CAREER EPISODE 1

Construction of New Muscat and Salalah International Airport

INTRODUCTION

CE 1.1 In this career episode I would be describing my project to construct New Muscat and Salalah International Airport in Muscat, Oman. The project started in Feb 2011 and was completed by Dec 2016. I was working for the organization Hill International as Project Engineer – Lead Structural Steel. The main purpose of this project was to expand and modernize the existing airport. The capacity of the newly established airport is around 12 Million passengers per annum with the extension up to 20 Million passengers. The project was spitted in several phases MC3 Main Terminal, MC2 – Control Tower, MC5 – Salalah Airport, MC8 – Baggage Handling System etc. The objective of this project was to build and construct a new control tower, terminal building along with all the other ancillary buildings, access ramps, bridges, roads and car parking, and baggage handling systems.

BACKGROUND

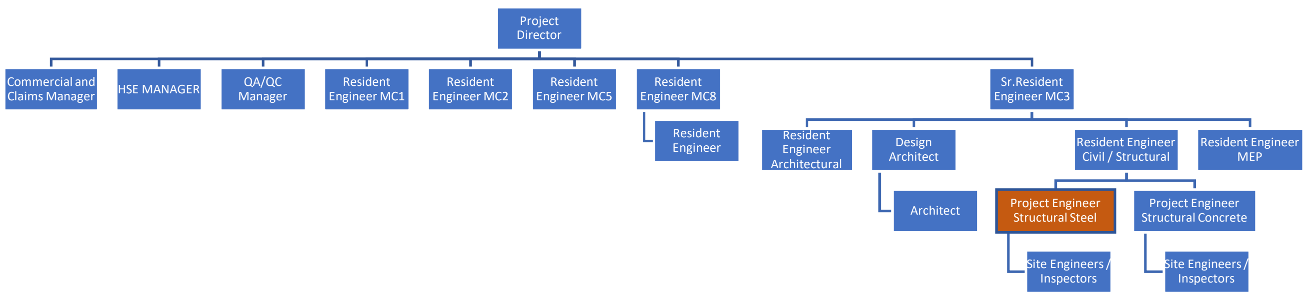
CE 1.2 Hill International was appointed to provide consultancy and construction supervision services taking over from the previous consultant COWI-Larsen JV where I was working. During the transfer process I was employed by Hill International as a Project Engineer to lead and supervise the steel structure package.

CE 1.3 My main project responsibilities were:

- To study and improve the specification for the steel structure and design performance reports.
- To examine the IFC (Issued for Construction) drawings, calculations and design basis document.
- To inspect and verify the construction materials used for connections and main structural steel elements.
- To evaluate and validate the method statements, procedures for delivery and fabrication of structural steel.
- To monitor the delivery, assembly and erection progress of structural steel and provide a progress report to the management.

- To ensure that the HSE requirements are met before and throughout the construction activities.
- I managed and coordinate a team of site engineers/inspectors for inspecting the supplied and installed elements and ensure the completed job is as per the project specification - client expectations.
- I monitored the design changes and ensured proper implementation.

CE 1.4 My reporting hierarchy was



PERSONAL ENGINEERING ACTIVITY

CE 1.5 I started with evaluation of the project specification and design performance documentation. I studied IFC (Issued for Construction) drawings and evaluated of the design calculations of the main structure. I found that some details not fulfilled by the contractor Bechtel - Enka JV and I organized meeting with all the parties to highlight these issues and agreed on a suitable solution.

CE 1.6 The project was already running for almost 12 months, after the investigation I found that the structural design for the main structure passenger terminal building and connection details was already approved. I secured approval on the remining design calculations and approval of the construction materials before commencement of the installation. I ensured that the execution of the project in particular the steel structure is as per the client specifications and relevant standards.

CE 1.7 I requested the planning manager for baseline schedule with resource-loading to observe the critical activities, milestones and man-power requirements. One milestone was the approval of the connection design. I resolved and accelerated the submission of the connection design. Using my experience and academic knowledge for the design of structural steel, I reviewed and approved the design documents. For the validation of the design, I used the, BS 6399, BS 9590, UBC1997 and BS EN 1993 codes. The verification of the connections was done using STAAD structural analysis and Prokon software.

