How Computational Thinking Is Reshaping Engineering Theory

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Faculty of Architecture, Kasetsart University

TBIM BIM Showcase 2026
14 March 2026, SCG, Bangkok, Thailand

ผศ.ดร.ศิรเดช สุริต

ความเชี่ยวชาญ

Structural Optimization, BIM, FEM,
Generative Design, AI, Virtual Environment

- Doctor in Engineering, Kasetsart University
- อาจารย์ประจำภาควิชานวัตกรรมอาคาร คณะสถาปัตยกรรมศาสตร์ มหาวิทยาลัยเกษตรศาสตร์
- อาจารย์ประจำหลักสูตร ป.โท นวัตกรรมโครงสร้างเพื่อสิ่งแวดล้อมสรรคสร้าง คณะวิศวกรรมศาสตร์ มหาวิทยาลัยเกษตรศาสตร์
- อาจารย์พิเศษ คณะวิศวกรรมศาสตร์ มหาวิทยาลัยเกษตรศาสตร์
- ผู้ก่อตั้งเพจ https://www.facebook.com/StructuralStudio

Architect

CAD for Arch Presentation	**Revit** Anusorn Petchtiam Siradech Surit
Adv. BIM for Architect	**Rhino + Grasshopper** **Revit + Dynamo** Walaiporn Nakaphan Anusorn Petchtiam Siradech Surit
BIM/CAE	**Revit + Robot + Dynamo** **Fusion 360** Siradech Surit
Computer Application in Product Design	**Fusion 360** **Stable Diffusion** Siradech Surit
BIM for Bld. Innovation Design	**Revit + Robot + Dynamo** **Insight / Ecotech** **Naviswork** Parames Kamhangritriong Pattaranan Takkanon Siradech Surit

Engineering

Computer Application for Structure Engineer	**Revit + Robot + Dynamo** **Fusion 360 / Python** Benjaphon Wethyavon Siradech Surit
Structural System Modeling	**Robot** **Fusion 360** Benjaphon Wethyavon Siradech Surit
BIM for Sustainable Design	**Revit + Robot + Dynamo** **Insight / Ecotech** **Naviswork** Parames Kamhangritriong Pattaranan Takkanon Siradech Surit
Multi Disp. Dsn. Optimization	**Revit + Robot + Dynamo** **Fusion 360** Siradech Surit

Fac Arch bbit: bachelor in building innovation and technology (arch)
mbit: master in building innovation and technology (arch)

Fac Eng ce: bachelor in civil engineering (civil)
stbe: structural technology in build-environment (civil)

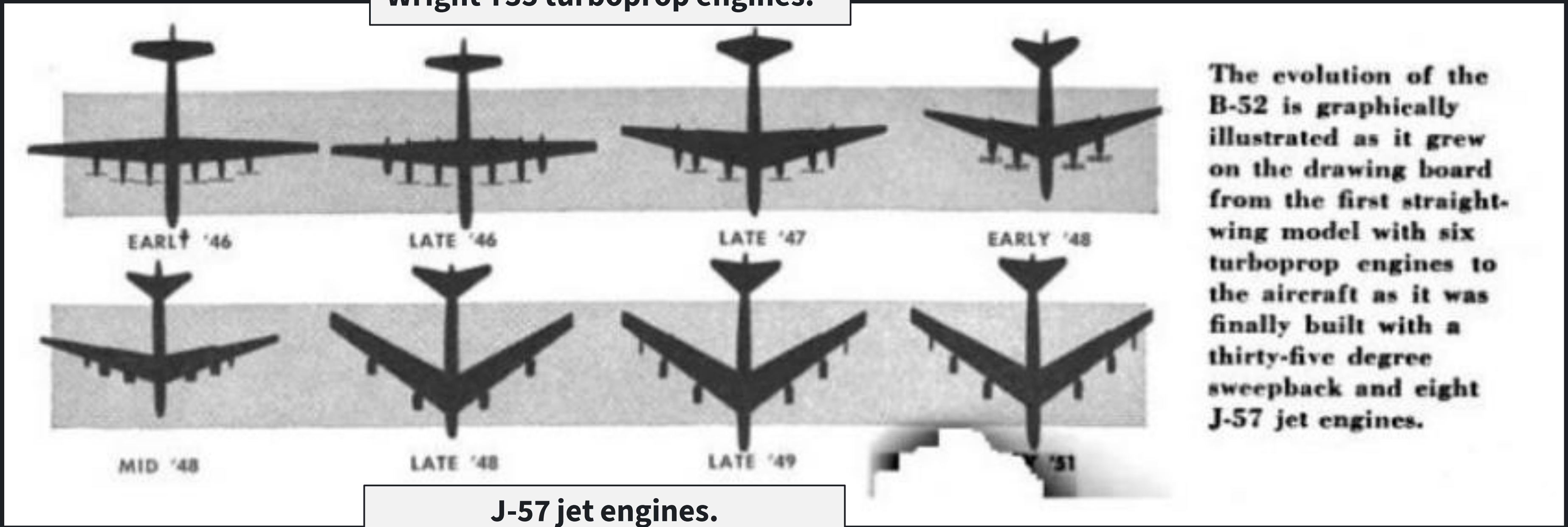
How Computational Thinking Is Reshaping Engineering Theory

Interactive Live Demo →

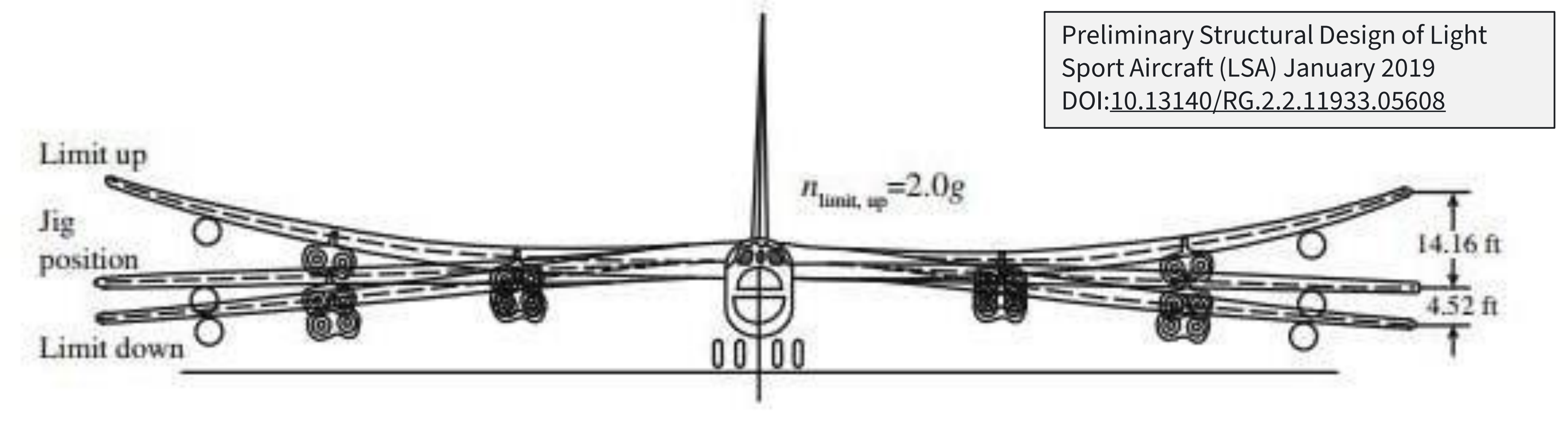
A video from british pathé FILM ID:2622.19 (XB-52 Stratofortress Test flight 1940s)

The Origins of the Finite Element Method

Wright T35 turboprop engines.



J-57 jet engines.

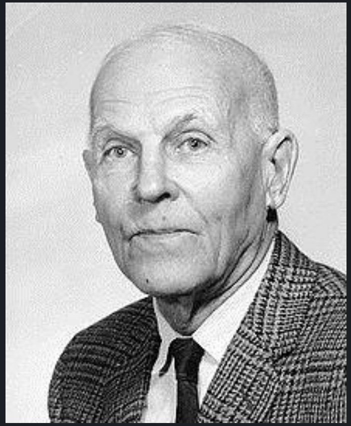


Preliminary Structural Design of Light Sport Aircraft (LSA) January 2019
DOI:10.13140/RG.2.2.11933.05608

The Origins of the Finite Element Method

B-52 Stratofortress
April 15, 1952: B-52 first flight

The Origins of the Finite Element Method



Alexander Hrennikoff

Hrennikoff, A. "Solution of Problems in Elasticity by the Framework Method", Journal of Applied Mechanics, 8, pp. 169-175, 1941.

1941 – 1943

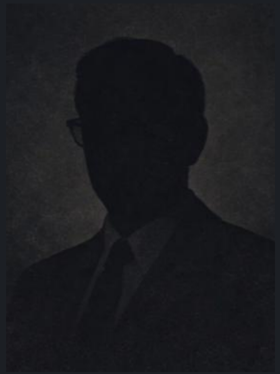
Rectangular Plate - Membrane

Richard Courant

Courant, C., "Variational Methods for Solution of Equilibrium and Vibration", Bull. Am. Math Soc., Vol. 49, 1943, pp. 1-43.

1943

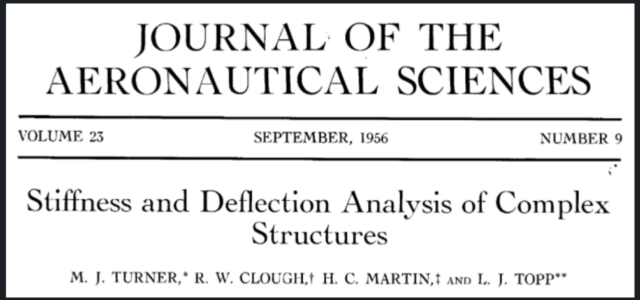
Constant Strain Triangle; CST



M. J. Turner ***R. W. Clough*** ***H. C. Martin*** ***L. J. Topp***

M. J. Turner, R. W. Clough, H. C. Martin, and ***L. J. Topp*** "*Stiffness and Deflection Analysis of Complex Structures,*" *Journal of the Aeronautical Sciences,* one of the **first articles concerning the application of the finite element method.**

1954 → Published 1956



JOURNAL OF THE AERONAUTICAL SCIENCES

VOLUME 23 SEPTEMBER, 1956 NUMBER 9

Stiffness and Deflection Analysis of Complex Structures

M. J. TURNER,* R. W. CLOUGH,† H. C. MARTIN,‡ AND L. J. TOPP**

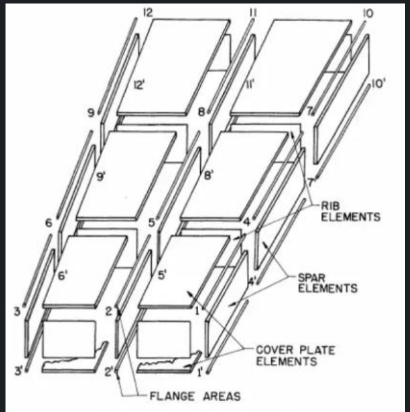
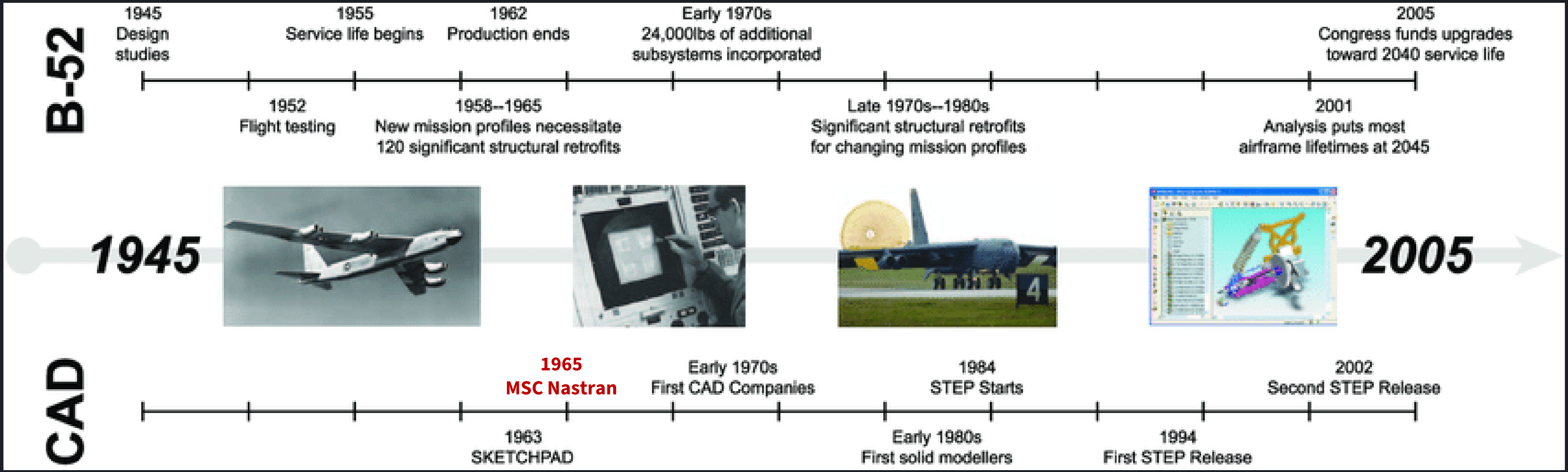


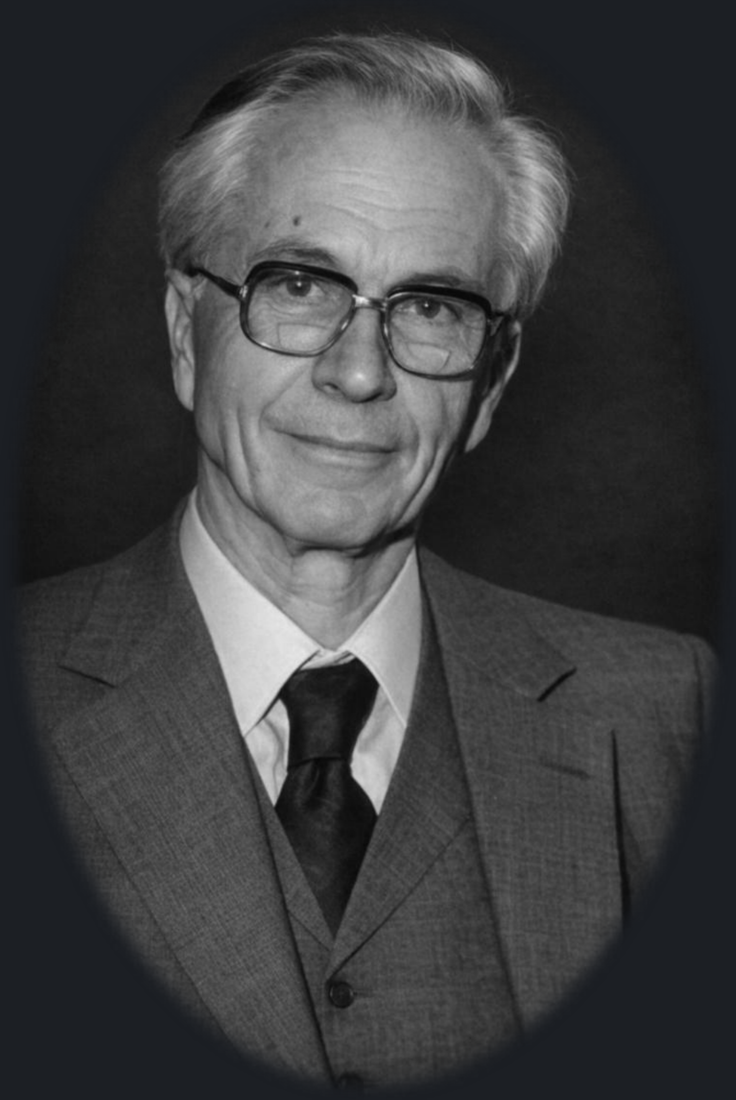
Fig. 3. Wing structure breakdown.

The Origins of the Finite Element Method



CAD ARCHIVES BASED ON OAIS. Proceedings of IDETC/CIE 2006
ASME 2006 International Design Engineering Technical Conferences &
Computers and Information in Engineering Conference
September 10–13, 2006, Philadelphia, USA

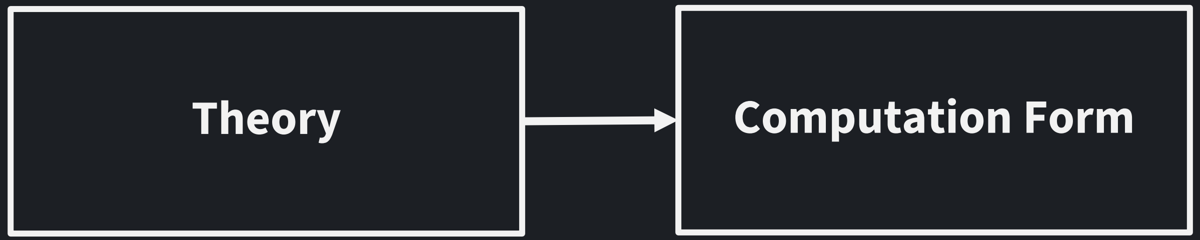
https://cradle.co.th/cradle-cfd/



John Argyris (1913-2004)
one of the pioneers of computational mechanics

- Matrix structural analysis
- Energy-based FEM formulation
- Nonlinear finite element development
- Large-scale computational mechanics

“The Computer Shapes the Theory”



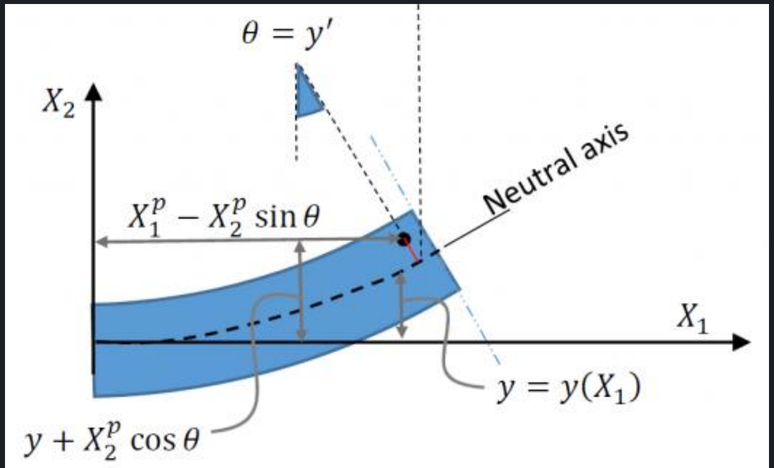
1956 – Birth of FEM

1960 – Computational mechanics emerges

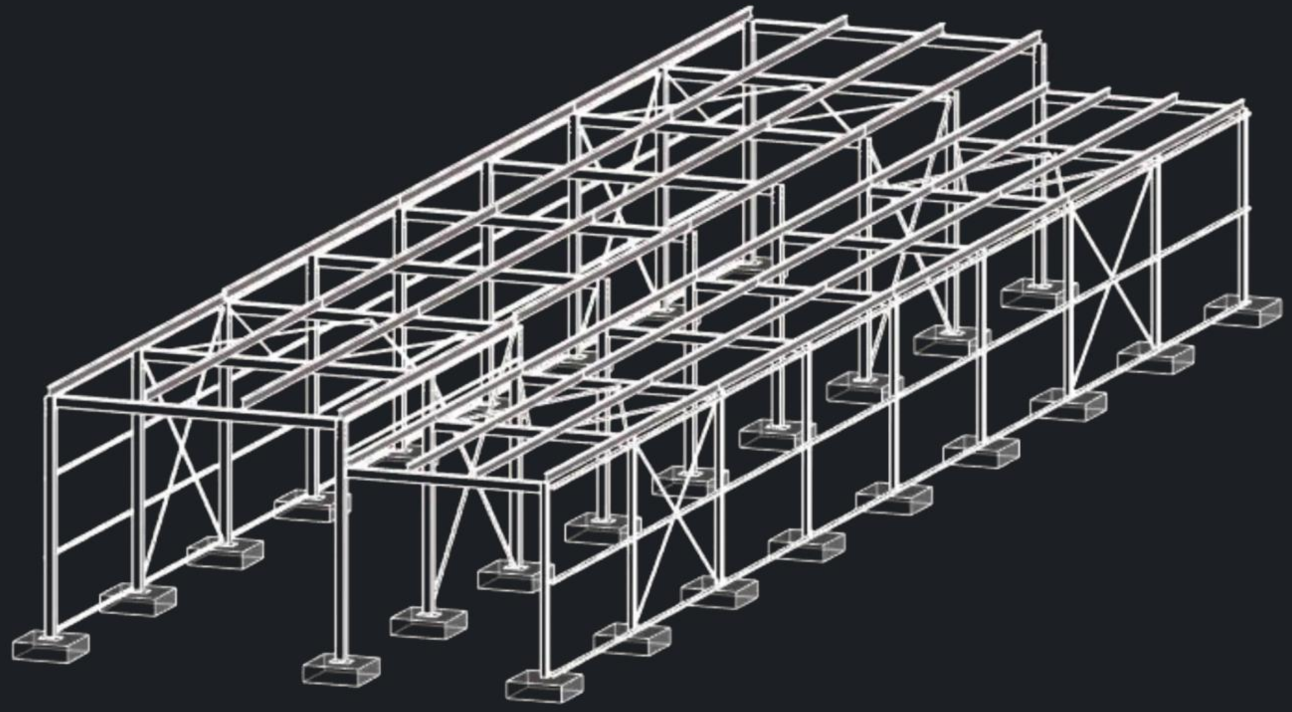
COMMUNICATIONS IN NUMERICAL METHODS IN ENGINEERING Commun. Numer. Meth. Engng 2004; 20:665–669 (DOI: 10.1002/Cnm.709)

