Revolutionizing Bridge Engineering with Generative AI: The OpenBrIM Journey

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OpenBrIM Platform

Cagin Yakar — Chief Executive Officer

Disclaimer of Liability

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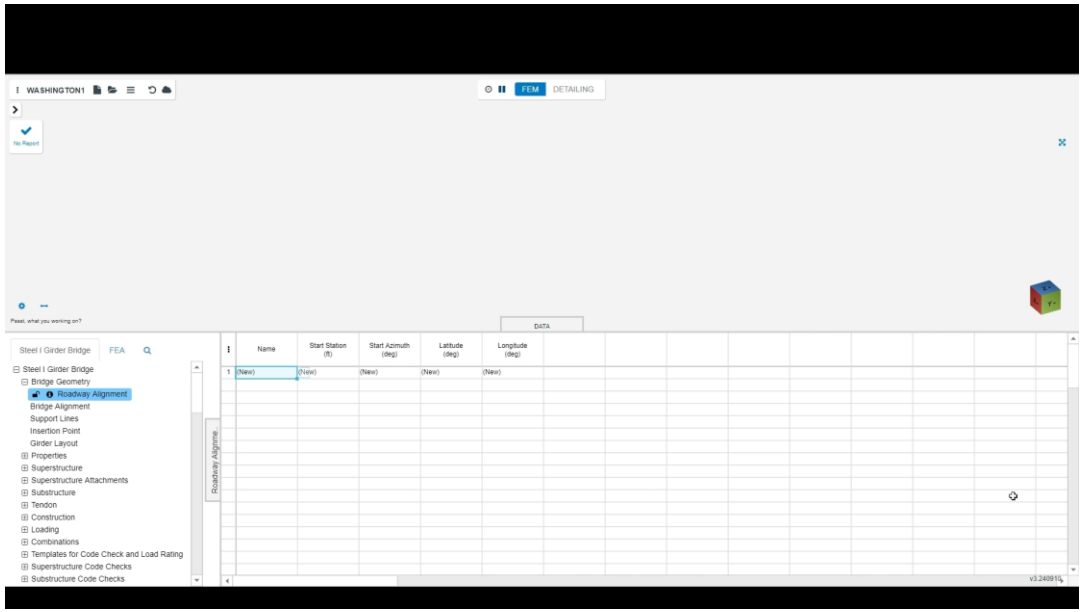
A Note Before We Begin

With due respect, deep familiarity with a subject can sometimes make it easy to overlook the challenges of being new to it. In this presentation, I'll aim to convey the information clearly, using basic examples to help bridge that gap.

OPENBRIM GENERATIVE OBJECTS



https://dev.openbrim.org/platform/?application=app&prj=objidk9lp3i92q4p83lia1c1tdq&devcons=1&branch=cadd6&active=GraphicsView