CE 1.8 After investigating the design documents, I proceeded with investigation of the documentation required for the installation of the structural steel. These documents were: method statement for installation, inspection and test plans and site procedures for multiple activities.

CE 1.9 I organized workshops with the contractor to go through the critical activities and shared my experience for management of storage, assembly and installation conditions and investigation of lifting studies and lifting methodologies. I ensured that all the aspects of HSE are described and elaborated, since most activities are categorized as high risk.

CE 1.10 Throughout the execution of the project, I monitored/examined the progress of the storage, assembly and the installation site activities as per the tolerances in the BS EN 1090-2. I verified the conditions of the site welding by NDT (Non-Destructive Tests) for the structural welds. I examined the bolt tightening activity with the calibrated torque wrench and its compliance with the approved procedures and finally, I verified the DFT (dry film thickness) of the paint applied during the touch-up activity.

CE 1.11 I ran Random test on the steel structure elements; Onsite testing of welds using NDT (VT, UT, MP) Tests; Onsite testing connection bolts using bolt load meter and torque wrench to determine the pretension load; Onsite testing of post installed anchor bolts; Onsite testing -pull out test on the corrosion painting; Onsite testing on Intumescent and Cementitious Fire Protection Paint, and Onsite DFT inspection on the applied corrosion protection system

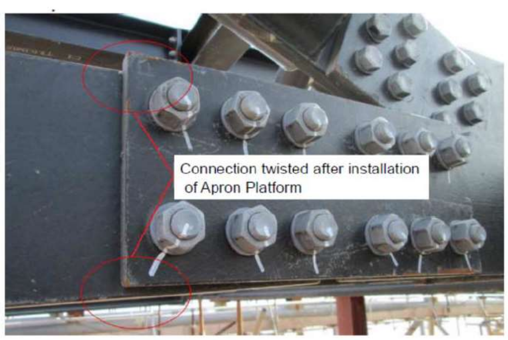
CE 1.12 I was responsible for resource allocation required for the inspection and following the program of works. I liaised with the authorities for approval of the drawings and design document. I was leading a team of site inspectors and site engineers to perform the site inspection and responding to all inspection requests. I met with site inspectors and site engineers every morning giving them guidance and controlled the nonconformities with NCR’s and quality action observations.

CE 1.13 I and my team prepared daily & monthly reports for the status of the reviewed submissions, construction works, and all the site inspections drawings, reports, method statements, shop drawings, procedures etc.

CE 1.14 I participated in commercial discussion for claims, modifications and arbitration related to the main steel structure package.

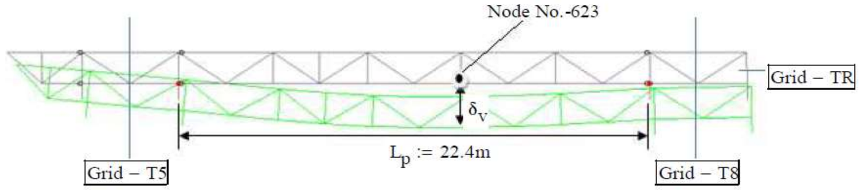
CE 1.15 I took HSE trainings for high-risk activities, project management PMP training, Primavera & planning management training and Bentley Structural Building Analysis – STAAD and RAM design training. I also completed my master's thesis for "Numerical Analysis Of Steel Structures For Aircraft Maintenance Hangar" and I have published a research paper under reference "*Mechanical Engineering – Scientific Journal, Vol. 33, No. 1, pp. 15–25 (2015)*"

CE 1.16 During the site inspection in the departure area at the terminal building I noticed excessive deflection of the roof structure, specifically the secondary steel trusses holding the roof system and transferring the loads to the main space trusses. I investigated if the correct methodology was followed for the installation. I also inspected the connections, and noticed excessive rotation in the connections – I took photographic evidence.



CE 1.17 I informed my line manager and raised NCR on Aconex (document management system) describing the non-conformance along with the project specification and standard references.

