Timber Tectonics in the Digital Age

MORVARID DILMAGHANI'S PORTFOLIO

PROFESSORS MARIAPAOLA RIGGIO AND NANCY YEN-WEN CHENG SPRING 2018

UNIVERSITY OF OREGON

OSU Oregon State UNIVERSITY

Columns and Beams

LEARNING OBJECTIVE

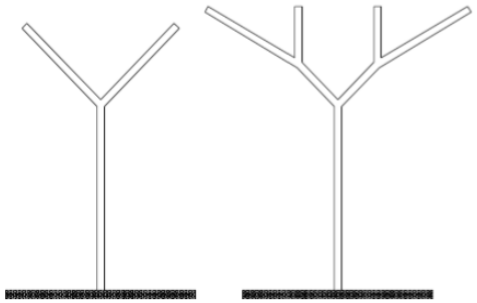
I learned from the course that the selection of the type of end connection used directly influenced the buckling capacity of a column. Timber columns are generally assumed to be pin connected (the middle-top picture).

I also learned from the handout that for a given value of the allowable stress at the top and bottom fibers, the deeper beam is capable of equilibrating a larger load, an increase in depth is more profitable than an increase in width.

A tree-like column is interesting for me which particularly well suited for only the one main load scheme for which it is optimized (the middle-bottom picture).

PSL offers good connection strength and ductility which can be used for heavily loaded columns.

Glulam pinned base connection
https://www.pinterest.com/



Tree-like columns

The walkway deck design taught me the different design of timber columns. The structure is supported by a series of timber columns, set in pairs and canted across each other like a pair of scissors. The paired scissor columns allowed more freedom for the foundations because they required smaller foundations and excavations than a single column would have needed.

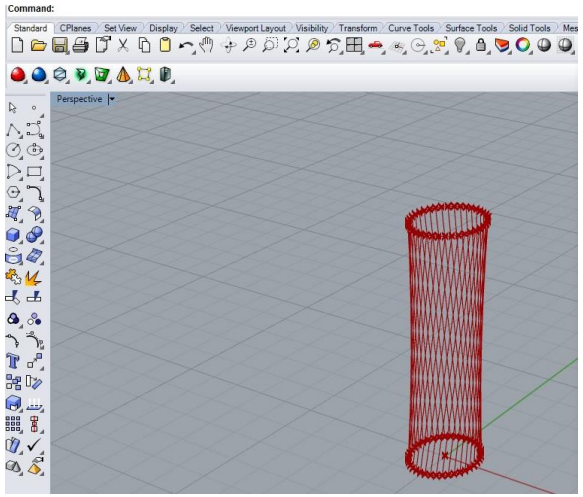
The top and base of each column is notched, pinned and bolted to a steel capping plate, ensuring that it takes only axial load (the right picture).

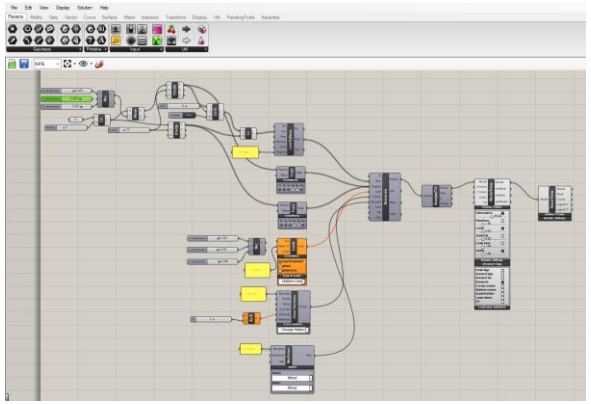
A view of Stihl Treetop Walkway
https://www.trada.co.uk/

