ES119852 - Dynam(o)ite Your Steel Design

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About me

- Technical Sales Specialist AEC @ Autodesk
- Computational Design & Engineering
- Structural Engineer based in Belgium
- +15 years experience in structural engineering

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www.linkedin.com/in/dietervermeulen
www.youtube.com/user/RevitbeyondBIM

www.revitbeyondbim.wordpress.com
www.autodesk.typepad.com/bimtoolbox/
AU Online Profile
Key Learning Objectives

In this class you will learn …

- about the power of computational design in the structural steel industry
- how to generate complex structural steel models in Revit using Dynamo
- how to reuse Dynamo data to create complex engineering models in Robot Structural Analysis Professional
- how to increase the fabrication capabilities for frames and panels in Advance Steel with Dynamo
Human Brain vs Computational Power
• 90% Increase in efficiency
• Fewer parts, greater reliability
• Reduced fabrication time
• Improved quality of signal
THE OLD WAY

Designer/engineer uses computer as passive machine

one human + one computer = limited design
one human + artificial intelligence algorithms + unlimited cloud-computing power = 100s to 1000s of design options

Computer and designer/engineer unite as cocreators

THE NEW WAY

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MARS TORUS ARENA
The story of a complex frame structure
Mars Torus Arena - Project Goals

- Design and fabrication of an optimal diagrid structure
- Meet fabrication requirements early in the design phase
- Fabricate with reduced waste
- Economic design taking into account fabrication costs
- Maintain aesthetic aspect
Mars Torus Arena – Structure Evaluation

- Structural framing cutting cost
- Structure weight
- Steel connection cost
- Strength of the framing structure
- Material waste during fabrication
- Cut length optimization
Mars Torus Arena – Structural Design Phasing

Phase 1
Concept Optioneering

Phase 2
Structural Analysis to Optimization

Phase 3
Framing Design

Phase 4
Fabrication Deliverables
Connected BIM: Design to Fabrication

Conceptual Design
- Set up computational logic for the framing structure
- Evaluate the structural concept
- Explore multiple design options

Optioneering

Structural Analysis
- Conduct advanced analysis
- Easily visualize detailed analysis results
- Check structural requirements
- Find optimal solution with parametric analysis

Design
- Create structural framing design model
- Verify fabrication requirements
- Add fabrication data to the BIM model
- Merge design changes with better accuracy and keep documentation up to date

Fabrication
- Creation of structural fabrication model
- Steel connection design
- Generate BOMs and Fabrication Drawings
- Drive workshop processes using model data
Design to Fabrication: Solution Mapping

- Conceptual Design
- Optioneering
- Structural Analysis
- Structural Design
- Fabrication

Software Tools:
- Autodesk Revit
- Dynamo for Revit
- Dynamo Studio
- Autodesk Robot Structural Analysis Professional
- Dynamo Customizer
- Advance Steel
- Project Fractal
Dynamo Platform

- Open Source
- Hosted in
  - Revit
  - Advance Steel

Dynamo Studio

- Standalone version
- Works outside of Revit
- Connects with the cloud
- Included in AEC Collection

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Dynamo Packages used

- Structural Analysis for Dynamo
- BIM4Struc.Productivity
PHASE 1
Concept Optioneering

- Set up computational logic for the structure
- Evaluate the structural concept
- Explore multiple design options
Conceptual Structure Optioneering

Diagrid Configuration

Structure Evaluation

Option Exploring by Other Stakeholders

Structural Concept Optioneering

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Structural Concept Evaluation

**INPUT**
- Torus size
- Diagrid Transversal Division
- Diagrid Lateral Division
- Bar Unit Weight

**CONSTRAINTS**
- Max Beam Stocklength
- Allowable Waste Percentage

**EVALUATION**
- Beam Cutting Cost
- Connection Cost (3 types)
- Structure Cost based on weight
- Waste\(^(*)\) Cost based on weight
- Total Cost
  - Material Cost
  - Waste Percentage

\(^(*)\) Waste is calculated based on the FFD Bin Packing Algorithm
First Fit Decreasing Bin Packing Algorithm