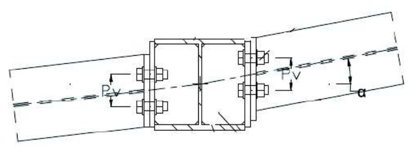
CE 1.18 I investigated the shop drawings showing the connection details and calculation reports for these connections to recheck the verification. I also evaluated the structural model and the analysis report to understand the behaviour under construction.



SL. No.	Loading Condition	Deflection at below marked node (mm)
1	Self weight without Roof Sheeting, Oval Duct and ACR excluding Live Load	46
2	Self weight, Roof Sheeting and Oval Duct including Roof Live Load without ACR	100
3	Self weight, Roof Sheeting, Oval Duct, ACR including Roof Live Load	106
4	Under complete loading at final design condition	180

CE 1.19 From the investigation I found that in there is underestimation of the connection stiffness. This underestimation contributed to a large deformation of the structure under the imposed loads during the construction.

CE 1.20 I organized a meeting with the structural coordinator and lead structural engineer to explain my observation and during the meeting where they verified my findings. I proposed to proceed with the additional welding around the connection to avoid refabricating and complete redesign.



Calculation of weld at Flange Side

Tension Stress due to Moment at flange side weld,

$$\sigma_M := \frac{M_d}{\dfrac{\left[\frac{1}{12}\cdot t_{st}\cdot D_{st}^{3}\cdot 2 + t_{st}\cdot D_{st}\cdot\left(\frac{W_{st}}{2}\right)^{2}\cdot 2\right]}{\frac{D_{st}}{2}}} = 14.172\cdot MPa$$

Vertical shear stress on weld,

$$\sigma_{sh} := \frac{V_d}{t_{st}\cdot D_{st}\cdot 2} = 14.046\cdot MPa$$

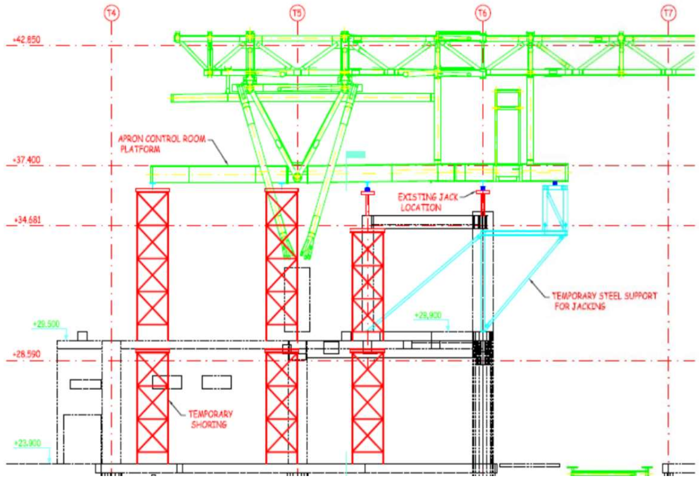
Resultant stress due to moment and shear,

$$\sigma_w := \sqrt{\sigma_M^{2} + 3\cdot\sigma_{sh}^{2}} = 28.155\cdot MPa$$

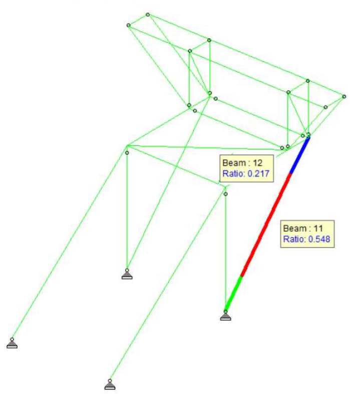
Pure tension at flange one side weld,

$$T_p := 0.5\cdot N_d = 236.635\cdot kN$$

CE 1.21 Since the structure was already deflected, I discussed several options with the contractor and we agreed to proceed with propping and reducing the loads with temporary structure that would take the self-weight loads. I instructed the contractor to submit this methodology for approval from the client.



