MEng Membrane Lightweight Structure

A MECHANICAL TENT DESIGN FOR DISASTERS

A Master's Thesis submitted for the degree of
"Master of Engineering"

supervised by
JURGEN HENNICKE

İSMAİL SARIAY

1028546

İZMİR, 23/11/2013

Affidavit

I, **İSMAİL SARIAY**, hereby declare

1. that I am the sole author of the present Master’s Thesis, "A MECHANICAL TENT DESIGN FOR DISASTERS", 91 pages, bound, and that I have not used any source or tool other than those referenced or any other illicit aid or tool, and
2. that I have not prior to this date submitted this Master’s Thesis as an examination paper in any form in Austria or abroad.

Vienna, 23.11.2013

Signature

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First of all I would like to express my thanks to our lecturers of our courses, whose experiences have encouraged us for designing elegant tensile fabric structures.

Secondly, I would like to thank to Jürgen Hennicke, who is my favorite pathfinder after Frei Otto, since I have stepped into the world of lightweights fabric structures in 1996.

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ABSTRACT

The most important problem is to built shelters for the disaster victims and urgent buildings like hospitals, crisis administration centers, schools, storages for the materials etc. after the earthquakes on the disaster sites.

In this thesis, it will be tried to find fast solutions for the need for housing of the victims. Because it takes time to build buildings for the victims using conventional constructions with reinforced concrete or steel structural materials. Waste of time can risk many people’s life in disaster conditions.

However, the most important outcomes of the earthquake are not only the damages in settlements, but also the damages at the transportation systems, electricity systems of the accommodation units and at the power plants and refineries.

Because of these reasons, this thesis aims to propose foldable, deployable or mechanical fabric structures in the case of “small tent” without the need for energy.

The advantages of such systems are, easy installation without special experts, portable feature, the ease of packaged and the ease of transport. Also, they are light to transport with helicopter or airplanes.

As a result the development of such systems will be useful in the earthquake disaster conditions.

Keywords:
foldable structures, deployable structures, tents, modular tents, mobile systems, mobile fabrics, modular systems, modular fabric systems, earthquake, origami

1.1 GOAL

Emergency shelter for disaster victims is the most important emerging problem after the earthquakes. The content of this thesis is to invastigate the possibility to meet this urgent housing problem in order to create a modular mechanical based small shelter in the case of “small tent”, which reguires minimum energy during the installation. On the other hand, this “small tent” should serve as many different functions due to its reproducibility property.

1.2 CONTENT

Construction of permanent campuses with sufficient infrastucture and activities for disaster victims will take time during the first few weeks after the earthquake.

But by the time the race starts from the first night. And practical structures will be needed for sheltering the wounded people, families and the relief teams and their equipments.

Under the conditions that may occur after an earthquake (conditions of roads, problems occured at the communications Networks and energy Networks, people exposed to disaster status) as an important proporty of an ideal type of such structures are prominent features include:

1. Lightness (to be established by several people)
2. The minimum energy use (if possible does not require any energy requirement)
3. Easy installation (requiring minimum professionalism and equipment)

Largest settlements based with necessary infrastructures can be quickly created during the next days with the help of reproducibility properties of such structures.

1.3 METHOD

The following steps were followed by the author in writing the thesis and in the collection of informations:

- Firstly, important concepts related to the subject will be explained.
- Literature survey about the background of the research topic will be handled.
- After establishing contact with the institutions dealing with earthquakes and earthquakes-aid, suitable systems and their potentails will be discussed.
- The existing systems used in various fields and the historical development of such systems will be invastigated.
- Giving direction to design and basic assumptions are described under the design criteria terms:

  1.Architectural design and functional diversity,

  2.Structural features,

  3.Easy installation, stroge and transportation feature,

1.4 DEFINITIONS

This chapter presents the definitions utilized in this thesis and explains, how they are defined in the literature:

SHELTER:"*Shelter is a habitable, covered living space. Sheltering is the process of providing shelter, involving non-food items and support. Sheltering is a continual process and requires monitoring.*

Shelter is not just a roof; For a space to be habitable, people living in it must have enough clothing, blankets, mattresses, stoves, fuel, and access to services such as water and sanitation.

People need shelter to keep healthy, safe and to help to retain their dignity. In emergencies, tents can help to provide for these needs in the following ways:

Health; Tents can protect people from external conditions such as rain, snow, wind, dust, sun and vector-borne diseases. By providing this protection, tents can help to preserve the health of those living in them.

Privacy and dignity; Tents provide a degree of privacy and help to maintain the dignity of people who may have recently lost everything.

Security; Although thin, a tent wall provides some physical protection, for example reducing the risk of theft, and a feeling of security among those living in the tent. Tent camps must have additional security measures established.

Livelihood support; Providing a tent can give people time to gather food and fuel, look after their children and conduct other essential activities."[1]

SETTLEMENT:*" A settlement is a community of covered living spaces providing a healthy, secure living environment with privacy and dignity for the people living within it.*

[1] **Ashmore Joseph** (2004: 4)

Shelter and settlement options for people who have been forced to move from their place of residence (displaced) are often different from those who remain near to their damaged houses (non-displaced).

Tents are one of the many shelter options available within settlements, particularly during emergencies. However, tented camps should be considered a last option as they may bring lasting problems."[2]

DISPLACED PEOPLE: *"After disasters, people will often have to move to an entirely new location. "*[3]

NON-DISPLACED PEOPLE: *"For non-displaced people, such as earthquake survivors, communities often remain intact and people may have access to their own land."*[4]

TENT: *"A tent is a shelter consisting of sheets of fabric or other material draped over, attached to a frame of poles or attached to a supporting rope. While smaller tents may be free-standing or attached to the ground, large tents are usually anchored using guy ropes tied to stakes or tent pegs. First used as portable homes by nomadic peoples, tents are now more often used for recreational camping and temporary shelters.*

Tents range in size from "bivouac" structures, just big enough for one person to sleep in up to huge circus tents capable of seating thousands of people.

Tents are used as habitation by nomads, recreational campers, and disaster victims. Tents are typically used as overhead shelter for festivals, weddings, backyard parties, and major corporate events. They are also used for excavation (construction) covers, industrial shelters.

Tents are often used in humanitarian emergencies, such as war, earthquakes and fire. The primary choice of tents in humanitarian emergencies is canvas tents, because a cotton canvas tent allows functional breathability while serving the purpose of

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[2] **Ashmore Joseph** (2004: 5)
[3] **Ashmore Joseph** (2004: 5)
[4] **Ashmore Joseph** (2004: 5)

temporary shelter. Tents distributed by organisations such as UNHCR are made by various manufacturers, depending on the region where the tents are deployed, as well as depending on the purpose.

At times, however, these temporary shelters become a permanent or semi-permanent home, especially for displaced people living in refugee camps or shanty towns who can't return to their former home and for whom no replacement homes are made available."[5]

"Tents are portable shelter with a cover and a structure.

A tent does not provide for all shelter needs. People living in tents must have access to suitable non-food-items. People must also have access to facilities such as water an sanitation. The shelter provided by a tent includes the area around it including drainage ditches and space for children to play in.

The primary priorit in sheltering people is to keep the immediate space around their body at a comfortable temperature, covered and dry. Clothes and bedding are the most critical parts of shelter. Tents provide a closed heatable space. "[6]

PORTABLE BUILDINGS:*"Portable buildings are those that are transported whole and intact. Sometimes they include the method for transport within their own structure (wheels, hull) and can be towed and carried. Howewer the dividing line between building and vehicle then becomes blurred, a few can be described as self-powered."*[7]

RELOCATABLE BUILDINGS: *"Relocatable buildings are those that are transported in parts but are assembled at the site almost instantly into usable built form. These are almost always carried but in a few limited cases may have part of their transportation system incorporated into their structure. The main advantages of this type are that it can provide space almost as quickly as the portable building without therestriction in size imposed by transportation."*[8]

DEMOUNTABLE BUILDINGS: *"Demountable buildings are those that are transported in a number of parts for assembly on site. They are much more flexible in size and layout and usually can be transported in a relativily compact space. They have some of*

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[5] Tents, Wikipedia, a free encyclopedia
[6] **Ashmore Joseph** (2004: 6)
[7] **Kronenburg Robert** (1995: 7)
[8] **Kronenburg Robert** (1995: 8)

the limitations that site operations bring to a conventional building and , depending on the size, complexity, and ingenuity of the system, are not as instantly available."[9]

PREFAB HOUSE:"*Prefabricated homes, often referred to as prefab homes, are specialist dwelling types of prefabricated building, which are manufactured off-site in advance, usually in standard sections that can be easily shipped and assembled. Some current prefab home designs include architectural details inspired by postmodernism or futurist architecture.*

The word –Prefab- is not an industry term like modular home, manufactured home, panelized home or site-built home. The term is an amalgamation of panelized and modular building systems, and can mean either one. In today's usage the term -Prefab- is more closely related to the style of home, usually modernist, rather than to a particular method of home construction.

-Prefabricated- may refer to buildings built in components (e.g. panels), modules (modular homes) or transportable sections (manufactured homes), and may also be used to refer to mobile homes. Although similar, the methods and design of the three vary wildly. There are two-level home plans, as well as custom home plans. There are considerable differences in the construction types. Mobile and manufactured houses are constructed in accordance with the HUD building codes in the U.S. while modular houses are constructed in accordance with the IBC (International Building Code).

- *Modular homes are created in sections, and then transported to the home site for construction and installation. These are typically installed and treated like a regular house, for financing, appraisal and construction purposes, and are usually the most expensive of the three. Although the sections of the house are prefabricated, the sections, or modules, are put together at the construction much like a typical home. Manufactured and mobile houses are rated as personal property and depreciate over time.*
- *Manufactured homes are built onto steel beams, and are transported in complete sections to the home site, where they are assembled.*
- *Mobile homes built on wheels, that can be moved."*[10]

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[9] **Kronenburg Robert** (1995: 8)
[10] Prefabricated Home, Wikipedia, a free encyclopedia (http://en.wikipedia.org/wiki/Prefabricated_home)

EARTHQUAKE:“*An earthquake is caused by a sudden slip on a fault, much like what happens when you snap your fingers. Before the snap, you push your fingers together and sideways. Because you are pushing them together, friction keeps them from moving to the side. When you push sideways hard enough to overcome this friction, your fingers move suddenly, releasing energy in the form of sound waves that set the air vibrating and travel from your hand to your ear, where you hear the snap.*

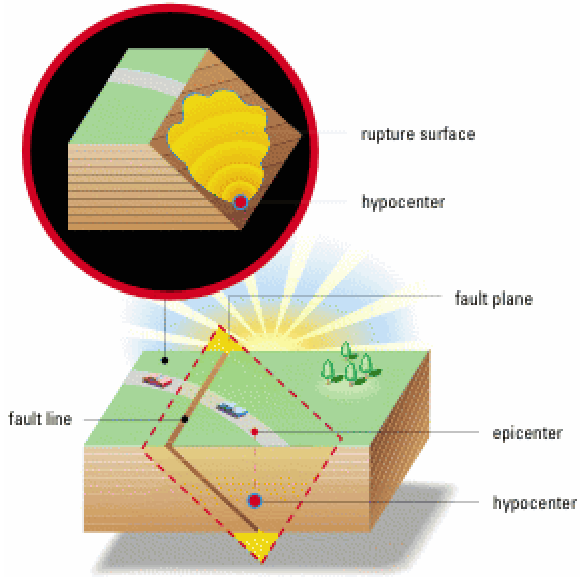


Figure-1, Earthquake

The same process goes on in an earthquake. Stresses in the earth's outer layer push the sides of the fault together. The friction across the surface of the fault holds the rocks together so they do not slip immediately when pushed sideways. Eventually enough stress builds up and the rocks slip suddenly, releasing energy in waves that travel through the rock to cause the shaking that we feel during an earthquake.

Just as you snap your fingers with the whole area of your fingertip and thumb, earthquakes happen over an area of the fault, called the rupture surface. However, unlike your fingers, the whole fault plane does not slip at once. The rupture begins at a point on the fault plane called the hypocenter, a point usually deep down on the fault. The epicenter is the point on the surface directly above the hypocenter. The rupture keeps spreading until something stops it (exactly how this happens is a hot research topic in seismology).”[11]

[11] http://www.earthquakecountry.info/roots/basics.html

“An earthquake (also known as a quake, tremor or temblor) is the result of a sudden release of energy in the Earth's crust that creates seismic waves. The seismicity, seismism or seismic activity of an area refers to the frequency, type and size of earthquakes experienced over a period of time.

Earthquakes are measured using observations from seismometers. The moment magnitude is the most common scale on which earthquakes larger than approximately 5 are reported for the entire globe. The more numerous earthquakes smaller than magnitude 5 reported by national seismological observatories are measured mostly on the local magnitude scale, also referred to as the Richter scale. These two scales are numerically similar over their range of validity. Magnitude 3 or lower earthquakes are mostly almost imperceptible or weak and magnitude 7 and over potentially cause serious damage over larger areas, depending on their depth. The largest earthquakes in historic times have been of magnitude slightly over 9, although there is no limit to the possible magnitude. The most recent large earthquake of magnitude 9.0 or larger was a 9.0 magnitude earthquake in Japan in 2011 (as of October 2012), and it was the largest Japanese earthquake since records began. Intensity of shaking is measured on the modified Mercalli scale. The shallower an earthquake, the more damage to structures it causes, all else being equal.

At the Earth's surface, earthquakes manifest themselves by shaking and sometimes displacement of the ground. When the epicenter of a large earthquake is located offshore, the seabed may be displaced sufficiently to cause a tsunami. Earthquakes can also trigger landslides, and occasionally volcanic activity.

In its most general sense, the word earthquake is used to describe any seismic even that generates seismic waves. Earthquakes are caused mostly by rupture of geological faults, but also by other events such as volcanic activity, landslides, mine blasts, and nuclear tests. An earthquake's point of initial rupture is called its focus or hypocenter.”[12]

[12] Earthquake, Wikipedia, a free encyclopedia (http://en.wikipedia.org/wiki/Earthquake)

2.1 HISTORICAL DEVELOPMENT OF THE PORTABLE STRUCTURES

The history of the shelter built with animal skins or woven materials is quite old in the history of mankind and architecture also.

The traces of such structures are to be found in villages of hunter-gatherer communities during the Upper Palaeolithic Period (40.000 to 12.000 years ago).

During the Soviet excavations in Puskari, Kostjenki, Timonnovka etc. found such constructions. Animal bones and tusks had been used for poles at these shelters. Their plans were in circle form with the diameter 5-6m. In Ukraine and Siberia had been found such *tents,* too.

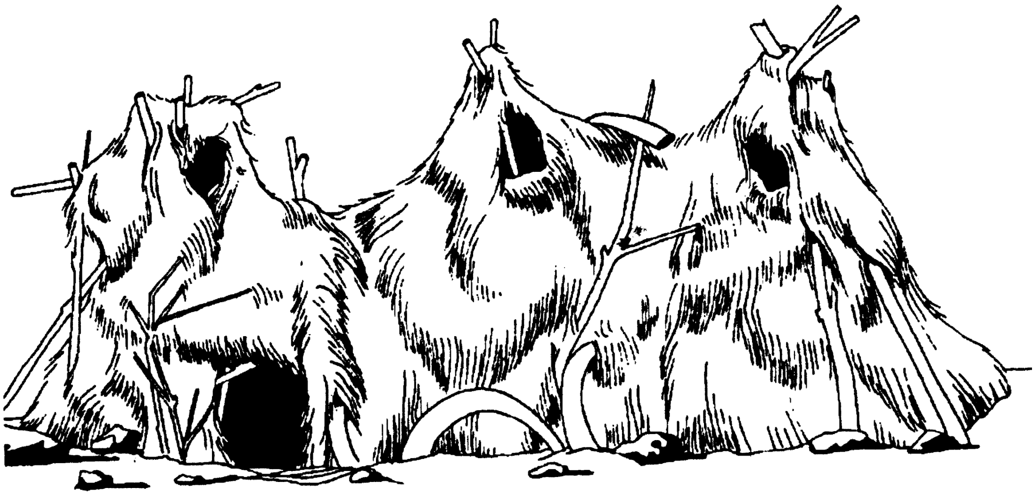


Figure-2, Reconstruction of tent from campsite discovered in Moldova, Russia, dated 40.000 B.C. animal bones and tusks were found which had been used for poles.

In Pincevent in the Seine Valley, Northern France has found traces of a shelter used about 10.000 years ago. The sizes of this portable shelter were approximately lived in 4,5 by 3m. and was constructed of wooden poles and covered with animal skins. It is estimated that used by hunters seasonally, between midsummer and midwinter.

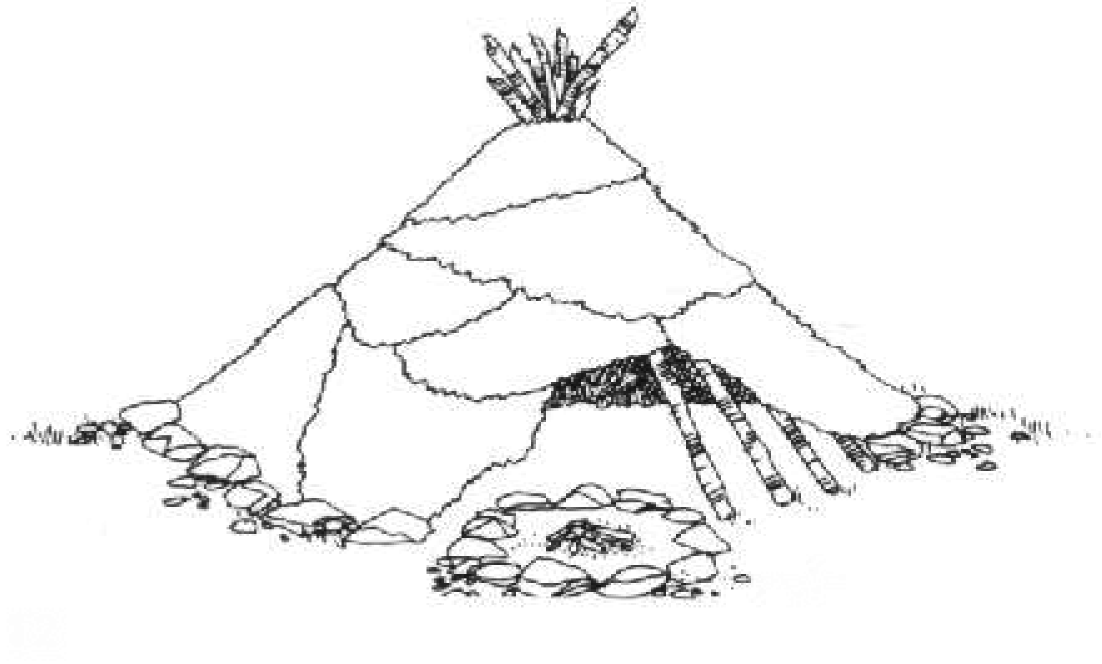


Figure-3, Reconstruction of 10.000 year old tent found at Pincevent in Northern France

Such portable shelters mentioned above has found so far chance of survival with the use of nomadic societies in the history. According a non-hierarchical observation, the main types of such demountable shelters are the tipi of the North American Indian; the tent structures of the desert nomad based primarily in North Africa; and the yurt of Asia.

"The Bedouin tent incorporates compressive struts and tensile membranes that utilise the same principles as modern tensile engineering systems. The North American tipi can be compared to a single cell of a space frame, adapted to use membranes without inherent strength (animal hides) and incorporating twin skin systems and natural air movement patterns for environmental modification. The Asian yurt uses modular manufacturing techniques and a geodesic-based wall structure that are familiar twentieth century constructional strategies. Contemporary portable buildings have a long and interesting pedigree, which includes principles that have been adapted into permanent construction."[13]

[13] **Kronenburg Robert** (1996: 1)

TIPI

For transport of the tipi of the American Indians served first dogs historically but than dogs were replaced by horses in more recent times.

Figure-4, Crow woman transporting tipi poles and covers. Bundles of ploels are attached to a horse, skins are drapped over its back.

The first step for the installation of tipi is drawing an egg-shaped oval plan on the ground. The entrances of tipis are always oriented towards the rising sun. The rear side of the tipi withstands the prevailing winds.

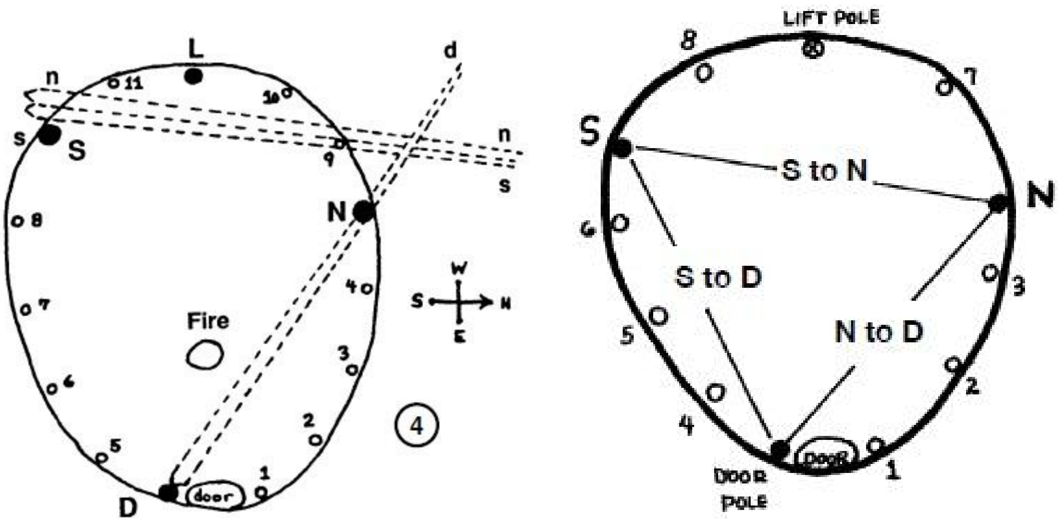


Figure-5, Groundplans of Sioux tipi

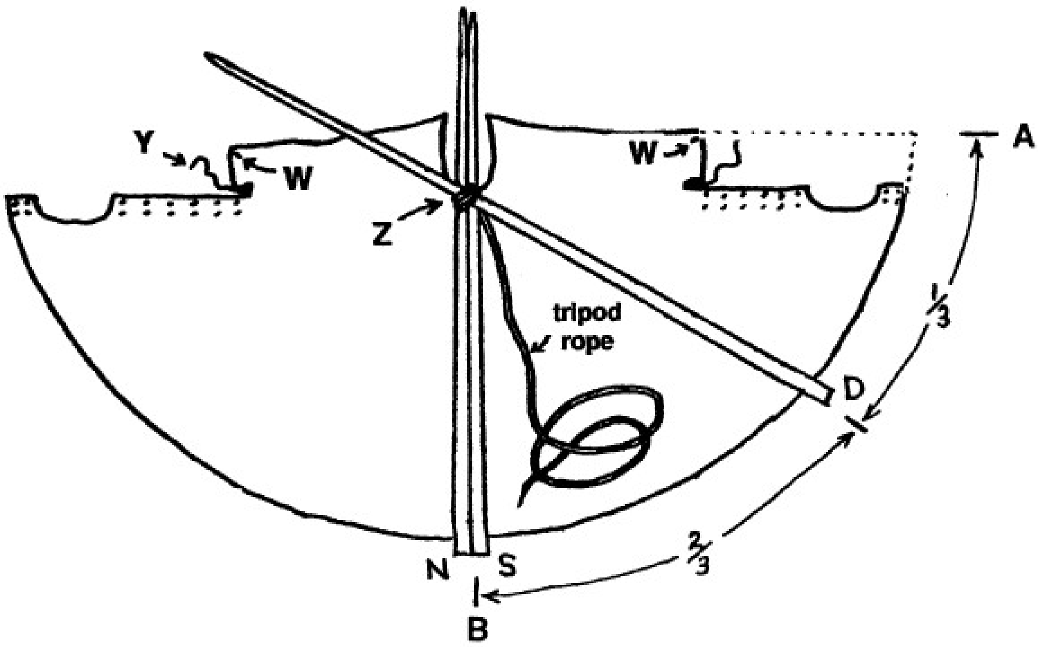
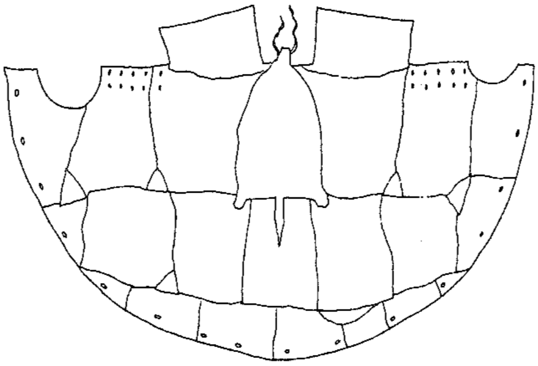


Figure-6, Ground Plan for the 12 & 14ft. Tipi Set up. Note that the 12' and 14' tipi set up requires only 12 tipi poles in the total framework.

