Bio-Inspired Design

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Abstract

The Bio-Inspired Design (BID) team has taken on the task of analyzing the heating, ventilation, and air conditioning (HVAC) of the Social and Behavioral Sciences West (SBS West) building at Northern Arizona University (NAU). Currently, SBS west is not up to building code with the current ventilation system. The first semester of this project was to analyze how the current system is functioning and developed theoretical ventilation designs for the current HVAC system. The second semester the team decided to focus on the bio-inspired aspect of the project, along with the pressure relief of HVAC system. It was found that the best way to approach this part of the project was to create a Design of Experiments (DoE). Based on the results from the DoE, it was found that all four vents produced similar pressure relief results. All vents relieved the pressure of the chamber in approximately 0.25 seconds. The termite mound vent experienced the fastest pressure relief while the flower vent experienced the slowest pressure relief. Since the four vents experienced similar results, the team decided to focus on the bio-inspired aspect to be implemented into the final design. The flower and Fibonacci vent were combined to produce the final design.

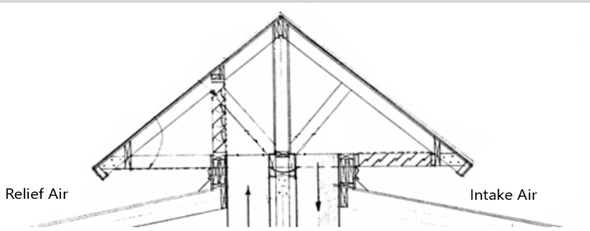

Figure 1:Current System, SBS West Ventilation Ridge

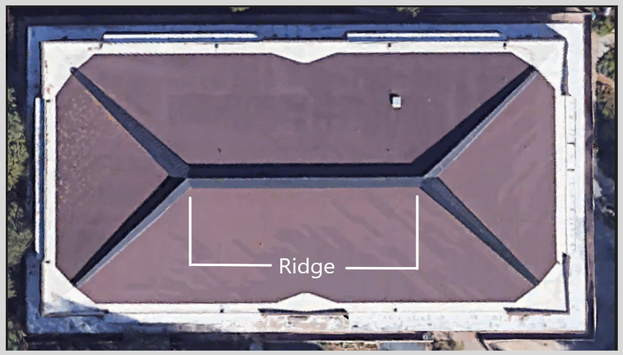

Figure 2: Aerial View of SBS West

Bio-Inspired Vent Designs

The bio-inspired vents incorporated difference aspects of nature into the design. These aspects included the Fibonacci sequence, a pinecone, a termite mound, and a flower.

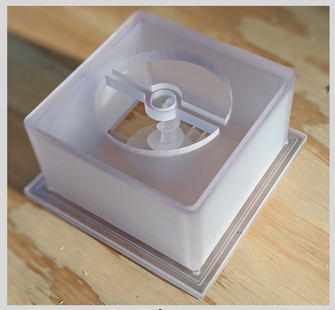

Figure 3: Fibonacci Vent

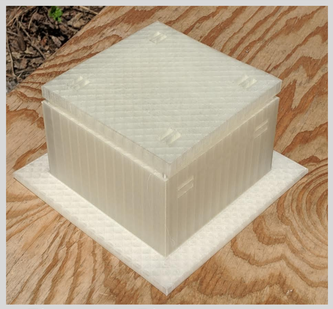

Figure 4: Pinecone Vent

Figure 5: Termite Vent

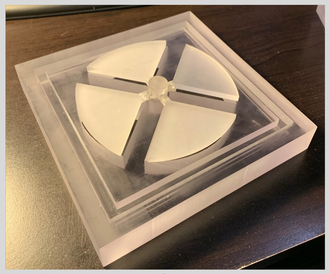

Figure 6: Flower Vent

Testing Method and Setup

1. Seal pressure chamber and set trap door release
2. Attach air pump to pressure chamber valve stem
3. Start recording pressure values from Arduino sensor
4. Pressurize chamber to desired testing pressure
5. Actuate trap door relieving the pressure
6. Save and graph time vs. pressure data

Figure 7: Test Setup with Termite Vent in Test Position

Pressure Relief Test Results

The pressure relief testing compared the gauge pressure versus the time it took for each vent to relieve the pressure in the chamber. Based on the results, each vent produced performed similar to each other when relieving the pressure.

