Tampereen ammattikorkeakoulu

Noise barrier

Automation of the building design of noise barrier

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OPINNÄYTETYÖ
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Rakennus- ja yhdyskuntatekniikan
Talonrakennustekniikka

TIIVISTELMÄ

Tampereen ammattikorkeakoulu
Rakennus- ja yhdyskuntatekniikan tutkinto-ohjelma
Talonrakennustekniikka

JAWAD MOHAMAD
Melueste
Meluesteen rakennussuunnittelun automatisointi

Opinnäytetyö 36 sivua
Syyskuu 2019

Opinnäytetyön tavoitteena on tutkia ja saavuttaa nopeita mallintamis- ja algoritmisia automaatioratkaisuja. Nämä tarjoavat insinööreille vahvan ja tehokkaan työkalun kokeilla monimutkaisten meluesteiden ratkaisuja lyhyessä ajassa.

Opinnäytetyön tavoitteena on kehittää ja osoittaa tekijän kykyä soveltaa meluesterakenteisiin liittyviä käytännön asiantuntijatehtäviä varten tarvittavia tietoja ja taitoja. Tavoitteena on oppia keräämään itsenäisesti tietoa meluesteiden suunnittelun automatisoinnista ja analysoimaan Ramboll Oy: n automaation nykyisiä piirteitä. Tämän lisäksi löytämään ja ratkaisemaan monimutkaisten rakenteiden ongelmat kehittämällä uusia ominaisuuksia meluesteautomaatioon.

Nykyaikaisilla tekniikkaohjelmilla rakennesuunnittelu ja mittapiirrostuotanto digitalisoidaan datan mallintamiseen ja rakenneanalyysiin. Tällaista algoritmipohjaisen mallinnuksen digitalisointia ja kehittämistä voidaan hyödyntää rakennesuunnitteluun ja meluestekomponenttien automatisointiin tarvittavassa ajassa. Yksityiskohtaisemmin tutkielmassa keskitytään siihen, kuinka rakenteellisten meluesteiden suunnittelu voidaan parametrisoida algoritmeilla ja siten automatisoida. Lisäksi automatisoidun järjestelmän on tarkoitus tuottaa meluesterakenteen kaksiulotteinen piirustus.

Asiasanat: noise barrier, structure, grasshopper, rhino

ABSTRACT

Tampereen ammattikorkeakoulu
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Degree Programme in Constructioin Engineering

Jawad Mohamad
Automation of building design of noise barrier

Bachelor's thesis 36 pages
September 2019

The objective of the thesis is to research and achieve fast modeling and algorithmic automation solutions which provide engineers with a strong and efficient tool to experiment with different solutions of complex noise barriers within a short time.

The aim of the thesis is to develop and demonstrate the capabilities of the author in applying the knowledge and skills required for practical expert tasks related to noise barrier structures. The topic of the thesis is a working life related. The objective is to learn to independently gather information about the automation of noise barrier design and analyze current features of the automation at the company Ramboll Oy. In addition, finding and solving problems of complex structures by developing new features in the noise barrier automation.

With modern engineering programs software, structural design and dimension drawing production are digitalized into data modeling and structural analysis. This kind of digitalization and development of algorithm-based modeling can be utilized to the time required for structural design and automate noise barrier components. In more detail, the thesis focuses on how structural noise barrier design can be parameterized by algorithms and thus automated. In addition, the automated system is intended to produce a two-dimensional drawing of the noise barrier structure.

Key words: noise barrier, structure, grasshopper, rhino

CONTENTS

ABBREVIATIONS

NURBS	Non-Uniform Rational Basis Spline
3D	Three-Dimensional
2D	Two-Dimensional
I/O	Input / Output - Modifiers
m	Meters
mm	Millimetres
ID	Identification Number
Brep	Boundary Representation
Debrep	Deconstruct Boundary Representation
BIM	Building Information Modelling
AEC	Architecture, Engineering and Construction
AC	ArchiCAD
ROI	Return on Investment

1 INTRODUCTION

Construction plan of designing noise barrier is primary stage for executing the work at construction site. It involves building 3D models and creating 2D drawings of the noise barrier. Modelling is a technique for creating 2D and 3D representation of surfaces and objects. Technology advances has been providing powerful components for developing dimensional visual software tools for efficient production of realistic drawings of objects and quality improvement in real-life construction. 3D modeling has been changing the presentation world of architecture designs.

The company Ramboll Oy has been planning to find new methods for developing 3D models and 2D drawings of noise barrier structures and minimizing the repetitive designing of barriers in construction projects. Design automation is key for this solution, providing fast configuring, designing and delivering of custom products.

The aim of this study is to explore methods and possibilities for creating an automation system for 3D modelling and 2D drawing of noise barriers and test the system on real-life projects. Innovation of algorithmic visual programming supports the fast creation of design automation. This thesis uses Rhino and Grasshopper3D tools for achieving the aims.

2 BACKGROUND AND OBJECTIVES.

2.1 Need for noise protection

According to Finnish law, a noise barrier is one of the main methods for protecting residential areas from excessive noise by audible reduction in roadway traffic noise. This law is enforced by the ministry of environment. In some cases, the implementation of noise barriers is prohibited because of environmental risks or high costs price.

PICTURE 1. Noise barrier in residential area (KOHLHAUER)

Even though noise barriers cannot eliminate the traffic noise completely, they can provide privacy for property owners from passing motorists. Noise barriers can be effective according to their designed height, width and length. The Finnish transport agency defines maximum noise levels in residential and, educational areas, as well as hospitals and healthcare facilities as at maximum 35 db. In industrial areas the limit is 45dB. In old residential areas the noise level is allowed to reach up to 50 dB at night. When engineers design streets, bridges, buildings etc, they aim to design noise barriers in a way that the noise level does not exceed the reference level what the law defines.

In 2005 the Finnish ministry of environment made statistics about different sources of noise and the number of residents affected. Approximately 90% of environmental noise resulted from road transportation

.

TABLE 1. Number of people exposed to noise from different noise sources (Finland- Survey 2005)

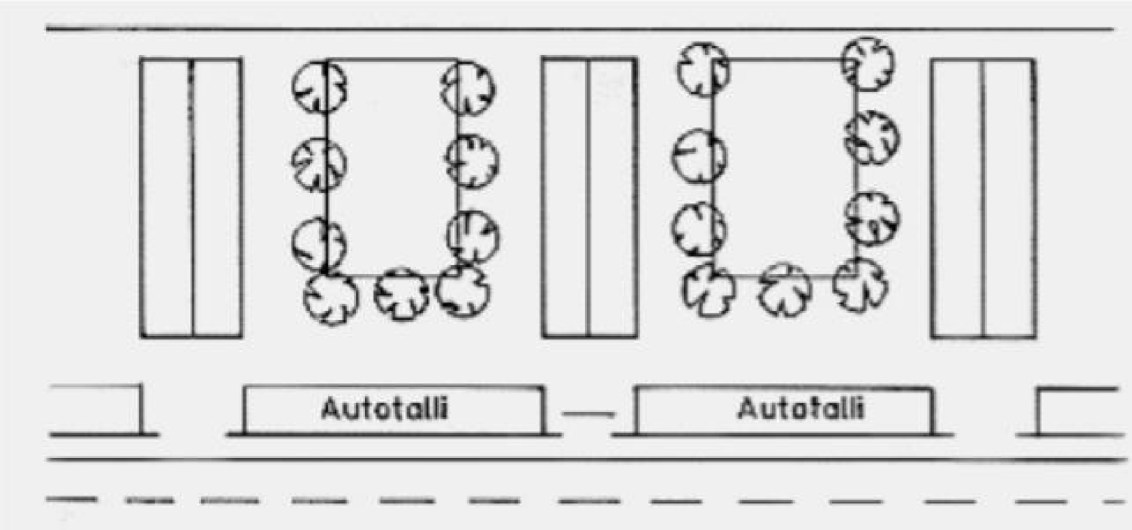
Noise source	Number of residents affected	Exposure limit
Main roads	315 500 – 384 500	L_{Aeq} > 55 dB
Streets in towns and cities	393 500 – 430 500	L_{Aeq} > 55 dB
Civil aviation	13 400 – 13 600	L_{den} > 55 dB
Military aviation	10 300 – 10 500	L_{den} > 55 dB
Rail traffic	43 500 – 53 000	L_{Aeq} > 55 dB or L_{Aeq} > 50 dB at night
Water traffic and ports	100 - 500	L_{Aeq} > 55 dB
Industry	4 000 – 6 000	L_{Aeq} > 55 dB or L_{Aeq} > 50 dB at night
Civilian shooting ranges	2 000 – 4 000	L_{AImax} > 65 dB
Motor-racing circuits	2 000 – 3 000	L_{Aeq} > 55 dB
Total	**782 000 – 908 000**	

Noise barriers can also carry some disadvantages if certain aspects are not taken into consideration. For example, too high barriers can reduce sunlight to properties, blocking views. Low quality materials can have remarkable effects on the reduce the efficiency of noise reduction of a barrier. Yet, the advantages outweigh the disadvantages. For instance, other benefits in resident areas are:

- Children are prevented from running to the road.
- Protection of traffic pollution.
- Reduction of hearing impairments.

2.2 Noise reduction options

According to the Finnish transportation agency, there are different solutions in achieving noise reduction. Examples include insulation, distance from traffic routes, area type (industrial / residential area) and, changing the usage purpose of the building among others. In the case of residential areas, reducing noise can be achieved by planning the zone in a way that the roads are built farther away from buildings. In some Finnish residential areas, outdoor storages building, trees and garages are commonly used in order to reduce noise levels. This is done by locating them between the houses and the roads. The image below shows an example of setting a garage between the road and the residential buildings.



PICTURE 2. Example of noise level reduction (Finnish Transport Agency)

Noise barriers are built also between houses in order to reduce noise levels from the surrounding neighbourhood. In residential areas, the transport agency has been reducing the traffic speed into 20-40 km/h, since speed play also a role in the noise levels. Reducing speed from 100 to 80 or 80 to 60 km/h reduces noise by approximately 2-3 db. A wide array of options therefore exists for reducing noise levels depending on the different conditions.

In general, there are two types of noise barriers, absorbing and reflective. The type of the barrier depends on the material. Absorptive means little or no noise is reflected back towards the source. Absorptive materials with the desired acoustic properties include wood and, soft, pliable and porous materials like cloth. Reflective barriers do not absorb the sound but redirect it back towards the noise source and beyond. Hard surfaces such as concrete, tile and, masonry, are considered to be reflective. Wooden noise barriers are an environmentally friendly and effective solution. Barriers can be made from pressure saturated or unsaturated wood.

Wooden noise barriers fit well into the Finnish landscape. Using various structure types and treatments for materials, wooden fences can be made very individual, stylish and durable. Weatherproofing usually plywood plate/ sheet is used on both sides of the barrier to protect the wooden frame from humidity, or any environmental stresses. This thesis focuses on the design automation of the wooden absorbing barriers.

2.3 Objectives of automation design of noise barrier

The centrepiece of the thesis falls into algorithmic modelling of a noise barrier through visual programming. The thesis applies parametric modelling for structural engineering, architecture and manufacture of the barrier. In addition, the project applies automatic production of two-dimensional drawings of complex barrier structures such as curved and angular noise barriers that allow the designer to envision the whole structure from all perspective views. 2D drawings support barriers that are manufactured as elements due to the production of high quality and economically competitive products.

