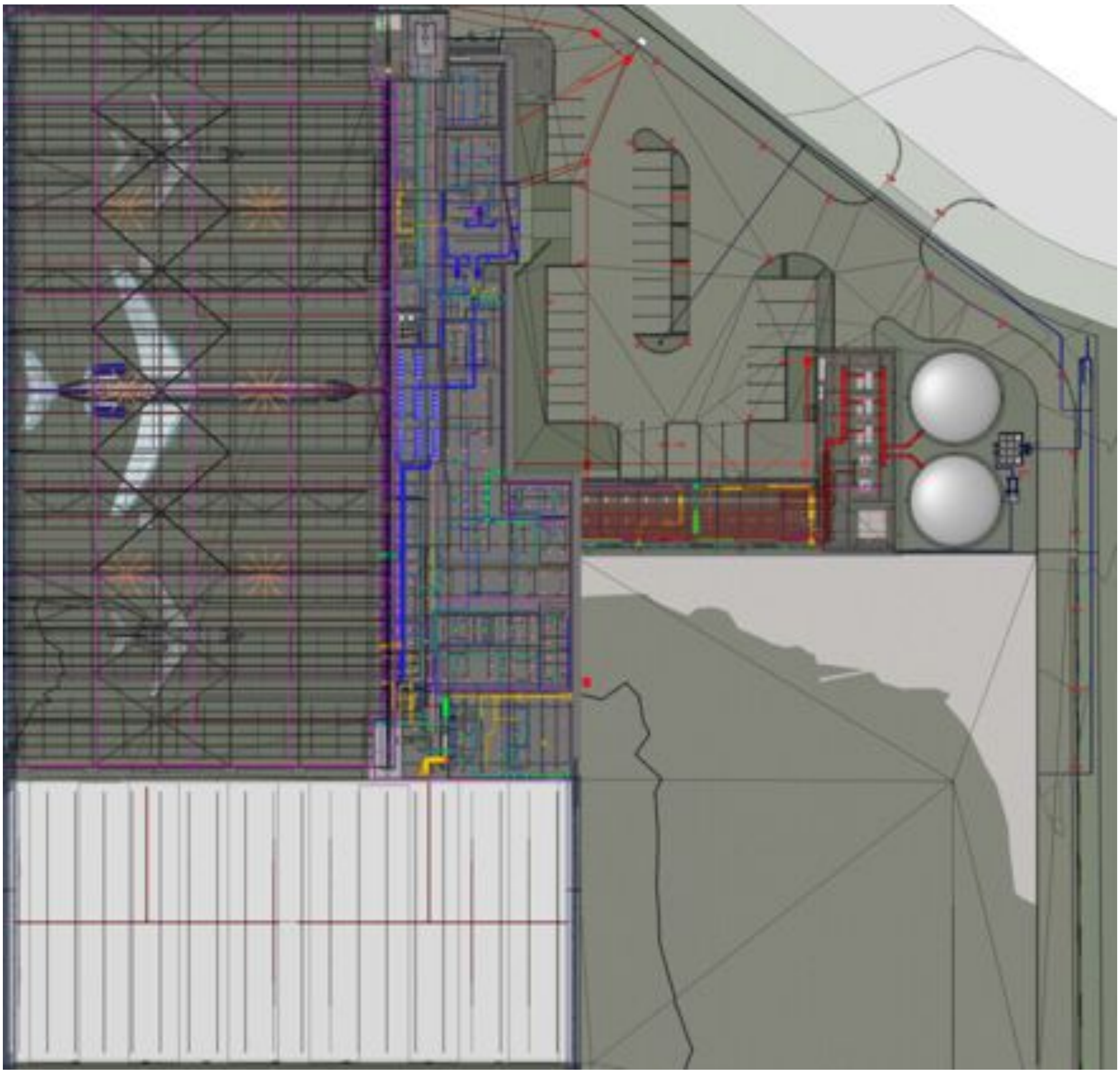

Fig 2 **Hangar Site Plan Extracted from BIM - New Hangar (top left), Existing Hangar (bottom left), workshops, Generator Driven Fire Pumps and Fire Tanks (centre and right) (Mott MacDonald)**

There was extensive collaboration on the design of the fire systems for the group class 1 aircraft hangar. The design was reviewed by MM's fire team in London and submitted to the Singapore Fire Authority for approval. The MM fire strategy report used elements of the BIM model to present MM proposals.