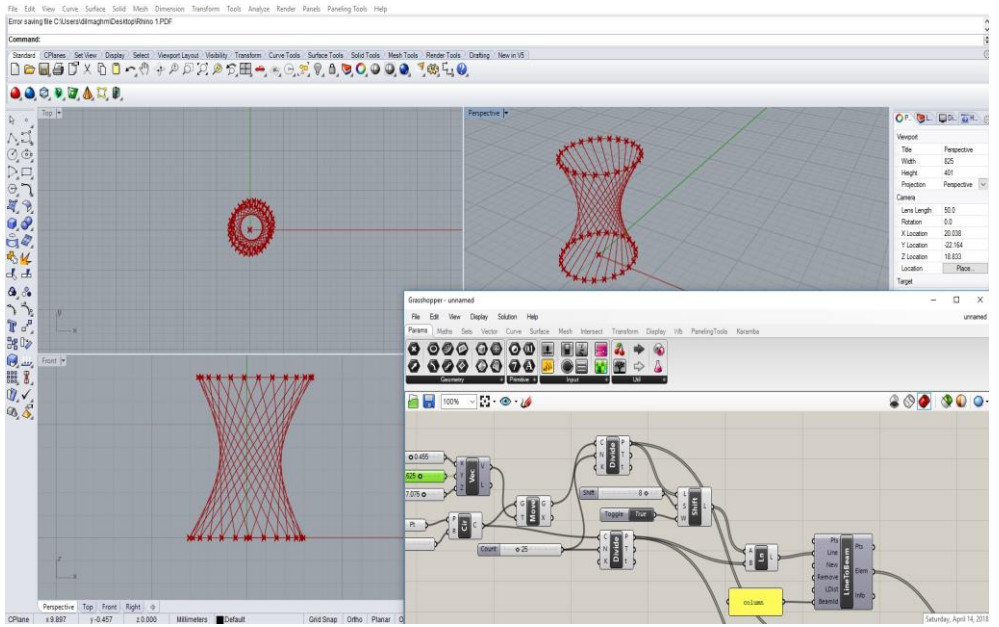
Columns and Beams

Grasshopper and Karamba

During the second week, I analyzed column and beam grasshopper. I explored the use of each input and repeated the example of a column. I tried to modify the shape of the model by changing the number of sliders.





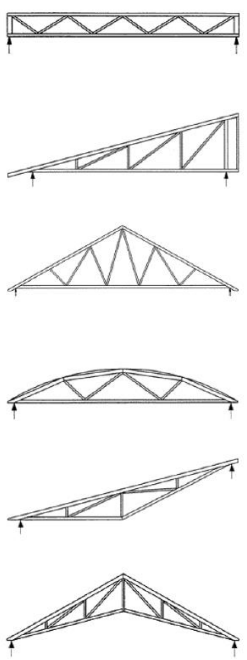


Frames and Trusses

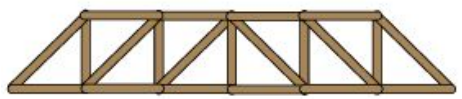
LEARNING OBJECTIVE

During the third week of the course, I learned the fundamental types of modern roof trusses.

I also learned from the handout that a flat Howe truss, is often preferred for heavy timber trusses. The Howe configuration allows the diagonal members to transfer their forces to the vertical and horizontal members by bearing directly against them; and timber members tend to be thick enough that buckling is less likely to be a problem than in steel members.



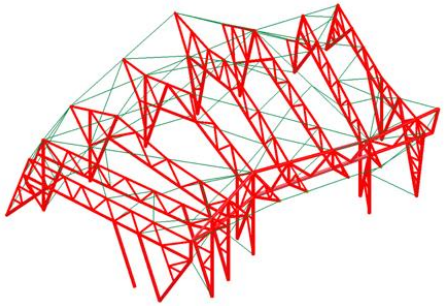
Fundamental types of modern roof trusses



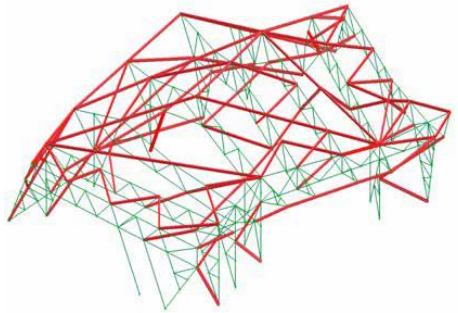
A Howe truss
https://www.pinterest.com/

Assembly Workshop, Hooke Park is an interesting example for me which consists of a series of truss frames. One of the most important challenges of this project was to keep each truss working with axial forces only, in order to maintain the primary principle of truss structure. So all load transfers, including the cladding, had to occur at truss nodes, thus eliminating bending force in the truss web and chord members.

The trusses highlighted in red in the top figure provide both vertical stability and act as portal frames to resist lateral wind loads. The bracing highlighted in red in the bottom figure uses the folded geometry of the building to tie the roof level to the ground and provide lateral stability in the longitudinal direction of the structure.