The automated system was created using the Rhinoceros 3D programme and the Grasshopper tool. The construction of the system consists of multiple stages. The stages include gathering reference data and structural design information, building code definitions for 3D barrier structures with parametric variables that allow a user to automate desired results, classifying data structures, producing of two-dimensional drawings and rebuilding 3D structure of noise barrier in the Tekla structures programme.

3 PARAMETRIC DESIGN

Parametric and generative modelling is used to rationalize, and control complex geometries associated in artistic architecture, such as cladding's division, foundation, roof etc. Our modelling tool Rhino supports the automation of multiple parameter combinations for specific performance. The ability to quickly analyse a substantial number of options enables the designer to efficiently identify the optimal option for complex structures and fulfil the requirements of individual projects.

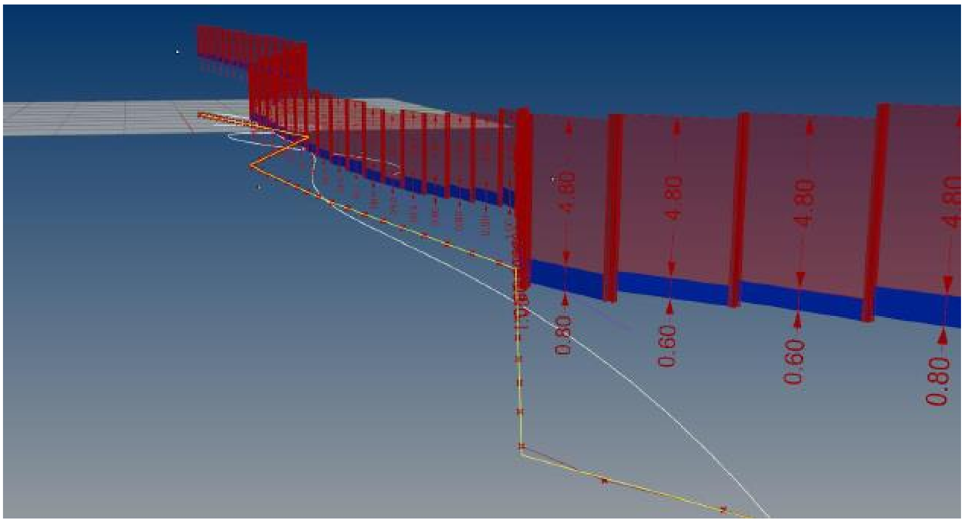
3.1 Point/Vector manipulation

A vector is a mathematical/geometrical object that has a magnitude (or limit) and direction. It starts from a point, passes toward other points with certain length and a specific direction. Vectors have vast usage in different fields of science and in geometry and transformations as well. GH has an enormous group of Point/Vector components which perform the basic operations of vector mathematics. [4]

Component	Location	Description	Example
Dist	Vector/Point/**Distance**	Compute the Distance between two points (A and B inputs)	
pComp	Vector/Point/**Decompose**	Break down a point into its X, Y, and Z components	
Angle	Vector/Vector/**Angle**	Compute the angle between two vectors Output computed in Radians	
VLen	Vector/Vector/**Length**	Compute the length (amplitude) of a vector	
vComp	Vector/Vector/**Decompose**	Break down a vector into its component parts	
Sum	Vector/Vector/**Summation**	Add the components of vector 1(A input) to the components of vector 2 (B input)	
Vec2Pt	Vector/Vector/**Vector2pt**	Creates a vector from two defined points	
Rev	Vector/Vector/**Reverse**	Negate all the components of a vector to invert the direction. The length of the vector is maintained	
Unit	Vector/Vector/**Unit Vector**	Divide all components by the inverse of the length of the vector. The resulting vector has a length of 1.0 and is called the unit vector. Sometimes referred to as 'normalizing'	
Mul	Vector/Vector/**Multiply**	Multiply the components of the vector by a specified factor	

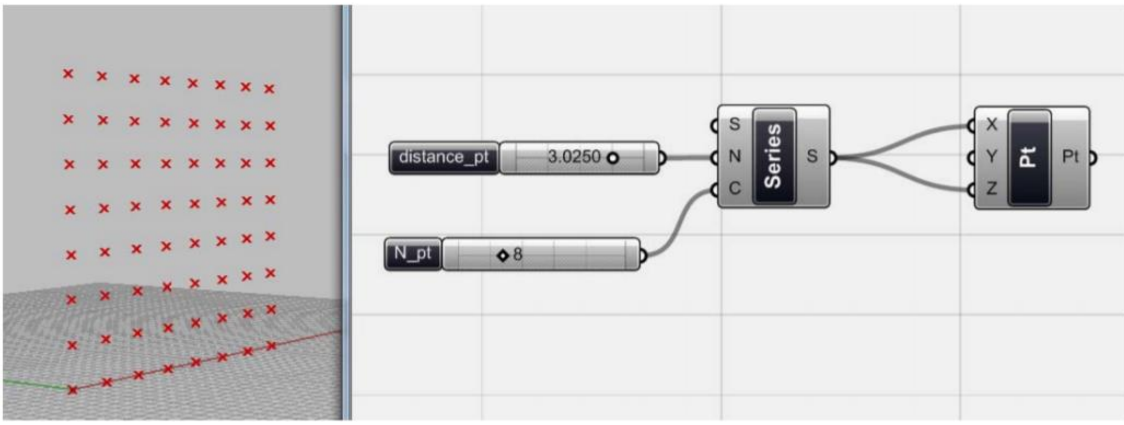
PICTURE 3. Below is a table of the most commonly used components and their functions. (Grasshopper primer)

Vectors are favourable and helpful geometries in the construction of wall structures. Through their use, a designer can adjust the direction of the barrier as well as its structural alignment.



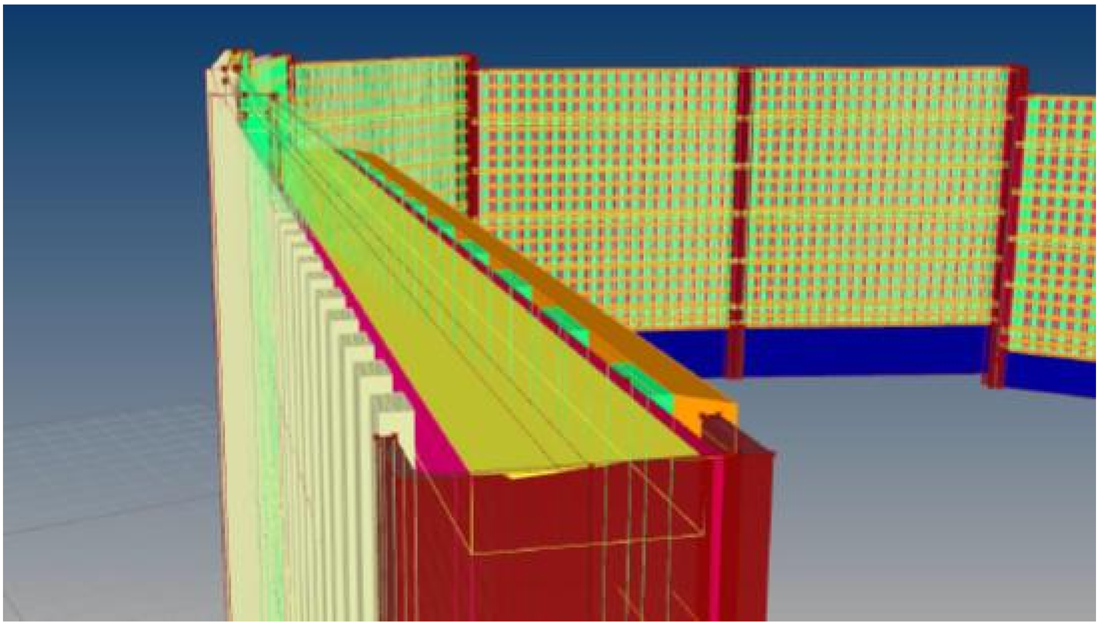
PICTURE 4. Example of noise barrier based on control line that determines its direction at each angle.

XYZ world points are one of the most enormous aspects in the manipulation of positioning, arranging, and ordering of geometries. Image below shows an example of algorithmic generation of grid using a “Series” component, allowing the designer to control the number of points and distance between them.



PICTURE 5. Algorithmic grid generation (Amazon S3)

Every surface/brep geometry in GH has a dependency on control points that identifies it’s start/end boundaries, spacing etc. The figure below shows how the claddings of barriers are created through control points that identifies the spacing between the elements.



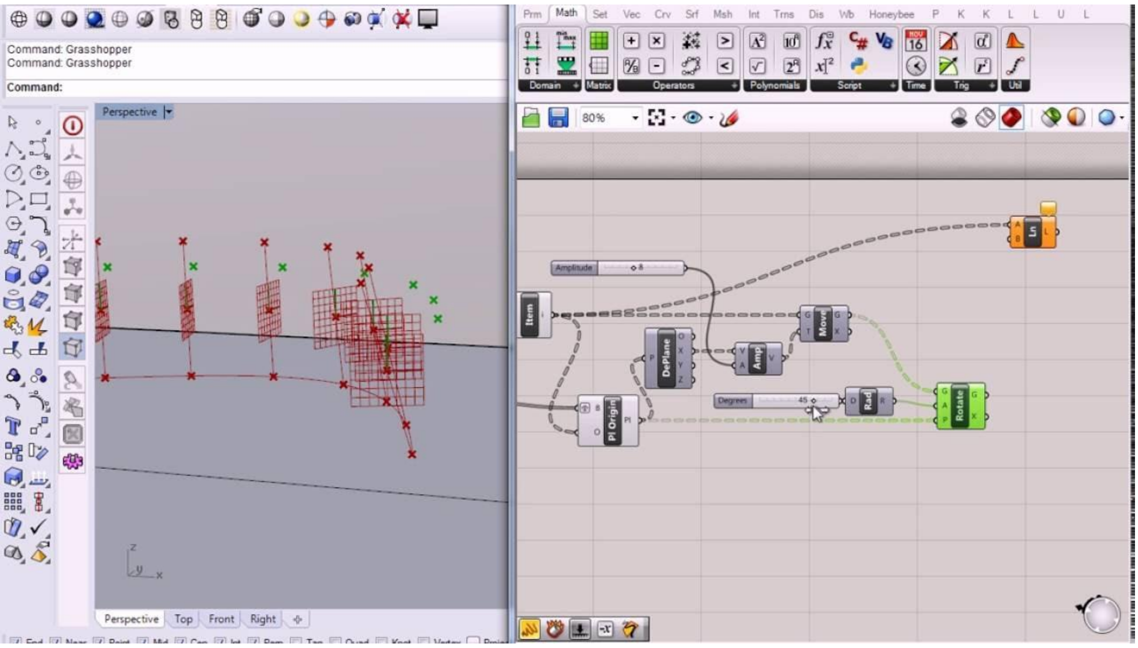
PICTURE 6. Spacing between cladding breps based on division points of the control lines of wall

3.2 Planes and surfaces

Planes are another advantageous set of geometries that can be described as boundless flat surfaces which have origin points. Construction planes in Rhino are these types of planes, that can be used to coordinate various geometries to them and execute some transformations based on their orientation and origin. Since in 3D space object cannot be orientated on a vector, it requires two vectors to construct a plane that the geometry can be tied to. (Amazon S3)

In the system, planes are used for determining the direction of the stud construction using the Z-axis of the plane. Each wall section in a barrier represents an infinite surface which provides the designer option to choose which side of the surface plane structures are aligned. For example, deciding whether the studs go to the highway or to neighbourhood side.

