CU Senior Design Spring 2019

EcosySTEM ARTS: Designing a STEAM Toy for Patients at Children's Hospital, Colorado

Test Report

Team #6

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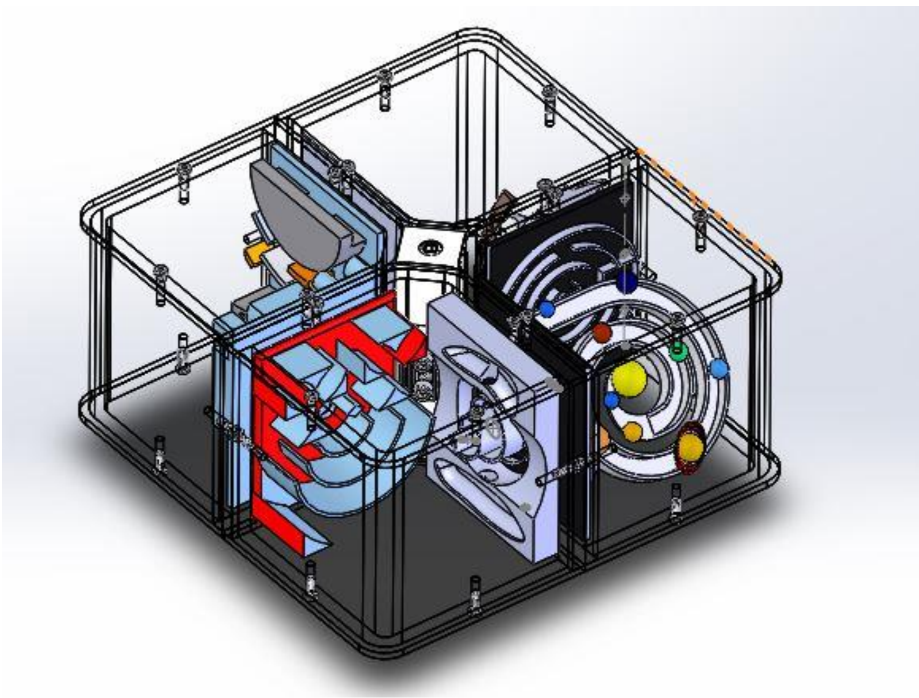
1. Redesign Overview

The Educational and Interchangeable STEAM 3D Maze is comprised of four adjoining polycarbonate cubes. The cubes are made of bent quarter inch polycarbonate and lids of eighth inch polycarbonate, fastened with 6-32 screws threaded into the walls. The outer 'window' of the cube has one 90-degree bend and the interior 'wall' of the polycarbonate contains two 135 degree bends. Each cube is fastened to the center interlocking component, made of 8020 extruded aluminum and Delrin caps. This design provided support from the interlocking component as well as from the adjoining cubes. All interior maze components are completely contained and protected within the polycarbonate cubes. The 8020 Aluminum, polycarbonate walls, and fasteners were all chosen to insure an industrial and strong design.



2. Mechanical Testing

This toy design had four cubes that all interacted with one another. This meant the structural integrity of the toy was dependent on the strength of the polycarbonate cubes. In order to know how strong, the cubes were together, we needed to test how weak they were individually. Thus, we heat treated our stock ¼" polycarbonate and bend two halves into the general shape of our professionally bent cubes. We attached the two bent halves together using steel fasteners and set the testing material in an Instron to perform a compression test. This compression test would describe at what force and deformation the polycarbonate cube would fail. This cube version would not have all walls, windows, and lids so it would not be as supported on all sides by material. This means the failure point for the testing material would theoretically be even less than the actual value that would cause compressive failure in our product.

We needed to test the compressive failure of our outer toy components to ensure the toy would not break when introduced to the hospital setting and when children interact with it on a daily basis. If any of the outer components fail, then this would be a major safety concern and the toy would not be able to be in the hospital. If any components on the inside break, this is fine since they are replaceable and can be repaired by the user. Thus, the failure mode of the toy's cubes was incredibly important to find.

a. Results

With the testing cube ready for compression, we completed compression testing. We crushed the cube using an Instron and recorded the results. Figure 1 demonstrates the process of testing, including the initial position, first material failure, final stage of compression, and complete material failure of the polycarbonate cube.