Maximum design interaction ratio for supporting frame

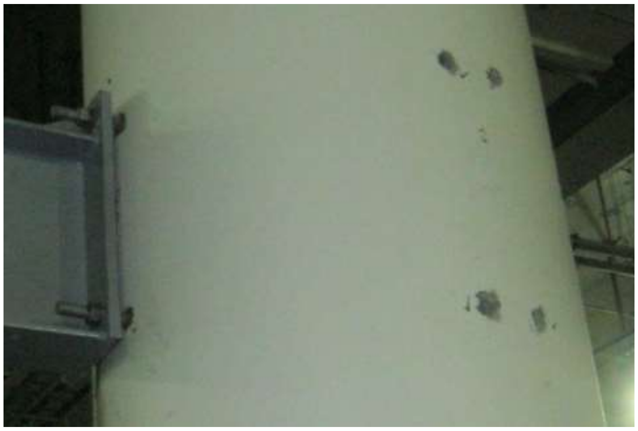


CE 1.22 The method statement and the temporary tower concept was reviewed and approved and the contractor executed the work. After completion I checked if the work is correctly, welded and give a go-ahead for de-propping. After de-propping I verified the movement of the structure if was behaving as per analysis model.

CE 1.23 During the site visit with the client around the passenger terminal building, I observed in the baggage handling area that the MC8 contractor had started the installation of the steel beams of the mezzanine floors. I observed numerous

deficiencies in the installation methodology practices, and discrepancies in installing the steel beams around the columns.

CE 1.24 After the site visit, I informed my Sr. Resident Engineer and discussed these findings with the project director. During the meeting he give me the authority to investigate, verify the design document and find appropriate solution.

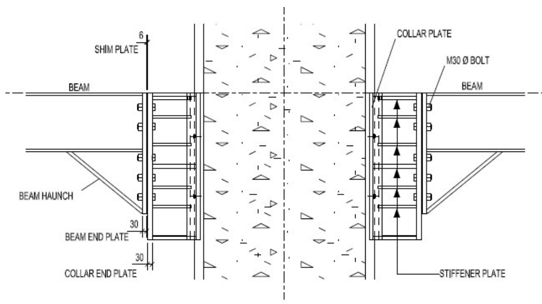


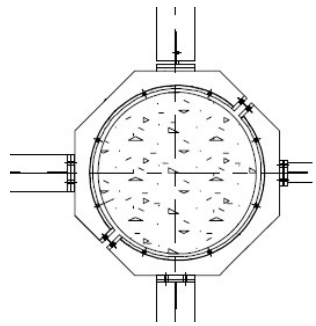
CE 1.25 I organized a meeting the responsible RE, draft the letter identifying all the non-conformances and advised him to send the letter to the contractor. The contractor also conducted a study with his design engineers to assess these observations.

CE 1.26 I investigated the design calculation reports, shop drawing and status of approval of these documents. I found there was a comment in the structural calculation that was never attended and resubmitted for approval. During the review and evaluation of the main analysis in Prokon software most of these connections were analyzed as moment connections due to the limitations on the depth of structural section where is guided by headroom space.

CE 1.27 This meant that the beams had to be designed as fixed end to contain deflections in the long spans which, with seismic requirements leads to heavy connection details required. I informed the RE for this package and strongly recommended sending NCR to the contractor and notify that the nonconformities need to be addressed at the earliest.

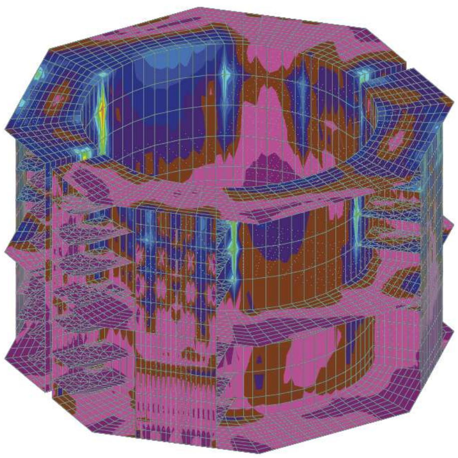
CE 1.28 I organized several workshops with the contractor’s designer to put an action plan and resolving these issues. I instructed the contractor to organize random pull test to determine adequacy of the anchors. During the pullout test I observed a major failure in the concrete cone.