The picture below shows an example of how surface planes can be deconstructed into its constituent vectors which are then used for implementing the transformation of the geometry.



PICTURE 7. Surface plane rotation, deconstruction and point transformation. (Paramarch)

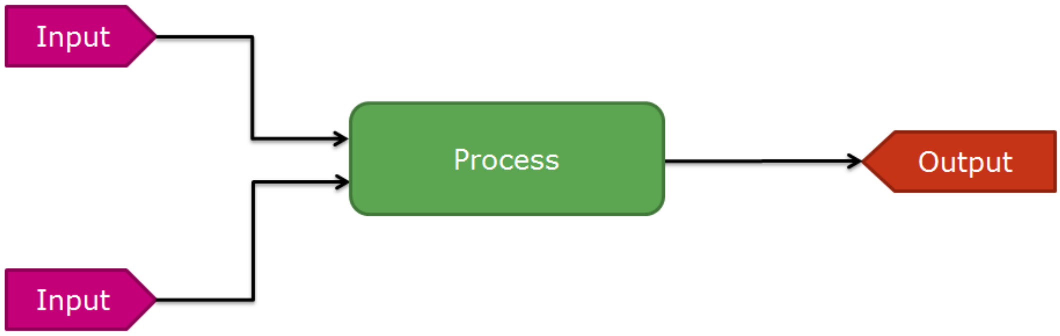
Rhino supports two common freeform surface types. First, NURBS surfaces which are used for generating and presenting surfaces and curves. They offer high resilience and precision for handling both analytic and modelled shapes. (Rhinoceros 3D)

Generally, all surface analysis elements can be implemented on the NURBS surfaces. For instance, retrieving the area, center origin and boundaries of a surface. The second freeform surface type is a “Brep”. Breps can be thought of as 3D solids that take into account the third dimension of the polysurface such as thickness, depth and volume. Breps are still NURBS surfaces, but they grouped together in order to form a 3D solid.

As we see the structures in picture 6, each one is a brep that is formed by lofting two surfaces into a brep. The loft component works by defining the surfaces between multiple curves and surface boundaries and composing a closed solid breps from them.

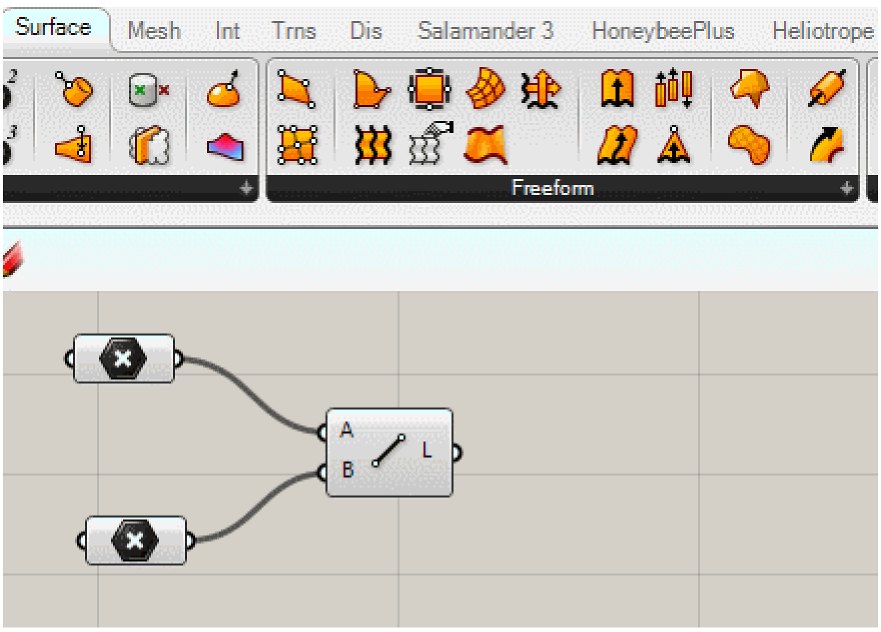
4 DATA INPUT PARAMETRIZATION

Grasshopper allows for parametric models to be described by essentially drawing a flow diagram of the process that is to be followed in order to create certain model. If the process can be presented as a diagram, Grasshopper can be used. (Ramboll blog)



PICTURE 8. Computational logic of Grasshopper components. (Ramboll blog)

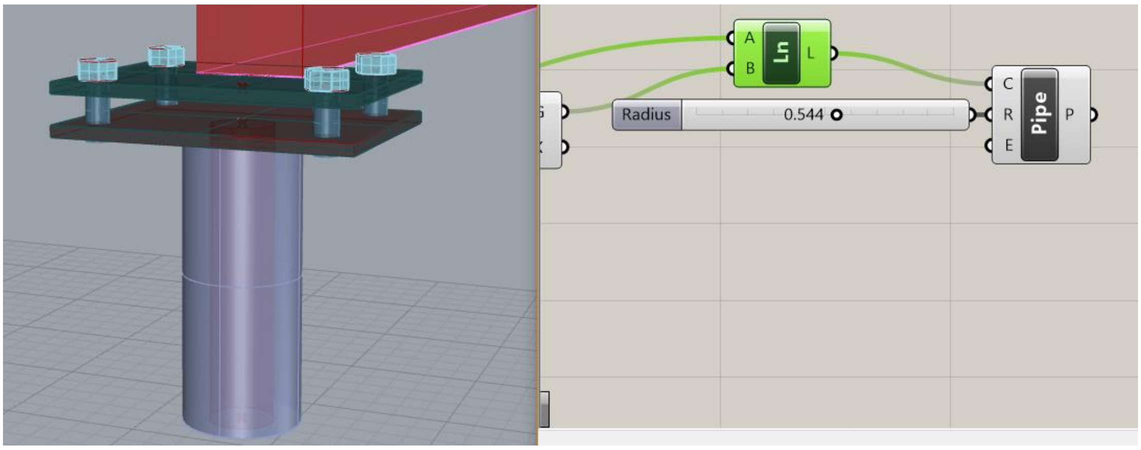
All components essentially work the same way; inputs on the left and outputs on the right. Connections between inputs and outputs can be created, which are represented as lines, and the way that data will flow between different operations can be chosen. (Ramboll blog)



PICTURE 9. Connection between components. (Ramboll blog)

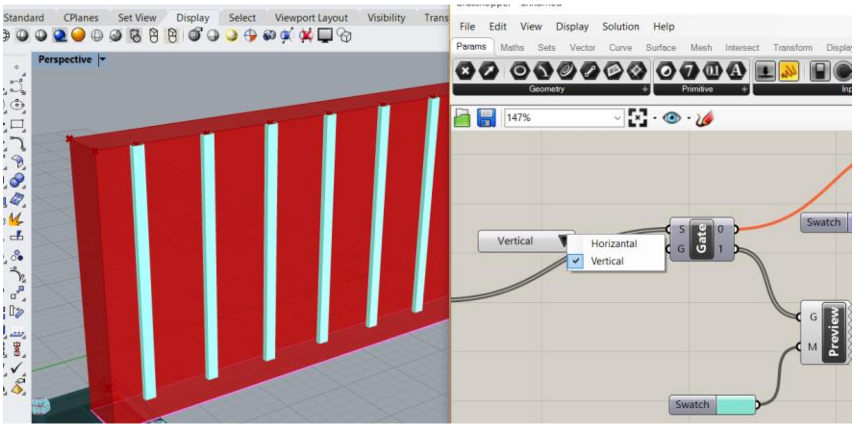
4.1 Dynamic interface objects

Input parameters are dynamic interface objects that allow the designer to interact with the definitions. A number slider is a little input widget that we can use to control a numeric input by just dragging the slider left or right. Sliders properties can be accessed and edited. For example, changing its minimum and maximum values by clicking on them and setting the domain it covers. In a noise barrier, pipes are used to create the piles in the foundations.



PICTURE 10. Computing the radius of pile

Another dynamic interface object is value list. Value list stores a collection of values with corresponding list of labels associated by way of an equal sign. It is particularly useful when one wants to have a few options with specific labels, that can supply specific output values. In noise barrier, value list is used to define where claddings are vertically or horizontally installed. (Fabrication lab)



PICTURE 11. Cladding modelling options using value list component

4.2 Data types

Grasshopper parameters can store two different kinds of data: Volatile and Persistent. Volatile data is inherited from one or more sources and is destroyed whenever a new solution starts. Persistent data is data which has been specifically initiated by the user. (Fabrication lab)

4.2.1 Persistent data

Persistent data is accessed through the menu and depending on the kind of parameter has a different manager. A Point parameter for example allows the setting of one or more points through its menu. But first a brief explanation about the behaviour of the point parameter. When the point is dragged and dropped onto the canvas from the Params/Geometry Panel, the Parameter is orange, indicating it generated a warning. It's nothing serious, the warning is simply there to inform us that the parameter is empty (it contains no persistent records and it failed to collect volatile data) and thus has no effect on the outcome of the solution. The context menu of the Parameter offers two ways of setting persistent data: single and multiple. Right click on the parameter to set Multiple Points. Once either of these menu items is clicked, the Grasshopper window will disappear, and a point can be picked in one of the Rhino viewports. (Fabrication lab)

Once all the points have been defined, the selection can be accepted, and they will become part of the Parameters persistent data record. This means the Parameter is now no longer empty and it turns from orange to grey. (Fabrication lab)

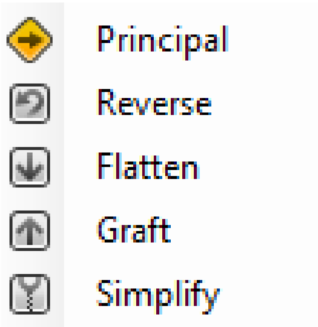
4.2.2 Volatile data

Volatile data, as the name suggests, is not permanent and will be destroyed each time the solution expires. However, this will often trigger an event to rebuild the solution and update the scene. As previously stated, Grasshopper data is stored in Parameters (either in Volatile or Persistent form) and is used in various components. When data is not stored in the permanent record set of a Parameter, it must be inherited from elsewhere. Every input parameter defines where it gets its data from and most parameters are not very particular. A number parameters (which just means that it is a decimal number) can be plugged into an integer source and it will take care of the conversion. We can change the way data is inherited and stored in the context menu of a parameter or component input. Data can be internalized from the parameter menu. This will make the Grasshopper definition independent from a Rhino file. A designer can also internalise data in a component input. Internalising the data will sever all the data streams represented by wires from the input. The data has been changed from volatile to persistent and will no longer update. If the designer wants the data to become volatile again, the wires simply need to be reconnected to the input and the values will automatically be replaced. (Fabrication lab)

5 MANAGEMENT AND CLASSIFICATION OF DATA

5.1 I/O Modifiers

I/O Modifiers are visual tags that are used in GH components to manipulate the structure of the data. They can be applied from the right click Context Menu of either a component's input or output parameters. I/O Modifiers are a great help to keep data structure of noise barrier in control.