From Analytical Thinking to Algorithmic Thinking

$$\frac{d^2}{dx^2}\left(EI\,\frac{d^2\Delta}{dx^2}\right) = w$$



Euler-Bernoulli Beam Theory



Real world structure

Computational Mechanics and Structural Reformulation

$$\frac{d^2}{dx^2}\left(EI\frac{d^2\Delta}{dx^2}\right) = w$$

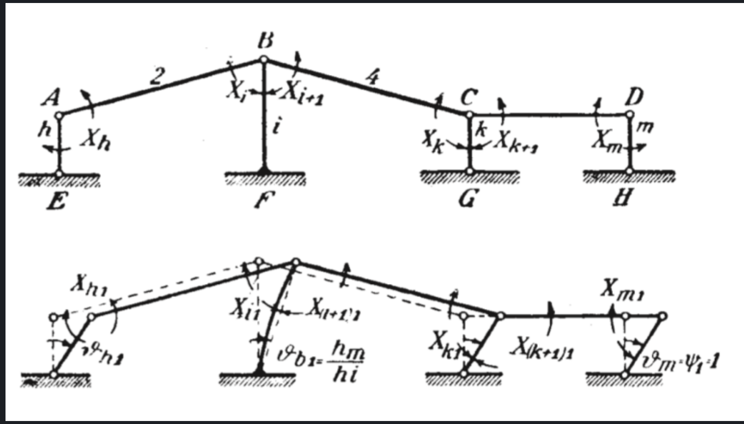
Analytical (Differential Equation)

$$M_{AB} = \frac{2EI}{L}(2\theta_A + \theta_B - 3\psi) + \frac{2EI}{L^2}(2\Delta_{A/B,ext} - \Delta_{B/A,ext})$$
$$M_{BA} = \frac{2EI}{L}(\theta_A + 2\theta_B - 3\psi) + \frac{2EI}{L^2}(\Delta_{A/B,ext} - 2\Delta_{B/A,ext})$$

Algebraic formulation
(No Differential Equation)

Slope Deflection Method

George Alfred Maney (1915)



Human Calculator

$$(K_{AB}2 + K_{AE}2)\theta_A + K_{AB}\theta_B - 3K_{AE}\psi_A = -(M^F_{AB} + M^F_{AE})$$
$$K_{AB}\theta_A + (2K_{AB} + 2K_{BC} + 2K_{BF})\theta_B + K_{BC}\theta_C - 3K_{BF}\psi_B = -(M^F_{BA} + M^F_{BC} + M^F_{BF})$$
$$K_{BC}\theta_B + (2K_{BC} + 2K_{CD} + 2K_{CG})\theta_C + K_{CD}\theta_D - 3K_{CG}\psi_C = -(M^F_{CB} + M^F_{CD} + M^F_{CG})$$
$$K_{CD}\theta_C + (2K_{CD} + 2K_{DH})\theta_D - 3K_{DH}\psi_D = -(M^F_{DC} + M^F_{DH})$$

Simultaneous equations

Computational Mechanics and Structural Reformulation

$$\frac{d^2}{dx^2}\left(EI\,\frac{d^2\Delta}{dx^2}\right) = w$$

Analytical Method

Algorithm thinking

→

Machine Calculator

$$\begin{array}{cccccc} u_i & v_i & \theta_i & u_j & v_j & \theta_j \end{array}$$

$$\mathbf{k} = \begin{bmatrix} \frac{EA}{L} & 0 & 0 & -\frac{EA}{L} & 0 & 0 \\ 0 & \frac{12EI}{L^3} & \frac{6EI}{L^2} & 0 & -\frac{12EI}{L^3} & \frac{6EI}{L^2} \\ 0 & \frac{6EI}{L^2} & \frac{4EI}{L} & 0 & -\frac{6EI}{L^2} & \frac{2EI}{L} \\ -\frac{EA}{L} & 0 & 0 & \frac{EA}{L} & 0 & 0 \\ 0 & -\frac{12EI}{L^3} & -\frac{6EI}{L^2} & 0 & \frac{12EI}{L^3} & -\frac{6EI}{L^2} \\ 0 & \frac{6EI}{L^2} & \frac{2EI}{L} & 0 & -\frac{6EI}{L^2} & \frac{4EI}{L} \end{bmatrix}$$

Numerical Method

Computational Mechanics and Structural Reformulation

STRUCTURE

Click a member to inspect

MEMBERS

- Member 0
- Member 1
- Member 2
- Member 3
- Member 4

MEMBER ANALYSIS

Select a member to view analysis details

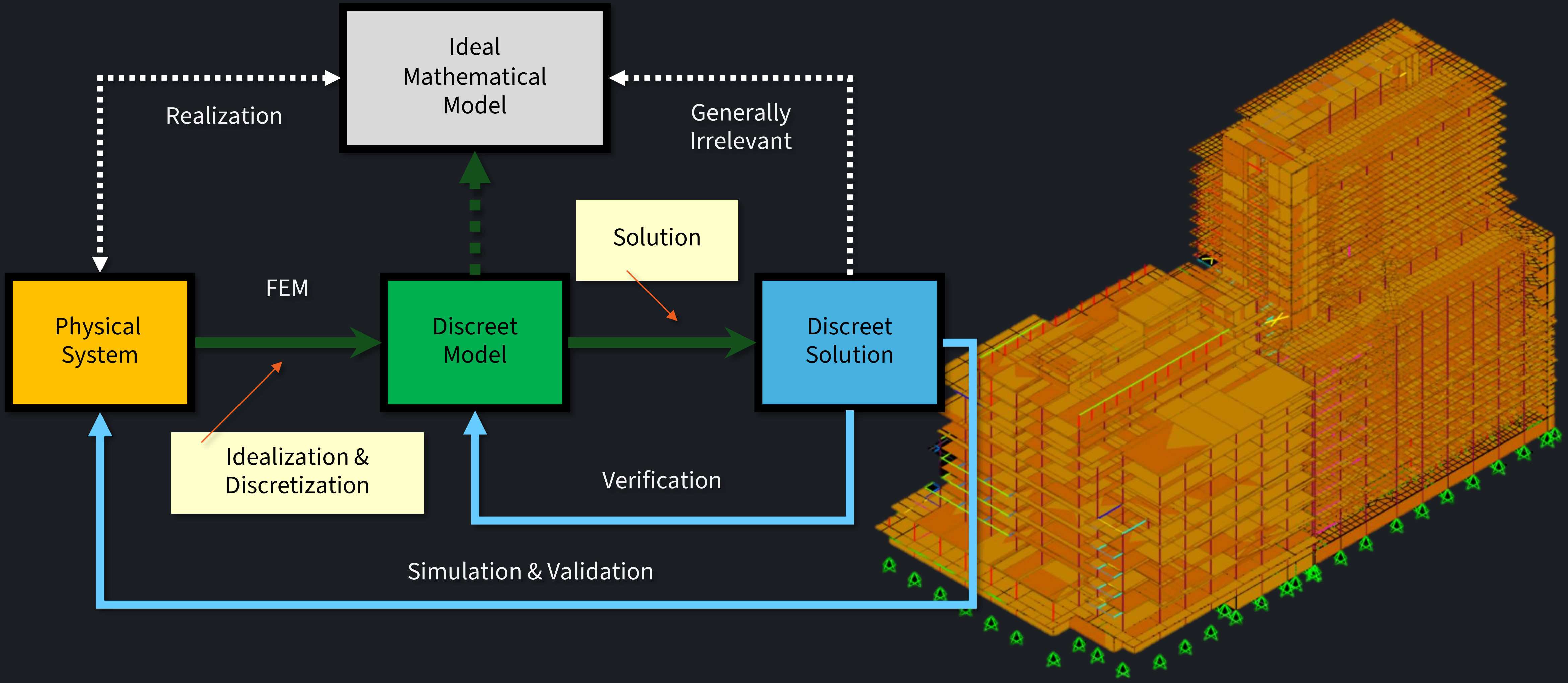
GLOBAL STIFFNESS MATRIX [K]

0 / 5 Assembled

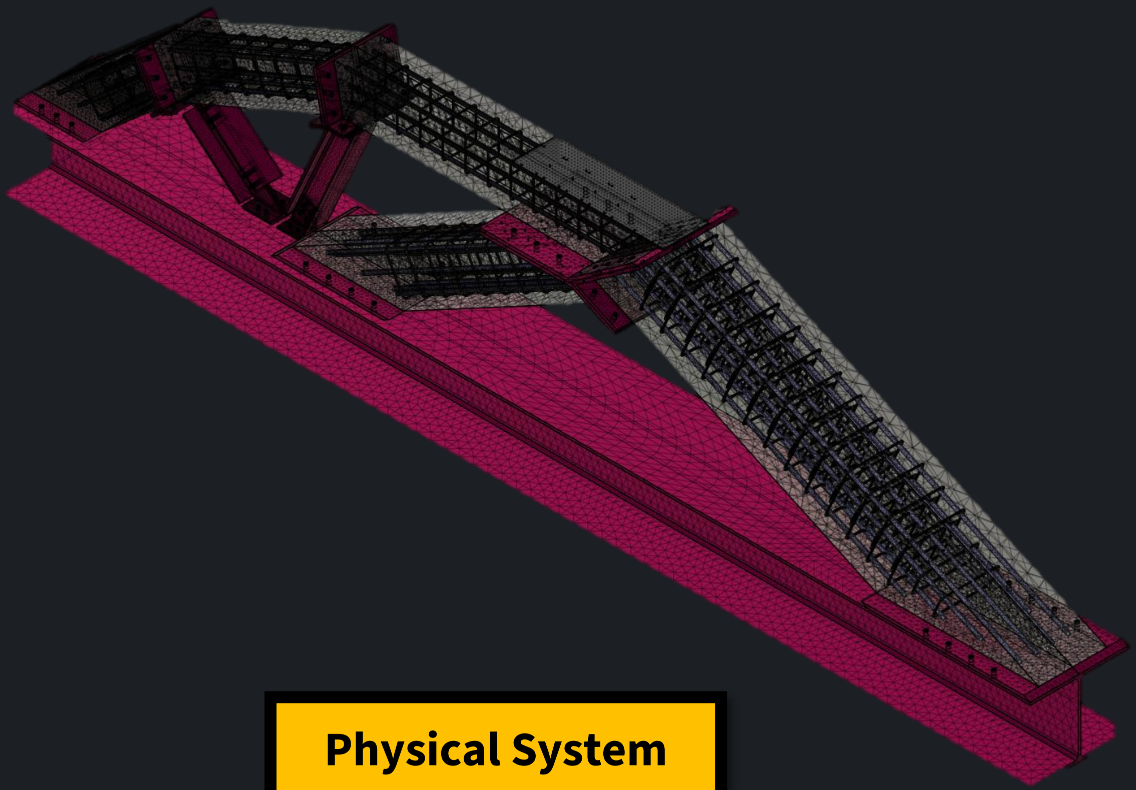
	u0	v0	u1	v1	u2	v2	u3	v3
u0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
v0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
u1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
v1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
u2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
v2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
u3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
v3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

System Size: 8x8 • Total DOFs: 8

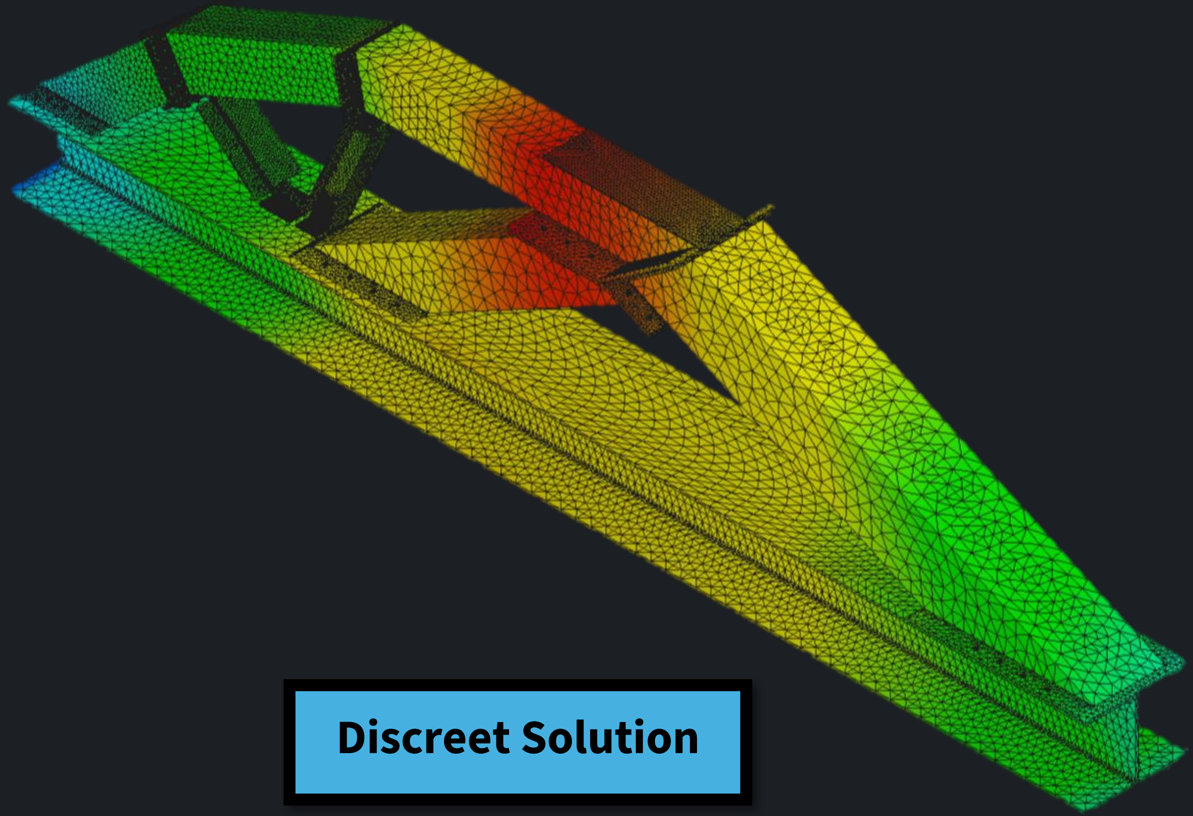
Computational Mechanics and Structural Reformulation



