Timber Tectonics Case Study

A Comparison of Two Structures

ARCH 510 | Spring 2018

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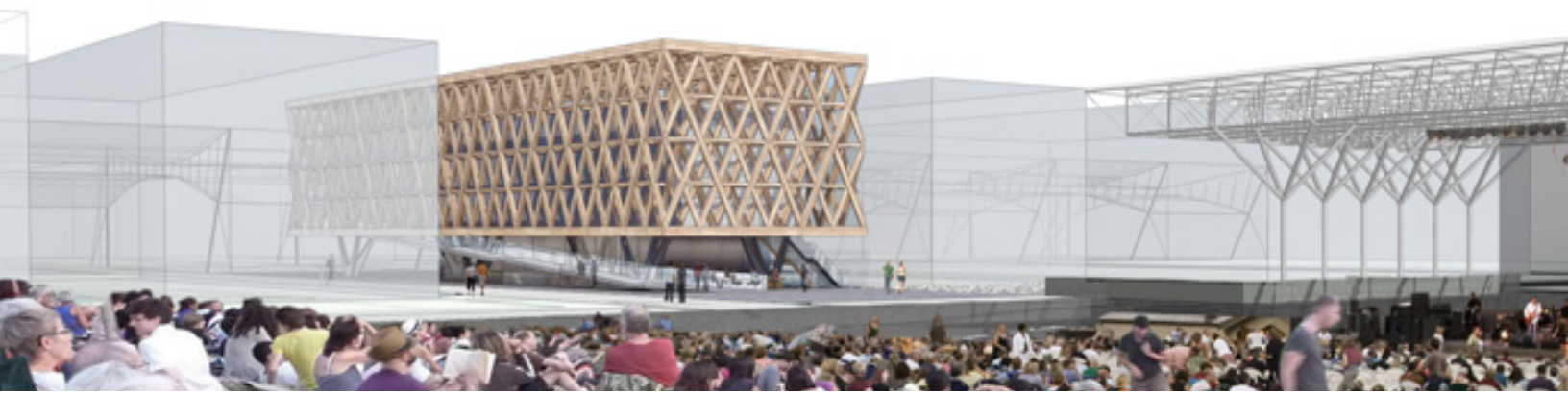
Malaysian Pavilion - Expo Milano 2015

Chilean Pavilion - Expo Milano 2015



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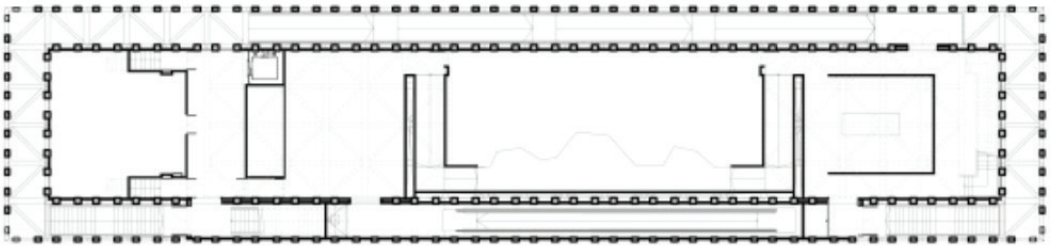
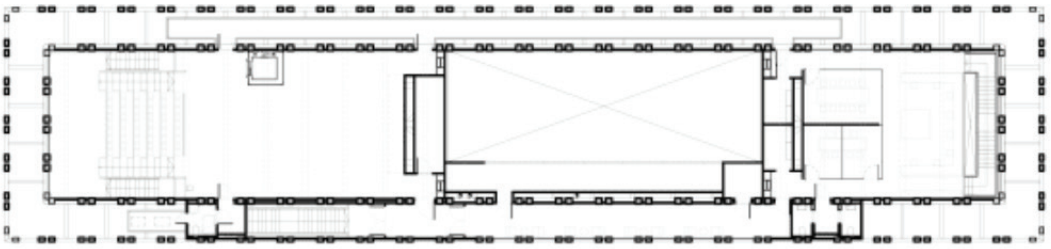
Chilean Pavilion - Milan 2015

