

1. Introduction

Retaining walls are very important for keeping sloped or embanked ground stable. They stop soil erosion and keep infrastructure strong. When designing a retaining wall in civil engineering, it is common to figure out important factors including drainage capacity, scour resistance, and structural stability. This paper shows how to use Dynamo for Revit to make a parametric model for creating a gravity retaining wall. It focuses on comparing three distinct wall options. The model lets you compare how well a wall works depending on how well it can handle floods, how well it can handle scour, and how well it uses materials.

The wall design is evaluated using two key performance criteria:

1. **Flood and Drainage Resilience:** The wall's ability to manage floodwater and make sure that water drains properly through weep holes.
2. **Scour Safety:** The wall's resistance to erosion or scouring around its base under high water flow conditions.

2. Objective and Scope

The main goal of this project is to use Dynamo for Revit, a visual programming tool, to make a parametric model for a gravity retaining wall. The model figures out how well three different types of retaining walls work by changing the values of WeepHoleDia, WeepHoleSpacing, and ToeProtectionWidth. The study looks at how these options compare in terms of drainage performance and scour safety. It also shows how wall shape affects performance and material use.

Input Parameters:

Parameters	Dimension (m)
Base Slab Thickness (BSt)	12
Retained Height (H)	8
Stem Top (St)	0.8
Stem Bottom (Sb)	15
Toe Length (Tl)	3
Heel Length (Hl)	5
Wall Length (L)	20

3. Methodology

The design and analysis of the gravity retaining wall were performed using the following steps:

3.1. Step 1: Parameter Setup in Dynamo

Input Parameters:

- Wall Height (H): 6 meters for all alternatives.
- Weep Hole Diameter (WeepHoleDia): Varies between 0.08 and 0.12 meters.
- Weep Hole Spacing (WeepHoleSpacing): Ranges from 1.0 to 1.5 meters.
- Filter Thickness (FilterThickness): Between 0.2 and 0.3 meters.
- Toe Protection Width (ToeProtectionWidth): Varies from 1.5 to 2.5 meters.
- Embedment Depth (EmbedmentDepth): Ranges from 1.0 to 1.8 meters.

The first step in the project was to define the input parameters for each alternative. These inputs were parameterized using Number Sliders and Lists to allow easy adjustments for different alternatives. Each alternative was modeled by adjusting one or more parameters:

1. Alternative 1: High WeepHoleDia and WeepHoleSpacing values, representing a design focused on drainage.
2. Alternative 2: Medium values for WeepHoleDia, WeepHoleSpacing, and ToeProtectionWidth, representing a balanced approach.
3. Alternative 3: Low values for WeepHoleDia and EmbedmentDepth, focusing on scour resistance.

3.2. Step 2: Geometry Generation in Dynamo

Dynamo nodes were used to model the geometry of the retaining wall:

- Line.ByStartPointEndPoint: Created the wall's base and height.
- Surface.ByPatch: Defined the wall's surface.
- Extrude.ByCurve: Used to extrude the wall geometry based on the surface.
The geometry was adjusted dynamically by changing the parameter values using sliders and lists.

3.3. Step 3: Performance Evaluation

To evaluate the performance of each alternative, we calculated:

- Drainage Resilience Index: Based on the formula for drainage capacity, considering weep hole diameter and spacing.

- Scour Safety Index: Evaluated based on the embedment depth and toe protection width. These indices were used to rank the alternatives in terms of flood and scour resilience.