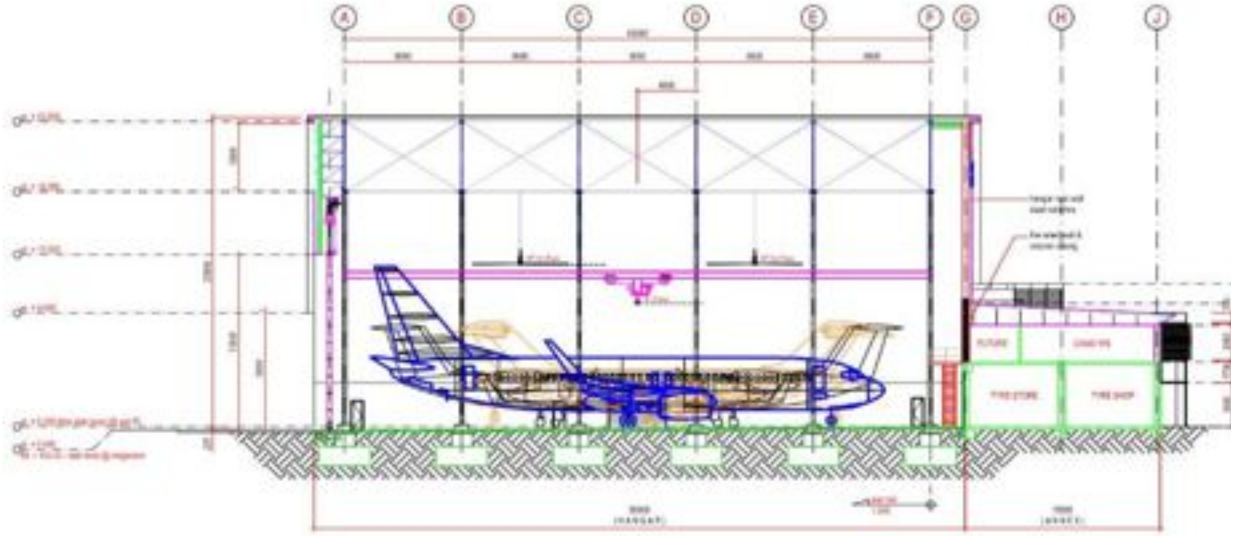

Fig 3 Cross section - new hangar (Architect)

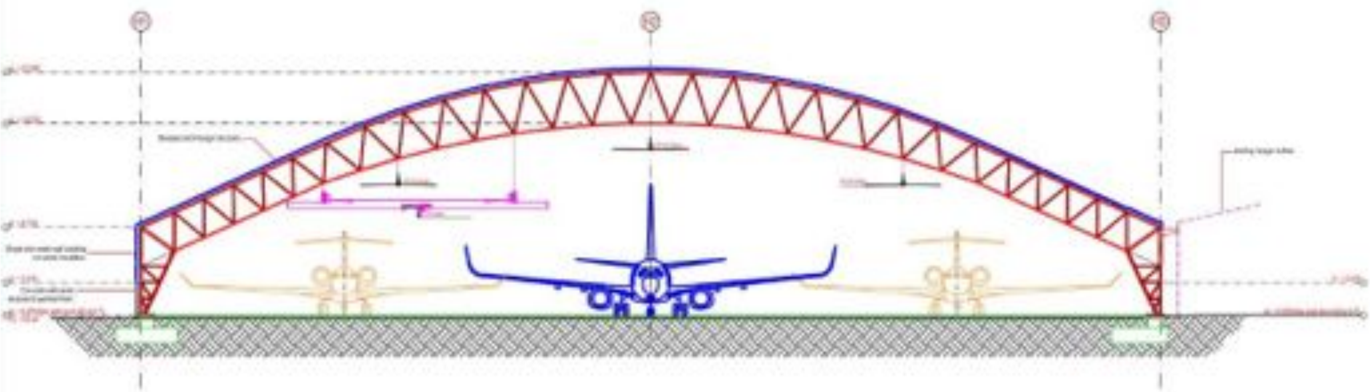

Fig 4 Longitudinal Section - new hangar (Architect)

5. Improved Process

The foundation design was incorporated early into the BIM model. Forces developed from the BIM Tekla software were used to rationalise the piling plan taking into account the mixture of vertical and horizontal loadings which required the design of a pile collar or muff to accommodate large moments in the upper portion of the spun piles.

