Viewing Tower at Acadia National Park

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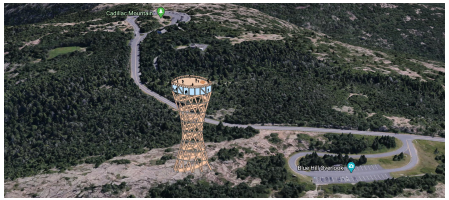
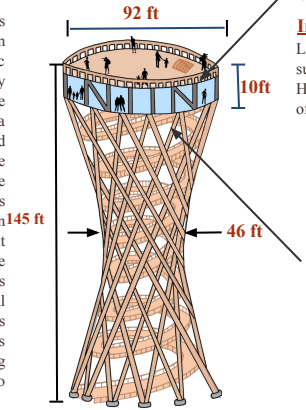
Existing Site Conditions & Project Scope:

The focus of this project is building a wooden diagrid structure to support a 1-Story commercial space for Acadia National Park in Maine. The structure is to be used as a viewing tower as well as include a restaurant and observation deck. The location selected for the proposed tower is on Cadillac Mountain, a unique location and at 1,530 feet in elevation, is the highest point along the North Atlantic seaboard and the first place to view the sunrise in the United States between the months of October and March.



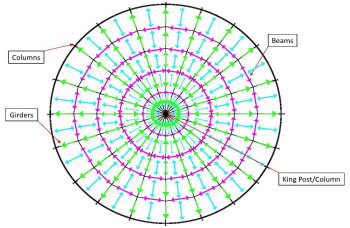
Site Location With Structure

The National Park receives approximately 3.5 million visitors a year, and Cadillac Mountain is the most densely populated area within the park. The location lacked a nearby restaurant and could use with less congestion at the mountain peak Our structure addresses this issue and gives visitors that chance to soak in breathtaking views. without obstructing the views from the mountain peak, as well as taking away minimal woodland through its construction. The structure is located between 2 parking lots, giving ease of access to visitors that visit the peak.



Beam Slab System Load Path:

- One-way slab (blue) spans between the beams as a distributed load
- Beams (purple) transfer load to the girders as a point load
- Girders (green) transfer load from members to the columns



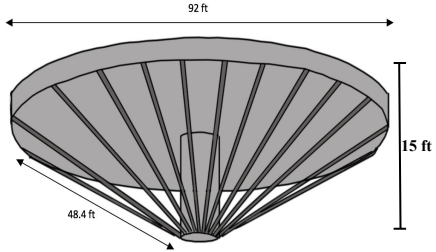
Load Path of Beam Slab System

Lateral Force Resisting System:

Composed of 4 steel braced frames, spaced at 90° increments around the perimeter of the restaurant level.

Inverted King Post Truss:

Located under the restaurant, the inverted king post is used as a slab support system. It includes a concrete filled steel column and 20 HSS rods in its design. This system is able to withstand the weight of the entire 92 foot wide floor system.



King Post Truss Model

Diagrid Optimization:

To pick an optimum diagrid structure, three types of optimization tests were ran. The first bein being the angular test, where we tested ho much weight was required to carry loading was we changed the inclination angle of diagrid members. The second test was to determine the optimum ring stiffener size, as these ring stiffeners were essential in increasing buckling strength. The last test was to determine how many nodes would be suitable for this structure, since this determined how many members would be utilized.

Diagrid Optimization results:

Angular Optimization

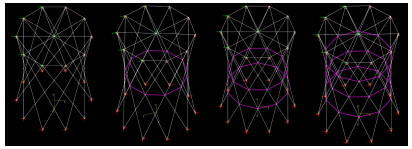
From the ring angular optimization test, we found that the angle which allowed for the least volume required to carry the loading was 67.5 degrees. This was expected because at 35 degrees is the most optimum angle to resist shear (wind) based on published data, and 90 degrees is optimum to carry gravity loads. Therefore, the maximum to carry both would be within the range of both.

Ring Stiffener Optimization

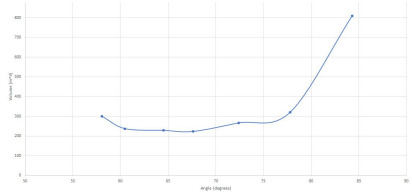
From the ring stiffener optimization test, we found an optimum ring stiffener which is highlighted in yellow. This ring allowed for a strength increase from 141 kips to around 713 kips. During the test, we found that there were limiting values in terms of A and Iy and if these limiting value requirements were not met, no increase in other parameters would help increase buckling strength.

Node Optimization

From the node optimization test, there were many combinations of ring stiffeners and number of nodes tested. We found that for all the models (10,20, or 30 nodes) as we increased number of ring stiffeners we were able to drive down the weight required of the structure. This is because ring stiffeners increases the buckling strength exponentially. This is because these braces decrease unbraced length and since unbraced length is a squared term in Euler buckling, the change will be exponential. Therefore, we are able to decrease the diagrid members size significantly. This allows for weight to drop significantly enough that even adding the ring stiffener the new weight of the structure will still be lower than the previous (without ring stiffener).



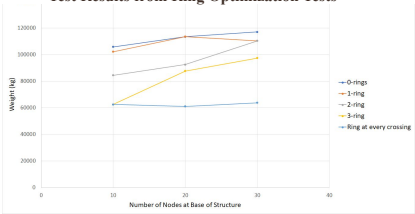
Models for Node Optimization Test



Graph showing the volume of structure required vs inclination angle

Buckling resistance with 1-ring: Area=1.55in^2						
Moment of Inertia	Moment of Inertia Z (in^4)					
	24	240	2403	24025	240251	2402510
24.0251	150	150	150	150	150	150
240.251	280	280	280	280	280	280
2402.51	713	713	714	718	722	723
24025.1	741	743	746	750	750	750
240251	741	746	749	750	750	750
2402510	740	746	749	750	750	750
24025099	685	686	702	750	750	750

Test Results from Ring Optimization Tests



Graph of Weight Required to prevent buckling for different number of Nodes/ Ring Stiffeners