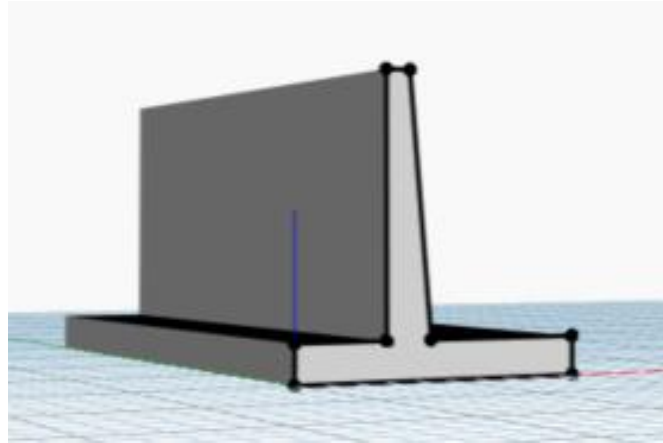


Figure: Geometric Model of Retaining Wall

3.4. Step 4: Sorting and Comparison:

The results for drainage resilience and scour safety were sorted using List.Sort in Dynamo. This allowed for a direct comparison of the three alternatives, highlighting their strengths and weaknesses in terms of material efficiency and performance.

4.1. Drainage Resilience Index

Alternative	WeepHoleDia (m)	WeepHoleSpacing(m)	Drainage Resilience Index
Alternative 01	0.12	1.5	0.0024
Alternative 02	0.10	1.2	0.0006
Alternative 03	0.08	1.0	0.0005

Alternative 1 showed the best drainage resilience due to the larger weep hole diameter and spacing. Alternative 3 had the lowest drainage resilience due to smaller weep holes and closer spacing, indicating it may not be as effective in flood conditions.

4.2. Scour Safety Index

Alternative	Embedment Depth (m)	ToeProtectionWidth (m)	Scour Safety Index
Alternative 01	1.0	1.5	1.5
Alternative 02	1.8	2.0	3.05
Alternative 03	1.5	2.5	1.95

Alternative 2 had the highest scour safety index due to its deeper embedment and wider toe protection. Alternative 2 had the highest scour safety index due to its deeper embedment and wider toe protection.

5. Discussion

The three alternatives were compared based on both flood resilience and scour safety. Each alternative presented trade-offs in terms of performance and material efficiency:

- Alternative 1 used the least amount of concrete, but it wasn't very safe from scour, so it wasn't a good choice for areas with a lot of water flow or erosion risk.
- Alternative 2 was the safest choice for scouring, but it wasn't as good at draining because the weep holes were smaller and farther apart. This makes it great for places where erosion is a big problem and scouring is a big worry.
- Alternative 3 was the most flexible choice since it had a balanced solution with modest drainage resilience and scour safety.

6. Conclusion

The study showed how well a parametric model in Dynamo can be used to analyze gravity retaining walls based on scour robustness and drainage resilience. Three distinct retaining wall layouts may be evaluated using the model by varying important factors like WeepHoleDia, WeepHoleSpacing, and ToeProtectionWidth. While Option 2 offers better scour safety, Option 1 is best for drainage resilience. A middle ground between the two is provided by Option 3, which gives balanced performance.

For engineers looking to maximize retaining wall designs while striking a balance between material consumption and performance, this study offers insightful information. Future upgrades may concentrate on economic analysis, environmental effects, and seismic design issues.

7. Future Work

Future research could expand on the current model by:

1. Adding seismic load analysis to assess wall performance in dynamic environments.

2. Including environmental effects to better optimize designs for sustainability (e.g., embodied carbon in materials).
3. Adapting the model to various soil types while taking compaction and soil pressure differences into account.

8. References

1. Bowles, J.E., *Foundation Analysis and Design*, 5th ed. McGraw-Hill, 1995.
2. Brooks, H., *Basics of Retaining Wall Design*, 8th ed. HBA Publications, 2010.
3. Das, B.M., *Principles of Foundation Engineering*, 7th ed. Cengage Learning, 2014.
4. American Concrete Institute, *Building Code Requirements for Structural Concrete (ACI 318-19)*, Farmington Hills, MI, 2019.
5. Tanyu, B. F., Sabatini, P. J., Berg, R. R., *Earth Retaining Structures*, Federal Highway Administration, 2008.