Kenny Arnold 4/20/11
IP Thesis

Tetra: Shelter for those in need.

Introduction

Tetra couples research on disaster management with my interest in structural modularity. I have created rapidly deployable, economical, modular, collapsible, water-proof, and adaptable shelters for people who need to escape disaster. Tetra also comes with a detachable awning that also doubles as a temporary protection from the elements. The purpose of this awning is two fold. Its first function is to provide shade and provide covering for someone wishing to inspect the outside without getting their head. The second function is its ability to detach and act as an umbrella of sorts to provide protection from the rain.

When Tetra's awning is extended it can overlap the awning of another Tetra to provide a physical connection between tents and additional protection from the elements. The reasoning behind the desire to attach tents comes from the psychological phenomenon known as a "coping response". All humans have an innate ability to persevere through terrible circumstances using the power of will. Having a community to rely on strengthens this ability. With the presence of a neighbor and a friend your collective coping response increases and you lower your vulnerability drastically

By empowering the community's collective "coping response" together they can move towards recovery.

Tetra is a three-sided pyramid, a tetrahedron. In order to empower the people who are living in a disaster zone, I designed a tent that can accommodate many scenarios: It offers maximum mobility to give its users people the option of leaving and finding a new place to live, it is walls can be customized, its modular to allow people to connect to one another, and it is rapidly deployable so that it can be set up as fast as possible.

Historical Background

When disaster strikes, communities are torn apart, infrastructure crumbles, and individuals become victims. To compound the issue, disasters tend to occur in areas where there is, poor infrastructure, high levels of illiteracy, and sometimes extremely violent conflicts i.e. Haiti, Indonesia, etc. Experts in disaster risk management, like anthropologists, architects, sociologists, and geographers, have determined that by addressing communities affected by disaster in terms of vulnerability (Bankoff, Hillhorst, Frerks 18), they can then reach more manageable goals to help rebuild and guide recovery.

Based on my research on disaster relief there is a strong need for the enabling of individual victims of disaster so that they can strengthen and rebuild their own communities. Historically, “relief” is a Western ideology and can be viewed as “imposing aid” and can alienate the relief organizations from the people they are trying to help. Even though relief is steeped in good intentions, Western aid workers are reputed to approach disaster-stricken areas with a biased idea that they a “universal knowledge” of how to solve all the problems-(Bankoff, Hillhorst, Frerks 26). Now there is a trend in disaster management to start from the bottom up and focus on the “local knowledge” from the people who live in the region affected

(Bankoff, Hillhorst, Frerks 28). Instead of issuing the orders, aid organizations now identify their role as an enabler to local groups, thereby enhancing their capacity to rebuild and recover. By using Tetra, shelters can be setup almost immediately by one person and create a semi autonomous system for setting up a camp. I believe that by giving people the option of taking their shelter with them, Internally Displaced People camps could get smaller and recovery might even happen faster as people move away together in an effort to rebuild their lives.

Origins of my inspiration.

In my studies through the School of Art and Design, I have explored my growing fascination with modularity and collapsibility. In my first advanced studio, entitled "Paper Engineering," I created a series of cubes that popped-up out of a square, as well as a modular building-block friction-fitting system inspired by nature. In a class entitled "More with Less" I developed a portable kitchen designed for disaster relief, and within that project, I created a cooking grill for an open fire and designed a self supporting chain link structure that could roll up into a smaller footprint when not in use. I subsequently invented a modular toy that uses balance and gravity to develop spatial intelligence and creativity in children earlier than existing building block toys on the market. These examples demonstrate a trend in my overall work and help explain why I have chosen to develop a tent that is modular and collapsible.

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Applying Research

As discussed in both Healing Communities in Conflict and Mapping Vulnerability: Disasters, Development & People- there is an innate human resilience to traumatic experiences that psychologists label as a "coping response" (Bankoff, Hillhorst, Frerks 37). It is an individual's ability to reduce stress and anxiety in extremely tense environments. In a community that has experienced a natural or manmade disaster this ability is multiplied by the amount of people undergoing the same experience then distributed over their collective empathy. I therefore designed a shelter system that strengthens people's emotional connection through physical attachment to their family and friends.

Since people are inherently mobile it made sense to me to create a shelter that you can take with you.

Buckminster Fuller was a prolific engineer, architect, designer, thinking and philosopher. He coined the word "tensegrity" by combining tension and integrity (Fuller 283). He realized that tension and compression cancel each other out to create extremely strong and stable units. Coupled with his search for the simplest building block in nature he found the tetrahedron. Inherently stable and structurally sound, the tetrahedron is the simplest three-dimensional geometrically shape possible. If it had one less line it would cease to be a 3D shape. (Fig.1). Using this shape, I have developed a large-scale tetrahedron that collapses into a very small bundle of poles.

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Form Development

The process that led me to my final form began by researching the tension structures of Buckminster Fuller and Kenneth Snelson. Kenneth Snelson and Buckminster fuller were pioneers in tensegrity structures, used the same tension-compression principles to create sculpture (Fig. 2) and shelter (Fig. 3). Fuller used tensegrity to create his geodesic dome, while Snelson used tensegrity to create towering and cantilevered sculptures.