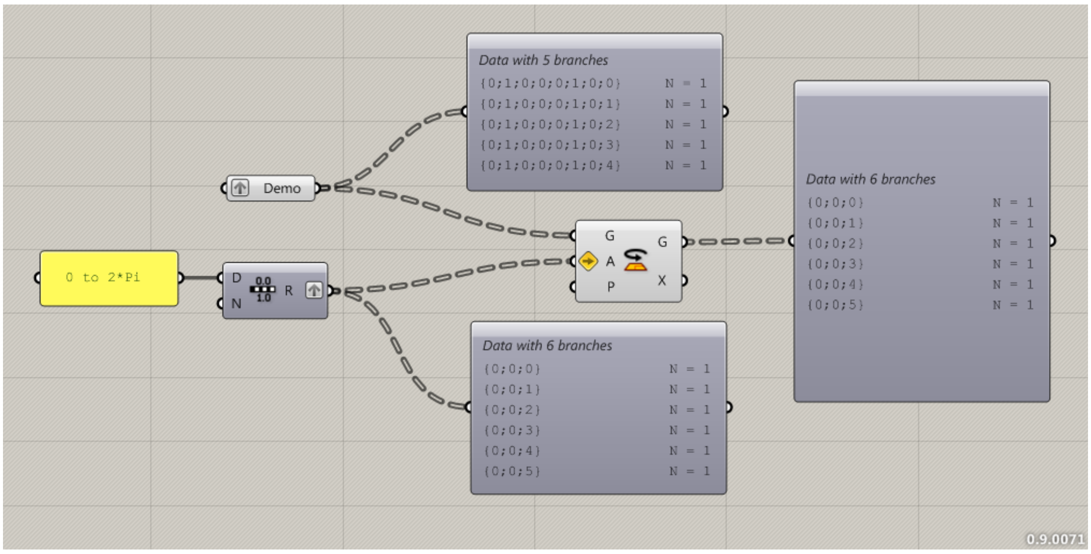


PICTURE 12. Main I/O Modifiers icons (Grasshopper discussions)

In GH, data structure can be one value, a list or a tree of objects. Objects can be referred by ID, path or branch. Let's have a look into how I/O tags can modify the data structures.

a. Principal

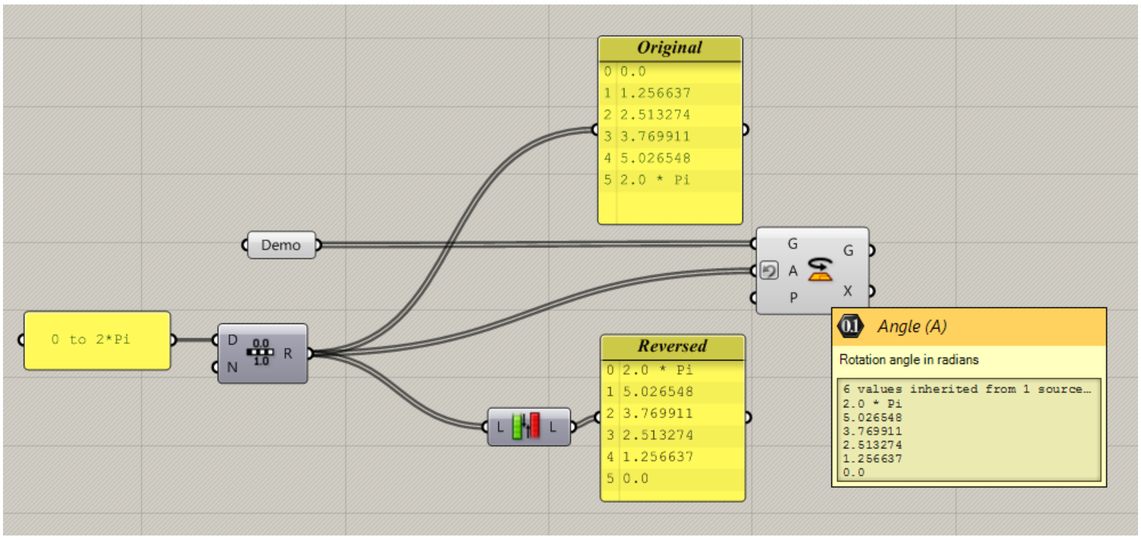
An input with the Principal Icon assigns the principal input of a component for the aims of path assignment.



PICTURE 13. Principal input for path assignment to the data. (Grasshopper discussions)

b. Reverse

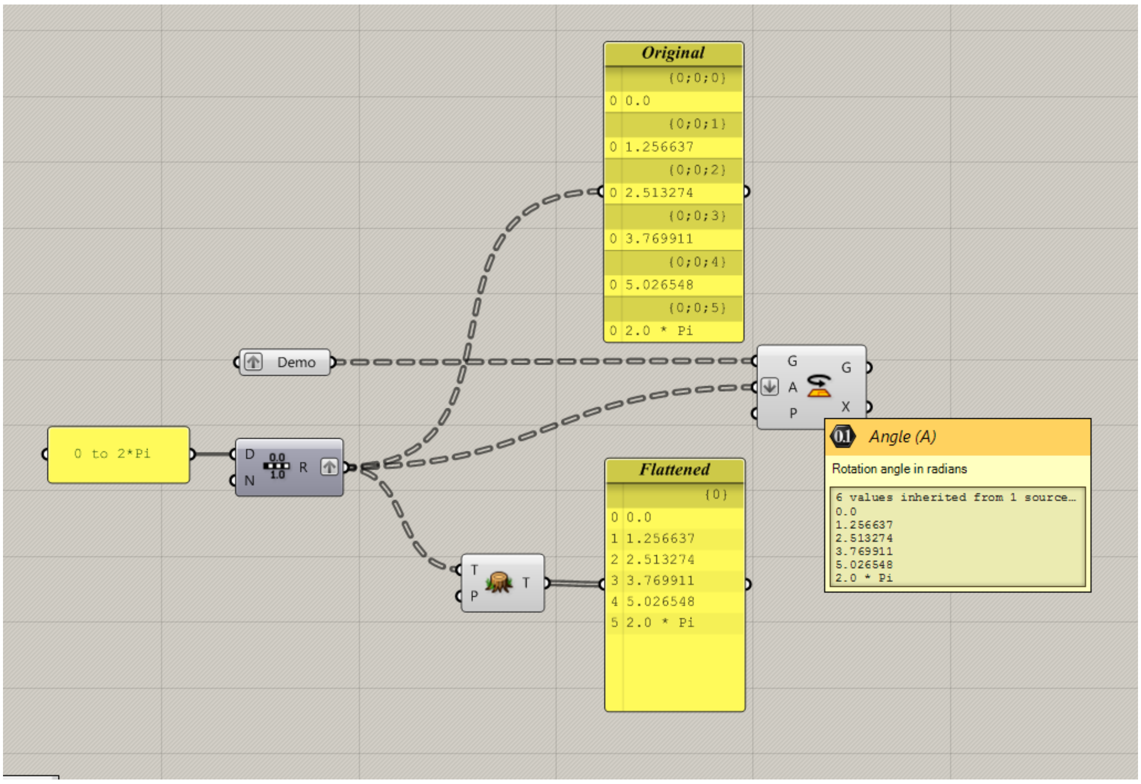
The Reverse I/O Modifier will reverse the order of a data list or lists in a multiple path structure, which it is called as data tree.



PICTURE 14. Reversing data structure (Grasshopper discussions)

c. Flatten

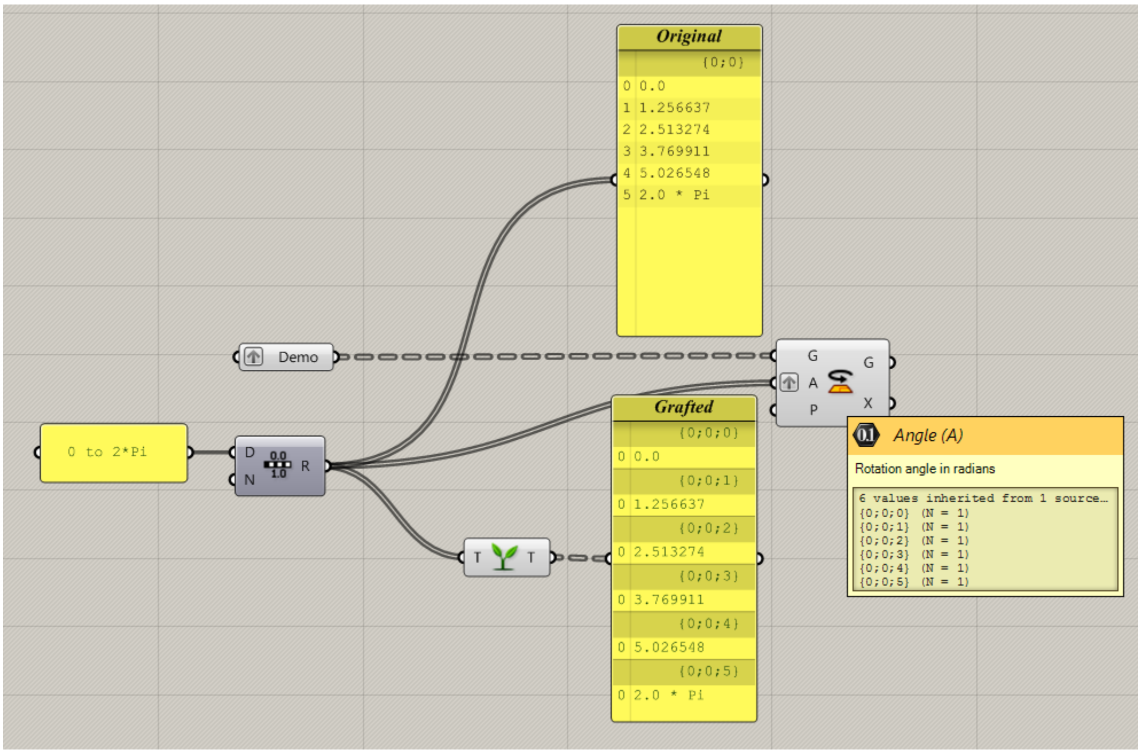
The Flatten I/O Modifier will cut a multi-path tree down to a single list on the {0} path.



PICTURE 15. Reducing complex data structure into one list (Grasshopper discussions)

d. Graft

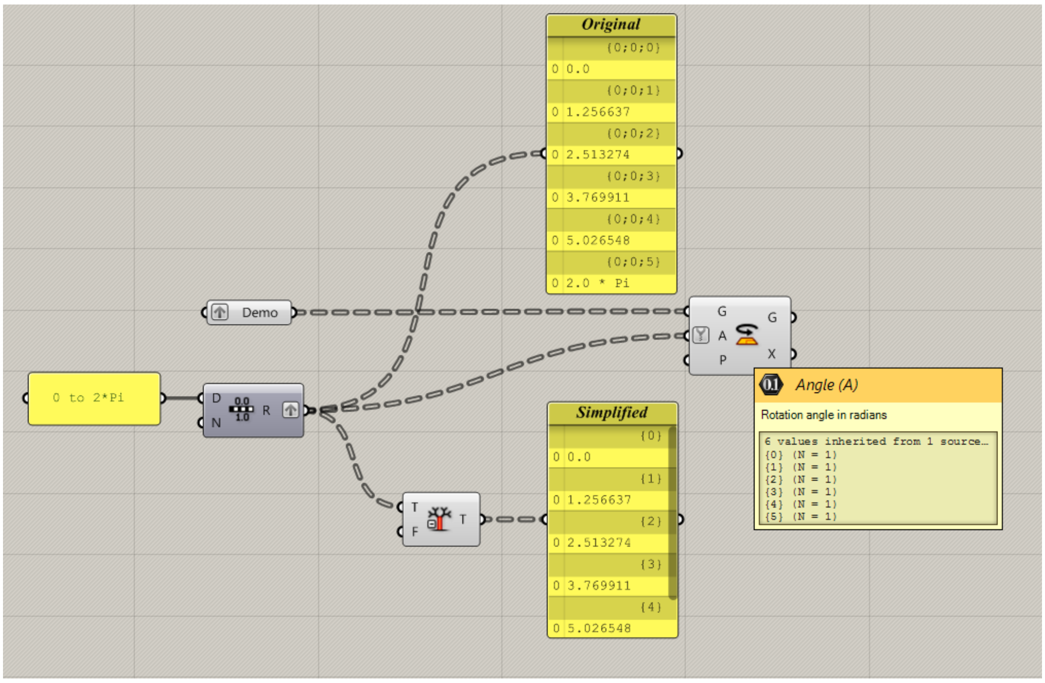
The Graft I/O Modifier creates a new branch for each individual item in a list (or data trees)



PICTURE 16. Branch reconstruction of data items (Grasshopper discussions)

e. Simplify

The Simplify I/O Modifier removes the overlap shared amongst all branches.

