Sustainable Temporary Architecture[1]


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Abstract: *This research concerns about the shelter designing in post disaster cases and its ability to apply the sustainability principles. First, temporary architecture design has defined, then by defining the post disaster steps, the principles of sustainable architecture is explained. Thus the applicability of the principles of the shelter has been shown and has been used as basis for evaluating the application techniques in shelters. These techniques was classified into three classes: tents, prefabricated shelter and earth buildings. Finally, a general conclusion of the research and its assessment was done, and it explains how the most convenient for using each class.*

Keywords: *Disaster, shelter, dwelling, sustainability*

Sürdürülebilir Geçici Mimari

Özet: *Bu araştırma afet sonrasında kullanılacak barınakların tasarımı ve bu barınakların sürdürülebilirlik ilkelerine uygun şekilde tasarlanmasının yollarını araştırmaktadır. Öncelikle, geçici mimari tasarım konsepti tanımlanmış, daha sonra olağanüstü durum aşamaları açıklanarak sürdürülebilir mimari prensipleri değerlendirilmiştir. Böylelikle barınakların uygulanabilirlik ilkeleri gösterilmiş ve dayanak olarak barınaklarda uygulama tekniklerini değerlendirmek için kullanılmıştır. Bu uygulama teknikleri üç sınıfta (çadırlar, prefabrik barınaklar ve kerpiç barınaklar) irdelenmiştir. Son olarak genel değerlendirmeler ve analizler ortaya konulmuştur ve her sınıf nasıl en kullanışlı şekilde kullanabileceği anlatılmıştır.*

Anahtar Kelimeler: *Afet, barınak, mesken, sürdürülebilirlik*

1. INTRODUCTION

The disasters like earthquakes, landslides, floods, rocks fall, fires, avalanche, storm, rising of ground water, and wars have extensive and violent effects, cause loss of life and property, substantial effect on the communal life. The huge number of damaged and collapsed buildings after the disaster creates a housing problem needing urgent attention.

Accommodation is a major problem following any disaster because of its effects in physical, social, psychological and environmental ways. The rebuilding and inhabit victims after disasters could also lead to new models that enable urban and rural renewal in settlements. The emergency accommodation conditions, created for disasters victims, concentrate on overcoming the negative post-disaster conditions

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and protecting the victims from external effects. The construction of temporary housings necessarily entails a process radically different from the construction of housings at normal.

Rapidly there is increasing in need of energy and housing in the world according to the speed of the population increase, while there is limit of resources to achieve our needs by industrializing and technologically developing world.
Therefore the opportunity of facing an environmental harm or disaster increasing by the time. The constructing of buildings acts a main role in this fact, so one of our goals should be taking into consideration to apply sustainability criterions during planning and designing new buildings.
Moreover, and as it is important to apply sustainability criterions to new permanent buildings, it is more important to apply it to the temporary dwellings especially by consideration the economy side in temporary architecture.

2. THE CONCEPT OF SUSTAINABLE TEMPORARY ARCHITECTURE

2.1 Defining Temporary

A reviewing of the post-disaster cases in many countries around the world lead us to conclude that passing directly to permanent housing stage from the emergency stage is impossible. We should find another stage which represent the period from the termination of the emergency aid stage until normal living was established in permanent houses, and that what we call “temporary stage”.

Consequently, we can analyse the post-disaster period into three stages like this (Figure 1):

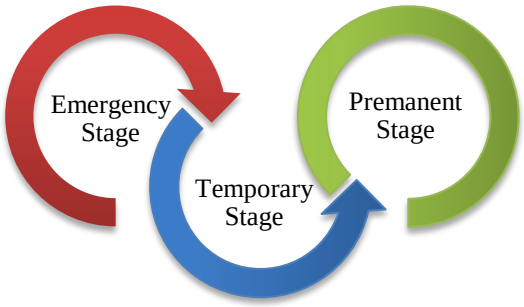


Figure 1. The three stages of post-disaster period

Emergency Stage is the stage that the homeless victims making their own accommodation positions or provided with emergency tents by governments or charities [1].

Temporary Stage must start in a shortest period after disaster and emergency stage. It continues until the permanent houses are completed. In this stage, the housing is solved by the temporary dwellings. The length of the rehabilitation stage is a consequence of providing the permanent housing and is never determined in advance. Due to the delay of the reconstruction stage, in some cases the temporary stage may continue up to 30 years [2]. In such cases, the temporary houses undertake extemporary functions related with the usage style and period.

Permanent Stage develops and rebuild disaster stricken region or reconstruct accommodation complexes and aims to provide proper permanent housing for the victims in a short period.

2.2. Defining Sustainability

Brundtland (1987) first put the now-traditional concept of sustainability forward as '"Sustainable development seeks to meet the needs and aspirations of the present without compromising the ability to meet those of the future' [3].

The preservation and developing of the resources are at the base of the sustainability and sustainable development. The assessment of the resources by their continuous preservation, especially the defense of the renewable resources without going beyond their renewal limits to the development form the base of the development philosophy preserving the environment [4].

There are many principles that the temporary architecture should achieve to reach sustainability. Fundamental elements has been choesen wich cover most of the sustainability principles in temporary architecture, and that takes us to the third chapter of this research.