I began by modeling my tent on my "Paper Engineering" collapsing cubes, but when I created large-scale models I could see that a flat roofed shelter would collect water. The form was overly complex and solving a need I didn't mean to focus on. After abandoning the pop-up designs I began redesigning with a scale tension modeling system created by Kenneth Snelson to measure equal tension with rubber band, paper clips, and straws. (Fig. 4) Once I settled on the tetrahedral shape I physically prototyped successively larger models while addressing issues in previous designs.

Using two paper clips on both ends of the rubber band, I hooked one paper clip on one end, stretched the rubber band through the straw to hook the other paper clip in on the opposite side. This method can determine if your structure adheres to the principles of tensegrity. If so, it can be scaled to any size provided the tension and compression components are proportional in size and strength.

In creating a large-scale prototype, I need to overcome a few issues. While my straw model demonstrated that the tension and compression was at equilibrium I could not use straw and rubber band for a better prototype. Instead cPVC piping, bungee cord, and hooks were used. The result was a large version of my rubber band model with more accurate materials.

At this point my shelter used six PVC poles. Three formed a bottom triangle for the base and three formed the walls and the point at the top. After some revision I removed the bottom three poles and used the compression of the top three poles along with the fabric tension to create a tensegrity tent that used half the amount of compression members as before. Once I tested out a large-scale prototype I discovered that the PVC lacked the density to resist the necessary loads but it fell under its own weight. By pitching the poles with stakes, the tent worked as if it were not under any loads at all and extended to its full length. While this was a success I needed to switch to metal compression members so the tent could stand on its own while being under the same loads.. To remedy this issue I changed the material of the compression members from cPVC and PVC to zinc plated steel conduit tubing, the conduit still is staked so it does not become a kite in the wind. In addition to tubing the final material used for protection against the elements is waterproof nylon that is light- weight and backed with PVC. Inside the conduit runs a bungee cord with two hooks at each end. One hook links to the other hooks to form the point of the tetrahedron, and at the other end each hook attaches to the nylon through metal grommets that bring overlapping flaps of each triangular wall together. Because the bungee links all of the components and since the conduit is attached to each wall by Velcro sealed sleeves, the compression and tension between the nylon and the conduit achieves Tensegrity.

In the process of creating this Tetra, I moved away from the earlier iteration that used a hexagon. Both tents are modular, the hexagon because of its inherent geometry and Tetra's ability to attach to another Tetra by overlapping their detachable awnings.

The former hexagonal tent had bungee cord threaded throughout the array of tubes to provide the tension for it to stand up, by comparison Tetra uses bungee cord to create tension as well, except it is not threaded throughout the entire structure. Instead each tube has a single chord of bungee strung through it. The final design uses less material and is cheaper to make while being more robust and simpler to make and set up. As opposed to the flat roof of the hexagonal tent, the peak of the triangular profile leaves no doubt that water to slide right off. Additionally this tetrahedral tent stands fully erect on it own and just requires stakes just to remain resistant to wind. The structural integrity of Tetra has been proved by its ability by to withstand winds strong enough to blow over telephone poles, rain, and snow (Fig. 7-15).

Other Models of Innovative Shelters

In my research I have studied other designs for shelters that assist in the rebuilding of communities. One is called LifeLink (Fig. 5 -6) It is not a tension structure but rather a vacuumed-sealed inflatable unit that can lightly attach to other units to reestablish community. It is good in concept because it can be rapidly deployed like mine however it does not seem possible for it to deflate once inflated. Furthermore it is only a concept not an actual prototype. This shelter validates my belief that a tent can have a greater purpose than to simply be a roof over ones head. In contrast here is another solution implemented right now and they have even housed over a third of Haiti's population: Shelter Box. Shelter Box is a brilliant solution that comes contained in a green plastic tub. Inside are a large geodesic dome, blankets, toys, first aid supplies, and cooking supplies. While Shelter Box does not offer modular features and shelters many more people than Tetra is designed for, one person can set up Tetra and Shelter Box requires a team. The families that occupy a Tetra can choose to move their homes if they're surroundings are not safe. Shelter Box ingeniously packs vital equipment like cooking equipment, blankets, and first aid supplies into a single package. Because Tetra is a pre-assembled tent ready to be deployed rapidly, if blankets and other important supplies that are not too bulky are left in a Tetra when it is collapsed and stored than Tetra too can come prepared with useful items to aid survival. Tetra also features a removable skylight that can be unvelcroed to adapt to a condition where it might be ideal to cook inside. The walls of Tetra, zipper together to allow easy customization, a family can switch in an additional door instead of an additional window wall it can be installed by them wherever they are by zippering it in.

Conclusion

Tetra is an extension of my interests in collapsibility and modularity. Right now it is in its prototype phase of development but the design of Tetra is not material specific. In the future I would like to experiment with sustainable materials like bamboo and oiled skin to add sustainable to Tetra's growing list of features. By changing the materials Tetra can be built locally from combinations of materials that meet the requirements of tension and compression. Now that my shelter has proven its ability to withstand rain, snow, and extreme wind I plan on taking it with me as I travel in Australia and elsewhere in the coming year.