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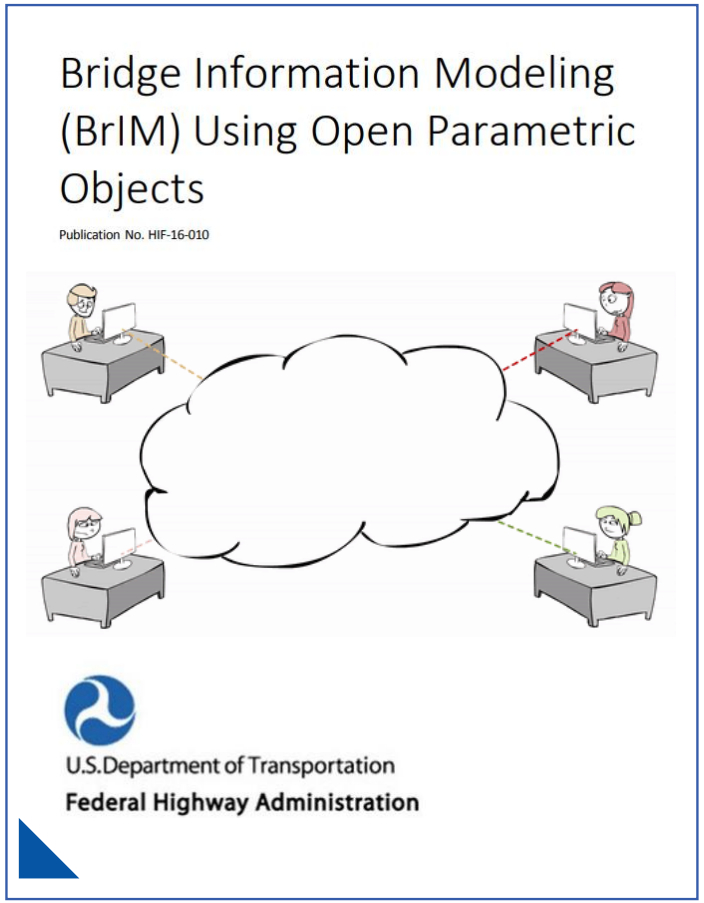
HOW OPENBRIM MAKES THE IMPOSSIBLE POSSIBLE?

How Did We Get Here?



Under Development Since 2015

https://www.fhwa.dot.gov/bridge/pubs/hif16010.pdf

- **Transforming bridge practice from paper delivery to digital delivery**
- **Developing digital BrIM standards**
- **Developed Parametric Library Objects**

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WHAT IS A HARD PROBLEM FOR AI?

Chess: A Historical Milestone

- Early Benchmark: Once seen as a test of intelligence.
- AI Breakthrough: Deep Blue's victory over Kasparov in 1997.
- Current Status: Chess is now a manageable problem for AI, mastered through advanced algorithms and computational power.

Is Chess Still Hard?

- **Finite Problem:** Despite complexity, it's a finite, rule-based game.
- AI Mastery: Chess is no longer a challenge, with AI dominating the game.

Real-World Decision Making: A True Challenge

- **Dynamic Environments**: Tasks like autonomous driving require real-time decisions in unpredictable settings, far more complex than chess.

YouTube

MarI/O - Machine Learning for Video Games
11M views
9 years ago

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SIMPLIFYING BRIDGE ENGINEERING FOR AI: SINCE 2015

"Any intelligent fool can make things bigger, more complex, and more violent. It takes a touch of genius—and a lot of courage—to move in the opposite direction."
— **Albert Einstein**

