FASCINATING HABITATS

Chuck Henderson, a US inventor has developed a shelter system called Conics. Niranjan Mudholkar finds out more

One of the most important factors that make mountain ranges like the Himalayas endure weather's highs and lows for such a long time is their shape – their multiConic form. Fascinated by this phenomenon, Charles Henderson, a US inventor, decided to utilise it for creating a new shelter system called Conics using plywood.

It makes a lot of sense to learn from nature. In fact, that's how the human race has survived and progressed, by adapting nature's methods. That's how humans have learnt to build homes. Mr Henderson explains the advantage of the multiConic form in nature's context, "This form is very efficient at handling and disbursing high wind loads according to our empirical studies. Intense wind tends to reinforce the multiConic structure by creating resultant downward forces on all surfaces. Examinations of established mountain ranges like the Himalayan (Asia), Brooks Range (North America) and others show the same multiConic form being the most lasting of geologic geometries. Mountain ranges shaped primarily by erosion, wind, rain, snow and so on (rather than tectonic uplift and shifting) migrate to the multiConic form as the multiConic geometry seems to use the forces of nature to reinforce itself."

The first assembly of the Burning Man Conic built in 2002

Sierra Range Mountain: Nature uses the multiConic geometry in the formation of mountain ranges

The inventor of Conics

Charles E Henderson, known as Chuck Henderson to his local community located near Pt Arena, California, US, is the patent holder of the multiConic design (US Patents 4,794,742 and 3,990,208). He says, "After building several dozen Conics, mostly in California and the Pacific Northwest of the United States, I've realised that Conics are well suited to provide low-cost and permanent shelter to poor and disaster-stricken communities. Conics may be especially suited to tropical and sub-tropical climates where non-structural walls can be made of local materials or be simply omitted. Of course the same multiConic geometry can be used to create professional finished structures for residential, business and industrial applications in any climate." Conic Shelters is seeking investors to explore and develop the many potentials of multiConic geometry. For more information, log on to www.fishrock.com/conics or contact directly at chuck@conicshelter.com

Simple and economical

Conics hold a lot of promise due to their simple method of construction that costs very little and provides good shelter. So, how did it all begin? Was this the only form with which the inventor experimented? Mr Henderson discovered Conics while researching and experimenting with fundamental geometric forms and their structural qualities. He also tried rectilinear structures, partial spheres, hypar (hyperbolic paraboloids) structures and so on. “All shapes were fair game. In retrospect, although I was building and experimenting with many geodesic forms, I guess the challenge was to ‘think outside the sphere’. But I kept the basic architectural vision of pursuing the most shelter for the least material and labour investment. The goal was to create a shelter system that was both economical and very easy for unskilled labour to build,” he informs.

Structural characteristics

One wouldn’t expect a simplistic structure like Conics to display any special features. However, its structural characteristics are quite surprising. Mr Henderson explains, “Although most of our data is empirical, it appears that Conics exhibit perfect live load distribution characteristics. Wind and other loads appear to be disbursed with remarkable efficiency. If hit with a point load the Conic shell absorbs and rebounds like a trampoline. After working with these structures it becomes obvious that even a powerful earthquake would have great difficulty causing any permanent deformation, let alone failure of the Conic form.”

The Conics resemble the roof. What about the walls? Mr Henderson answers, “Because Conics sit on a tripod structure, the roof is self supporting – not requiring any exterior walls to support the roof. Walls, if any, are therefore non-structural and can be built from any material.” That really is a unique system.

Building method

Conics combine structure, sheathing and roofing in the simple plywood shell. The construction process is relatively simple. Plywood panels (120 cm x 120 cm) are bolted together using an 80 mm overlap. The resulting shell is a continuous sheet of plywood. The plywood shell exhibits bending and other characteristics not normally associated with a single sheet of plywood. When the multiConic shell is erected the plywood almost wants to move into the multiConic geometry. The surface material is non-toxic acrylic elastomeric which provides a longlasting roof.