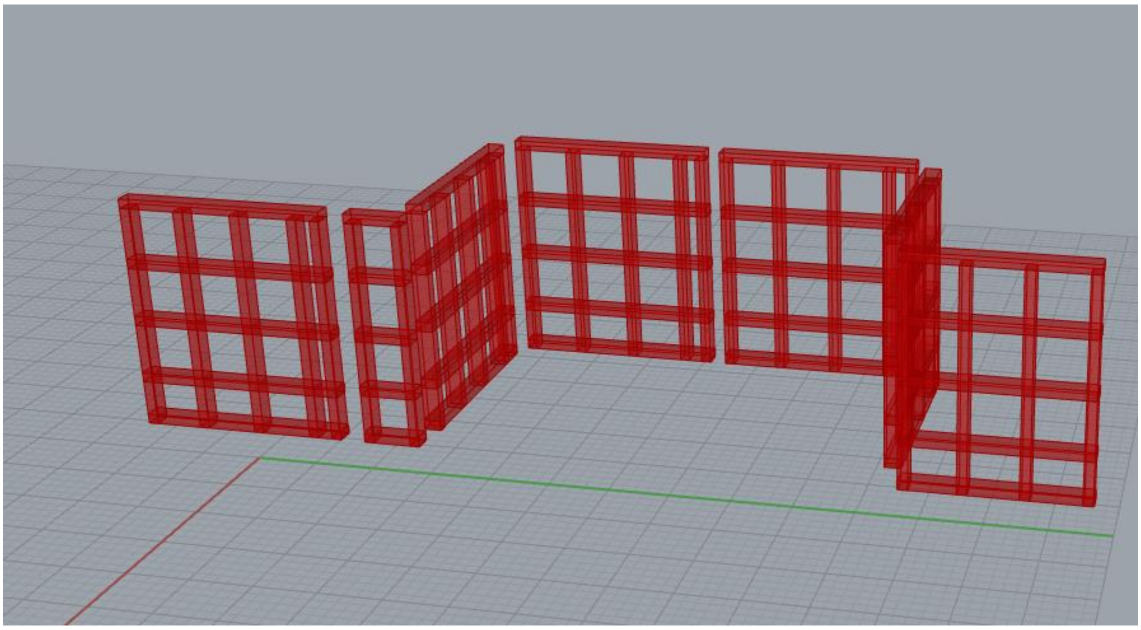


PICTURE 17. Simplifying the branching structures. (Grasshopper discussions)

5.2 Classification of data geometry

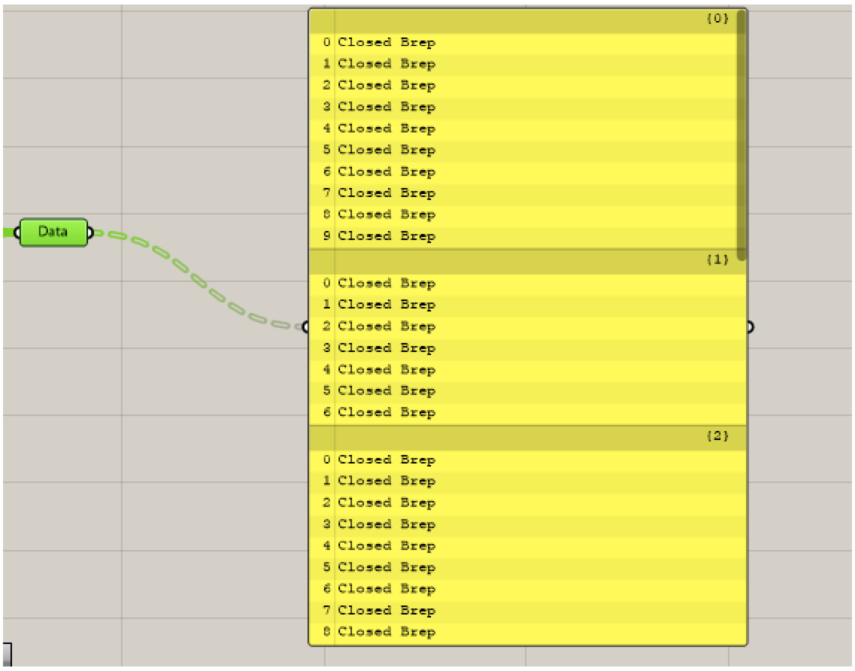
As noise barrier is a collection of walls, it can usually consist of set of distinct geometries. For instance, if there is a control line of 12 meters and 5 meters long wall elements are desired, the end result will be 3 walls with 2 distinct geometries. Two walls with 5m length and one wall with 2m lengths. Another aim of the thesis is to create an engine that classifies distinct wall geometries into sets that include certain information (name of the set, wood geometry dimensions, number of pieces).

Let's step deeper into this topic with an example. The picture below shows a case of angular noise barrier that results with distinct frame walls. The desired wall length is 5m.



PICTURE 18. Wooden frame walls.

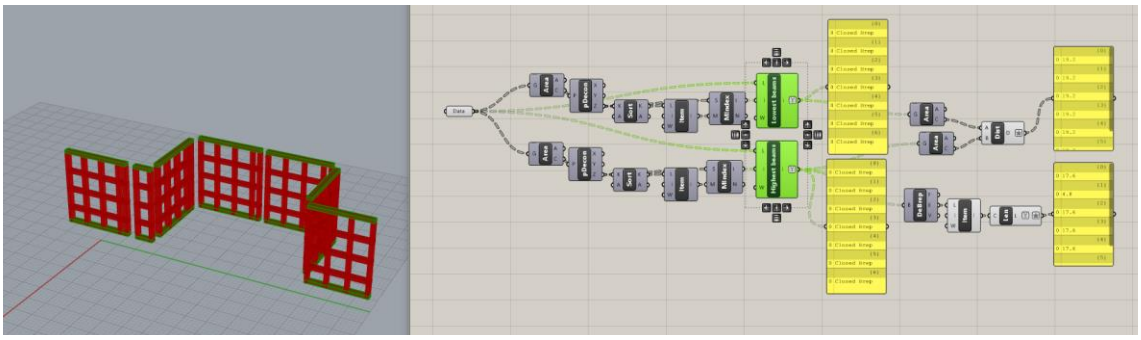
In this case, the data structure is a tree. In more detail, every wall has its own path where each path contains a set of branches which are the wooden beams. Figure below shows what the structure looks like.



PICTURE 19. Data tree of walls beams.

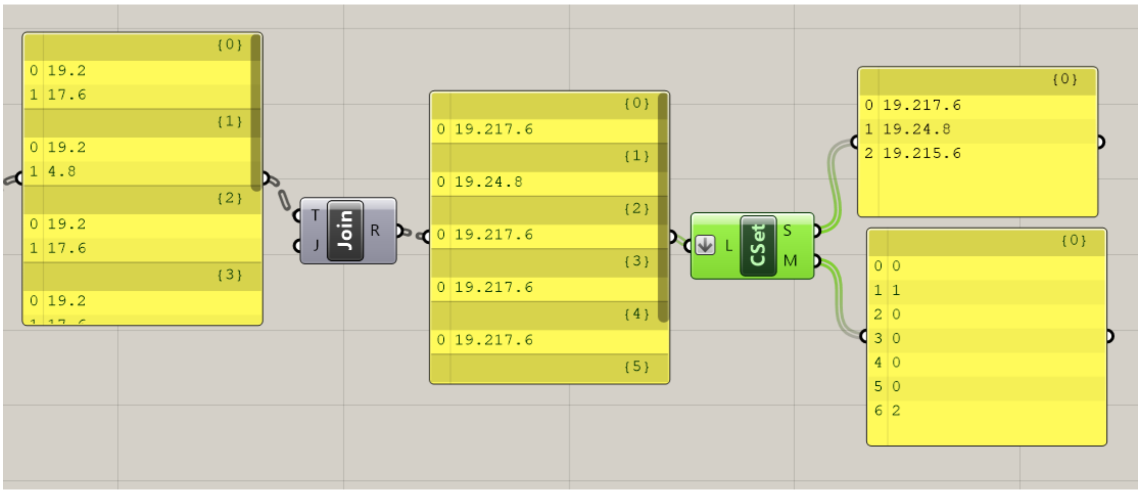
The benefit of Grasshopper is that data structures are always maintained, every data item has its own ID and data lists are always in same order. This facilitates the easy use for the designers.

First, the width and the height of every wall geometry needs to be known in order to classify them. The highest and lowest horizontal beam of every wall will be taken and the width of the first beam and the distance between both beams, is calculated along the length of the wall



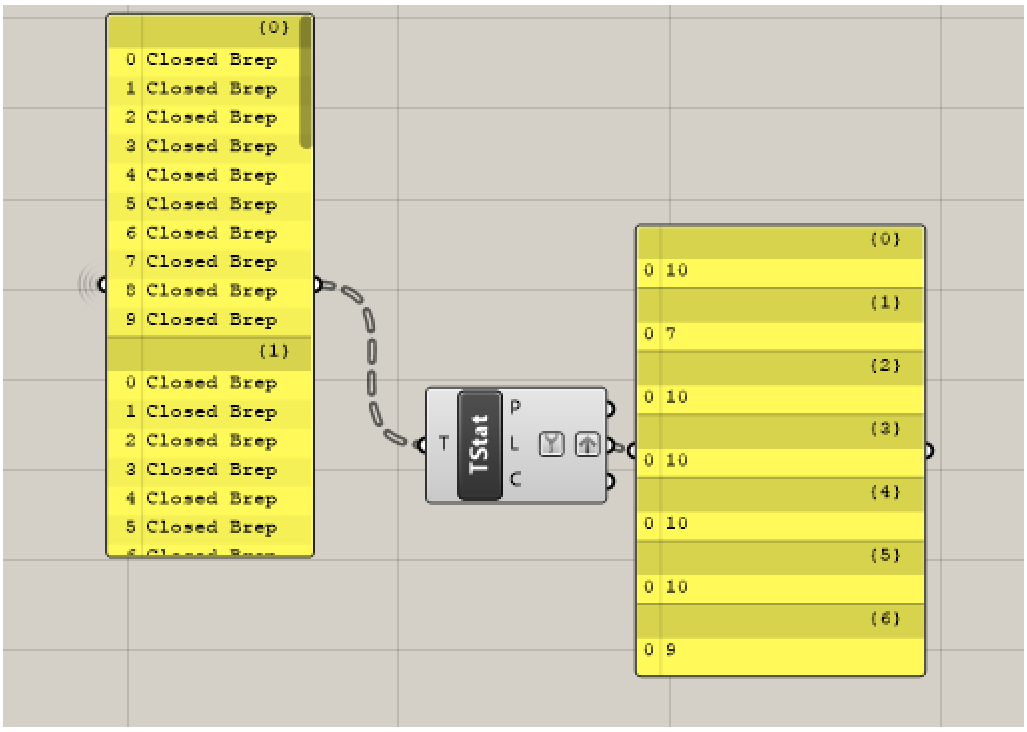
PICTURE 20. Calculating wall dimensions.

