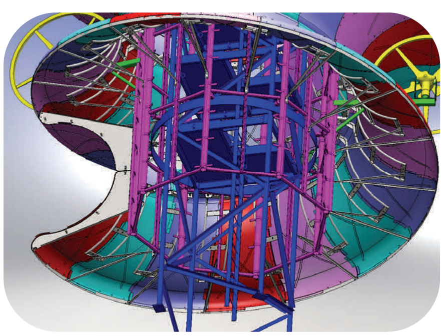
Cleveland State University
Fenn College of Engineering

Progressive Field Experimental Helical Wind Turbine

Completed: April 2012

In the quest for sustainable nonpolluting energy, Cleveland State University's Engineering Department under the direction of Dr. Majid Rashidi began research into how to maximize the efficiency of smaller wind turbines for application in congested urban areas where the more common large turbines would be impractical.



The University received a grant from the United States Department of Energy to design, construct and erect a helical assembly to study the effect of wind amplification on standard commercially available small wind turbines.

As a complement to their previous Green Initiatives, The Cleveland Indians Baseball Team offered Cleveland State the opportunity to install this device over the bleachers in right field, 125' above street level.

"One of the most complex projects in recent memory. The project was on a tight time schedule and required a substantial amount of thinking outside of the box."

As a one of a kind project, unlike anything done before in a typical construction business, this project presented a host of unique challenges to our crew of ironworkers, millwrights and engineers much more familiar with structural steel buildings that would typically come with a set of dimensioned drawings.

During the bidding process it was immediately apparent that this complex device could not be assembled in place on top of Progressive Field. Therefore it would need to be pre-assembled, and since it would be too large to ship, it would have to be preassembled at the project site.

The first immediate challenge was to field measure the location of the three 24" diameter steel columns so the supporting platform could be pre-fabricated to be erected as one assembly. These dimensions were shot to within 1/32" accuracy. These field measurements were the basis of assembling the triangular platform. A discrepancy of as little as 1/8" would have resulted in the platform not mating with the existing Progressive Field Structure.

The next and biggest challenge was how to assemble the eighty flexible plastic panels. The panels formed a helix 18' in diameter and 25' tall. Each revolution consisted of sixteen panels with a rise of 9' per revolution. Attaching the panels to the rotating aluminum armature required extraordinary precision as any small errors in locating the panels in three dimensions would be cumulative. For example, if the inside or outside radius was off by as little as 1/16", after one rotation the panels could be off by 1" and would not mate with the following row of panels.

The location at Progressive Field where the turbine was installed required a 250 ton crane to make the height and reach. The final challenge was to develop and orchestrate an erection sequence that would allow the final lift and assembly to be completed in one day.

Since the turbine was to be assembled on the ground at the project site, it needed to have a temporary support structure to keep in from blowing over during the assembly process. C.T. Taylors's engineers designed and fabricated a "tree stand" out of structural steel and concrete deadmen to hold the unit during this process.

The eighty flexible plastic panels, since they were sloped, skewed, and curved, had no means of attaching a tape measure to locate them. Both the inner and outer radii had to be located precisely in order for each

16 panel revolution to mate with the succeeding layer.

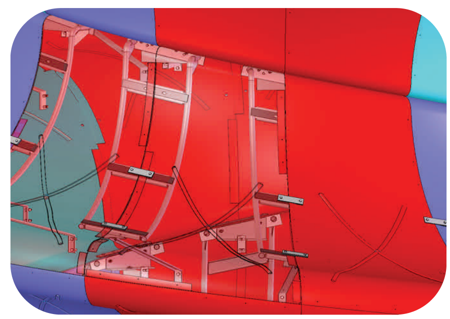
Since the supporting aluminum structure did not have a physical center axis, one had to be created optically with a series

of laser instruments to define radial and angular locations of the panels.

As designed, the supporting platform required a substantial amount of welding to secure it to the existing structure. The idea was to erect the platform first, and then to lift the turbine assembly.