The trusses (in red) provide vertical stability and act as portal frames to resist wind loads

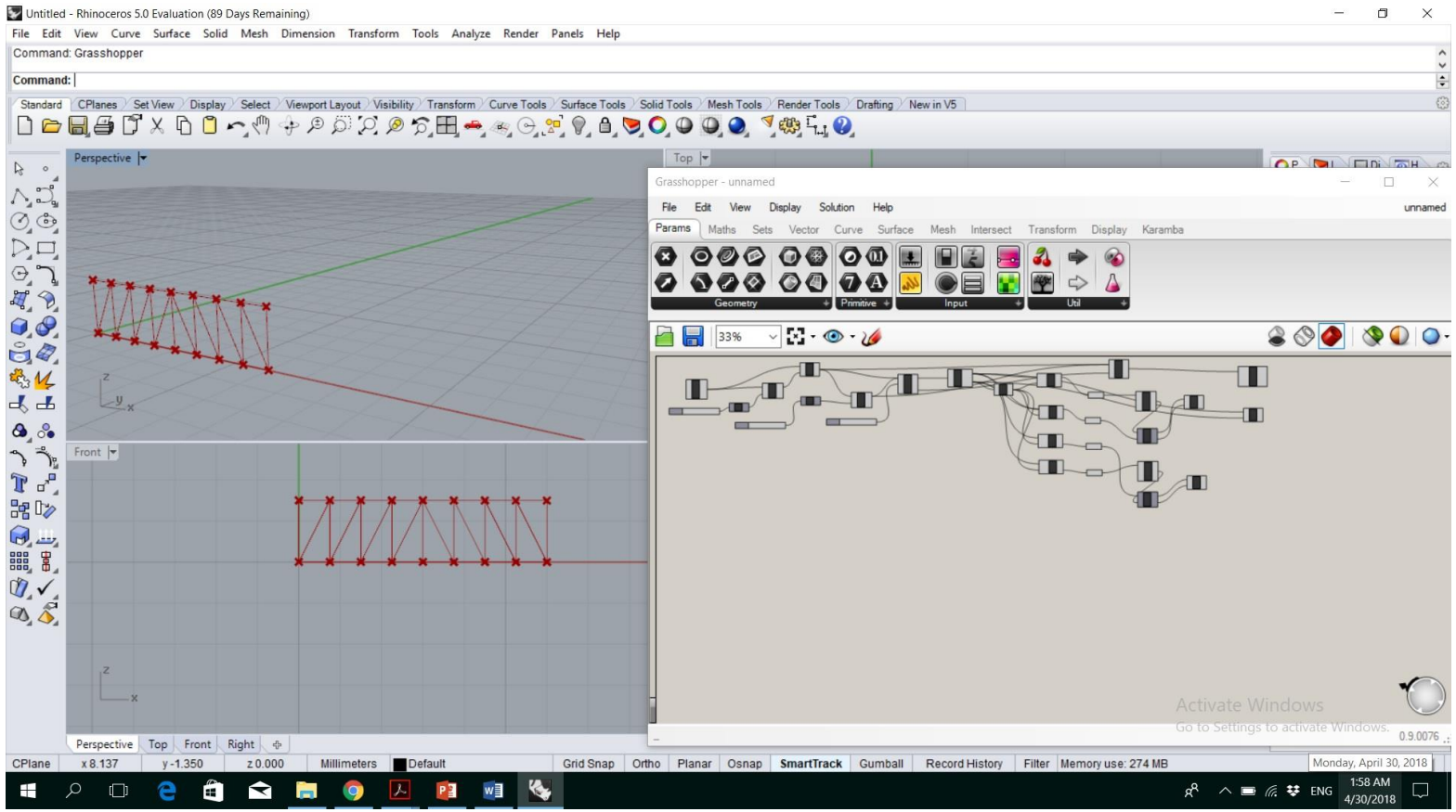


The bracing (in red) uses folded geometry to tie the roof level to the ground and to provide longitudinal lateral stability

Frames and Trusses

Grasshopper and Karamba

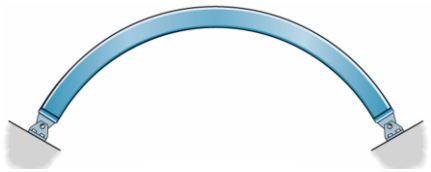
This week, I played with making my own trusses and analyzing them. I could design a truss in Grasshopper that it can be calculated in Karamba. In this case, I could be able to change the segment. I also repeated this example and tried to modify the shape of the model.



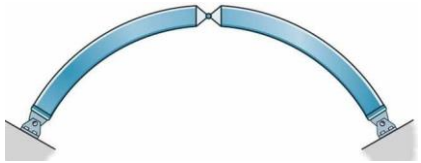
Arches and Domes

LEARNING OBJECTIVE

I learned the differences between two types of arches, from the course lecture. The two-hinged arch is sensitive to support settlements or/and moisture changes. The three-hinged arch is thus not subject to additional stress caused by thermal change.



Two-hinged arch
http://classes.mst.edu/



Three-hinged arch
http://classes.mst.edu/

I also learned about Geodesic domes which are composed of triangles. The triangular elements, distribute the structural stress throughout the geodesic sphere. Due do the triangulated geometry, geodesic dome structures do not need any additional bracing members. Geodesic domes have superior load-carrying capacity than similar radial rib domes .