Computational Mechanics and Structural Reformulation

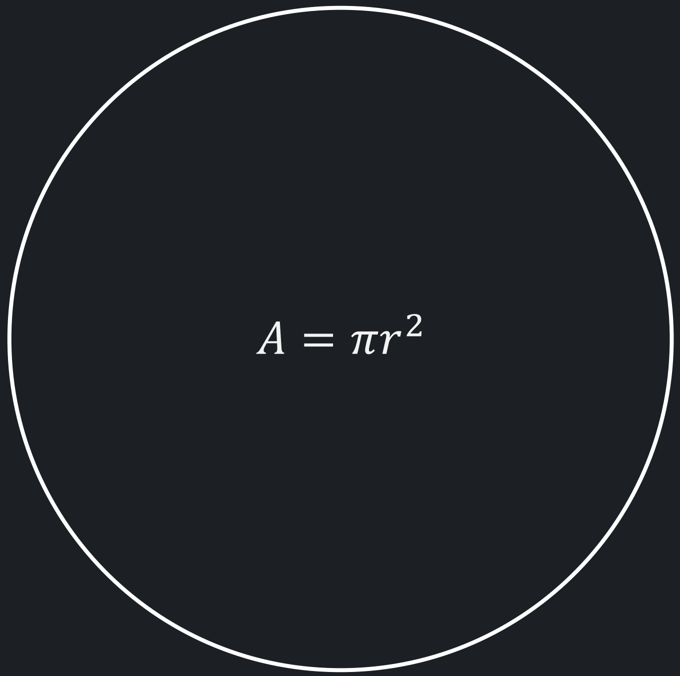


Physical System

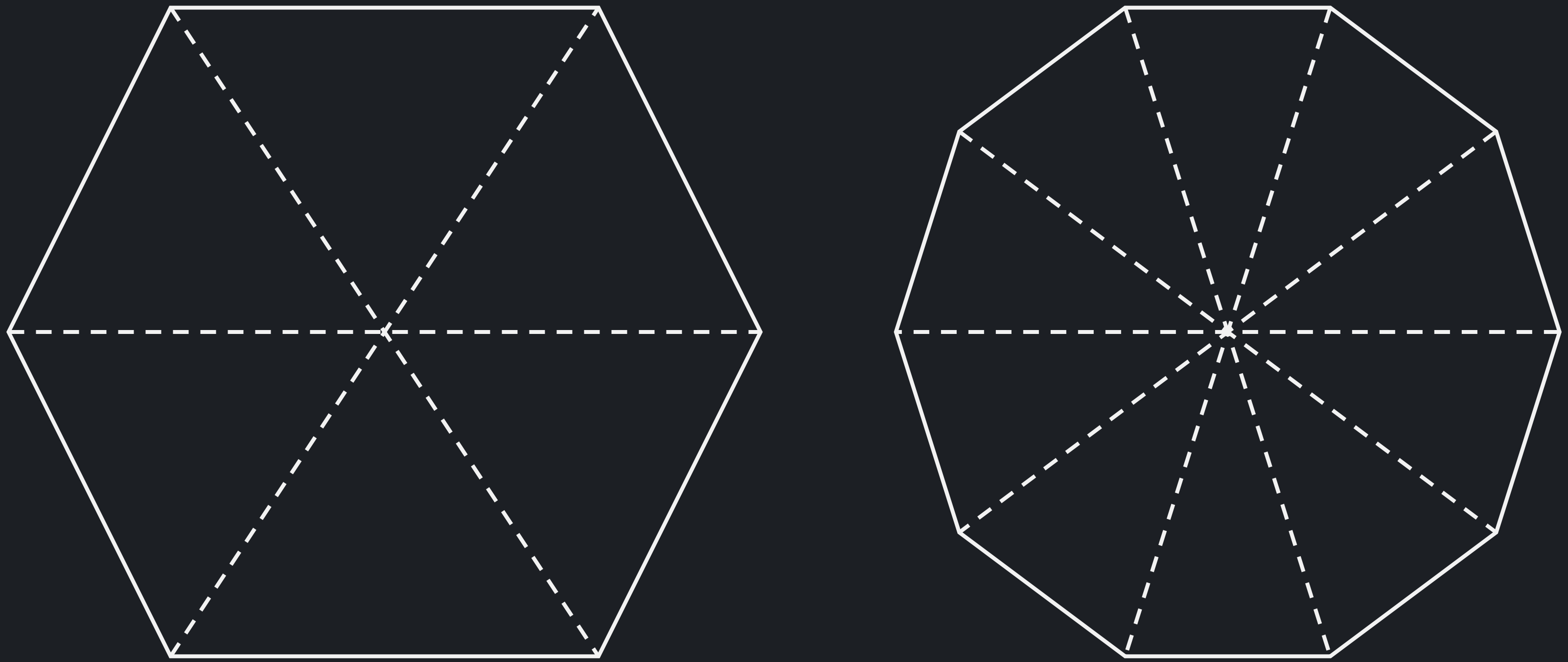


Discreet Solution

From Analytical Thinking to Algorithmic Thinking



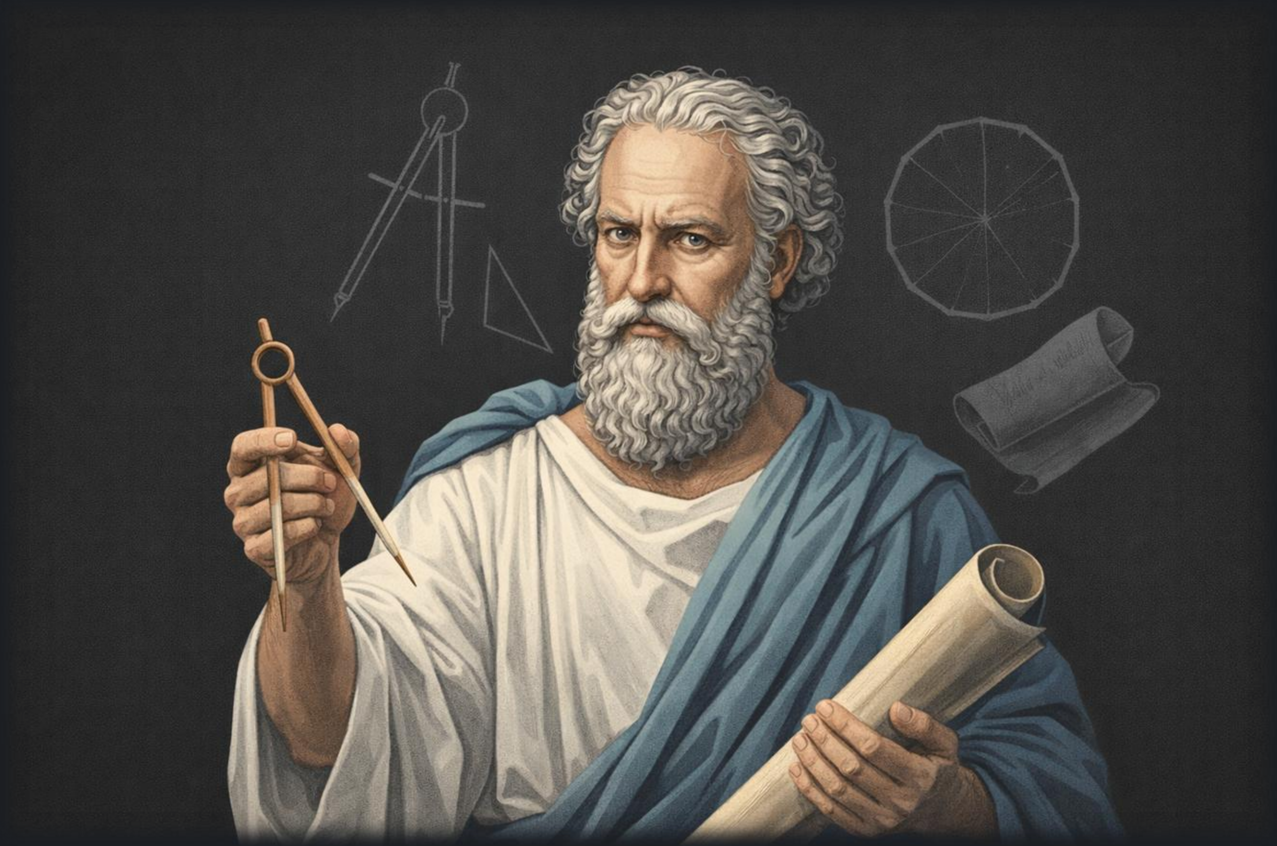
Analytical Thinking



Algorithmic Thinking

Note Today is Pi day = 3.14

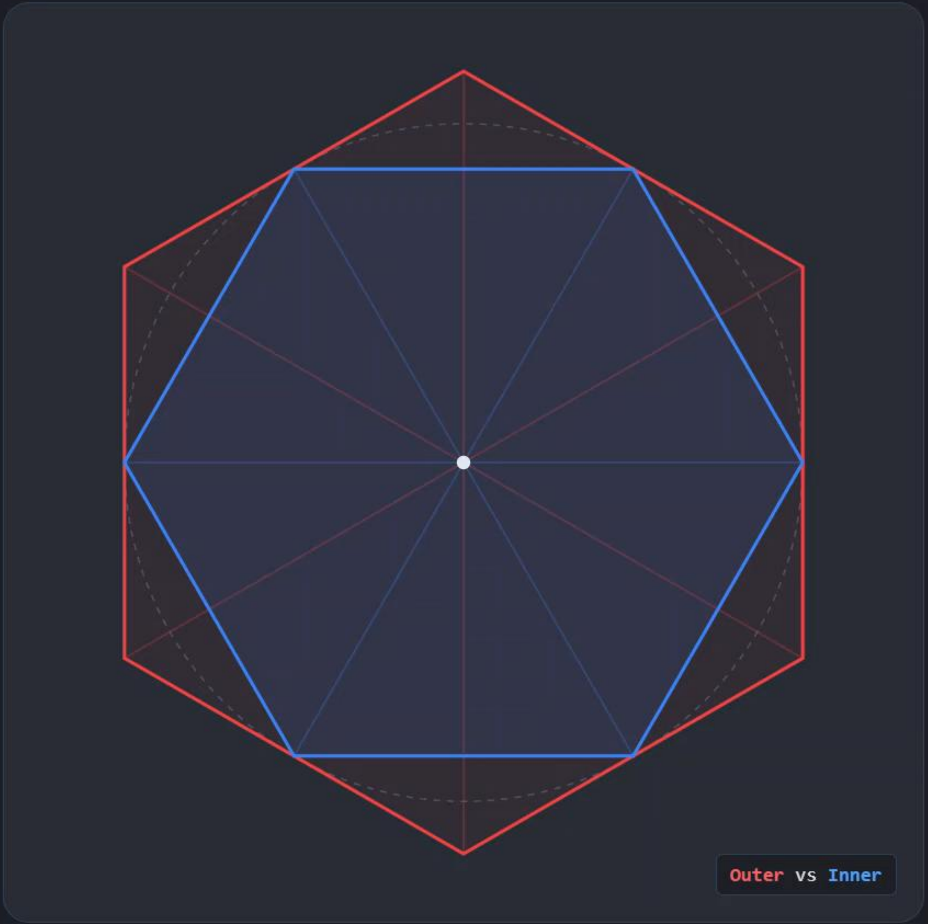
From Analytical Thinking to Algorithmic Thinking



"Do not disturb my circles."
Archimedes of Syracuse, 287–212 BCE

Define Parameters
↓
Generate Model
↓
Evaluate Performance
↓
Update Variables
↓
Converge

From Analytical Thinking to Algorithmic Thinking



Auto Run | Step (2n) | Reset

Sides (n)
6

Accuracy
9.05e-2

Approximation Values Target: 3.141592654...

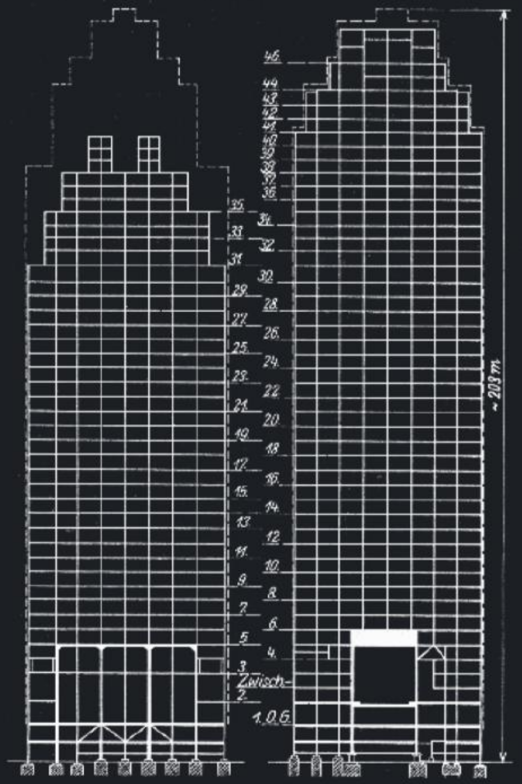
Upper Bound (Circumscribed) 3.464101615138

Lower Bound (Inscribed) 3.000000000000

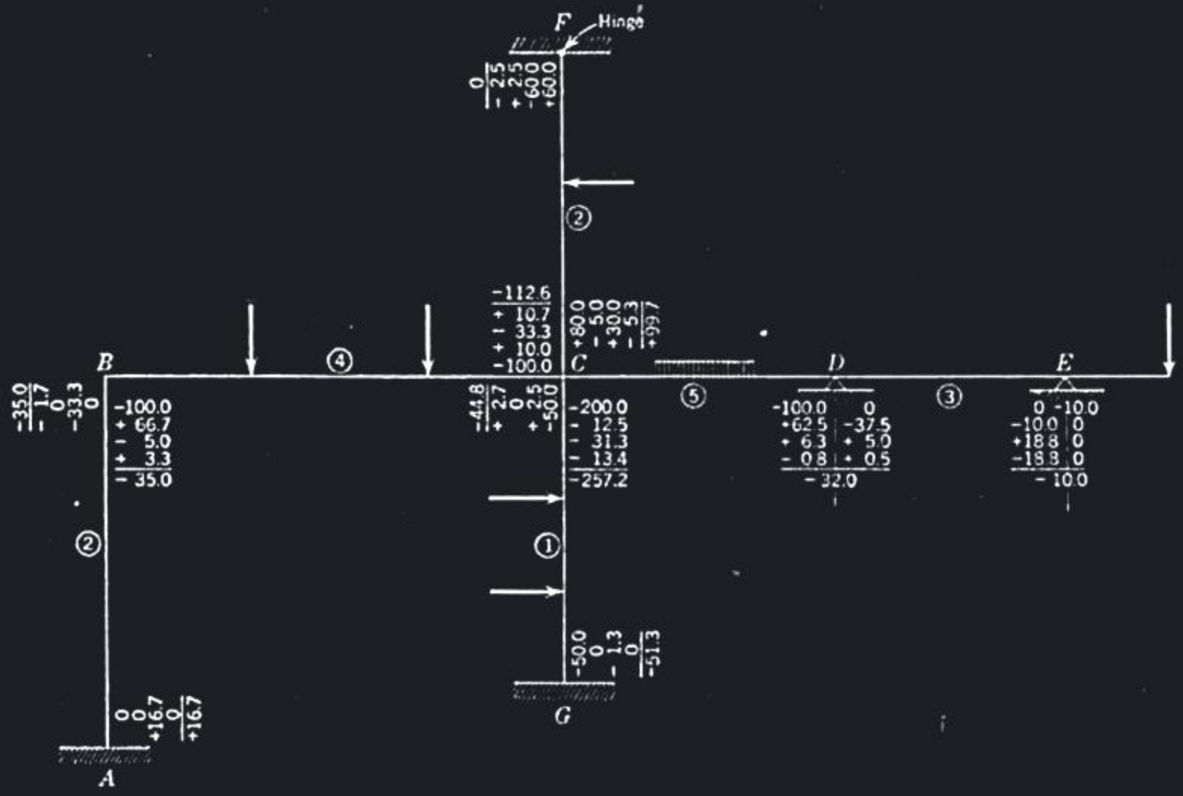
Average **3.232050807569**

Convergence History

From Analytical Thinking to Algorithmic Thinking



Hardy Cross

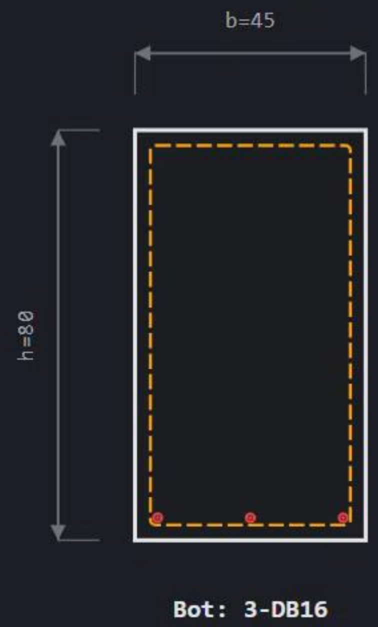


Moment Distribution, 1932

Defining Objectives and Constraints

Classic Structural optimization Process

1. **Implementation of the design variables** : May be continuous or discrete, but commonly treated as discrete
   - Geometry
     - Cross-sectional
     - Dimensions or Member sizes
   - Material Properties
2. **Collect all design constraint →** Constraint function (s)
3. **Establish the objective function (s)**
   - Maximizing stiffness
   - Minimizing cost

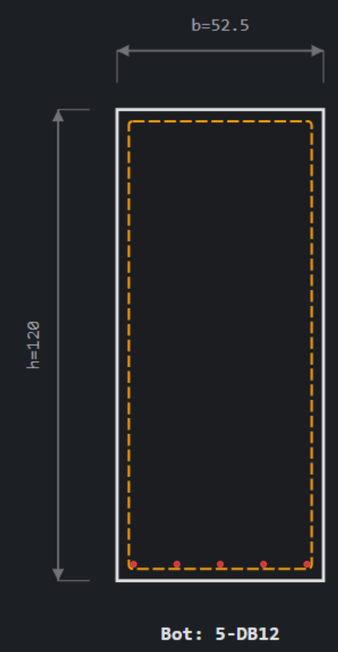


General form of Optimization problem

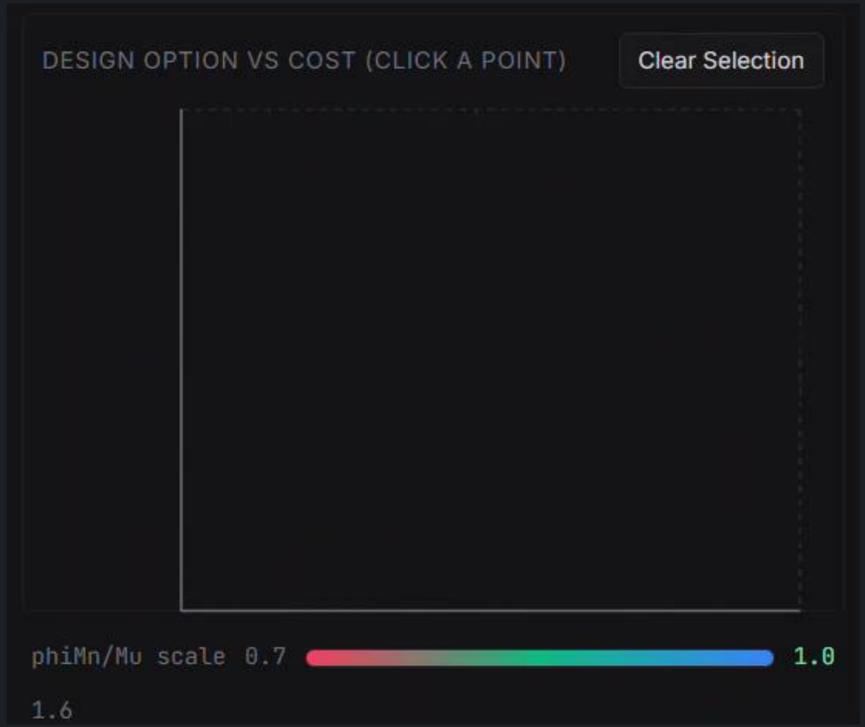
Minimize	$f(x)$		→ **Objective function**
Such that	$g_j(x) > 0$	$j = 1,\ldots,n_g$	**Constraint functions**
	$h_k(x) = 0$	$k = 1,\ldots,n_k$	

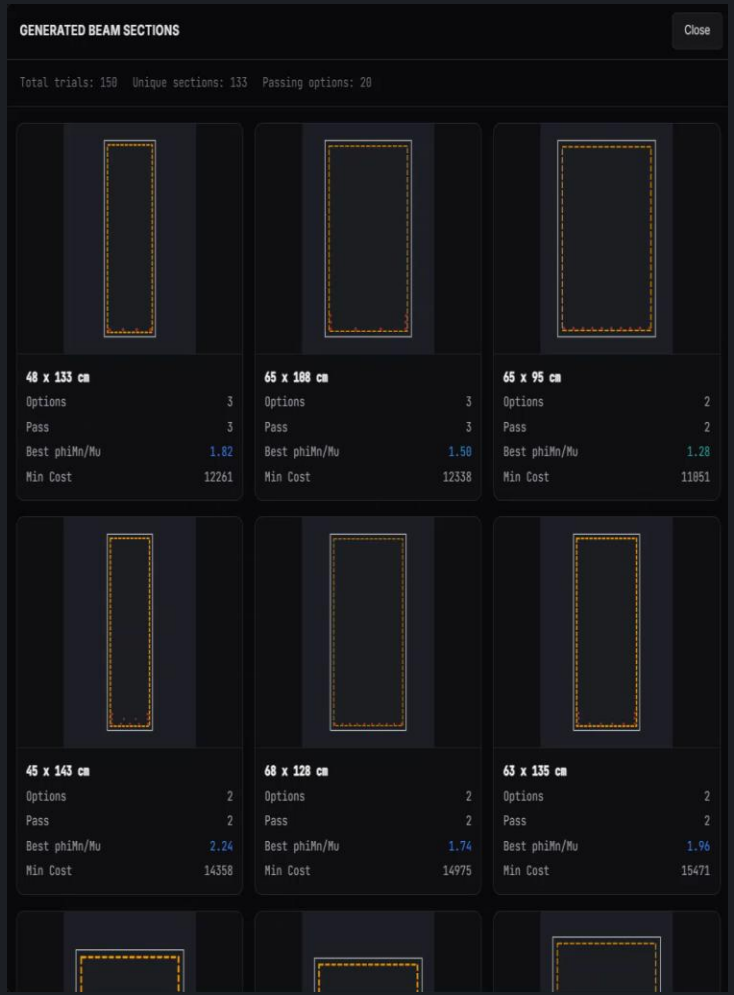
Scale Changes Design Logic

The difference is not speed.
The difference is scale.



