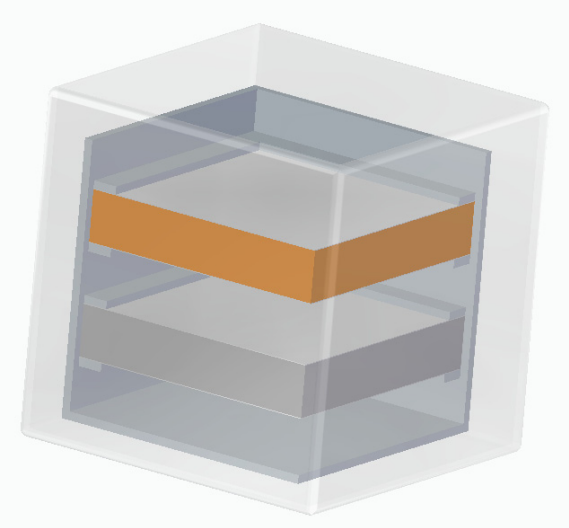
The effects of vacuum of outer space on space structures (from IFF 361)



APPLICATION FOR SPACEFLIGHT

Cubes In Space Research Balloon 6 - 2020

ABOUT US

The school

The San Felipe Neri Institute is a school located in the city of Buenos Aires, Argentina. For over fifty years, the institution has been devoted to educating Argentine youths in all their levels of education: Kindergarden, Elementary, Middle and High school. Instituto San Felipe Neri has been a pioneer in the incorporation of cutting-edge pedagogical methods, currently incorporating numerous technological resources for the development of STEM subjects.

The Team

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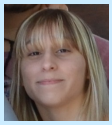

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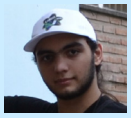

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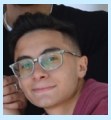

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The effects of vacuum of outer space on space structures

Hypothesis

If the vacuum is high then the structure warps due to the variations of the internal tensions of the structure.

The independent variable is the low-pressure produced by the vacuum of outer space in an altitude of about 30 km, and the dependent variables are the thickness and shape of the panels.

Experiment Purpose

Our proposal is to design and build two different “sandwich” structures with aluminum and two different types of internal material (foam and composite material) in order to determine the best structure that can resist the effects of vacuum of outer space, measuring the deformation on the structure thickness.

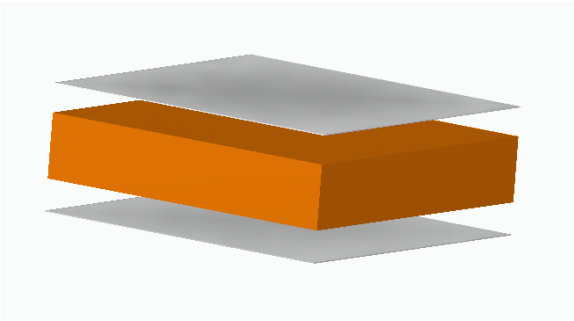
Experiment Description

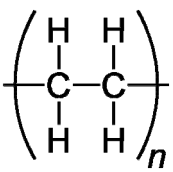
Sandwich structures are characterized by being made up of several layers of different materials, with different properties. These materials are joined by an adhesive hence the study of their properties is complex.

Inside of the structure there are holes which could contain air held at the pressure and temperature in which the structure was built. In the space vacuum, the air contained within will put pressure on the inner layers of the structure. If these layers are not rigid the structure will deform.

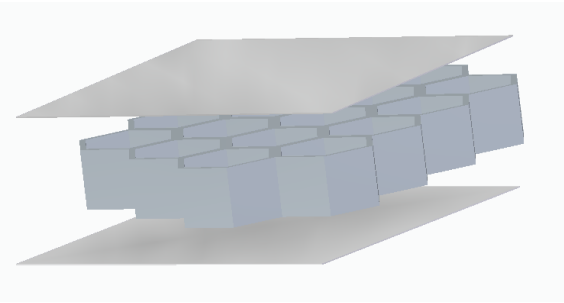
We will build two different sandwich panels, one with polyethylene foam and the other with a honeycomb structure made of PLA (Polylactic acid) using a 3D printer.