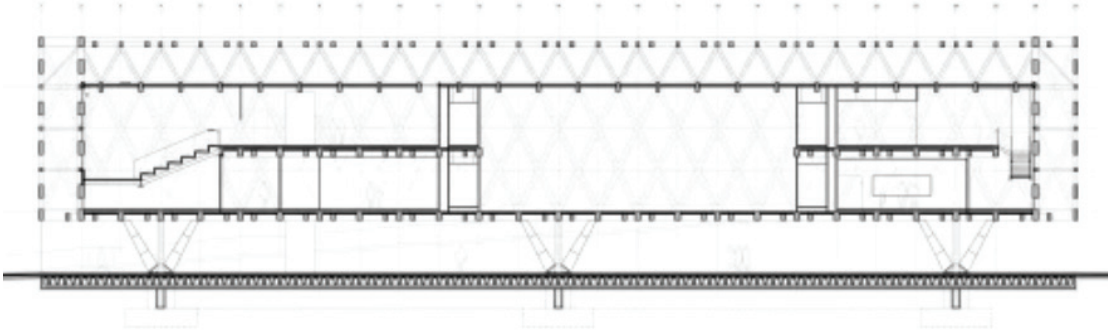
The Chilean Pavilion was designed in 2015 by Chilean architect Cristián Undurraga to be an example of a beautifully designed, sustainable building that could be dismantled and moved for varying sites and uses. From a program standpoint, the goal of the project was to showcase the beauty and culture of Chile, through the open and welcoming design of the structure. The warm feeling given by the wood façade adds to the program by drawing people in, while the ingenuity of the diagrid system showcases the capabilities of wood as a building material, while also adding a depth and an engaging portal for those who view it.



PLAN| FIRST LEVEL



PLAN| SECOND LEVEL



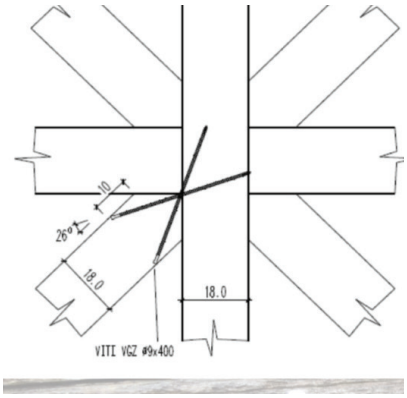
SECTION| LONGITUDINAL

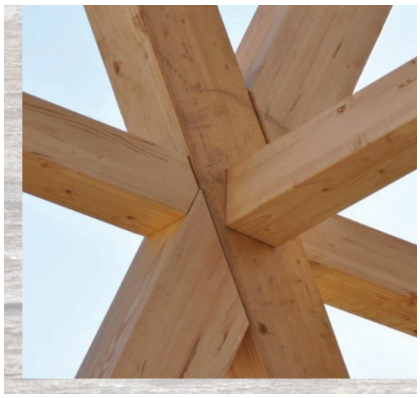
Materials

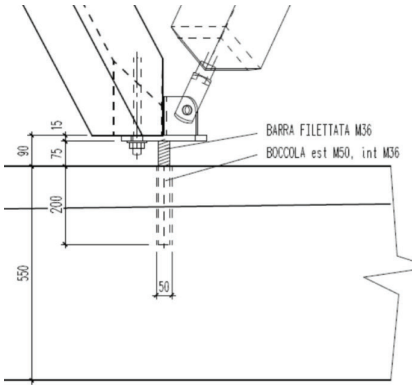
The material used for this project is glue-laminated beams and columns, attached to one another through wood and steel connections. One reason the architect selected glulam as the primary building material is because of the tradition of its use in Chilean architecture. As the program of this project celebrates the history and culture of Chile, wood seemed a natural choice for this project. In addition to the Chilean use of the product, it was a parameter for the exposition in Milan to emphasize the sustainability of natural building materials. The project used over 1,000 square feet of glulam as a result and as this isn't a sustainable system for a temporary structure, the architect believed that in order for it to become sustainable, the life of the project had to last longer than the 6-month time period of the exposition. Consequently, from the beginning of the design, it was important for the building to be able to be moved back to a location in Chile after the exposition was over and this created sustainability for the project, thus greatly influencing the design of the structure.

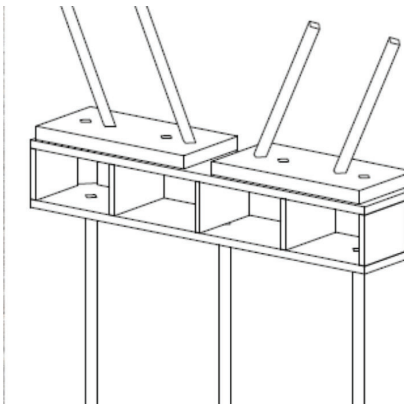
Connections

To make the project movable and deconstructable, then reconstructed on a different site, a series of bays were created with differing connection systems to make the pieces mobile. Each 'X' in the diagrid is attached through an interlocking wood connection system, tightened with screws through all connecting pieces to create rigid connections. These 'X's are pieces that stay together, creating larger elements that allow for easier transport. The beams in the diagrid system are attached horizontally through hidden connections and then vertically through steel connections to transfer the force without bending. The resulting stability of the material and connections is successful in supporting the 20,000 square foot structure, but also allows through the pin-connections surrounding the 'X's to be detached, then re-attached at a later time. The pin-connections in the system are all metal connections.