On Mathematical Maturity Thomas Garrity

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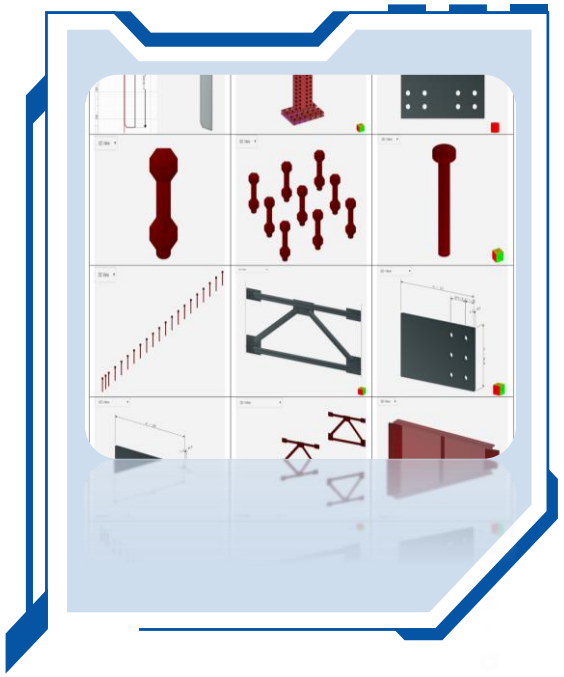
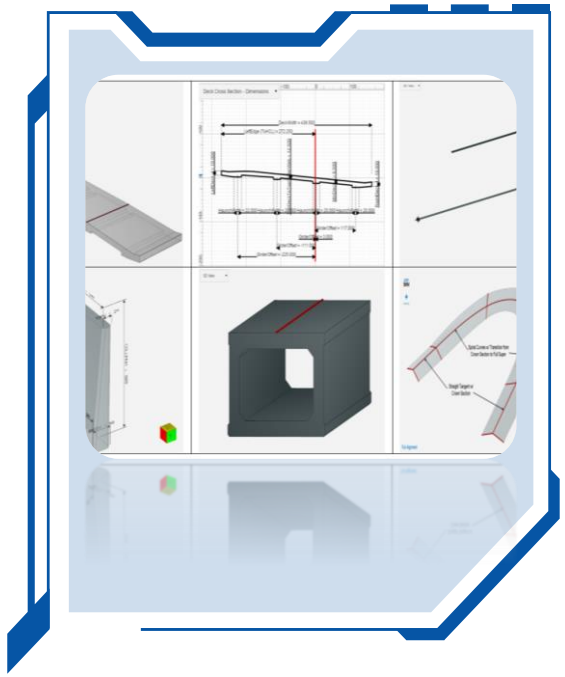
OPENBRIM LIBRARY: BRIDGE ENGINEER'S FUNCTION CONTAINER





Transparent parametric dependencies

Customizable dependencies according to different project and company requirements

Reusable and modular way to define parametric relationships

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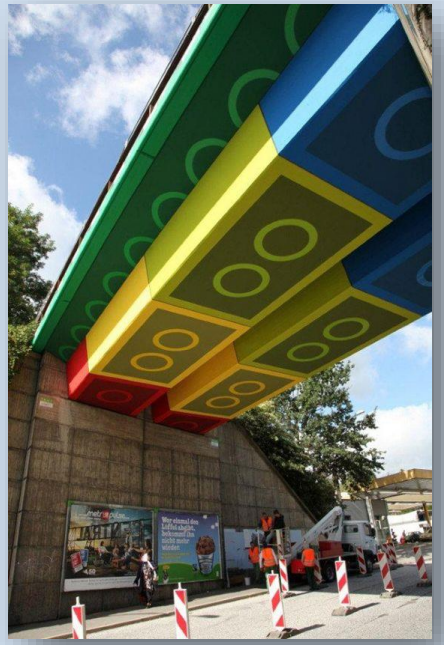
OPENBRIM LIBRARY: BRIDGE ENGINEER'S FUNCTION CONTAINER

Parametric Bridge Library

LEGO Structures



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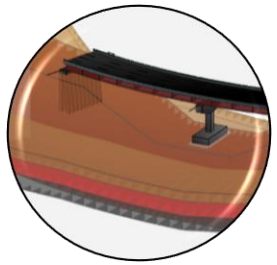
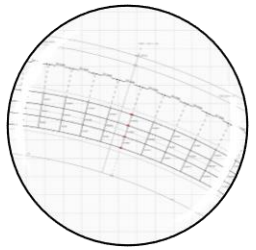
THE SYNERGY OF PARAMETRIC ENGINEERING AND HOLISTIC APPROACH

Defining a Bridge with Parameters

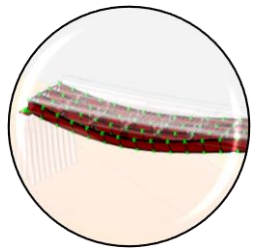
- **Automatic Model Generation:** Key parameters drive the creation of the bridge's 3D and mathematical model (FEM).
- **Seamless Analysis Integration:** The analysis engine simulates behavior.
- **Automated Specification Checks:** Each bridge component is automatically verified against relevant design codes and specifications.



