Kuwait International Airport Terminal II Inner Structure

BIM Modeling
BIM Coordination
Structural Design Verification
Custom Software Development

2020 / 04



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BIM WITHSTAND

Introduction

Challenges of the Project

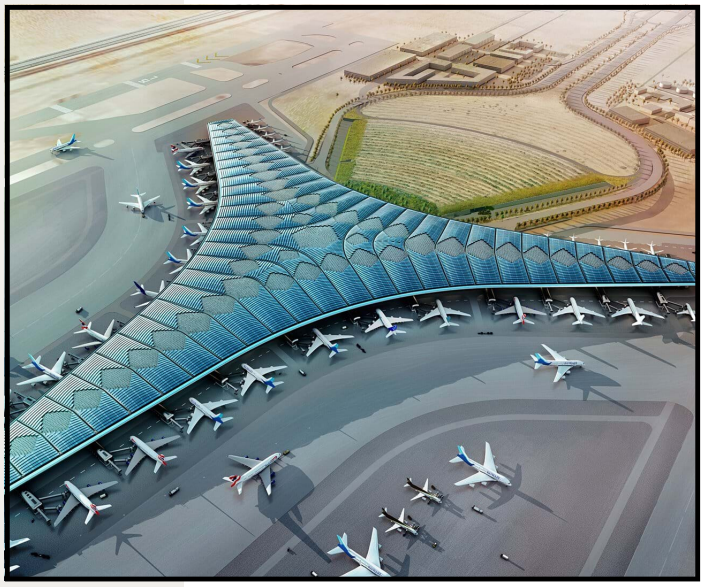
STAND Engineering, a pioneering structural engineering and design firm was engaged to provide, BIM Modeling, BIM Coordination, Structural Analysis and Design Verification to Limak Construction, one of the biggest construction company in Turkey, for the Kuwait International Airport T2 Inner Structure project.

The terminal has a trefoil plan, comprising three symmetrical wings of departure gates. Each façade spans 1.2 kilometres and all extend from a dramatic 25-metre-high central space.

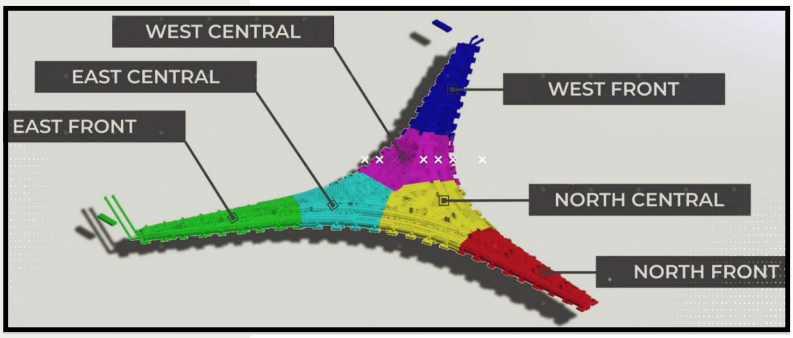
In order to realize such a huge building, latest design and construction methodologies have been used throughout the project. Many local and international consultants have been involved and **a massive BIM modeling/coordination process have been utilized.** It was not only with e-mail communication but also through various cloud collaboration tools.

Some of the challanges of the project could be listed as follows:

- 650.000 m2 of building in one BIM Model? Should breakdown the model?
- One big raft foundation through the building which has no expansion joints.
- Fast-Track Approach.
- Tender Project's Discrepencies(Mep vs Arch. vs Str.)
- Structural Analysis & Verification should be done without model breakdown since foundation does not have expansion joint.
- Information extraction from the BIM Models.



Foster and Partners design KIA T2



KIA T2 Inner Structure Breakdown



Rendered BIM Model

7 International design firms where all are geographically dispersed, have worked together and resolved more than 100.000 design clashes / issues.

