PROJECT REPORT

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Parametric Modeling

Individual Assignment 2

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Project Proposal: Application of Image Processing Technology in civil engineering

1. Introduction:

As a follow-up to the previous assignment, which was an introduction to the world of ontological modeling of steel bridges, this report dives into the application of parametric modeling for the design of a Truss Steel Bridge using Dynamo BIM. With this approach, we extend the conceptual framework established earlier, now focusing on the dynamic interplay between structural integrity and material efficiency, which is an integral part of the framework established earlier. With the use of Dynamo BIM, we are able to explore several configurations, which enhances our understanding of the relationship between design parameters and their impact on the performance of the bridge. The purpose of this study is to provide a comprehensive understanding of civil engineered systems by synthesizing theoretical insights from ontological modeling with practical design adjustments, resulting in a comprehensive understanding of the matter.

2. Background and Objectives

Background:

As part of our Civil Systems Engineering course on Parametric Modeling, this project explores the use of parametric design in bridge structural engineering. Using Dynamo BIM, we aim to integrate theoretical principles with practical design aspects, particularly in relation to steel bridge construction.

Objectives:

- An investigation of the structural feasibility and efficiency of various bridge designs under specific loading conditions is undertaken.
- It is important to understand how parametric modeling can be used to optimize bridge design, particularly in terms of cost and aesthetics.
- It is the objective of this project to apply theoretical knowledge from ontological modeling to practical design scenarios, in order to enhance understanding of civil engineering systems.

3. Methodology

3.2. Design Challenge: I have considered the challenge of minimizing material usage while maximizing load capacity and aesthetic appeal in the design of a footbridge.

3.3. Parameter Selection

Optimizing the load-bearing capacity and material efficiency of steel bridges. It is important to balance the structural integrity (load-bearing capacity) of the bridge with its economic feasibility (material usage).
The bridge will be 18 meters long and designed for pedesterians.

4. Experimentation and Analysis

Based on the pedagogical directives of the Civil Systems Engineering curriculum, I have developed three distinct design scenarios for a proposed bridge structure. In order to challenge and enhance our understanding of parametric design applications in civil engineering, the scenarios have been developed methodically.

4.1. Design Alternatives

For each scenario, let's create a simplified example with the same total load. For a bridge 18meters in length and 3 meter in width, I will consider a uniformly distributed load (UDL) of 5 tons (5000 kg).

Scenario 1: Wooden Girder without Bracing: Using wooden girders without additional bracing, the design supports a dynamic live load of 100 people. Based on geometric constraints and performance criteria, this scenario examines the structural capacity of wood in isolation, optimizing the girder dimensions to withstand the specified load.

Let's assume a rectangular wooden beam:

Width (b) = 0.3m (30cm)

Height (h) = 0.5m (50cm)

Section modulus (S) = $\frac{b*h^2}{6}$ = 0.0125m^3 or 12500 cm^3

Assuming a UDL of 278 kg/m (5000 kg / 18 m)

Assuming an allowable stress (σ) of 10 MPa (or 10 N/mm² for wood).

Maximum bending moment (M) is M= $\frac{W*L^2}{8}$, where L is the span length.

span length of 1.8 meters between supports: M = $\frac{278*1.8^2}{8}$ = 139 Kg-m or 13900 N-m since 1 kg-m = 9.81 N-m.

Section modulus (S) required is S= $\frac{M}{\sigma}$ = $\frac{13900*10^3 N-mm}{10 N/mm^2}$ = 1390000 mm^3