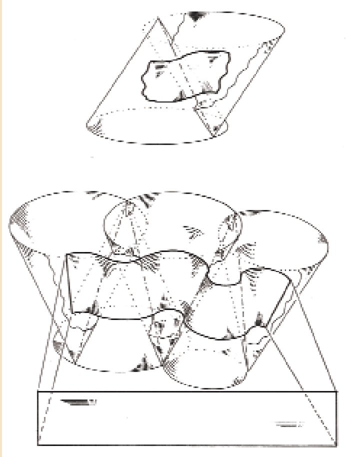
The cone shape itself has its benefits. Mr Henderson clarifies, “Cones have a unique three-dimensional shape because they can be made to unfold and lie flat without distorting the surface geometry. Conversely, properly designed flat materials can be easily curved into multiple cone shapes without distorting the surface geometry. Construction techniques where fabrication and assembly occur simultaneously are therefore possible.”

Advantage Conics

We have seen the ‘natural edge’ of the conical shape. Of course, it has many advantages over traditional structures. The construction details of erecting a Conic are so simple that even

The geometry

The simple cone shape most closely approximates compound curvature (curving in all directions) while at the same time being made of two-dimensional flat materials. Multiple regular and inverted cones can be nested into a hexagonal geometric pattern making the multiConic structure. Maximum efficiency of the multiConic form appears to coincide with a hexagonal pattern of mutually tangential regular and inverted cones. Mr Henderson provides some interesting information about the geometry, “MultiConic geometry uses cones with a top angle of approximately 97 degrees. This particular angular geometry allows for the primary shape of all components that make up the shell surface to be square or rectangular – thus minimising the materials (and waste) while building a Conic. And this angle happens also to be the exact diagonal angle of the great Cheops Pyramid in Egypt. So if the Cheops Pyramid were to be spun on its axis so fast that it blurred into a cone, the top angle of that cone would be the same as the primary cone used in all multiConic forms. This 97 degree angle also corresponds to the angle of repose, a geologic term that describes the angle that mountain slopes migrate to as they naturally decompose as a result of wind, rain, snow and temperature fluctuations."



MultiConic Patent drawing: Flat surface material can be easily curved into the multiConic form. The new curved surface translates from one cone to another at the tangent line where adjacent cones touch

A small team of unskilled workers constructing a large Conic

CMYK

children can help without any training. Several Conics have been erected and then disassembled for later use. The plywood does not maintain its curvature so a Conic, disassembled forms a neat stack. Preliminary calculations indicate Conics have the lowest 'embodied energy' of any prefabricated structure. The Conic shell is flexible and can move and deform out of its natural position by 300 mm or more without failure. After a shock wave or other flexure the Conic shell quickly returns to its original position.

Proposed Kalani Resort Meeting Hall designed for Hawaiian environment. As Conic walls can be constructed from any non-structural material, here a lightweight glass window treatment has be proposed

Burning Man

A computer model of the 1000 sq ft Conic that was built at the Burning Man celebration at the Black Rock Desert, Nevada. Assembled by unskilled labour this structure was erected in less than two days. The annual art extravaganza known as Burning Man, a Nevada desert celebration of Americans and participants from around the world, has hosted two Conic Shelter pavilions in recent year. This "Butterfly Formation" provides a dramatic vault opening and a free standing peak or 'horn' at which no tripod supports are required. This very lightweight structure covers an astounding 1000 sq ft and has withstood 70 mile per hour wind and dust storms without any visible deflection. Under these severe wind conditions the Burning Man Conic Shelter apparently creates high pressure zones on the leeward side where no wind is perceived. On the windward sides, wind vectors were apparently dispersed upward with great efficiency. The wind loading observed during major wind events appeared to be working to reinforce the multiConic integrity although the mechanisms that perform this phenomenon are not clearly understood.

Of course more studies and tests will have to be made. But experiments so far have been heartening as Mr Henderson says, "I have not met an environment where the multiConic geometry has failed. Even differential snow loads (up to 1.5 ft) have not affected the structure. Of course more experimentation and engineering studies will reveal the limits of the multiConic geometric form." These will perhaps substantially establish Conics as an important shelter system.

Adaptability: One of the important tests for any new system is its adaptability with existing materials. Conics have been very promising on this front as well. Mr Henderson explains, "Conic Shelters made with ferro-cement applications have provided very strong results. Some have suggested using sandwich panels of foam and wire mesh to create the multiConic form ready for spray cement, fibre-crete or other thin-shell type applications. These have not been tested but may prove promising for large structures."

Why plywood?