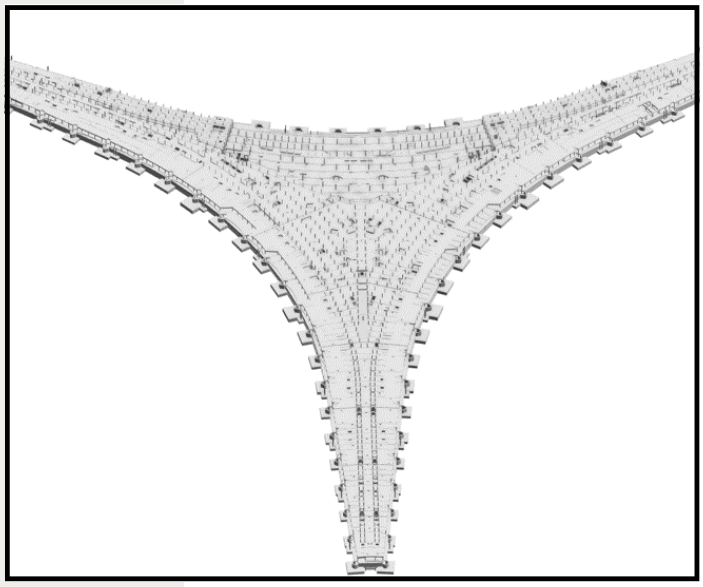
BIM Modeling

Managing more than 5000 structural columns

Project's unique design, required many customized families. For example, in the Img.2, structural columns that intersect with the upper level's expansion joint, must be splitted and they should be reinforced accordingly.

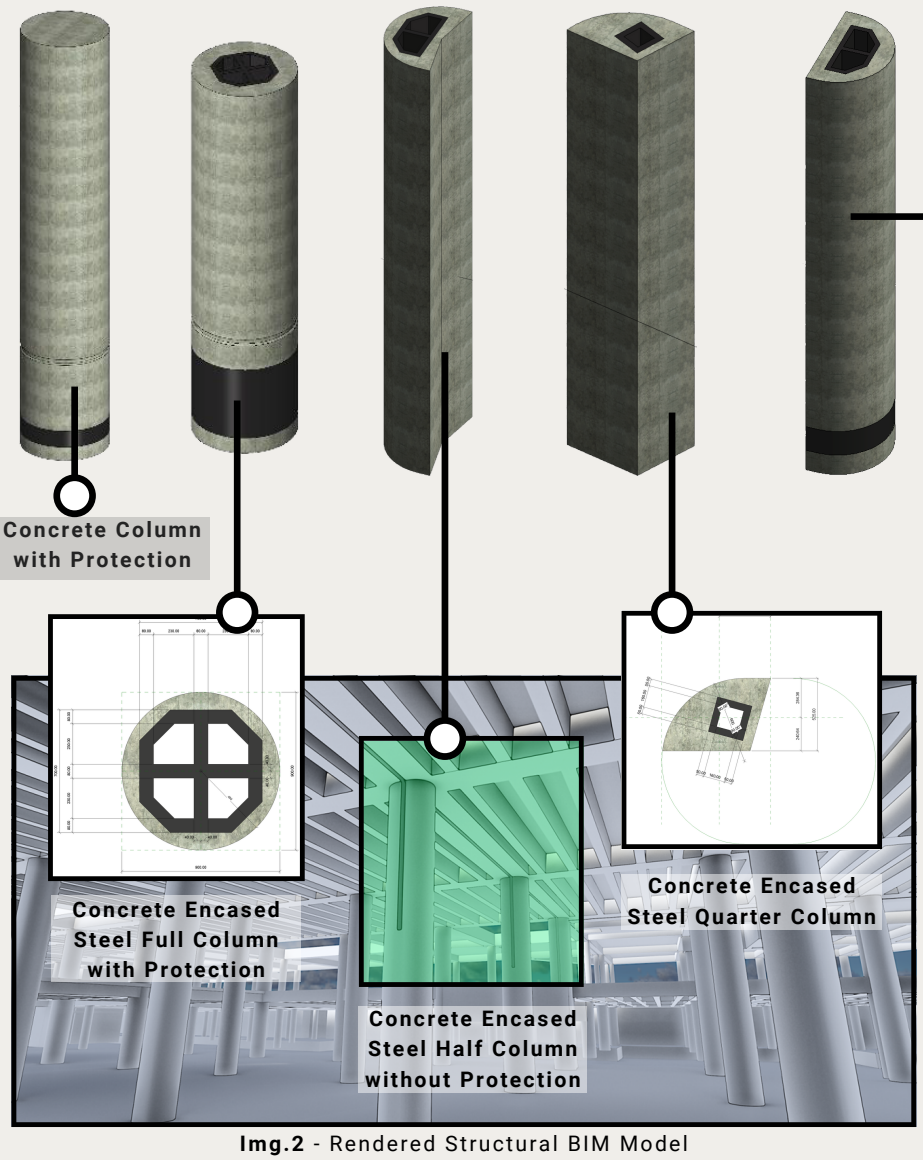
Due to the plan geometry and as the building didn't have expansion joint on the foundation, different shapes of structural columns modelled. Also at the upper levels at some open areas, structural column material must be white concrete due to the coherence between the GRC ceiling, structural beam and the column. See Img.3