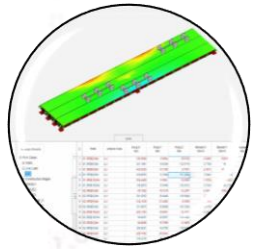
3D MODEL



2D DWG



FE MODEL



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SPEC CHECKS

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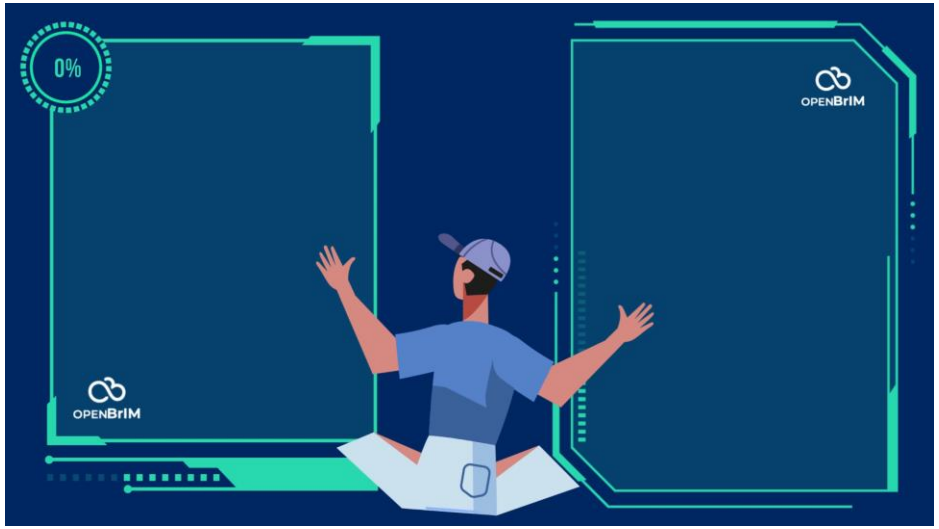
THE SYNERGY OF PARAMETRIC ENGINEERING AND HOLISTIC APPROACH

With OpenBrIM, we're empowering bridge engineers in ways never before possible.

Any sufficiently advanced technology is indistinguishable from magic.



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The Exponential Growth Of Combinations & Computational Challenges

- **Total Combinations:** 1,166,200
- **Time Required per Evaluation:** 0.5 seconds
- **Total Computation Time per Scenario:** ~97 hours
- **Geometric Growth:** Number of alternatives and required resources increase geometrically.
- **Human Limitations:** Given the vast number of combinations, evaluating every scenario would far exceed human lifetimes.
-

Optimization Configuration

Parameter Name	Description	Min Value	Max Value	Increment
dw_Input	Web depth	72	105	1
tw_Input	Web thickness	0.5	1.25	0.125
tft_Input	Top flange thickness	0.75	1.5	0.125
tfb_Input	Bottom flange thickness	0.75	1.5	0.125
bft_Input	Top flange width	12	30	2
bfb_Input	Bottom flange width	12	30	2

Objective Function: The goal of the optimization process is to minimize this function. [Area of section]

(dw_Input*tw_Input)+(tft_Input*bft_Input)+(tfb_Input*bfb_Input)

Total Combinations: 1166200

Maximum number of solutions:

