PARAMETRIC MODEL REPORT

Parametric Modeling of a Reinforced-Concrete Retaining Wall for Containment Structures Using Dynamo BIM

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1. Introduction

Reinforced-concrete retaining walls are commonly used in containment structures, industrial platforms, and environmental protection systems. Their geometry strongly affects structural stability, durability, and material consumption. Traditional design requires multiple iterations to balance stability and concrete volume.

Parametric modeling provides a more efficient alternative: geometric parameters can be modified instantly, allowing rapid evaluation of design trade-offs.

This project develops a parametric Dynamo BIM model of a reinforced-concrete retaining wall. The model uses adjustable input parameters to generate a fully extruded 3D retaining wall based on a 2D section, following the same methodology used in the TU Berlin arch-bridge tutorial. The goal is to identify design relationships, explore the design space, and evaluate at least three meaningful alternatives.

2. Design Challenge & High-Performance Criteria

2.1 Design Challenge

The challenge is to balance two competing goals:

- **Provide sufficient stability against sliding and overturning**
- **Minimize concrete volume and footprint**

Increasing geometric dimensions improves safety but increases cost. The parametric model allows us to explore these relationships through controlled slider inputs.

2.2 Selected Performance Criteria

(1) Stability Performance Criterion

Retaining wall stability depends mainly on:

- Wall height (H): affects earth pressure
- Base width (B): determines lever arm
- Heel length (Lh): increases resisting moment
- Stem thickness (ts): increases flexural resistance

A design is considered “high-performing” if overturning resistance improves without excessive dimensions.

(2) Material Efficiency (Concrete Volume)

Concrete volume is driven by:

- Stem thickness
- Base width
- Wall height
- Wall length (extrusion length)

Efficient designs minimize volume while still satisfying stability requirements.

(3) Optional Criterion: Footprint Minimization

In many containment applications, space is limited. Minimizing the wall’s footprint (especially heel projection) is an additional performance goal.

3. Parametric Model Logic

The model is organized into four groups, mirroring the bridge-tutorial modeling sequence.

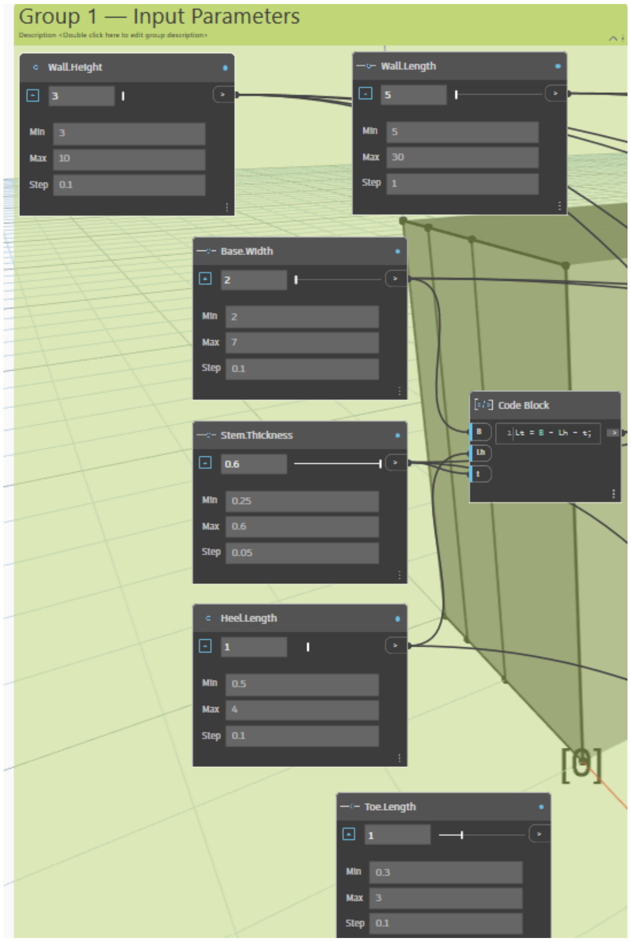
3.1 Group 1 — Input Parameters

The model uses six primary inputs:

Parameter	Symbol	Range	Purpose
Wall Height	H	3–10 m	Controls earth pressure magnitude
Wall Length	L	5–30 m	Extrusion depth of the wall
Base Width	B	2–7 m	Governs stability and footprint
Stem Thickness	t⍰	0.25–0.6 m	Influences bending behavior

Heel Length	L⍰	0.5–4 m	Major contributor to overturning resistance
Toe Length	L⍰	Derived	L⍰ = B − L⍰ − t⍰

Figure 1: Group 1- Input Parameters



Wall.Height: 3 (Min 3, Max 10, Step 0.1)

Wall.Length: 5 (Min 5, Max 30, Step 1)

Base.Width: 2 (Min 2, Max 7, Step 0.1)

Stem.Thickness: 0.6 (Min 0.25, Max 0.6, Step 0.05)

Heel.Length: 1 (Min 0.5, Max 4, Step 0.1)