VS

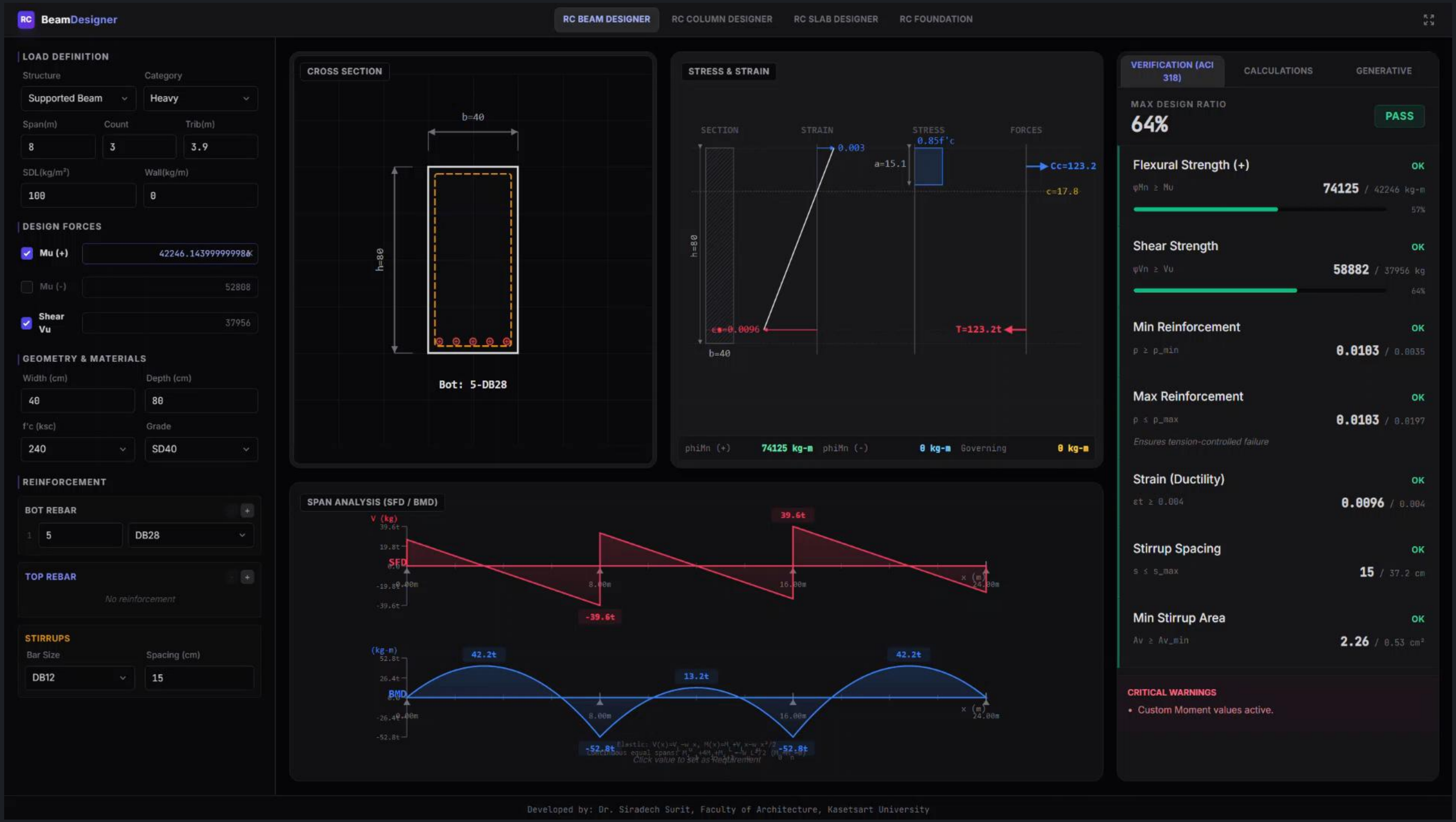




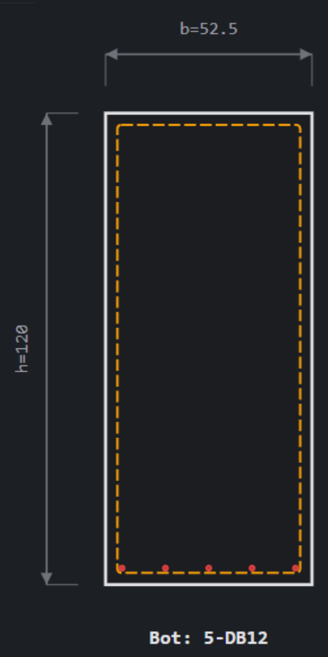
1 solution

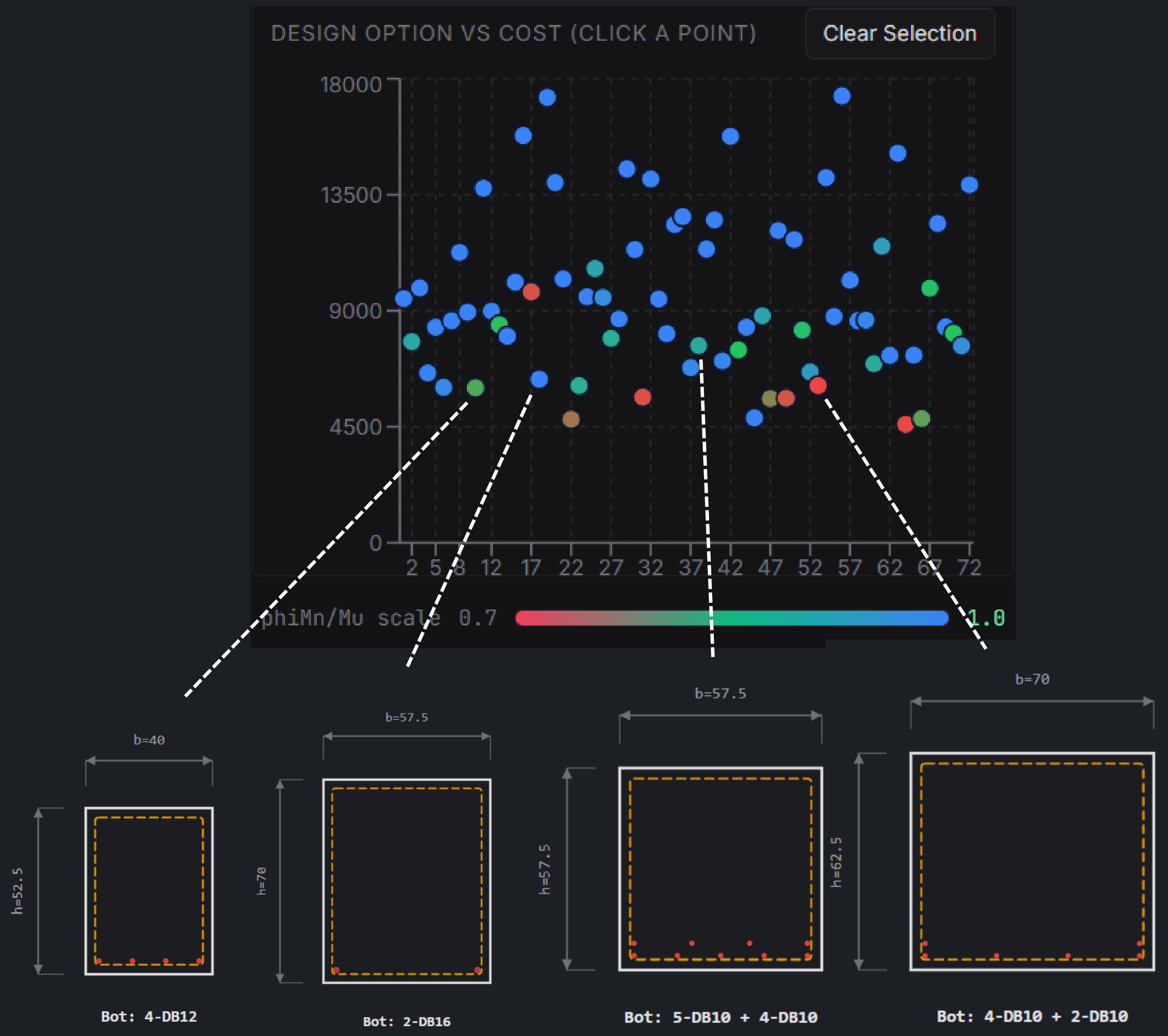
1000x solutions

Reinforcement Optimization



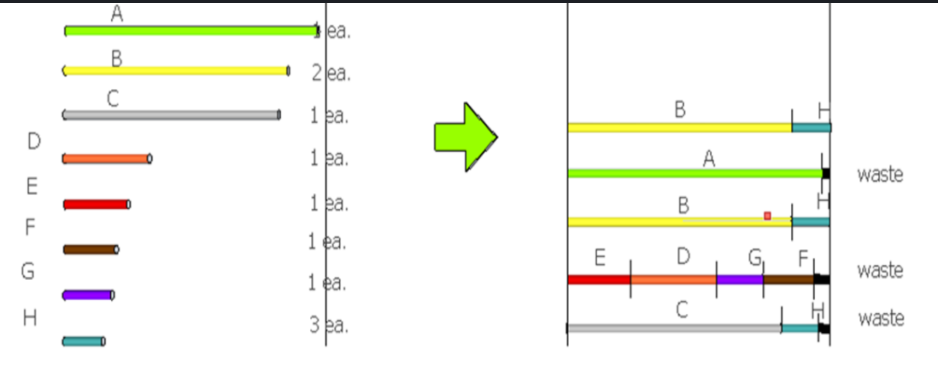
From Checking to Searching

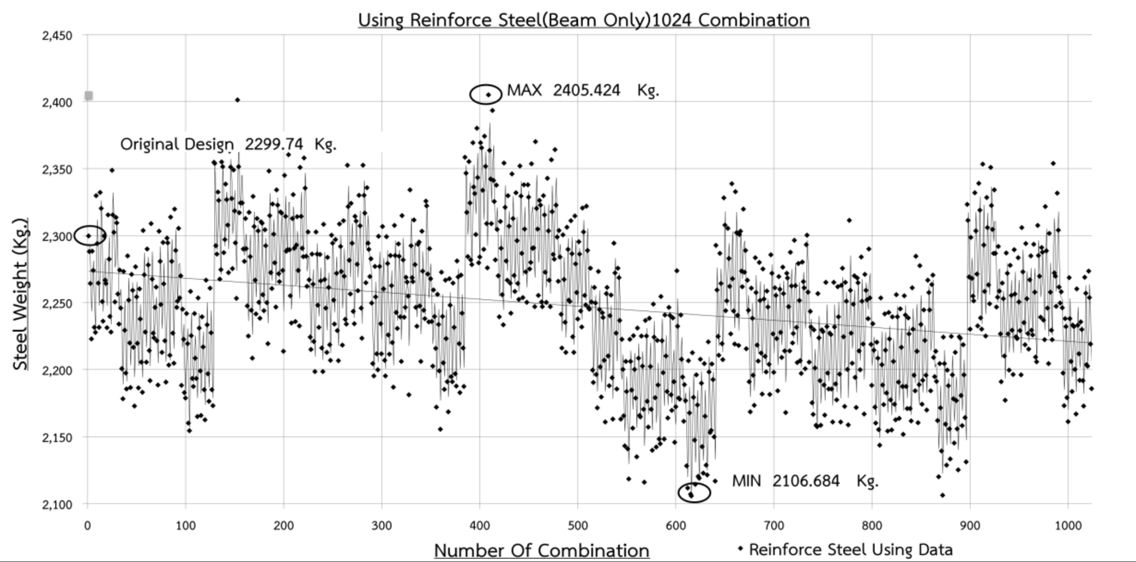




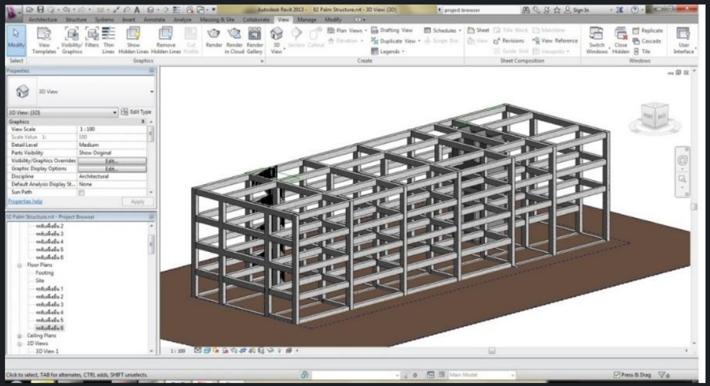
Bar cut Optimization & Building Information Modeling (BIM)

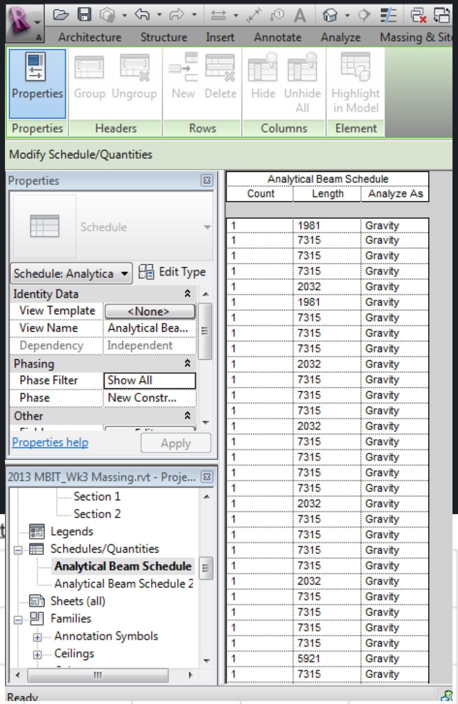
Bar cut Optimization

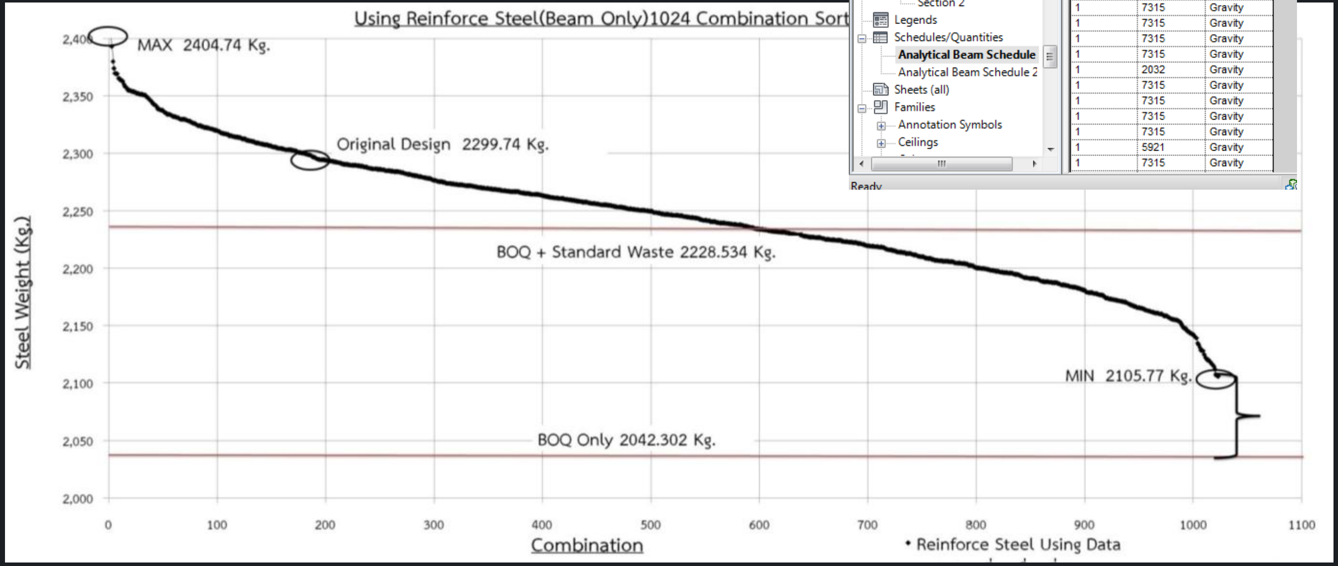




Building Information Modeling (BIM)

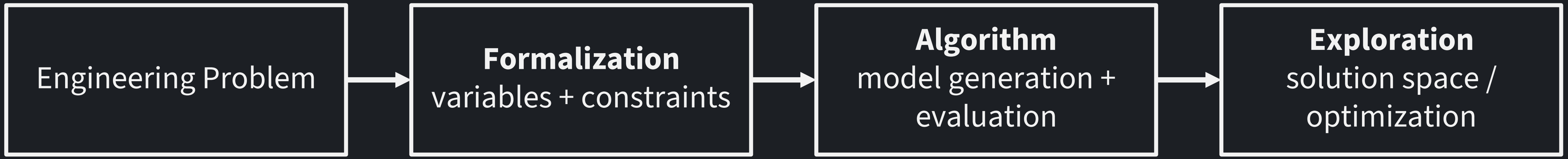


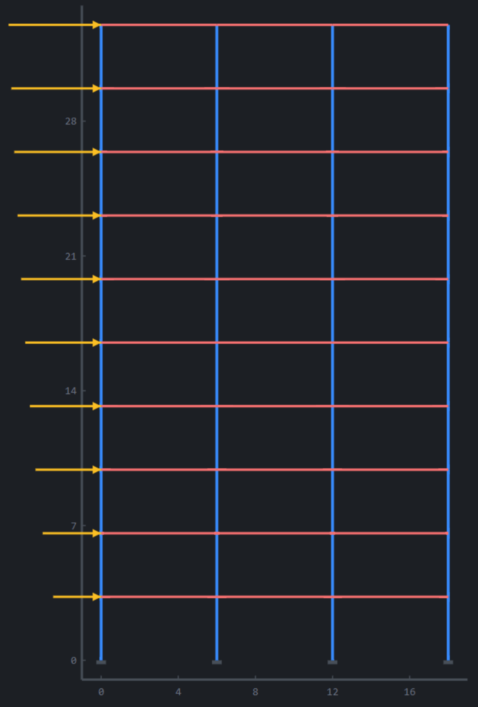


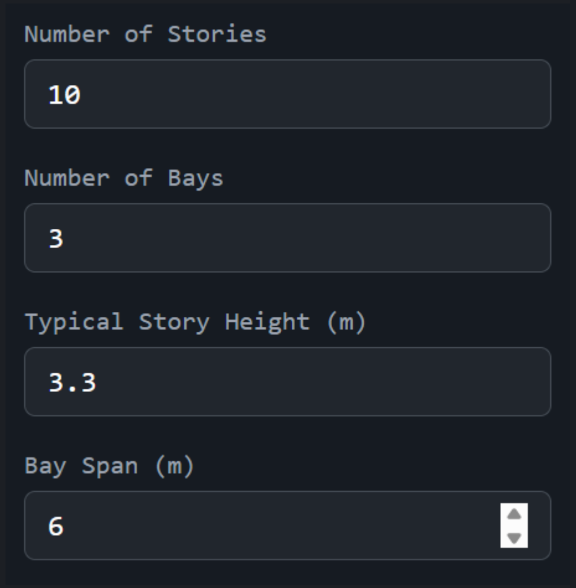


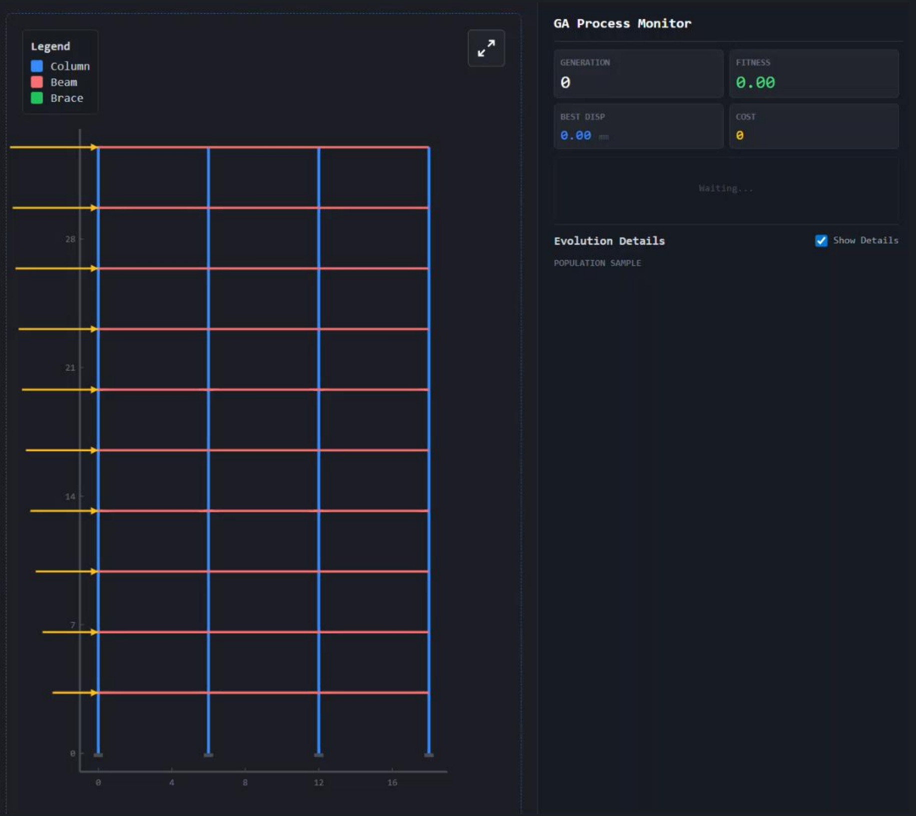
Large-scale combinatorial optimization algorithm for reinforced steel bars in bim-oriented projects **Dr.Siradech surit and polsiwat sribanpone Sega 04 2015**