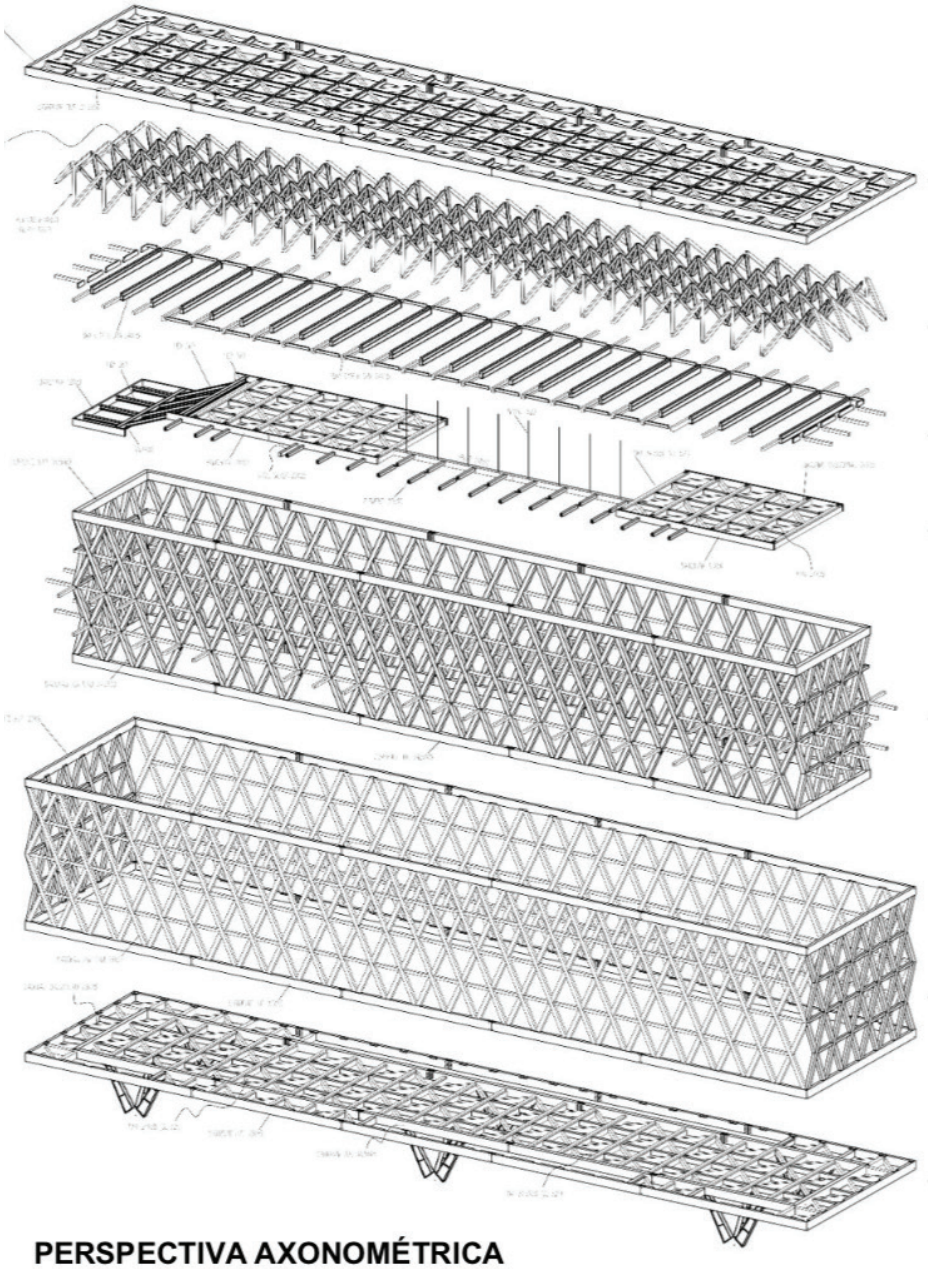






Structure

The structural system used in this case study follows a diagrid system. The diagrid works for both vertical and lateral loads. By using the 'X' form repeated throughout the structure, the system creates a large truss, which then acts like a bridge, allowing a shaded but open first level space. The whole diagrid system is supported by six steel columns acting in compression that fan out from the base to create an upside down pyramid, creating both vertical and lateral support for the system as a whole, giving the appearance of a floating rectangular box. There are two concurrent skins in use, with one as an interior shell, and another as an exterior to give visual dynamism to the project. Both skins use the diagrid truss system, and the effect of the dual system works both structurally and aesthetically by providing shadows and light throughout the pavilion.