After that, the width and length lists are merged into one list resulting in both width and length branches in every path. Then the values are compared using “Create Set” component, to get the distinct dimensions. The benefit of “Create Set” component is that it assigns unique IDs for distinct wall geometries.



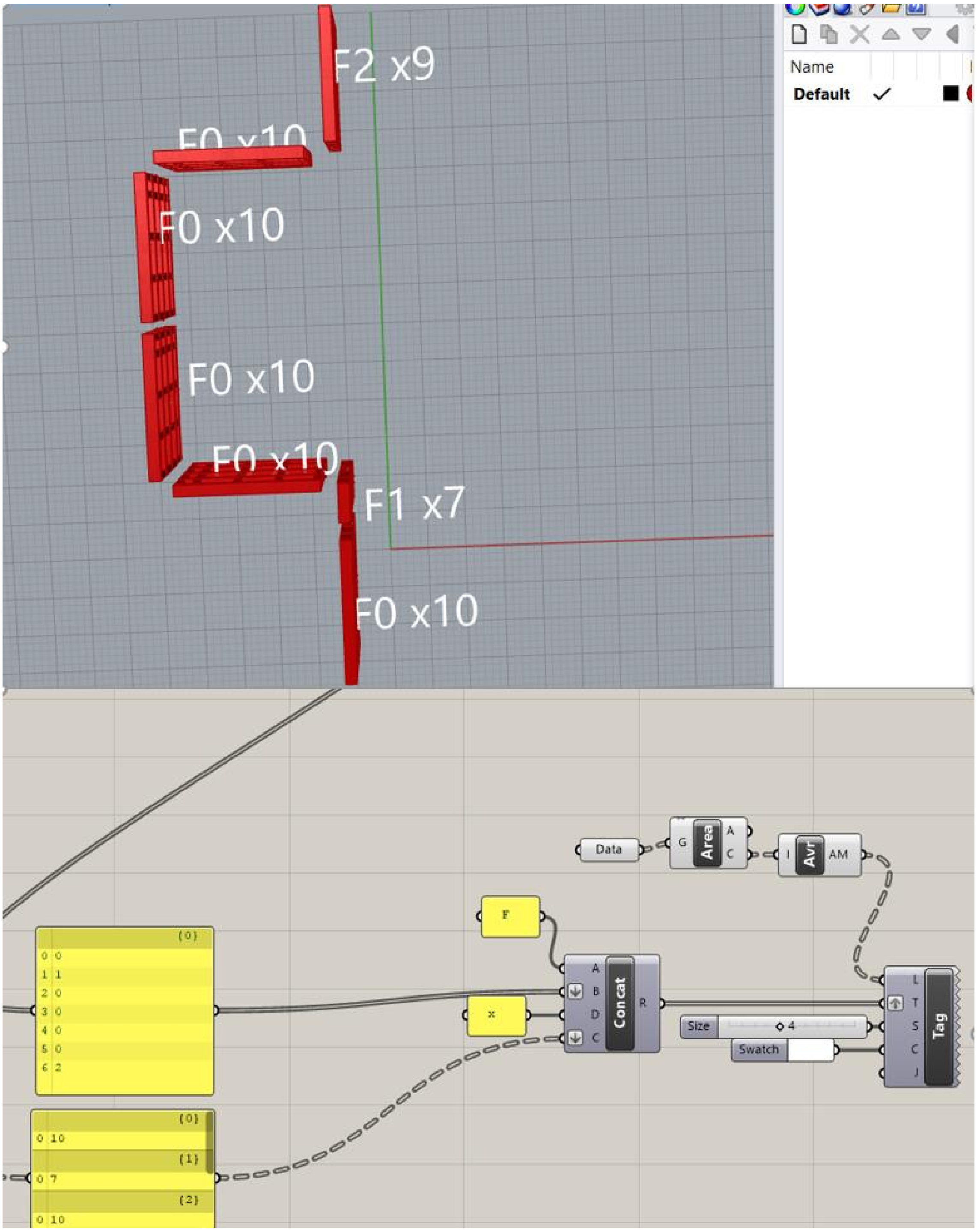
PICTURE 21. Creating sets of distinct wall geometries.

Second, number of beams are calculated in each wall by checking how many branches exit in each path. Grasshopper contains a component called “Tree Statistics” that counts the branches in each path. Through it we can reach the result of total sum of beams in each distinct wall.



PICTURE 22. “Tree Statistics” component.

At last, we align an information text on each wall. Using “Concatenate” C, we can merge text information by paths. Then, we take the centre of gravity for each wall in order to locate the target point for the texts.

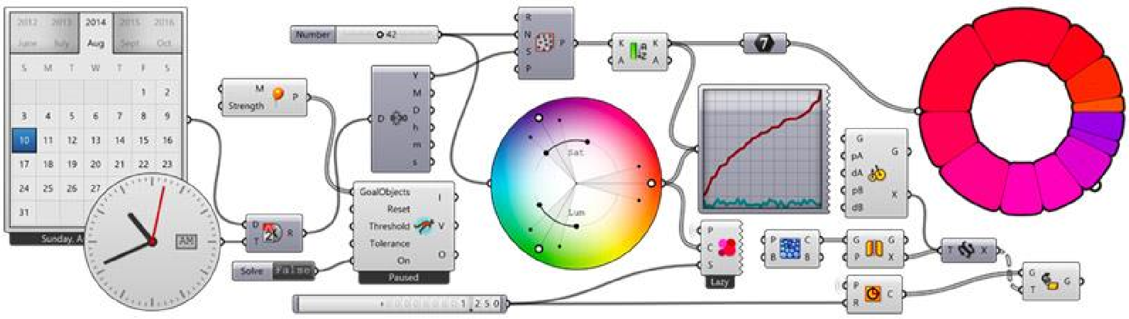


PICTURE 23. Aligning classification texts to walls.

Using this method, a designer is able to create classification of any data tree geometries, such as claddings, studs, etc. Nowadays barriers are built as elements in factories, and this classification engine serves the constructors there well.

6 AUTOMATION OF 2D DRAWINGS

The new version of RH enables the most ambitious design projects. GH has become a robust development platform, providing foundation for components ranging from environmental analysis to robotic control.



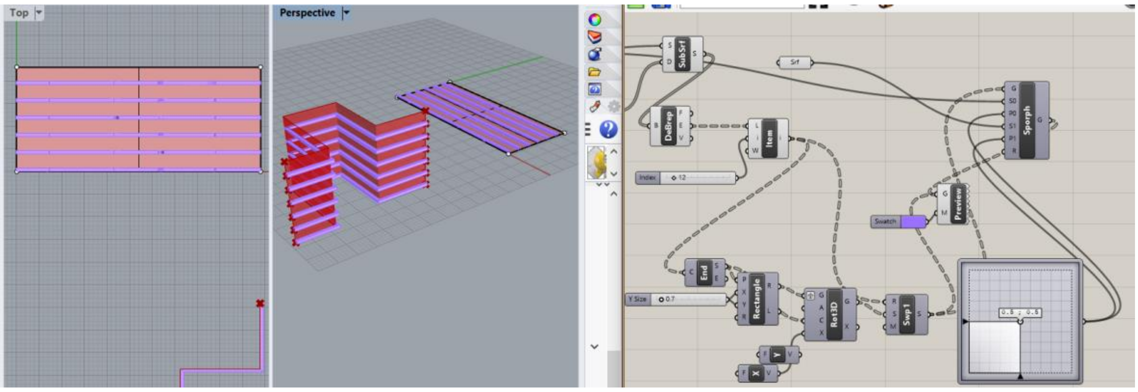
PICTURE 24. Part of Grasshopper's new components. (GOMEASURE3D)

Modelling is just one part of the design process. In building construction, we need also to show how to build the design. With Rhino version 6, it is now easier to accurately and clearly convey 3D structures into 2D drawings.

With a barrier, aiming for automatic creation of various documents of the design models and subsequently, a designer can produce clear and accurate drawings of complex structures such as elliptical and tangential walls.

6.1 Spherical morph

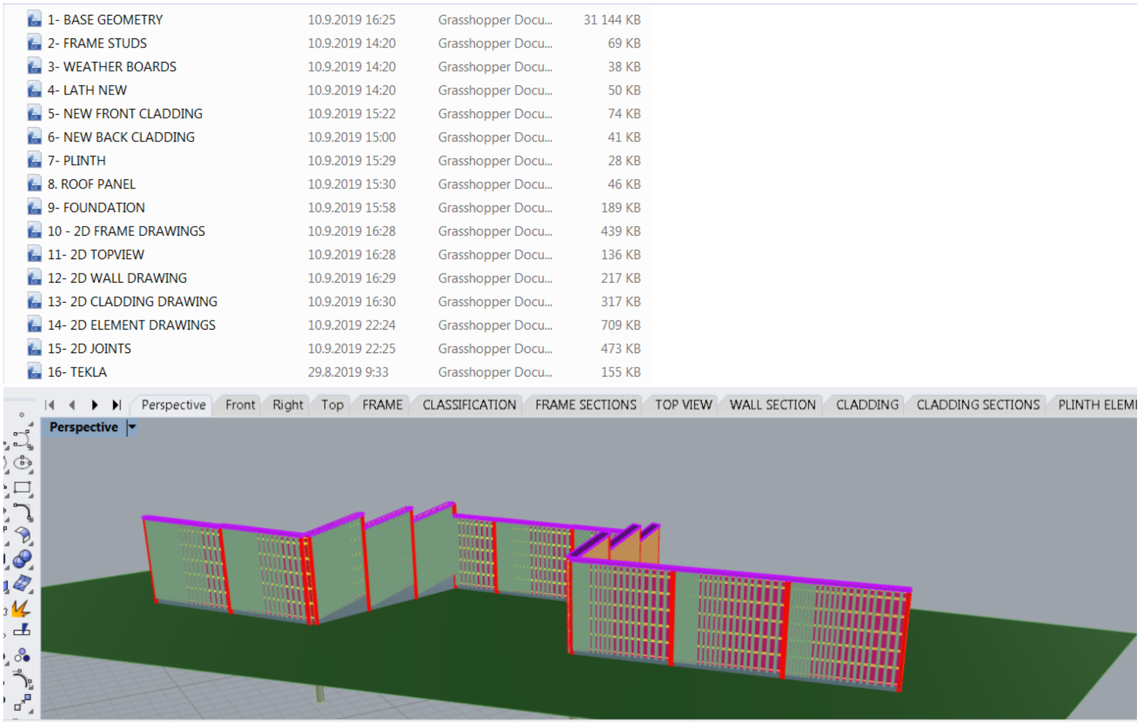
Morphing is an algorithmic technique for the transformation of 3D geometries. It entails the projection of an object from a source surface to a target surface. The figure below shows a simple example of the projection of wooden beams that follow a tangential line into flatten surface that is oriented to XY plane.