Another option for the structural column was the circular steel protection beneath. Eventhough this was an architectural detail, due to the BIM requirements we modelled the steel protections.

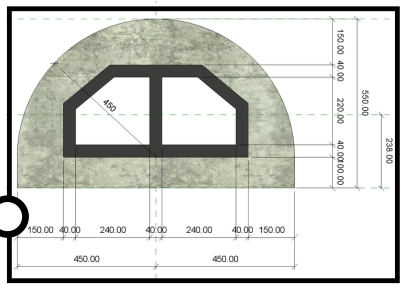


Img.1 - Structural BIM Model

Sample Structural Column Families



Img.2 - Rendered Structural BIM Model



Concrete Encased Steel Half Column with Protection

We modelled 19 different shaped column families. In the end 261 column types with different variations of reinforcement, encasement and options of white concrete material, with steel protection, or both at the same time.

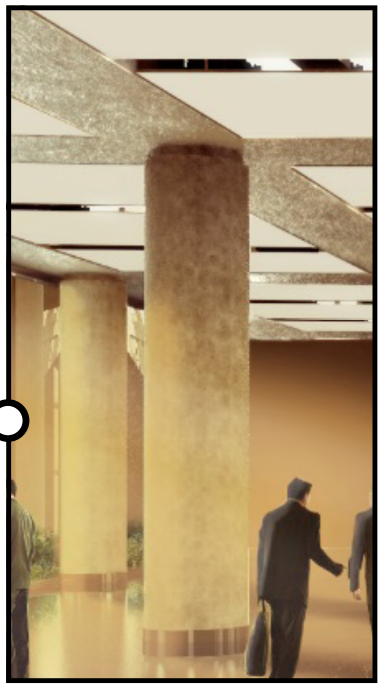
BIM Modeling

Ceiling Coordination

Due to the design at 200 Level, suspended ceiling is flush with the bottom of the beam level so there is no space between the structural beam and the ceiling. As you see there is a smooth transition. In order to achieve this look the structural beams have been modelled with the specified GRC Cladding.



Img.3 - Level 200 Ceiling



Zoom - White Concrete Grooved Column with steel protection

Moreover this design required to have peneterations on the structural beams for MEP systems which then required a tremendous coordination with MEP and Architecture disciplines. Check out the naked BIM Models where the structural beams are penetrated for fire suppression pipes on Img 4 and 5.