Computational Thinking in Practice



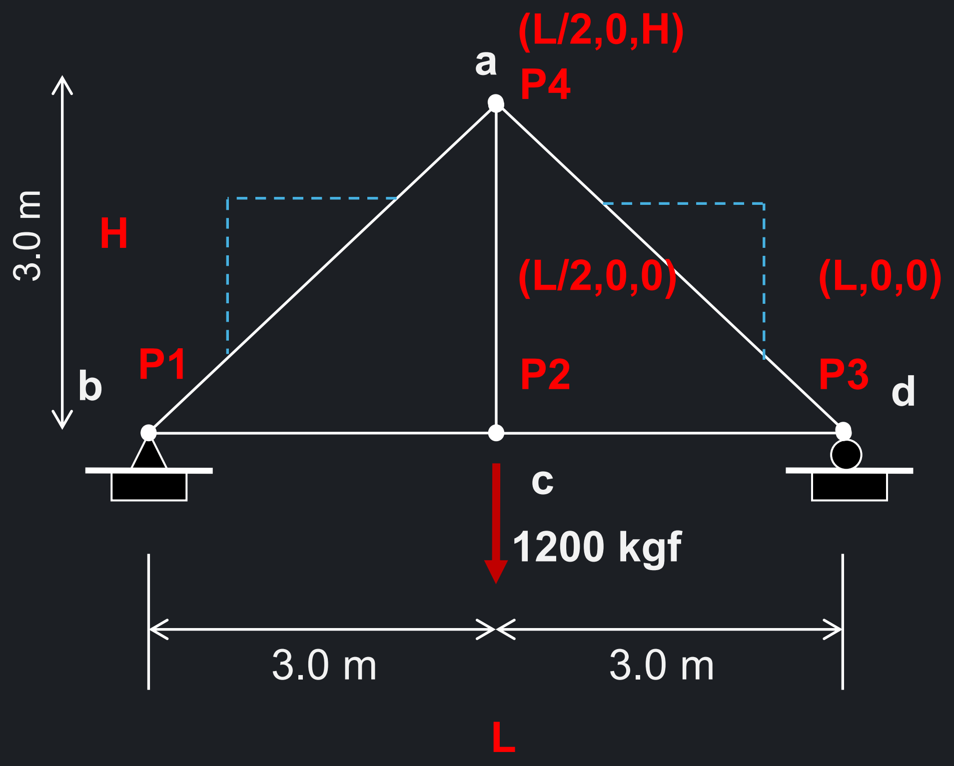


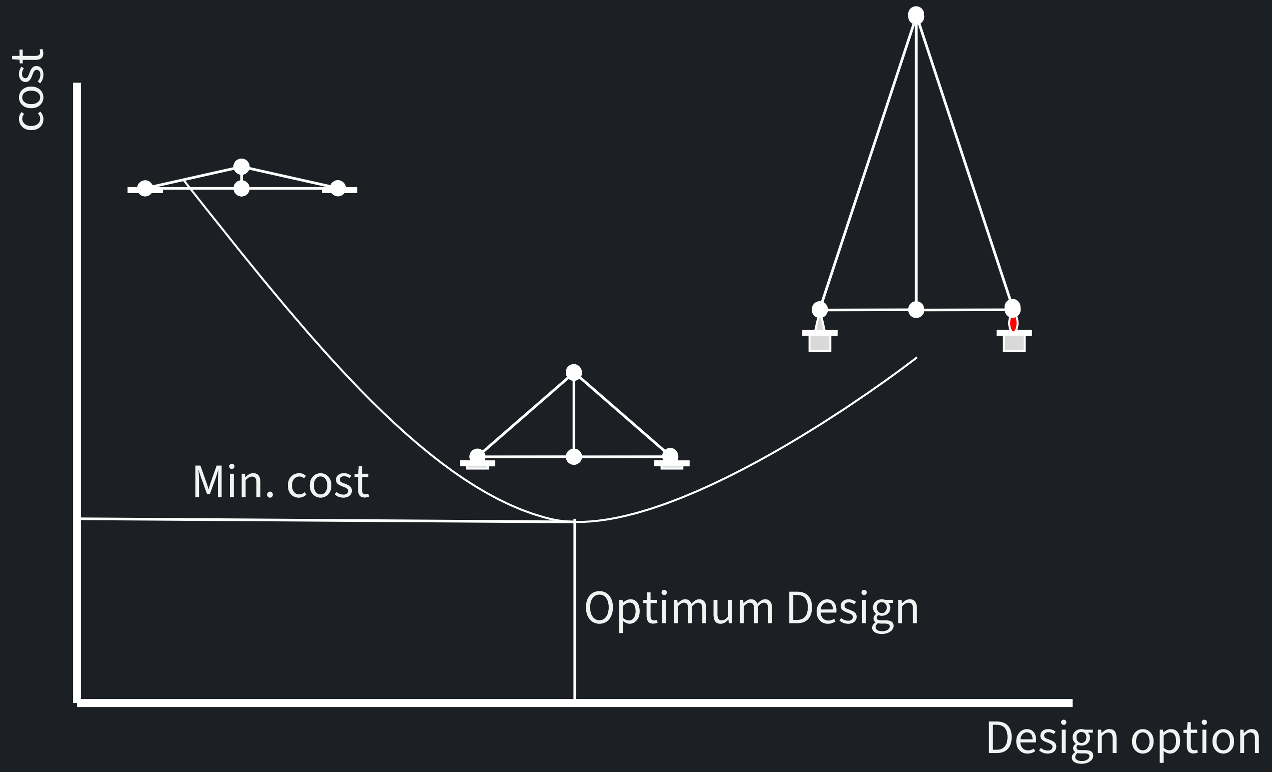




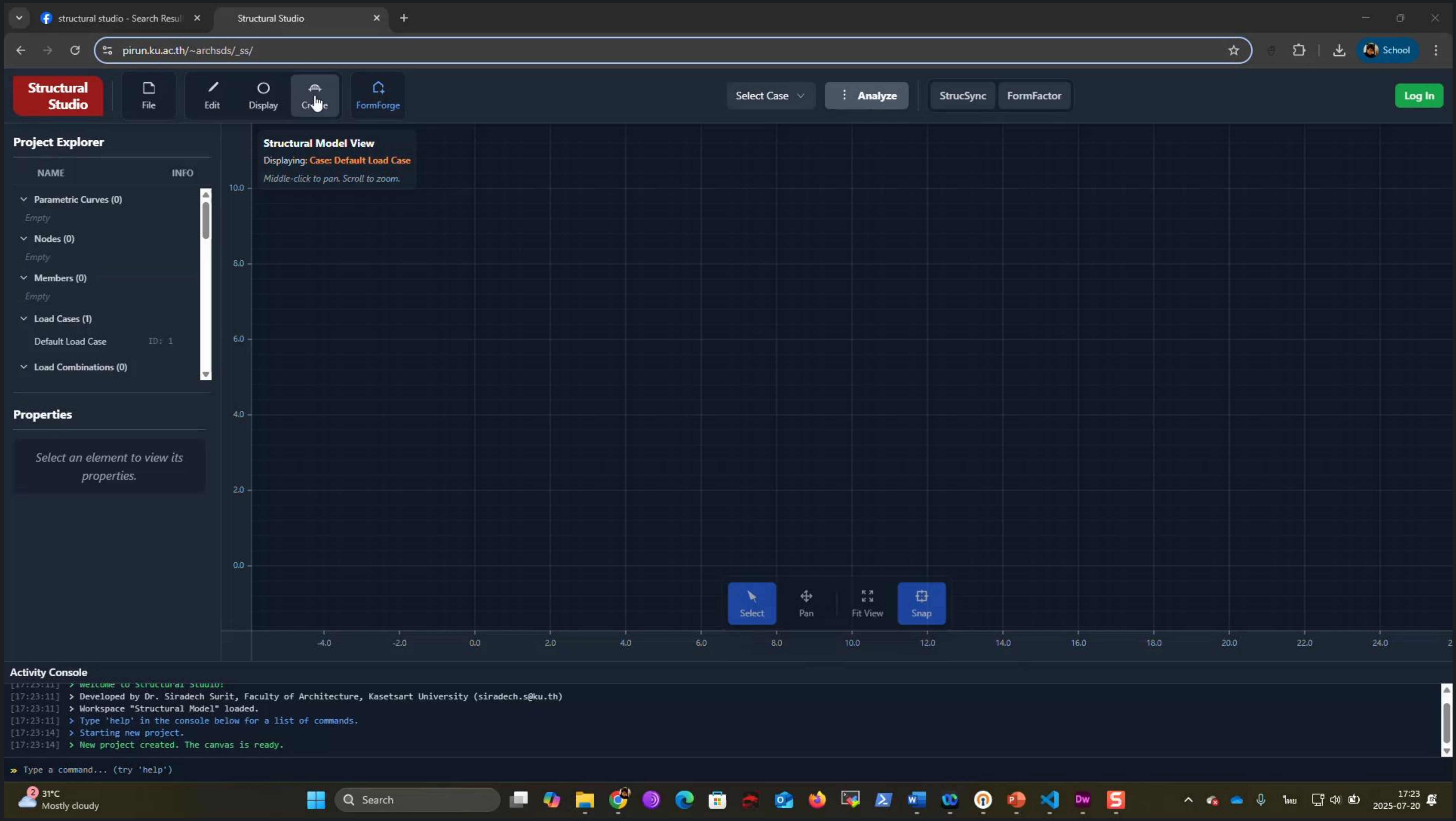
Practical Applications

Optimization in Structural Design

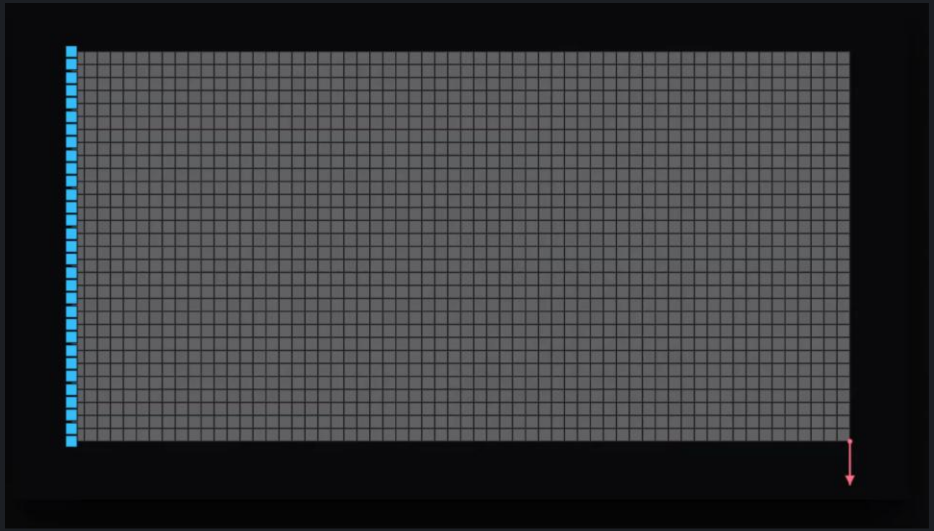


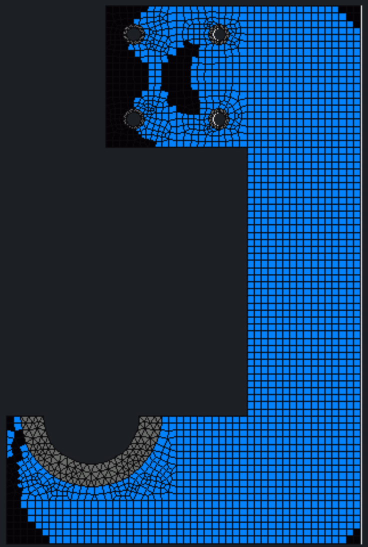


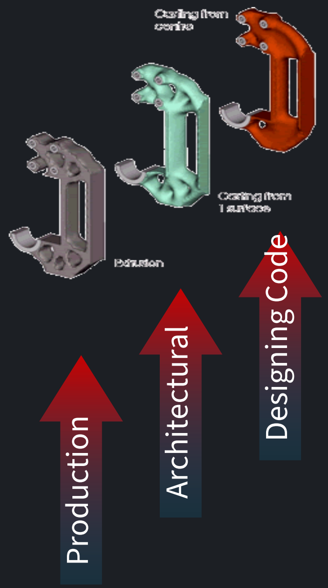
Optimization in Structural Design



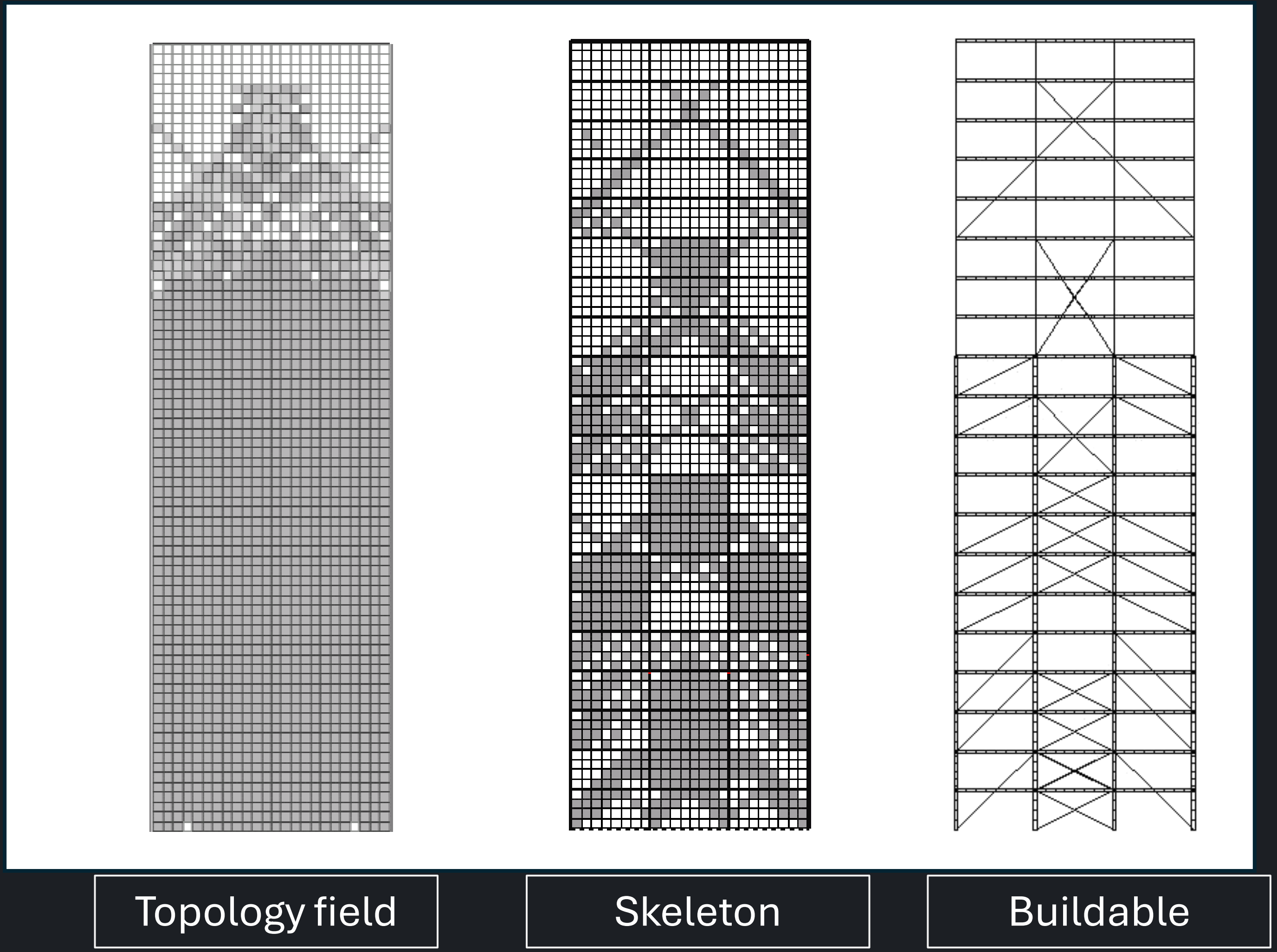
Topology Optimization Toward Buildable Forms



