To: Dr. Trevas and Class Aides

From: Bio-Inspired for Energy Efficiency

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Subject: Prototyping Summary

The final step of the semester was to create a prototype for a subsystem to represent or understand it further. The prototype for this project comes in a few different forms. First a physical model was created to understand how to amplify the movement of a smart material to open and close vents. Secondly, a code (matlab script) was written to calculate the venting and recirculating needs of the building based on the pressure and temperature of the air being relieved. Finally, the prototype of the housing unit was constructed in solidworks in order to understand the load distribution and deformation that will occur due to the load.

Proof of Concept: Smart Material Amplification

In Appendix A, figure A.1 the proof of concept model displaying smart material deflection amplification can be seen. This model was created to better understand how a smart material could be used as a vent actuation device for the vents that will be installed. This process needs to be researched more but the mechanical actuation design proved that it is possible to amplify the displacement of the smart material through the use of levers and mechanical advantage.

Proof of Concept: MATLAB Code for Ventilation

In Appendix B, the code which was created to find the percentage of return air, pressure needing to be relieved, number of SBS West current vents, and number of BEE vents is given. This code allows for the team to understand and visualize how the outside temperature impacts inside temperature and pressure. The code may seem simplified but this is due to a large amount of assumptions having to be made, along with most derivations of the equations used being done by hand. The computer model (or prototype) allows the team to better understand where improvements can be made and what other analyses need to be done.

Proof of Concept: 3D Rendering of Housing and Structural Analysis

In Appendix C, figure 1 and 2 display the front and back views of the housing created in solidworks. This housing was constructed and iterated upon until it met the needs of the team and client and was then considered to be a final hypothetical model or a prototype. In the figures shown the displacement of the housing can be seen as a 6ft snow load is applied directly to the housing unit. This proved to be satisfactory by the client and plans to iterated the design next semester to reduce materials used and cost of the housing were discussed.

Conclusion and Future Prototyping

All of the prototypes generated allow for a better understanding of the system which the team has designed. Providing insight non what can be improved and what may not work the way the team believes. Moving forward the Team plans to create higher quality prototypes, such as an Alpha and possibly Beta Prototype. However, due to funding being scarce at the moment (which a search for sponsorship is still underway), the team must stick to low cost prototyping and computer generated prototyping.