Plywood and almost all sandwich materials made via cross-lamination have phenomenal shear and tensile strength. Mr Henderson explains, "Because these materials develop even more strength when they are curved we can bend plywood to support both convex and concave curvatures. Conics use plywood to form a true shell, rather than a tensile or "hung" structure. The tensile and compressive characteristics of plywood allow us to achieve unsupported curves that move both inward and outward (concave and convex) along the surface of a Conic. Interconnected cone segments can propagate to create unlimited architectural variations while at the same time maximising the utility of thin, flat shell materials like plywood or other sandwich panels. MultiConic geometry forces all loads into tension and shear elements of the shell components. For this reason, and others, plywood is an obvious best choice for the primary construction material." Plywood (both wood and bamboo) is now made with relatively non-toxic marine glues. So any health hazards posed by plywood are minimal. The most negative aspects of plywood are health hazards during manufacturing. Workers are subjected to fine particles of wood and glue. This is by reference the most challenging environmental aspect of Conic manufacturer.

Has any other material option being tried? Mr Henderson informs, “We are investigating many other laminate materials, primarily bamboo and hemp, as alternative ply components. Although a full sized Conic using bamboo has yet to be constructed, our preliminary evaluation indicates that bamboo plywood (plyboo) will be far superior to traditional plywood materials. And because bamboo grows so quickly in a sustained fashion, we anticipate plyboo becoming the primary material for Conics in the near future.”

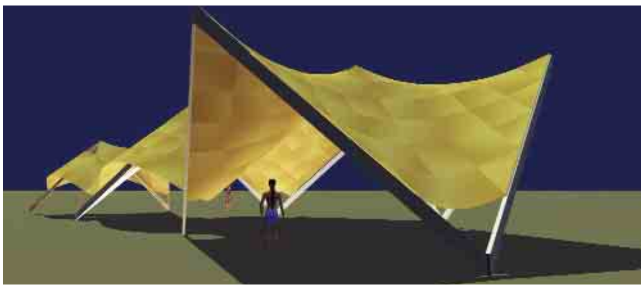
Practical use

Since the first Conic Shelter was built in 1974 approximately 30 structures have been built. Existing structures are primarily used for simple, small footprint, residences mostly in Northern Coastal California. After several Conics were built in the 1970s and early 1980s, Conic Shelters have gained the interest of several experimental builders. Ron Woolsey of Willits California has embarked on the most ambitious

Inventor’s desk in Conic, Circa 1974. Interior corners of Conic shelters easily accommodate rectilinear furniture

Conic Shelter project to date, a 2,500 sq ft structure with five vault openings and three interior horns or peaks made of three intersection inverted cones. By creating sandwich panels on both the inside and outside surfaces and then using these sandwich panels

Rendering of Ron Woolsey’s ambitious project in Willits California to be used as a pottery and design studio



Ultimate recognition

Awards and recognitions motivate inventors to improve upon their works. Though Conics haven’t won any official award as such, its ultimate recognition came from none other than Richard Buckminster “Bucky” Fuller (1895-1983) a US visionary, designer, architect and inventor, famous for his geodesic dome. In the words of Mr Henderson, “Perhaps the most satisfying recognition I have received came from R Buckminster Fuller. The geometry of Conic Shelters was an outgrowth of RB Fuller’s designs and philosophy. When I was lucky to meet with him in private and show him the simple Conic form he was very thoughtful and inspiring. After spending several minutes with his calculator he gave the Conic a hearty endorsement saying that he thought in many applications Conic Shelters would be more economical than the geodesic form. A high compliment indeed.”

as components in the building, it should be possible to build inexpensive Conic Shelters to cover stadiums and other large venues. The most promising use of Conics may well be in disaster relief. In these situations Conic parts can be air lifted to remote regions and a small team can be deployed to train the locals to quickly erect Conics for immediate habitation. With minimum tools and training unskilled labourers can create immediate shelters that can last for decades.

Basically, the multiConic shape provides for a generic shelter that can be used for almost any application. Emergency shelter, industrial, sports, office, residential, animal shelter, aircraft shelter, shop or other out building, performance halls, outdoor food processing facilities… the list is extensive.

The future

With multiple applications possible, the Conics shelter system certainly has great potential. Moreover, these applications would be possible with simple building methods, at low cost and at minimum environmental risks. Of course, they would also be durable. So what does the inventor feel about its future? Mr Henderson says, “As world resources become scarce and populations are forced to do more with less, opportunities to leverage intelligent design over wasteful design will begin to flourish. Hopefully Conics will take a role in this new world and new economy. I see Conic Shelters, with appropriate international funding, providing very low cost housing to every homeless family in the world.” A very noble thought indeed.