ES9542
Dynam(o)ite Your Design for Engineers

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Technical Specialist Structural Solutions, Autodesk EMEA NE

@BIM4Struc

Class summary

Learn how you can catch the architectural design and add behavior and rules to the structural design in Revit and Robot Structural Analysis. You will discover how to apply computational design with Dynamo in RSA. You will also learn how to apply structural optimization techniques to your analysis models introducting genetic algorithms.

Key learning objectives

At the end of this class, you will be able to:

- to generate complex structural models in Revit using Dynamo
- to rewire the analysis design in Robot Structural Analysis with Dynamo
- to apply intelligent behavior to structural analysis models using Dynamo
- to introduce structural optimization techniques in the analysis process

About me

- Technical Specialist Structural Solutions @ Autodesk
- Working for EMEA NE region
- Structural Engineer based in Belgium
- +15 years experience in structural engineering
- “Revit Beyond BIM” & “BIM Toolbox”



Get Connected



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www.linkedin.com/in/dietervermeulen



www.youtube.com/user/RevitbeyondBIM



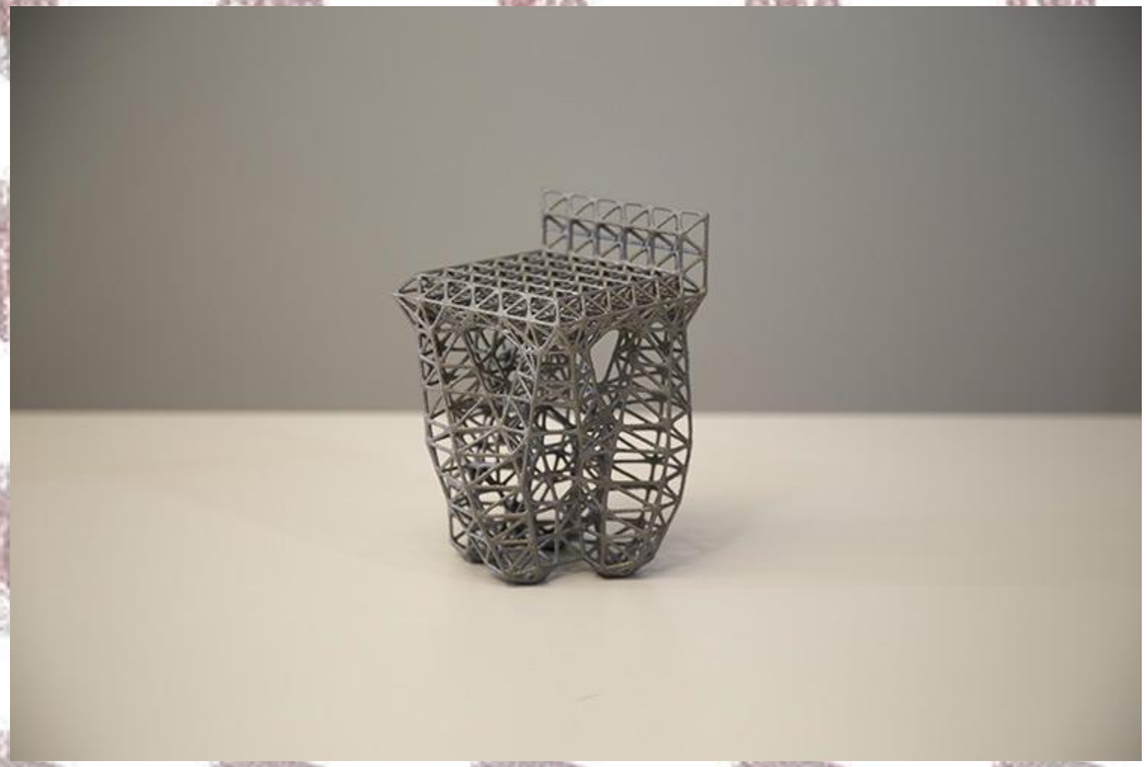
www.revitbeyondbim.wordpress.com

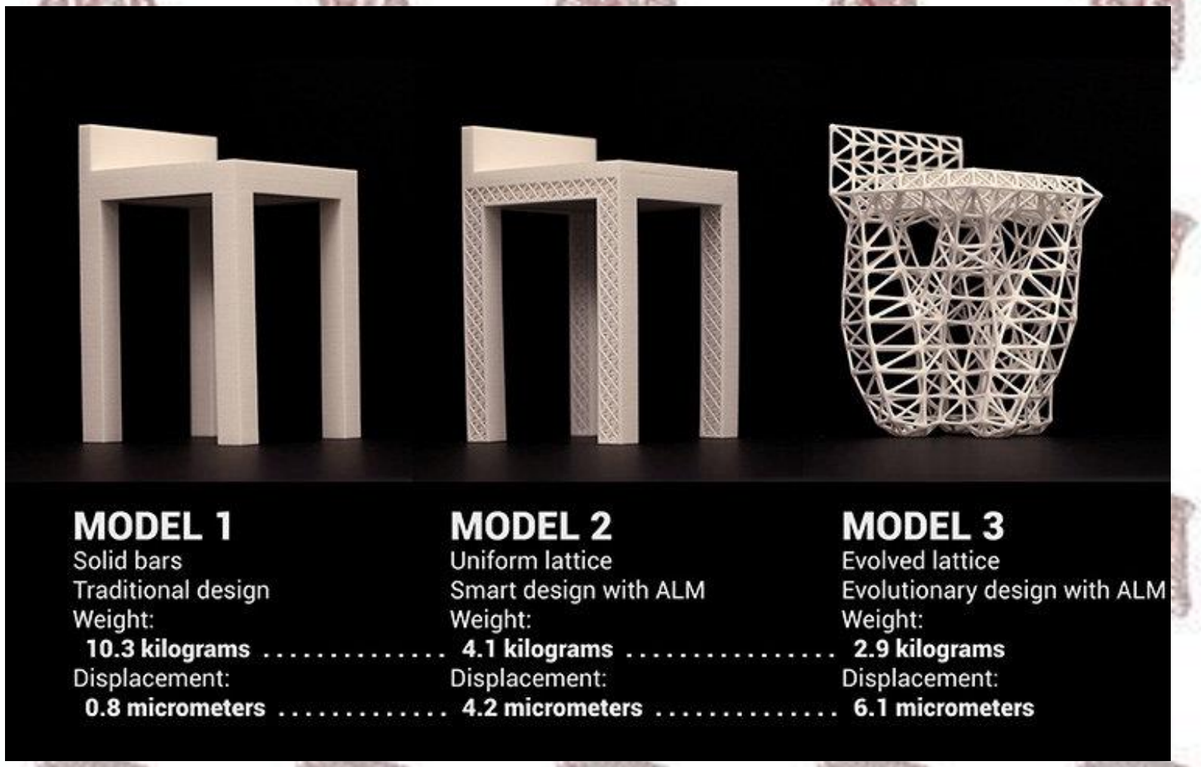


www.autodesk.typepad.com/bimtoolbox/

Optimal Design ?

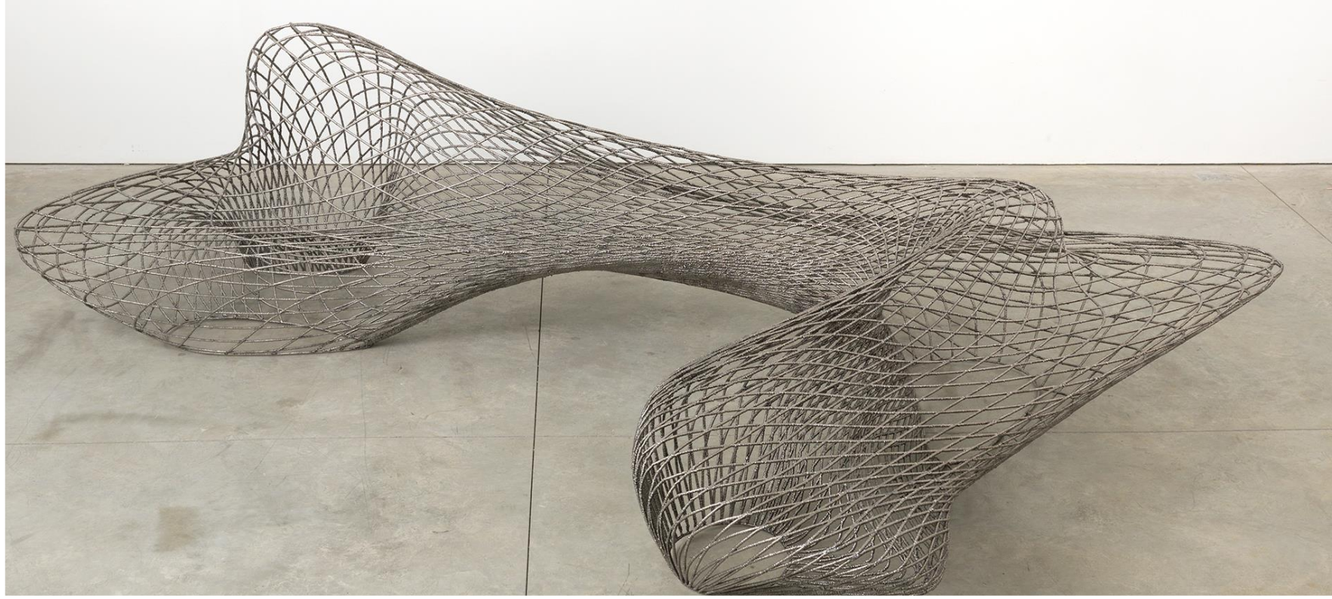
Artificial Intelligence ?



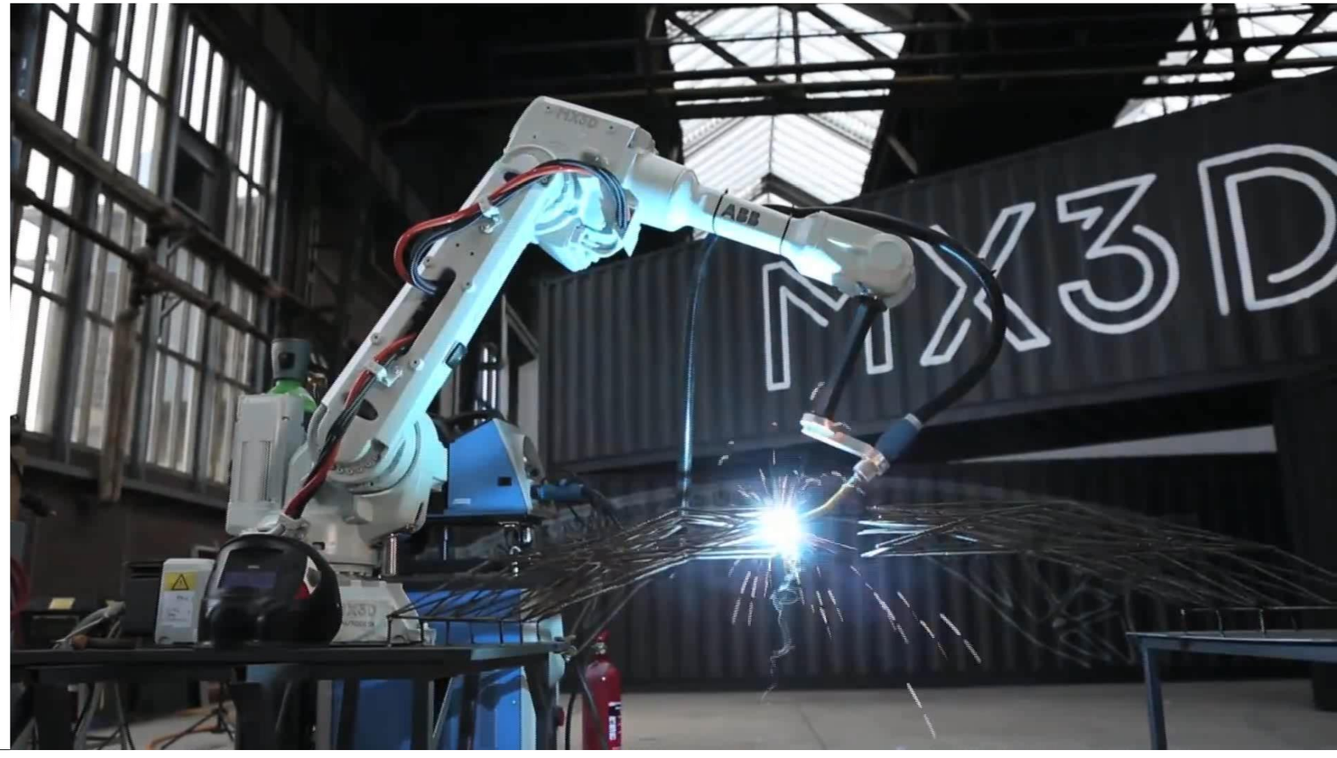

MODEL 1
Solid bars
Traditional design
Weight:
10.3 kilograms
Displacement:
0.8 micrometers
MODEL 2
Uniform lattice
Smart design with ALM
Weight:
4.1 kilograms
Displacement:
4.2 micrometers
MODEL 3
Evolved lattice
Evolutionary design with ALM
Weight:
2.9 kilograms
Displacement:
6.1 micrometers


Chairs ?