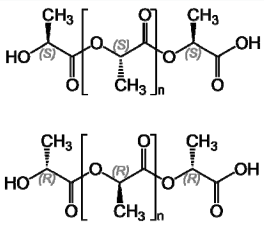
A





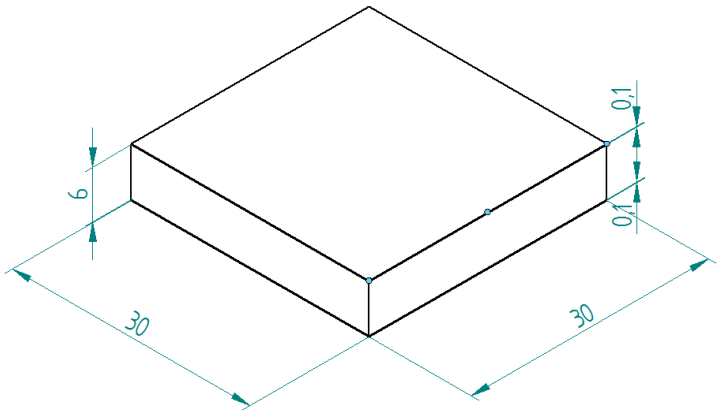
B



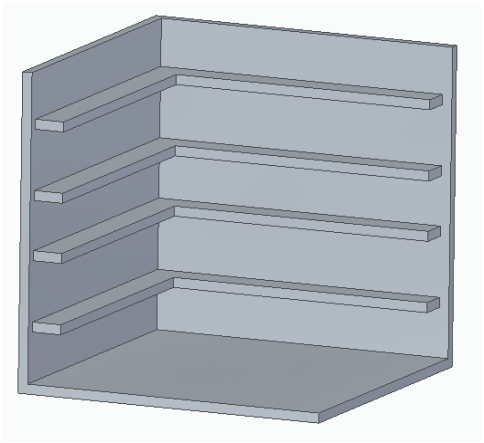


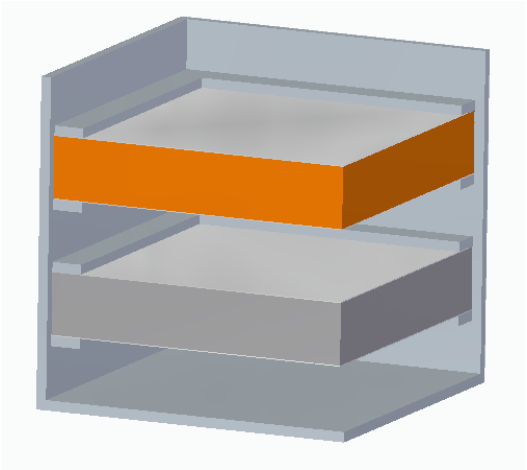
Sandwich structure using polyethylene foam (A) and Polylactic acid honeycomb (B)

The foam structure will be adhered with silicone glue to the aluminum plates of exactly 30 x 30 mm.
The honeycomb structure will be printed in PLA on a 3D printer in an exact measurement of 30 x 30 x 6 mm, then the 0.1 mm thick aluminum plates will be adhered with epoxy glue.



After they are built, they will be mounted on a PLA support printed with a 3D printer. These structures will be added to said support using epoxy glue following this configuration:





A double-sided tape will be placed on the outside of the support to fix the experiment to the flight box.

The **estimated weight** of the experiment will be 25 grams.

Pre-Launch Experiment Materials

Experiment:

- Thin aluminum sheets (0.1 mm)
- Polyethylene foam
- 3D printed honeycomb structure
- Support built with PLA
- Silicone based glue
- Epoxy glue
- Double-sided adhesive tape

Tools:

- Scissors
- Cutter
- Digital scale

Pre-Launch Experiment Directions

1. Cut four (4) aluminum plates into 30 x 30 mm squares.
2. Cut a polyurethane foam plate into a 30 x 30 mm square.
3. Cement the aluminum plates with the foam, using silicone glue.
4. Cement the aluminum plates with the honeycomb structure, using epoxy glue.
5. Let the structures dry for 24 hours.
6. Bond the structures to the support using epoxy glue.
7. Let the structures dry for 24 hours.
8. Verify alignment and integrity. In case of discrepancies, redo everything from point 1.
9. Store the experiment in the transport box.

Integration procedures

1. Remove the experiment from its packaging.
2. Set the base of the support to the bottom of the cube using the double-sided tape.
3. Close the cube.

De-integration procedures

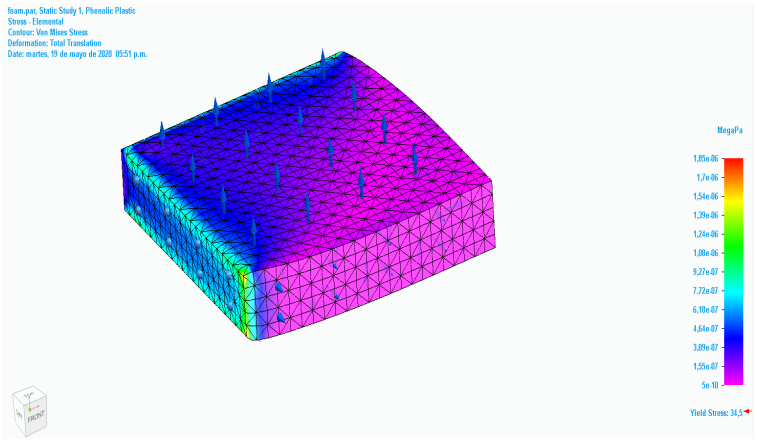
1. Open the cube.
2. In case the experiment needs to be taken out of the cube, mind the added tape at the bottom of the structure. Mishandling could result in the alteration of the experiment.
3. Place in the transport box.

Post-Launch Experiment Directions

1. Perform a visual inspection of the components, verifying their integrity.
2. Photograph the structures attached to the support.
3. Using a caliper, measure the deformations produced in the structures on the three axes.
4. Document in a spreadsheet and calculate the differences.

Analysis Plan

The connection to the space-based problems is the study of the deformation that supports the spaceship and the payload. In outer space, the environment is in an almost perfect vacuum condition. In these circumstances, the structures could warp.
The best way to study these variations is to perform a test in a real balloon. On Earth, vacuum machines are far too small for structures of this magnitude. It is quite difficult to design a hardware that reacts to these conditions the same way a balloon at 30 km.
To get an approximation of the behavior of the structures in vacuum conditions, we performed a simple simulation using the finite element method (FEM), to see the expansion of the set in the conditions of outer space



Once the experiment is finished we will see the deformation of the structures and evaluate improvements in construction, as well as improvements in the materials used and the method of adhesion.

Communication Plan

Sandwich structures can be an excellent alternative for the construction of light weight structural assemblies or skeletons of larger structures, including the possibility of further applications in the construction of mechanisms and buildings.
We work in coordination with the Aerospace Technology Group, dependent on the National Technological University, which provide us with advice and facilities.
All the work done is being documented from the beginning. In addition to the photographic record of each student, a collaborative blog and an informative video, we will prepare a final document to be presented to the educational authorities of the school and the University.
We also hope to be able to hold talks at educational establishments in Buenos Aires, relating our experience to inspire other students to participate in CiS 2021.

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