PICTURE 25. Morphing Beam geometries to XY plane

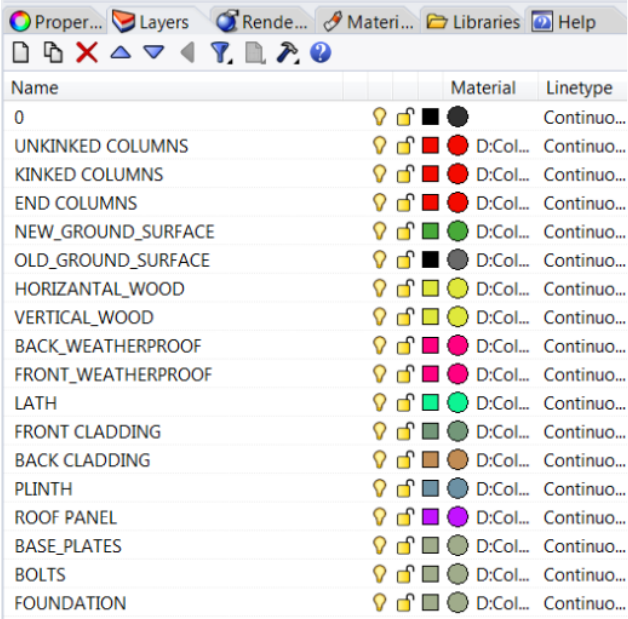
Thus, setting the view to the top, provides us with a straightened wood geometry. The Morph component is a great way to achieve the visibility of all objects in a complex structure from a perpendicular view.

Let's step deeper into this topic and see how morphing accomplishes the construction of 2D drawing of the noise barrier. First, let's run the definitions that we have built for each noise barrier part in order to have a fully automated 3D noise barrier structure.



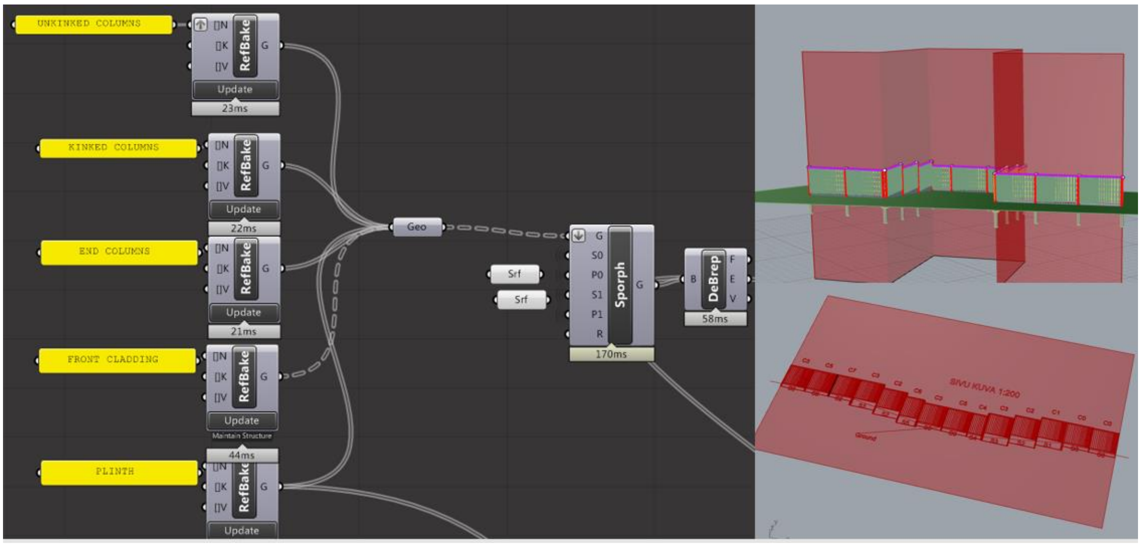
PICTURE 26. Noise barrier 3D structures

One of the good features in our developed noise barrier system is the formation of layers for each part in the noise barrier, so that we can refer to different parts separately. Hence, allowing us to morph any combinations of parts we want to have in the 2D drawing.



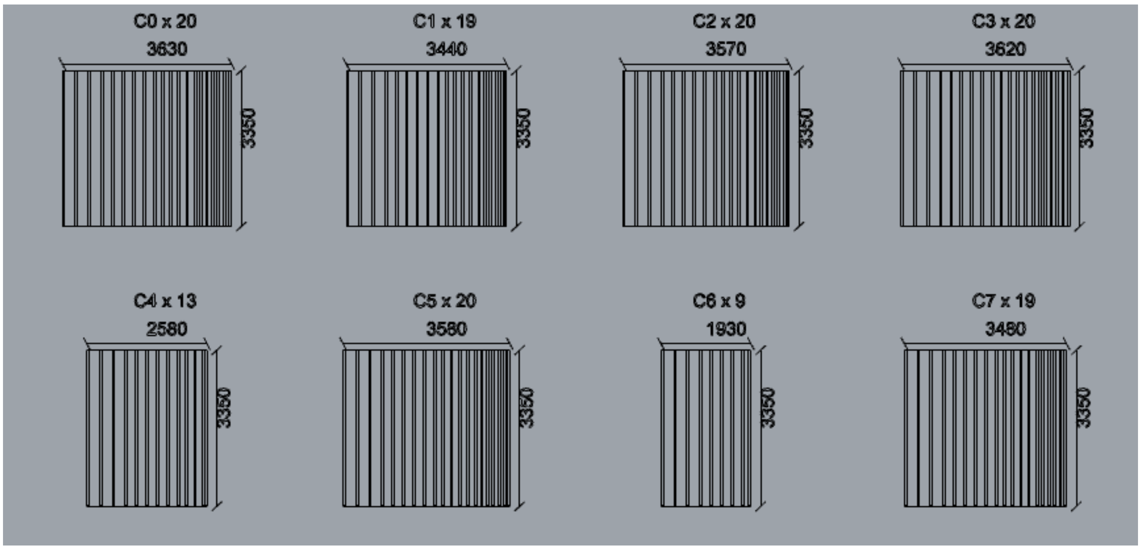
PICTURE 27. Noise barrier part layers.

let's create for example side view of the noise barrier. On this occasion, the designer needs to use the pillar, cladding and roof panel geometries. GH contains components that allow the user to refer to geometries by giving layer names as parameter to the component. Then, the designer creates base surface by moving a copy of control line by Z vector and lofting between the both control lines. Next, evaluating the base surface is needed to construct a target surface on XY plane with the same domain. At last, performing debrep function retrieves the edges of the geometries.



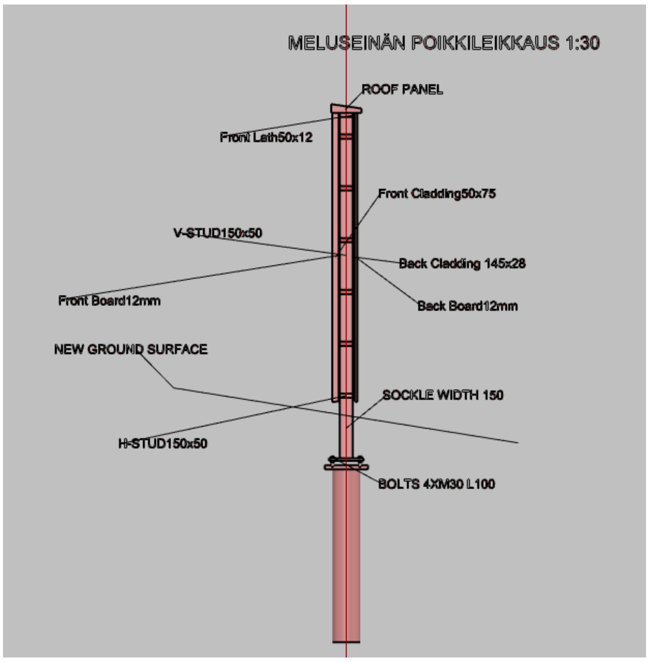
PICTURE 28. Creating side view

In the previous chapter, implementation of data classification is explained. Therefore, combining the data classification with the geometry morphing achieves the alignment of structures along with their information on XY plane. Image below show a2D drawing of the cross-section's claddings.



PICTURE 29. The cross-sections of the claddings

Another example of morphing is generating a wall cross-section, Choosing the first branch from each part's data tree, provides the combination the first wall section parts. Subsequently, morphing it to a target surface aligned on YZ plane results in having 2D wall cross-section view.



PICTURE 30. Noise barrier's cross-section view.

6.2 Model arrangement

6.2.1 Introduction to layouts

The last step in the thesis is to arrange, annotate, and plot a noise barrier model. A layout in Rhino is the full-size representation of the sheet or paper that will be sent to the printer or virtual printer, like a PDF creator. we can add a Layout or multiple Layouts to any Rhino model.

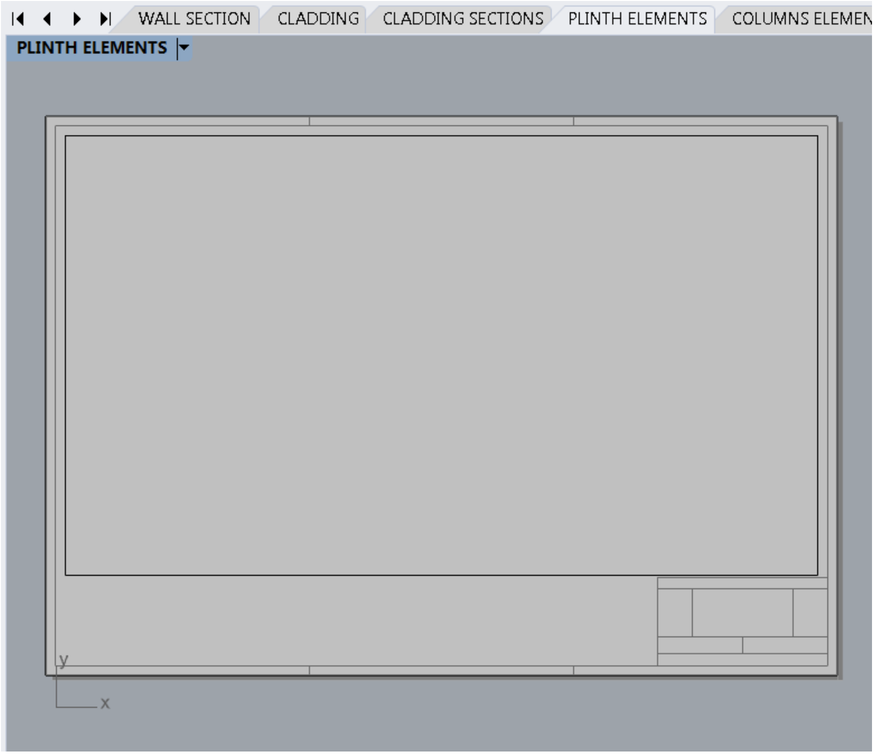
On the layout we will add details and annotation objects like title blocks and texts. The layout is typically plotted full size, or 1:1, since the scale has already been set to each detail. The layout is arranged with views of the model called details. Details are like "windows" into the model or views of the model that show different parts of the model. Here are some features of Details:

- The Details can be set to a scale.
- Details allow for layer and colour visibility per viewport.
- Layers in the detail can be turned off so that the objects on these layers are not visible in that detail, only.
- Specific objects in the detail can also be hidden, while other objects on the same layer remain visible.
- Layers can be assigned print and display colours that may be different in each detail (Amazon S3)

6.2.2 Drawing set up

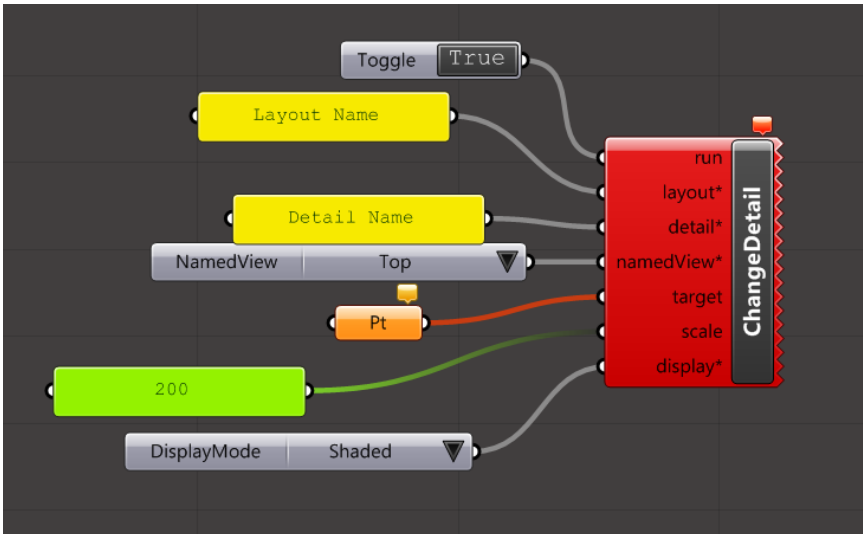
6.2.3 Detail window management

In Rhino, we are creating a layout template for each noise barrier structure. Each containing a title block and detail window(s).