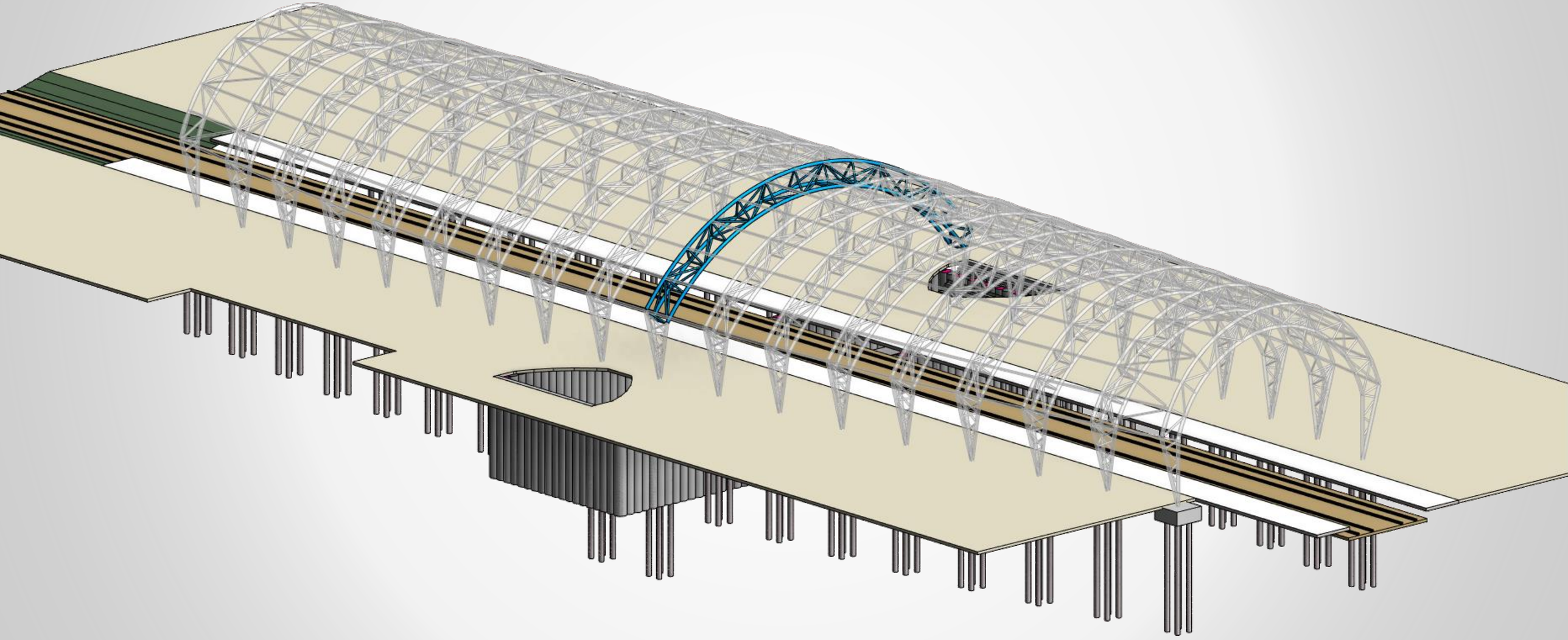





MX3D

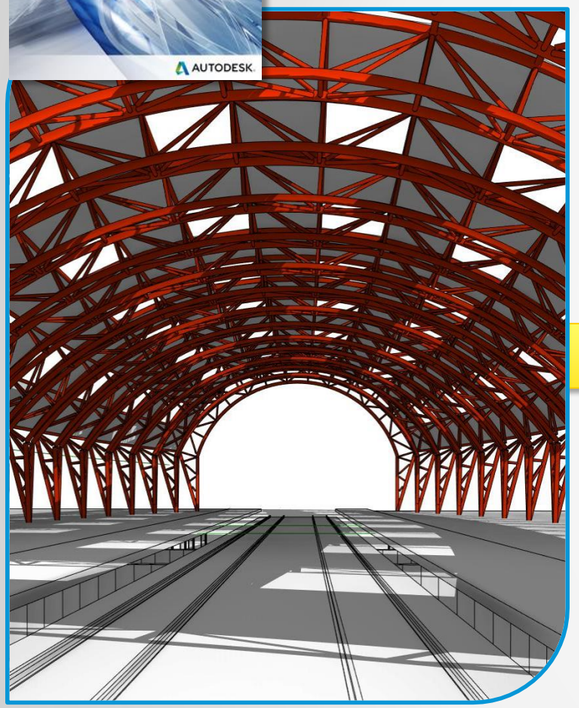
Project Description

Millennium Railway Station – Armadillo Roof

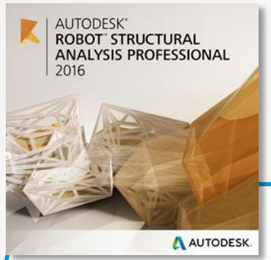


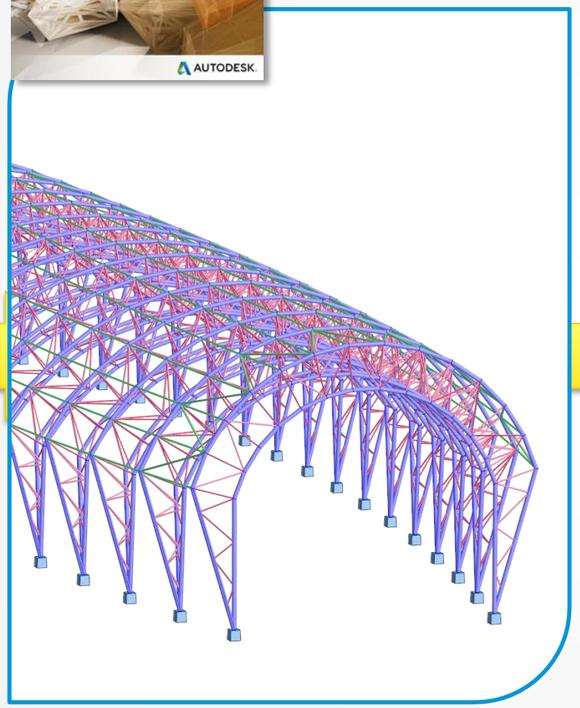
From modelling to optimization



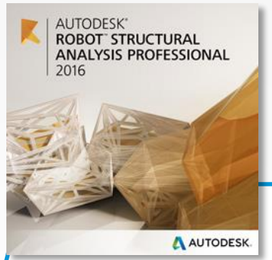


Structural Modelling

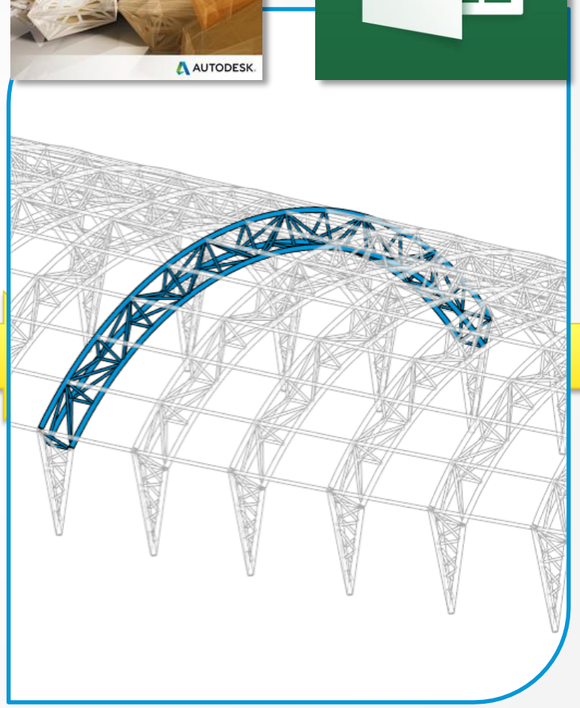




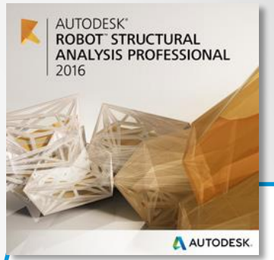
Structural Analysis

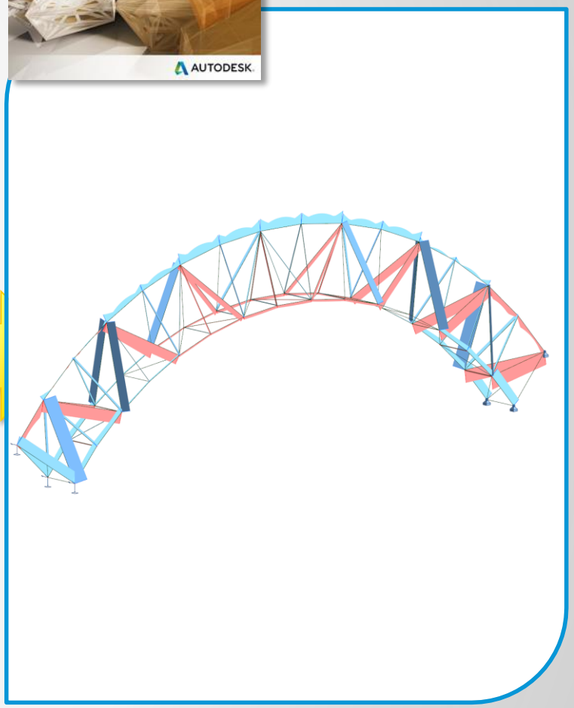






Manual Optimization





Genetic Optimization

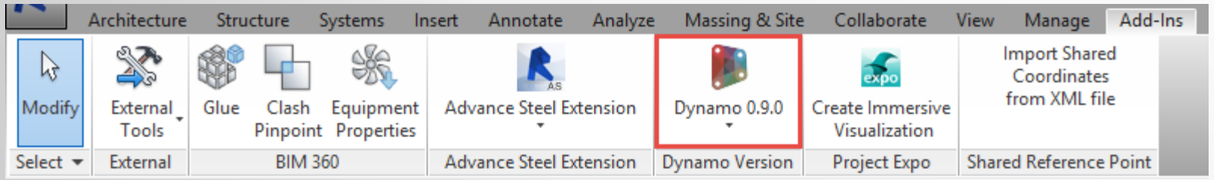
Dynamo Platforms Used

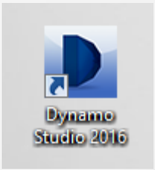
Dynamo

- Open Source
- Available in Revit
- Freely available

AUTODESK®
DYNAMO STUDIO

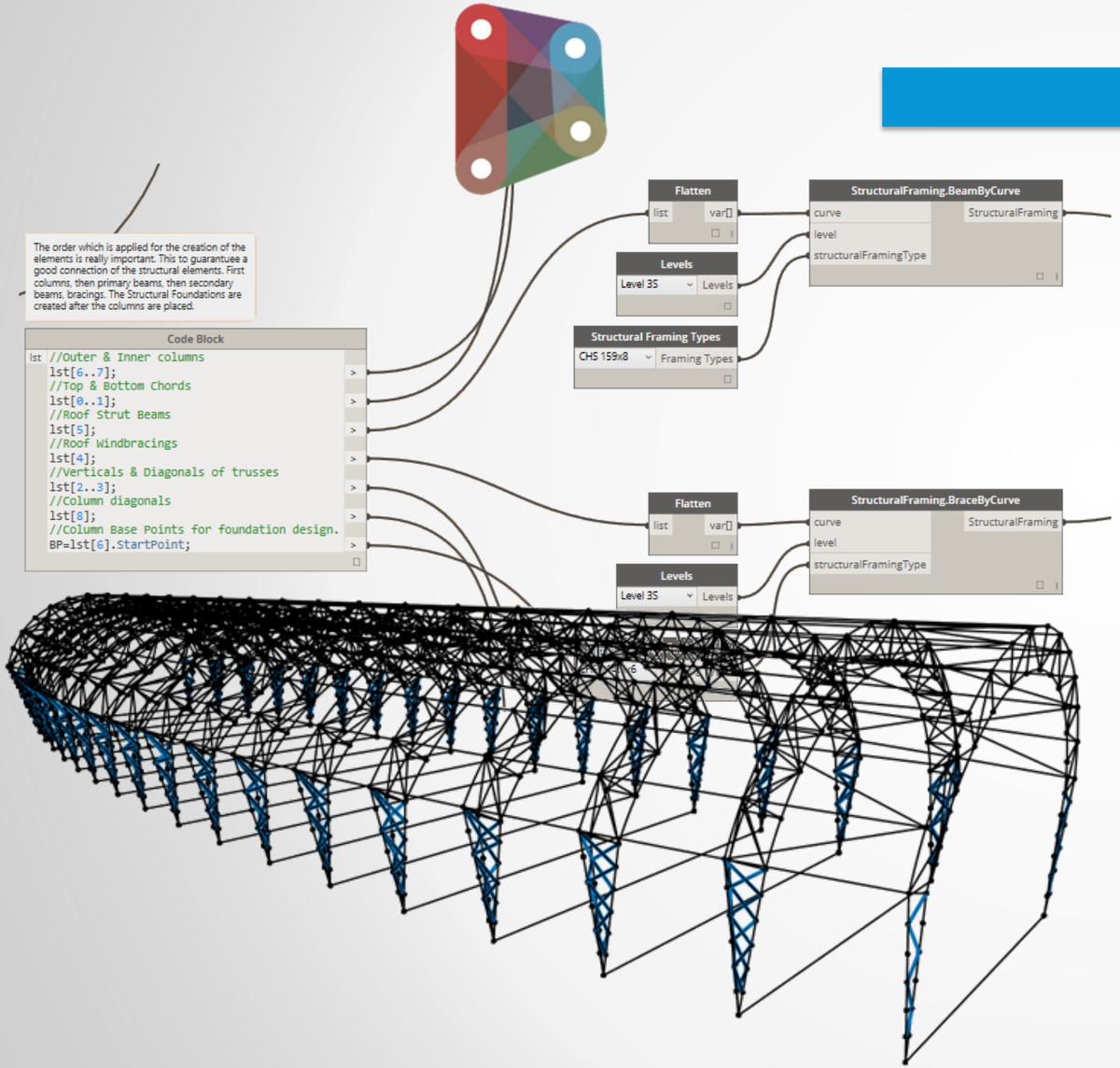
- Standalone version
- Works without Revit
- Desktop Subscription