Img.4 - Structural BIM Model Level 200 Penetrated Structural Beams



Zoom - BIM MODEL - White Concrete Grooved Column with steel protection



Img.5 - Structural BIM Model Level 200 Penetrated Structural Beams



Zoom - BIM MODEL - Fire pipe penetrates structural beam

BIM Modeling

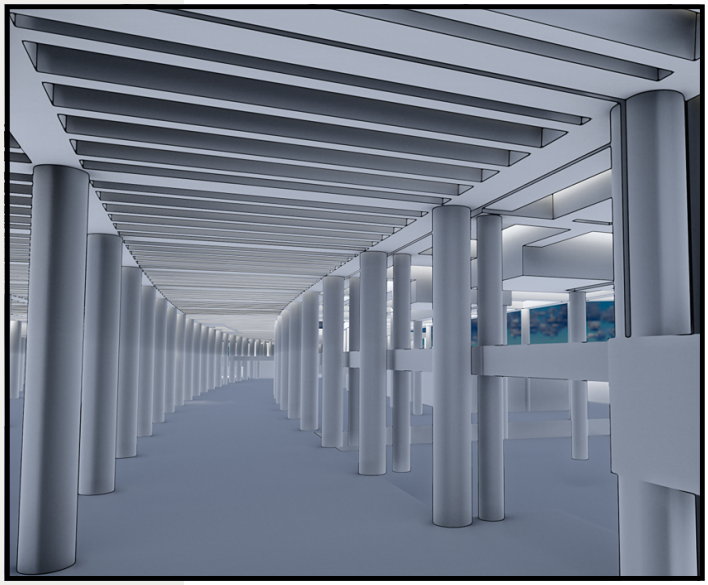
Structural Framing

Through the basement up to Level 100 trapezoidal ribbed slab was the dominant structural system. Just like some of the columns, there were also steel beams with concrete encasement.

So, in this case we modelled 9 different parametric beam families, ending up in total 276 different structural framing types with the option of GRC Cladding on more real than 25.000 structural frame elements.

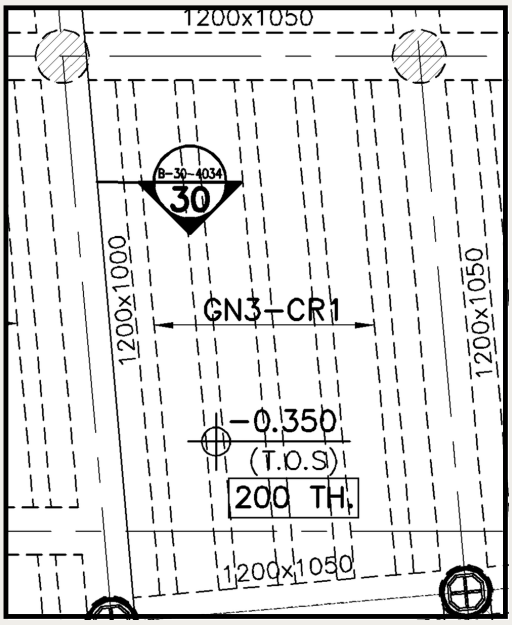
Our design has been perfectly in line with the design intention and projects' BIM standards.

This approach also enabled to extract the real information from the BIM Model and generate the Bill of Quantities precisely.