**ORIGINAL SET**

8
5
4
5
3
2
6
1
2

**DECREASED ORDERING**

8
6
5
5
4
3
2
2
1
1
First Fit Decreasing Bin Packing Algorithm

SIZE OF 1 BIN = 8

WASTE = 3
Configuration of the diagrid concept

Autodesk® Dynamo Studio

**MARS TORUS ARENA**

**DYNAMO PROJECT**
MARS TORUS ARENA OPTION EXPLORING

**ASSOCIATED FILE(S)**
/

**AUTHOR(S) / CREATION DATE**
Dieter Vormwald, Autodesk / 2017.10.18

**DESCRIPTION**
Graph that creates the conceptual design of the Mars Torus Arena, based on swept surfaces and diagrid creation. The design is evaluated based on cost for bar cuts, joint connections, material usage, and waste. The cut optimization and waste is defined based on the "Fit Decreasing" bin packing algorithm. The allowable waste percentage is a measure for acceptable designs.

**DYNAMO VERSION**
1.3.2.2488

**ADDITIONAL COMMENTS**
- Due to some custom nodes, this script is not compatible with Project Fractal.
- Project and graph in [m]
- Enable the "T-spine" geometry in Settings > Experimental

**REQUIRED DYNAMO PACKAGES**
BIM4Struc, Productivity
Evaluation of the structural concept

Autodesk® Dynamo Studio

MARS TORUS ARENA

DYNAMO PROJECT
MARS TORUS ARENA - OPTION EXPLORING

ASSOCIATED FILE(S)
 /

AUTHOR(S) / CREATION DATE
Dieter Vormaulen, Autodesk / 2017.10.18

DESCRIPTION
Graph that creates the conceptual design of the Mars Torus Arena, based on swept surfaces and diagrid creators.
The design is evaluated based on cost for bar cuts, joint connections, material usage and waste.
The cut optimization and waste is defined based on the “First Fit Decreasing” bin packing algorithm.
The allowable waste percentage is a measure for acceptable designs.

DYNAMO VERSION
1.3.2.2480

ADDITIONAL COMMENTS
- Due to some custom nodes, this script is not combinable with Project Fractal.
- Project and graph in [m].
- Enable the “T-spline” geometry in Settings > Experimental

REQUIRED DYNAMO PACKAGES
BIM4Struct/ProductsKit

INPUT:

Arena: Torus Diameter
18,000

Arena: Sweep Angle Opening
80,000

Arena: Torus Transversal Diameter
10,000

Odd numbers only

Even numbers only

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Bin Packing Results Visualization

Autodesk® Dynamo Studio
Option exploring by other stakeholders

Dynamo Customizer

MARS TORUS ARENA

DYNAMO PROJECT
MARS TORUS ARENA OPTION EXPLORING

ASSOCIATED FILE(S)
/

AUTHOR(S) / CREATION DATE
Dieter Vermeulen, Autodesk / 2017.10.18

DESCRIPTION
Graph that creates the conceptual design of the Mars Torus Arena, based on swept surfaces and diagrid creation.

The design is evaluated based on cost for bar cuts, joint connections, material usage, and waste.

The cut optimization and waste is defined based on the "First Fit Decreasing" bin packing algorithm.

The allowable waste percentage is a measure for acceptable designs.
Structural concept optioneering

Project Fractal
PHASE 2
Structural Analysis to Optimization

- Perform structural analysis
- Check weight and deformation
- Find optimal solution with parametric analysis
Structural Analysis to Optimization

- Reuse Diagrid Configuration
- Configure Analysis Model
- Evaluate Analysis Results
- Manual Optimization Parametric Run

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Configuration of the analysis model

Autodesk® Dynamo Studio & Autodesk® Robot™ Structural Analysis Professional

MARS TORUS ARENA

DYNAMO PROJECT
MARS TORUS ARENA ANALYSIS
ASSOCIATED FILE(S)
/
AUTHOR(S) / CREATION DATE
Dieter Vermeulen, Autodesk / 2017.10.18
DESCRIPTION
Graph that creates the conceptual design of the Mars Torus Arena, based on swept surfaces and diagrid creation. The structural design is evaluated with Robot Structural Analysis. With the graph several options can be evaluated and compared against each other.