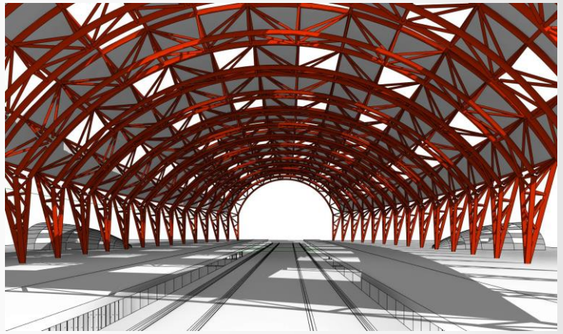


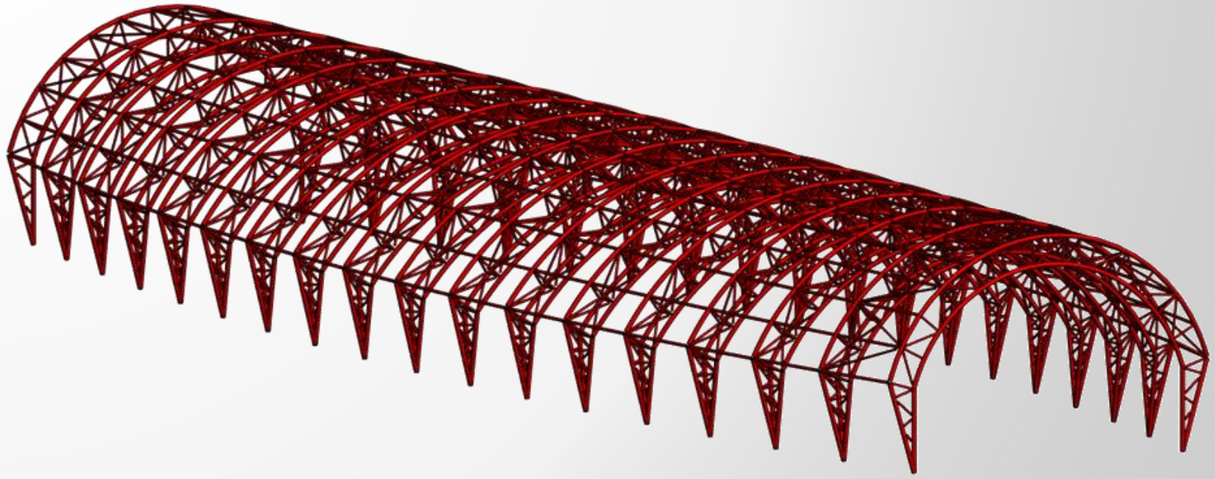
Structural Modelling

Structural Modelling with Revit

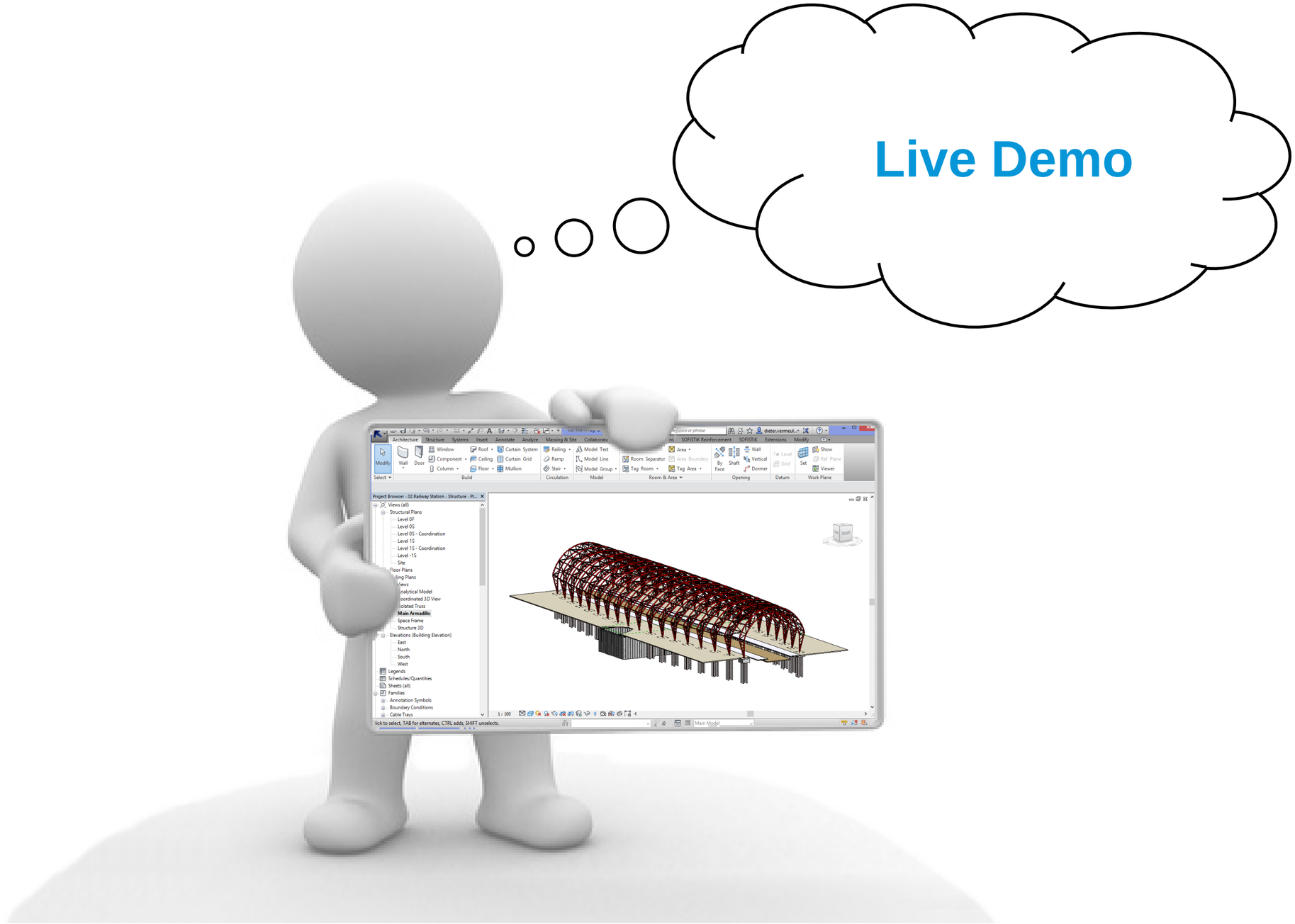








Live Demo

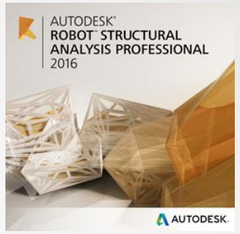


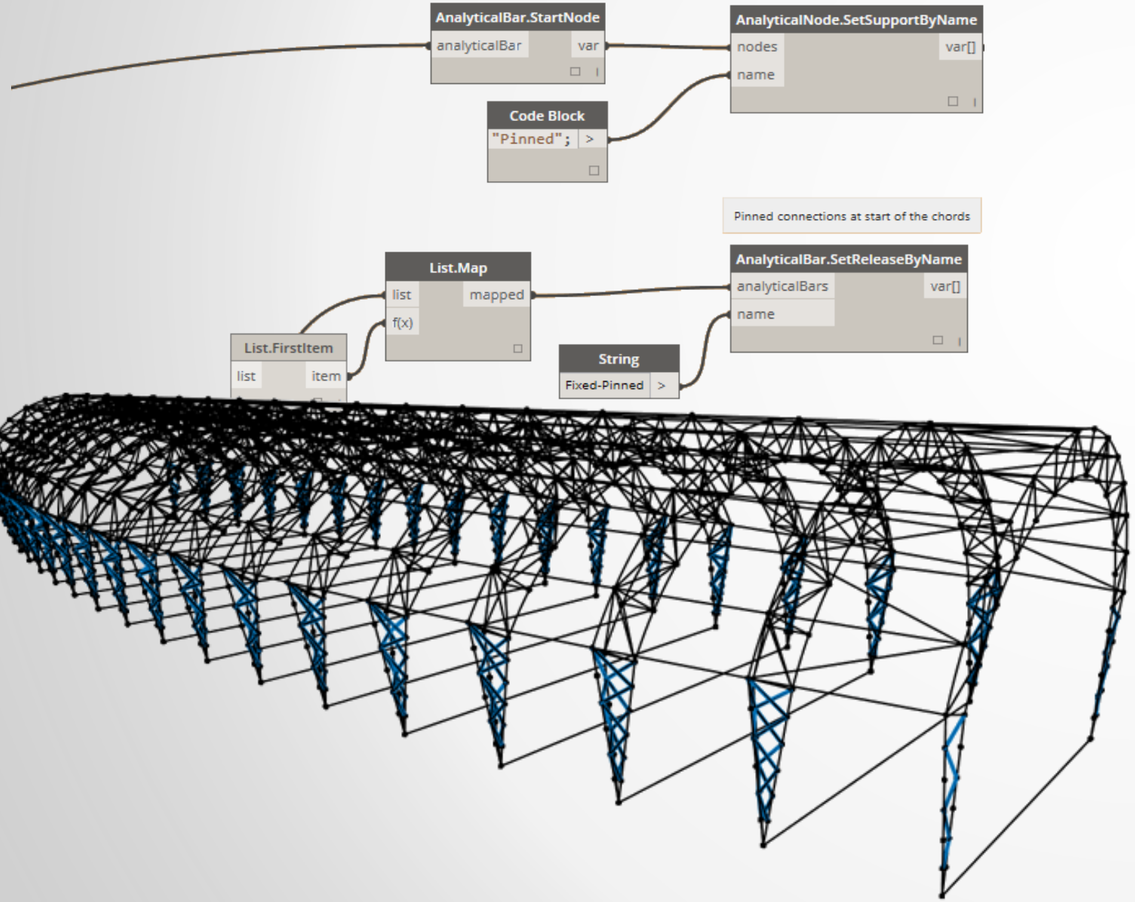
Structural Analysis

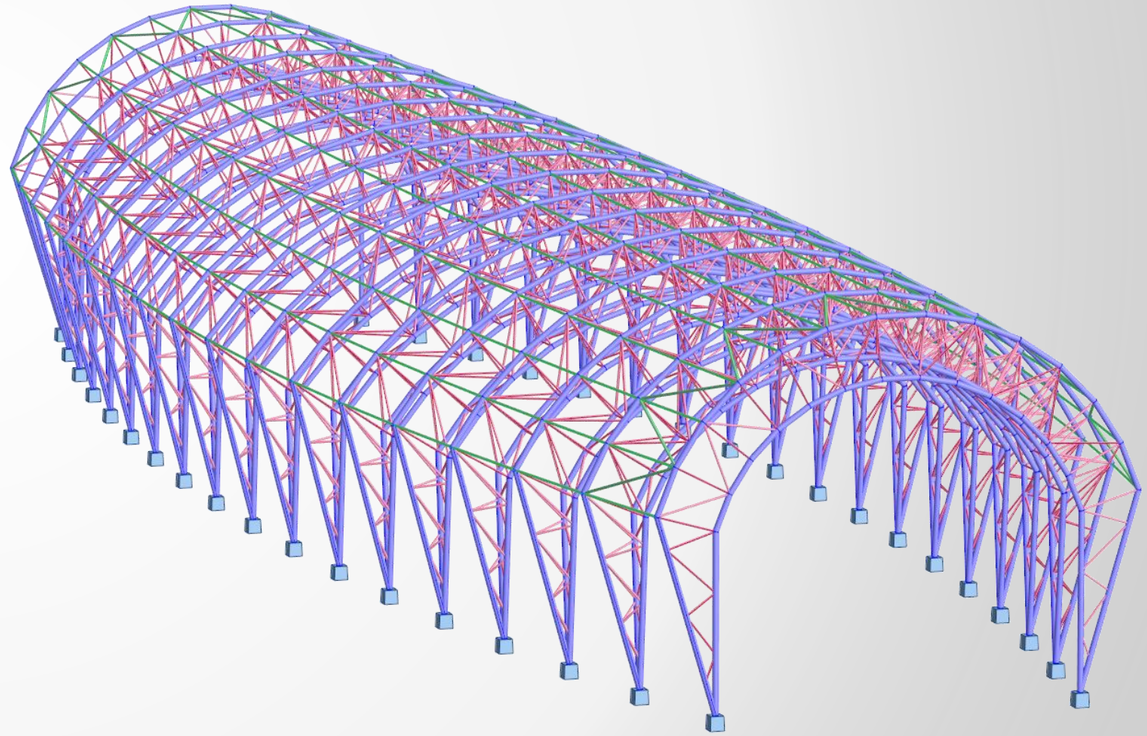


Structural Analysis with Robot Structural Analysis









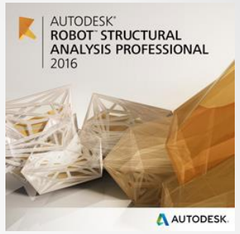
Live Demo

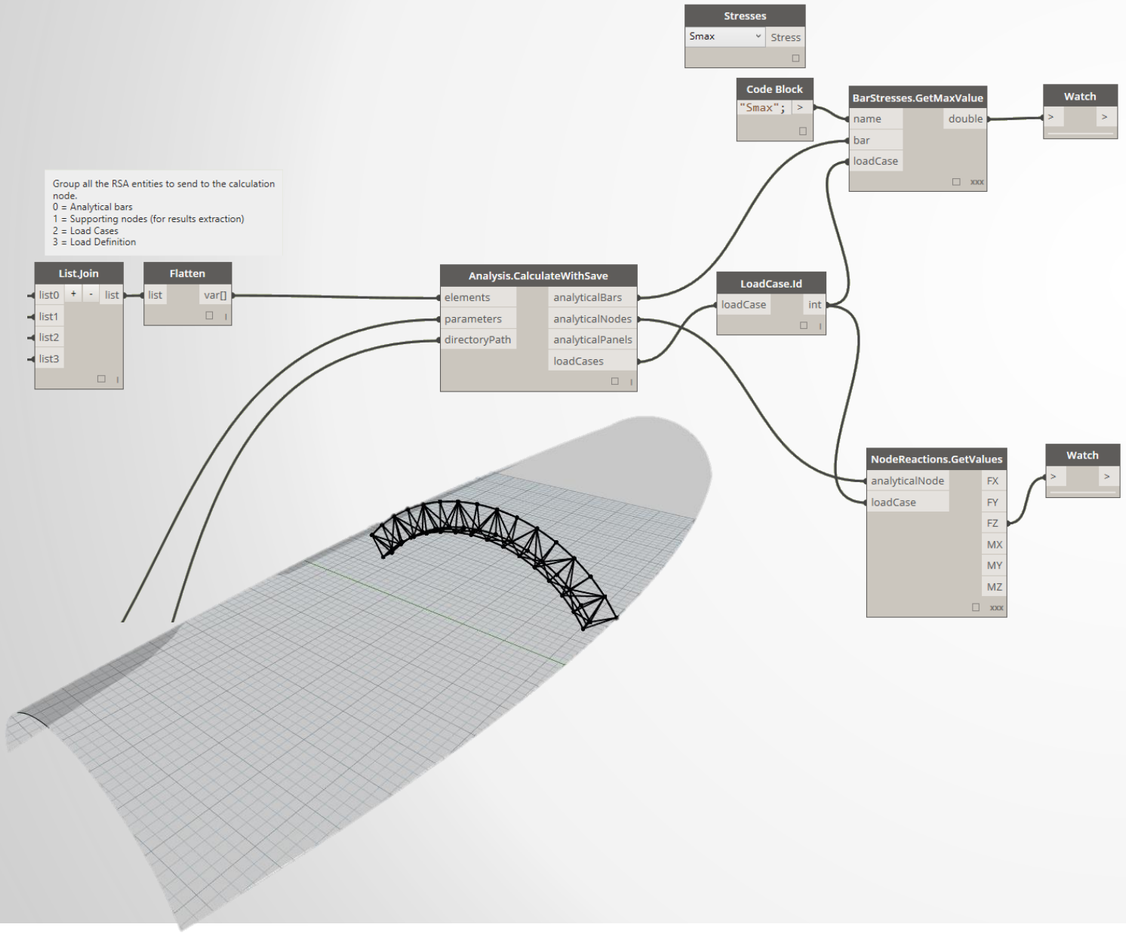

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Help
Updating...
Library
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Analyze
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BIM4StrucProjects
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Core
Display
Cone
CoordinateSystem
Cuboid
Curve
Cylinder
Edge
Ellipse
Manual
Run