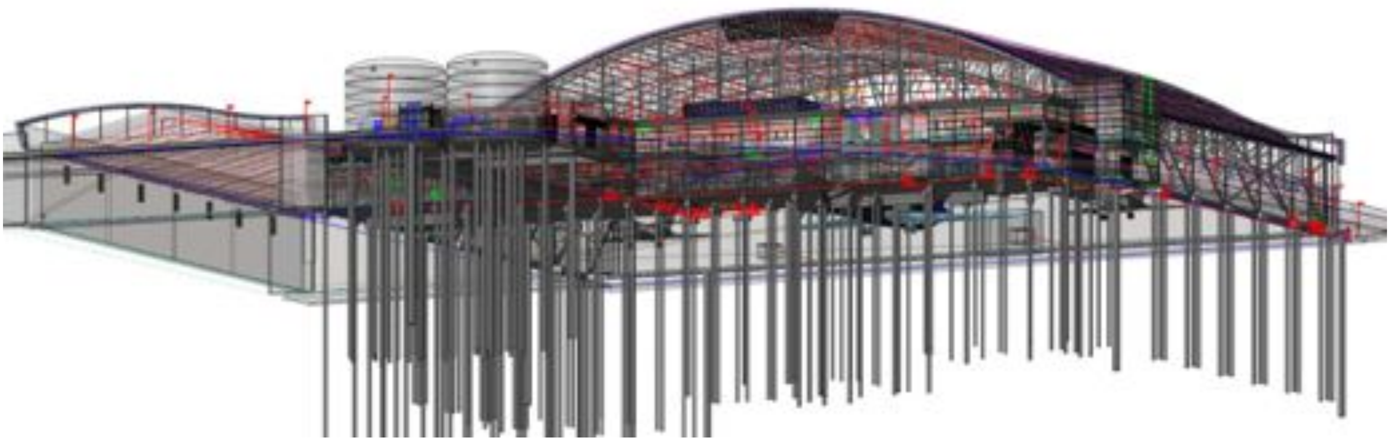

Fig 5 Foundation Design

In addition to design coordination and clash detection, which is an established part of the BIM process, simulation of the installation of foam deluge pipework in the initial horizontal situation was carried out in BIM, to ensure buildability. With the installation at ground level, the fire services are lifted into position as part of the roof frame and we had to address the foreshortening of lower structure longitudinal dimensions to avoid mechanical stress during the lift.

This was part of the decision making in using a configuration of ten fire zones, each across the full width of the hangar. Connections of deluge pipework longitudinal to the hangar were supported on the top nodes to reduce movement. We then calculated the pipework forces in discharge mode for anchoring design.

Using two hydraulic programs, a static and dynamic analysis was carried out at every node of the foam deluge system due to the roof curvature. This was necessary to achieve the minimum discharge density within the variances specified in NFPA. Dimensional data was taken from the BIM model into our hydraulic analysis and shared with the client’s fire engineer who was able to review and interrogate the calculation results independently.