DYNAMO VERSION
1.3.2.2480
ADDITIONAL COMMENTS
- Works with Robot Structural Analysis 2018
- Project and graph in [m]
- Make sure an active RSA project is open before you run the script

REQUIRED DYNAMO PACKAGES
Structural Analysis for Dynamo
Manual Optimization with Parametric Analysis

AUTODESK® DYNAMO STUDIO

AUTODESK® ROBOT™ STRUCTURAL ANALYSIS PROFESSIONAL

Microsoft® Excel

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Manual Optimization with Parametric Analysis

Autodesk® Dynamo Studio & Autodesk® Robot™ Structural Analysis Professional

MARS TORUS ARENA

DYNAMO PROJECT

MARS TORUS ARENA OPTION ANALYSIS

ASSOCIATED FILE(S)
Mars Torus Arena Analysis.dyn
Mars Torus Arena Results.xlsx

AUTHOR(S) / CREATION DATE
Dieter Vermeulen, Autodesk / 2017.10.18

DESCRIPTION
Graph that creates the conceptual design of the Mars Torus Arena, based on swept surfaces and diagrid creation.

The structural design is evaluated with Robot Structural Analysis. With this graph several options are generated in a "parametric run" and the results are compared against via an Excel export.

DYNAMIC VERSION
1.3.2.2460

ADDITIONAL COMMENTS
- Works with Robot Structural Analysis 2018
- Project and graph in [m]
- Make sure an active RSA project is open before you run the script.

REQUIRED DYNAMO PACKAGES
Custom node: Mars Torus Arena Analysis.dyn

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PHASE 3
Structural Framing Design

- Create structural framing design model
- Verify fabrication requirements
- Add fabrication data to the BIM model
Structural Framing Design

- Reuse Diagrid Configuration
- Create structural design
- Cut Length Optimization
- BOM Generation

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Generation of the Structural Framing Design

Autodesk® Revit® & Dynamo for Revit®
Include Fabrication Data in the BIM Model

Dynamo for Revit®

ASSIGN "MARK" TO THE BEAMS
PHASE 4
Fabrication Deliverables

- Create structural fabrication model
- Steel connection design
- Generate BOMs and Fabrication Drawings
- Create fabrication data for CNC
Structural Framing Fabrication

Reuse Diagrid Configuration

Create framing model

Connecting Tubes

Fabrication Deliverables

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Creation of the Framing Model

Dynamo for Advance Steel
Add Fabrication Details

Autodesk® Advance Steel
Generate Fabrication Deliverables

Autodesk® Advance Steel
ARMADILLO ROOF PANELS
Efficient fabrication of panels on a curved roof
Armadillo Roof Panels - Project Goals

- Generate a design & fabrication model for roof panels
- Meet fabrication requirements
- Find optimal solutions
- Streamline digital dataflow from design to fabrication
Armadillo Roof Panels – Fabrication Readiness Check

Panel dimensions

Reduce number of custom panels

Planar Deviation
Armadillo Roof Panels – Project Phasing

Phase 1: Concept Optioneering

Phase 2: Roof Panel Design

Phase 3: Roof Panel Fabrication
Connected BIM : Design to Fabrication

Conceptual Design
Optioneering

+ Set up computational logic for the roof panel model
+ Evaluate the panel layout
+ Explore multiple design options
+ Include fabrication requirements

Design & Detailing

+ Create roof panel design model
+ Verify fabrication requirements
+ Add fabrication data to the BIM model
+ Merge design changes with better accuracy and keep documentation up to date

Fabrication

+ Creation of panel fabrication model
+ Generate BOMs and Fabrication Drawings
+ Drive workshop processes using model data
Design to Fabrication : Solution Mapping