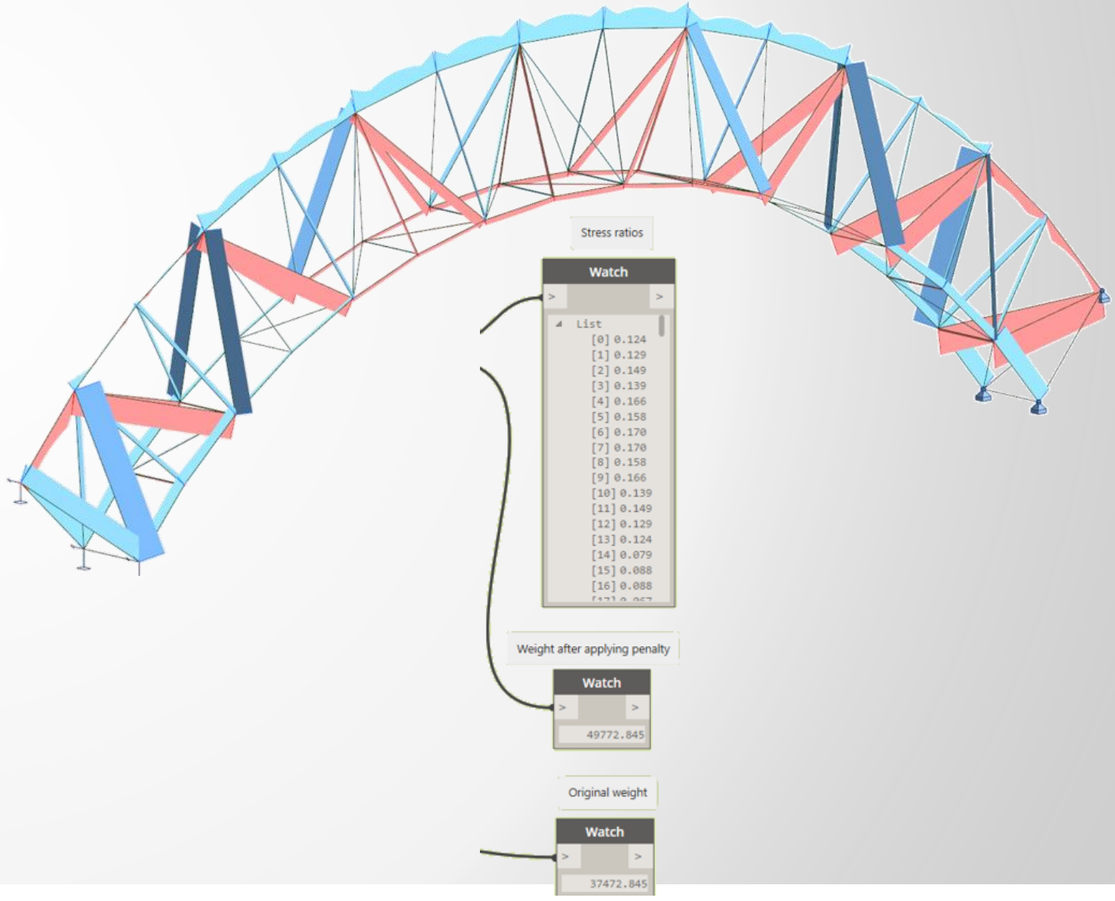
Single Truss Analysis



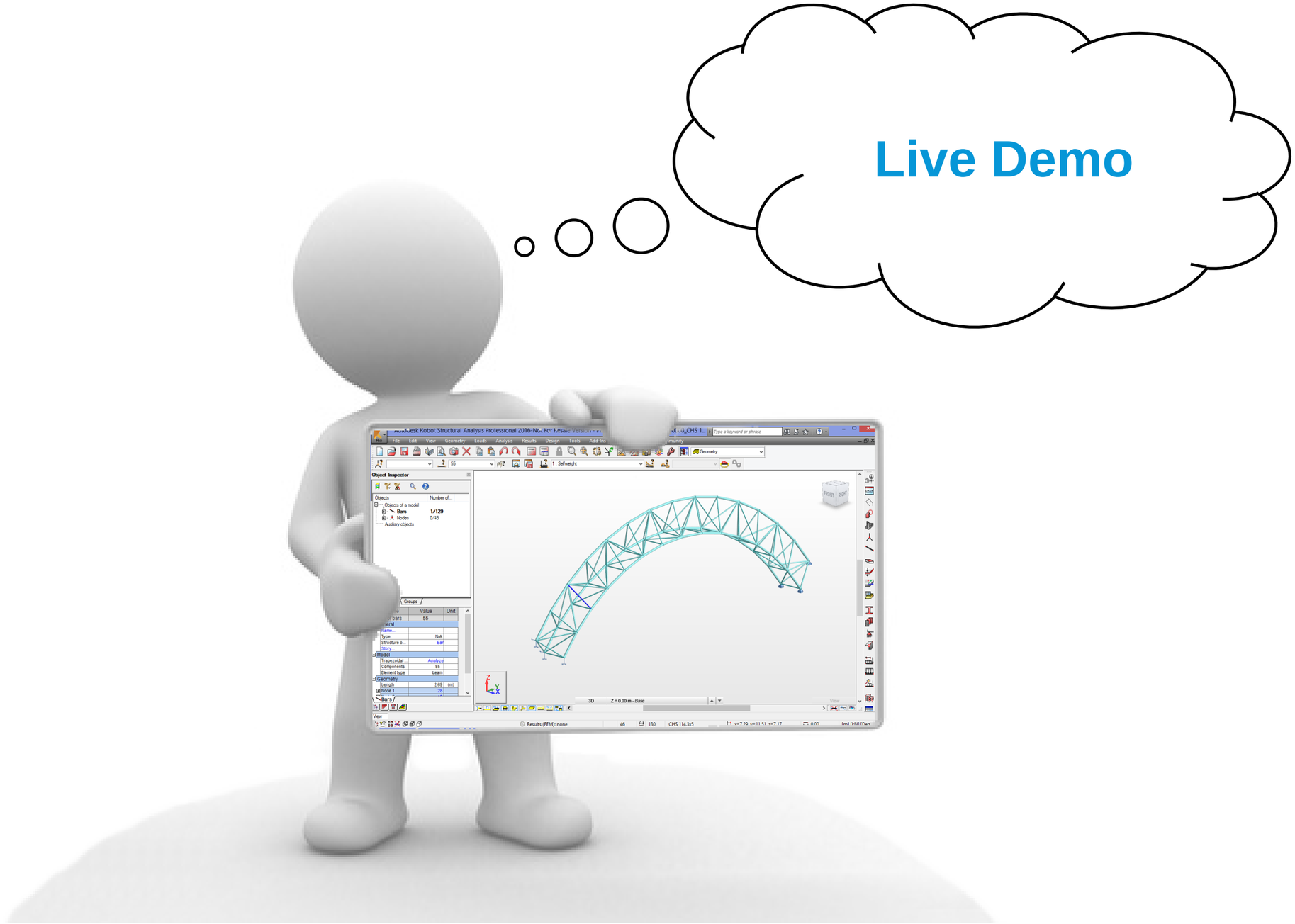








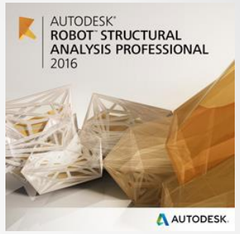
Live Demo

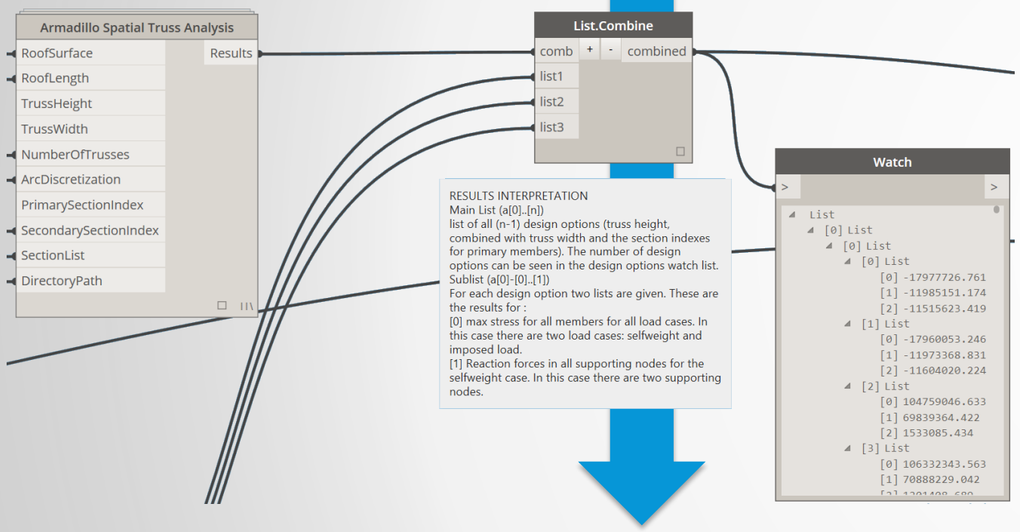


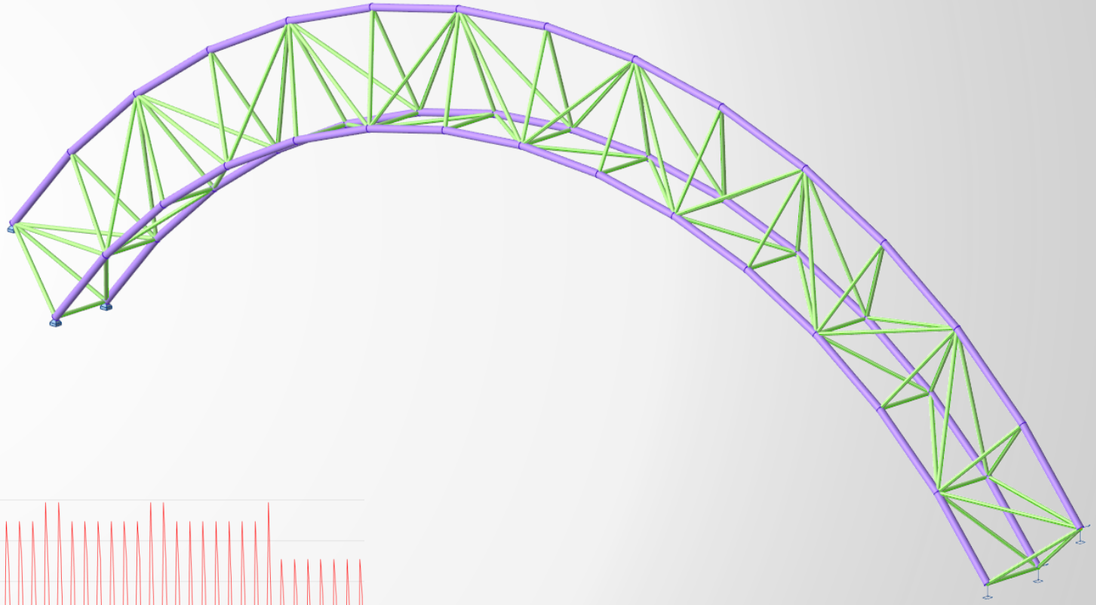
Structural Optimization

Manual Optimization / Parametric Run





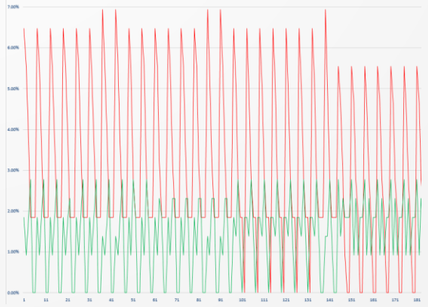






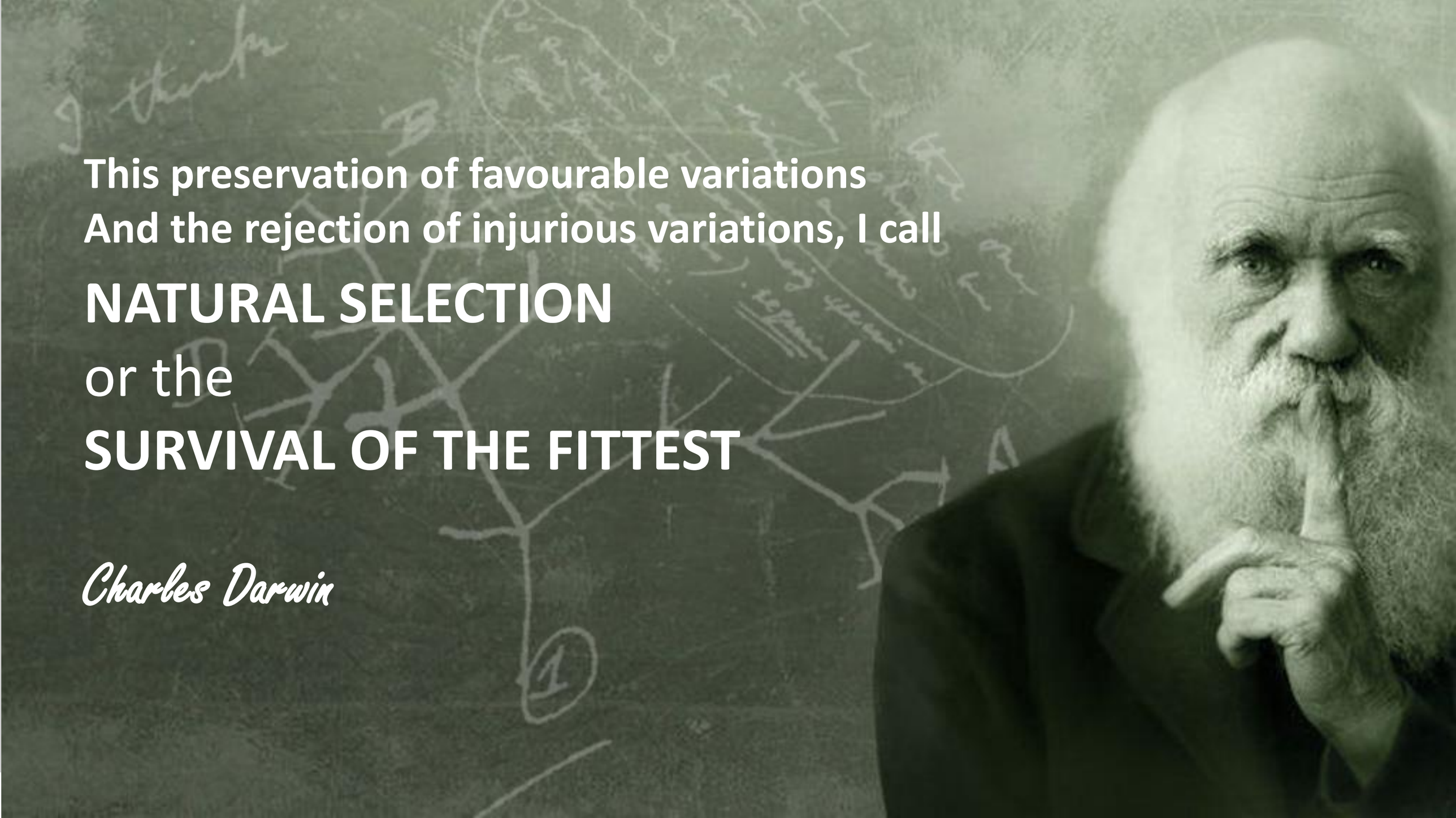


Truss Height (m)	Primary Section	Secondary Section	Actual Weight (kg)	Weight Score	Overstressed Members	Overdesigned Members	Within Range Members
2.00	1.9	CHS 76.3x6	4405.52	21055.52	6.48%	91.67%	1.85%
2.00	1.9	CHS 139.7x6	4695.28	20475.28	5.03%	93.52%	1.38%
2.00	1.9	CHS 165.3x6	5224.86	19424.86	2.78%	94.44%	2.78%
2.00	1.9	CHS 193.7x6	5568.62	19038.62	1.85%	96.76%	1.38%