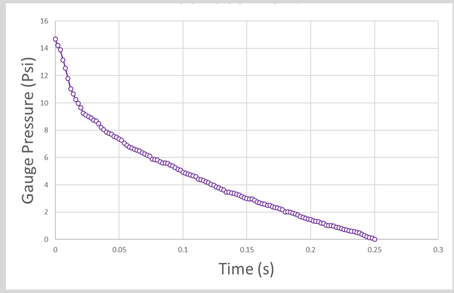

Figure 8: Fibonacci Vent Test Results

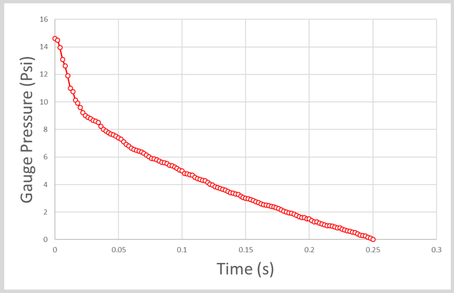

Figure 9: Pinecone Vent Test Results

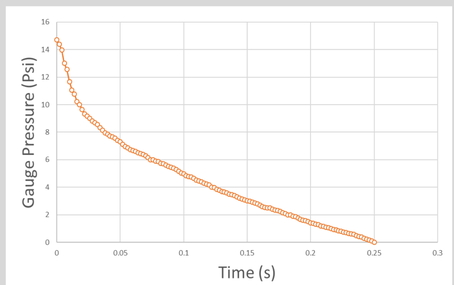

Figure 10: Termite Vent Test Results

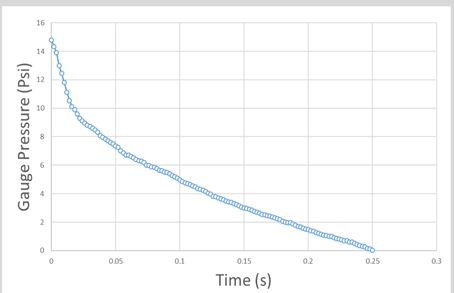

Figure 11: Flower Vent Test Results

Final Design

- To replace SBS West ventilation ridge on roof
- Solar collection
- Bio-inspired vents
- Increase energy collection
- Increase pressure relief
- Vent sits in the ducts that attach to the ridge replacement structure

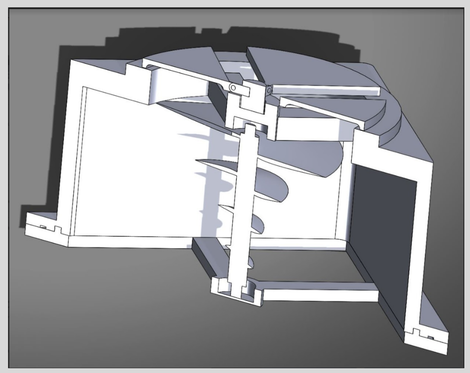

Figure 12: CAD model, section cut view, of Final Vent design, Combination of the Flower and Fibonacci Vents.

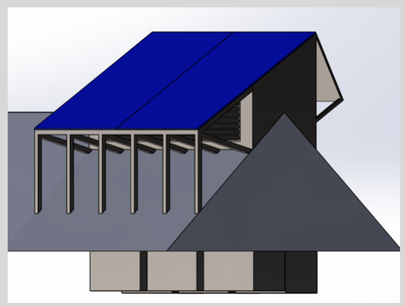

Figure 13: CAD of Ridge replacement structure with Solar Panels, Sitting on Roof.

Future Work

- Create an implementation plan
- Replace current HVAC system
- Energy and cost analysis of solar implementation
- Perform a feasibility study of replacing the ridge

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