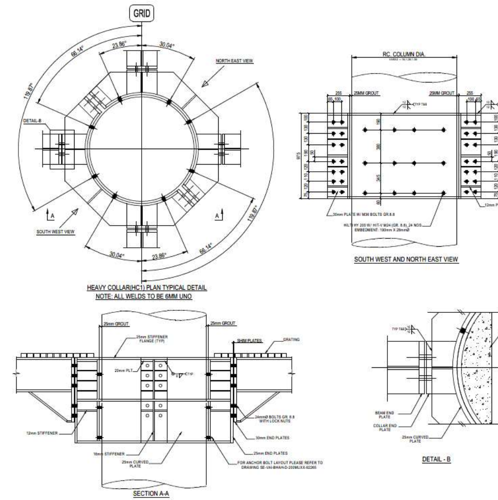


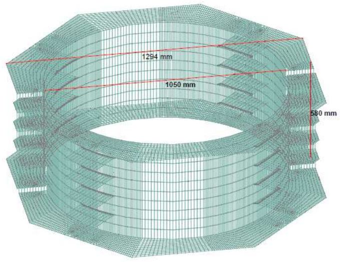


CE 1.29 After the assessment of the pull-out failure, I called urgent meeting with the main designer and gave a possible solution to provide clamp connections “collar” around the columns to have the complete moment restrain and better support conditions and reduced drilling on the heavily reinforced columns. After agreement I proceeded. The revised analysis calculation report for the structure verified the support conditions and related loadings as per UBC 1997 I thus approved the calculations of the structure.

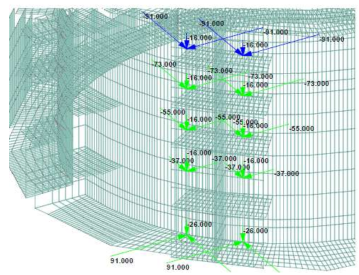
CE 1.30 All the loadings were converted to point loads on the location on the bolts and applied in the STAAD model as presented in the figure below. I verified the maximum stresses on the steel plates and the reaction stress on the concrete columns and anchor bolts forces. I requested for the redesign of the remaining connections on similar basis and submit for official review.







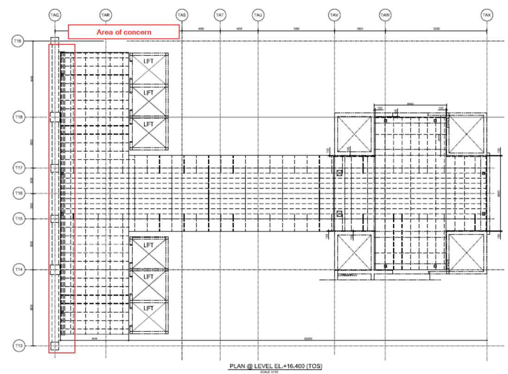
COLLAR DIMENSION



CE 1.31 After the design review was completed, the fabrication and the installation work commenced. I visited the factory, checked the welding and plate details as per the approved drawing and advised for all the required quality document to be included during the delivery of the material.

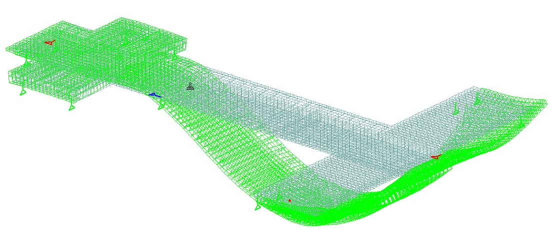
CE 1.32 After material delivery I organized one sample to be completed with all the approving authorities as per the approved methodology of installation. The works were successfully completed and the contractor has implemented the same for all the remaining areas.