First two or three poles are laid on the ground and tied near the top. After the poles are standed up, the position of their ground support points are adjusted to create the basic structural frame.

Figure-7, Women of the Blackfeet tribe building a tipi ca. 1900.

Historically, animal skins were the the first traditional enclosure, but replaced in recent time with woven canvas. The entire enclosure was made from eight to more than twenty buffalo skins. This was wrapped around the conical frame. Flaps at the bottom would function as doors, others at the top as ventilation units and wind guides.



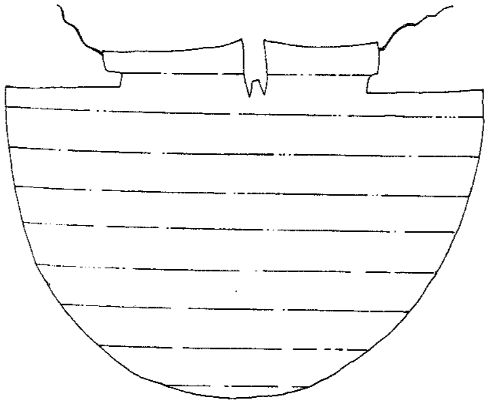


Figure-8, Patterning of buffalo hide cover **Figure-9**, Patterning of canvas cover

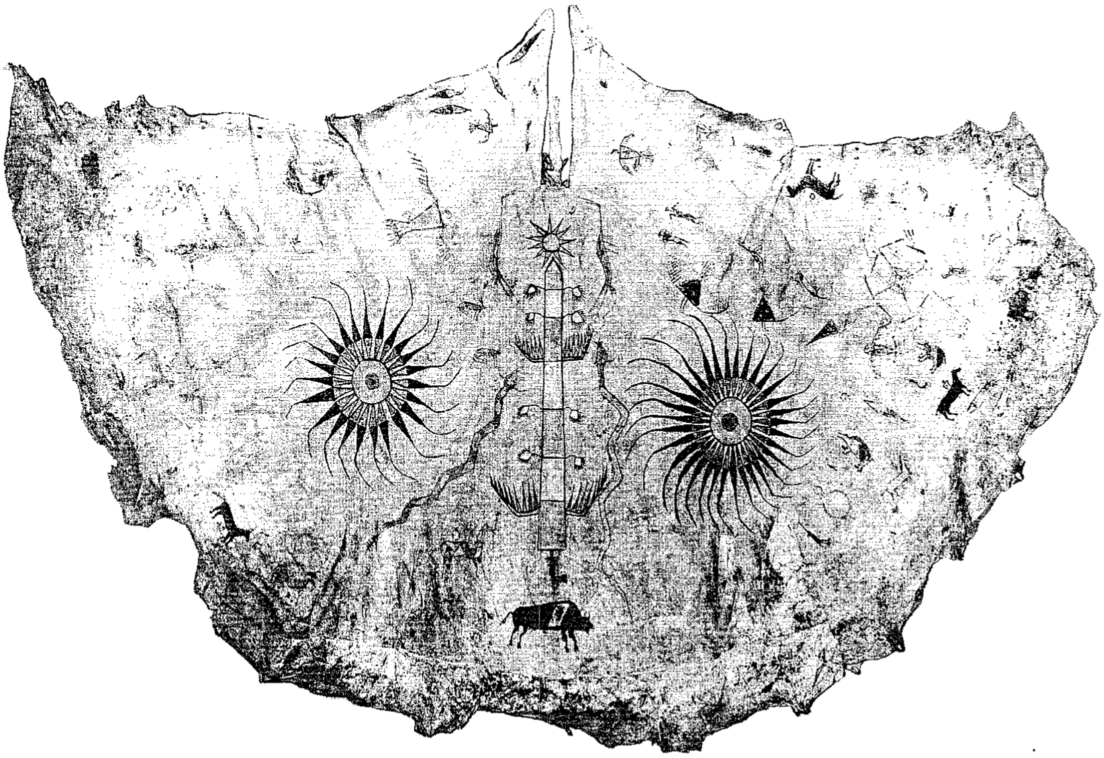


Figure-10, Sioux tipi cover with decorations. The large suns, here on the east and west walls, are feathered, because the Sioux believed the sun to be a bird which flies from east to west.

Tipis can be cooled on hot summer days by air flow creating between the skins, if bottom edges are been lifted up. The space between the skins is been filled in winters with dry grass for improving insulation.

In most Indian communities of central North America, the installation is the task of woman. They are the installer and the owner of tipis. The duties of men are the outside decoration and hunting.

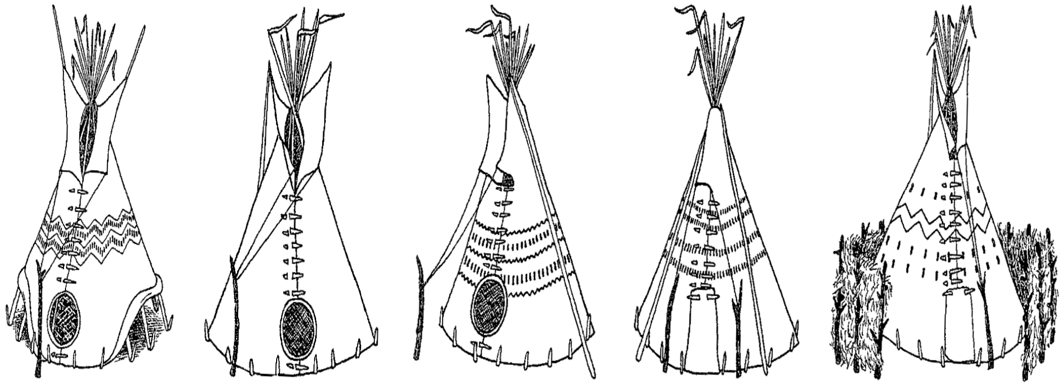


Figure-11, Although tipis were light, easy to put up and take down, they were comfortable housing units which could adapt to various weather conditions. The tipi could be closed up or opened, flaps could be adjusted to control wind and air flow, and a protective fence could be installed around the periphery in the winter. Insulation could be added between double skins and a fire could be lit.

NORTH AFRICA TENTS

North Africa tents are a relic in the traditional sense, which have been developed by nomadic people over thousands of years according to the climatic and topographic conditions.

Nomadic lifestyle also played an important role in the development of this tents, too. Although they can make short trips for feeding animals, according to the seasons can they make the long migration from the desert to South and back again. They prefer to spend the winter in the warm deserts and to spend the summer in South.

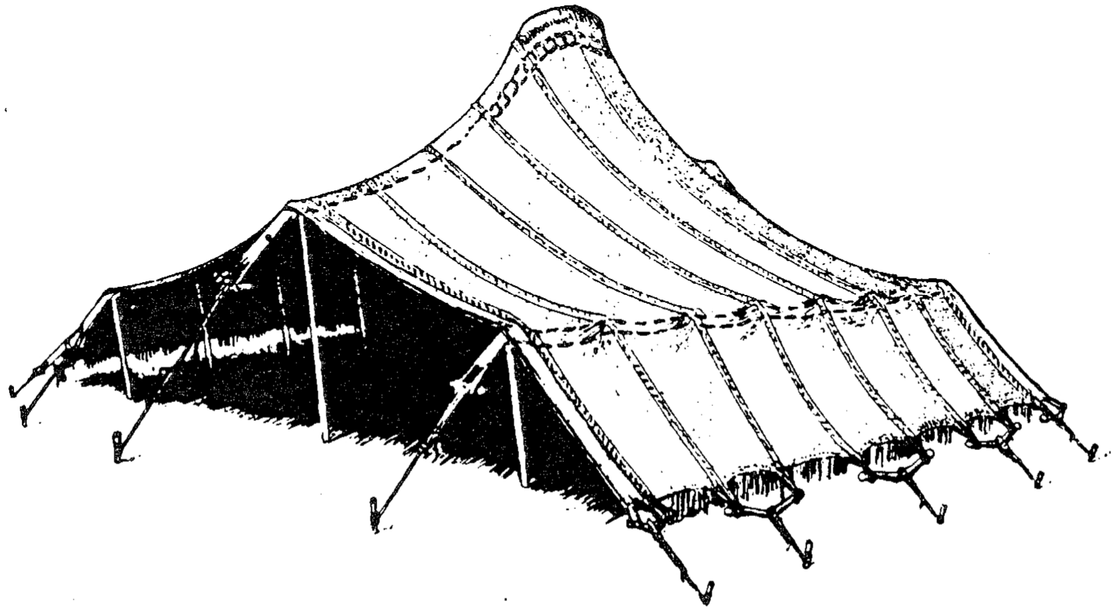


Figure-12, Arab black tents show the most advances tensile technology of the pre-industrial age. A fabric skin is draped over ropes along the ridge and the eaves. Struts form support along these rope lines. Stakes anchor the ropes and the fabric into the ground. The materials are foldable and light enough to be carried on the back of a camel or even a horse.

The Bedouin named *nomads of the nomads* are been integrated with these tents. These tents are named as a black tent, because it is made of black goat hair, sometimes mixed with camel or sheep wool and they can be carried and erected with two people.

"The Bedouin call their tents beit sha'r, -house of hair-. The main fabric of the tent is woven in strips between 60 and 70cm. across and sewn together incorporating strengthening tapes that run crosswise to which tension fasteners are attached. This large, generally rectangular piece of fabric is spread out and the poles areerected inside, with a wooden shoe or rags to spread the load where it comes into contact with the cloth. The tent is tensioned and pegged, or in unsuitable ground conditions the guy ropes are fastened to a bush which is buried. The walls of the tent are suspended around the perimeter and the bases buried in sand or covered with rocks and bushes. These parts of the tent rot first, so the tent is constantly being renewed from the top portion, growing as the bottom disintegrates."[14]

[14] **Kronenburg Robert** (1995: 18)

Interior layout of these tents is very clearly defined. There are two main spaces divided with curtains. In women' s spaces are there articles for daily use and in men' s side are there mattresses. This sides is the intimate parts of nights. The erection and the maintenance are the duties of women. The men' s side of tents is always towards holy city Mecca.

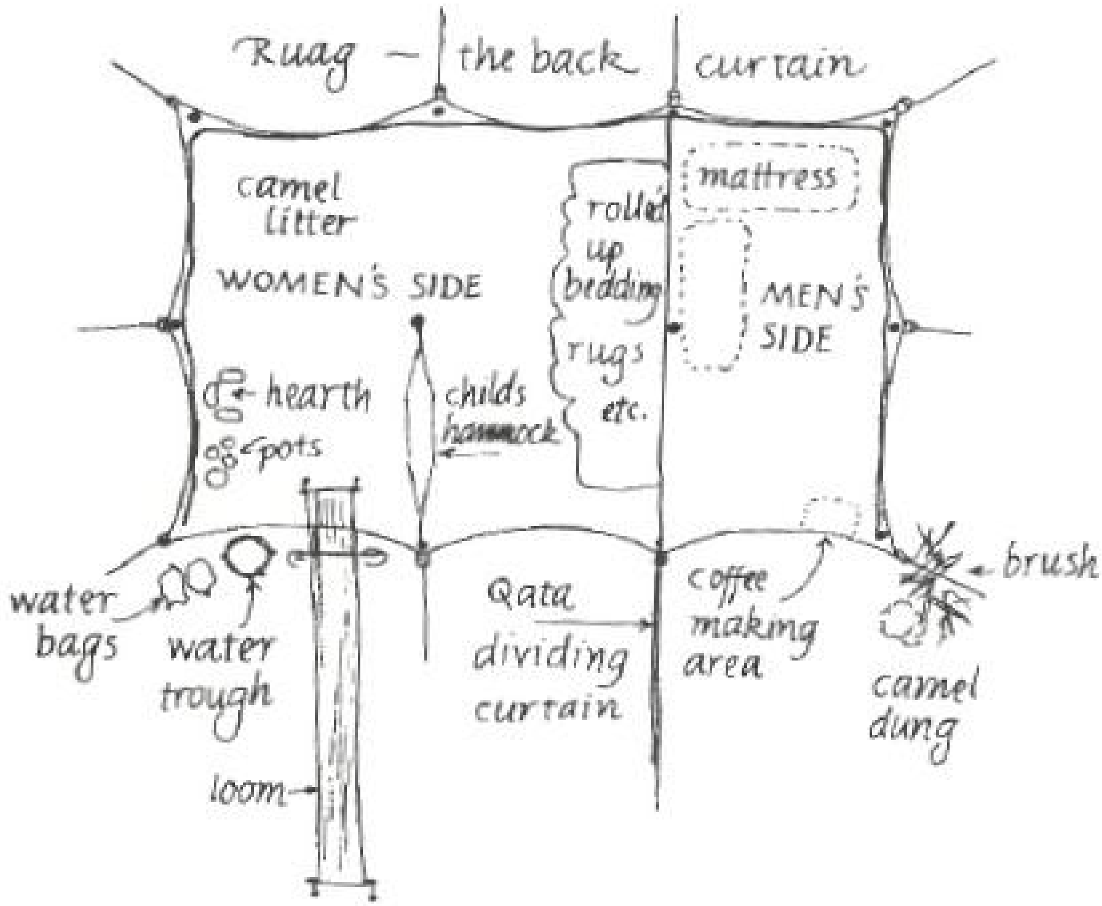


Figure-12, A general plan of a bedouin tent.

These tents have very great flexibility in the way it is used. They can be divided into many parts according the needs or can be used as large storage area. The quality of tents material and the size are shown the owner's wealth and importance.

Figure-13, A Bedouin tent in the Judean hills between Jerusalem and Jericho in Israel.

Out of *Black Tents* is there some other systems like *mat tents* of Tuareg nomadic and semi-nomadic herders of the central and southern Sahara. They cover thier tents either skin sor mats. Traces of both the tent forms of North Africa and the yurts of Asia tents are seen at its form, construction and materials.

The structure is formed by using of bent poles which arch to form a barrel-vault type structure. This main structure is encircled with a rectangular wall section made from wooden poles. A complex dome-like shape of roofs is made by using slender rods.

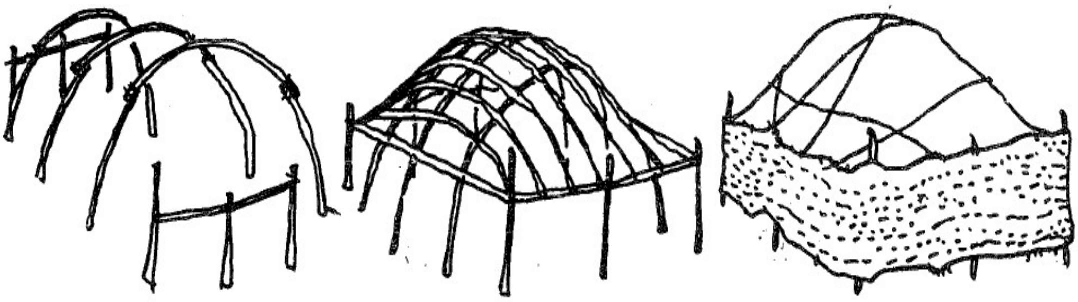


Figure-14, Erection procedure of a Tuareg mat tent.

THE YURTH (YURTA)

The yurt is used over thousands of years in the great Central Asian Stepe. This area begins from the Caspian Sea and runs along southern Russian, goes through Mongolia and stops at the limits of Siberia.

The shape of the yurt is like the dome and so it has maximum volume with a minimum of surface area. Becouse of the framework circular walls needs it no poles stand inside. In winters it is kept warm with adding layers of thick wool felt to the walls and in the summers, the sides can be rolled up to cool the inside of yurt.

Figure-15, a village which occured from yurta tents

"A yurt can be put up or taken down in less than an hour. Loaded on the backs of two camels, bullocks, or yaks -one carries the cover, the other the frame- it travels anywhere in steppe, desert, or mountain country. Because the yurt frame is self-supporting, it can be moved without taking it down: To clean house, the yurt is picked up and moved to a new spot. In the past, it was sometimes mounted on top of a wagon. Herodotus tells of Scythians who moved their tents mounted on ox carts with axles twenty feet long."[15]

[15] **Faegre Torvald** (1979: 79)

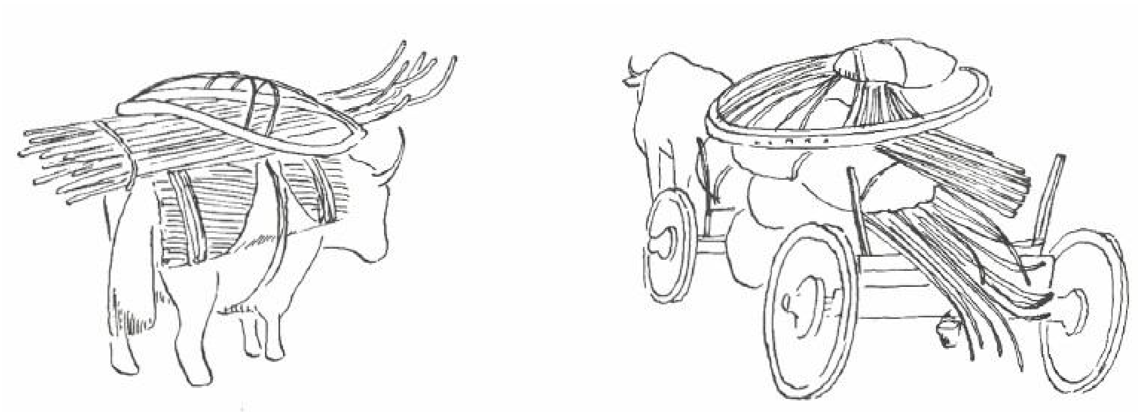


Figure-16, Kırgız yurt trawelling by yak (left); Turkmen yurt moving bt ox and wagon(right)

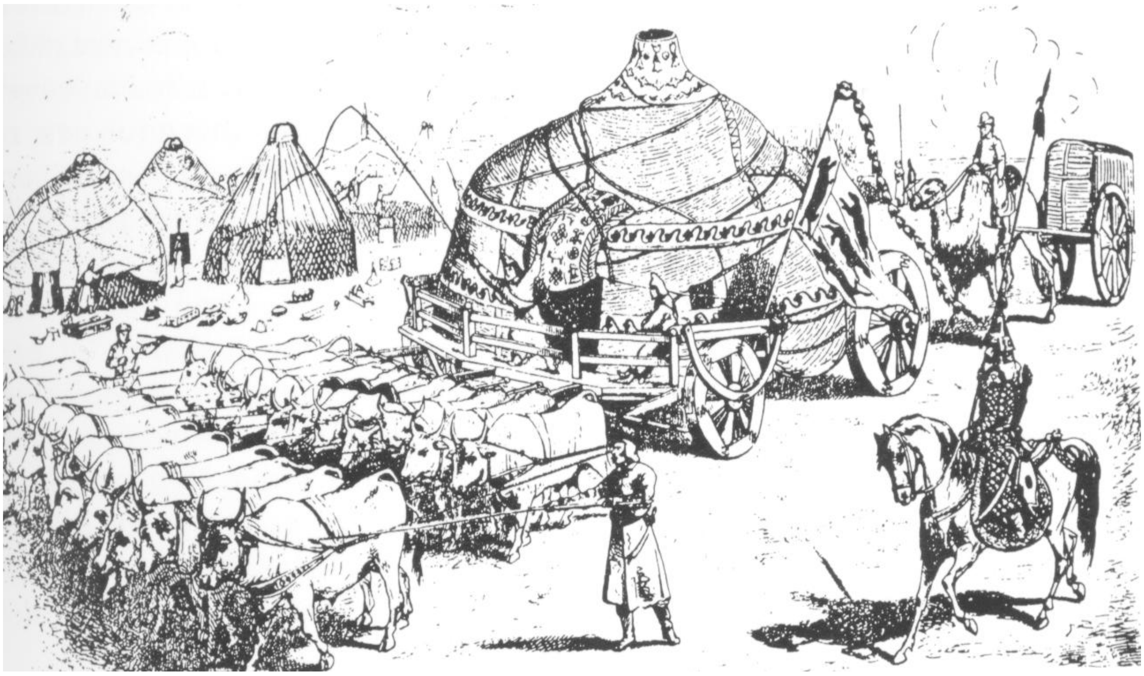


Figure-17, A Illustration of Ser Marco Polo, a 13.th Century Tartar encampment with yurts

In the literature are there two main yurt types used by the stepe tribes. (this characterization was proposed by the Russian ethnographer Charusin in 1896, firstly). The Mongol (Kalmuck) yurt is used by the Mongol, Aitian, Buriat, Tatars and the Kalmucks. These tribes are in the west and east part of steppes, where is spoken mostly a Mongol-derived language. The most important difference in this type of yurt (yurta) is a conical shaped roof. The Kirgiz (Turkic) yurt is used by the the Kirgiz, Kazaks, Uzbeks, and Turkmen, which are Turkic-speaking tribes. Its dome-shaeped roof form separates it from Mongol (Kalmuck) yurt.

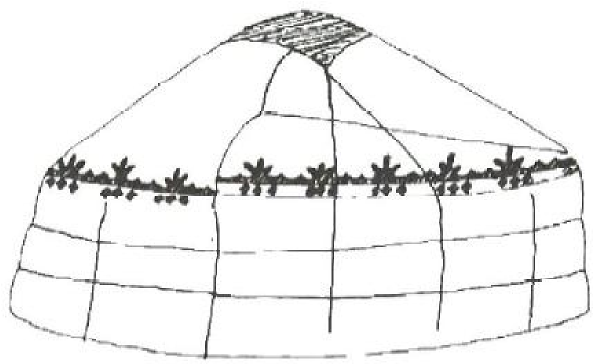


Figure-18, KIRGIZ - A design in Brown felt is sewn to the border of the white felt cover.

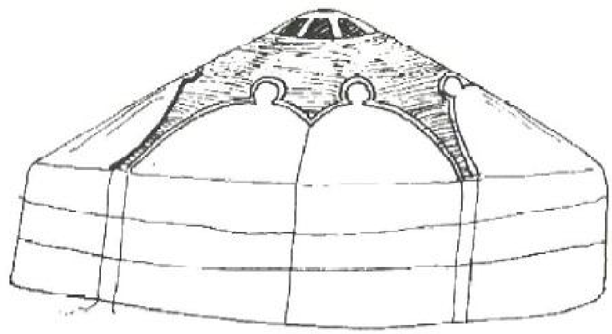


Figure-19, MONGOL - A colored “collar” is placed on the roof.