A geodesic dome
http://geodesicgreenhouse.org/

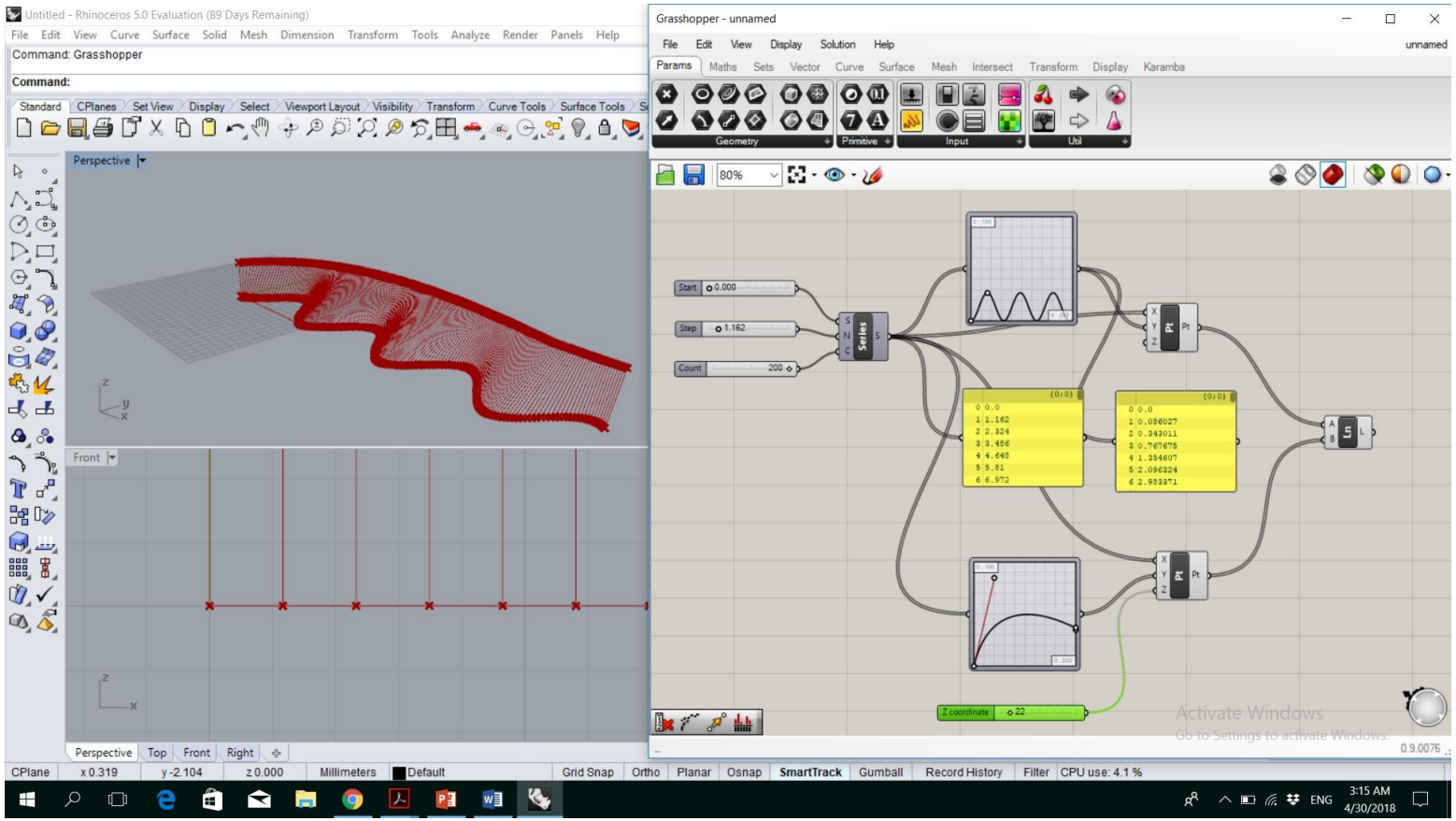
The Globe at CERN structure is an interesting example for me. Because, a temporary central tower was erected to support the vortex. When the vortex raised into position and the inner arcs and cladding were installed, then the outer arcs and bracing were installed. After all, the central tower was removed. In this structure, the inner and outer shells each comprise 18 glue-laminated cylindrical arcs.

The Globe at CERN, a relocatable exhibition pavilion made entirely of wood.

Arches and Domes

Grasshopper and Karamba

I practiced this example according to a Youtube video which has been mentioned in the handout of this week. I tried to learn and design a different shape. I could learn Graph mapper component. By that, I could be able to play with some of the equations to get different shapes.