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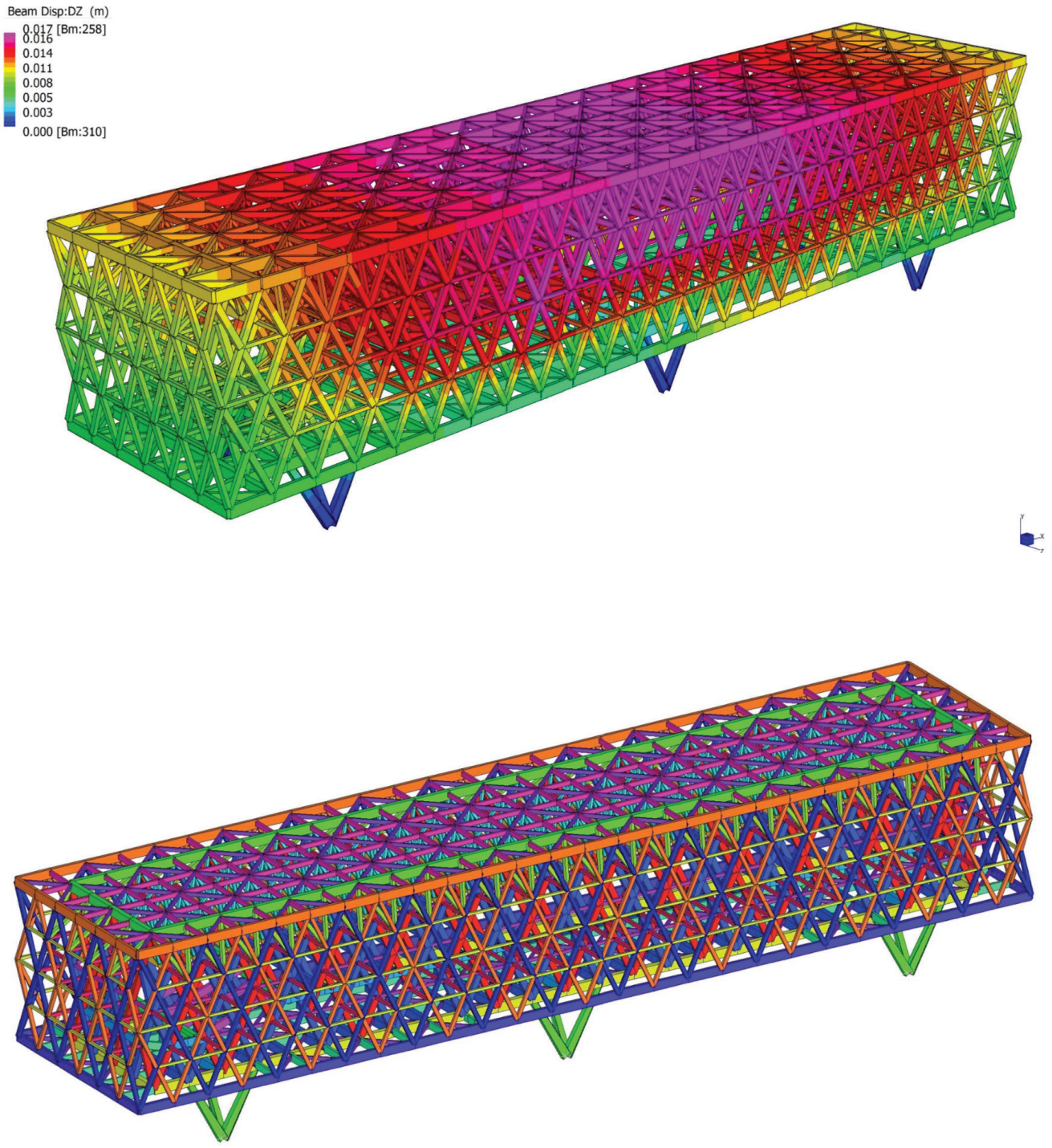