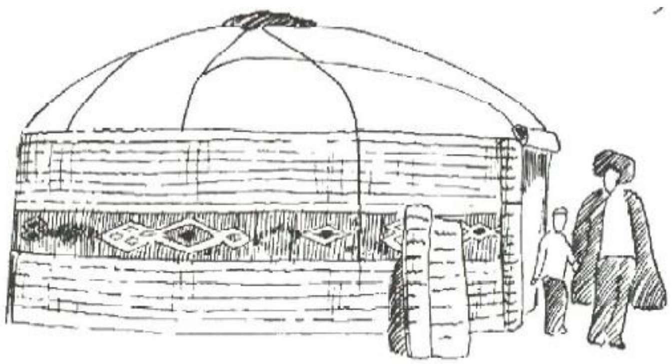


Figure-20, TURKMEN - reed mats on the wall with a woven band.

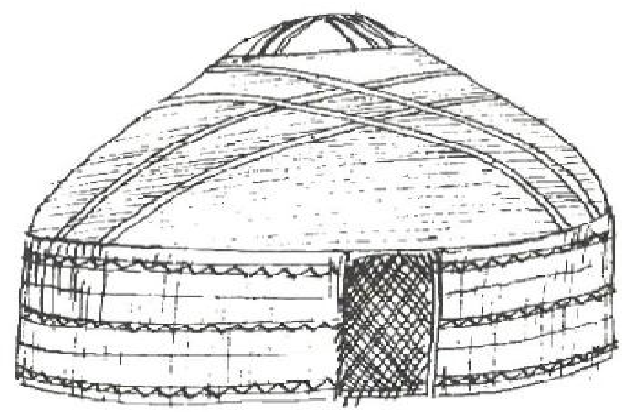


Figure-21, UZBEK – black felt roof with white bands and reed mat walls

The yurt and felt are both inventions of Central Asia's people. This material is unsurpassed as protection against cold, wind, and rain. Felts are used as 8 layers to have insulation and to keep inside warm. Sometimes the top layer is oiled to help water run off.

The walls are the most interesting elements of yurts. These are erected in a circular shape and a tension band is placed around the top and tied to the door frame. In this circular form are inserted three roof poles held in place by two central poles whilst the rest of the roof poles are added. After the installation of the structure it is covered with felt, sometimes plain, sometimes decorated or coloured.

Men's duty is the wooden parts of the yurt but the women make the felt and are responsible for the erection and dismantling of the building. It takes 30 minutes to install this shelter.

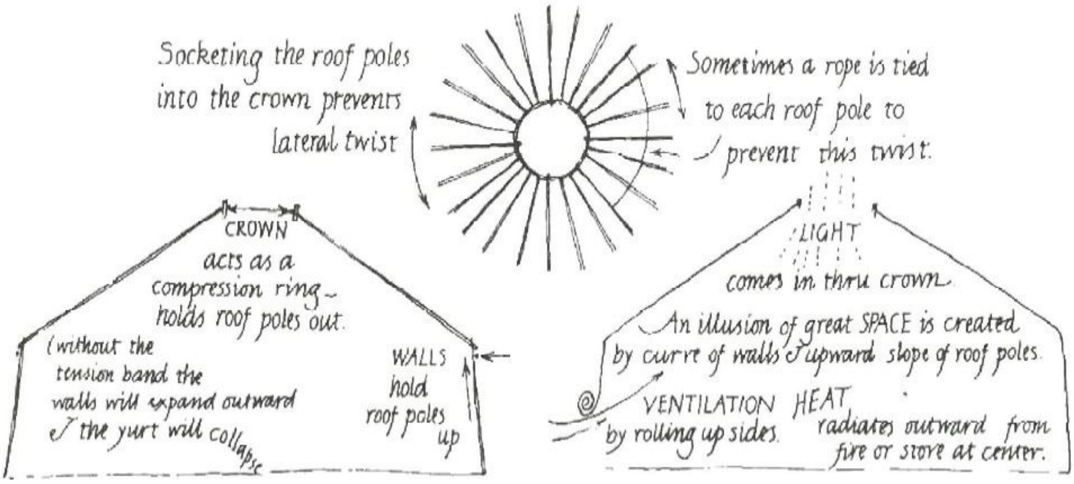


Figure-22, the engineering of the yurt.

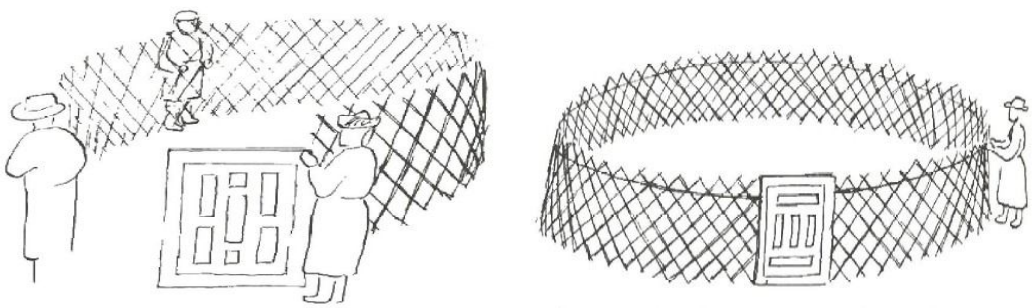


Figure-23, Khana are expanded lashed to each other and to the door frame(left), the tension band is placed around the top of the khana and tied to the door frame(right)

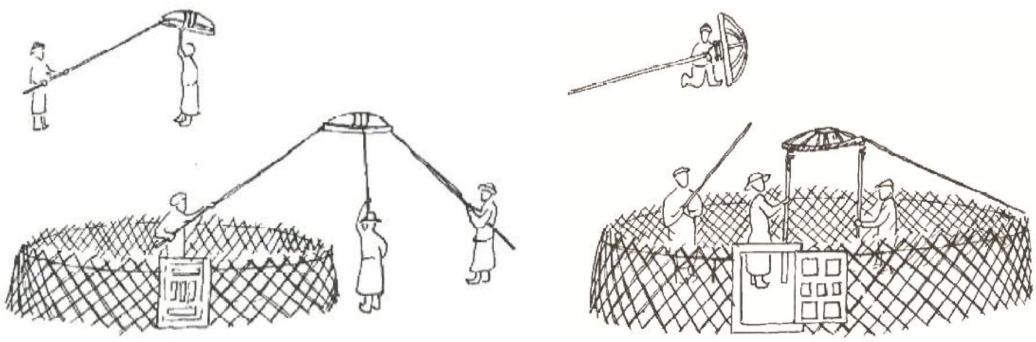


Figure-24, the whole works is carried over the yurt or (left), crown is lashed to the two center poles and is held in place as the roof poles are put up. (right)

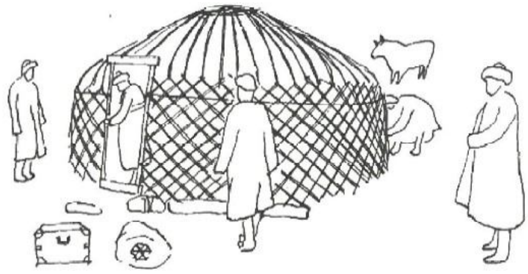


Figure-25, And then the rest of the poles can be added

Interior layout of yurt is very clearly defined as the black tents of nomadic peoples of Sahara. The women’s side is the eastern half of the yurt and the men`s side is the western half of the yurt. The visitors are entertained on the side of men. The stove is at the central point named heart. The place of honor is located iin the back of the hearth on the warm side. As with other tribes set up tent is the duty of women, the men may only assist.

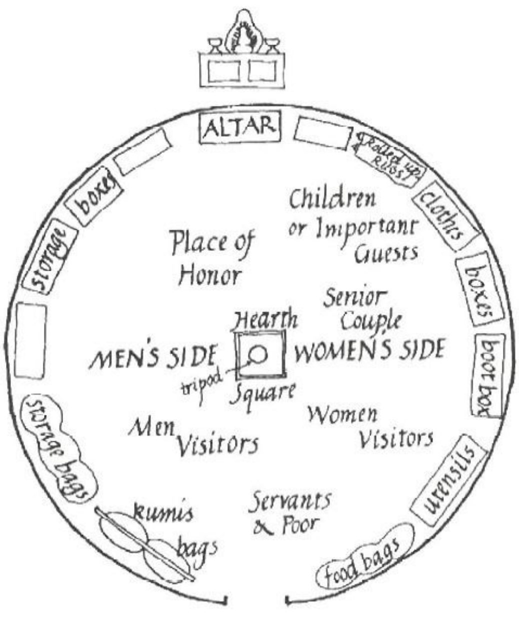


Figure-26, the plan of yurt

"As one enters a yurt it is considered impolite to step on the threshold or touch the tent ropes. The floor is covered with a thin felt rug in the summer. In the winter, a layer of felt is put down, then covered with four inches of dried grass, and topped with felt rugs. Today in Mongolia wooden floors are preferred-covered with felt and woven rugs. In the center a space is left for the hearth. Four boards form the hearth square and an iron tripod holds the cooking pots. Charcoal is burned where available, but more often there is only dried dung for fuel-the roof becomes blackened with its acrid smoke. Sometimes a stove was built of adobe with an iron plate top, but today sheet iron stoves are preferred. These have a stovepipe so that the smoke hole can be closed with a plastic sheet to keep the heat in."[16]

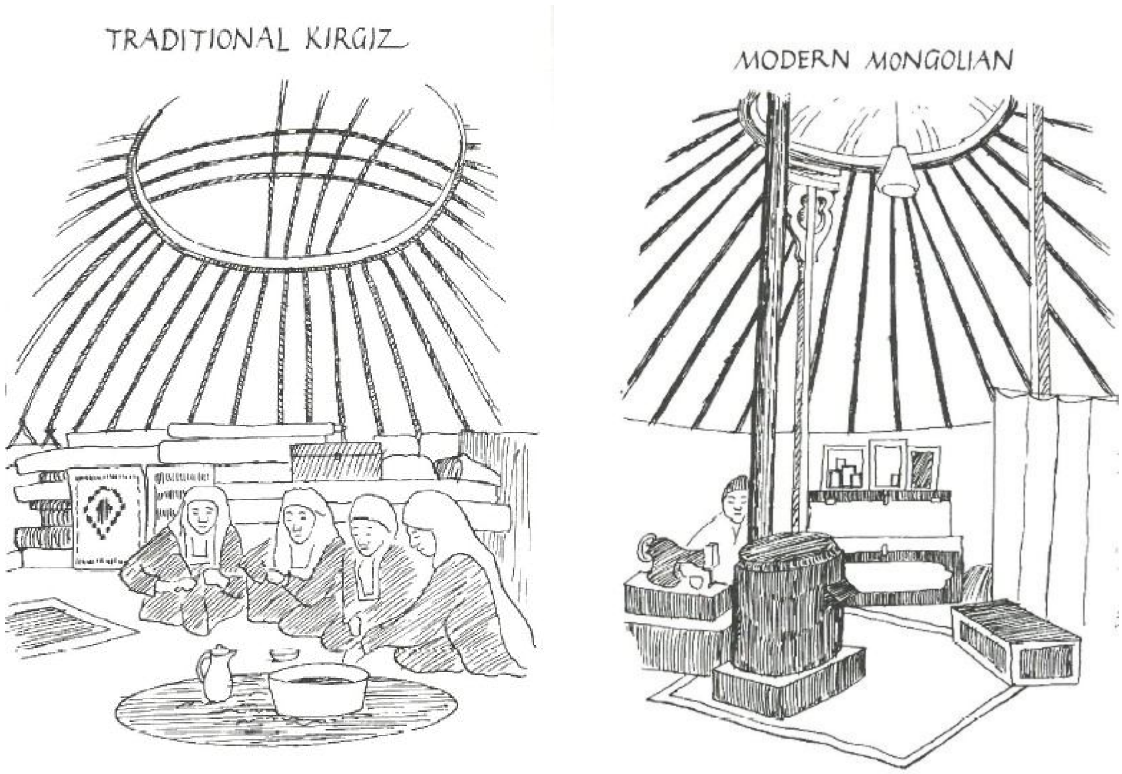


Figure-27, the traditional Kırgız yurt (left) the modern Mongolian yurt (right)

[16] **Faegre Torvald** (1979: 87)

2.2 SUCCESSFUL EXAMPLES USED IN VARIOUS FIELDS

ANTARCTIC EXPEDİTİON TENT

Buro Happold engineer and founding partner Ian Liddell designed this demountable shelter for Roger Mear for his” in the Footsteps of Scott” journey to the South Pole in 1985-86. They have not changed the dome-form of the tent, but utilised modern materials to provide low weight combined with high strength.

The structure of the tent is designed as an umbrella type. The main carriyng elements, six glass-fibre poles are contained as a long bundle with within a tent membrane. The poles become a curved shape under compression in the fabric were fixed with a removable pin to a machined aluminium radial element at the top of the tent at the opening prosses.

The tent was covered from Gorotex fabric which allows moisture from inside the tent to pass thourugh and this iner skin was combined with a nylon outer layer. a PTFE skin was bonded as abase sheet to the underside. Kevlar tapes were bonded into the fabric to provide additional strength.

Figure- 51, installation on poles

“DE MARKIES”

This mobile camper is designed by Eduard Böthlingk, who’s Office is located in Maasland, the Netherland. It was an entry in the "Temporary Living" competition 1985 and was awarded at the Rotterdam Design Prize 1996.

It includes two retractable sides, which hosts a nuclear family for daily-life.

The off status-dimensions are 2.00m by 4.50m and its floorspace can be increased threefold in a matter of seconds. (bedroom part and living room part)

Figure-28, side view of “De Markies”

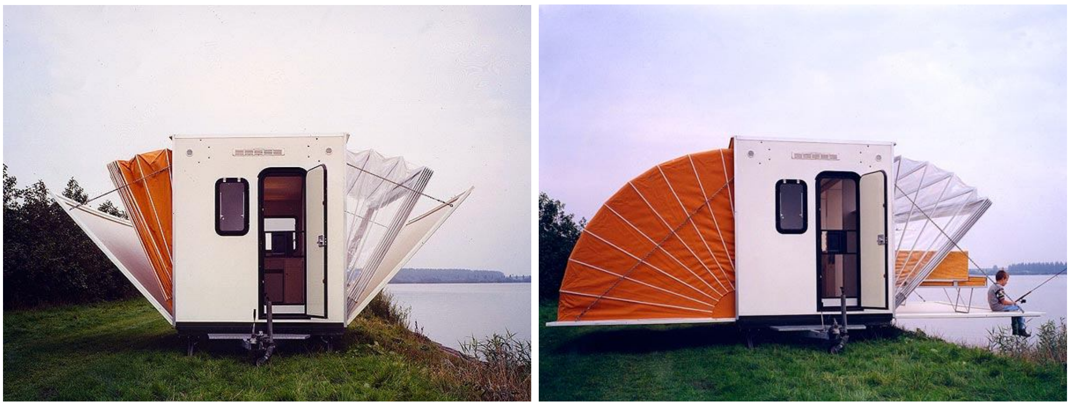


Figure-29, the opening stages of “De Markies”

Figure-30, interior view from the transparant part

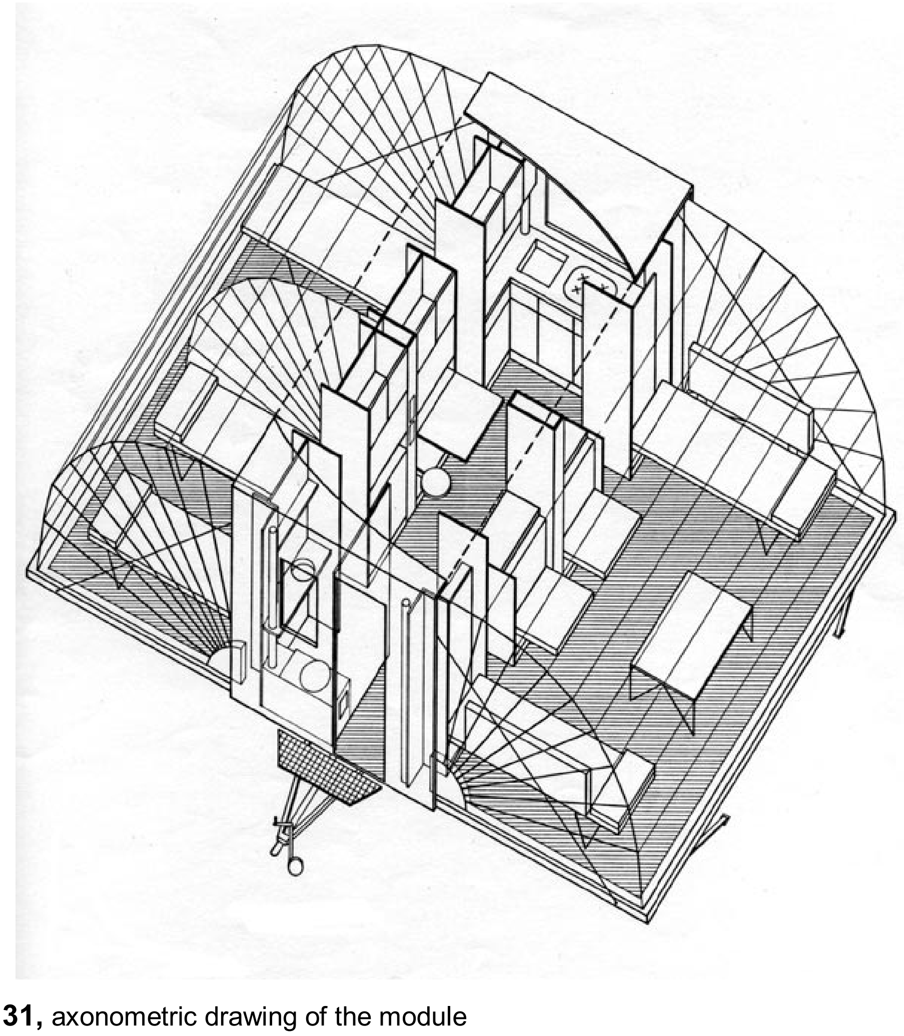


Figure- 31, axonometric drawing of the module

LOFT CUBE

LoftCube designed as an element of urban, mobile, convenient to move helicopter units and these units consists of different combinations. Units with an area of 40 square meters, and a comfortable living area, as well as offering a mobile lifestyle. Residential, hotel unit and television studio, LoftCube used with different functions.

It is designed by Werner Aisslinger in 2001. LoftCube exhibited first at the 2003 Berlin Designmai and currently used in over 50 countries.

Today here, tomorrow may be somewhere else. LoftCube can be moved in any desired location. It is very easy to desmantleş move and install it. It fits through the bridge system transversely or longitudinally into the desired area.

Each facades of Loftcube can be changed with colored glass panels, indoor panels, glass or combinations of different types of shading elements. So it can be created in different facades.

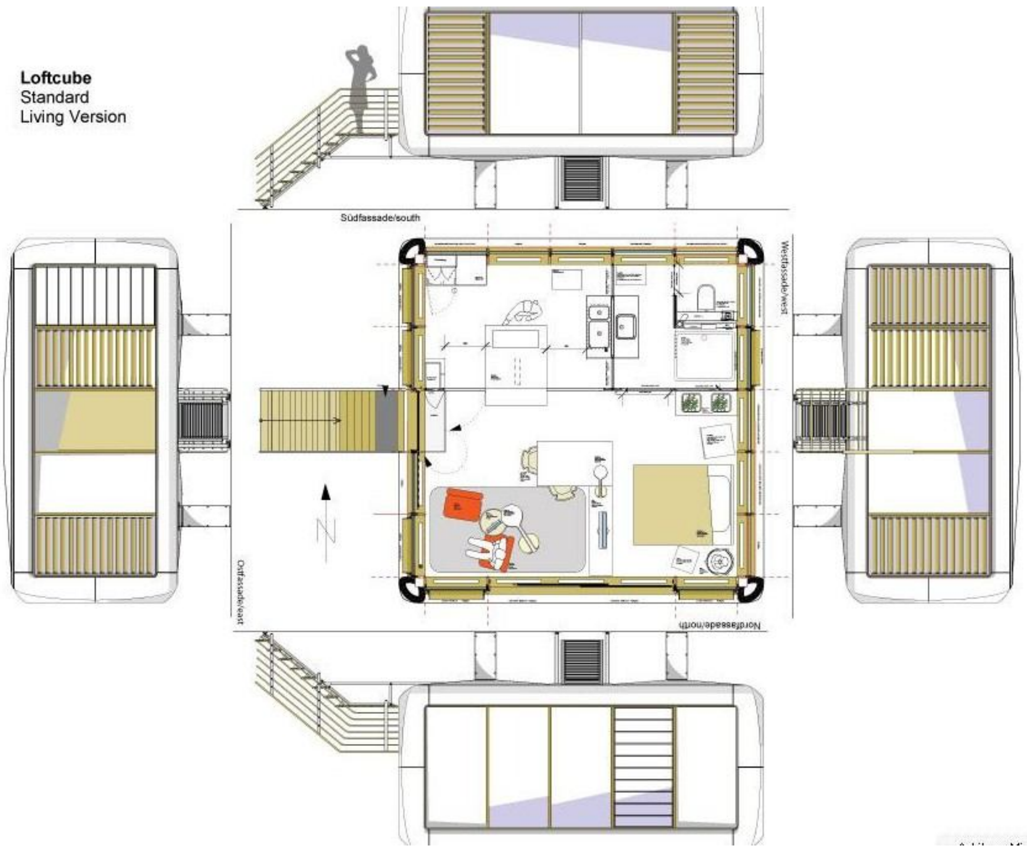


Figure- 39, the standart living version of Loftcube

Figure- 40, the standart living version of Loftcube

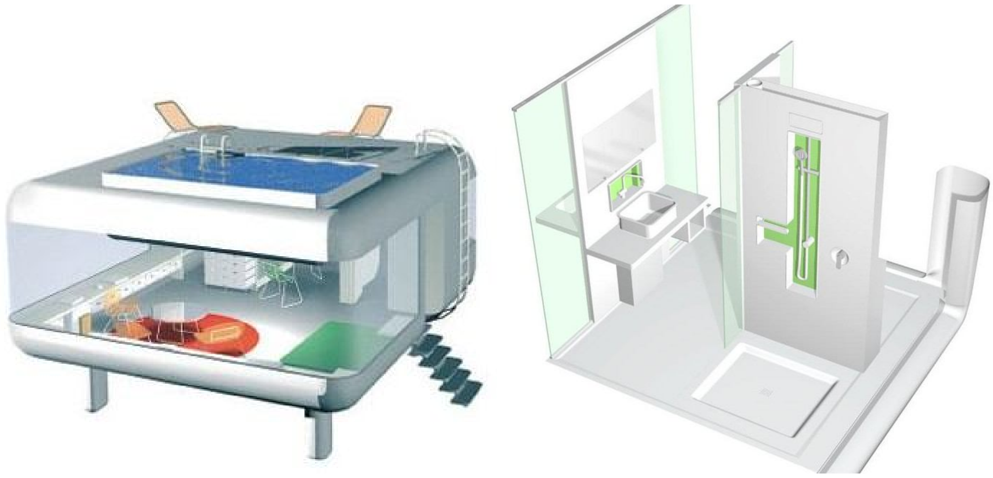


Figure- 41, 3D model for summer house(left) interior view from bath of Loftcube

Figure- 42, a photo near the lake

MICRO COMPACT HOME (M-CH)

The M-Ch is designed as a joint Project with the team of researchers and designers based in London and at the Technical University in Munich. Firstly it is developed for answering of the increasing demand for short stay living for students and then the commercial-version are designed for business people, sports and leisure use and for weekenders.

