April 11, 2021

Dear Mr. John M. Vassiliades P.E.,

I would like to thank the PECG for the great honor of receiving the James E. Roberts Award 2021 for my science project called Safer Shakes. I am so happy that my question about the shape of houses and their stability in earthquakes was of interest to them.

I was born to British parents and live here on the San Andreas Fault Line in Southern California. Earthquakes were a new experience for them when they arrived here but, for me, they have always been in my life. I also live in a geodesic dome house and, when an earthquake does occur, I can almost feel how the plates have shifted: Sometimes it's a jolt, sometimes a rattle, and sometimes it's like being on a wave. I found out that our house is based on the architectural designs of a man called Buckminster Fuller, and that his dome house is supposed to be relatively safe in an earthquake. All of this information and experience made me curious about the strength of different shapes of buildings.

I undertook some research on the strength of shapes in nature, geometrics, and buildings. I found out that the circle, and therefore the sphere, is the strongest structural shape: The reason for this is because stress is distributed evenly. Even though the circle is the strongest structural shape, triangles are incredibly strong too; you can put a lot of pressure on the vertex on the top and the stress is distributed equally across the base. Crosslates are used in cube and rectangular prism buildings to stiffen, structurize and strengthen the building. Brunel Trusses are also used in structures such as stadium roofs, to strengthen the structure and make the forces distribute to the strongest point. What I found really interesting, after researching shapes, was my house. My house contains four hexagons, and each hexagon contains six triangles next to each other so I hypothesized that it must be very strong. It seems that nature also really likes hexagons for their strength, for example, bee honeycombs, insects' eyes and basalt columns!

I decided to test how different shapes of house models hold up under earthquake conditions. I built ten house models: two consisting of all squares; three consisting of all triangles; and five combined of triangles and squares. I also made a homemade shake table to test my house models on. My hypothesis was that a dome house would survive earthquake motion with less damage than other shaped structures. I thought this because a dome house has lots of triangles. My findings did indeed support my hypothesis. Houses made mostly or entirely of squares did not hold up very well at all resulting in complete or near complete collapse. Houses made mostly or entirely of triangles were much stronger, sometimes not showing any damage at all. An interesting model was the triangular prism. When the triangle was along the shake direction it did well but, when the square was along the shake direction, it did worse in terms of damage. Perhaps my findings will influence architects, local government and town planners, structural and civil engineers, the Building Standards Commission and executives at the National Institute of Standards and Technology (NIST).

From a very young age, I have always been interested in buildings, to the point of making my own dirt cement at age two and building with homemade sand bricks, bits of wood I found and even old rebars. I really enjoyed researching this project, constructing the different models, and testing out my ideas. I feel very proud to have had my work and curiosity recognized by the PECG with this award and I am inspired to keep on investigating stronger and more earthquake-resistant housing. I am planning to become an architect, structural or civil engineer later in life.

Sincerely,
Francis Lawton
Saint Timothy School