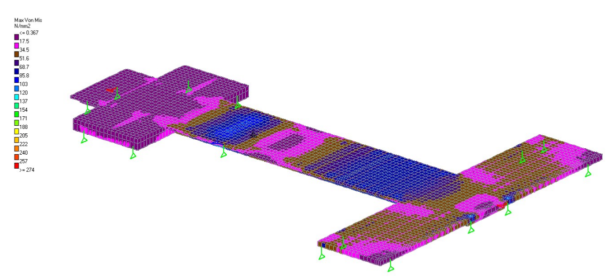
CE 1.33 After installation of the bridge and the lift shafts, I found that the hall the end of the bridge had disproportionate slope at the corner of the bridge. I asked the contractor representative to check with the survey report for actual deflection and evaluate the results. In the concerned portion of the bridge the results were showing deflection of around 10mm. My string line check showed much a higher deflection of approximately 18 mm from the one printed in the geometrical survey report.



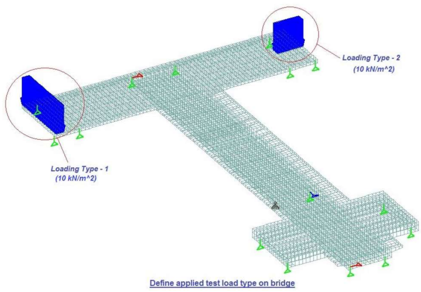
CE 1.34 I raised this concern to all the parties to explain the deviations between the geometrical report and actual scenario. I also had an independent survey to recheck the results and found that in other locations the data was more or less matching besides the one at that location.

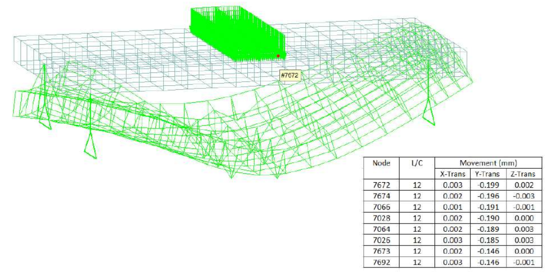
CE 1.35 I went back to the original approved design documents and evaluated the IFC drawings, fabrication drawings and shop drawings to see if there is any deviation. I iterated the STAAD model and properly analysed the behaviour and checked the deflections and their compliance as per the BS 5990 standard. I also checked the maximum stresses and the weld verifications since the entire bridge was welded box structure.



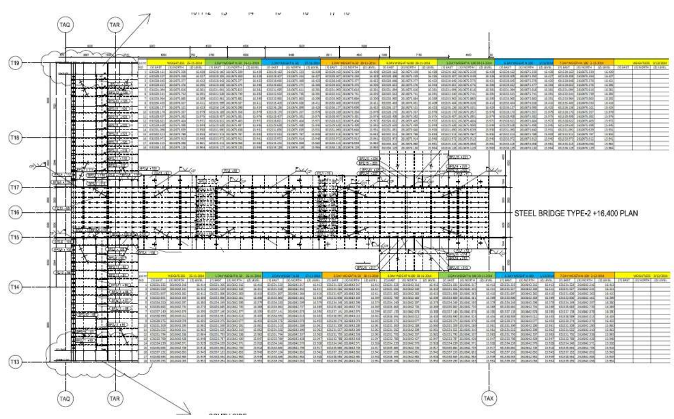


CE 1.36 After reverifications process I had another round of discussion with the structural engineer and PE structural coordination and I requested a site load test on the bridge to verify the performance of the structure of the concerned area. We established the load criteria and the deflection criteria to check the performance. Sample of these verifications are shown below.





CE 1.37 Once these criteria were established separate method statement was developed and we agreed that the survey would be conducted in four phases. First phase survey the bridge with no loads, second phase 50% load and monitor the deflection and third phase 100% load and after removal of the load complete survey to determine if the structure returned to the original condition (see below)



CE 1.38 After the loading was completed and the result found to comply with the initial analysis, it was agreed to rectify the excessive deflection area with local modification on the upper part of the plate elements and the level difference to be rectified with levelling screed.

SUMMARY

CE 1.39 In this project I was a consultant overseeing the construction and upgrading of the Muscat airport. I assured that the building requirements were as per the client specifications and completed following the construction standards and regulatory requirements and the project was completed timely meeting the budgetary requirements.