It combines combines techniques for high quality compact living- spaces which is used in aircrafts, yachts, cars, and micro apartments. The teams based in London and Munich were inspired for its design by Japanese tea house, that is combined with advanced concepts and technologies.

"*The m-ch units can be modified with a second door at the kitchen end and a connecting link to another m-ch unit. This would provide short stay accommodation for two or four people.*

The micro-compact low e-home is all-electric and powered by photovoltaic solar panels of 8 sqm with a small diameter vertical axis wind generator. Day-time excess power is diverted into the grid. Night-time power is provided by the wind turbine and reserve batteries. Heating and air conditioning is ducted to each of the four function spaces. Long duration LED lighting is used internally and for the external walkways."[17]

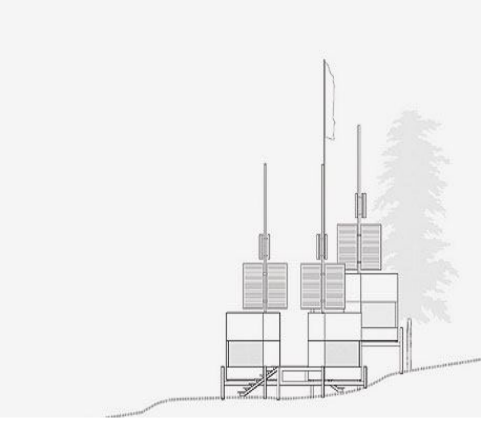



Figure- 32, side view (left) and models of M-CH

[17] http://www.microcompacthome.com/company/
accessed on 21/08/2012

Figure- 33, forms of transport of M-CH

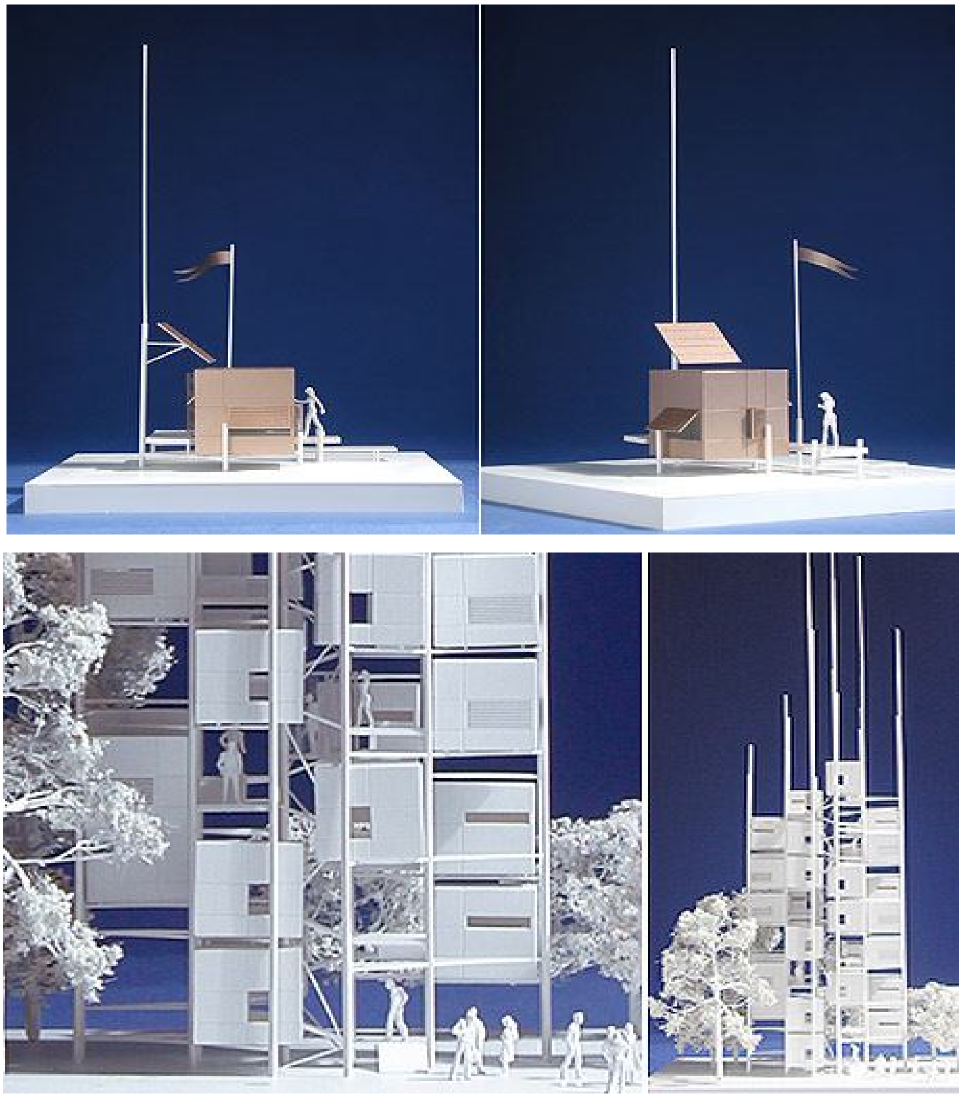


Figure- 34, alternative models for the other uses of M-CH

MICRO COMPACT PACO HOME

Jo Nagasaka and Schemata architecture offices from Japan has designed this ultra-modern compact house. It is a totally unique, unconventional, futuristic house.

The micro compact house is a tiny cube with three meters square. Paco House packs alternative energies into its small but oh-so-sweet design. This eco-friendly self-contained shelter uses solar and wind energy and has water recycling and a biodegradable toilet unit.

Figure- 47, paco home everywhere

The movable roof is achieved by hydraulic cylinders.

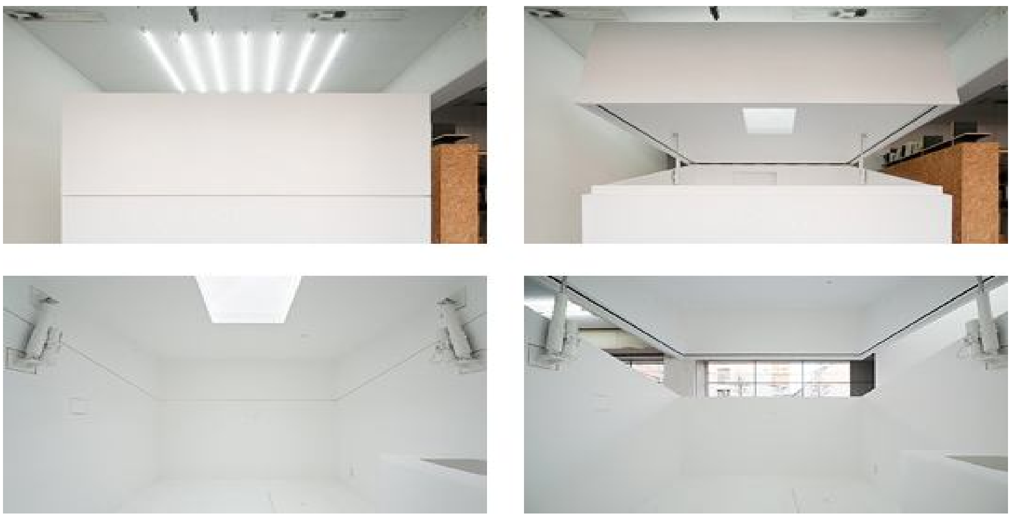


Figure- 48, details from interior side (1)

In the interior of Paco House is used energy-efficient LED luminaire for lighting. the skylight, that has made of two sheets of glass with air trapped, is used at the roof for taking the advantages of natural day-light.

Figure- 49, details from interior side (2)

The sleeping quarters does not require any floor space, further maximizing the micro compact layout. The hammock is made of a three-dimensional stereoscopic knit that maintains its elasticity and conforms to the body.

Figure- 50, details from interior side (3)

MOBILE DWELLING UNIT (MDU)

The Mobile Dwelling Unit (MDU) is a shipping container transformed into a portable shelter. The metal walls of the container are cutted anda re generated sliding sub-volumes. Each volume has one living, working or storage function.

While it is transported, each sub-volumes are pushed in container and then interlocked with each other. After it reached to the area, where it will be used, all sub-volumes are pushed out and so it is created a circulation area between each volume.

One of this type of structure is exhibited at Whitney museum of American Art, New York, Walker Art Center, Minneapolis, University Art Museum, UCSB at 2003.

Figure- 35, the open position-1 of MDU

Figure- 36, the open position-2 of MDU

Figure- 37, the interior view-1 of MDU

Figure- 38, the interior view-2 of MDU

MOMI TENT

It is designed for the National Film Theatre and the Museuem of the Moving Image and situated in London' s South Bank Cultural Area to accommodate up to 450 people for periodic special events. The designer's created a 28m. by 9.6m. fully serviced building for above mentioned uses. For the main fabric membrane was used (PTFE), Tenara woven fibre, that was made from polytetraflouroethylene and fabricated in Germany. For the end walls was used a transparent film Hostaflon ETFE.

"The arches that support the skin are made from polytrusions, glass-fibre reinforced polyster rods fixed with epoxy to stainless steel joints braced with stainless steel cables. The end arches are substantial steel frames made from hollow steel sections and plate and are lifted in by crane and fixed to the flor structure with diagonal struts that brace them in position. These arches lean outwards to resist the linear tension of the membrane skin. Once the primary structure is completed the fabric membrane is spreaded over it and tensioned down to edge connections along its length and at the end arches."[18]

Figure- 43, a photo from the enterance fassade of MOMI TENT

[18] **Kronenburg Robert** (1996: 31)

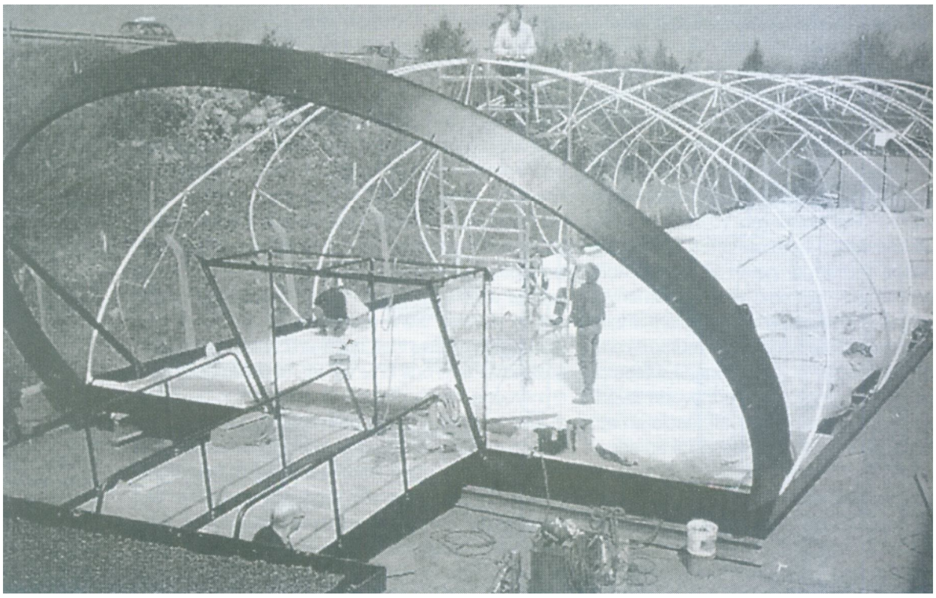


Figure- 44, a photo from the montage phase of MOMI TENT

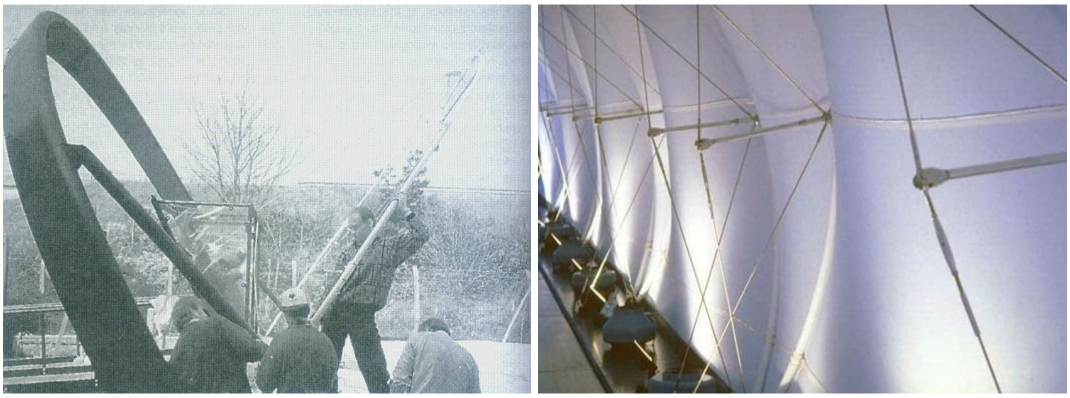


Figure- 45, a photo from the montage phase-2 (left) interior details (right)

Figure- 46, a photo after montage of MOMI TENT

2.3 THE EXAMPLES USED IN DISASTER

AFRICAN PREFAB HOUSE (ABOD HOUSE)

"BSB Design has developed a low-cost, high-quality, prefab house for South Africans. The entire home is shipped in one box and can be easily assembled in one day by four people, using only a supplied screwdriver and an awl. The home's shape is the Catenary Arch, that makes the 10' x 12' footprint seem larger"[19]

For the construction is used fiberglass material, corrugated panels and plexiglass panels, which provide maximum daylight. Arched structure resembling agricultural greenhouses have been manufactured and designed in a way as possible benefit from rainwater. At the same time such as ağabeynets can be used at the emergency cases like floods, landslides, earthquakes, disasters.



Figure- 52, Model-1 Model-2 Model-3

Figure- 53, interior view of ABOD HOUSE

[19] http://www.trendhunter.com/trends/african-prefab-houses-the-abd accessed on 16/03/2013

ASGBB

The turkish design Office “KARABEY LI(MI)TED MIMARLIK” has designed the ASGBB (original name: ***A***fet ***S***onrası ***G***eçici ***B***arınma ***B***irimi; translate: Post Disaster Temporary Housing Unit), because they have seen large space at the Turkish public opinion on this issue. At this point, "search for the answer to a unasked question" they set to work.

ASGBB in the plan; consists of five modules with 90cm. x 210cm. gross-dimensional. Internal height is 210cm and the total area is 10m2. This equipped with the official "prefab" is larger than tent and but smaller than a furnished housing. From the entrance back three modules is used for the life-unit, the fourth for the kitchen and the fifth for WC and illusion. On the corner of the shower, a mini sink can be added using the same battery. It does not have side Windows to be helpful to use the units side by side. Details are usually solved by published methods nickname. So all the prism assembly (installation of the fitments not included) almost without tools, can be do by two people, in one hour.

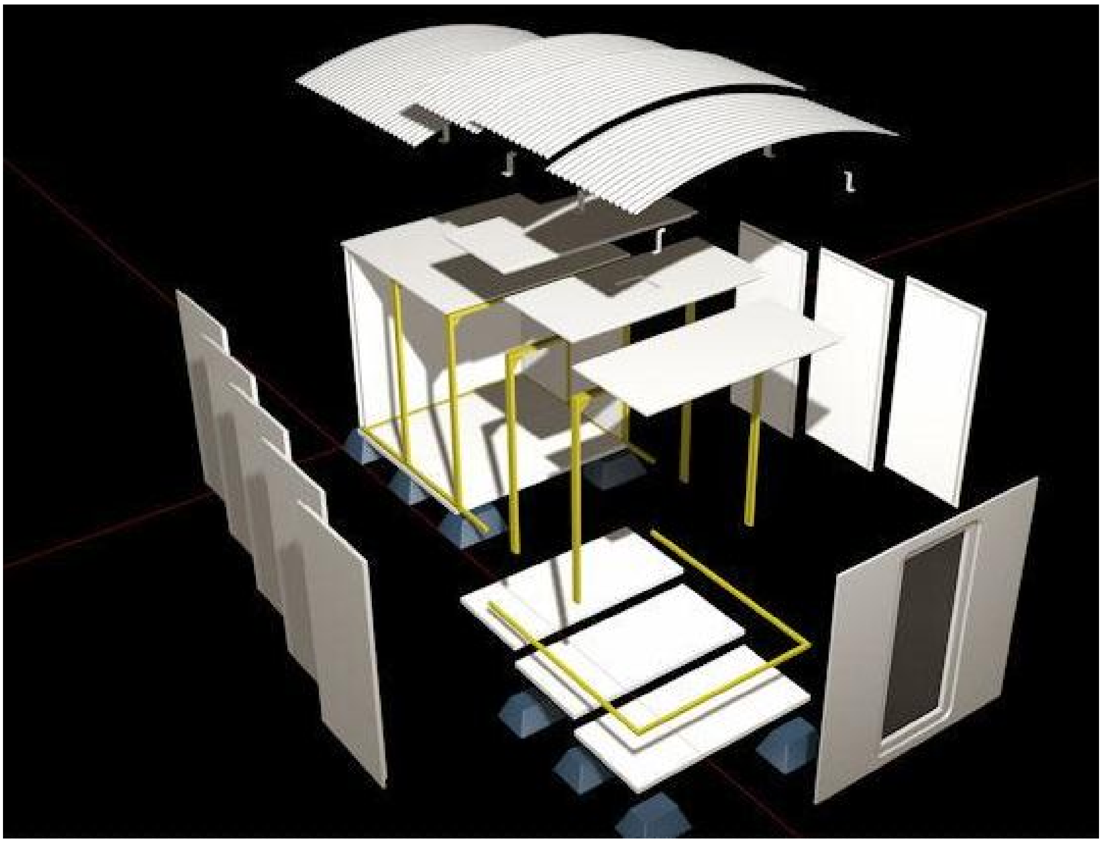


Figure- 58, structural elements of ASGBB

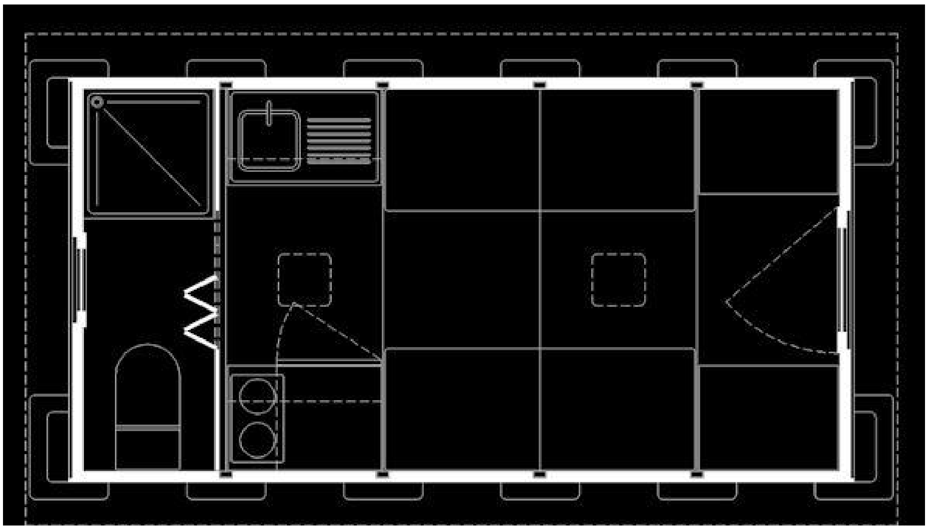


Figure- 59, plan drawing of ASGBB

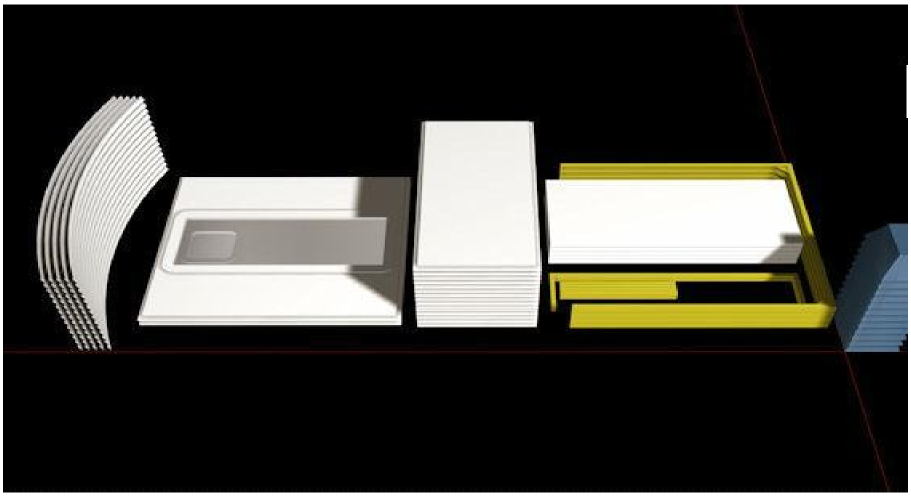


Figure- 60, structural elemants in the stored form

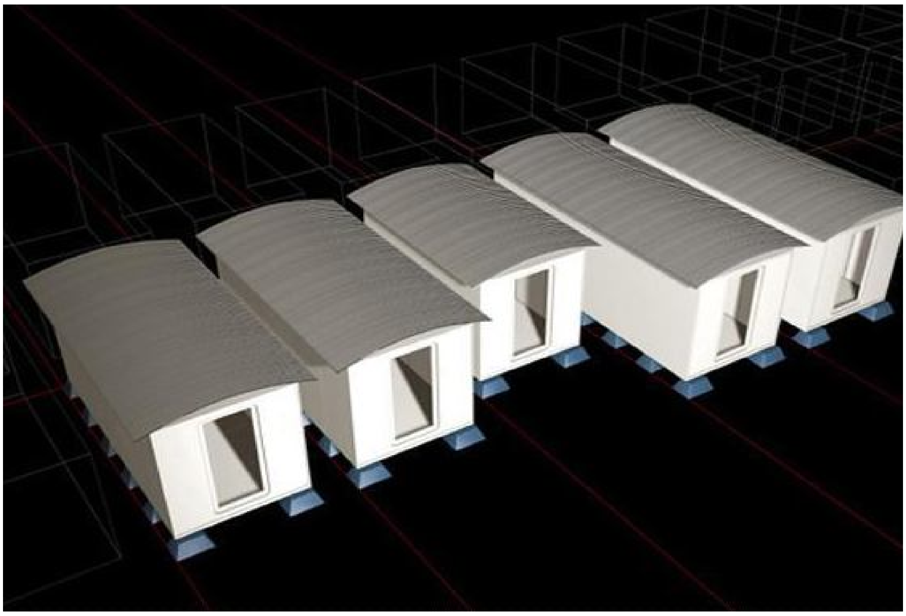


Figure- 61, axonometric drawing of ASGBB

CONCRETE CANVAS SHELTER

The award-winning Concrete Canvas Shelter is designed by the British engineers Peter Brewin and William Crawford. They have planned to provide shelter as infrastructure like buildings for headquarters, relief-worker housing and supply storage.

The durable structure, which comes from spherical form, has a good earthquake performance and the low mass becuse of the shell structure hepls it, too. Thermal properties of this shell structure can be enhanced by covering it with earth or snow according to the physical conditions of area.

"Setup is a snap, just fill the sack of cement-impregnated fabric with water and unfold it. The structure is then inflated with a chemical pack containing a measured amount of gas. In less than a day, the structure has expanded, hardened and is ready for use. After that cut doors and spaces for ventilation from the newly formed concrete -cloth." [20]

Figure- 65, Photos: Courtesy of Concrete Canvas

[20] http://www.wired.com/culture/lifestyle/multimedia/2007/10/gallery_instant_housing?slide=12&slideView=7
accessed on 19/04/2013

DOWN HOME

California architect Gregg Fleishman has designed this portable DH1 disaster house that uses tabs -like a 3-D puzzle - to fit together without fasteners or other hardware.