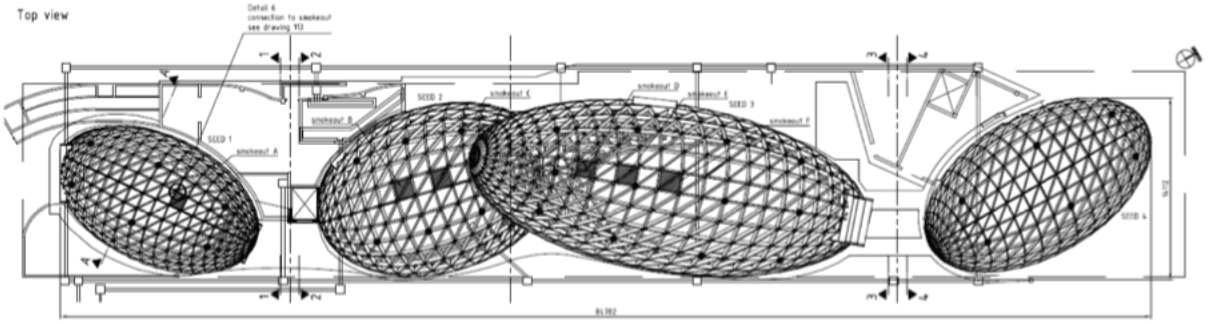
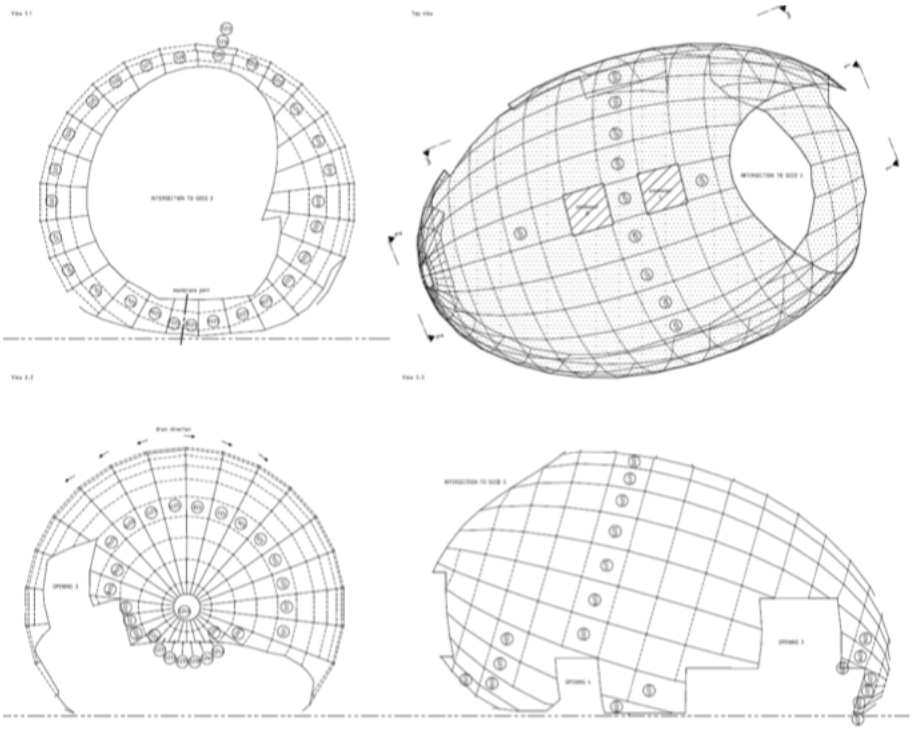