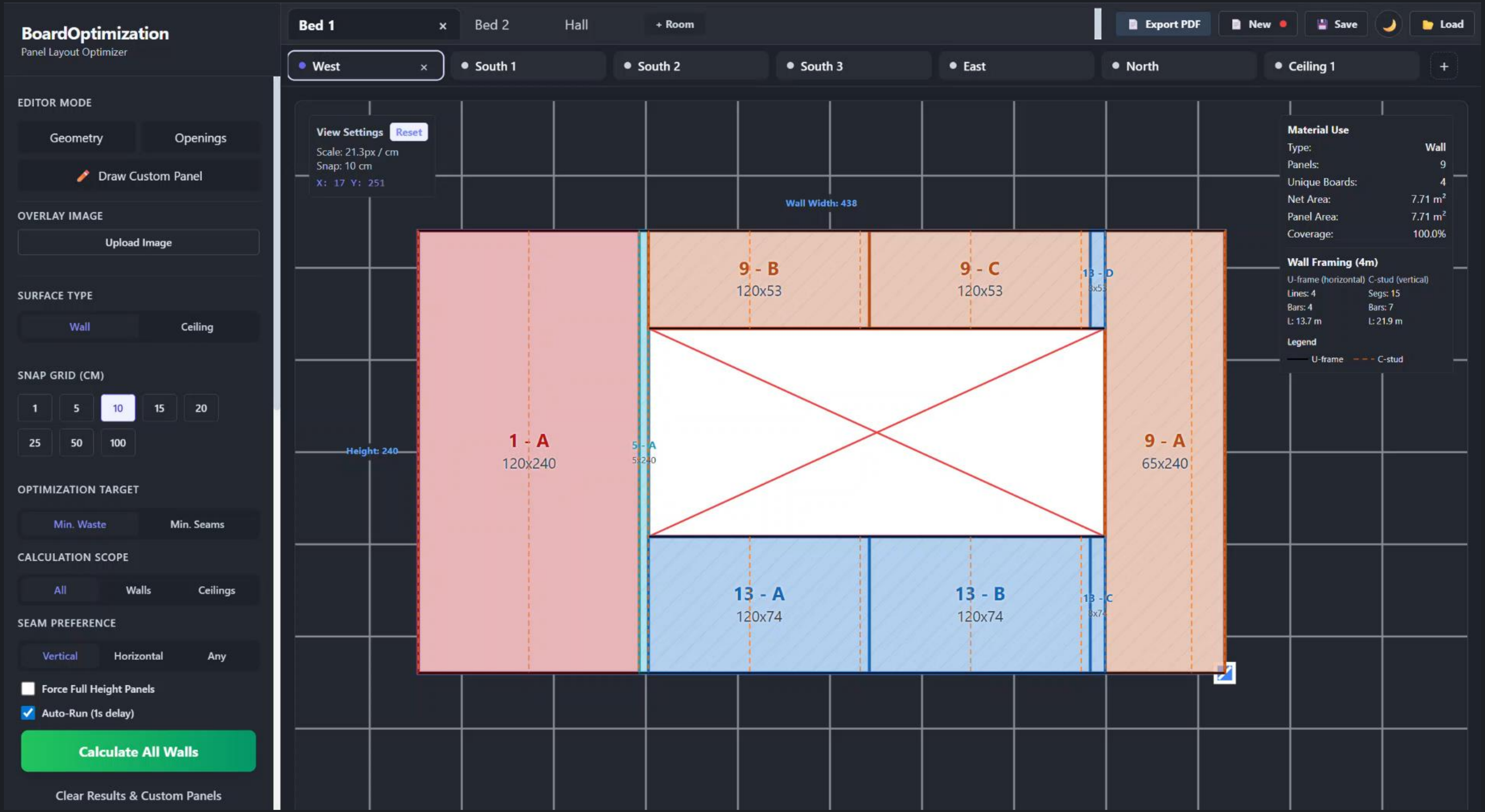




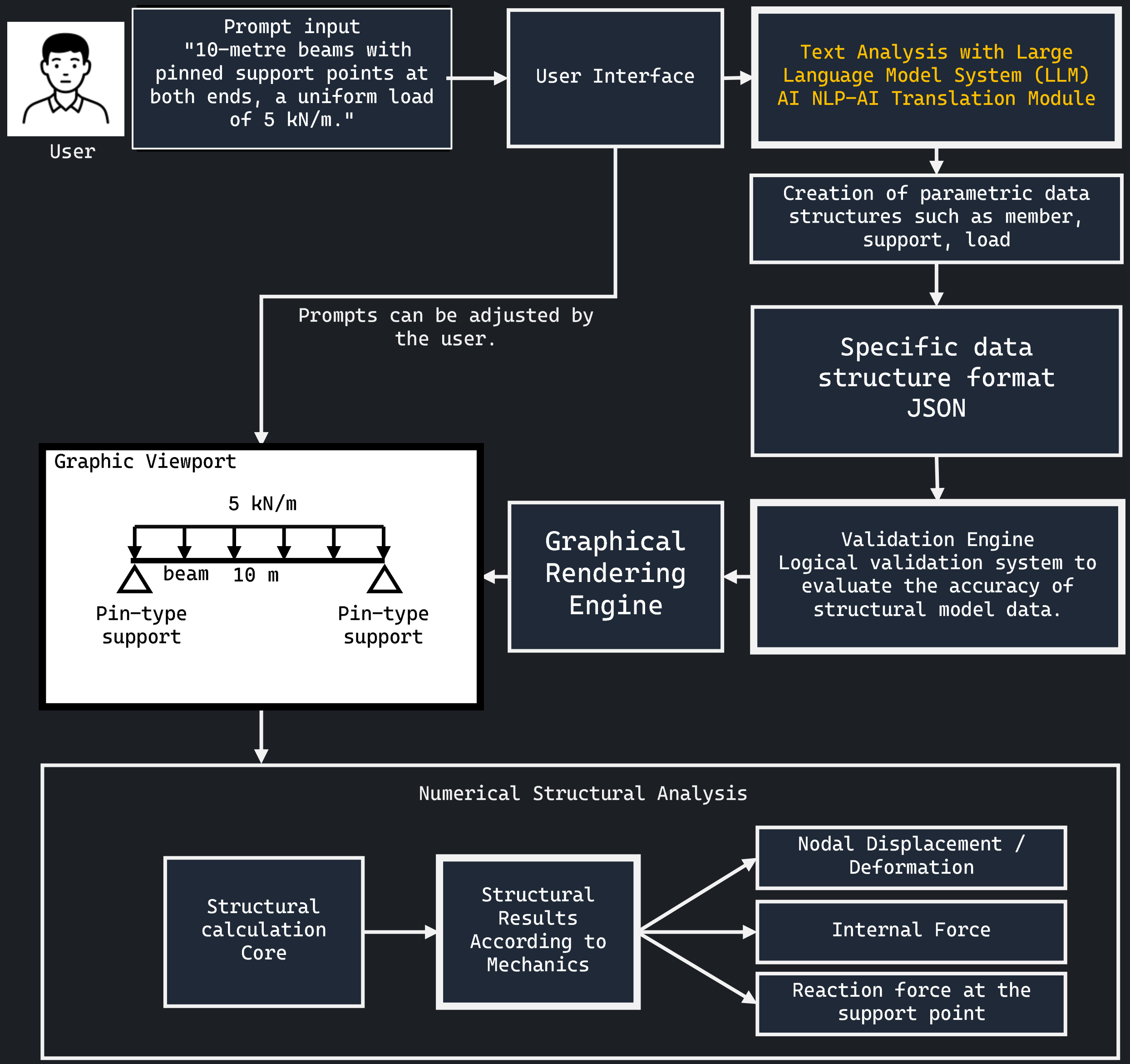
Optimization Engineering logic Construction system

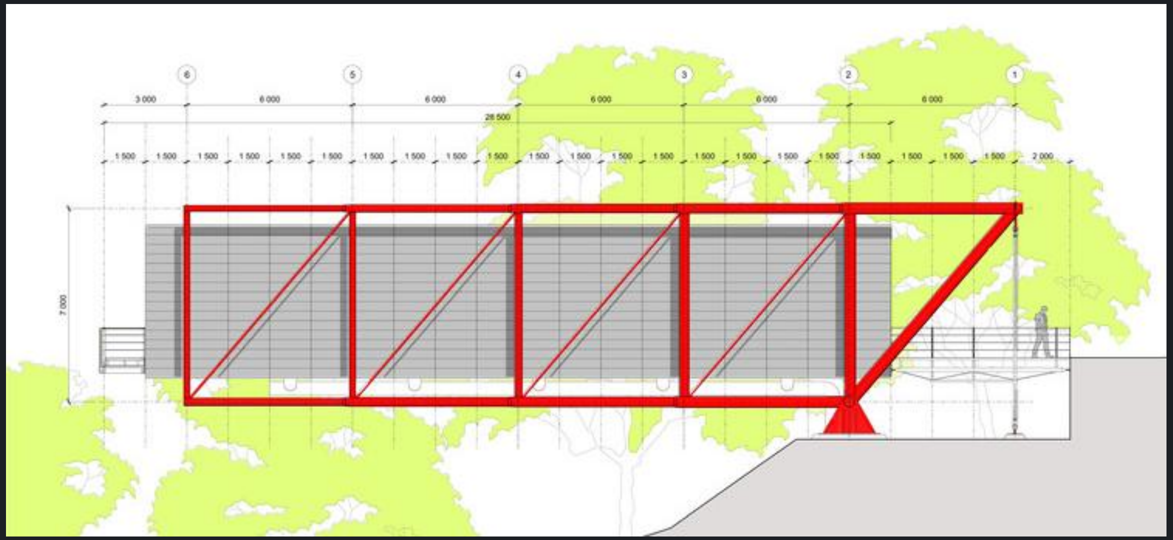


Lightweight Panel Optimization



AI-Assisted Implementation in Engineering Workflow



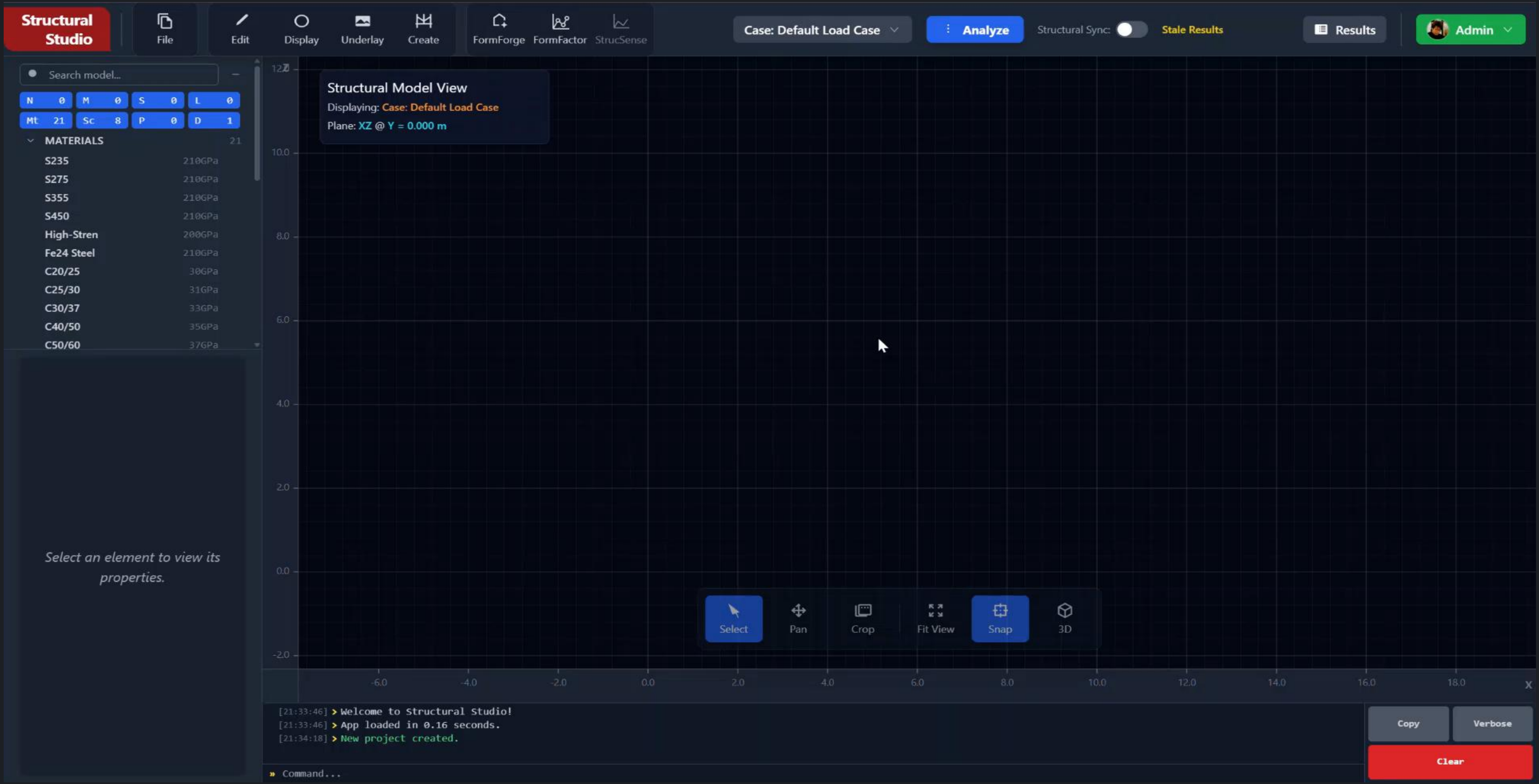


courtesy of RSHP
https://rshp.com/projects/culture-and-leisure/the-richard-rogers-drawing-gallery/

Prompt input

Model a cantilever steel gallery structure using a rectangular box truss. The building is about 27 m long, 6 m wide, and 4 m high, with roughly 15 m cantilever beyond the main support. Use two longitudinal trusses connected by floor and roof beams, with vertical members and diagonal bracing. The support is located at one end on a pile foundation and should be modeled as fixed. Add tension cables near the cantilever tip and apply a uniform floor load.

AI-Assisted Implementation in Engineering Workflow



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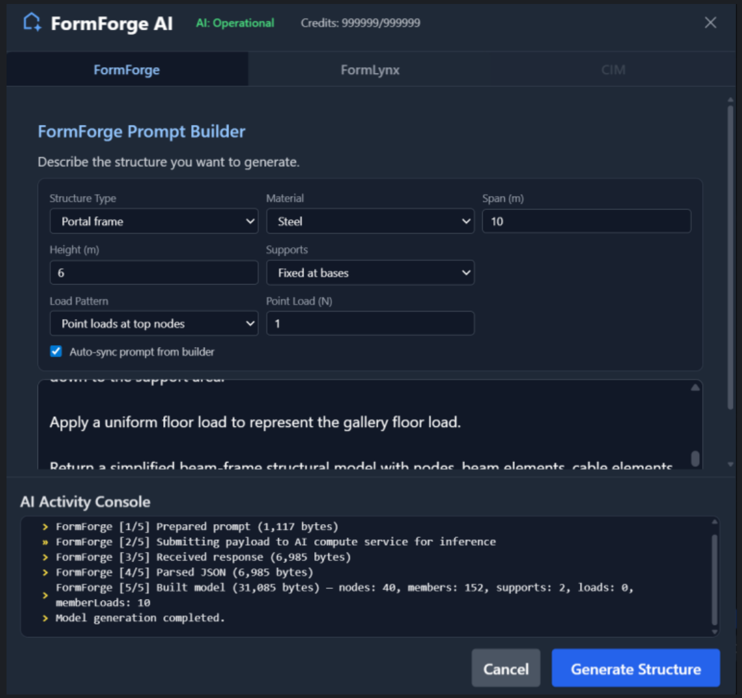
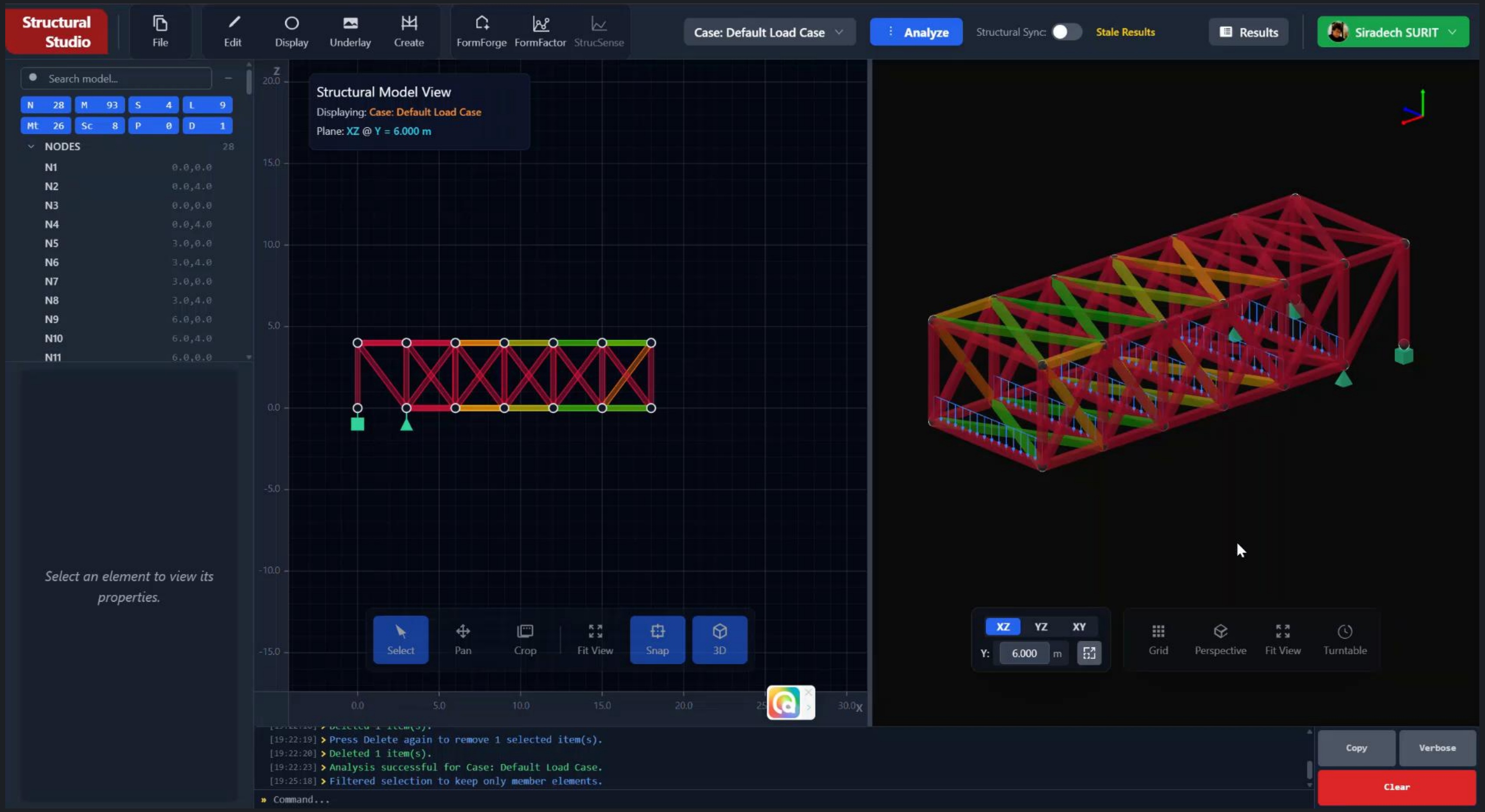
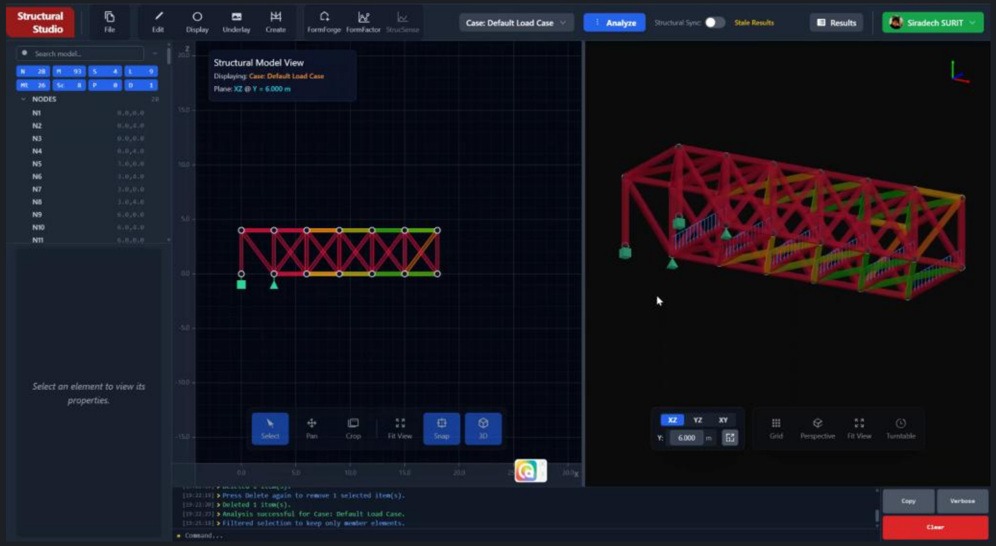
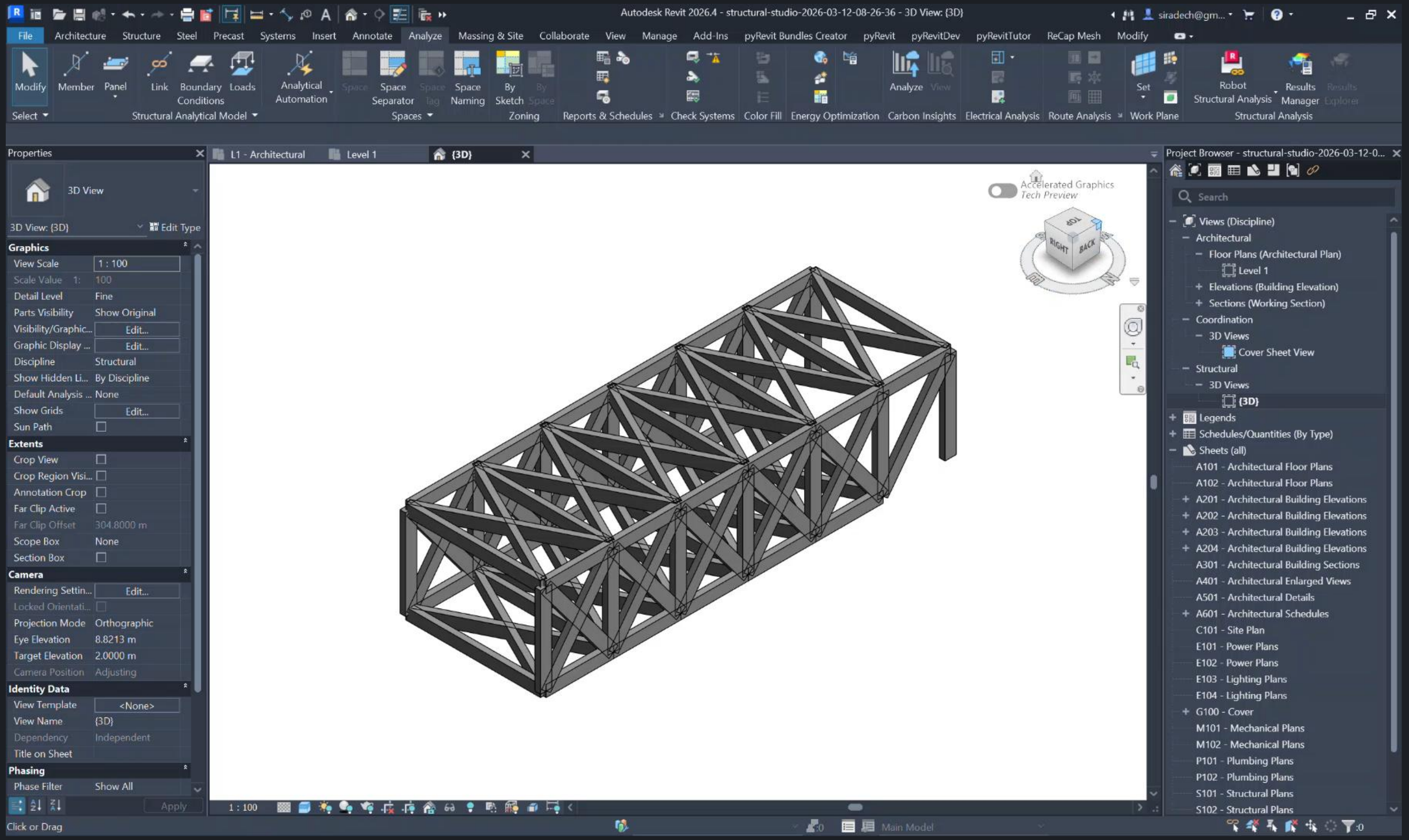