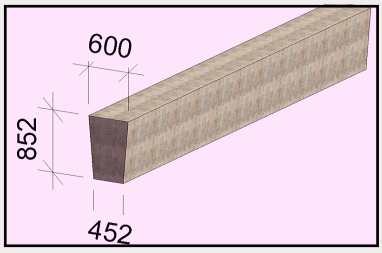


Img.6 - Structural BIM Model - Ribbed Slab

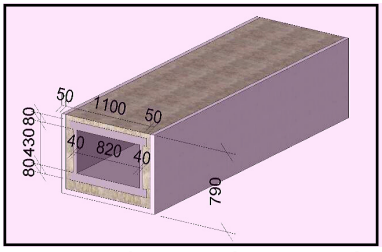
Sample Structural Framing Families



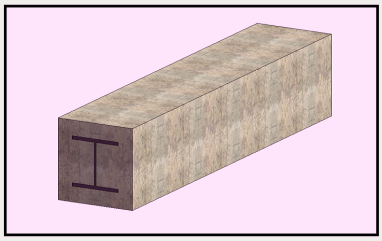
Tender Design Drawing



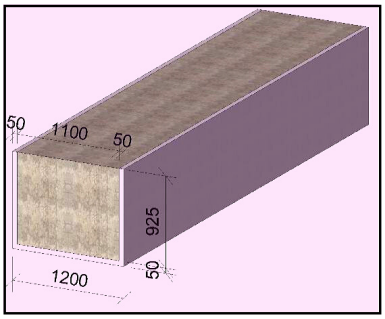
Structural Trapezoid Rib



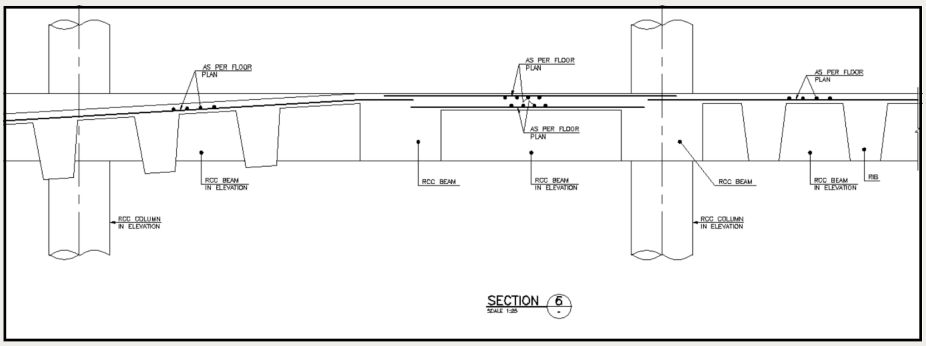
Structural Encased Beam with GRC Cladding



Structural Encased I Beam



Structural Beam with GRC Cladding



Tender Drawing - Section

We achieved a high quality BIM model where the spatial and parametric representation meet the promoted BIM competency.

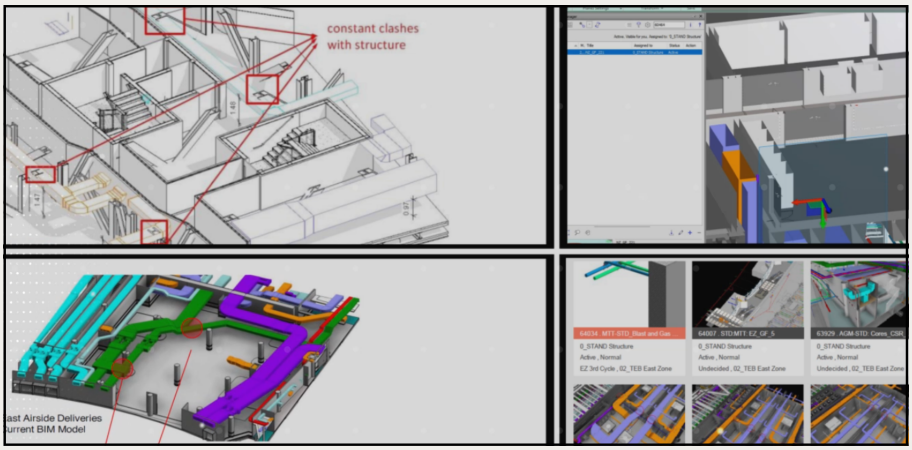
BIM Coordination

Issue Management

Before starting the clash detection process, a BIM execution plan has been provided by the BIM Management team (Aecom Spain) and published among the disciplines. It provided each project team a clear guidance on tools, procedures and systems that were to be used for the design, coordination and utilization of BIM.

One of the main importance of the BEP is that it enabled disciplines to work on models that shared the same standards such as the project coordinates and parameters.