PICTURE 31. Layout template with one detail window

Grasshopper offers a component that allow the user to automatically change the detail view settings. The figure below shows how to refer to any template using layout's and detail's names. The target parameter represents the point where the camera of the detail is set to. So, in every drawing, the average centre of gravity of the structures is used to specify target point of the detail. Thus, having a camera set to right place.

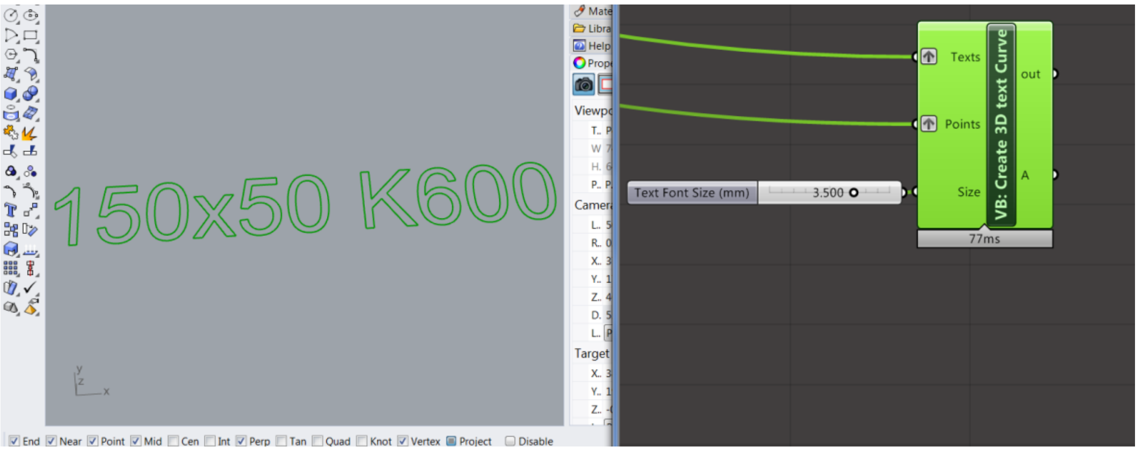


PICTURE 31. Detail window setting component.

Scaling has its own parameter also in the detail component. According to the size of the structure we can assign the right scale to the drawing. In Finland, constant official scales that consultancy companies use for noise barriers. They are referred as 1:5, 1:10,1:20, 1:50, 1:100,1:200, 1:250, 1:400 and 1:500.

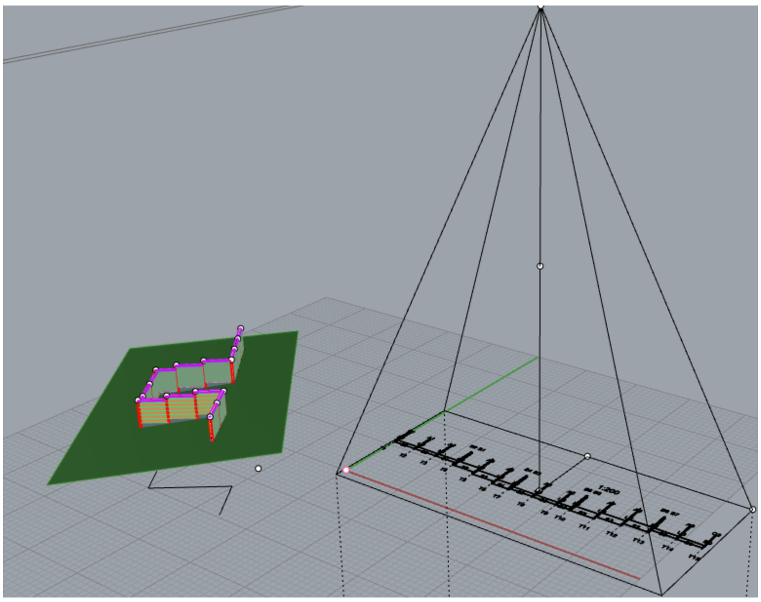
6.2.4 Dimension text scaling

Grasshopper can output and bake the texts into Rhino as curve geometries. Using Number slider component, we can choose the size of the text.



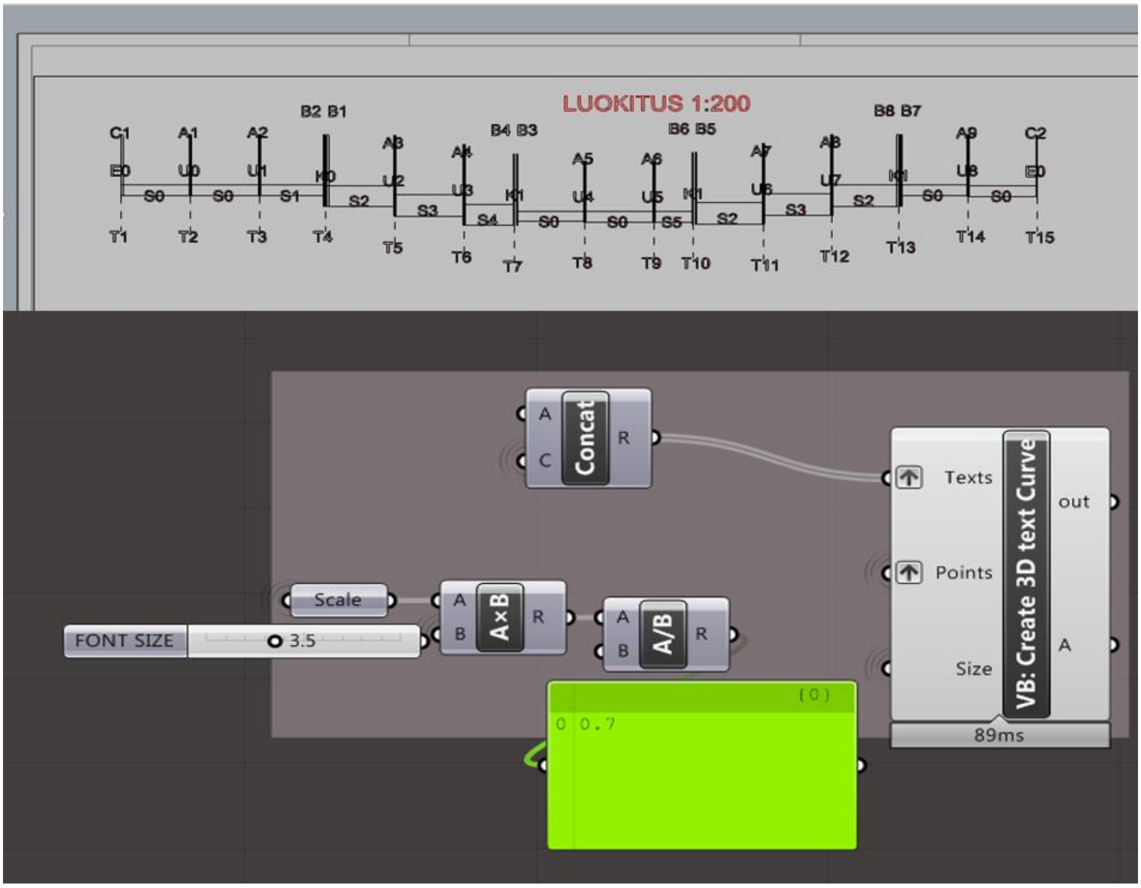
PICTURE 32. Text size adjusting

In the detail window, scaling the camera doesn't keep the texts in the right size because the camera works by zooming in/out from the geometries. So, the system solves the problem by checking the scale of the detail window and then calculating the right size for the text in order to achieve desired view.



PICTURE 33. Camera frames towards drawing's structures.

The picture below demonstrates an example of 3.5 mm desired font size of text in the detail window. The system multiplies the font size with the scale which is 1:200, then divides it by 1000 so that the detail displays the right size. In this case, the correct size is 700mm (0.7m).



PICTURE 34. Text size scaling.

7 RHINO COMPATIBILITY WITH PROGRAMS

BIM is an intelligent 3D model-based process that gives AEC professionals the tools to plan, design, construct, and manage buildings and infrastructure more expertly. Most common BIM tools in use are: Autodesk Revit, ArchiCAD, Tekla, Solid Works, Sketchup.

BIM is mostly associated with design and preconstruction, but it absolutely benefits every phase of the project life-cycle, even well after the building is complete. BIM allows projects to be built virtually before they are constructed physically, eliminating many of the inefficiencies and problems that arise during the construction process. (connect.bim360.autodesk.com)

More Benefits that BIM holds are:

- Better collaboration and communication
- Model-Based cost estimation
- Improves coordination and clash detection
- Reduce cost and Risk
- Improve scheduling
- Safer construction sites (connect.bim360.autodesk.com)

Connecting a powerful design tool such as Rhino to BIM, enables a very efficient and smart workflow for the industry. For example, the connection between Grasshopper and AC allows us to convert all geometries to AC in true native BIM elements. The result of this creation of a full BIM model as if it was created in AC. Also, we can import Rhino models straight to AC or hotlink them as modules so that AC can be updated as the Rhino file changes. The same applies also in the connection in between Grasshopper and Tekla. Noise barrier system is connected to Tekla allowing Grasshopper components to create and interact with objects live in Tekla.

8 CONCLUSION

In conclusion, Rhino-Grasshopper achieves efficient design and construction of a noise barrier model. It produces a parametric model that encapsulates frequent tasks and allows for extremely fast iterations. It therefore, provides a high rate of flexibility in creating complex noise barrier structures. In addition, generating automated 2D drawings for structures are achieved at high performance. In more detail, the system accomplishes clear and accurate 2D drawings for complex noise barrier structures such as tangential and curved noise barriers, by flattening the whole structures and classifying them. In fact, today's construction tools cannot perform this kind of action due to its algorithmic complexity.

The company Ramboll will continue developing this project by adding new features that achieve more efficiency and high integrity of the product. Hence, leading to ROI improvement qualitatively. Some of the features to be added are automation of structure's cost calculation. Grasshopper would be able to calculate costs for each part of the barrier based on the type of the structure and the quantities of the materials. Automation of load measurement could be also implemented Grasshopper would be able to measure the body weights for the parts and checks the loads transferred to each pillar and foundation.

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