Conceptual Design
Optioneering

AUTODESK® REVIT®

DYNAMO FOR REVIT®

AUTODESK® FOR REVIT®

DYNAMO STUDIO

PROJECT FRACTAL

AUTODESK® ADVANCE STEEL

DYNAMO FOR ADVANCE STEEL
Additional Project Challenges

- Base roof model created in specific way
- Panels with adaptive components → planar deviation
- Curtain System in Revit doesn’t generate flat panels
- Evaluation of the surface in Dynamo results in warped panels
Base Mass Family – Family Construction Method

Autodesk® Revit®
Adaptive Component Panels - Planar Deviation

Autodesk® Revit®
Curtain System can’t use custom families

Autodesk® Revit®
Evaluation of base surface with Dynamo

Dynamo for Revit®
PHASE 1
Concept Optioneering

- Set up computational logic for the model
- Evaluate the panel layout
- Explore multiple design options
- Include fabrication requirements
Panel Concept Evaluation

**INPUT**
- Roof Surface
- Transversal Division
- Longitudinal Division
- Bar Unit Weight

**CONSTRAINTS**
- Max Panel Surface
- Max & Min Edge Length
- Planar Deviation = 0

**EVALUATION**

<table>
<thead>
<tr>
<th>Quadrilateral Panel</th>
<th>Regular panel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surface Check</td>
<td>Within Design Rules</td>
</tr>
<tr>
<td>Edge Length Check</td>
<td>Outside Design Rules</td>
</tr>
</tbody>
</table>

- Triangular or Pentagonal panel
  - Custom panel

**Goal:**
Low amount of Custom panels

**Non-acceptable designs:**
When regular panels don’t meet the design rules
Conceptual Panel Optioneering

Evaluate Base Surface ➔ Planar Panel Model ➔ Fabrication Readiness Check ➔ Panel Layout Optioneering
Roof Surfaces to SAT

Autodesk® Dynamo Studio

1. Create SAT files from the mass surfaces in Revit
2. Import in Dynamo Studio
Creation of flat panel layout system

Dynamo Studio
Fabrication Readiness Check of Panels

Dynamo Studio
Panel Layout Optioneering

Project Fractal
PHASE 2
Roof Panel Design

- Set up computational logic for the model
- Evaluate the panel layout
- Explore multiple design options
- Include fabrication requirements
Roof Panel Design

0. Evaluate Base Surface
1. Create Panel Layout
2. Fabrication Readiness Check
3. Generate Panels
4. Panel Design Fabrication Data

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Generate Panels with Adaptive Components

Dynamo for Revit®
Add Fabrication Data to the BIM model

Dynamo for Revit®
PHASE 3
Roof Panel Fabrication

- Creation of panel fabrication model
- Generate BOMs and Fabrication Drawings
- Drive workshop processes using model data
Roof Panel Fabrication

Evaluate Base Surface
Create Panel Layout
Generate Panels
Additional Fabrication Data
Generate Fabrication Deliverables

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Create the Panel Fabrication Model

Dynamo for Advance Steel
Generate Fabrication Deliverables

Autodesk® Advance Steel
Fabrication of panels

Autodesk® Revit & Dynafold for Dynamo

Generate **fabrication drawings** from panels of a curved surface. Drive CNC machinery with a DXF export.
Conclusion
How did I do?

- Your class feedback is critical. Fill out a class survey now.
- Use the AU mobile app or fill out a class survey online.
- Give feedback after each session.
- AU speakers will get feedback in real-time.
- Your feedback results in better classes and a better AU experience.
Come and Cheer at the Dynamo Design Slam

- Class?
  EDU133178 - “Mars Home Planet" Design Slam

- When?
  Today at 4:30 pm

- Where?
  Venetian H, Level 2
Architectural Fabrication Workflow for Panels

- **Class?**
  AS119863 – Dynam(o)ite Your Architectural Design – Optimization of Facade Panels

- **When?**
  Thursday at 3:30 pm

- **Where?**
  Delfino 4101A, Level 4
AUTODESK UNIVERSITY 2015

- Dynam(o)ite Your Design for Engineers
- Dynam(o)ite Your Design From Concept to Fabrication

AUTODESK UNIVERSITY 2016

- Dynam(o)ite Your Rebar Design
- Construction Dynam(o)ite: Explode Productivity with Dynamo