Without the welding, or some other means of restraint, the turbine assembly would not have withstood any significant wind loads after the superstructure subassembly was attached. At $6,000 a day for the crane, it would have become quite expensive to perform the work. C.T. Taylor's engineers again come up with an innovative way to secure the platform by means of cable tie downs that would enable erection of the turbine in one day and allow the balance of the welding to occur over the next few days without the necessity of keeping the crane on site.

It would have been virtually impossible to close one of Cleveland's busiest intersections, East 9th and Carnegie to set up a crane. The only other location availa-



ble was the parking lot the Cleveland Indians players use. Not completing the project and restoring the lot prior to opening day was not an option. As a constant daily reminder, the huge banner overhead displayed the days remaining until opening day of the 2012 season.

The supporting structure and rotating aluminum frame were provided and fabricated under C.T. Taylor's contract. Most of the rest of the components such as the plastic panels, gear drive and panel support brackets were to have been owner furnished items. With the deadline approaching to begin assembly, the University was unable to find a fast vendor that would produce the compound curved stainless steel brackets called for in the original design. In consultation with the University and their structural engineer it was agreed that these brackets could be simplified and fabricated out of aluminum angles.

Now that the design was fundamentally changed from the 3D CAD model, all the attachment holes that were to be in the plastic panels were no longer in the right place. Through a series of round

trips between the bracket fabricator and the panel fabricator we were able to reverse engineer the hole locations on the five axis CNC router to mate the two sets of components.

With the banner overhead on the side of the stadium continually displaying the few number of days to "First Pitch" the millwright crew set the aluminum cage in a vertical position supported by guy wires and started assembly of the plastic components.

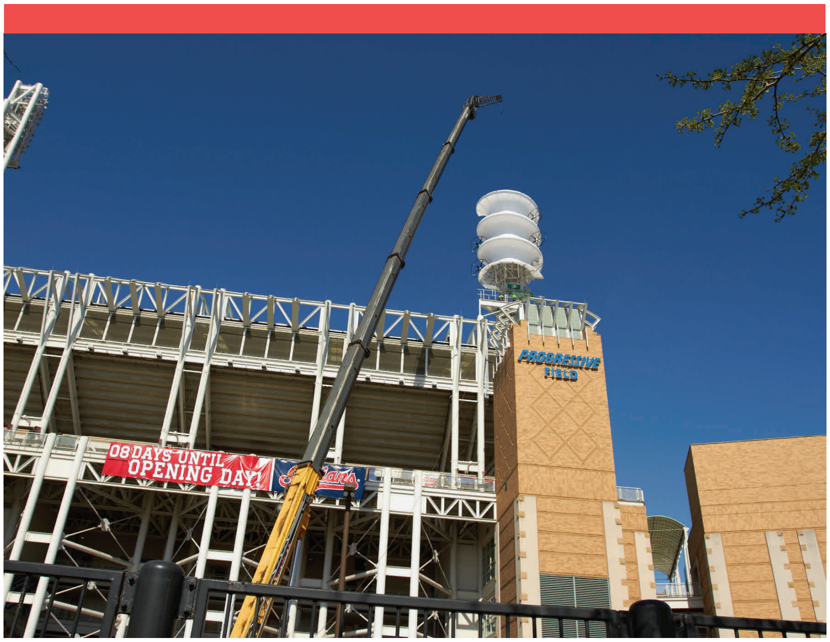
"... working with C T Taylor is definitely a pleasure. The University is extremely satisfied with the work that C T Taylor has performed and would welcome them on future projects."

Now that the unit was assembled it would require a relatively calm day to safely lift it 200' up above the stadium and land it. The moment of truth came with only eight days remaining. The triangular platform attached perfectly with the existing structure. A testament to both the surveyor, for their dead accu-

rate field measurements, and the fabricator for the close tolerances they held in the finished product.

There are no words, nor mathematical formula to describe the form of the turbine. The best we could come up with is a cylinder, that as it is rotated, gains 9' per revolution to form a "corkscrew" that one reporter described as a "twisted ice cream cone".

This would have been difficult to assemble even in a heated indoor shop. As it was, it had to be assembled outdoors, utilizing man lifts, in March. Considering the obstacles, we are extremely proud of the skill and dedication of our



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