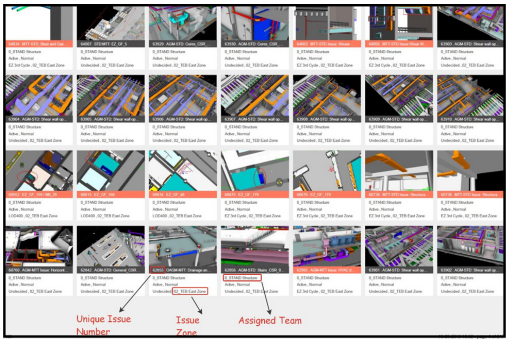
Navisworks software put into use at this stage and each discipline's architect/engineer were responsible for ensuring the exporting procedure of the models to NWC format on a weekly basis. So every week the clash detection was renewed and published to the cloud.



Inspection and reporting of interferences in the project model was crucial in terms of eliminating the mistakes and clashes. Therefore a cloud based issue management add-in was decided to be used. By this way, every change from the tender project would be recorded, and also every issue were tracked and resolved in the order of its priority.

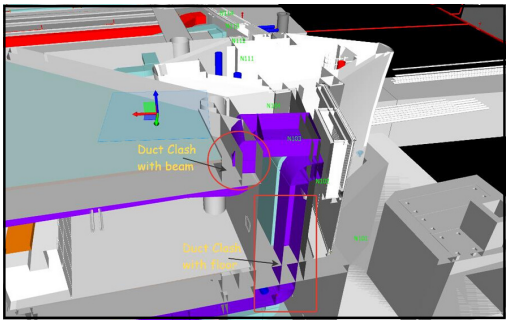
On the other hand, in order to manage large number of issues, it was critical to adopt a model breakdown to 6 zones. Breaking down the model in smaller zones brought a fundamental structural challenge. Since the global analysis required a single whole analytical model, we had to the re-join the divided parts for analysis.

Through the life cycle of the project some major design changes have also been made due to architectural (or other) requirements. Such revisions that have an effect on structural system are verified by structural analysis derived from revised structural BIM model.



Cloud Issue Management Platform

In this platform, issues could have series of comments from every disciplines' consultants together with images. **This enabled everybody to communicate through screenshots and the location of the issue in the model.** So, an issue entry is, basically consisting of the issue creator, issue assignee, and the viewpoint to the problematic area and it goes directly to the viewing position when clicked in Navisworks.



Here, (1) mechanical duct is clashed with a structural beam, and (2) other ducts are clashing with the structural floor.

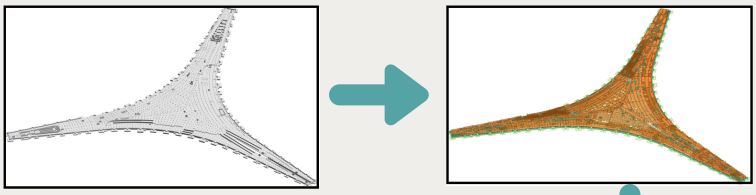
A slab opening on the structural model should be provided for the case (1), clash with the floor.

But, the clash with the beam (2) should be resolved by the mechanical team (find another route for the duct) since a structural beam had priority over the mechanical duct.