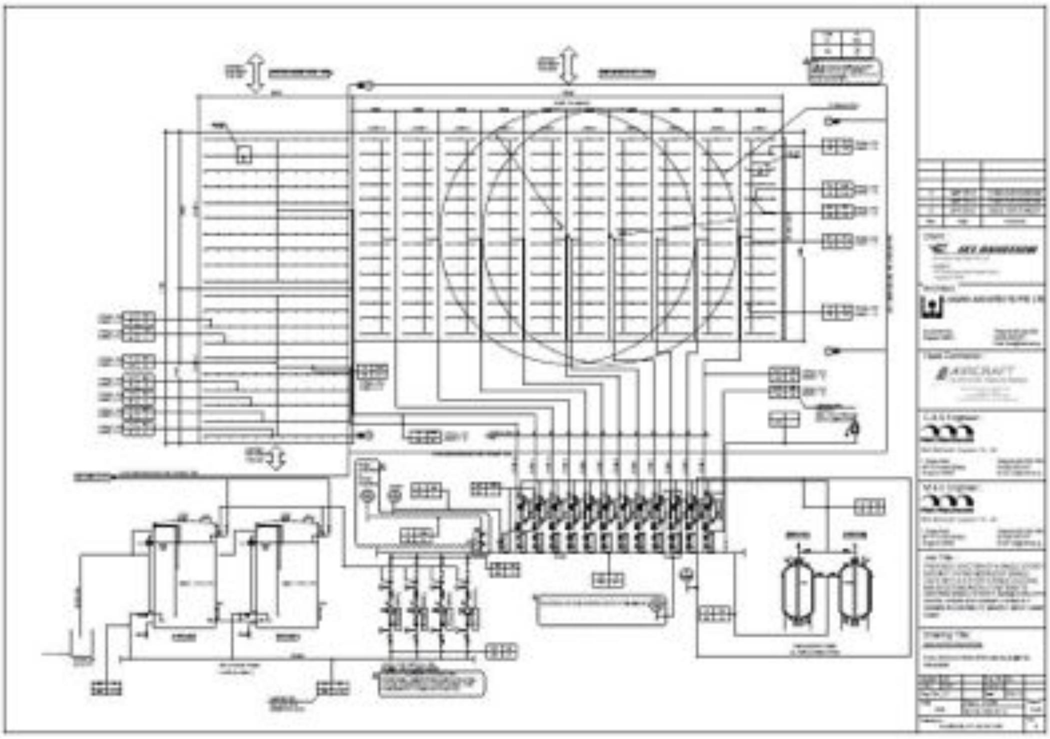

Fig 6.1 Schematic Design of Deluge Fire System Zones to NFPA and to meet the hangar structural design

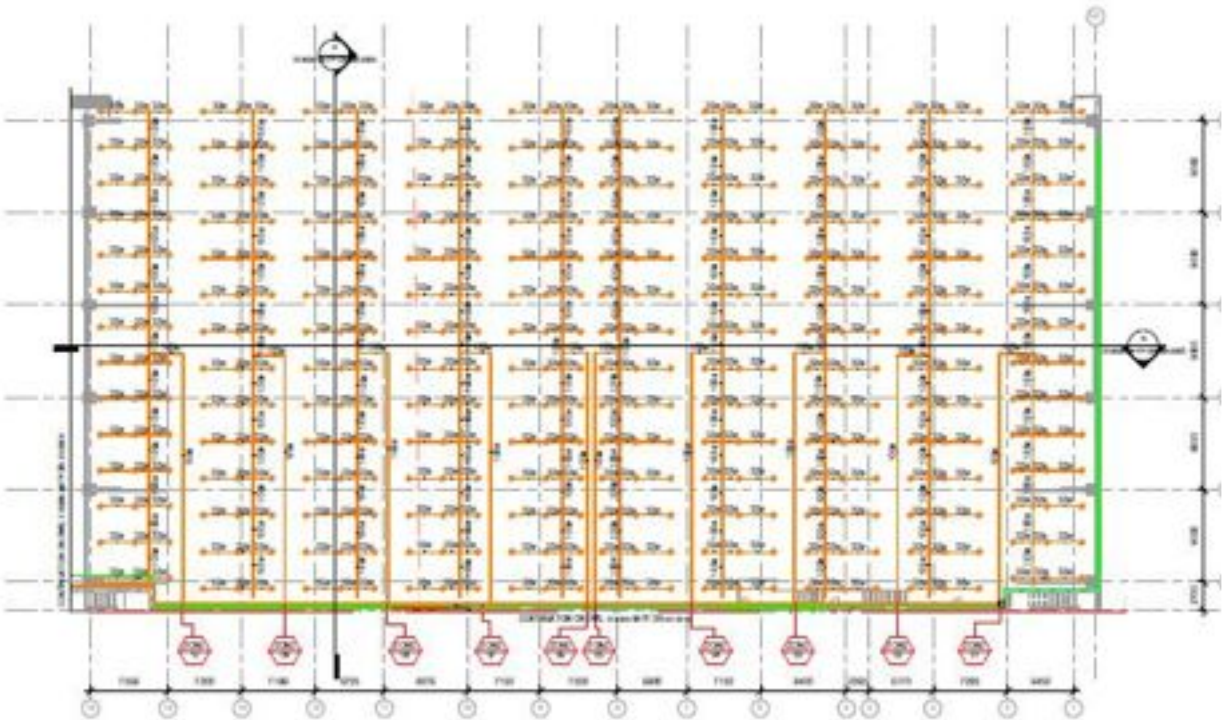

Fig 6.2 Schematic Zones of the foam deluge system translated to detailed design extracted from the BIM model