Toe.Length: 1 (Min 0.3, Max 3, Step 0.1)

```
Lt = B - Lh - t;
```

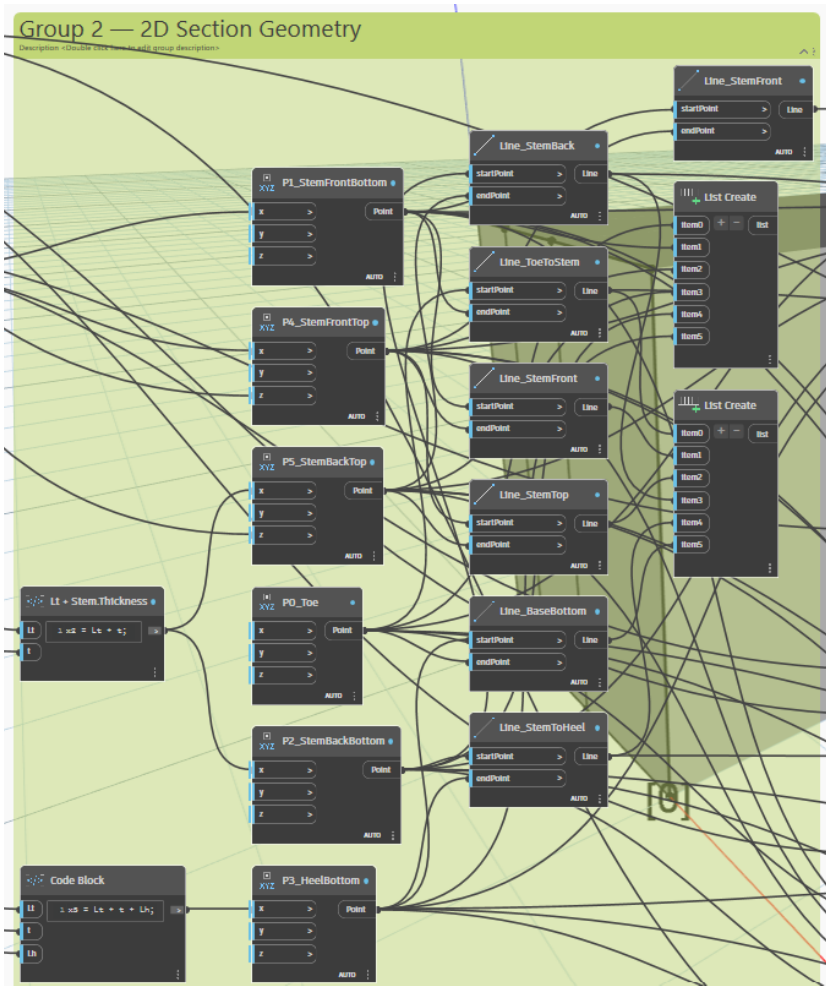
3.2 Group 2 — 2D Section Geometry

Using the above sliders, the model calculates the toe, stem, and heel points in the 2D plane. These six points define the characteristic L-shape of a retaining wall:

- P0 – Toe bottom
- P1 – Stem front bottom
- P2 – Stem back bottom
- P3 – Heel bottom
- P4 – Stem front top

- P5 – Stem back top

These are connected with Line.ByStartPointEndPoint to generate the section.