2.00	1.9	CHS 219.1x5	6936.90	19536.90	1.85%	98.15%	0.00%
2.00	1.9	CHS 244.5x10	8502.80	19902.80	0.00%	98.15%	1.85%
2.00	2	CHS 76.3x6	4496.47	21096.47	6.48%	91.67%	1.85%
2.00	2	CHS 139.7x6	4860.22	20468.22	5.03%	93.52%	1.38%
2.00	2	CHS 165.3x6	5269.01	19469.01	2.78%	94.44%	2.78%
2.00	2	CHS 193.7x6	5633.56	19083.56	1.85%	96.76%	1.38%
2.00	2	CHS 219.1x5	6981.85	19581.85	1.85%	98.15%	0.00%
2.00	2	CHS 244.5x10	8547.74	19947.74	0.00%	98.15%	1.85%
2.00	2.1	CHS 76.3x6	4542.34	21442.34	6.48%	91.67%	1.85%
2.00	2.1	CHS 139.7x6	4906.09	20506.09	5.03%	93.52%	1.38%
2.00	2.1	CHS 165.3x6	5315.68	19515.68	2.78%	94.44%	2.78%
2.00	2.1	CHS 193.7x6	5679.43	19129.43	1.85%	96.76%	1.38%
2.00	2.1	CHS 219.1x5	7027.72	19627.72	1.85%	98.15%	0.00%