Structural Analysis

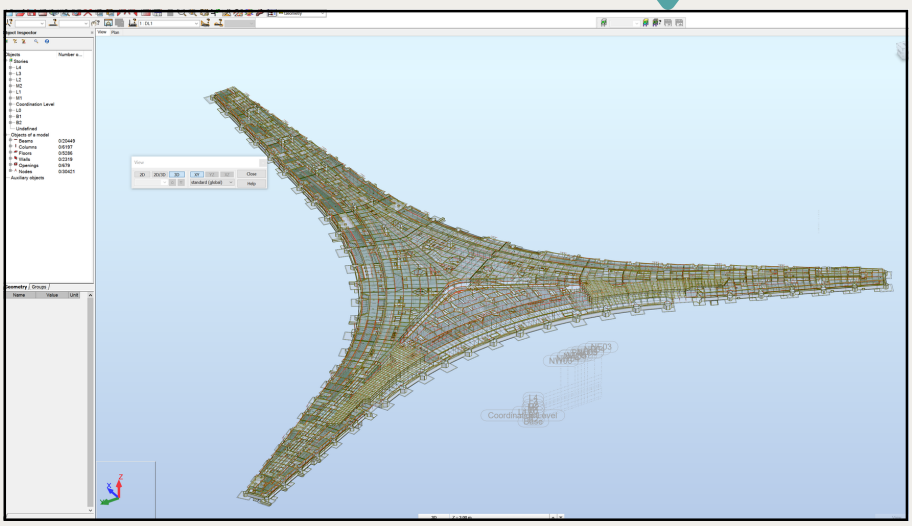
Design Verification

As we build the physical model in Revit, **the analytical model geometry automatically gets created** in parallel on-the-fly, leaving us only the definition of material and loading properties. And then we can directly transfer the analytical model from Revit to Robot. The integration of Revit with Robot Structural Analysis allowed us to exchange the model data perfectly.



Revit Physical Model

Revit Analytical Model

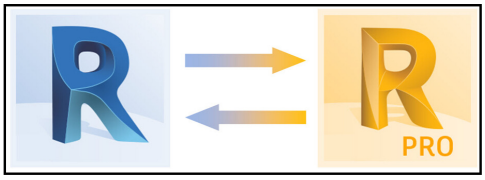


Robot Structural Analysis

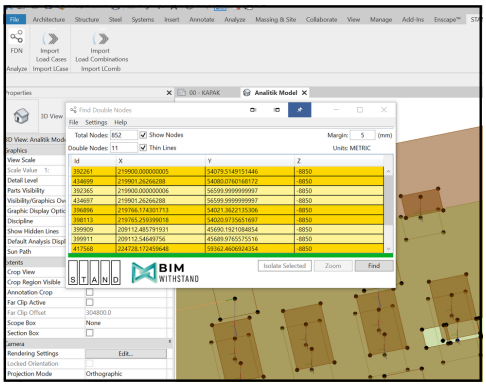
So, we made the structural analysis first by setting up the Analytical model in Revit. **However, it is vital to carry out the finite element analysis correctly.** Therefore, we've used our own application called Find Double Nodes and we overcame the problems of analytical nodes being unconnected and precision issues.

With the help of Robot Structural Analysis software, we could easily test the effects of the structural loads that we defined in Revit. The integration between Revit and Robot allowed updating the analysis model in Robot after making changes in the physical model.

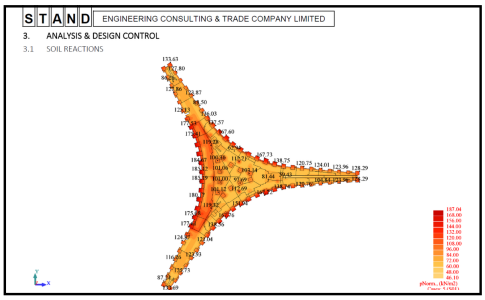
Reusing data from the BIM model to run the analysis in Robot, not only **maximizes the efficiency, but also removes the rework and provides convenience on revisions.**



Revit & Robot Interoperability



Find Double Nodes add-in significantly accelerates the work of preparing the Revit® Analytical Model for the Structural Analysis. With one click, it automatically checks all analytical nodes and lists the unconnected nodes within the given margin.



Structural Analysis results in the report

Based on the experience in this project, time can be saved through building one integrated model instead of two separate representations for analysis and documentation.

Software Development

We develop advanced software in-house

In large projects like KIA, many automation tools are required to perform tasks in a time effective way. Dynamo for example, one of the main tool provided by Revit, is an open source visual programming interface that gets you under the hood of Revit, so you can automate tedious tasks with ease.