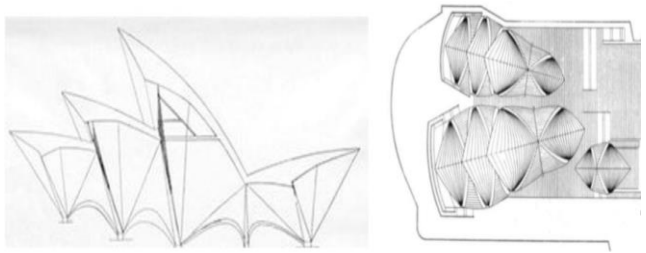


Diagrids, Shells and Gridshells

LEARNING OBJECTIVE

I learned from the course that the structural efficiency of a diagrid system helps us to be flexible with the floor plan because of avoiding interior and corner columns. I also learned that diagrid structures do not need high shear rigidity cores because shear can be carried by the diagrids located on the perimeter. Another advantage of a diagrid system which we can use in our design is that floor plates must not be regular, they can change from one level to the next. This helps us to create different shapes.

The example of Sydney opera house taught me that the shells all can be created as sections from a sphere. This allows arches of varying length to be cast in a common mould, and a number of common length to be placed adjacent to one another, to form a spherical section. This was an interesting part of the design for me.



Sydney Opera House
https://www.pinterest.com/

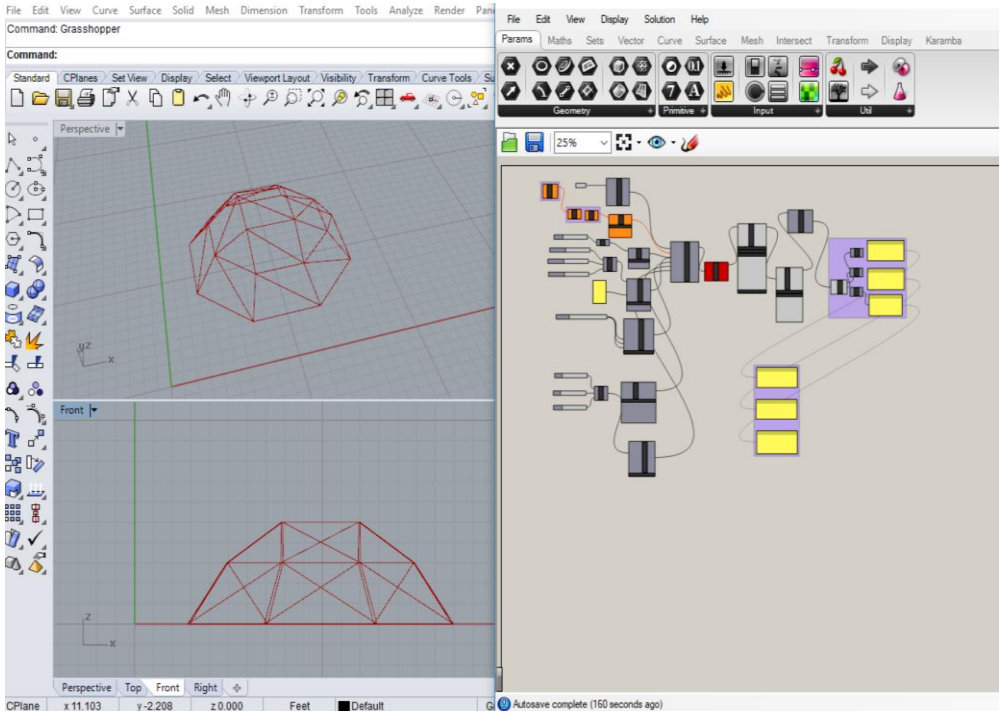
I also learned the different construction methods of gridshells. One type of gridshells is made of a flat grid deformed elastically to obtain the shape desired. In this case, the primary grid is assembled on the ground. Then, the erection of the grid is done, for example with the help of cranes. Each beam located on the edge of the grid is brought to its correspondent anchorage. Other type of gridshells are made of prefabricated shorted curved members, jointed and fixed on site.