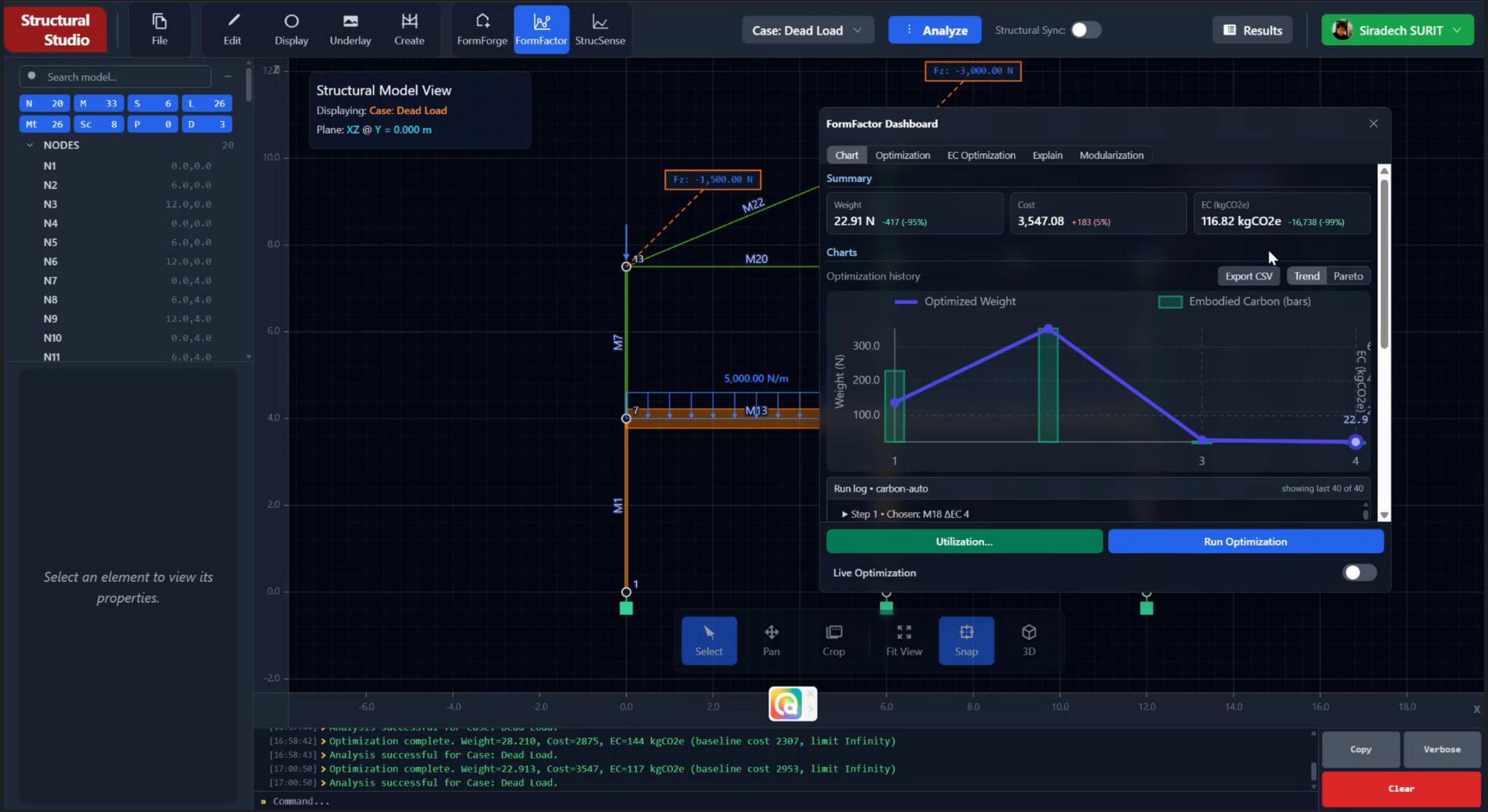
AI-Assisted Implementation in Engineering Workflow



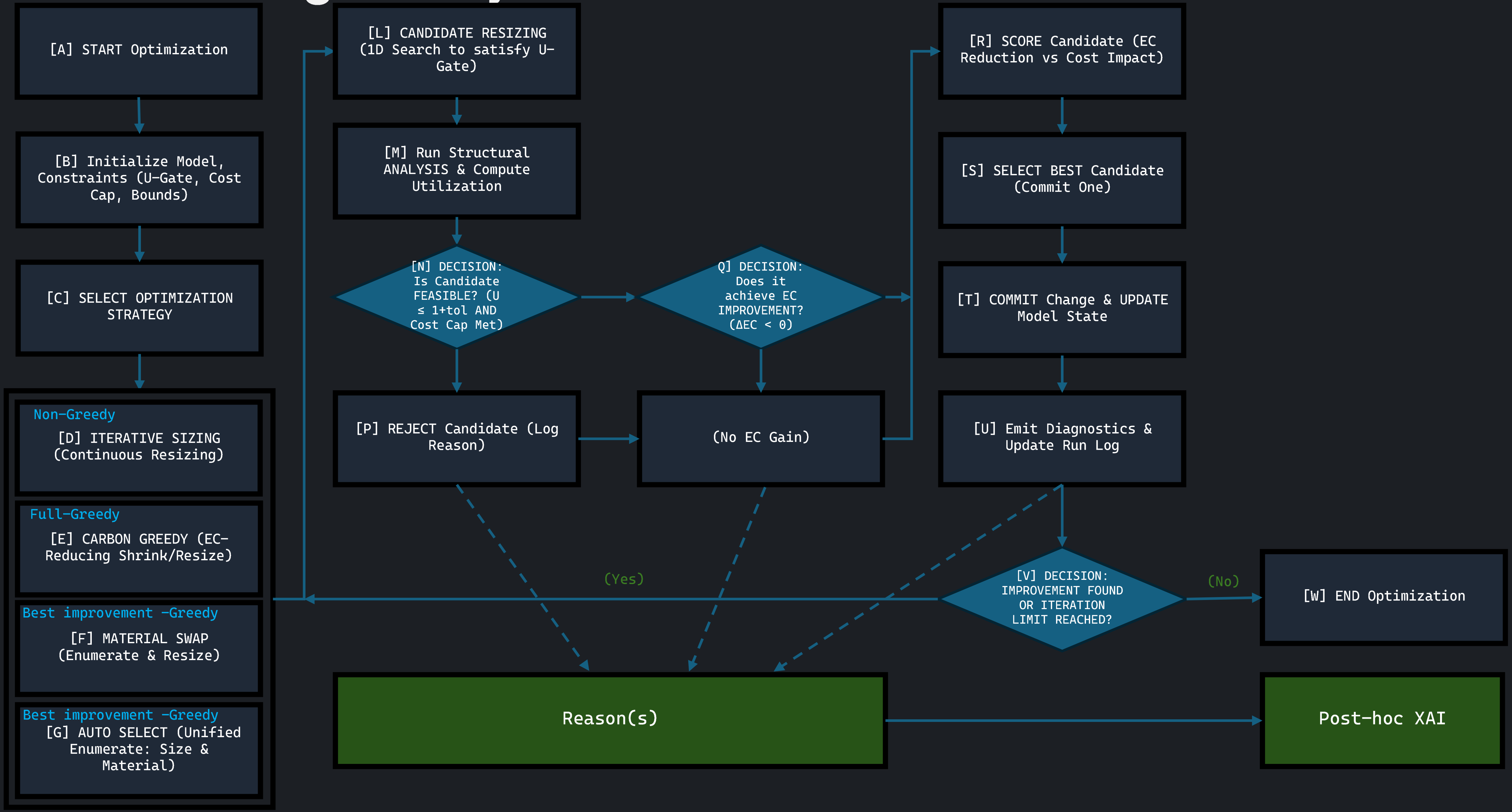
IFC



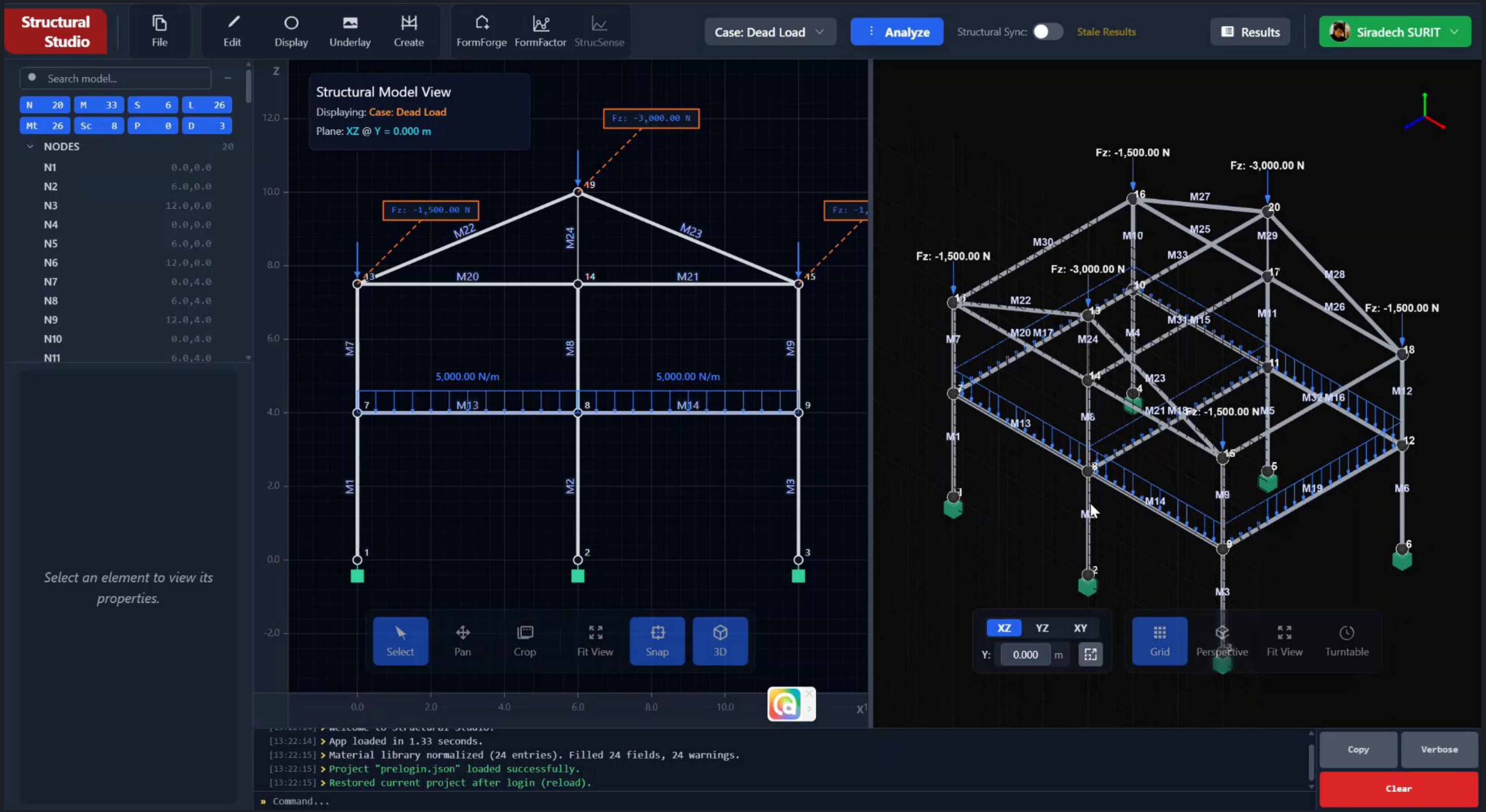
Carbon-Intelligent Objective Functions



Carbon-Intelligent Objective Functions

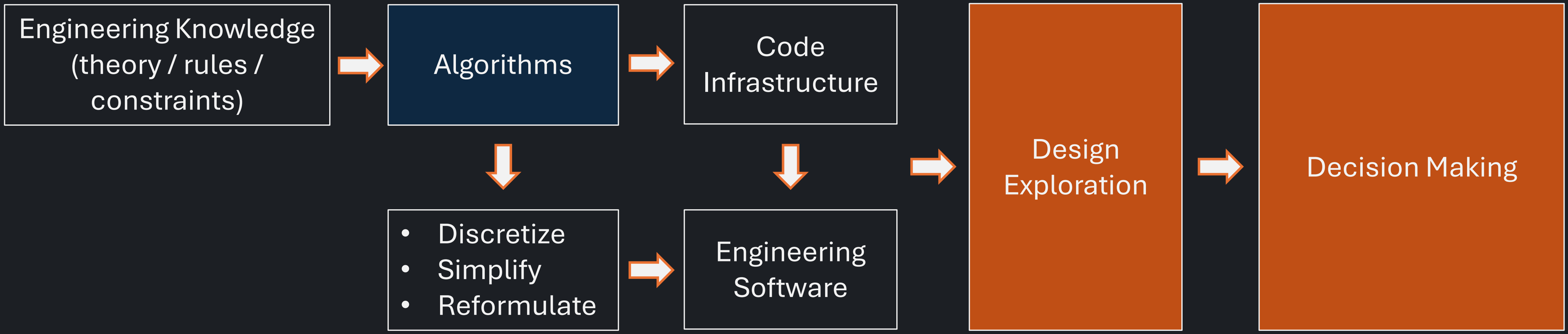


Constructability as a Computable Metric



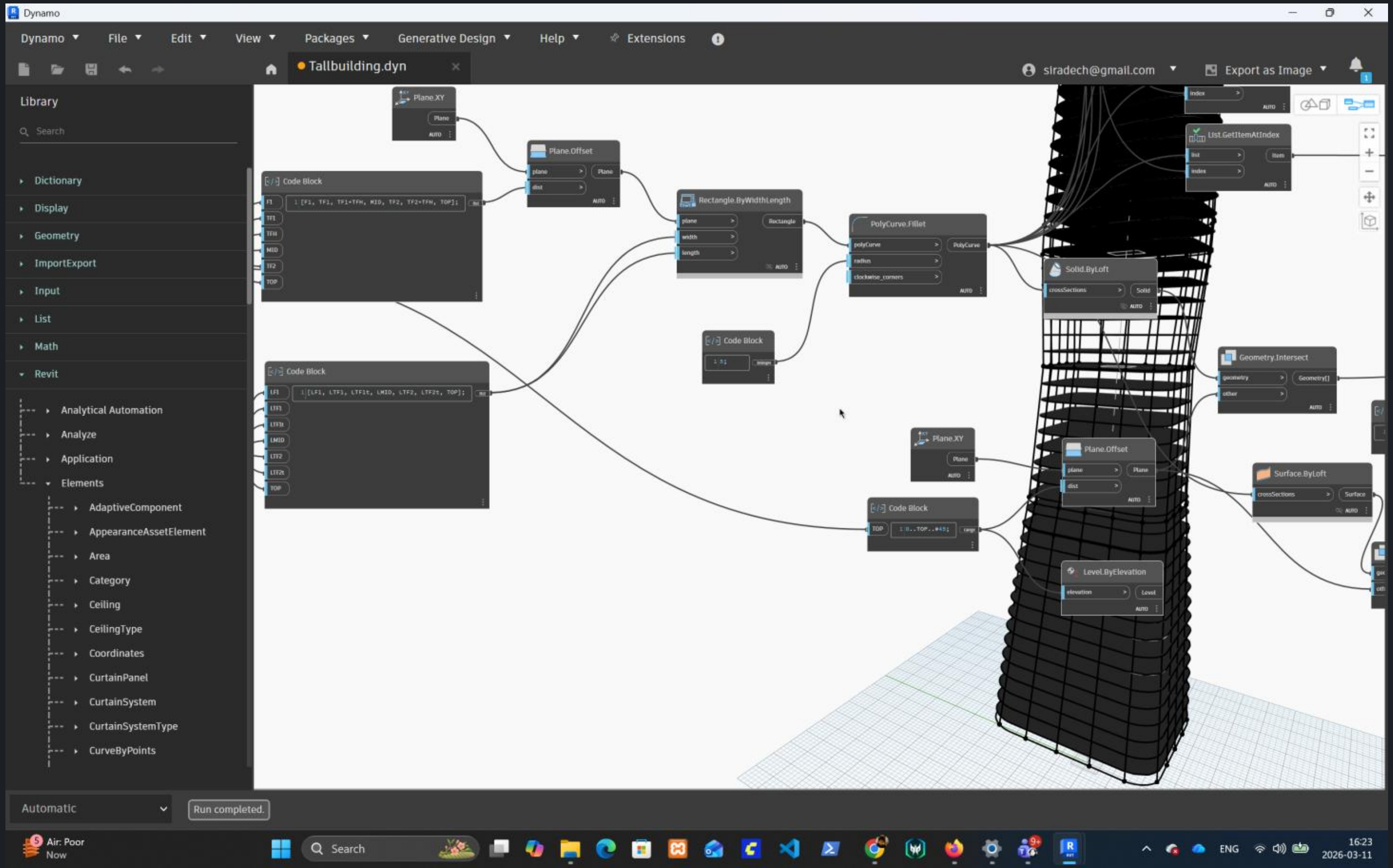
Theory Under Computational Constraint

Across engineering disciplines, theories evolve when they must become computable.