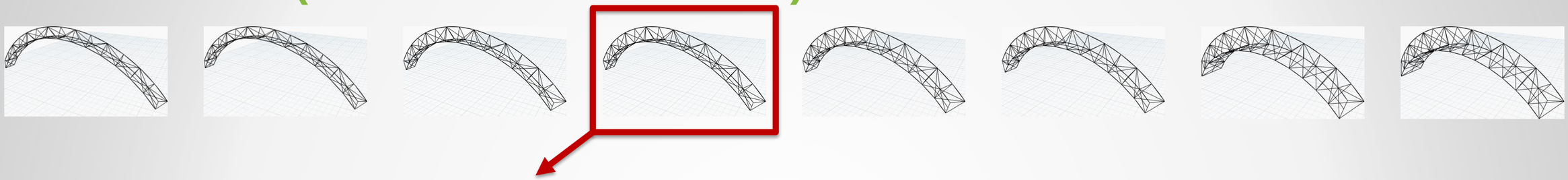
Live Demo


Object Inspector
Objects
Number of...
Objects of a model
Bars 0/2894
Nodes 0/1104
Auxiliary objects
Geometry
Groups
Name
Value
Unit
CHS 114.3x5
CHS 244.5x10
CHS 88.9x4
RIGHT

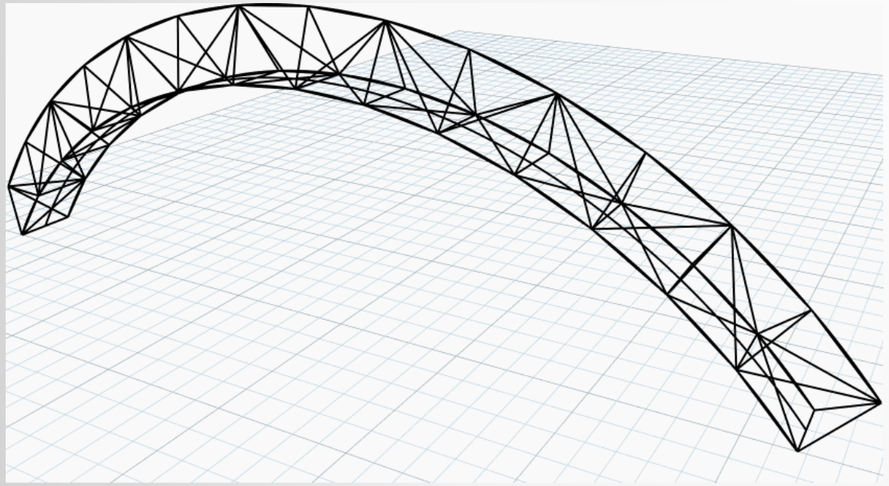

This preservation of favourable variations
And the rejection of injurious variations, I call
NATURAL SELECTION
or the
SURVIVAL OF THE FITTEST
Charles Darwin

Structural Optimization using Genetic Algorithms

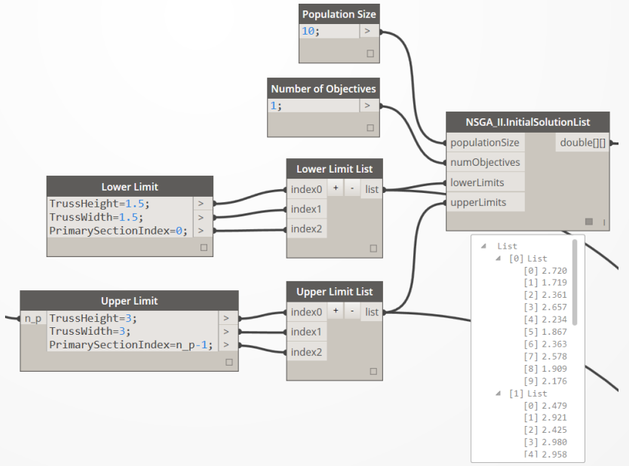
POPULATION (= initial set of solutions)



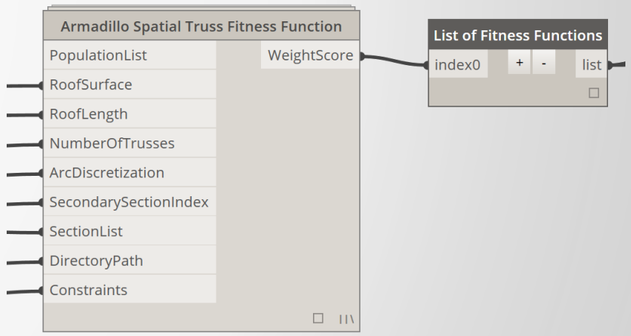
PHENOTYPE



GENOTYPE



FITNESS FUNCTION



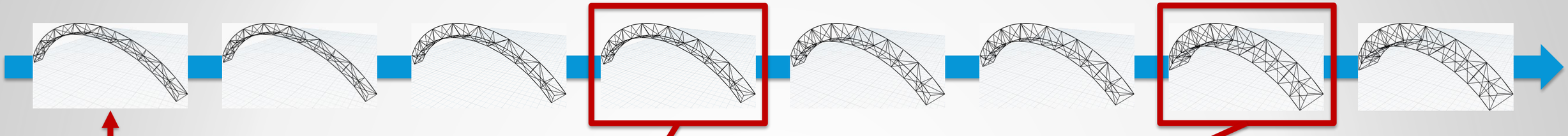
Shape

Parameters

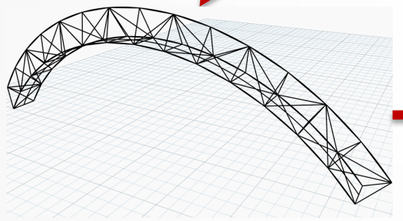
Evaluation

Structural Optimization using Genetic Algorithms

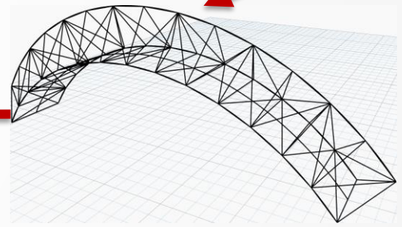
EVOLUTION



Selection

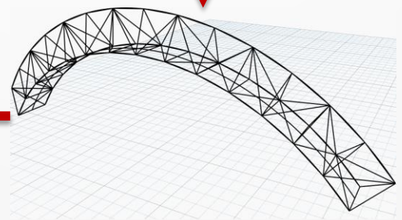


Parent Solution 1
"Dad"



Parental Solution 2
"Mom"

Cross Over
Mutation



Child Solution
"Baby truss"

Evaluation
Insert to the population

Iterate Generations

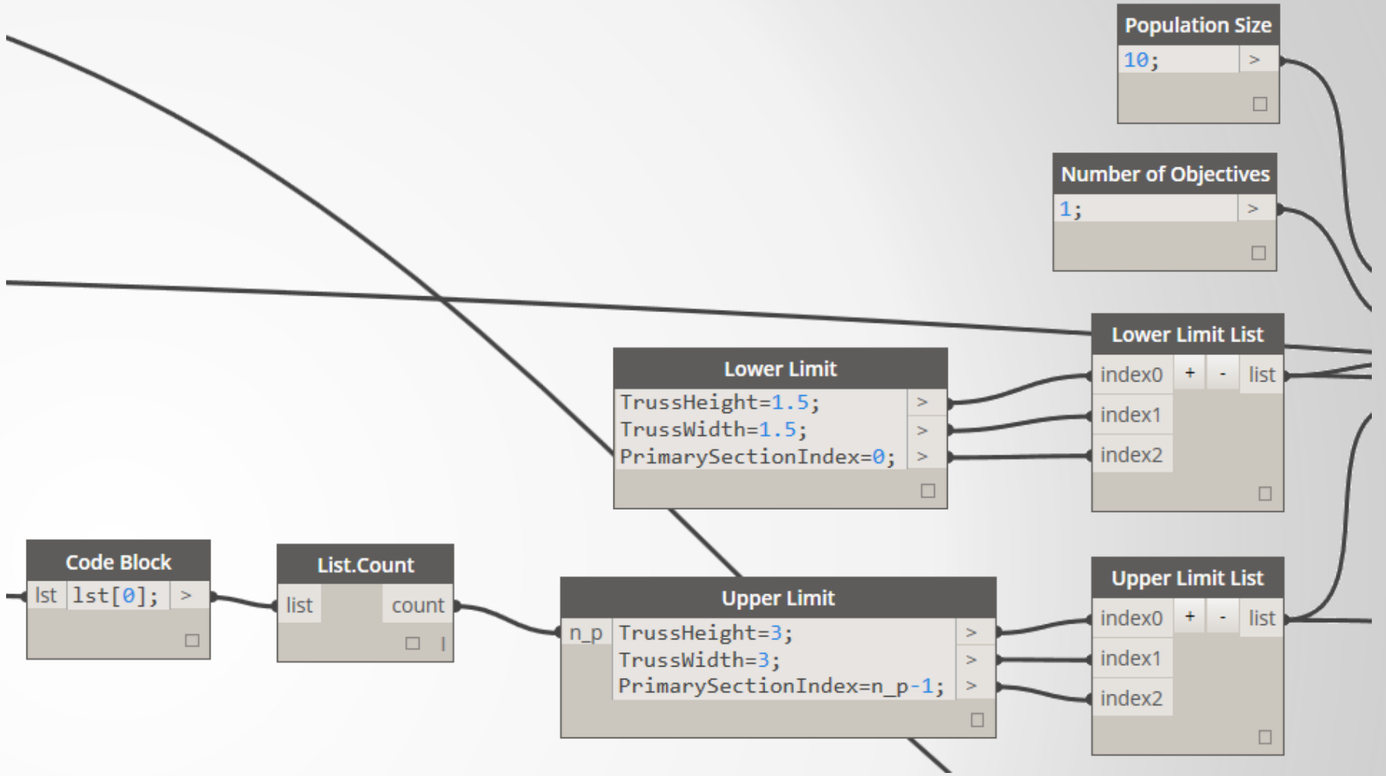
Representation of Optimization Problem

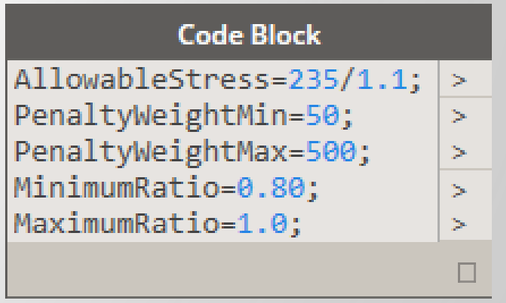
Objective:
- Minimal Weight Score

Design Variables:
- Truss height
- Truss width
- Cross section primary members

Design Variable Domain :
- 1.5 m ≤ Truss height ≤ 3.0 m
- 1.5 m ≤ Truss height ≤ 3.0 m
- 0 ≤ Primary Section Index ≤ n-1 (n = number of sections in the list)