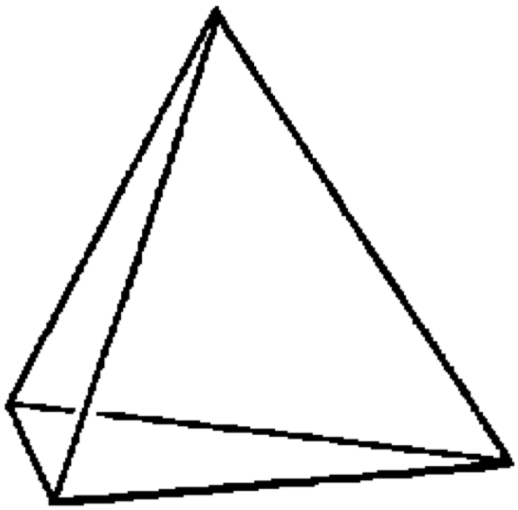


Fig. 1

Dragon, 2000-03
stainless steel
30.5 x 31 x 12 feet
9.3 x 9.5 x 3.65m

Fig. 2

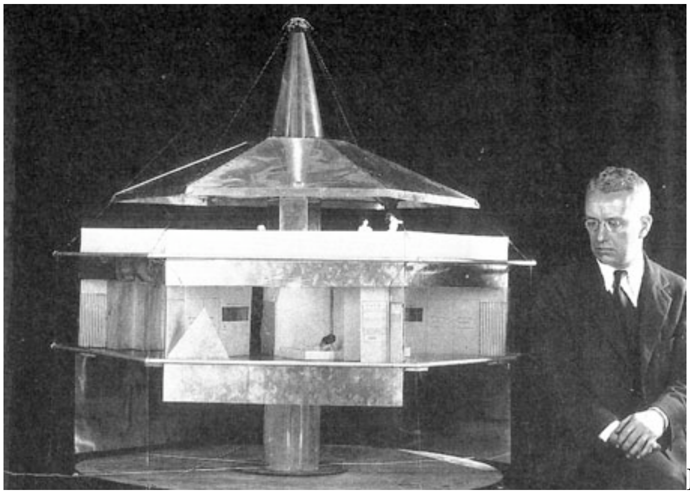
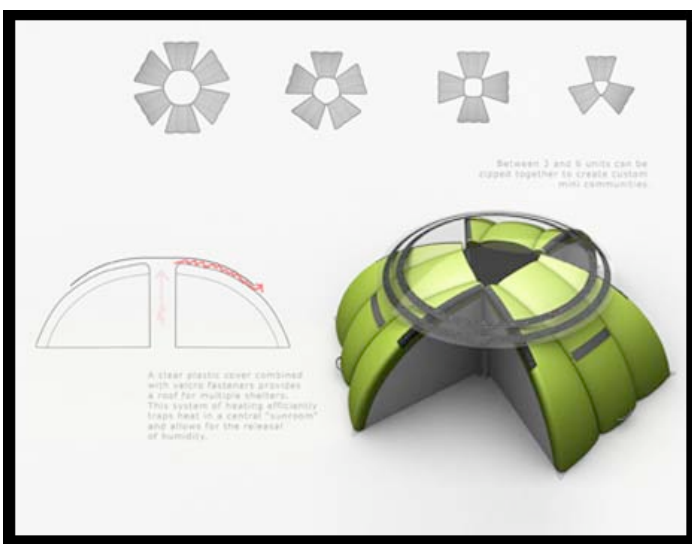


Fig. 3

Fig.4


Between 3 and 6 units can be zipped together to create custom mini communities
A clear plastic cover combined with velcro fasteners provides a roof for multiple shelters. This system of heating efficiently traps heat in a central "sunroom" and allows for the releasal of humidity.


C 1000 denier nylon walls
D Zippered flaps for attaching multiple units.
A
Apx. Dimensions:
height 7'
depth 9'
widest 8'
narrowest 5'
The unit is manufactured and vaccum packed allow-ing for compact storage and easy deployment in the field.
The package is simply cut open and the soft shell expands. The side poles are erected and corner stakes put in place. Zip-pered flaps connect mul-tiple units from top to bottom and keep out moisture.
Between 3 and 6 units can be zipped together to create custom mini communities.

Fig 5-6

Fig. 7-15

Works Cited

Ashmore, Joesph. *Tents: A Guide to the Use and Logisitics of Family Tents in Humanitarian Relief*. United Nations Publication. Print.

Bankoff, Greg, George Frerks, and Dorothea Hillhorst. *Mapping Vulnerability: Disasters, Development, and People*. Earthscan Publications, 2004. Print.

Fuller, Richard Buckminster, Arthur L. Loeb, and EJ Applewhite. *Synergetics: Explorations in the Geometry of Thinking*. Macmillan Pub, 1982. Print.

Heartney, Eleanor. *Kenneth Snelson: Forces Made Visible*. Har/Com ed. Hudson Hills, 2009. Print.

Maynard, Kimberly A. *Healing Communities in Conflict*. Columbia UP, 1999. Print.