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x2 = Lt + t;
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```
x5 = Lt + t + Lh;
```

Figure 2: Group 2-2D Section Geometry

3.3 Group 3 — Outer Control Polygon

For 3D extrusion, a simplified quadrilateral outer boundary of the wall is created:

- Bottom left (0,0)
- Bottom right (B,0)
- Top right (B,H)
- Top left (0,H)

This ensures a clean, closed polygon suitable for **Surface.ByPatch**.

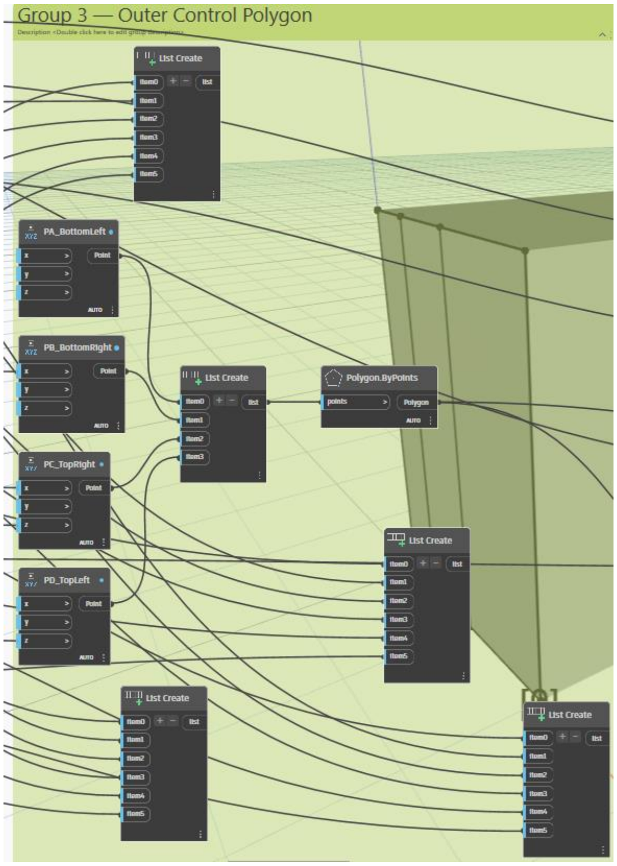

Figure 3: Group 3-Outer Control Polygon

3.4 Group 4 — Wall Section Surface & 3D Wall Extrusion

The quadrilateral is converted into a surface, then extruded along the wall length. Dynamo nodes used:

- Surface.ByPatch → creates 2D region
- Vector.ByCoordinates (0,1,0) → extrusion direction
- ExtrudeAsSolid → generates 3D retaining wall

Thin internal surfaces showing toe, heel, and stem thickness are generated using Curve.Extrude.

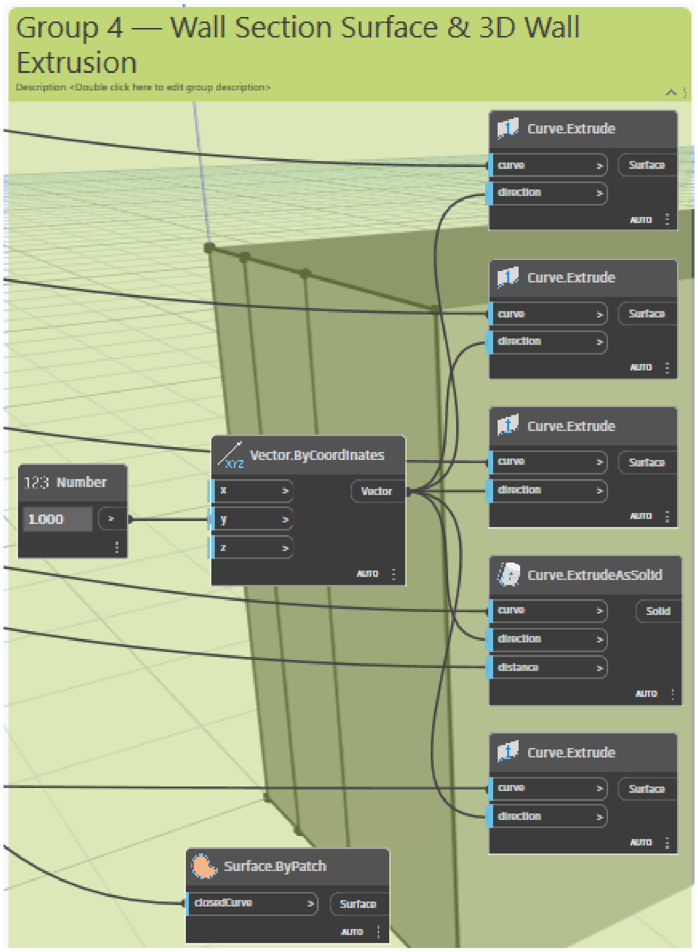

Figure 4: Group 4- Wall Surface and 3D Extrusion

4. Design Space Exploration & Alternatives

By varying the input sliders, a large design space emerges. Three representative solutions were selected based on stability and material use.

Alternative A: Material-Efficient Wall

- H = 5 m
- B = 3 m
- L⍰ = 1 m
- t⍰ = 0.30 m

Pros:

✓ Low concrete volume
✓ Small footprint

Cons:

✗ Reduced overturning resistance
✗ Suitable only for moderate loading

Alternative B: Maximum Stability Wall

- H = 7 m
- B = 6.5 m
- L⍰ = 3.5 m
- t⍰ = 0.50 m

Pros:

✓ Highest safety margin
✓ Excellent overturning and sliding resistance

Cons:

✗ Very large footprint
✗ Highest material cost

Alternative C: Balanced Wall (Recommended)

- H = 6 m
- B = 4.5 m
- L⍰ = 2 m
- t⍰ = 0.40 m

Pros:

✓ Good stability
✓ Moderate concrete usage
✓ Balanced footprint

Cons:

✗ Not ideal for extreme height or surcharge loads

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5. Discussion

The model shows clear engineering relationships: Increasing heel length greatly improves overturning resistance. Increasing wall height raises earth pressures dramatically. Stem thickness affects structural bending but has smaller impact on global stability. Base width is the dominant factor balancing stability vs. material usage. The Dynamo model makes these trade-offs immediately visible by allowing real-time adjustments. Instead of manually recalculating geometry, the designer can generate alternatives in seconds.

6. Conclusion

This assignment successfully created a parametric Dynamo BIM model of a reinforced-concrete retaining wall for containment structures. The model reflects realistic geometric dependencies and can generate a wide range of feasible designs. Two performance criteria—stability and material efficiency—were used to evaluate alternatives in the design space.

The resulting model and report demonstrate:

- the ability to abstract engineering geometry,
- apply parametric modeling techniques, and
- explore trade-offs in structural design.

This fulfills the objectives of the course assignment and mirrors the methodology applied in the arch-tied bridge example.