Malaysian Pavilion - Milan 2015

In comparison with the Chilean project, the Malaysian project in the Expo Milano also used a glulam system to create their pavilion. This project designed by Hijjas Architects + Planners was designed to celebrate the culture and history of Malaysia. Instead of rectangular shapes, like the previous project, they utilized the glulam to create a series of curved structures that fit together and worked as a group. This project relied heavily on parametric design and focused on a gridshell with straight pieces of glulam and metal connections. The big idea for this project was the idea of rainforest seeds and how these seeds can grow into trees that provide life and growth for Mother Earth. In Malaysia, the rainforest is important for the people who live there and it only seemed natural for the team of architects designing the project to focus on a such a vital life giving symbol.



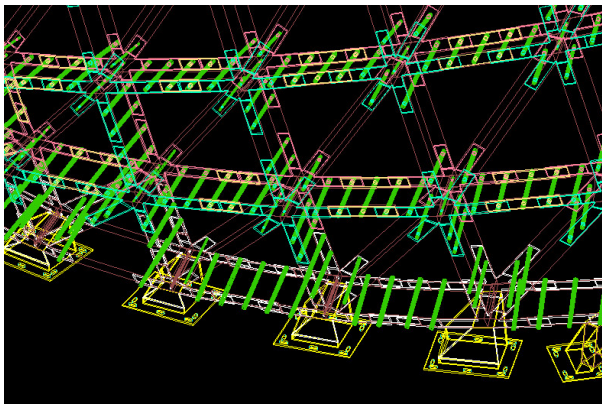
PLAN| TOP VIEW

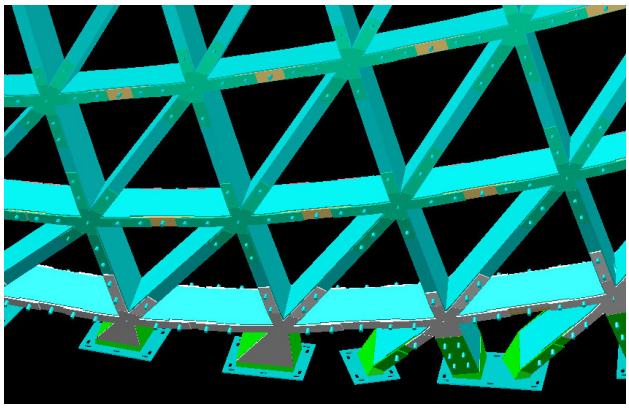


DIAGRAMS| STRUCTURAL BANDS

Materials + Connections

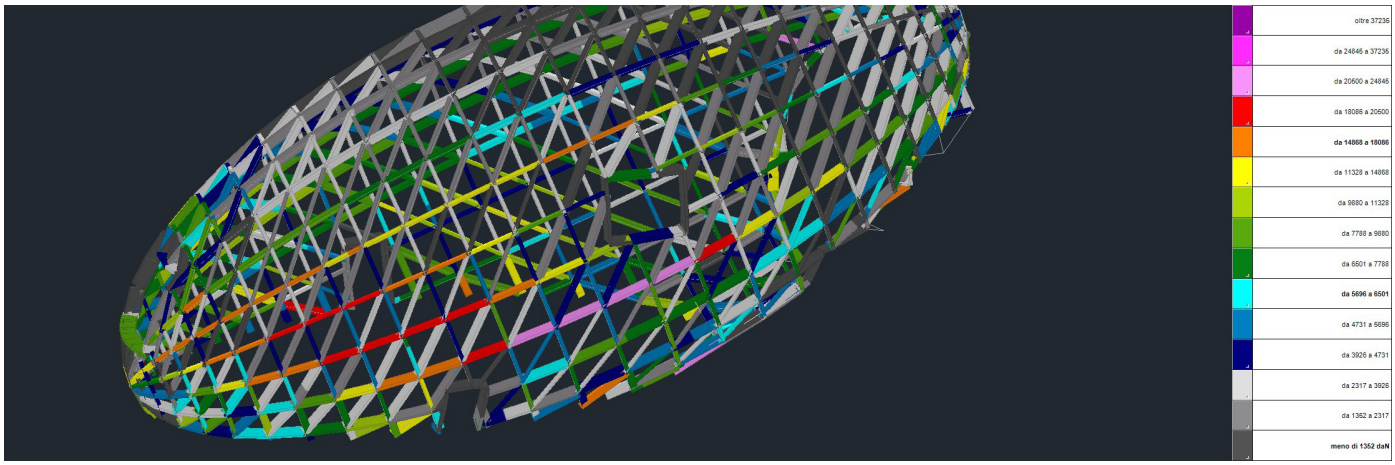
The material chosen was glulam as it is sustainable and has strong structural properties that would allow each short piece between the connections to span a little farther than that of other types of engineered wood products. The connections between each wood piece are through exposed steel plates, connected with long steel bolts on each side of the glulam, thus creating rigid connections between them. Each 'seed' is connected through wood bridges and pathways to further emphasize the connection to Malaysia and the rainforest. The system is fairly straightforward in construction, but required a lot of planning ahead of time in order to arrange and organize all the pieces that would be put together to create these organic and curved forms. By utilizing and emphasizing the connections, this provides a great example of what wood can do within architectural form.