APPENDIX A

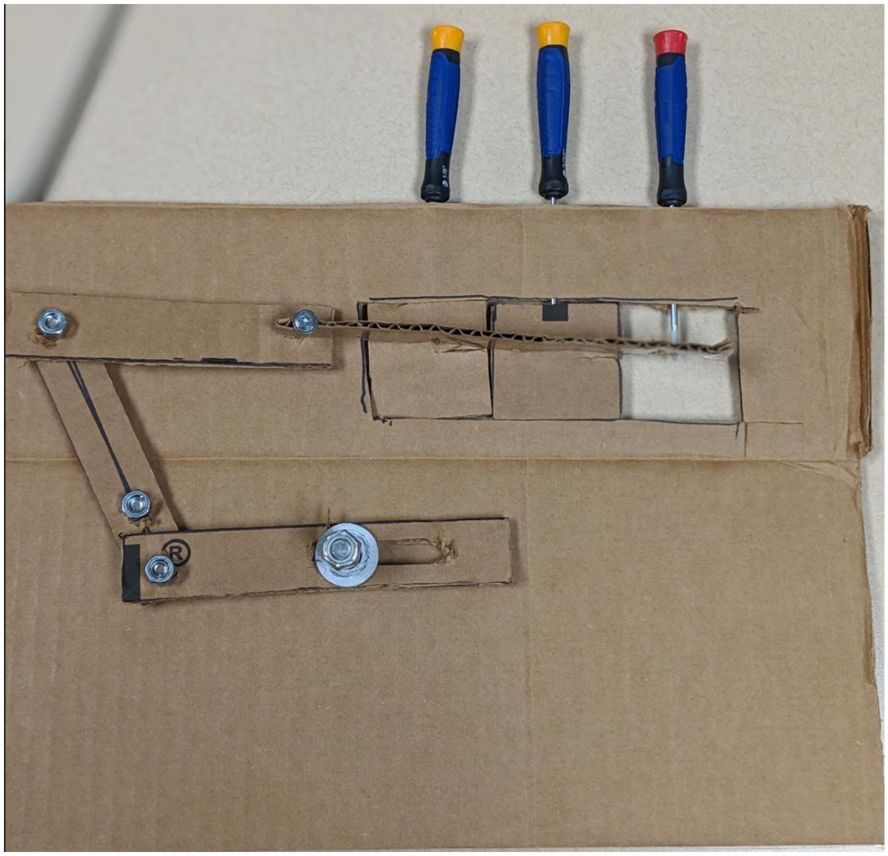

Figure A.1: Proof of Concept Prototype of Vent Actuator

APPENDIX B

```
Q = 9.438949; %m^3/s flowrate
P_atm = 78.22; %Atmospheric pressure at 7000 ft
P_1 = 1.5 * (P_atm);
A_c = 0.16908; %Surface area of the current relief vent
A_bee = 3 * A_c; %Surface area of the vent designed
A_p = 9.51446; %Area of Plenum
T_1 = (72-32)*5/9; %Temperature of air after HVAC
T_3 = (78-32)*5/9; %Temperature before in Plenum
p = 0.93820; %density of atm at 7000 ft
R = 0.2871; %kJ/kg*K
prompt = 'What is the air temperature in degrees F';
T_inf_i = input(prompt);
T_inf = (T_inf_i-32)*5/9;
if T_inf > -2 && T_inf < T_1
    T_4 = T_1;
    x = (T_4-T_3)/(T_inf-T_3);
elseif T_inf >= T_1
    x = 0.9;
    T_4 = T_inf*x+T_3*(1-x);
elseif  T_inf <= -2
    x = 0.1;
      T_4 = T_inf*x+T_3*(1-x);
end
y=(1-x)*100;
T_3m = T_3 * (1-x);
P_r = p*R*T_3m;
v_r_air = (2*(P_1-P_r))^(1/2);
A_r = A_p/v_r_air;
N_c = A_r/A_c;
N_bee = A_r/A_bee;

fprintf('Percent back of relief air %f',y)

fprintf('Pressure need to be exhausted %f',P_r)

fprintf('Number of current vents needed to relieve excess pressure
%f',N_c)

fprintf('Number of B.E.E vents needed to relieve excess pressure
%f',N_bee)
```