The durability and flexibility provided slotted plywoods were used as a carrying and divisive structural element.

Its most big advantages are transport and easy installation. Small and light pieces can be transported and erected without cranes, forklifts or other industrial equipment.

This relief units sit 30inches off the ground to avoid water damage in areas. A stretched piece of tarp or canvas would be needed for extreme weather conditions for example for waterproofing.

Figure- 69, Photo: Courtesy of Gregg Fleishmann

EASY AS 1,2,3

The Hexayurt cardboard house, which is designed by Lindsey Darby and Vinay Gupta, takes just a few hours and a roll of industrial tape to build.

Their costs are considerably cheaper, because they made from sheets of coated, pre-cut cardboard for a quick build.

There are many different sizes (small, medium and large) the opportunity to build them. The Hexayurt can be expanded to 12-foot ceilings by stacking containers.

The price tag is changing between 200$ - 500$ according to use of a stove, composting toilet, solar power and water purification. One family-support unit can provide all the necessities in a disaster-struck area with cheapness and easy installation features.

Figure- 68, Photo: Courtesy of Vinay Gupta

THE FUTURE SHACK

It is designed by Australian architect SeanGodsell, the Future Shack has a parasol style roof made from recycled plastic to collect water for storage, and includes solar cells to generate electricity.

The Future Shack is a self-contained, modular housing unit, which can be used a versatile emergency-housing unit at all over the world. It can be stored very easily because there is no element protruding too much.

The twilight zone of land use conditions is solved with telescoping legs for support. The with telescoping legs equipped Future Shack can be assembled within 24 hours on almost any terrain with no excavation, which means construction does not add to soil erosion problems.

Figure- 62, Photo: Courtesy of Sean Godsell Architects

THE HUB

The Hub is designed by John Dwyer, who is founder of Shelter Architecture, a Minneapolis-based design studio. This self-sustained portable machine is a recycled shipping container in the reality. Each modul includes a power station and water-purification plant, which provides enough energy, water and sanitation for up to 150 people. Instead of using as a disaster shelter, it can be used as a basic elemant on disaster-stricken areas.

"*The Hub can be fabricated and shipped anywhere in the world in a few days and once at its destination, takes less than an hour to erect. A V-shaped roof collects rainwater, 16 solar panels generate electricity, and an underground reverse-osmosis filtration system recycles and stores water. When in use, the Hub produces enough compost to sustain a small vegetable garden. The first prototype was built in June 2007 and delivered to New Orleans, where it is currently in use as part of an urban agriculture project.*"[21]

Figure- 63, Photo: Courtesy of Shelter Architecture

[21] http://www.wired.com/culture/lifestyle/multimedia/2007/10/gallery_instant_housing?slide=12&slideView=7
accessed on 19/04/2013

NEXT_GEN DOME

It was designed in 1993 by homeless activist Ted Hayes and architect Craig Chamberlain. A family with 5 people can use it very comfortable. Two people can assemble it in less than four hours with a screwdriver and ladder because their weight is 70pounds apiece. Poetry is the use of light weight fiberglass-composite panels. They can easily be carried by hand from a distribution point to the desired build site.

"The original design was incorporated into the Dome Village, an alternative, noninstitutional shelter made up of residential domes, kitchens, offices, bathrooms, laundry faculties and computer rooms intended for homeless people in Los Angeles. "[22]

These domes can be used in all weather-conditions on overall of the world and can withstand a Category 4 hurricane or 8.5-magnitude earthquake.

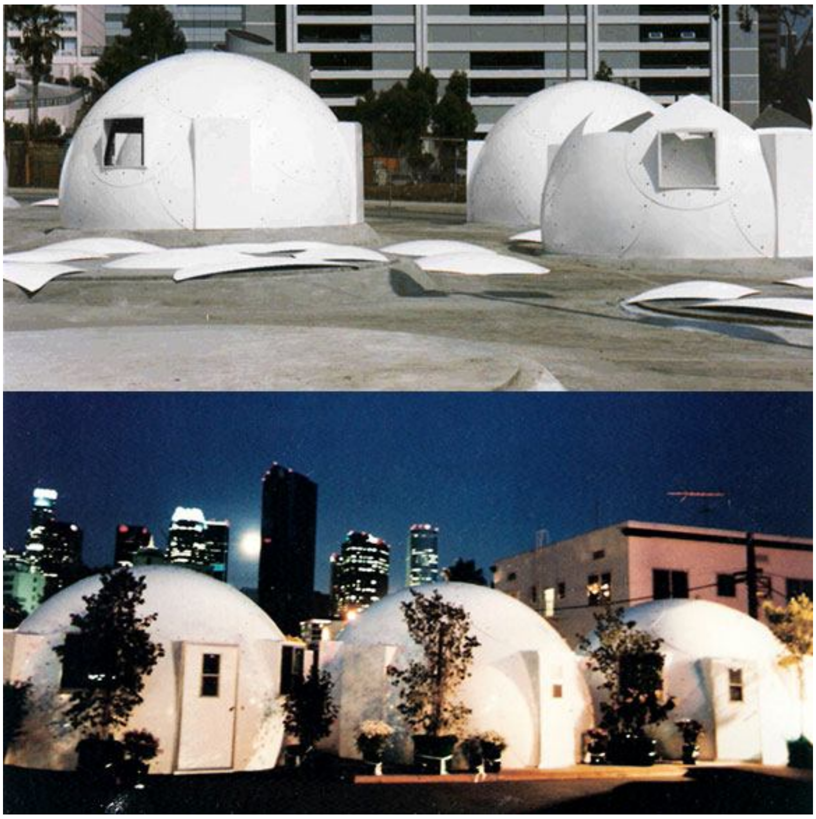


Figure- 71, Photos from setup phase and night view

[22]http://www.wired.com/culture/lifestyle/multimedia/2007/10/gallery_instant_housing?slide=12&slideView=7
accessed on 19/04/2013

ORIGAMI HOUSE

Origami houses are designed by father-and-daughter team Daniel and Mia Ferrara. These elegant, portable and cost-effective houses were made from flat-packed cardboard. In each boxes of this emercengy units is there an easy diagram for construction. It requires only simple tools for building. These shelter were erected at all over the world like in Grenada (after Hurricane Mitch), Pakistan (post-2005 earthquake) and in Mississippi (after Katrina).

"*Each sheet of corrugated cardboard is laminated for water resistance and is fire-retardant. The sheets lie flat for transport, and the structures arrive ready for assembly in less than an hour. A 67-square-foot version with a maximum height of 7.5 feet costs just $550 per unit.*"[23]

Figure- 67, Photos: Courtesy of Global Village Shelters

[23] http://www.wired.com/culture/lifestyle/multimedia/2007/10/gallery_instant_housing?slide=12 &slideView=7
accessed on 19/04/2013

PAPER LOG HOUSE

"Shigeru ban is a Pioneer of paper tube structures (PTS) he investigated the substance and found that not only could recycled cardborad be molded into load-bearing columns, bent into beatiful trusses and guickly assembled but it could also be made waterproof and fire resistance. In the space between the paper tubes self-adhesive waterproof sponge tape was applied to both sides."[24]

Shigeru constructed the first paper log house in 1995 in Kobe, Japan, as a earthquake shelter. Berr crates were used by him as a foundation and at the same time for maintaining the houses from small water floods. Plastic tarbs were used as a waterproofing cover on top of the roofs of paper-log houses, that were used in Kobe.

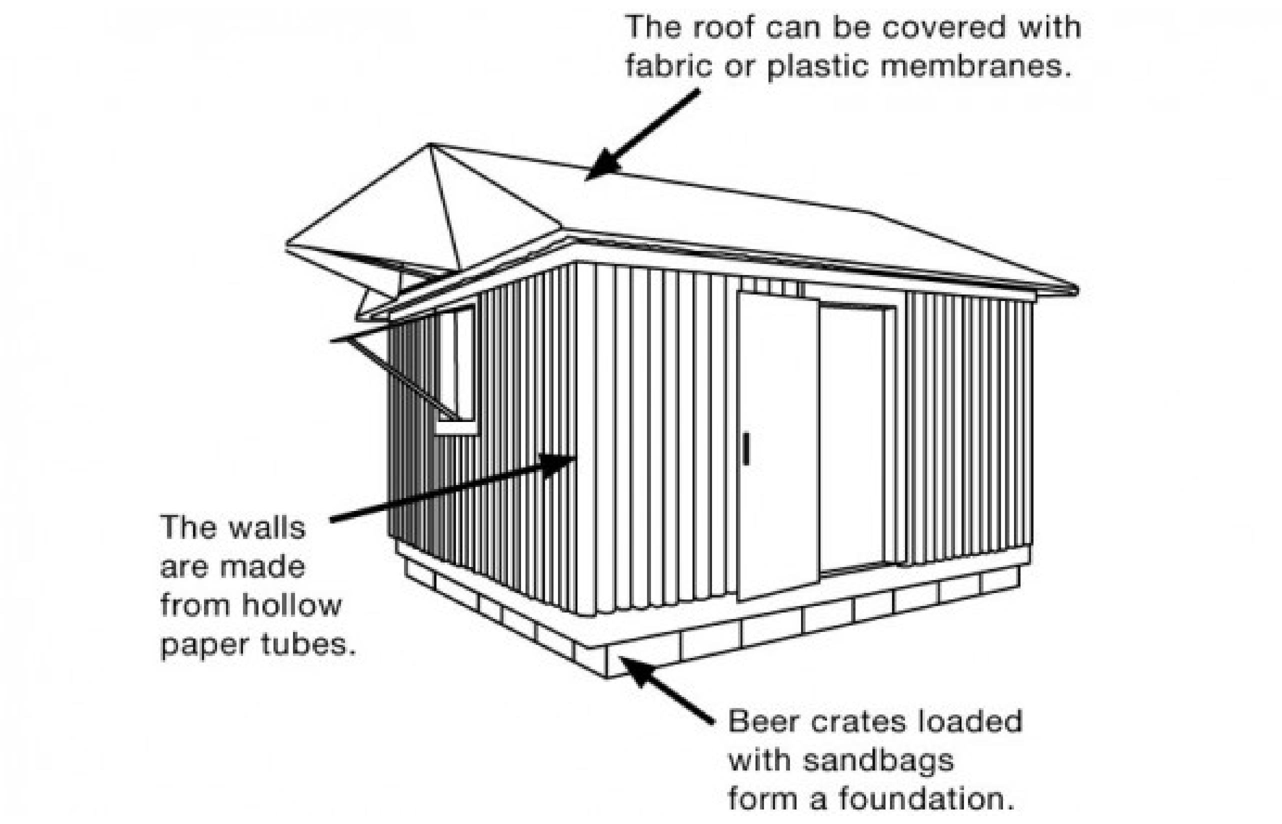


Figure- 54, axonometric drawing of the paper log house

[24] http://whatwow.org/paper-log-houses/
accessed on 12/02/2013

Figure- 55, external appearance-1

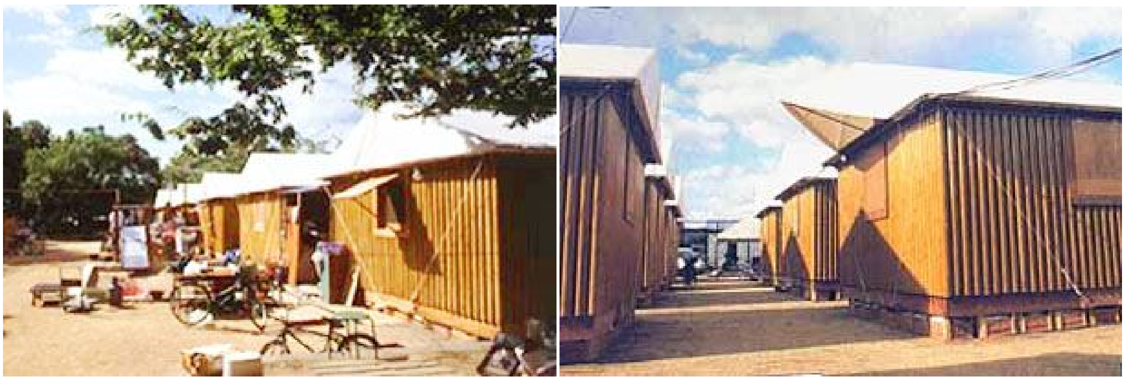


Figure- 56, external appearance-2

Figure- 57, external appearance-3(left) and detail from outside(right)

Q_ SHELTER

It takes approximately 20-30 minutes to build this shelter. It is very easy to carry and storage it, because the structure of this tent is composed of very light elements. It is first used in 1985 and than is used extensively in the Southeast Asia affected by the 2004 tsunami.

Q_shelter used flame-retardant, UV-resistant, heavy-gauge plastic sheeting can be use as a house for a family of six people or as storage or as a clinic to administer medical care.

Figure- 70, Photo: Courtesy of World Shelters

REINVENTING THE TENT

This lightweight emergency shelter is designed by Patrick Wharram It is easy to transport and to erect it immediately. It won first place in nonprofit " Design 21's ShelterMe" competition in the Summer 2007.

This is a one piece shipped shelter. Because an aluminum frame from tube profiles is sewn into a piece of recycled polyester fabric, the workers have no possibility of misplacing pieces at the disaster eraes.

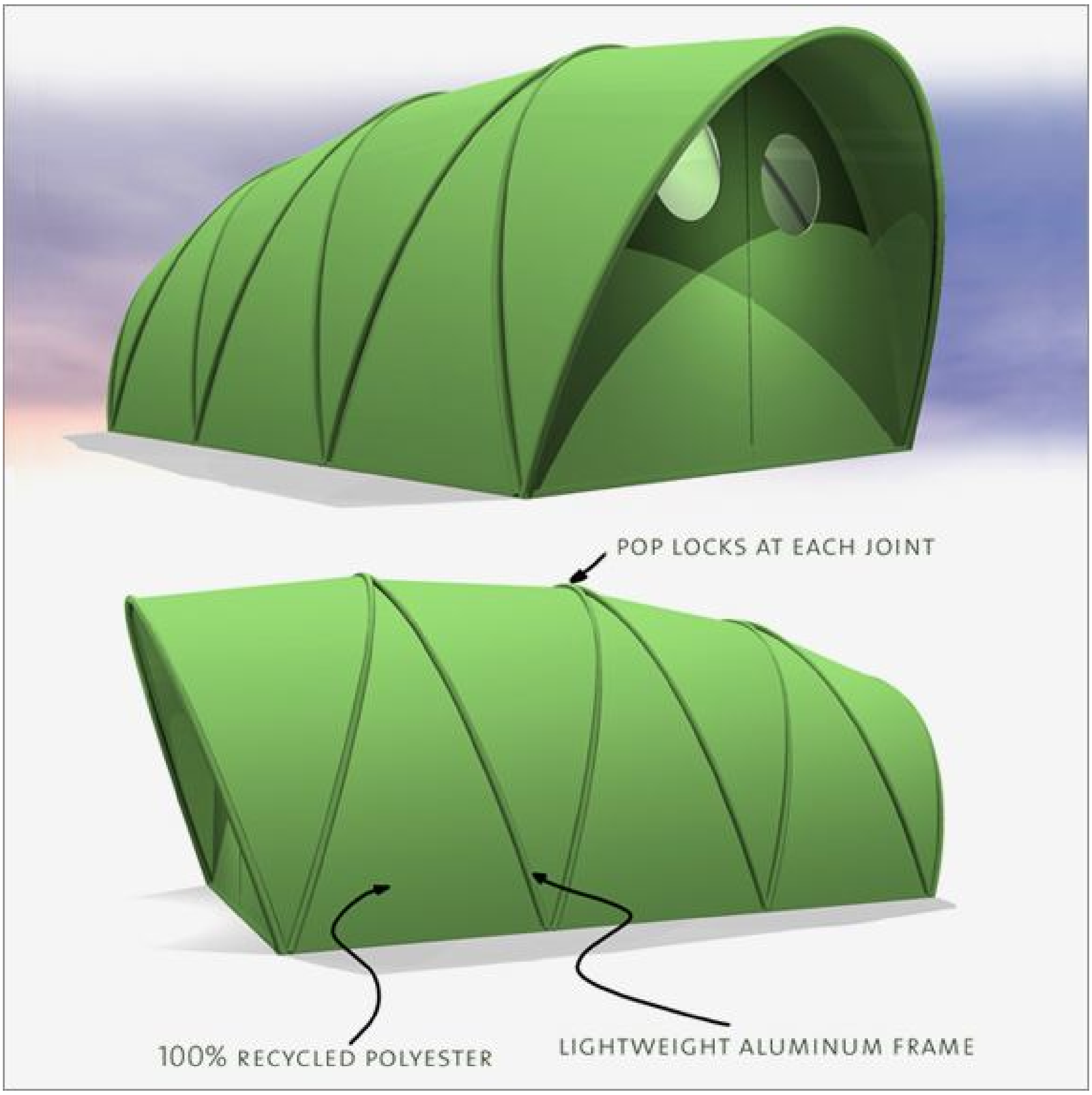


Figure- 66, Illustration: Courtesy of Design 21

3.1 ARCHITECTURAL DESIGN AND FUNCTIONAL DIVERSITY

The architectural design stands out as the most important criterion for the realization of the purposes at the forefront.

The idea described in section “goal” is to create a modular mechanical based small tent, that does not require the use of energy or at least require the use of energy, to solve the urgent housing problem under the earthquake conditions. On the other hand this “small tent” should serve to many different functions due to its reproducibility property.

Because after the first urgent housing phase begins the other phases like:

- elimination of health problems,
- educational and recreational needs of children,
- meeting the needs of primary care (taking a dush .etc.)
- the formation of public kitchens to meet the needs.

The different functions are in two categories; the first is the first-degree emergency utilizations and the second is the second-degree emergency utilizations.

The first-degree utilizations are like:

- urgent housing problem of families,
- urgent stroge problems of relief teams,
- urgent space requirement for medical intervention of wounded peoples.

The second-degree utilizations are like:

- public kitchens,
- education shelters,
- shelters for personal cleanliness and maintenance.

This shelter can be storage again, after they fulfill their tasks for using in the future.

This “small tent” should have the spatial reproducibility property to have a change for the creation of the above-mentioned structural groups.

As in disaster areas of these types of structure are analyzed, four main groups are often gathered. These forms are circle forms (like doms shelter or yurta), polygon forms, square and rectangular forms (like containers).

The circle forms are not suitable for the spatial reproducibility to realize the second-degree utilizations. Polygon forms require intermediate members and the inner spaces of polygon forms bring challenges for interior furnishing.

The square and rectangular forms are more suitable for spatial reproducibility and their inner spaces are more suitable for interior furnishing, too.

In determining of area and size of small tent according to above mentioned operating functions is used " a guide to the use and logistigs of family tents in humanitarian relief " of OCHA (Offiece for the Coordination of Humanitarian Affairs) department of United Nations.

By the way, in determining of area and size are considered:

- Lightness, (to be established by several people)
- The minimum energy use, (if possible does not require any energy requirement)
- Packing in a small size,
- Easy installation. (requiring minimum professionalism and equipment)

During the design of architectural details are considered that can easily be applied by normal people.

3.2 STRUCTURAL FEATURES

The main structure is aluminium frame with double-sided canals system. This brings the lightness and opportunity to applicate (can be made if necessary) double-layer membrane in winter conditions or for the sound insulation.

Visual relationship breaker stretched exterior membrane provide the required strength against external physical conditions (like snow, wind etc. in all geographical areas of Turkey)

For the upper and lower membrane material is thougt to use tent materials of fabric firms, which have flame retardant, UV stabilized, antimould and antiwick properties for using and storage.

One of the main features of the project is the twilight zone of land use conditions for this small tent (the project will be implemented on what kind of terrain). But after earthquakes in recent years was made “urgent building layout planning” in many cities and regions of Turkey, however it can be used in the regions, where such measures are not taken. In these circumstances is taken to set a number of measures at the anchor plates.

One of the most important issues immediately after the earthquake is placing of non-displaced people in a sheltered environment to avoid the effects of the external physical conditons. Such as urgent housing structures should be designed according to the different components that protect people against external environmental conditions. (like thermal insulation, water and moisture insulation, sound insulation, resistance for fire. etc.)

The use of double-membrane (membrane + air pocket + membrane) thought to be beneficial in terms of thermal insulation. The water insulation problem at the top cover is solved with impervious waterproofing membrane material selection. On the ground would be appropriate with a small moat o to circulate the water around the small tent.

After the earthquake a fire is one of the most important problems of emergency shelters. In the past, to be a cause of fire is known the loss of many lives and property in Turkey. Therefore flame-retardant materials have been selected.

3.3 EASY INSTALLATION, STORAGE, SHIPPING FEATURE

Assembly and disassembly are the most important defining qualities for the design of such a urgent shelters:

- For the installation is required minimum professionalism and equipment. It is easy to erect without special experts with several people with minimum energy use.
- They are demontable and it is easy to package them in a small size to use in the future.
- They are light to transport with helicopter or airplanes in boxes.

It is thought to be useful to give a simple user guide in the packaging structure.

For reaching safely and fast to the disaster area of the designed module structure is packaging important:

- It must be inexpensive and simple, and should be used again,
- They have to portable size for transporting with a large number with vehicles,
- Module structure must fit into the smallest size exponentially.

Shipping is done in three ways:

- overland,
- by sea,
- by airmail.

But the mostly important outcomes of the earthquake are not only the damages in settlements on the other hand the damages at the transportation ways, the damages at the electricity systems of the accommodation units and the damages at the power plants and refineries. Therfore, they have to be light to transport with helicopters or airplanes in boxes.

As mentioned above, the mostly important outcomes of the earthquake are not only the damages in settlements on the other hand the damages at the transportation ways. Therefore, the storage of such structures is important in certain areas in cities.

4.1 DESIGNING A NEW MECHANICAL TENT FOR DISASTER

The following points are taken into consideration in design:

1. Lightness (to be established by several people)
2. The minimum energy use (if possible does not require any energy requirement)
3. Easy installation (requiring minimum professionalism and equipment)

The main structure is aluminium frame with double-sided canals (keder) system. This brings the lightness and opportunity to applicate (can be made if necessary) double-layer membrane in winter conditions or for the sound insulation.

By the way, the use of aluminium keder frame (75mmx100mm) with double-sided canals give a chance to divide the tent into to space through the middle aluminium frame. So you can have a space with 12m2 for daily-life between the front valance and the *bedroom*, that is privacy zone.

The front valance is thought to protect a space for daily-life from the wind and rain.

For the upper and lower membrane material is thougt to use tent materials of fabric firms, which have flame retardant, UV stabilized, antimould and antiwick properties for using and storage. This type of materials are ligth to install, to demontage and to stroge.

Base fabric		PES
Coating		PVC with acrlyc or pvdf lacquer
Total weight (g/m2)	DIN EN ISO 2286-2	650
Width (cm)	DIN EN ISO 2286-1	250-300
Tensile strength (N/5 cm)	DIN 53354	2800/2500 (warp/weft)
Tear resistance (N)	DIN 53363	300/250 (warp/weft)
Adhesion	DIN 53357	100
Flame retardancy	DIN 4102 / NF P 92503	B1 / M2

Table- 1, general specifications od fabric material

Because of the twilight zone of land use conditions for this small tent is choosen anchor pins with 50cm lenght, which have a chain ring at the top to facilitate the removal of anchor pins. The same chain ring is used at the anchor-plate, too. So, we can tension the fabric cover with the help of turnbuckles.

Furthermore, the intermediate purlins with the turnbuckle unit is used for stretching the membrane. So have the visual relationship breaker stretched exterior membrane the chance to provide the required strength against external physical conditions.

For easy installation (requiring minimum professionalism and equipment) of the frame elements and their compenents is used the switchblade-pin instead of bolts and nuts.