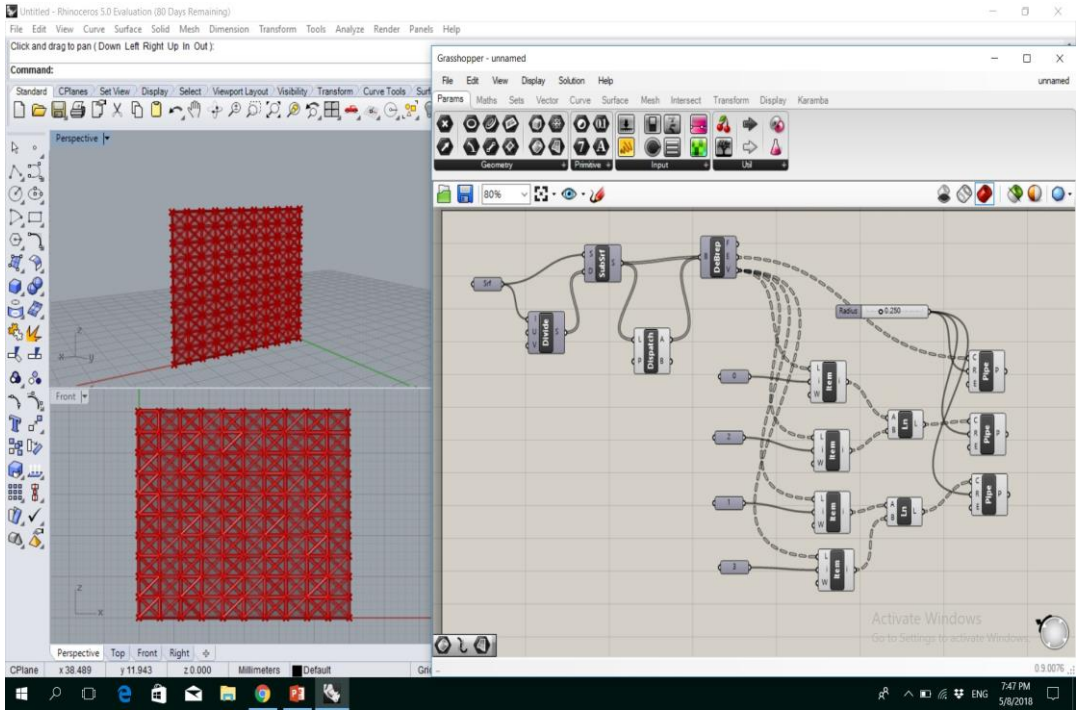
I also learned to keep in mind that gridshells are not diagrids. Gridshells rely on very specific constant curvature to create a shell structure that is comprised of thin elements. Gridshells, like diagrids, externalize their structure in the exterior envelope, but gridshells are shell structures, diagrids are not.

Diagrids, Shells and Gridshells

Grasshopper and Karamba

This week, I tried to develop my grasshopper model skill with examples from the class. I repeated the square dome example from the Karamba week 5. In addition, I tried to create a different parametric diagrid structure rather than the class exercise. I could design a diagrid in Grasshopper that it can be calculated in Karamba. I repeated this example and tried to modify the shape of the model.





Plates and Folded Plates

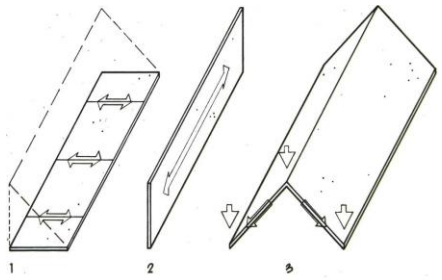
LEARNING OBJECTIVE

I learned from the course that cross laminated timber and plywood can be used for plate systems. Nail laminated timber can be coupled with plywood sheets as top layer.

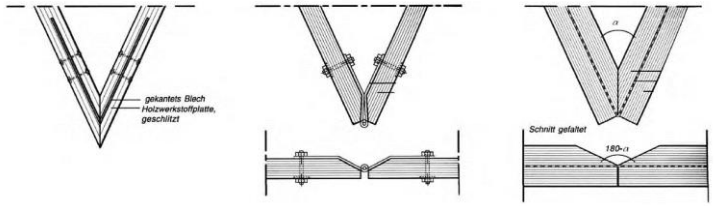
I also realized that the structural efficiency of plates can be increased by stiffening them with ribs, thus removing some of the material from the neighborhood of the “middle plane” of the plate and increasing its moment of inertia.

In addition, folded plate structures integrate the threefold load-bearing action of a slab, a plate and a truss in one element.