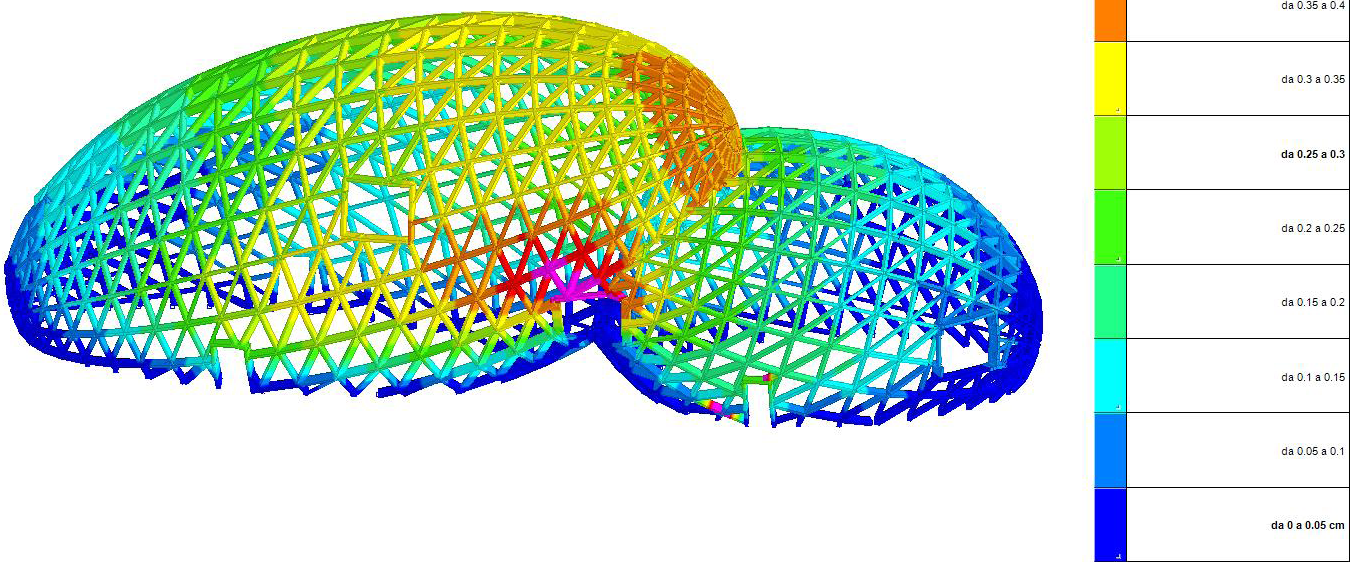




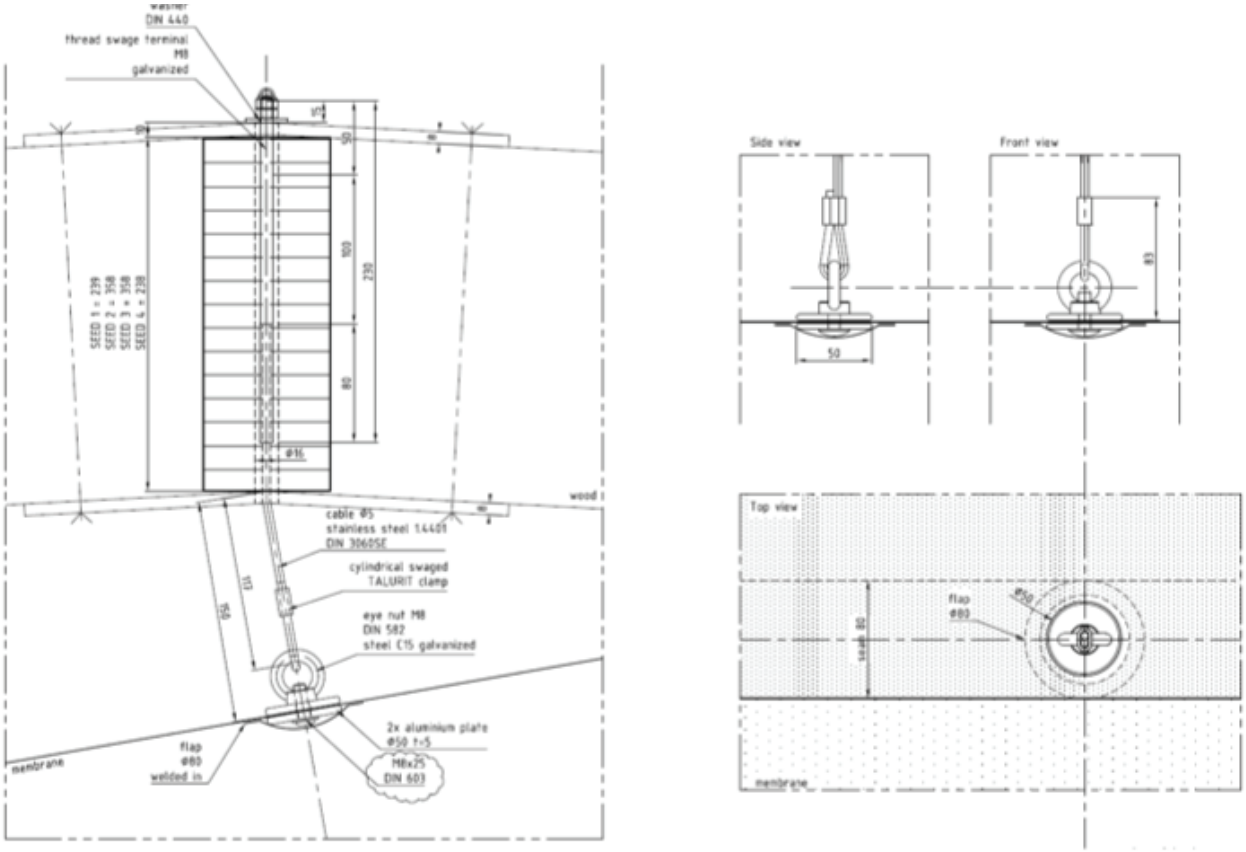
Structure

The structural system used is made up of short, straight pieces of glulam connected through exposed metal plates and bolts, to form arches to provide support for the structure through the grid shell design. As each node of the system has several pieces of glulam fanning out from the center, it creates a module for connectivity and support. The resulting network of glulam and rigid connections are both aesthetically and structurally pleasing. By using this repeating system, the nodes are arranged in long strips across the structure of each 'seed' to created arches that support the system longitudinally. The nodes work in the transverse direction as well, creating a stable system of arches in both directions. All of the pieces utilized a CNC to create the varying edges required for the connections at each node. All of the pieces were bolted together by hand.