4.1.1 THE ARCHITECTURAL DRAWINGS

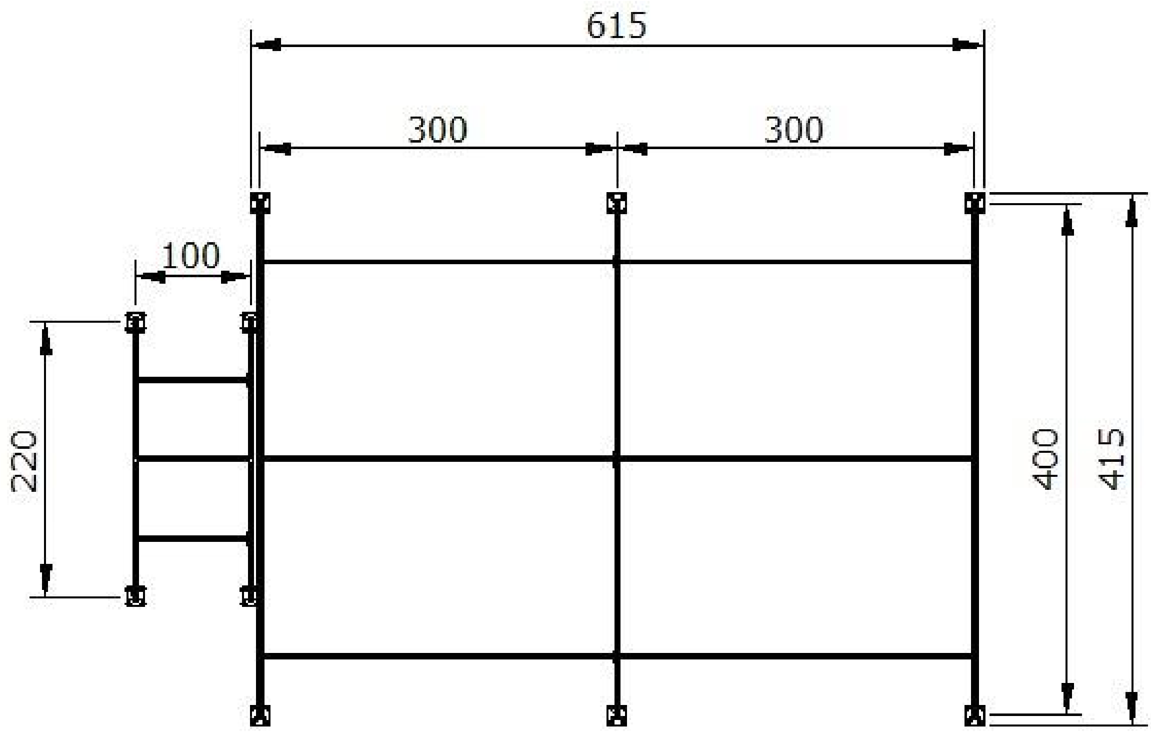


Figure- 72, Plan drawing

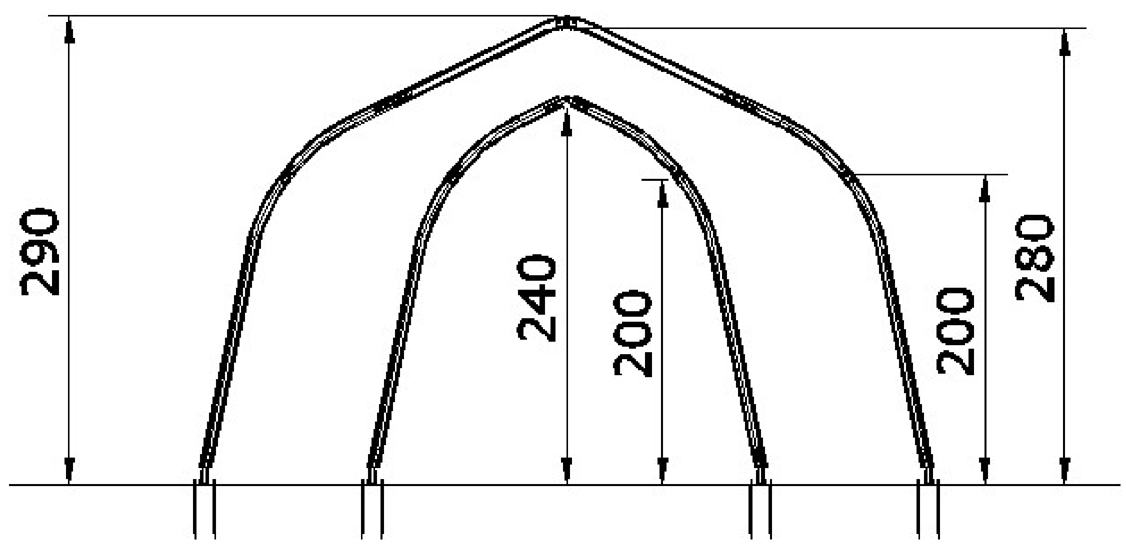


Figure- 73, Front View

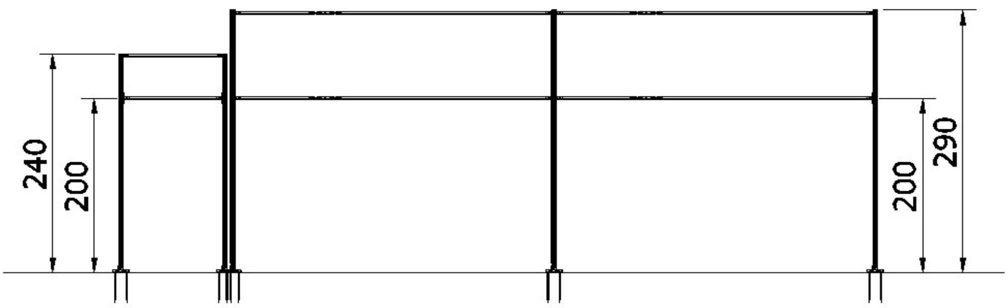


Figure- 74, Side View

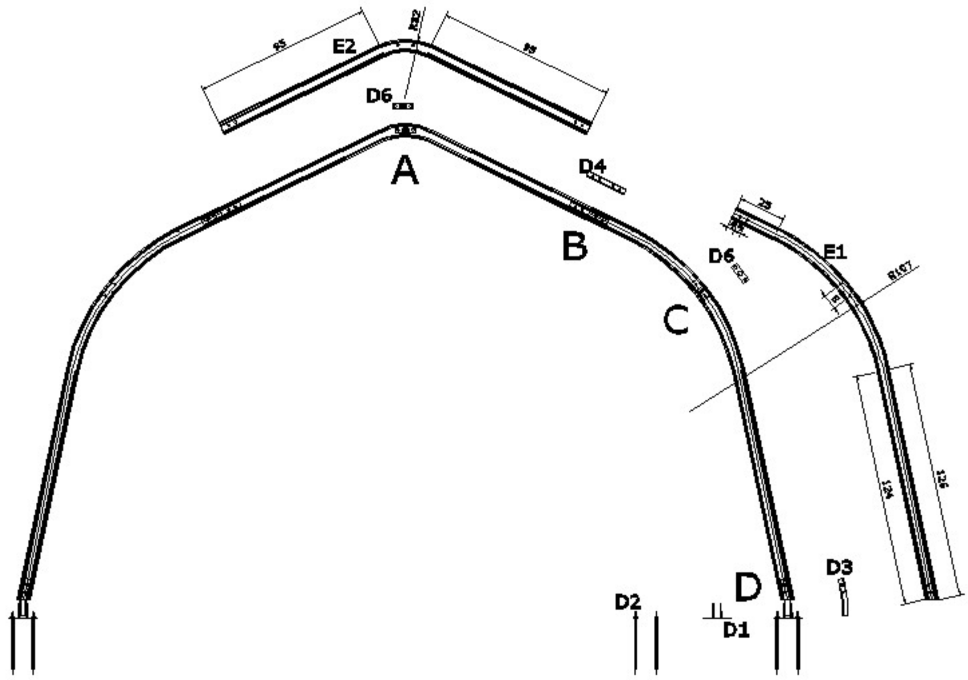


Figure- 75, Main Aluminium Keder-Frame

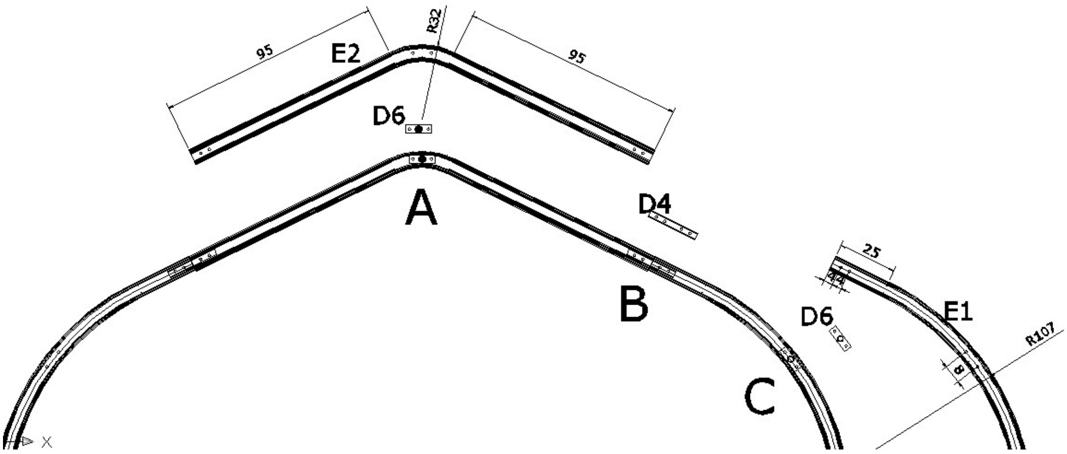


Figure- 76, Top of the Main Aluminium Keder-Frame

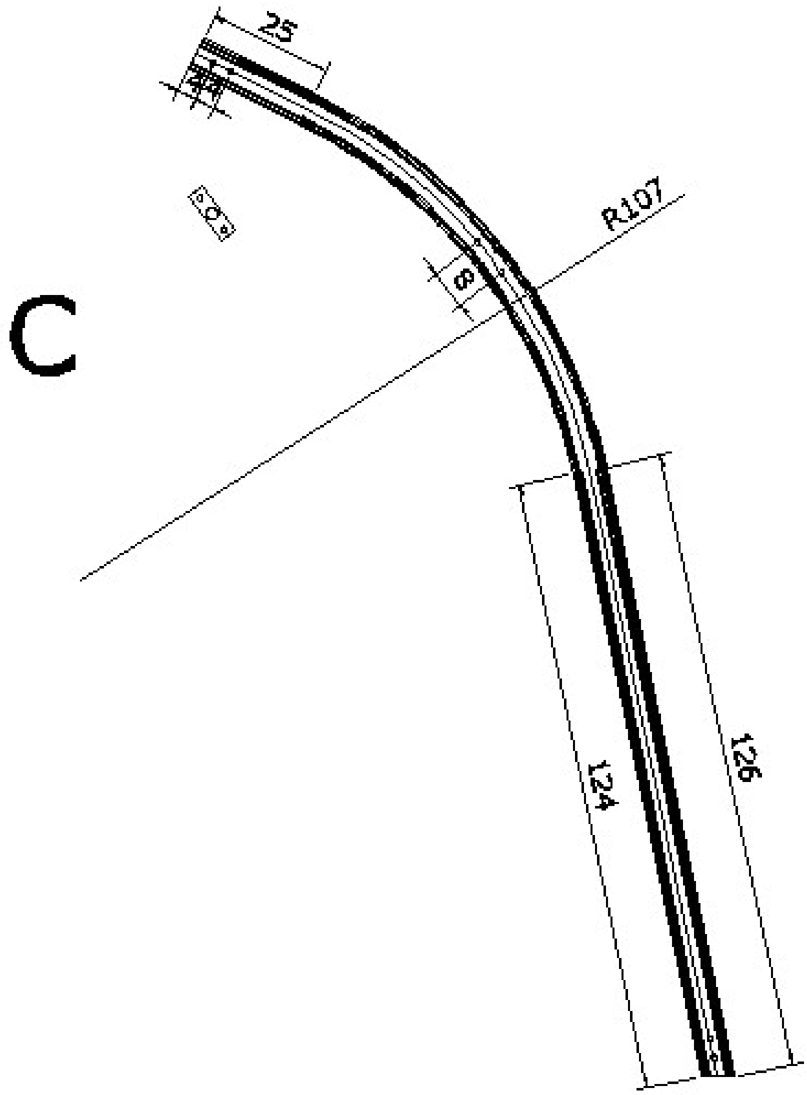


Figure- 77, The Element “E1” of the Main Aluminium Keder-Frame

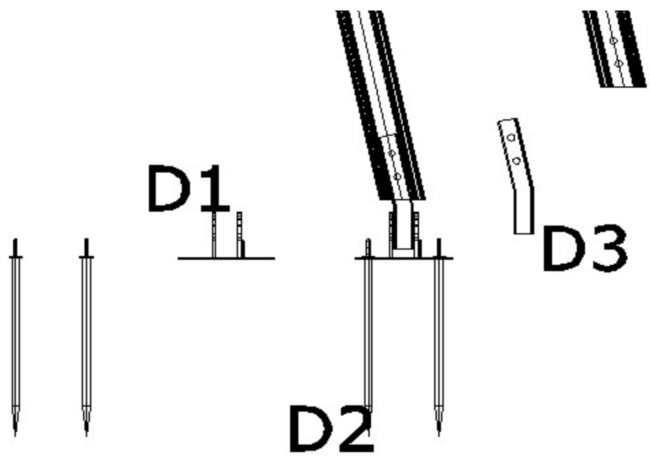


Figure- 78, The lower part of the Main Aluminium Keder-Frame and the Front Valance

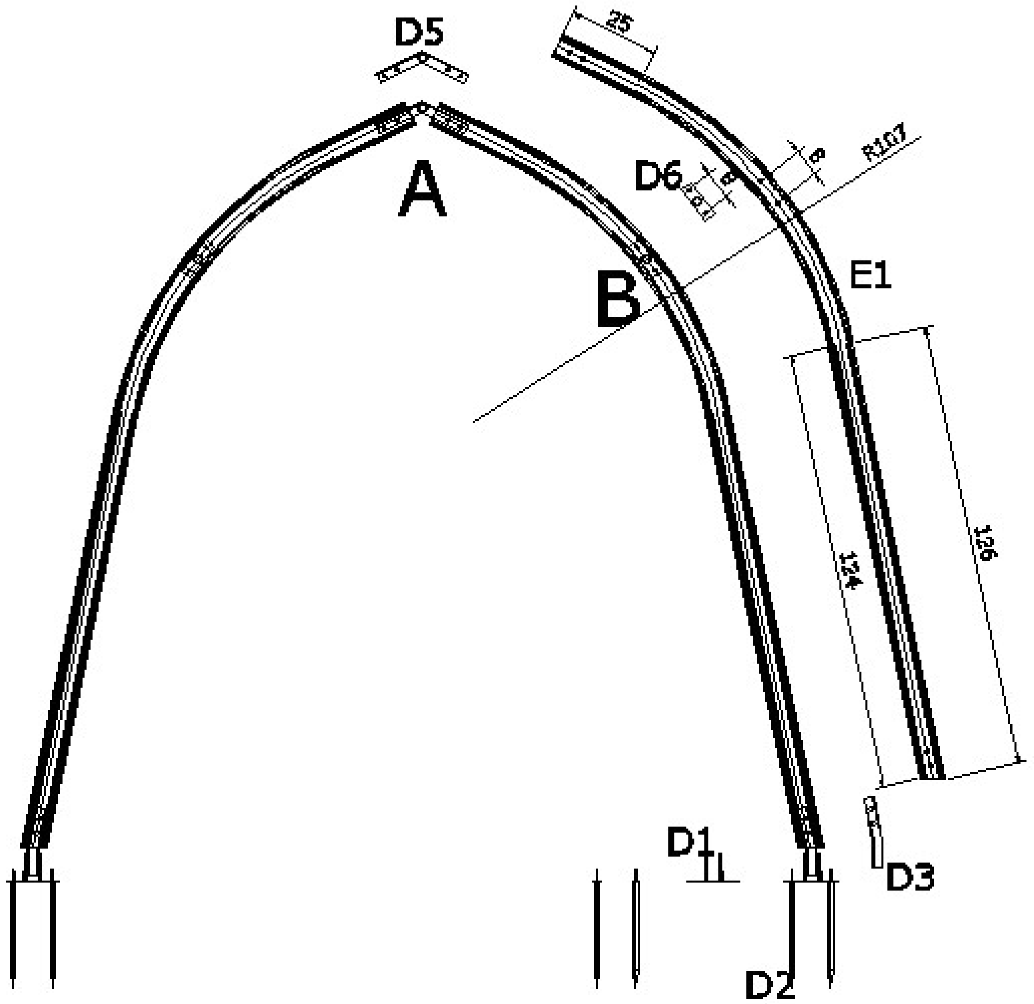


Figure- 79, The Front Valance

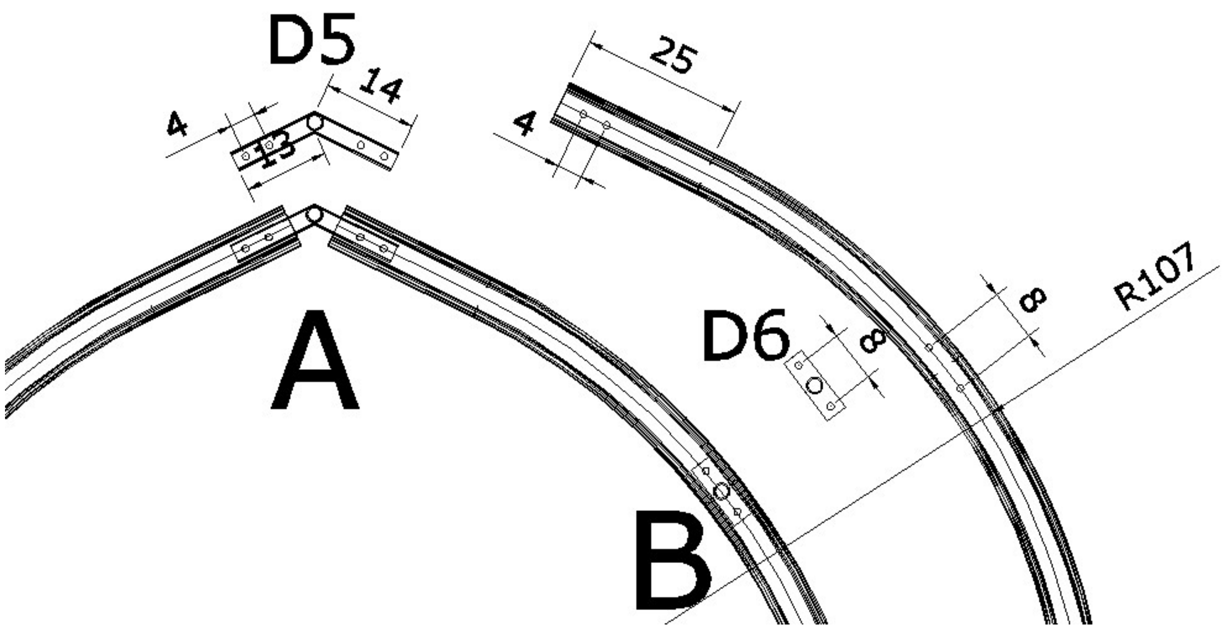


Figure- 80, The Top of the Front Valance

4.1.2 THE DETAIL DRAWINGS

The system consists of 5 structural elements and 6 components of these structural elements.

The list of elements:

CODE	NUMBER	WEIGTH (kg)	EXPLANATION
E1	10	20	The side element of the main frame and the front valance
E2	03	06	The top element of the main frame
E3	06	66	The intermediate purlin of the main frame
E4	03	09	The intermediate purlin of the front valance
D1	10	19	The anchor plate
D2	40	50	The anchor pin
D3	10	10	jointing component for E1 and the anchor plate
D4	06	06	jointing component for E1 and E2
D5	02	02	jointing component for the front valance
D6	16	05	jointing component for intermediate purlins and main frame

Table- 2, the list of system-elements

The total weigth of the struture is approximately 193kg. and the weigth of exterior membrane is approximately 80kg with the vertical fassades and the floor membrane.

The total weight of the system with accessories is approximately 300kg.