(1) slab (beam) action
(2) plate action
(3) truss action

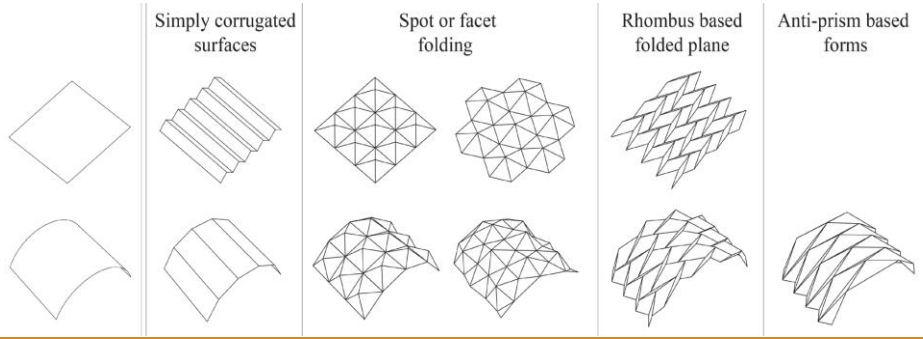


I also learned about joints for timber folded-plate systems which the most challenging task is the design and fabrication of efficient connections at the joints.



Textile joint Research at RWTH Aachen University 2000-2003

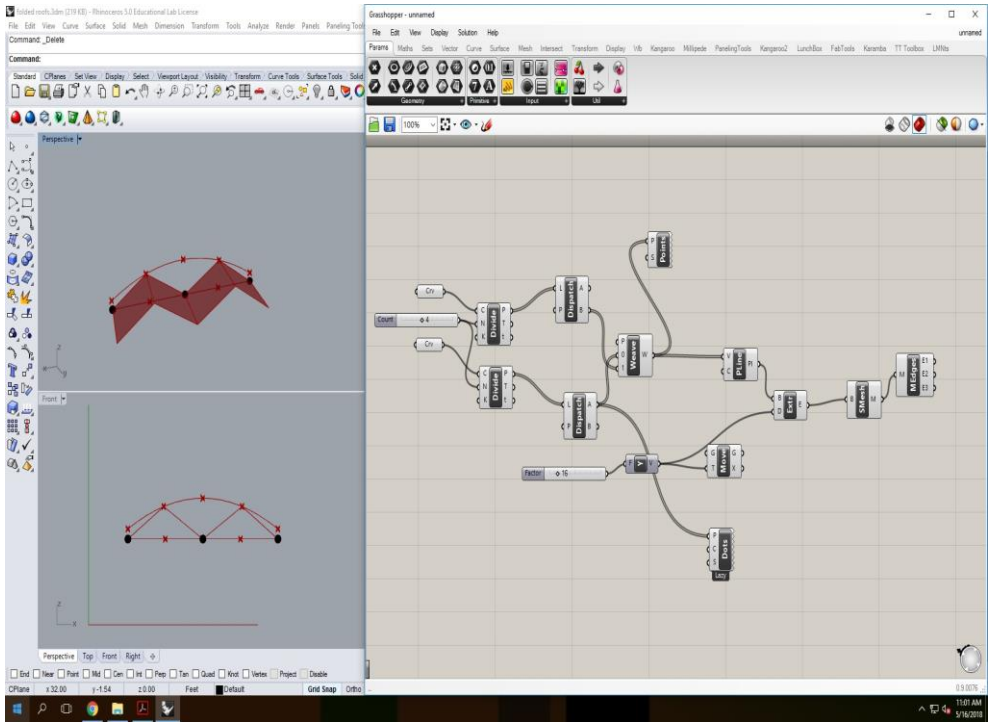
As an architect, I can use folded plate structures typically to cover large spans without vertical supports, which allows for mobility beneath. I can also use folded plates as vertical walls to resist both vertical and horizontal loads.