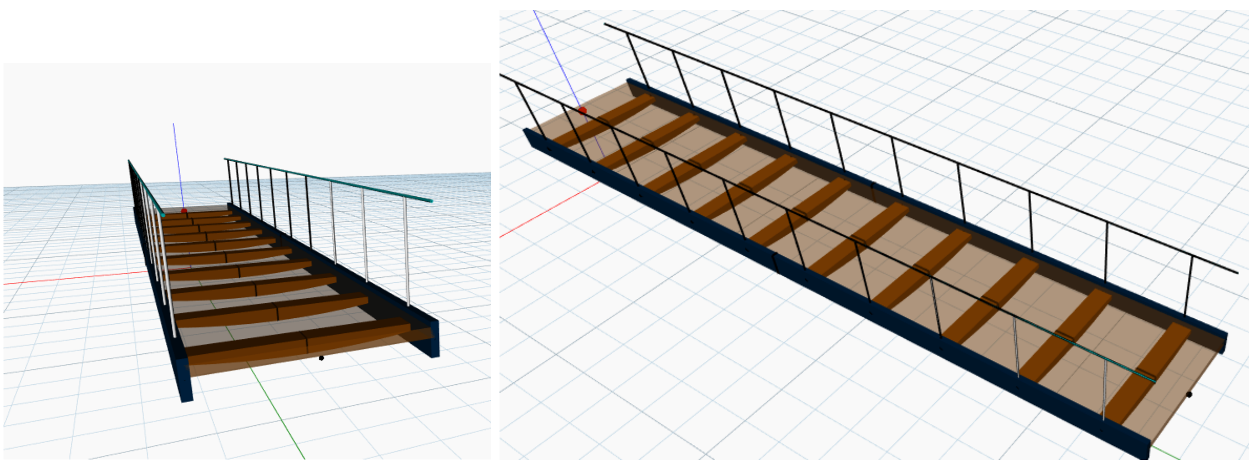

*Figure 1: **Scenario 1***

Scenario 2: Steel Girder without Bracing

The same dynamic live load can also be carried by steel girders without bracing in a comparative scenario. The engineering aspects of this scenario examine the specific properties of steel, such as its superior strength-to-weight ratio, evaluating the potential for more slender design profiles while maintaining safety and performance requirements.

Assume a higher allowable stress for steel, say 250 MPa (or 250 N/mm²).

Using the same bending moment M (13900 N-m), the required section modulus is S= $\frac{M}{\sigma}$ = $\frac{13900*10^3 N-mm}{250 N/mm^2}$ = 55600 mm^3

For an I-beam with a section modulus (S) of 55600 cm³, we can find dimensions like the following in a

steel shapes catalog:
Flange width: approximately 30-40 cm
Flange thickness: approximately 3-4 cm
Web height: approximately 80-100 cm
Web thickness: approximately 2-3 cm

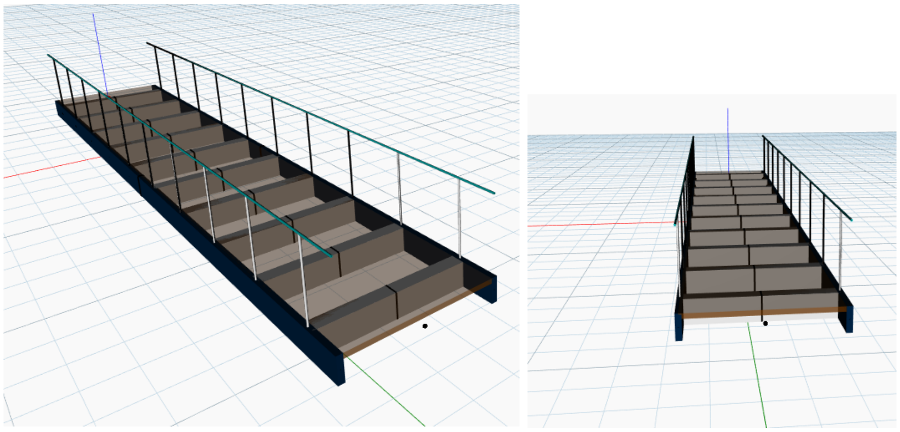

Figure 2: ***Scenario 2***

Scenario 3: Wooden Girder with Bracing Girders
The wooden girders are braced in this scenario, creating a truss-like structure that redistributes loads and enhances stability. By optimizing load paths and reducing material consumption without compromising structural integrity, it investigates the synergy between the girders and bracing.

The bracing girders will help to distribute the load, potentially allowing for a smaller section modulus.

If the bracing reduces the effective span or the effective load per girder, the bending moment M might be lower.

if the bracing halves the effective span to 1 -meter M = $\frac{278*1^2}{8}$ = 34.75 kg-m or 34750 N-m.