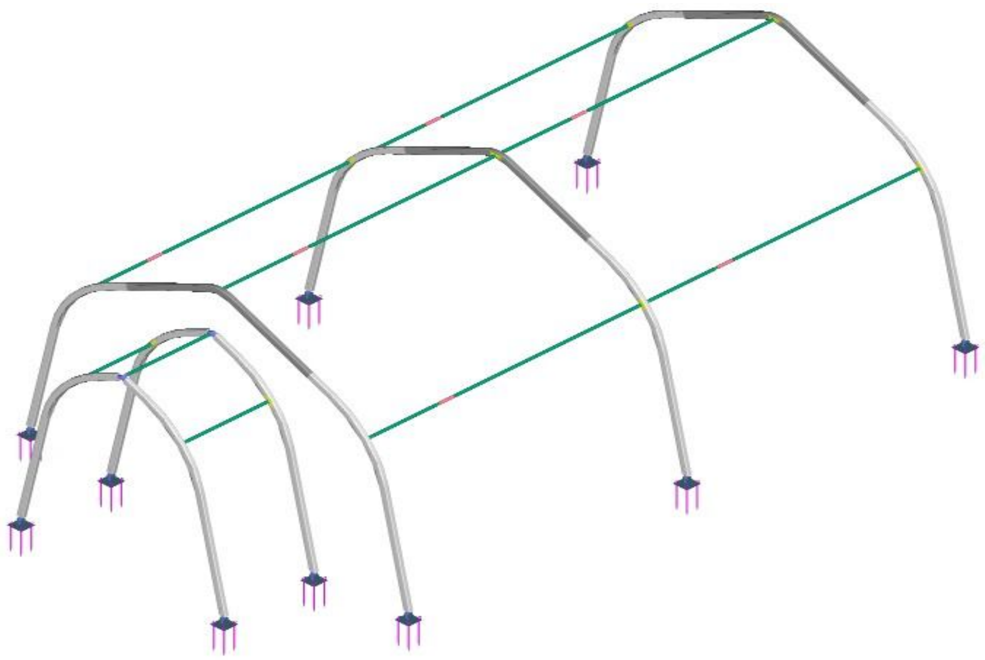


Figure- 81, The Axonometric View of the whole structure

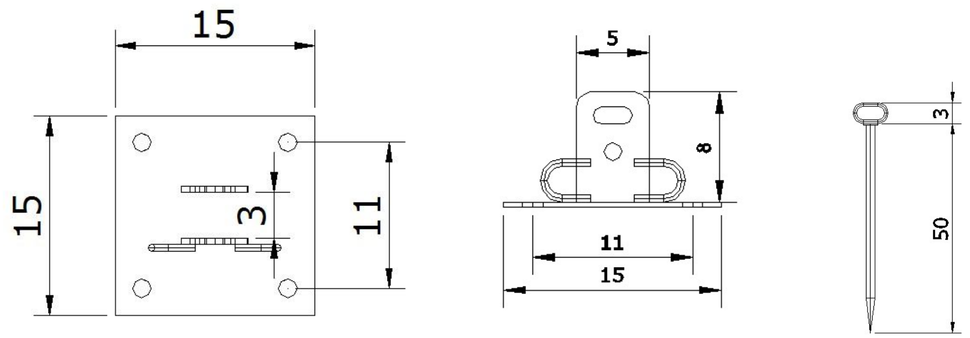


Figure- 82, The Anchor platte(D1 - left and mittle); the Anchor Pin (D2 - right)

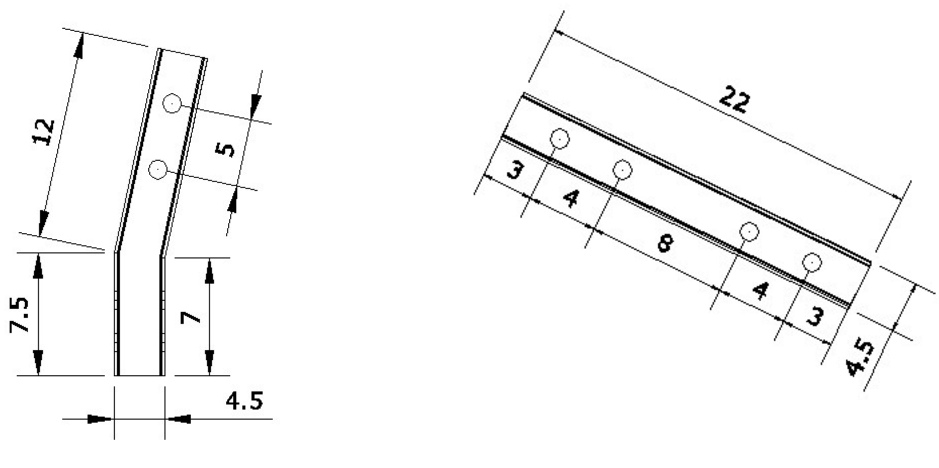


Figure- 83, The Component D1 (left) the Component D4 (right)

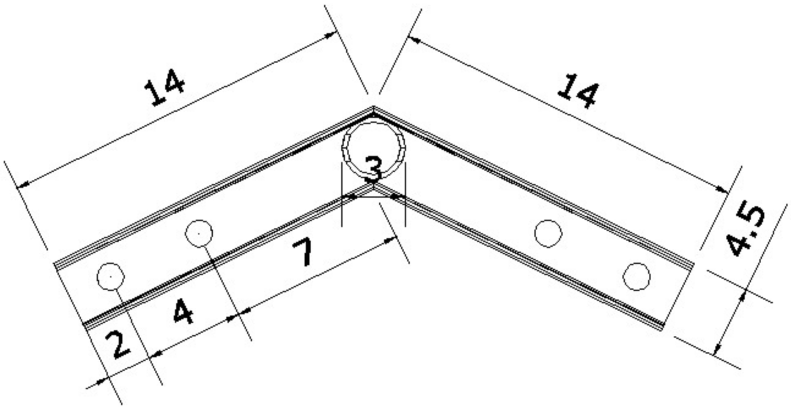


Figure- 84, The Component D5

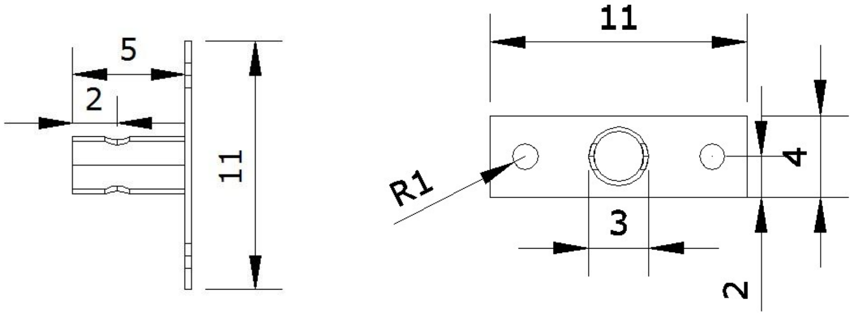


Figure- 85, The Component D6

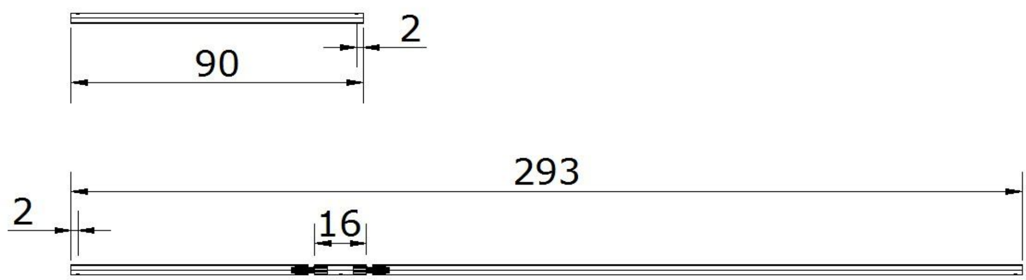


Figure- 86, The Structural Elements E4(short intetmediate purlin) and E3(long intermediate purlin with turnbuckle)

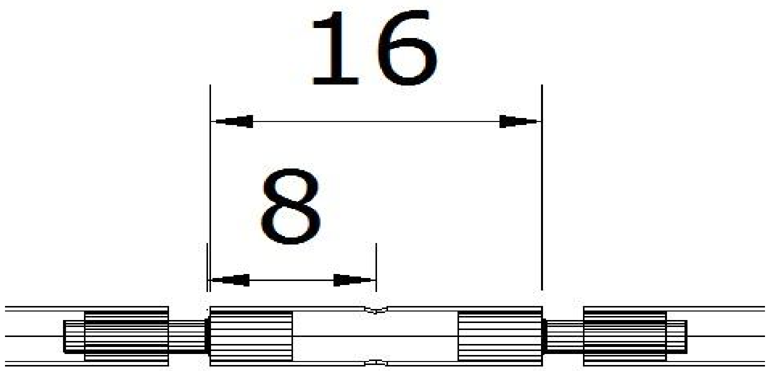


Figure- 87, The main fabric tensioned Turnbuckle of the Structural Element E4

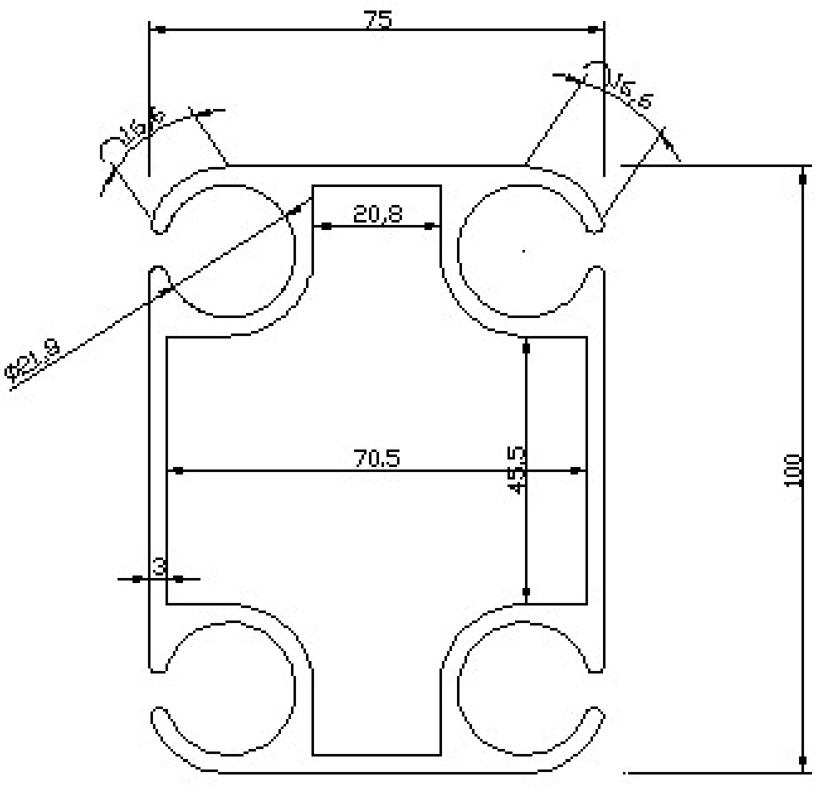


Figure- 88, The section drawing of keder-profile (75mmx100mm.)

4.1.3 THE RENDERS FOR DETAILS

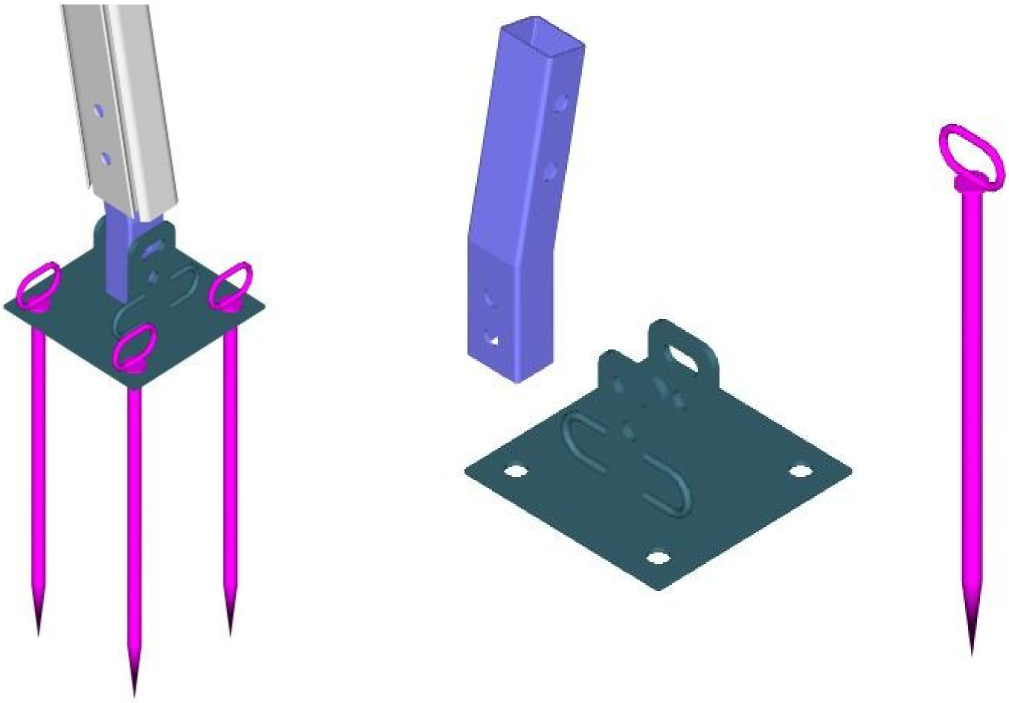


Figure- 89, The anchor platte and its components

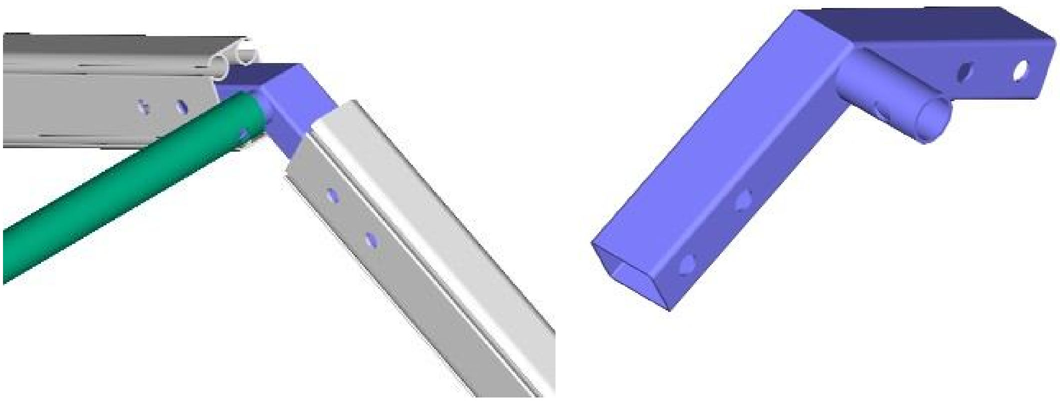


Figure- 90, The joint detail of the front valance (left) and its component profile D5

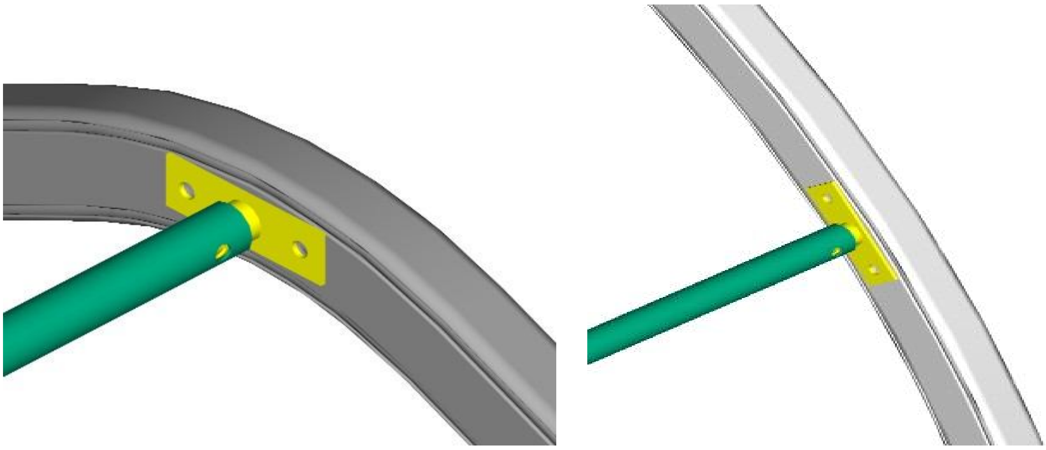


Figure- 91, The joint detail of the intermediate purlins with the strucyural elements E2 and E1

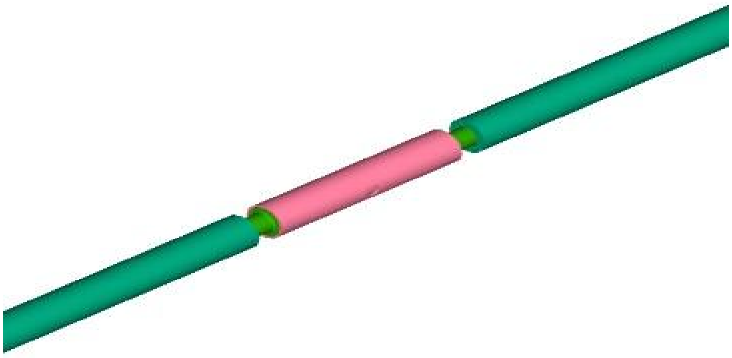


Figure- 92, The render of the main fabric tensioned turnbuckle of the intermediate purlins E4

4.1.4 THE RENDERS OF DIFFERENT USES

The " mechanical based small tent " should have the spatial reproducibility property to have a change for the creation of the structural groups for the second-degree utilizations like:

- public kitchen shelters,
- education shelters,
- shelters for personal cleanliness and maintenance.

By the way, the other commercial uses such a industrially produced tent can not be ignored like as a camp tent in the summer or as military tent.

EDUCATION SHELTER

Structure-groups can be created for education of people or for public kitchen use with some intermediate element (like accordion doors, bellows):

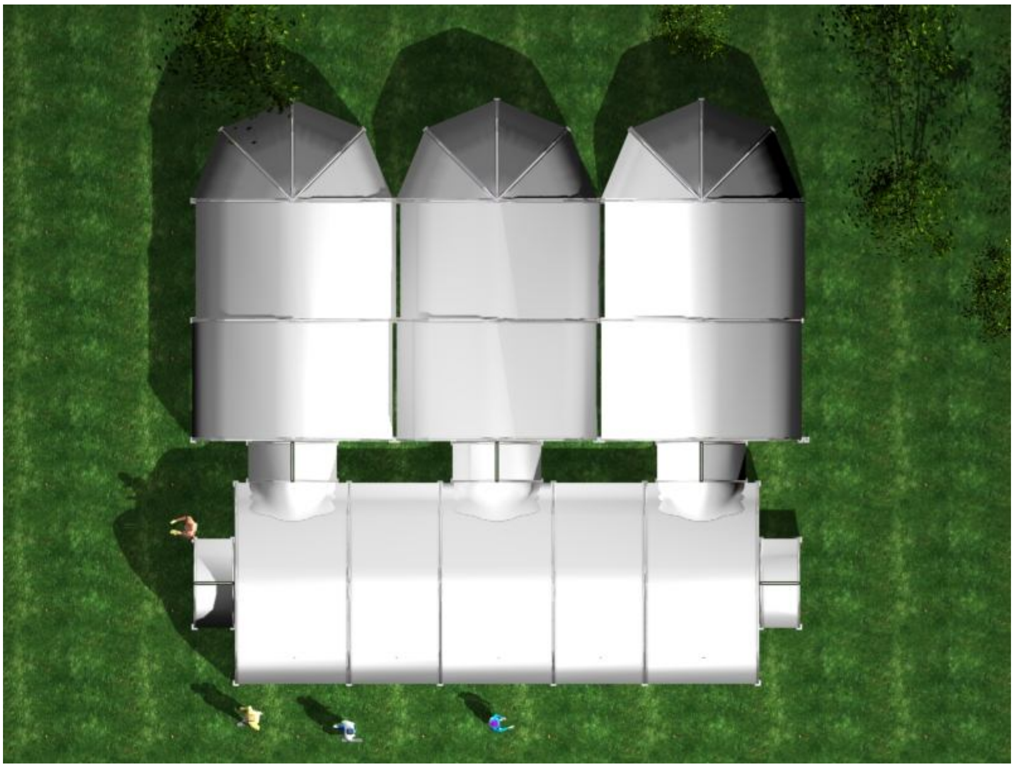


Figure- 93, The render of top view of structure-group for educatinal use

Figure- 94, The render of structure-group for educatinal use with fabric

Figure- 95, The render of structure-group for educatinal use with structural elements

CAMP SHELTER

Such a small tents can be used as a camp shelter out of disasters for commercial benefits with a front valance or without it and with minor differences.

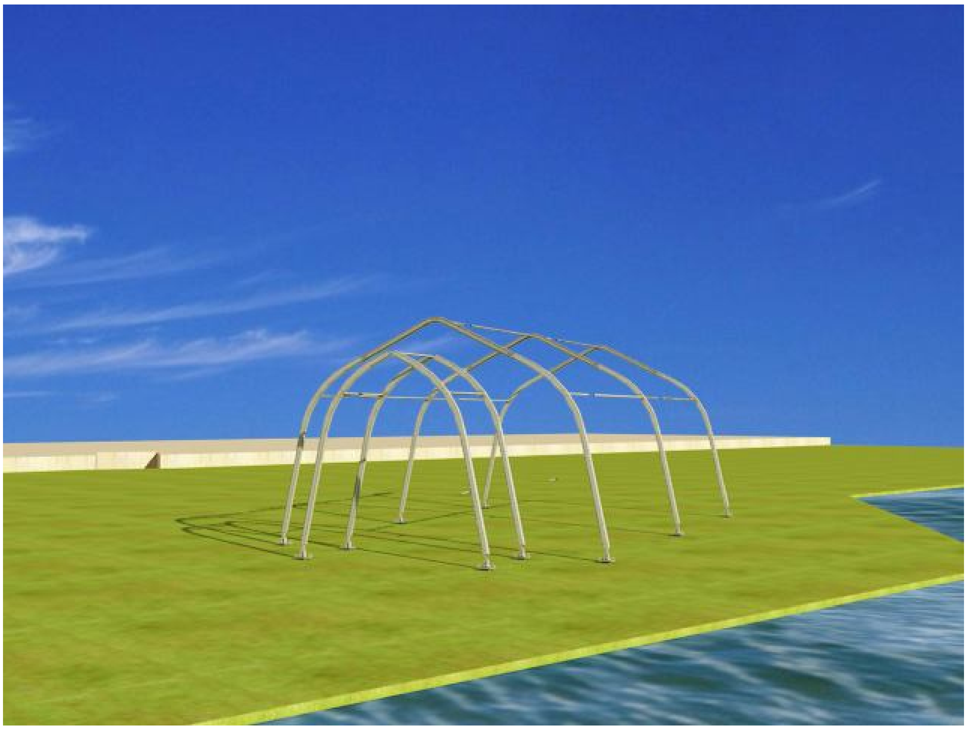


Figure- 96, The render of the structure of the camp shelter

Figure- 97, The render of the camp shelter with membrane

MILITARY USE

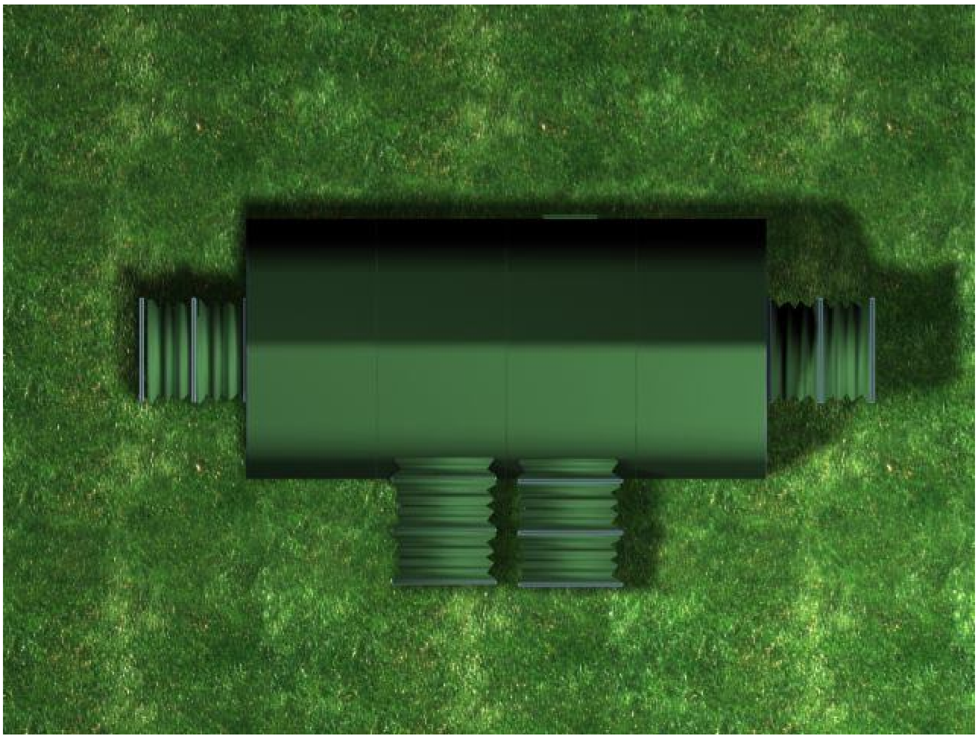


Figure- 98, The render of top view for the military use with accordion doors

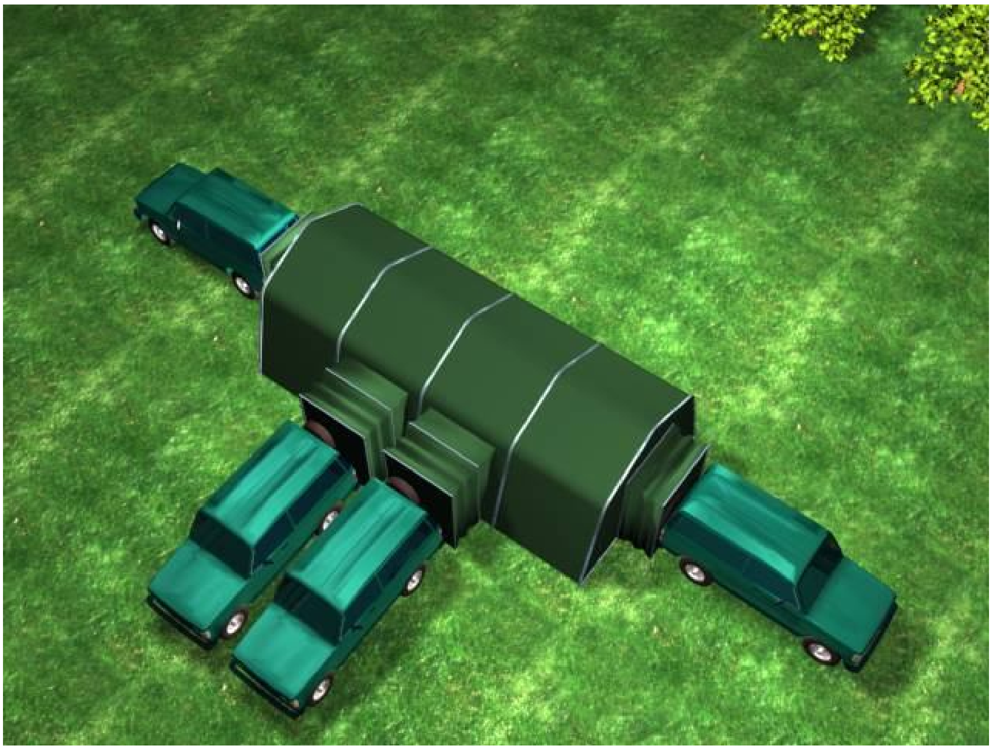


Figure- 99, The render of perspective view for the military use with accordion doors