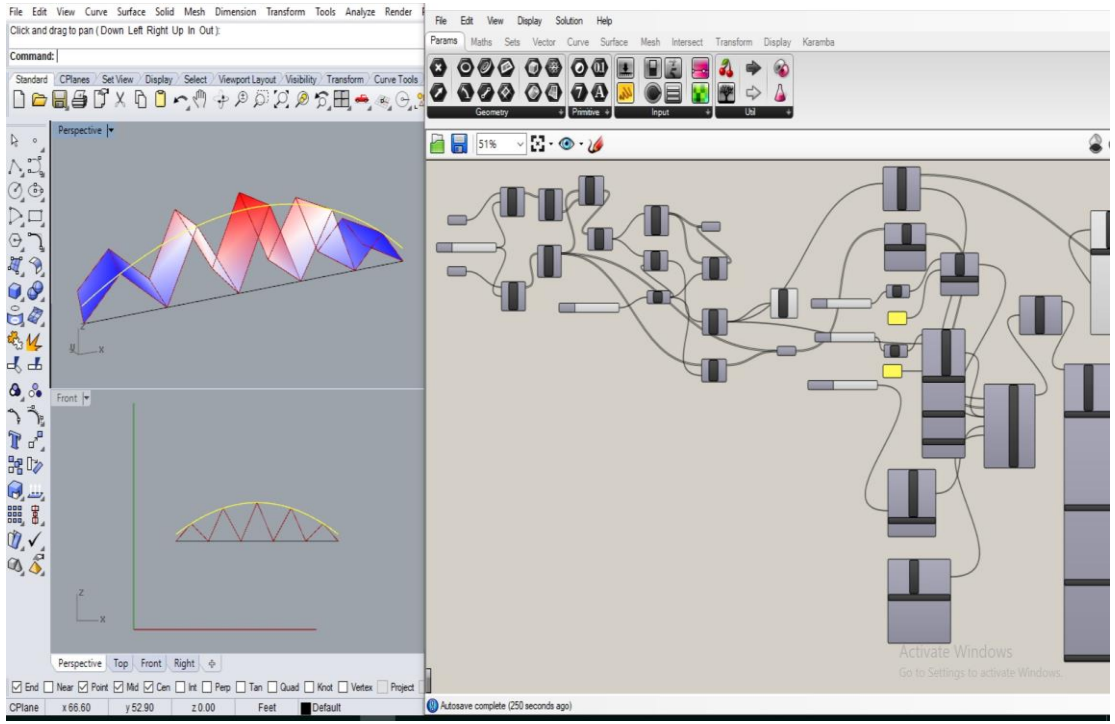


Plates and Folded Plates

Grasshopper and Karamba

This week, I tried to develop my grasshopper model skill with examples from the class. I repeated the folded plate examples from the Karamba week 7.





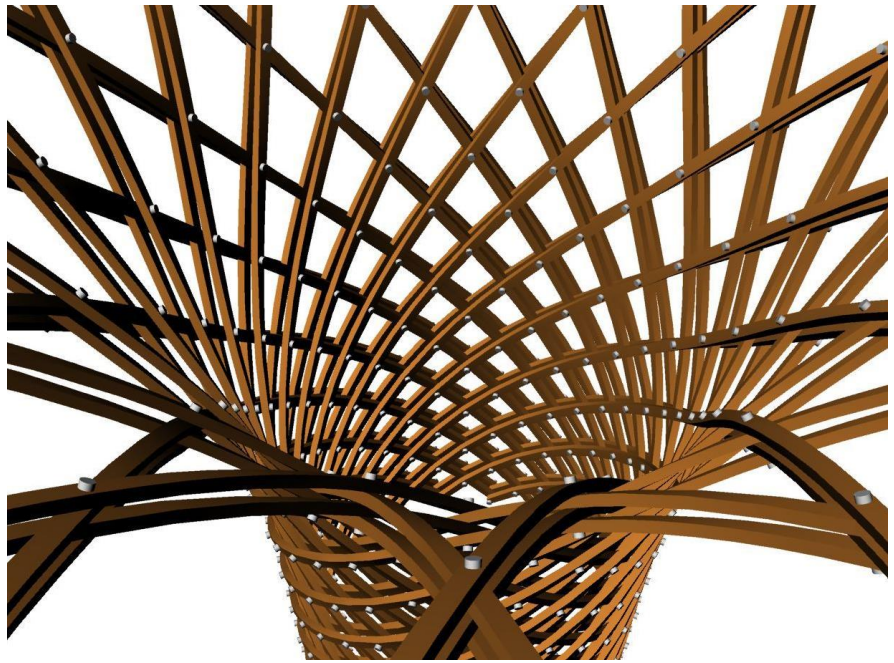
Summary

LEARNING OBJECTIVE

In this course, we learned the capabilities of timber products. I could be able to expand my knowledge about different structural systems through the labs and lectures. I learned how to model different structural systems in Rhino Grasshopper. It is always great learning a new computer program, especially if we can use that in real constructions. I also learned that when we change, member sizes, material type, and support conditions, those affect the reaction of body to loading. It was also very interesting to learn about the support conditions, joint conditions, and how the members are attached.

We also experienced how to collaborate with students from another school. I have a good collaboration with my teammates in order to make a progress in planning for our final project.

I found the week on diagrids, shells and gridshells more useful. Because, as a group we think that our final pavilion structure will be a diagrid of triangles which we may fill in with different materials.



Summary

LEARNING OBJECTIVE

For our final pavilion project, we have decided on a Möbius Loop. The loop will have one side raised above the ground to create some cover from the sun, and a place to relax, and the side opposite the raised one will be embedded in the ground to complete a subtle möbius form. We have received the feedback as positive changes to our designs to regularize the form. We will try to do by decreasing the amount of U and V divisions of the Möbius Loop in order to create a more rectilinear form rather than a curvilinear one.

MORVARID DILMAGHANI
Morvarid.Dilmaghani@oregonstate.edu

https://freedesignresources.net/

A Graduate Student

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