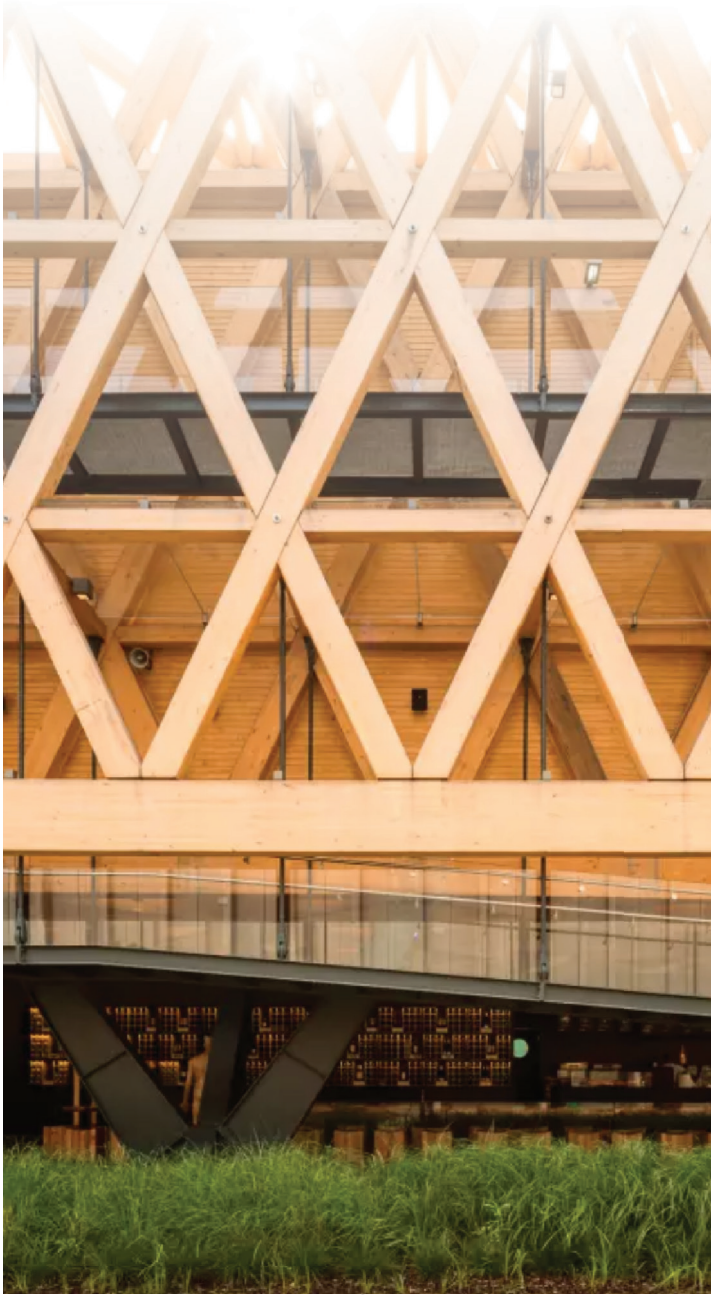
Construction



DETAILS| ENCLOSURE MEMBRANE

Conclusion

Each of these projects, through the use of parametrics and engineered wood products, can be used as tools to inspire more projects that can utilize the same materials and methods. The key to both projects is to create a node or a module that can be altered slightly to make up an entire structural system. By creating a repeating element that can be changed or shaped, a design can take on a myriad of forms and would only be limited by one's imagination. In each case, triangles were formed with each module, which allows for support in multiple directions and emphasizes the efficiency of the material and the design overall. By looking at examples of previous works that exemplify the capabilities of designing with wood, it inspires and pushes designers to make complex structures that can shape and improve the lives of future generations.



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