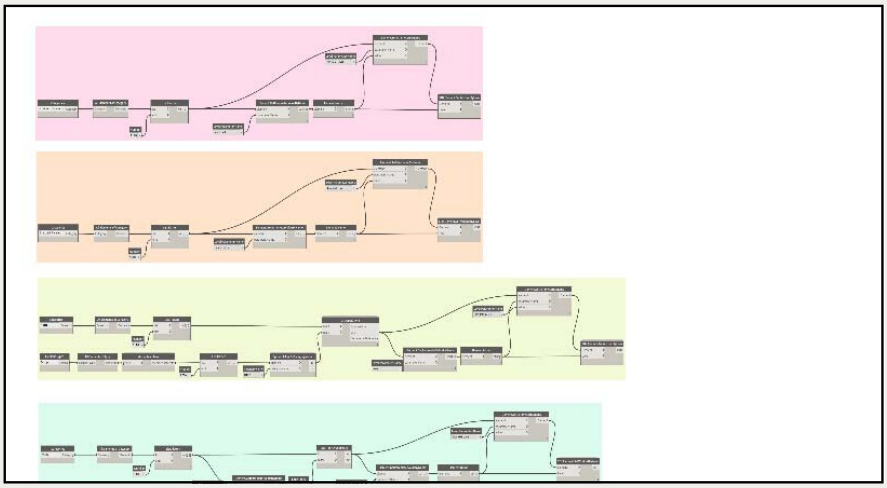
In Dynamo, each node performs a specific task. Nodes have inputs and outputs. The outputs from one node are connected to inputs on another using “wires”. The program or “graph” flows from node to node through the network of wires. The result is a graphic representation of the steps required to achieve the end design.

Over the project period we have written near to 30 dynamo scripts. Each have different purposes and answers various needs. Some of them are as follows:

NWC Export Dynamo Script: Since the NWC model exports needs to be shared each week we had to deal with many exports on Thursdays. This script exported 48 different views in one go just about in 10 minutes, otherwise it would take a day for an engineer to manually export all the views.

Dimension Recovery: Another dynamo script that we developed was for our draftsperson where we overcame a great deal of manual labor and automized the lost dimensions and tags error after a physical change made in the model. After feeding this script with the "error log export file" from Revit, it showed which dimensions/tags were lost and their exact position.

Duct/Pipe/Tray Opening: This dynamo script enabled us to double the speed for opening the necessary openings where the MEP interferences occur. Before developing this script we searched for some readily available add-on for creating the openings, however we were not satisfied with the software on the market. Then we decided to develop our own program.



Dynamo Scripting



Dynamo Player

We develop custom software solutions that respond to unique needs. We use our experience of Structural Analysis combined with our Computer Science proficiency to create best-fit solutions for each project.

Conclusion

BIM continues to evolve and grow with its applications in practice. Here we see that one of the key advantage of BIM is that it eased the development and sharing the detailed information among steakholders.

This study presented the evidence of benefits of BIM and its application of the process for a large complex infrastructure project.

The use of BIM also provided increased opportunity for owners, designers, and contractors to **collaboratively coordinate the design and build phases of the construction.**

On the other hand we see that interoperability between systems plays a very important role in BIM methodology. The primary benefits are:

- Precise modeling,
- Coordinate and track issues collaboratively,
- Provide structural analysis without repetition,
- Extract diverse information (i.e drawing outputs, instant 3D visualization of spaces and evaluation of alternatives)



A scene from design and construction coordination meeting of KIA



AITOR CHAVARRI
BIM Manager at AECOM

A very positive experience working with Sinan's team. Both personally and professionally. Guys are highly skilled and smart. They have efficiently managed to resolve thousands of structural issues in the Kuwait International Airport project.



EMRE ÖZKÖK
Structural Design Coordinator

We developed a great communication with Sinan and Serhan. Their expertise is evident in all aspects. They are the best design team that I've worked in the Kuwait International Airport project. Special thanks to their effort and imposing dedication.

We are glad that we have successfully delivered our services and also participated in such a prestigious project.

BIM WITHSTAND

YOUR PARTNER IN BIM AND CUSTOM SOFTWARE

About

We have been working with BIM software and tools for a long time on Structural Analysis & Design. Through all projects we have worked, we have gained substantial design practice on Revit–Robot and we have integrated custom software solutions to the design workflow. We are talented engineers who always strive for advancements and improvements in the BIM ecosystem.

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