100

Optimize

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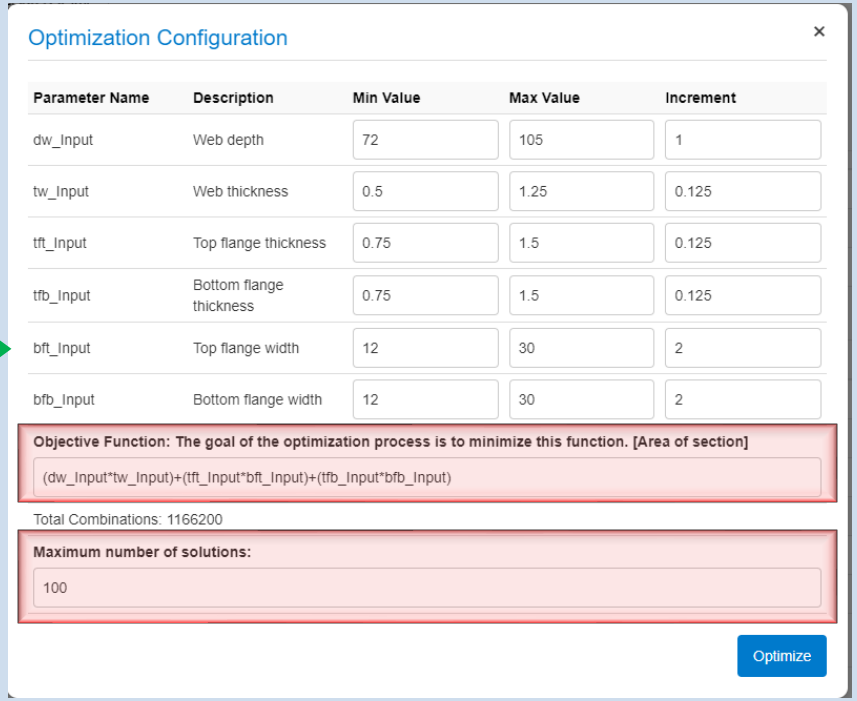
The Exponential Growth Of Combinations & Computational Challenges

How Can We Achieve Optimal Solutions Within Feasible Time and Resource Constraints?

- Define Your Goal:
  - **Objective Function:** Designed to minimize a specific parameter (e.g., area of the section).
  - **Maximum number of solutions**: Limits the scenarios the optimization process will evaluate in detail, focusing resources on the most promising options.
  - **Maximum DC Ratio**



Cutting Down Time and Resource Demands w Neural Networks / Genetic Algorithm / Parametric Bridges

The Art of Simplification: Experience and Education in Simplifying Solutions

Human

"Just as humans learn to filter out unnecessary solutions based on **education**, **experience, intuition and critical thinking**“

AI – Neural Networks

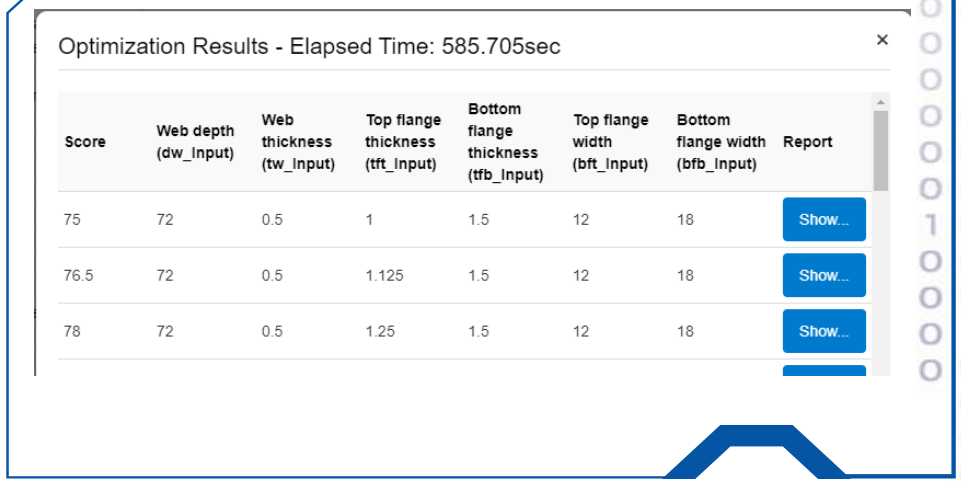
"AI systems are trained to recognize and discard less relevant options, focusing only on the most promising paths to efficiently solve complex problems.“

Albert Einstein

“Education is not the learning of facts, but the training of the mind to think.

Education is what remains after one has forgotten what one has learned in school.”