APPENDIX C

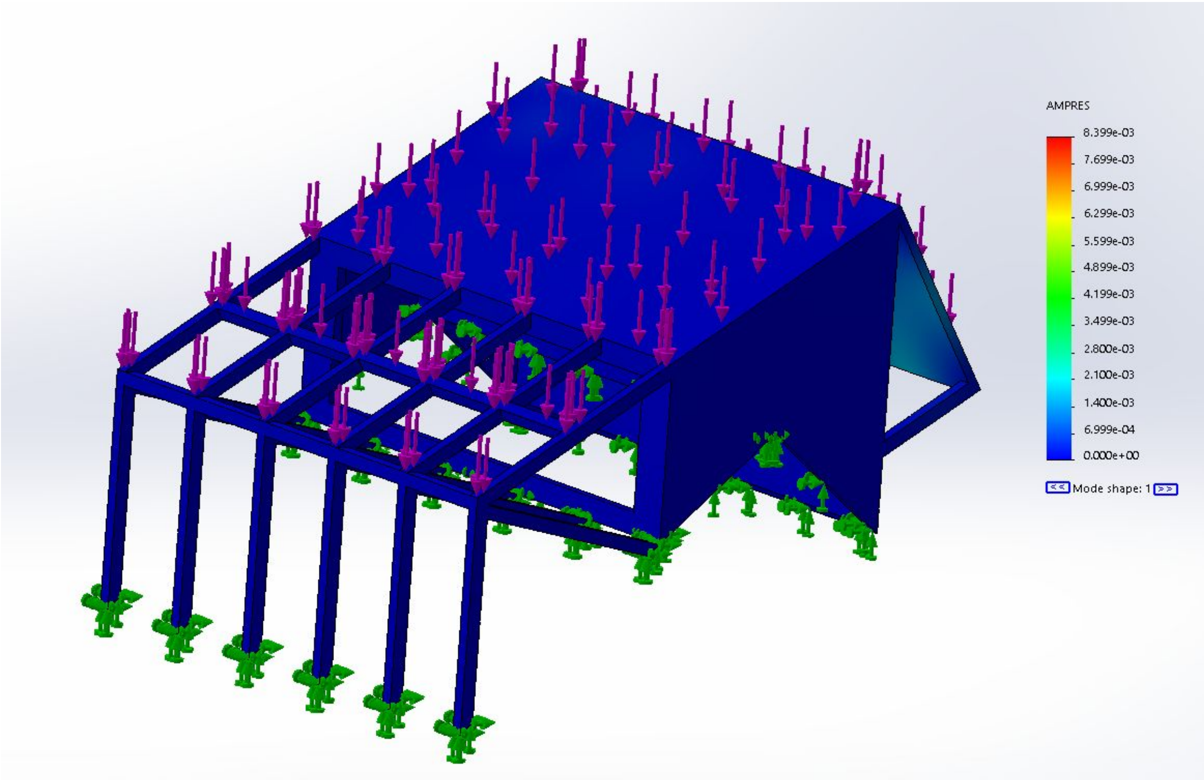

Figure C.1: Front (South) View of Stress Distribution of Snow

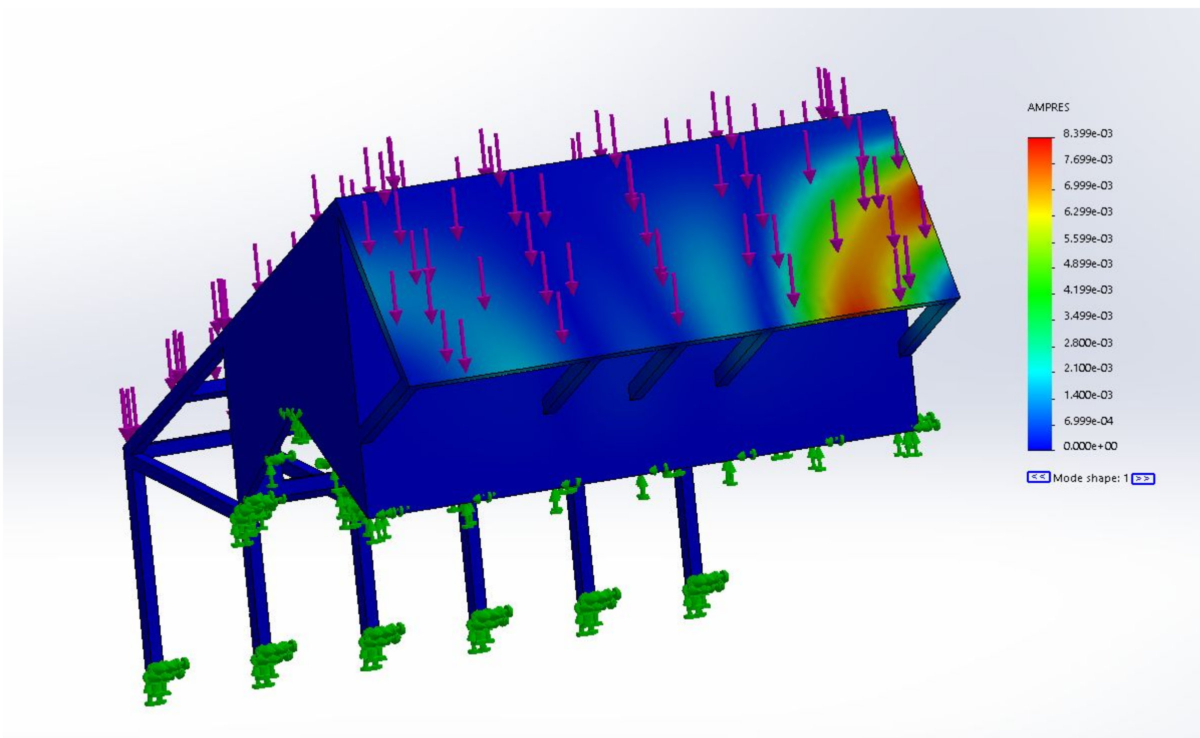

Figure C.2: Back (North) View of Stress Distribution of Snow