Coding as Design Infrastructure

Engineering Knowledge (theory / rules / constraints) → Algorithms → Code Infrastructure → Design Exploration → Decision Making



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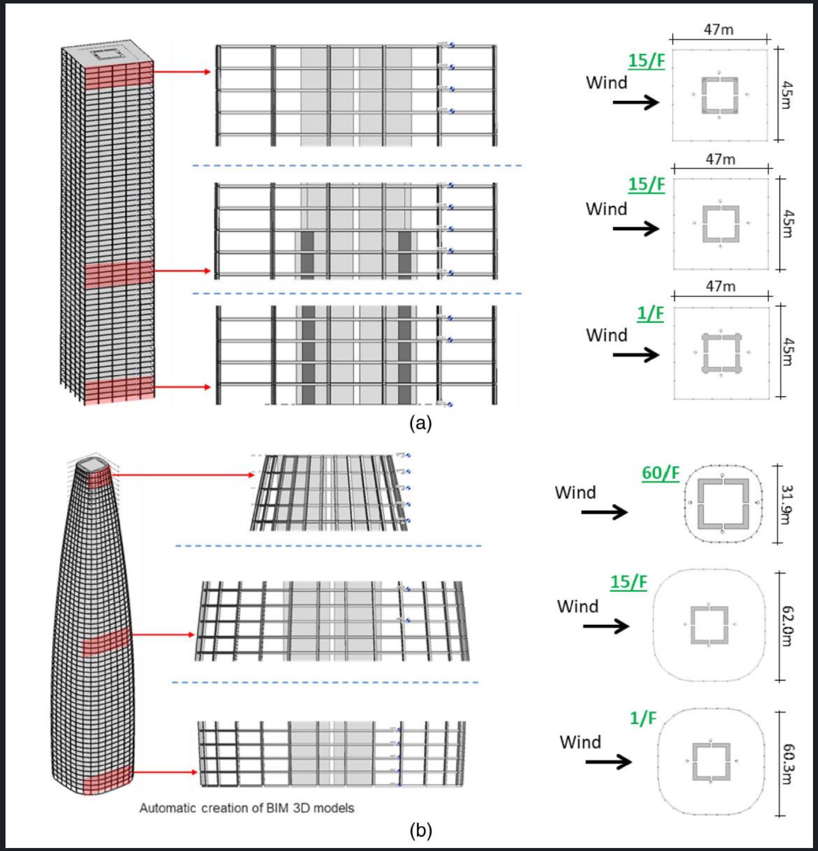
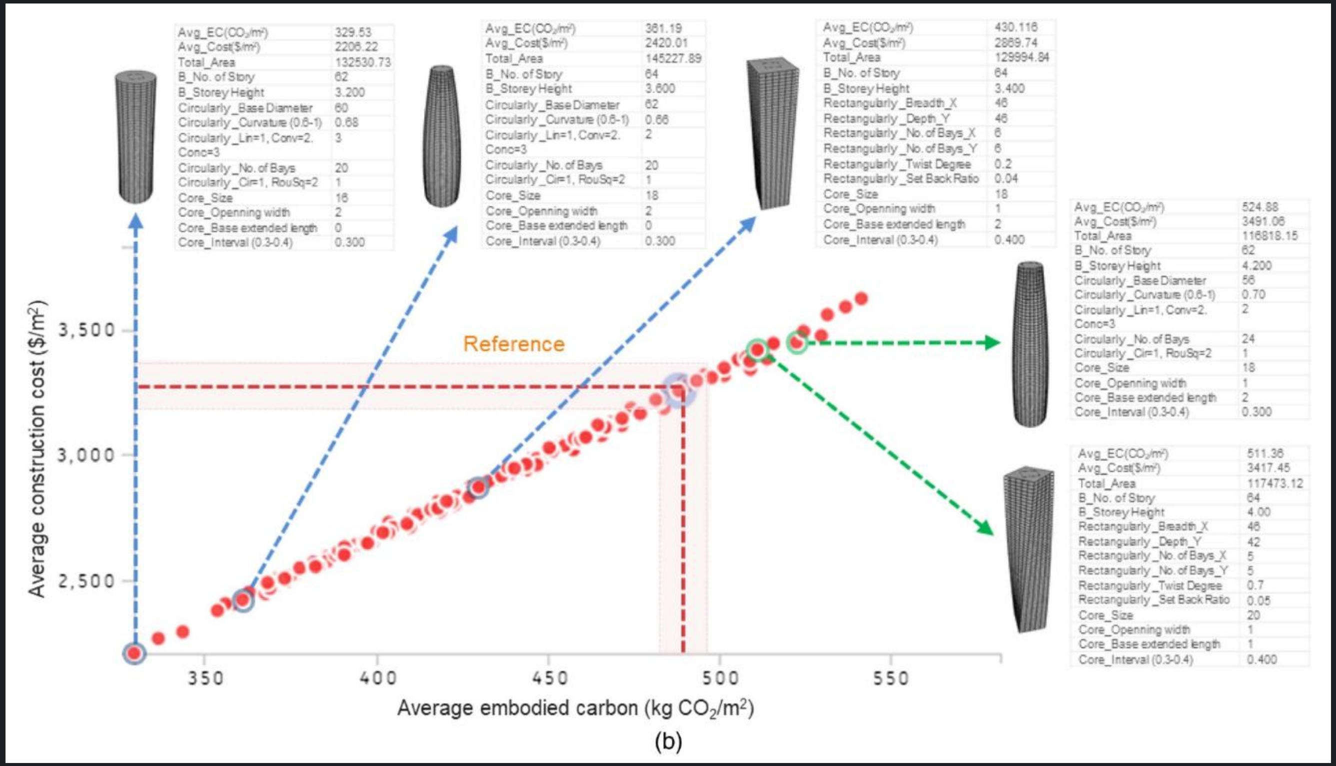
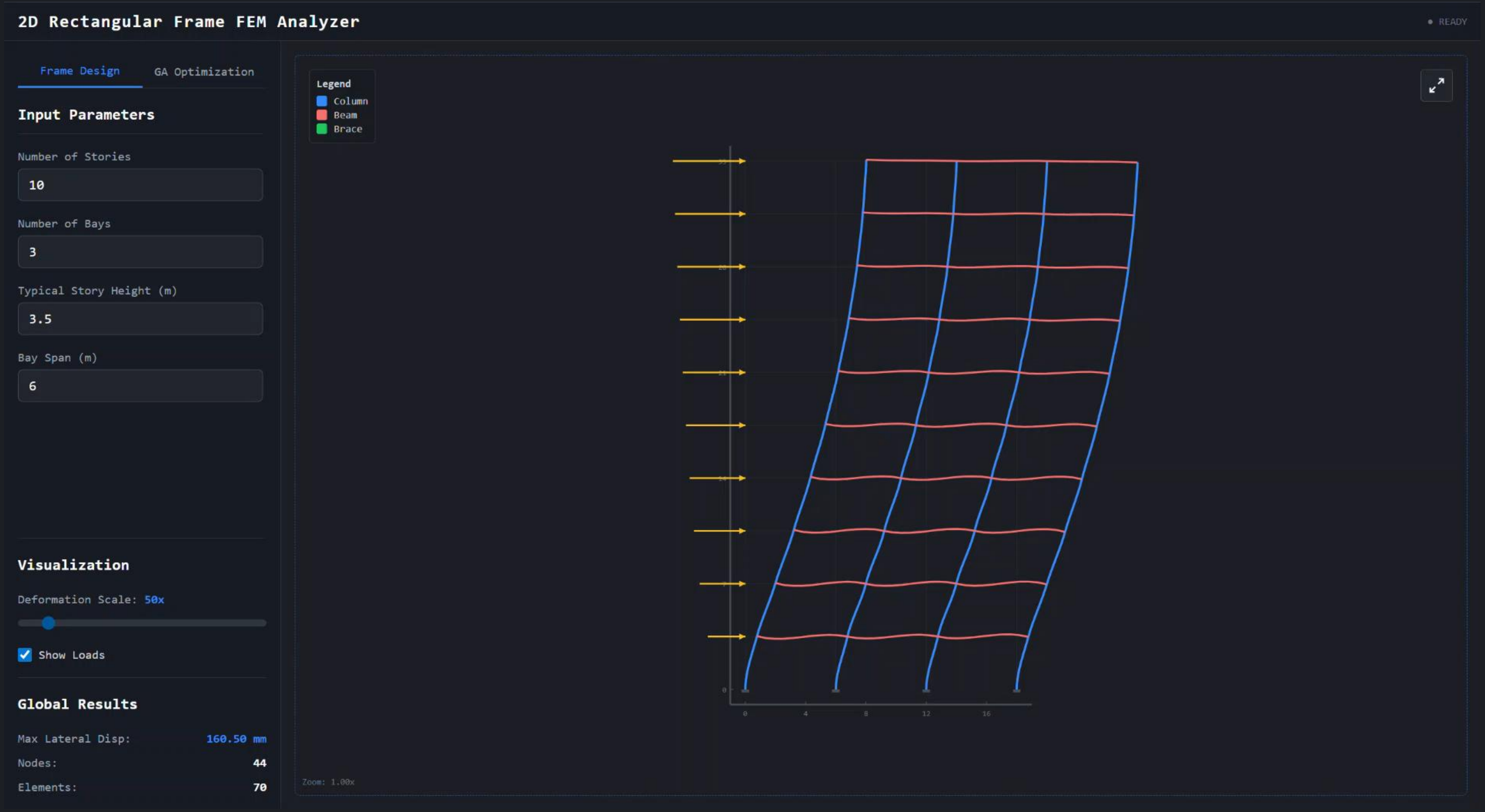




BIM-Based Building Geometric Modeling and Automatic Generative Design for Sustainable Offsite Construction; (2022) Vincent J. L. Gan, Ph.D., A.M.ASCE1

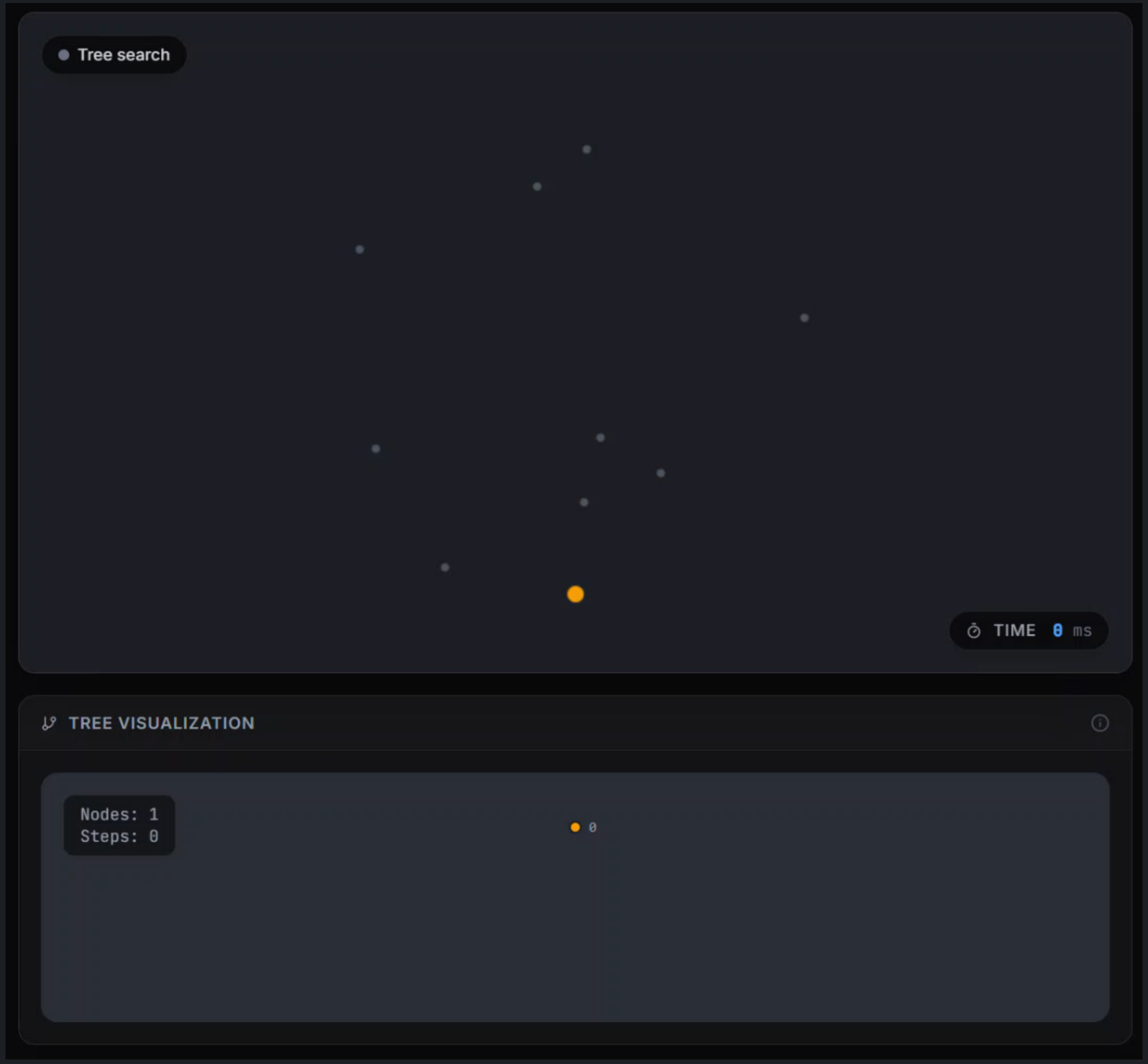
Coding as Design Infrastructure

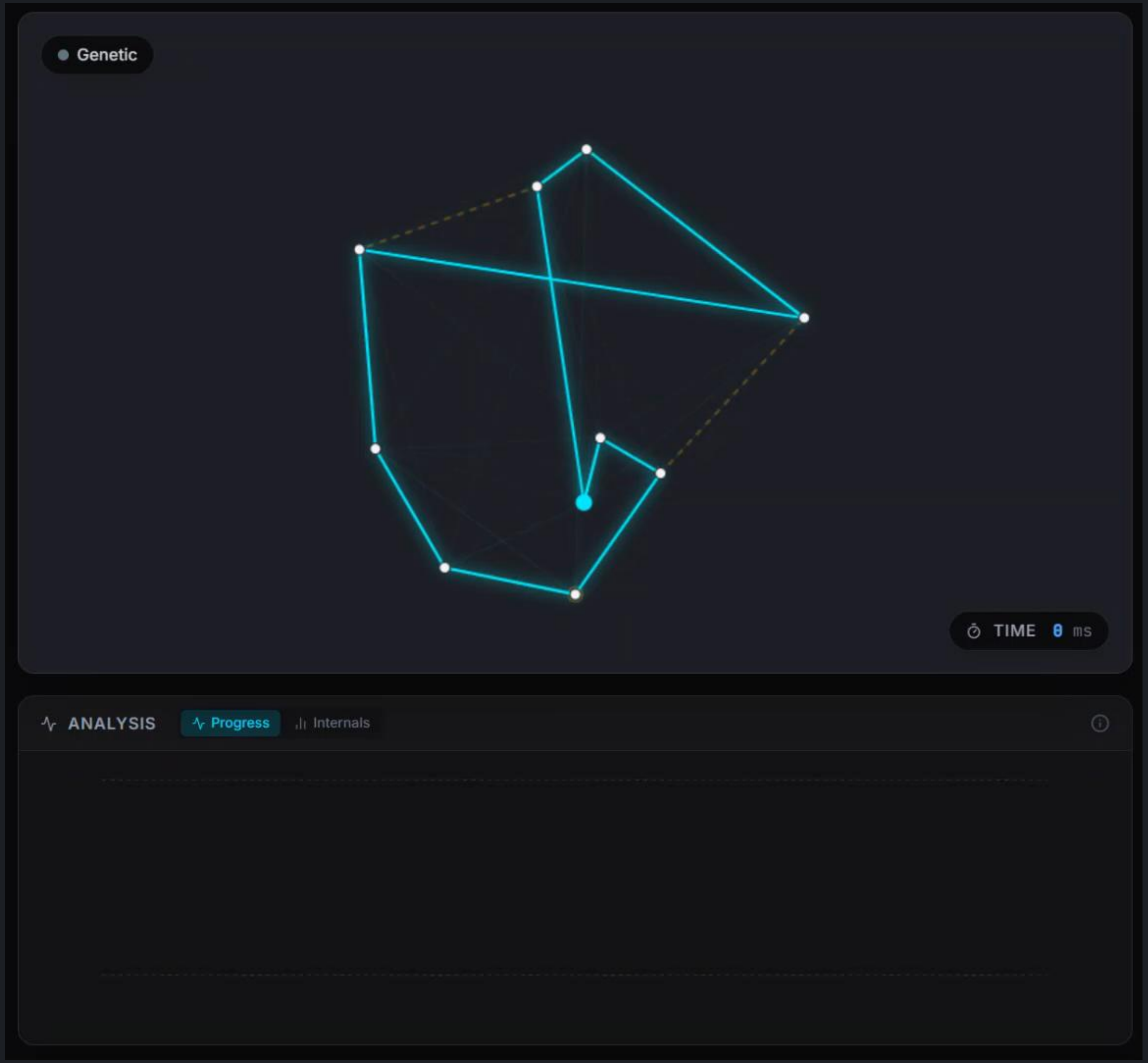


Education

Teaching Algorithmic Reasoning

Teaching Algorithmic Reasoning





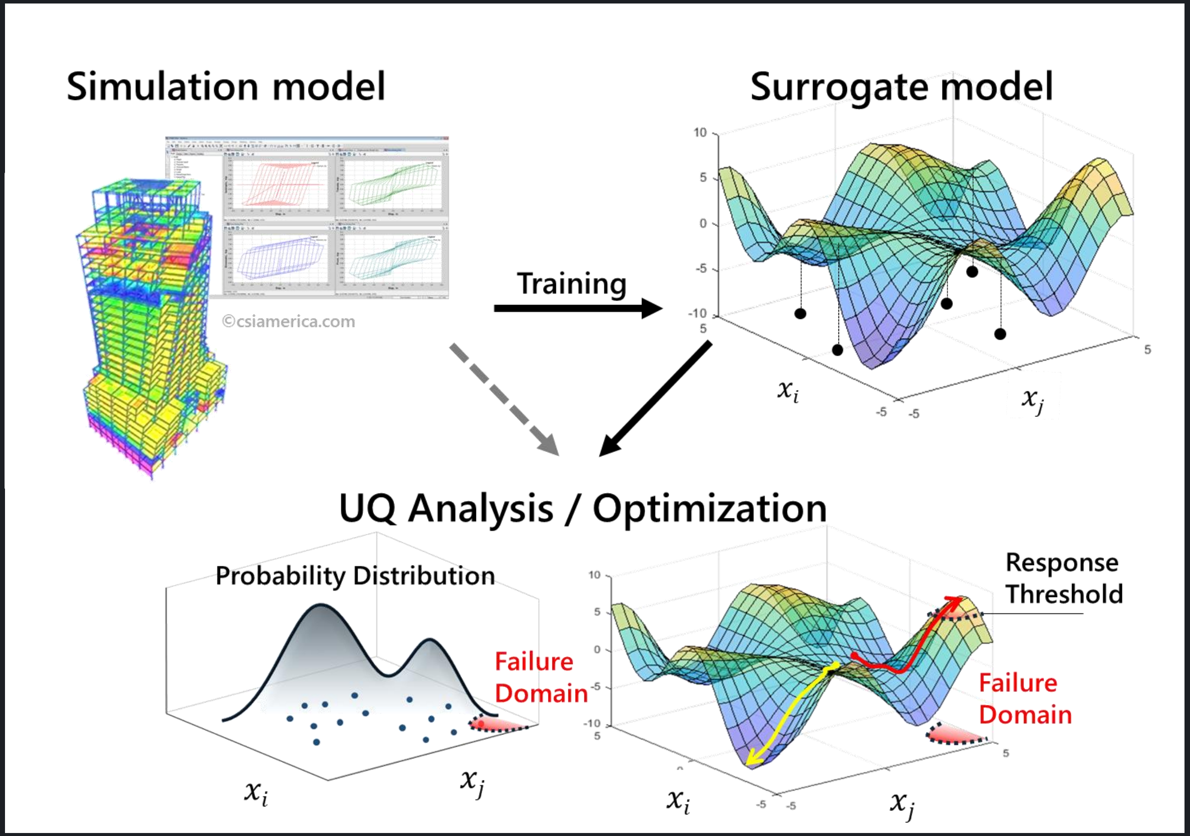
AI as Assistant, Not Replacement

Data-driven and AI-assisted algorithms do not replace structural theory.
They extend our ability to predict, approximate, and explore.

Data

Surrogate Modeling
Neural Networks
Reinforcement Learning
Approximate | Predict | Decide
Fast evaluation | Complex mapping | Sequential action

AI assists computation when engineering problems become too large to explore directly



https://github.com/NHERI-SimCenter

Revisiting Argyris: Does Computation Shape Theory Today?

- ❑ Engineering theory becomes operational through computation.
- ❑ Computational thinking transforms design from solving to searching.
- ❑ Engineers design the rules → computers explore the possibilities.

Engineering is <u>no longer about solving a problem.</u>
It is about <u>designing the space of possible solutions</u>.

Computational thinking does not replace engineering knowledge.
It gives us a **<u>new way to structure it</u>**.

And perhaps that is what Argyris meant when he said:
the computer shapes the theory.

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