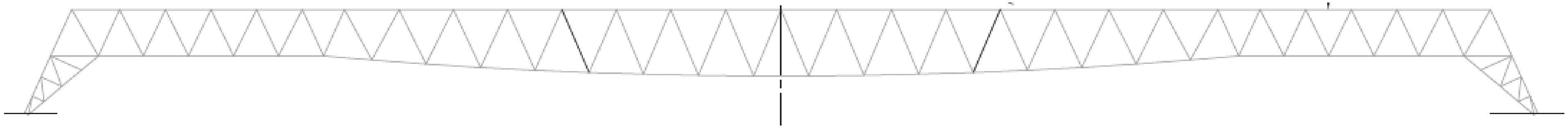

Fig 7.0 Structural roof frame schematic in its initial position for installation of deluge foam fire systems prior to being lifted.

6. Adding Value

Ground service pits are a key component in the maintenance of aircraft. They provide the aircrafts 400Hz, normal 50Hz, 3 phase and compressed air supply. These are positioned close to the aircraft under maintenance avoiding key health and safety issues of trailing cables across the hangar floor. The selection, alignment and integration of the high value engineering components is complex with an interactive decision making process involving Jet Management, Maintenance, Fixed Operations, Airport Services Industries and ground pit manufacturers in Sweden and Germany interfacing with Mott MacDonald.

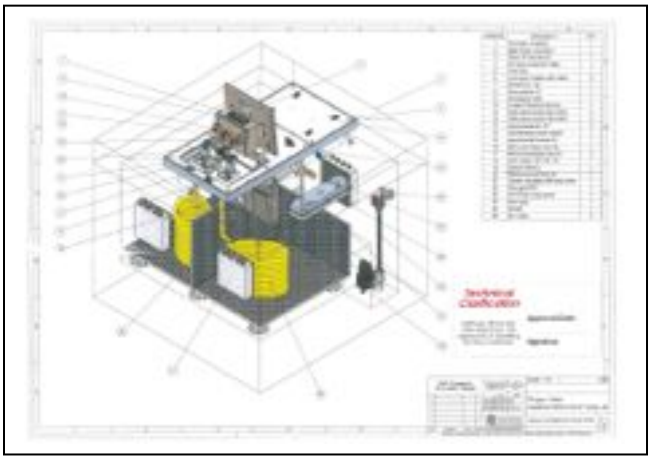

Fig 8.1 Ground Pits (Cavotec – Germany) (These are translated to the MM macros)

Unlike fixed commercial aircraft stands, flexibility in parking was a basic requirement. Originally eight service pits were designed within BIM. A more cost effective solution was then developed with two central pits and seven extended ground trenches at the perimeter on the model.