ONE PARAMETRIC BRIDGE = ∞ BRIDGES



Total Combinations: 1,166,200

Time per Evaluation: 0.5 seconds

Original Total Computation Time: ~97 hours

VS

Scenarios Evaluated: ~1,000

Optimized Computation Time: 10 minutes

Efficiency Gain: 600 times faster

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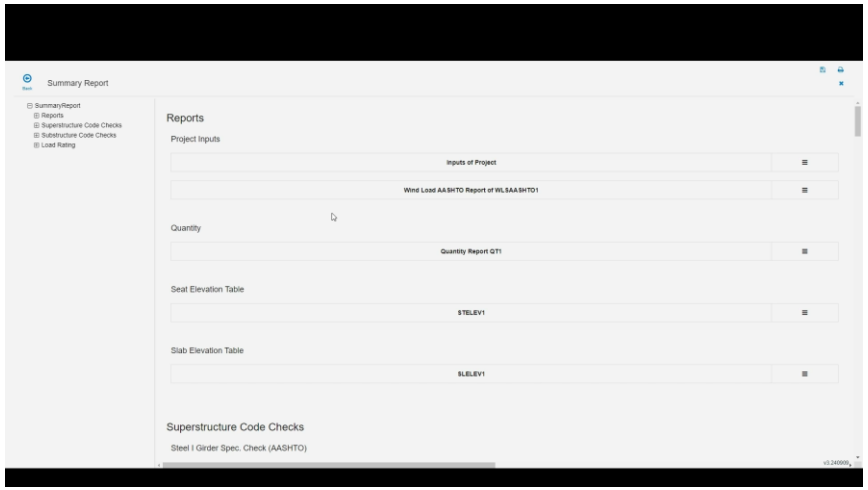
OPTIMIZE DESIGN PARAMETERS



Neural Network Space Reduction

Purpose
- Eliminate unnecessary solutions without evaluating them.

Process
- Focuses on relevant solutions, discarding irrelevant data early.
- Saves time and resources by reducing the search space.

End Result
- A more efficient model with only the most relevant solutions.

How OpenBrIM.AI is Trained

After Space Reduction
- Refined inputs from the reduced search space are used to train OpenBrIM.AI.

Genetic Algorithm Integration
- Genetic algorithm evaluates solutions, stores results in the cloud, and further optimizes the model.

Inputs and Outputs
- Evaluated inputs and outputs are continuously used to train and improve OpenBrIM.AI.

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AI IN THE DRIVER'S SEAT: HOW MUCH CAN WE TRUST ITS DECISIONS?

Autopilot's Weakness: A Stop Sign T-Shirt

Oversized Stop Signs Confuse Tesla's Autopilot

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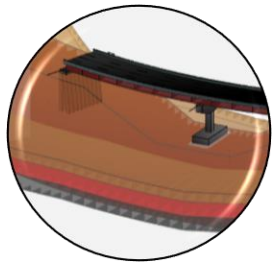
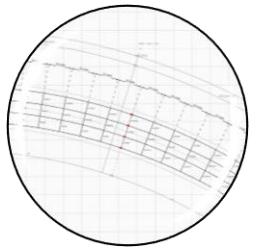
MERGING AI WITH TRADITIONAL METHODS



3D MODEL

- We, as OpenBrIM Engineers, are the Architects.
- We created OpenBrIM.
- And we've been waiting for you.



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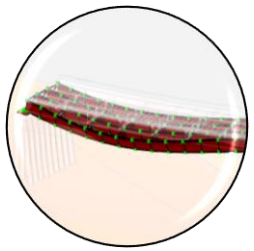
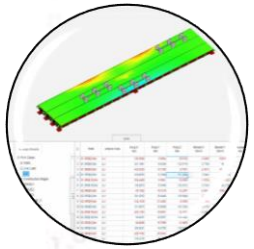


FE MODEL



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