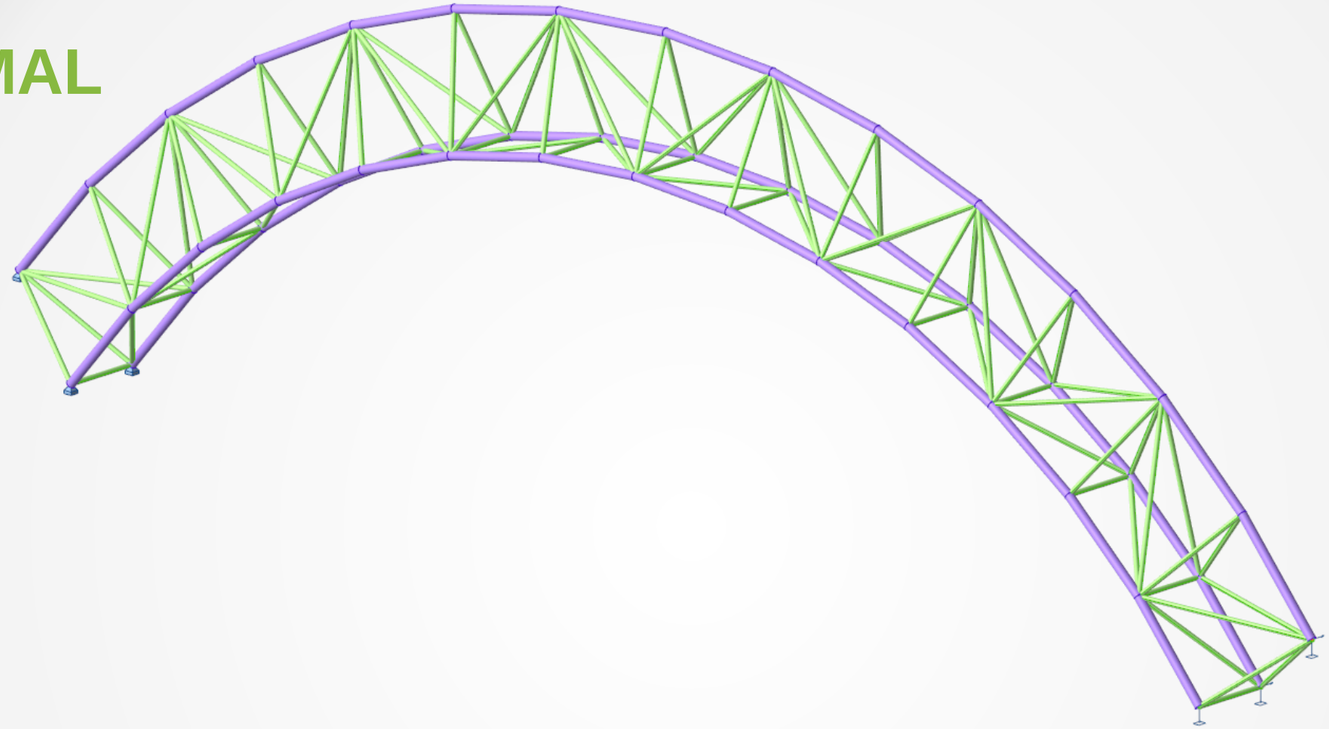
Constraints:
- Stress Ratio between 0.8 and 1.0 for allowable stress = 235 N/mm²

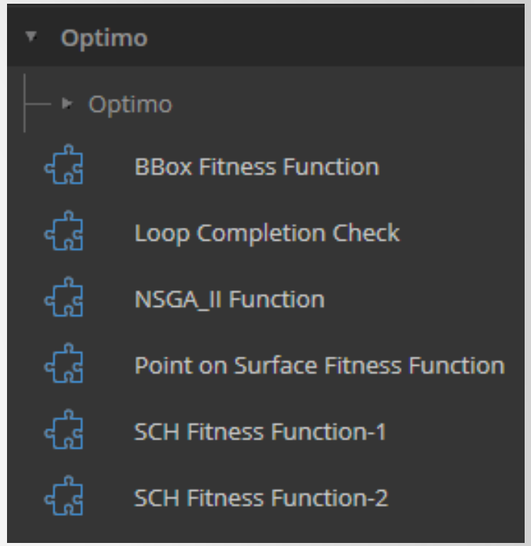




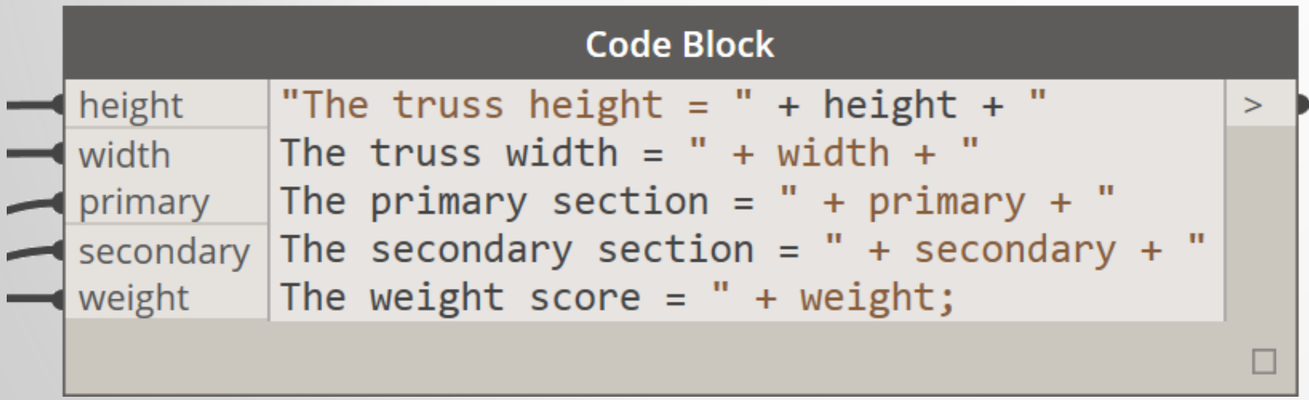
Structural Optimization using Genetic Algorithms

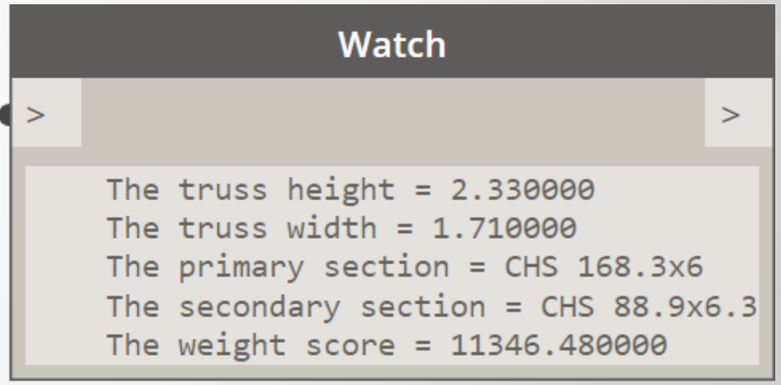
PARETO OPTIMAL





"Optimo" package





Live Demo

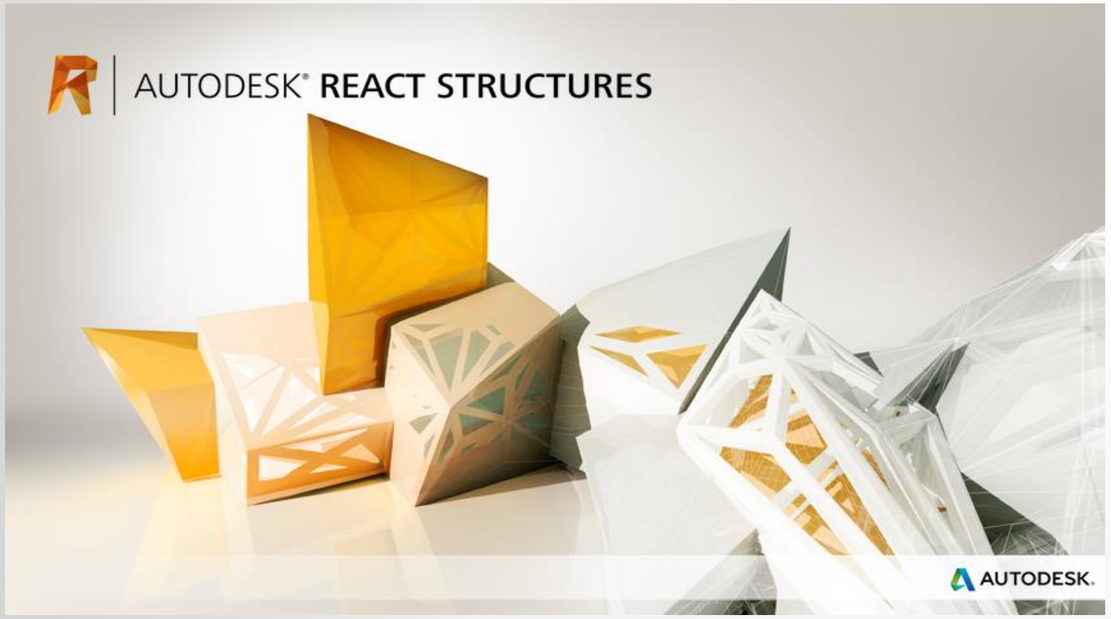

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Updating...
Library
Search
Analyze
BIM4Struc
BIM4StrucProjects
Builtin
Core
Display
Cone
CoordinateSystem
Cuboid
Curve
Cylinder
Edge
Ellipse
Manual
Run

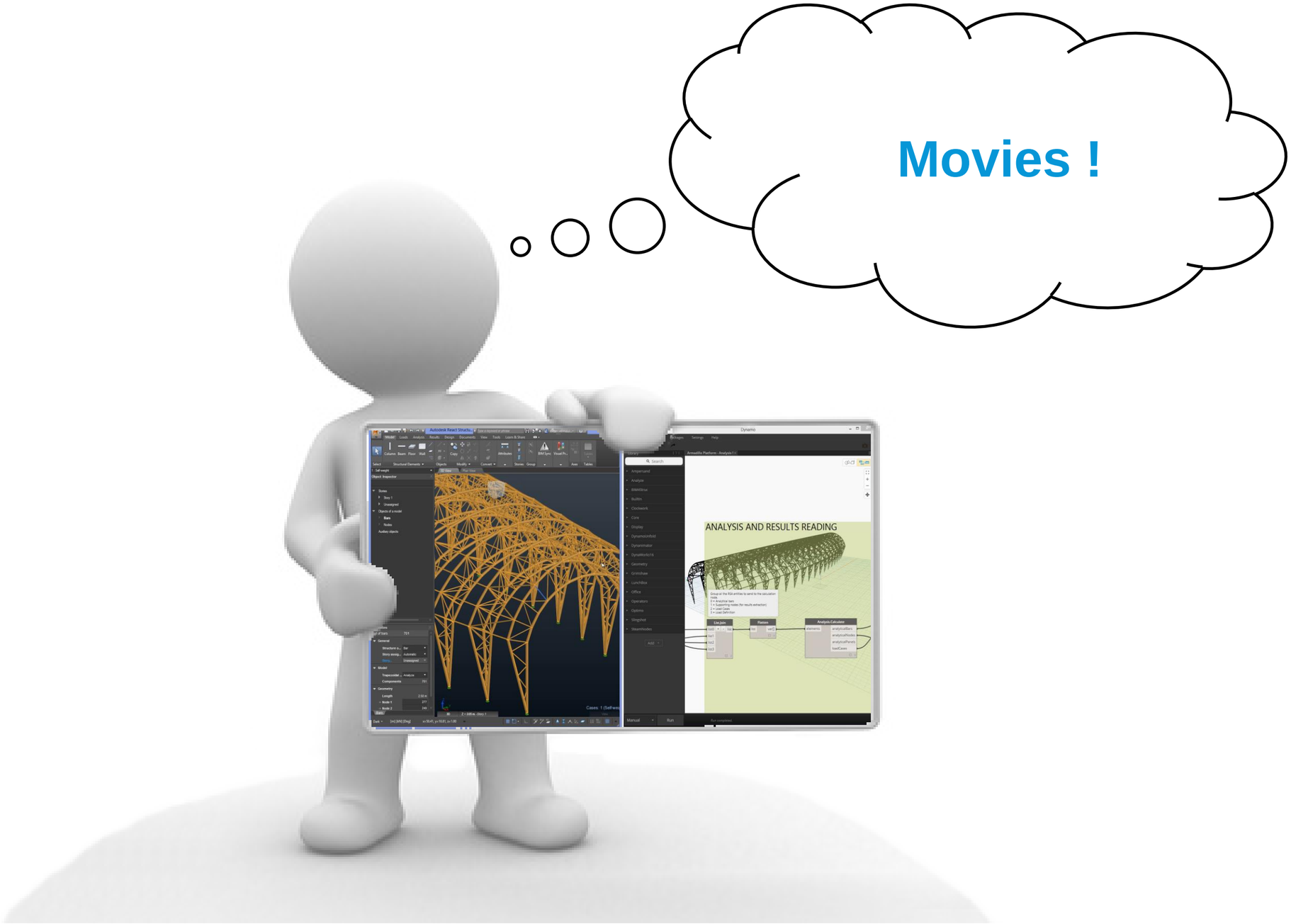
React Structures



Dynamo with React Structures Technology Preview

- Alternative with React Structures TP2
- Use in-product Dynamo 0.9
- Optimization runs till 10x faster