4.1.5 OVERVİEW ABOUT THE STATIC OF TENT

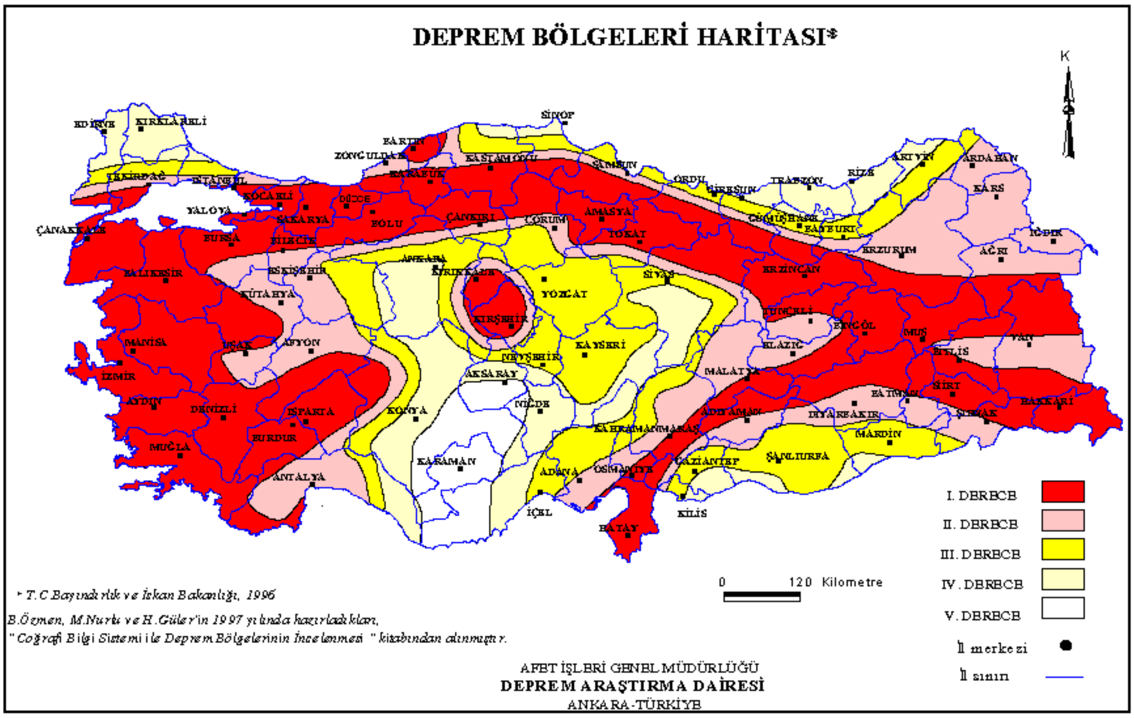


Figure-100, Seismic zone map of Turkey

Physical and Mechanical Properties for Aluminum 6061-T6 F29:

Density = 2.701 t/m^3

Young's Modulus = 70000 MPa

Shear Modulus = 26000 MPa

Poisson ratio = 0.35

Coeeficient of thermal expansion = 23 x 10^{-6}

Tensile Strength = 290 Mpa

Proff Stres = 240 MPa

Shear Strength = 190 MPa

Since the structure is light and single-storey tent, it is obvious that wind loads are more critical than the earhtquake forces. Thus earthquake scenario is neglected for the analyses. For lateral forces wind loads are be applied. Snow loads and the self weight of the structural frame and the membrane were applied in vertical direction.

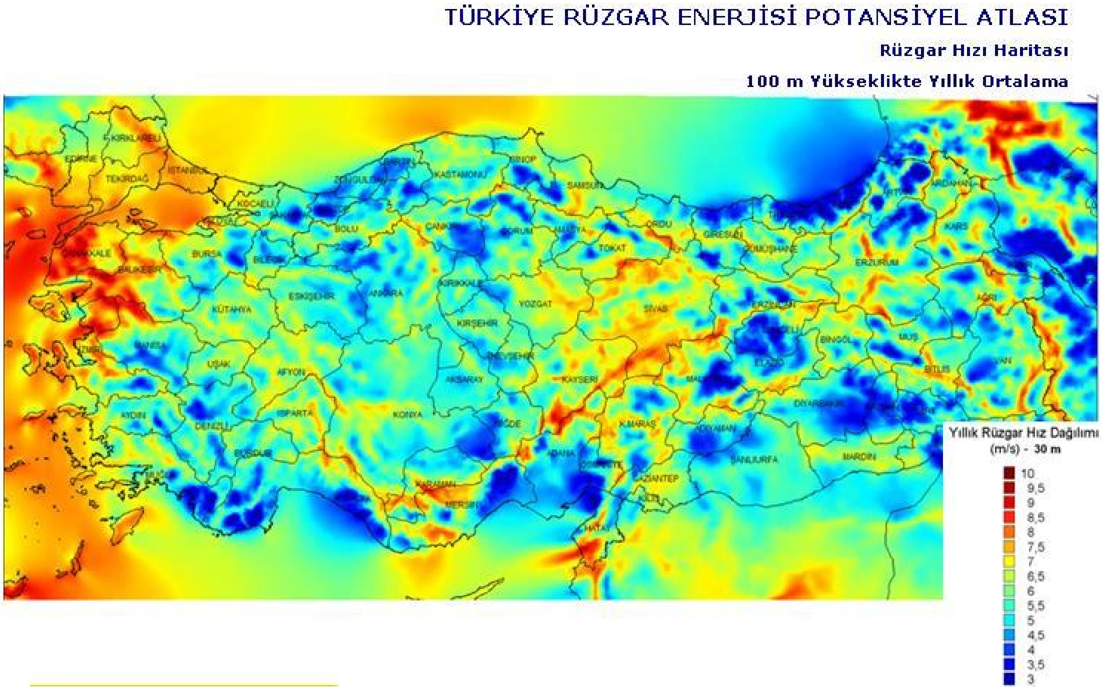


Figure-101, atlas of wind energy potential in Turkey

WIND LOADS

In Longitudional Direction (Along X-axis):

Wind loads that affect the structure was calculated according to TS 498 (Design loads for buildings).

Wind Pressure;

$w = C_p.q$ kN/m^2) q = Wind pressure kN/m^2) C_p = Coefficient of suction

In order to obtain the most inconvenient loading cases (snow loads and wind loads), altitude of the region that structure was built was chosen high.

Wind Suction;

q = 1.10 kN/m^2 (TS 498)

For the general structures that wind loads affect in perpendicular direction Cp is taken as 1.2

C_p = 1.20 (TS 498)

w = 1.20x1.10 = 1.32 kN/m^2 (wind load for per meter square)

Wind loads acting on the structure in perpendeciluar direction to longitudinal axis. Due to curved surfaces, the sructure was idealised in two parts. One of these parts has an angle close to 90 whereas the other part has a narrower angle with the ground surface. ($\alpha \approx 30$)

Main Frame between A-C:

Half length of the frame is approximately 3850mm
Length of A-C part is 1.80m

Edge Frames area = 2.00m x 1.50m = 3.00m^2
For suction surface, w = -0.40 x 1.20 x 1.10 kN/m^2 x 3.00m^2 = -1.58 kN
Uniform distributed load = 1.58 kN / 1.80m = 0.88 kN/m
For preassure surface, w =(1.20 x sin 30 -0.40) x 1.20 x 1.10 kN/m^2 x 3.00m^2 = 0.79 kN
Uniform distributed load = 0.79 kN / 1.80m = 0.44 kN/m

Mid-Frames area = 2.00m x 3.00m = 6.00m^2
For suction surface, w = -0.40 x 1.20 x 1.10 kN/m^2 x 6.00m^2 = -3.16 kN
Uniform distributed load = 3.16 kN / 1.80m = 1.76 kN/m
For preassure surface, w =(1.20 x sin 30 -0.40) x 1.20 x 1.10 kN/m^2 x 6.00m^2 = 1.58 kN
Uniform distributed load = 1.58 kN / 1.80m = 0.88 kN/m

Main Frame between C-D:
Length of A-C part is 2.05m

Edge Frames area = 2.00m x 1.50m = 3.00m^2
For suction surface, w = -0.40 x 1.20 x 1.10 kN/m^2 x 3.00m^2 = -1.58 kN
Uniform distributed load = 1.58 kN / 2.05m = 0.77 kN/m
For preassure surface, w = 0.80 x 1.20 x 1.10 kN/m^2 x 3.00m^2 = 3.16 kN
Uniform distributed load = 3.16 kN / 2.05 m = 1.54 kN/m

Mid-Frames area = 2.00m x 3.00m = 6.00m^2
For suction surface, w = -0.40 x 1.20 x 1.10 kN/m^2 x 6.00m^2 = -3.16 kN
Uniform distributed load = 3.16 kN / 2.05m = 1.54 kN/m
For preassure surface, w = 0.80 x 1.20 x 1.10 kN/m^2 x 6.00m^2 = 6.32 kN
Uniform distributed load = 6.32 kN / 2.05 m = 3.08 kN/m

SNOW LOADS

According to TS 498, snow load was calculated by planning the structure over 1000m and fourth snow region.(P_{k0} = 1.60 x 1.15 =1.84 kN/m^2; P_k=m.P_{k0})
m value was taken from Table 3 Reduction constant related to roof slope.
for 30 degree m = 1.00
for 32 degree m = 0.95
Snow loads acting on the structure respectively
Pk_1 = 0.95 x 1.60 kN/m^2 = 1.52 kN/m^2
Snow load = 1.52 x 0.5 x 0.64 = 0.49 kN
Uniform distributed load = 0.51 kN / 0.75m = 0.68 kN/m
Pk_2 = 1.00 x 1.60 kN/m^2 = 1.60 kN/m^2
Snow load = 1.60 x 1.50 x 1.55 = 3.72 kN (Edge)
Uniform distributed load = 3.72 kN / 1.80m = 2.07 kN/m
Snow load = 1.60 x 3.00 x 1.55 = 7.44 kN (Middle)
Uniform distributed load = 7.44 kN / 1.80m = 4.13 kN/m

SELF LOAD OF MEMBRANE

Total surface area of the membrane is approximately 80m^2 and the weight of it is 0.65 kg/m^2.Therefore the entire membrane has a 52KG of self load. As it is compared to other vertical loads it can be neglected.

LOAD COMBINATIONS (TS 648 , Turkish Earthquake Code , ASCE 7-10)

The load combinations are:
D+S
D+S+W_y/2
D+S+W_x/2
D+S/2+W_y/2
D+W_x
0.9D+W_y
0.9D+W_x
D+S/2
D+S/2+W_x/2
D+W_y

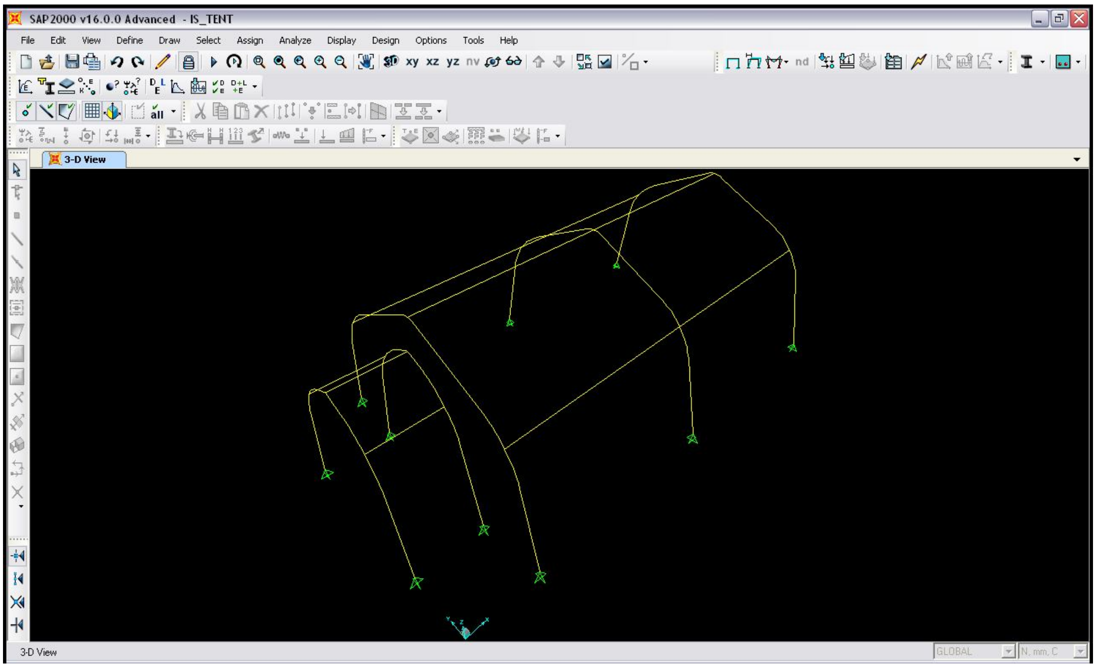


Figure-102, Mathematical model of the structure. (The model consists of frame elements that is defined by two points (start-end) and have 6 degrees of freedoms for each node. Frame elements have the capability of axial and bending behaviours. The structure is simply supported.)

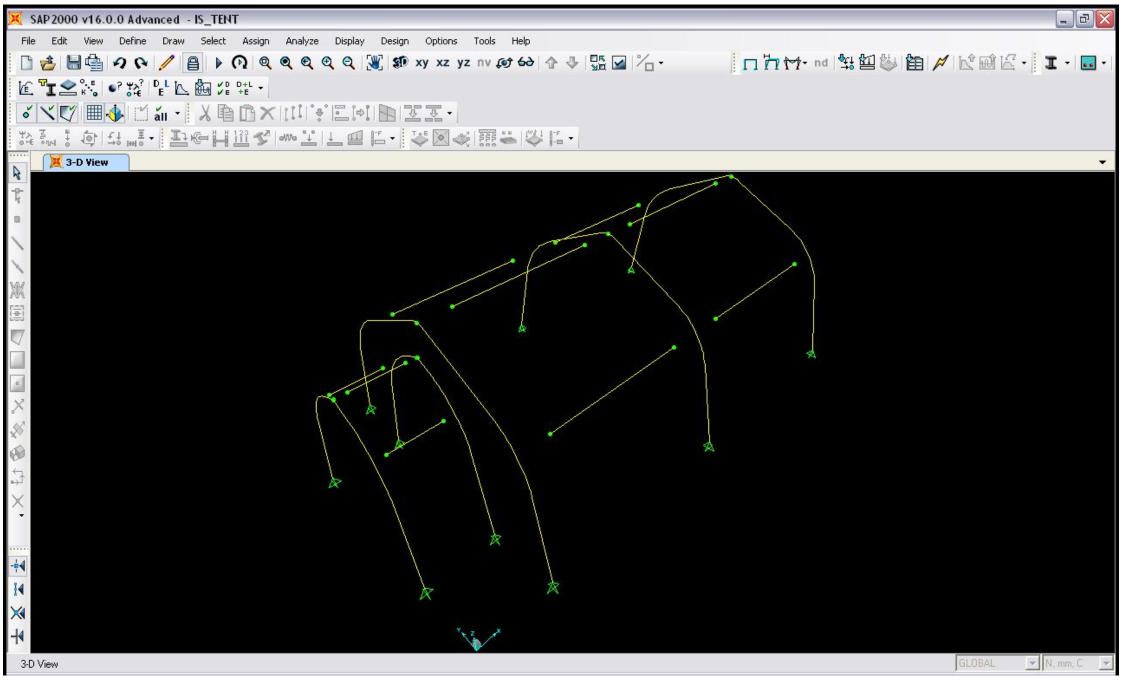


Figure-103, Frame Releases. (Frame releases added to provide the behaviour of the connection details. Therefore the purlins carry the axial loads and transfer them to the main frame.)

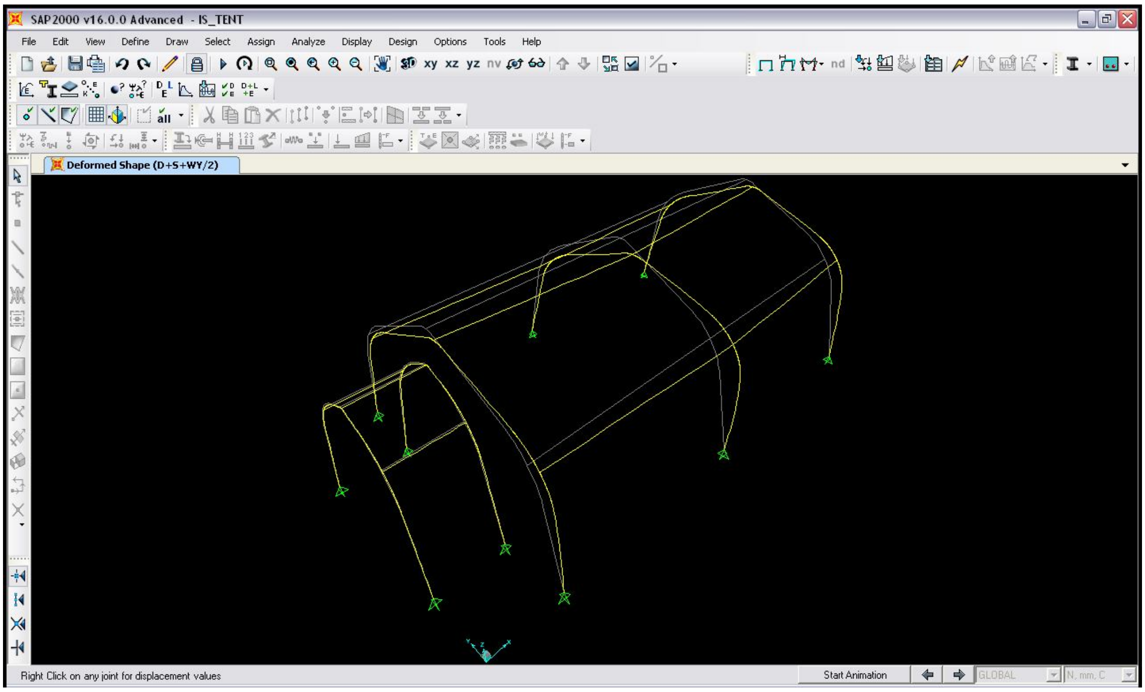


Figure-104, Deformed shape of the structure. (Scale factor was taken 10 in order to demonstrate the displacements clearly. Wire shadow indicates the undeformed shape. Maximum displacement in y-y direction is 33.43mm in D+S+0.5Wy load combination.

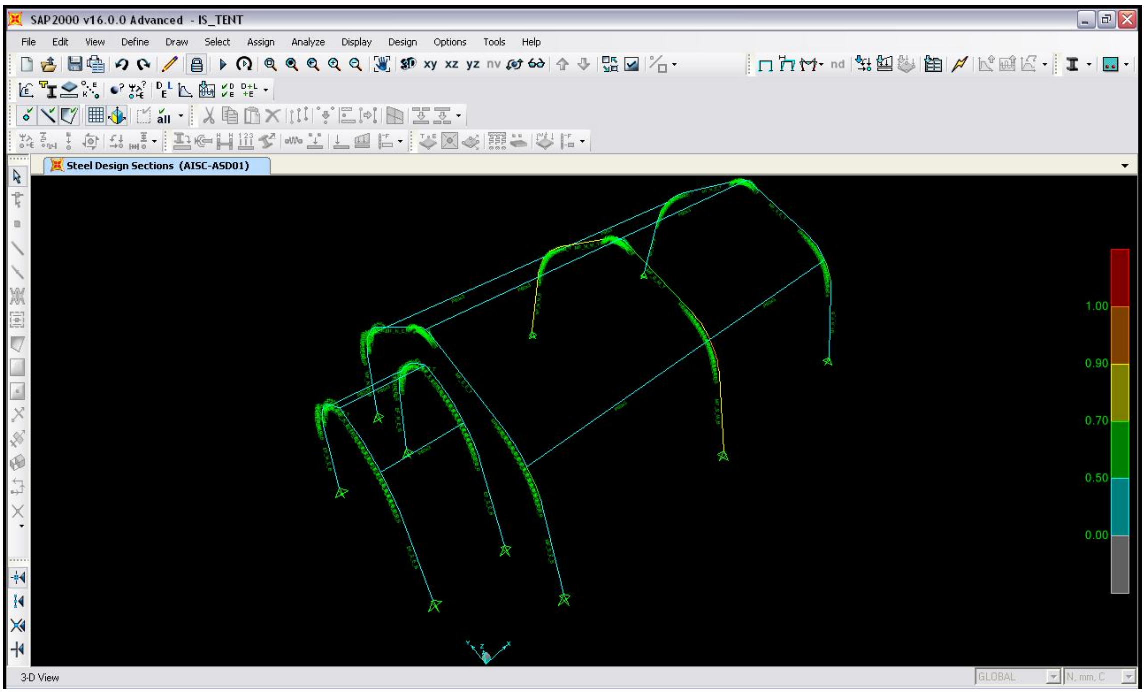


Figure-105, Capacity ratios of steel frame for AISC-ASD01 specification. (Sections used in the model was checked according to AISC-ASD01 spesification and it is clearly seen that all the members were passed the design controls. None of them is over the capacity. The highest capacity ratio is 0,951. Among the entire load combinations defined, D+S+0.5Wy combination was the most critical combination for mid-frame.

CONCLUSION

The most important problem is to built shelters for the disaster victims and urgent buildings like hospitals, crisis administration centers, schools, storages for the materials etc. after the earthquakes on the disaster sites.

Many tents with similar features can be made for this purpose - urgent housing problem after disaster-. But with this design has been attempted to deviate from the classic cotton fabric tent type used often by the Red Crescent in Turkey.

The main aim was to create a family tent had the outward appearance of a reassuring and which can be erected versus the external physical conditions in overall Turkey.

Because of the lightness and simplicity of this mechanic based tent, it can be established without the need for any energy and it is planned to storage these tents in containers near the post-earthquake emergency gathering area. In this way, without losing time with transport etc. people will be able to establish the necessary shelter immediately after the earthquake.

It is planned making concilium with municipalities for an organization to plan gathering area with containers in that these tents are storaged.

After the emergency shelter needs of families are fulfilled, the need for largest settlements based with necessary infrastructures beginn on the earthguake-area.can be quickly created during the next days with the help of reproducibility properties of such structures.

The “ mechanical based small tent ” have the spatial reproducibility property to have a change for the creation of the structural groups for the second-degree utilizations like:

- public kitchen shelters,
- education shelters,
- shelters for personal cleanliness and maintenance.

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