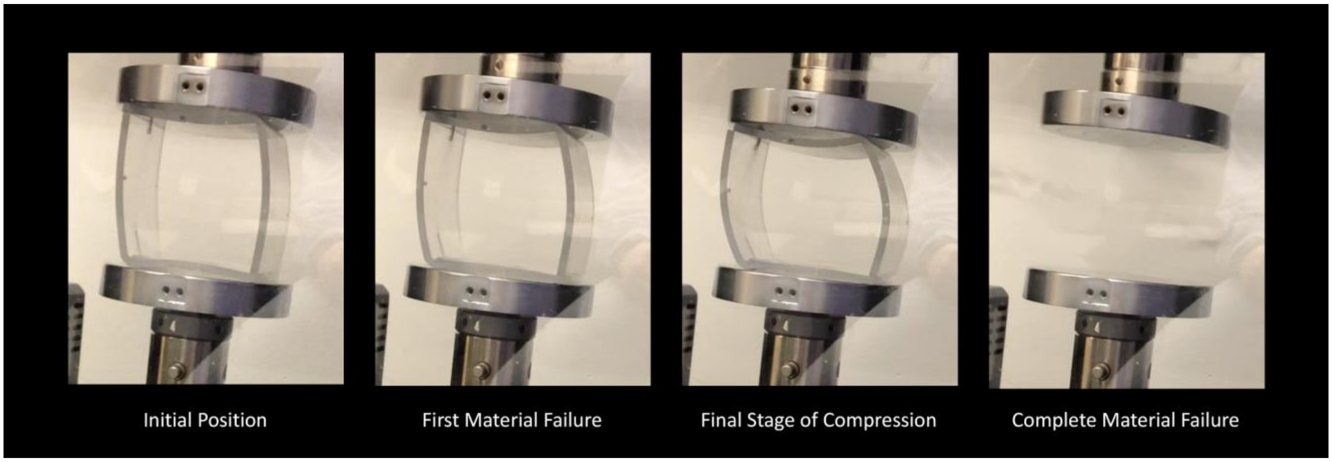


Figure 1: Setup for cube compression test and different stages of compression until final failure.

The data we collected during the testing phase enabled us to create a visual of the load versus deformation that the cube withstood. Figure 2 show this graph. The steady slope at the initial part of the graph demonstrates the elastic region of the polycarbonate material, where the material itself stores the energy from compression and does not have any permanent material deformation or failure.

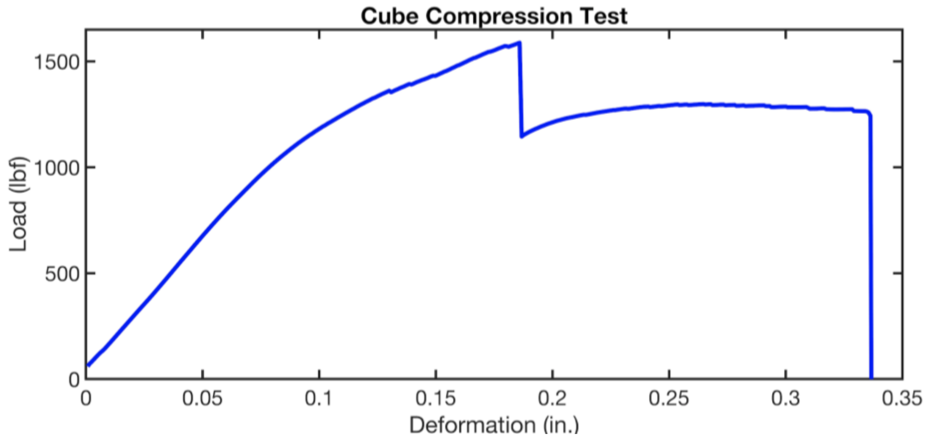


Figure 2: Load versus deformation of the polycarbonate cube.

The first material failure occurs at the peak, at around 1600 lbs. The polycarbonate fractured but still held its shape. The shape recovered some force and then the whole testing cube broke apart and flew off the Instron at around 1200 lbs.

The forces that finally caused failure are far larger than any force a child would be able to apply. A force of 1600 lbs. is about the weight of an Angus cow. This is a force that could only be applied by a said cow or machine, not a child. Thus, we are confident in our polycarbonate cube design and its structural strength and overall integrity. We would be comfortable introducing this to a hospital environment.

3. User testing

An essential part of testing for this project is user testing. Since we are making a toy, it was important for us to be able to talk to children about our current designs. Our client works at the Horizons K8 school in Boulder, so we were able to bring our prototypes to his classroom quite easily. We took our first fully functioning prototype to the kids to see what they thought and to get some constructive criticism.

The main comments we received after bringing this design to the school were; it is too heavy, make it easier to hold, add more colors, and add more 3D 'stuff' in the cubes. The kids were also bothered by how difficult it was to get onto the mazes. In this design the ball often was caught on the edge of the maze and would roll back and forth instead of jumping up onto the maze.

We took these comments and used them to make the design changes elaborated in the Redesign Test Report.