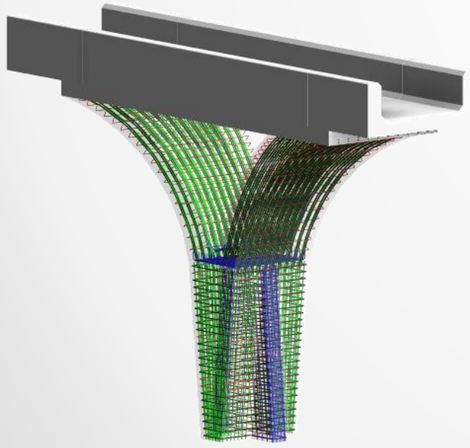


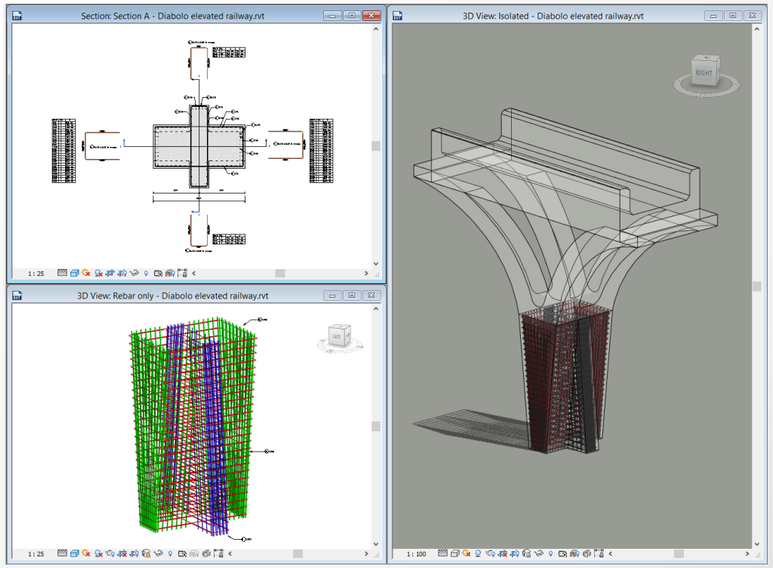


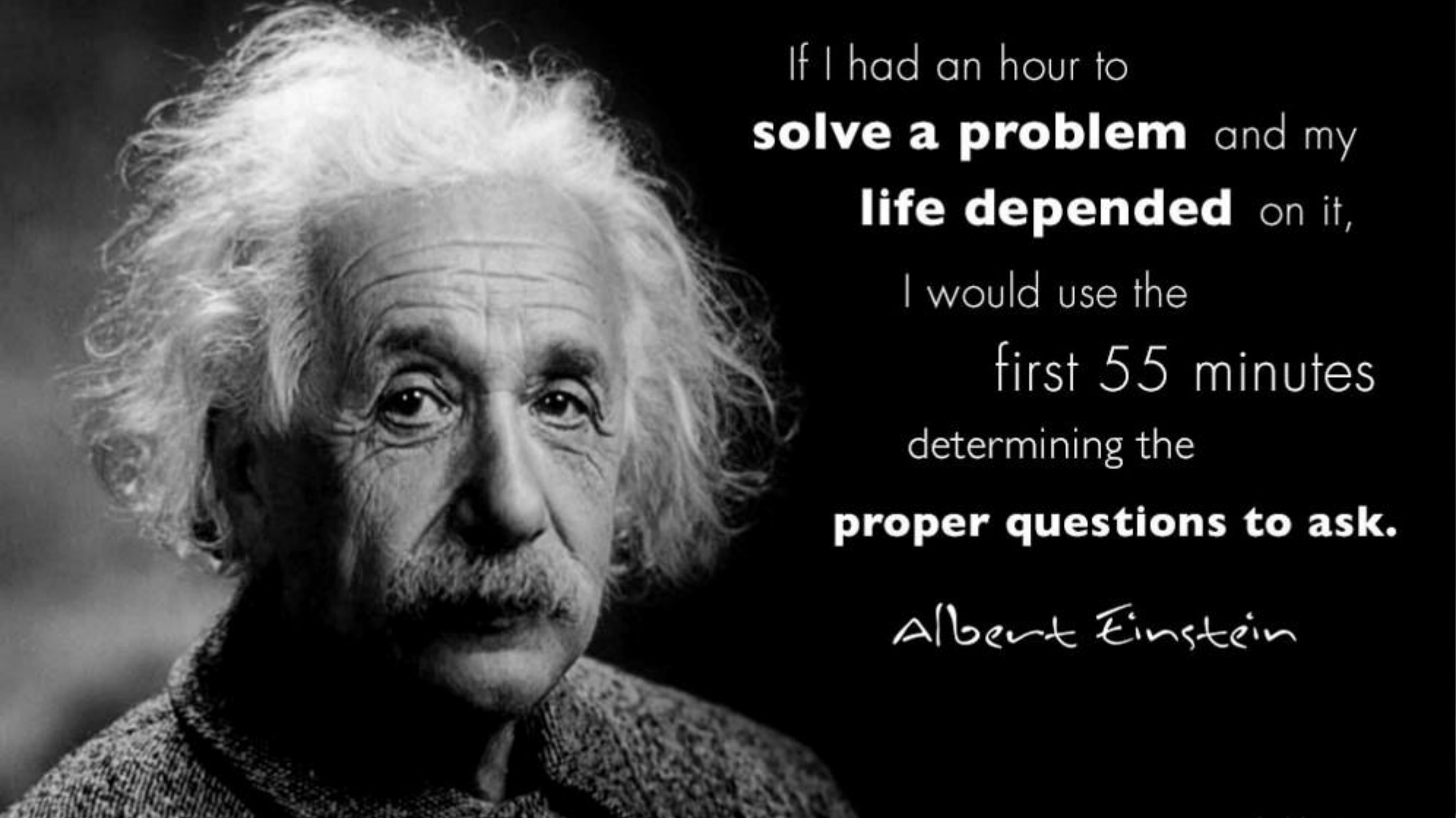
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More Dynam(o)ite Your Design for Engineers

- Keep an eye on **RevitBeyondBIM** blog
- Dynamo for Rebar in class **MSF11845 – Dynam(o)ite Your Design from Concept to Fabrication**

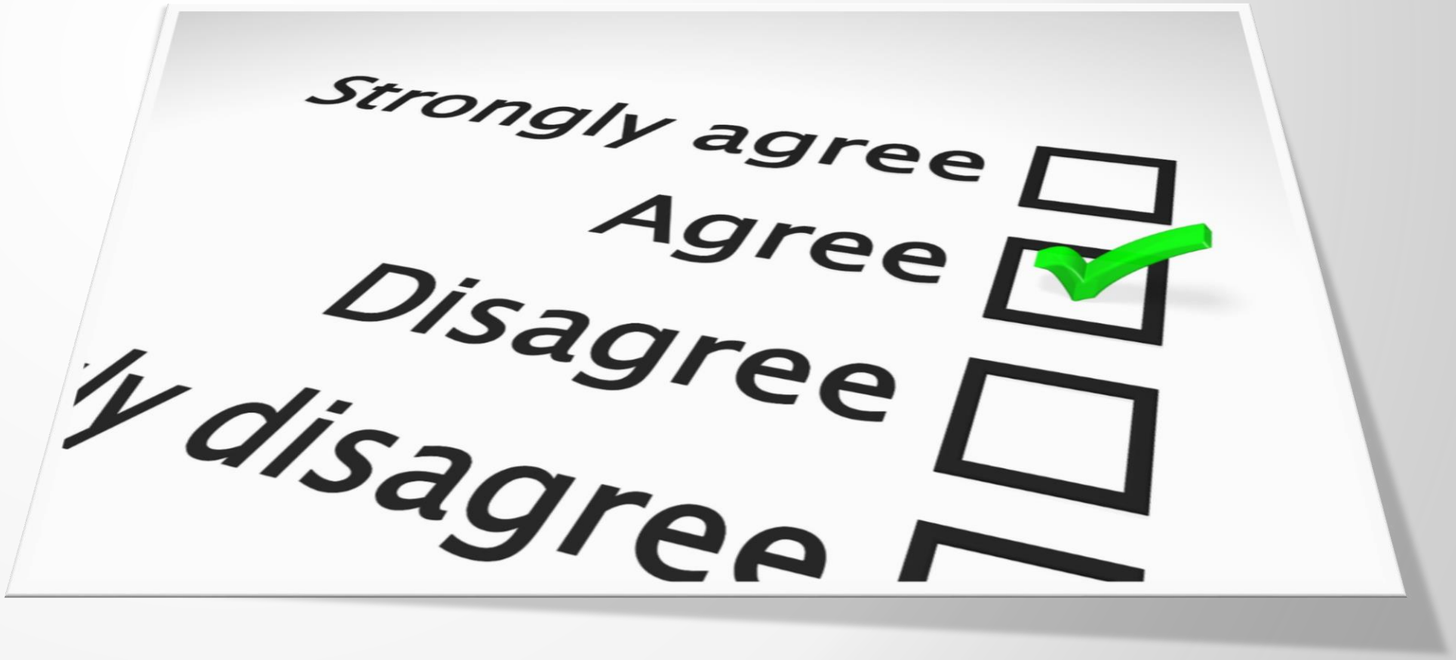





If I had an hour to
solve a problem and my
life depended on it,
I would use the
first 55 minutes
determining the
proper questions to ask.
Albert Einstein

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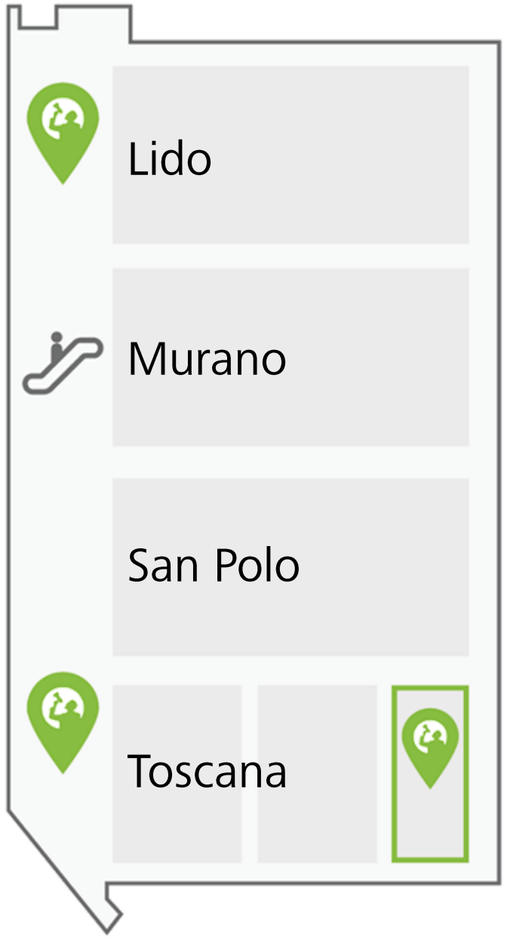
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