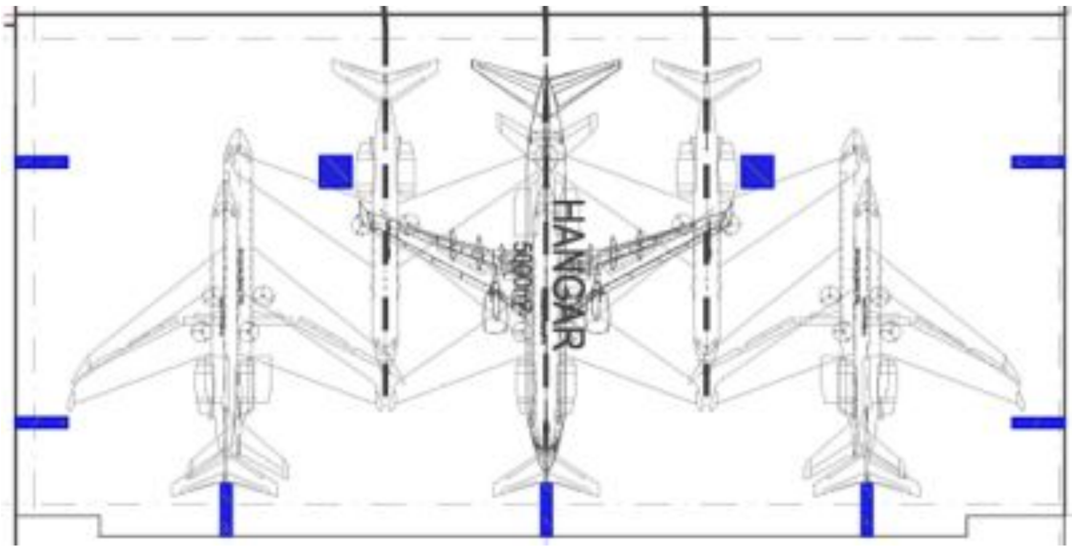

Fig 8.2 Ground Services Pits (Centre) and Ground Service Trenches (Perimeter) (Mott MacDonald)

Another major part of the design process was the analysis of aircraft waste and foam containment in the event of a fire situation and foam discharge. Closely working with the Singapore Environmental Agency, the BIM model was used to identify and analyse the spread of foam and containment in a discharge (Some 1400m^3 discharge over one hour in a fire event).

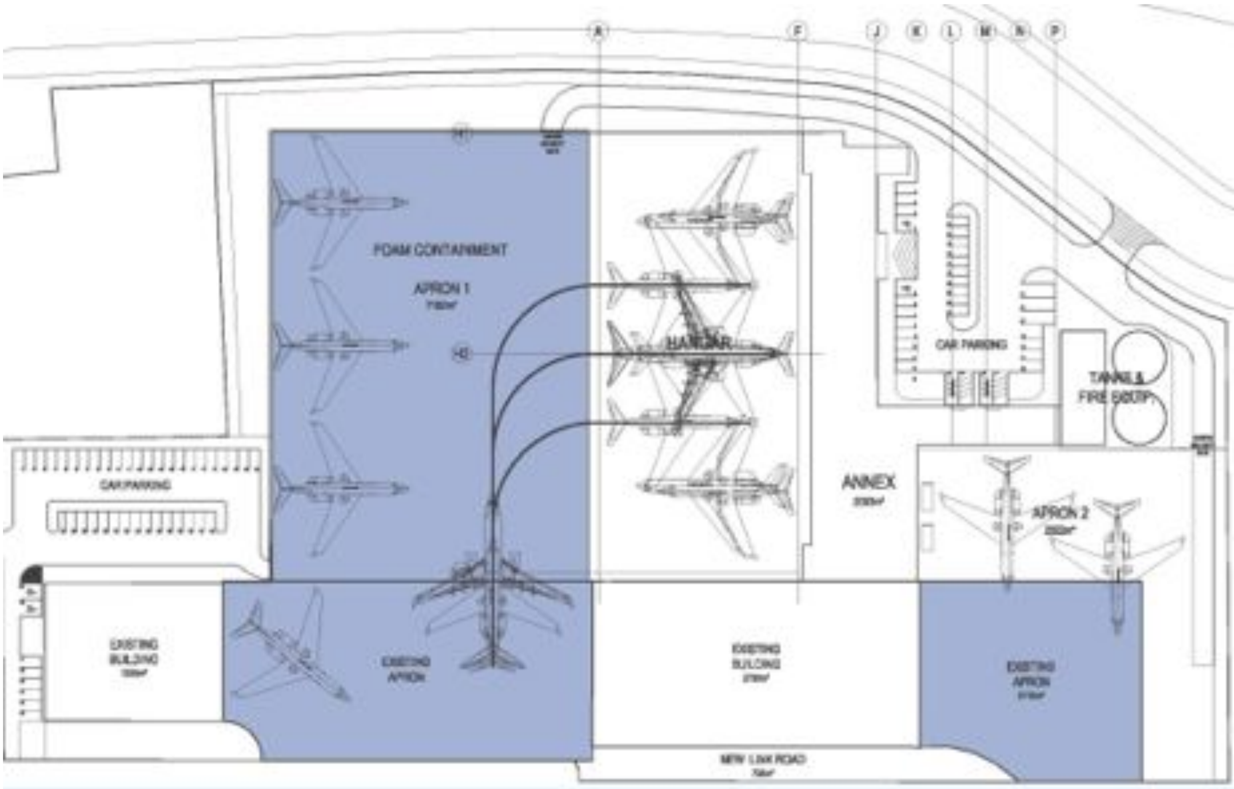

Fig 9 Environmental plan for foam containment within shaded areas (Mott MacDonald)

7. Interoperability

The hangar structural design used a proprietary stressed arch system which MM modelled independently to verify the design then submitted to the local authority for statutory approval.