The required section modulus with bracing becomes S= $\frac{M}{\sigma} = \frac{34750*10^3 N-mm}{250\text{N}/mm^2}$ = 3475000 mm^3

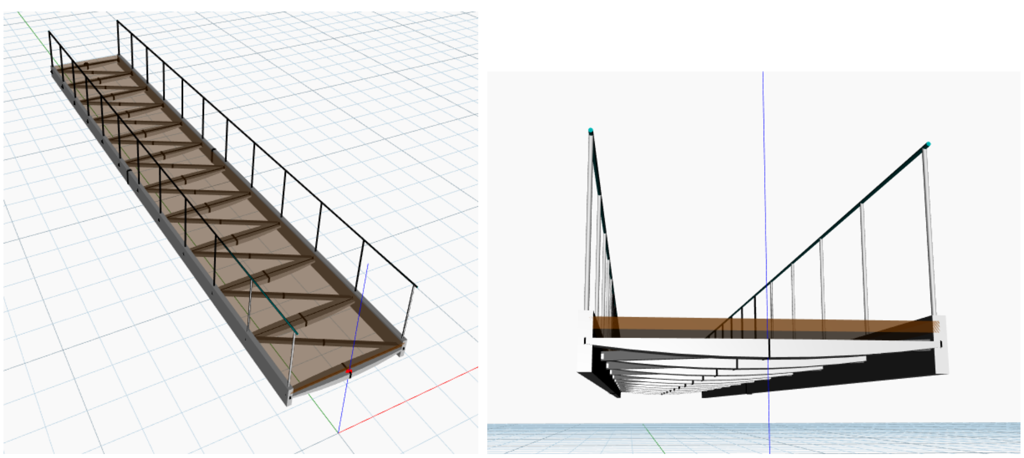

Figure 3: Scenario 3

4.2. Cost Estimation for Design Alternatives

In order to perform a simple cost estimation for each scenario, we will need to make some assumptions regarding the cost of materials and construction. Consider the following:

Wooden Girder Design: Assume wood costs €500 per cubic meter.

Steel Girder Design: Assume steel costs €800 per cubic meter.
Wooden Girder with Bracing: Assume a combined cost, factoring in additional bracing materials and complexity, of €600 per cubic meter.

Wooden Girder Design:

volume of 10 cubic meters.
Total Cost = 10 m^3 × €500/m^3 = €5000.

Steel Girder Design:

volume of 8 cubic meters (as steel can be more material-efficient).
Total Cost = 8 m^3 × €800/m^3 = €6400.

Wooden Girder with Bracing:

<u>Wooden Girder:</u>
volume of 10 cubic meters for the wooden parts.
Wood Cost = 10 m^3 × €500/m^3 = €5000.
<u>Steel Bracing:</u>
volume of 3 cubic meters for the steel bracing (since bracing generally uses less material than main girders).
Steel Cost = 3 m^3 × €800/m^3 = €2400.
Total Cost = Wood Cost + Steel Cost = €5000 + €2400 = €7400

5. Results and Discussion

A significant insight was gained from the analysis of the proposed bridge designs, under the specified load conditions:

Wooden Girder Design: As a construction material, wood has limitations as well as potential, as demonstrated in this design. A clear understanding of wood's applicability in bridge design was gained through the calculations for section modulus and load-bearing capacity.

Steel Girder Design: Steel's superior strength-to-weight ratio was highlighted in the design. With a specific section modulus, steel can support greater loads with slimmer profiles, as demonstrated by the calculated dimensions for an I-beam.

Cost Estimation: Integrating contemporary cost data into our Dynamo model enabled precise cost estimations for each design, supporting the economic feasibility of the bridge designs.

6. Conclusion

The purpose of this project was to demonstrate the utility of parametric modeling in the design of bridges. Our study explored different material scenarios and integrated cost analysis to gain a comprehensive understanding of how parametric tools can optimize design processes. An important aspect of engineering design is the balance between structural integrity, material efficiency, and aesthetic considerations. To equip future engineers with the skills necessary to handle complex design challenges efficiently, parametric modeling should be incorporated into civil engineering curricula.

7. References

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[2] https://awc.org/understanding-loads-and-using-span-tables/
[3] https://dcstructuresstudio.com/dcss-standard-footbridge-design-2017/