

**Introduction**

- Hurricanes and natural disasters are among the largest construction challenges today. Aerodynamic mitigation of tall buildings is subdivided into local and global shape mitigation.
- Local shape mitigation focuses on corner shape configurations while global shape mitigation has a major effect on architectural form and structural design as it looks at optimizing the overall shape of the building.
- Providing an infinite amount of possibilities, origami-inspired structures have been used to solve small scale engineering problems (Tolman et al., 2014).
- By taking dynamic building envelopes designed using origami principles, a new generation of smart structures can be built to sustain impacts by high winds.

**Objectives**

The objectives of this research investigation are to:
1. Review background information on adaptive envelopes and origami-inspired architecture.
2. Compare small scale wind-tunnel testing to large scale computational fluid dynamic analysis.
3. Evaluate performance of different wind tunnels in generating desired wind speed.
4. Determine if dynamic envelope prototypes are a feasible step in adaptive building design.

**Methods**

To create the small-scale adaptive envelopes would require not only a manufacturing mechanism that was cost effective, but also capable of making the complicated shapes as seen during computational analysis. Additive manufacturing using the Maker Select Plus printer was chosen to create models.

Three adaptive envelopes were made, at two scales: 24 mm and 80 mm. There were small imperfections in the surfaces of the prints, but the small size made it difficult to detect if these lead to performance changes.

To test these experiments with two wind tunnels were used. For the 25 mm scale buildings a hot wire anemometer was used over 30 seconds intervals to calculate the average wind speed versus the wind tunnel voltage, and buildings were compared against the unobstructed wind speeds.

Buildings were testing at 0 and 45 degrees angles to the wind crossflow to observe the flat surface performance versus wind coming off at an angle.

**Results and Discussion**

To look at wind flow, the 80 mm buildings were set in a separate wind tunnels, and smoke was move through the structure to examine wind patterns.

- The high wind speeds were observed at the corners of the building.
- This could be caused by wind flow patterns around the building, pushing wind behind to higher speeds than the wind tunnel originally produces.

The small scale wind tunnel testing showed higher wind speeds after actuating 2 at 0 degrees, even though building two is obstructed direct wind flow.

**Conclusion**

Through this pilot project, it can be observed how the wind speed changes based on different building envelope shape configurations. Understanding which shape provides best aerodynamic performance will provide the necessary information for future structural designs.

For small scale experimentation versus large scale computation, there is a great deal of variance with the difference in scales.

- Wind speeds, forces, and aerodynamic properties all have slight differences that make each building unique. However, by using both computational tools, behaviors can be predicted on each using experimental test can inform and calibrate computation models.

Establishing aerodynamic performance provides the next step for multiple projects, including:

- Building dynamic envelopes out of shape memory polymers and shape memory alloys using additive manufacturing.
- Behavior response to various electrochemical energy signals.
- Real-time morphing envelopes subjected to wind loading.

**Bibliography**