MM used BIM Tekla software to model the arch and design the foundation system, which was transferred into the Revit Model. In parallel, this proprietary information is used by specialist steelwork contractors to produce working drawings and connection details which were checked by MM against the BIM Model.

The overall budget limitations drove the iterative process of structural and foundation design optimisation, that was a key to the most economical outcome.

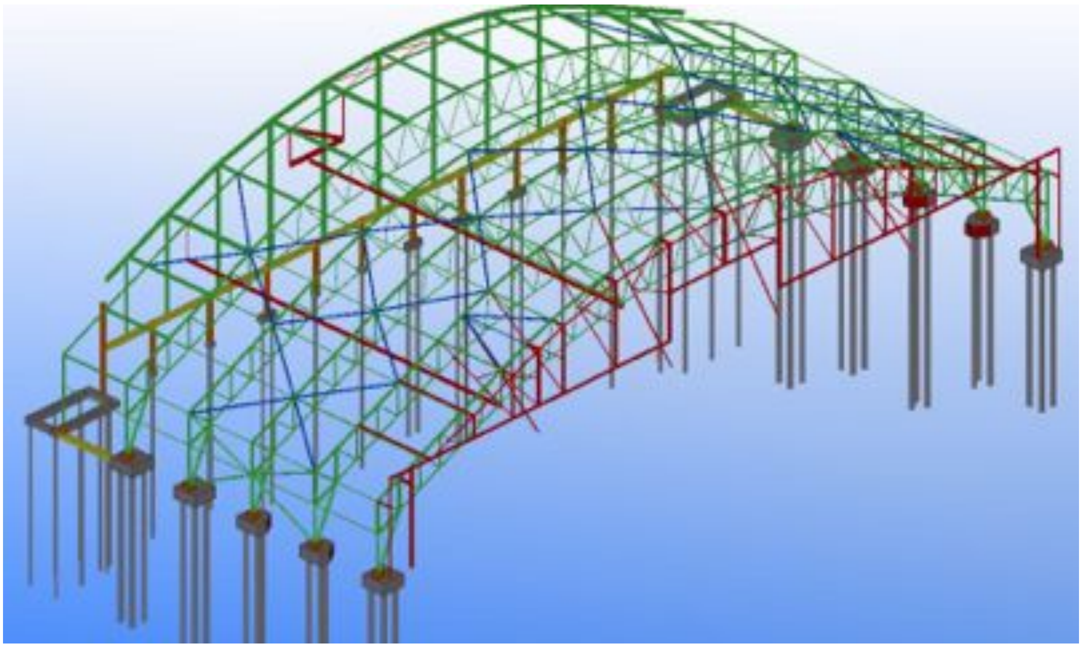

Fig 10 Tekla Model (Mott MacDonald)

8. Client Relationship(s)

The good relationship developed with JA and GD whilst working in a collaborative manner on alternative systems resulted in re-employment of the design team for the new scheme.

The re-design on BIM was not without issues and managing the client's expectations was crucial.

The time taken to produce the initial model, such that meaningful drawings could be extracted, was not as the contractor's programme. The programme was reworked (see Leadership) and after seeing the model in development in Singapore, when detailed drawings could be extracted, the client had confidence in MM's ability to deliver the project. After personally reviewing MM's work, the Airport Services Industries Manager stated:

"Our Design was the best documented engineering of all the hangars they had built to date."

9. Leadership

The decision to use BIM was made with the Architect when MM was appointed as Engineer for the second design (100m span).

MM's BIM Manager led the development of the model with the Architect.

Economical approach for procurement required the flexibility to extract individual discipline package tenders from the model.

The early difficulties of BIM was overcome by Mott MacDonald's leadership in producing a detailed design programme including, statuary approvals without change to the construction end date. Through appropriate MM change management, the extra programme work was paid for by the client.

MM led the discussions between the statutory authority, main contractor, architect and sub-contractors with aid of the BIM model.