3. SUSTAINABLE TEMPORARY ARCHITECTURE PRINCIPLES

3.1. Budget

The issue of the cost of construction work is one that is rarely far from the minds of construction clients, design teams, constructors and, of course, quantity surveyors. Generally, there are two types of costs in construction operation: capital costs and lifecycle costs, and in our case, it is very important to concentrate on both of them at the same time.Actually, in sustainable temporary architecture and in such post-disaster cases the client is the victims themselves or charities so undoubtedly the cost should be reduced to the maximum extent.The factors which affect the cost of the building include: the identity and priorities of the client, the nature of the project and who is responsible for developing its design, the choice of procurement options, the prevailing market conditions and legislative constraints.

3.2. Processing Period

As mentioned in "Defining Temporary" section, we must reduce the emergency relief stage as much as possible so we have to make a strategy or framework to inhabit the victims and to alleviate stress and sufferings of them in a short period of time. After required infrastructure is made, the critical part of rehabilitation stage is housing construction, because it is the real step that allows us to move from emergency to temporary stage.

There are a lot of solutions to reduce the construction period such as producing the shelters in factories while the infrastructure are being make in the site and all we have to do is to put them on its foundation which we already made there. Until now this is the most famous and used strategy, but in some cases - especially in wars- this could not be very useful because it may be expensive little bit and we have to transport these shelters to the site and this adds another costs. In other solutions, we can depend on the victims themselves to build by clay or any other material but this normally take a long period.

3.3. Usage Duration

When a desire to make a building in temporary (rehabilitation) stage as reliable as possible we should to think about its robustness and continuance because in some cases this stage could continue for a long period so the buildings or shelters we have to made must be robust for even years.

Several principles must be considered for understanding what robust design stands for, and as we think about a long time, so in the first place the main consideration should be an extreme environmental effects, everything in nature presents natural variation. It cannot be avoided but it can be controlled. In the other hand, the comfort of the victims in there shelters is also an important idea because a long time means that the family which lives in this shelter will have needs widely like permanent accommodation. Therefore,

the tent system, which normally used in the emergency stage, does not serve our purpose or even a one-room shelter –which is the most famous one.

3.4. Materials

In the design phase of any building industry, appropriate material selection is critical for the entire project. A poor choice of material may affect the quality of the project, lead to high cost during the long term operation and maintenance phases, and even endangering humans and the environment [5]. By intellectually integrating building materials and methods, a sustainable building may meet users' needs, reduce impact on future generations, and promote environment quality, economic vitality, and social benefits [6].

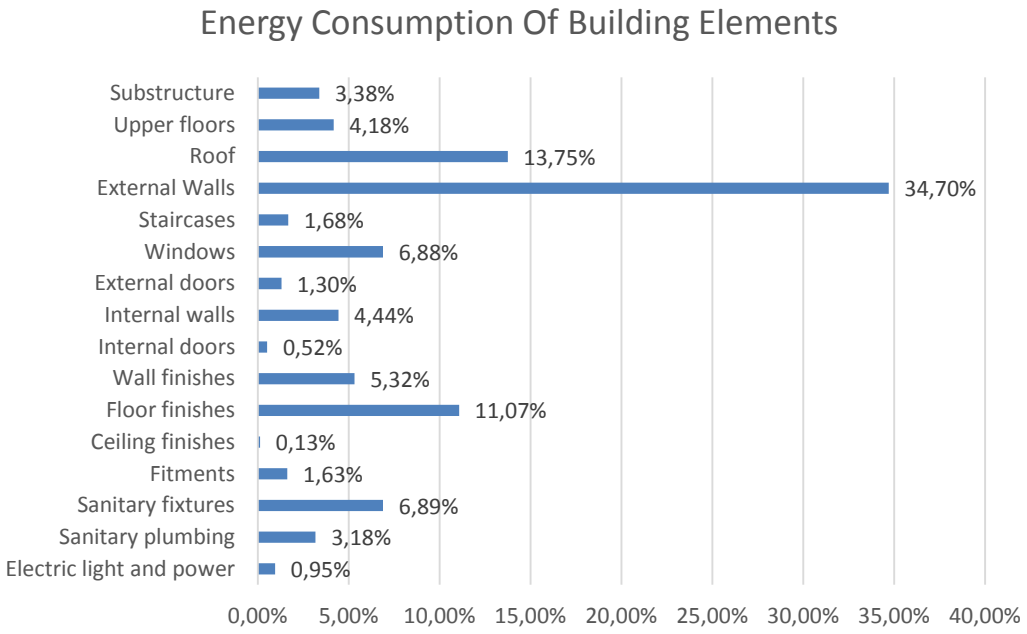
The conservation of environmental resources includes both the minimization of consumptive practices and protection of quality, of both non-renewable and renewable natural resources: doing more with less. Minimizing usage of valuable natural resources is an obvious element of sustainable practices. The mantra of "reduce, reuse, recycle," can be interpreted for this idea as: reduce consumption, reuse existing resources (salvage, recycled content or recyclable materials), and recycle waste produced [7].

3.5. Energy

Comparisons of energy savings are dependent on the energy intensities used within each dwelling. Homes have varied consumption rates depending on design, features and use. Comparisons must consider these factors and their costs [7].

In sustainable temporary architecture, the case is different from the cities because we do not have any infrastructures or even it could be so far from our site. Furthermore, the energy may be generated form charities. Therefore, to reduce the costs for these charities -that could continue for a long period- and by considering the lack of infrastructure we will find that the best way to providing our buildings in rehabilitation stage with energy is the sustainable one.

Table 1 Energy-consuming of building elements [8]



3.6. Water

Sustainable water reuse is a central theme in sustainable temporary architecture; water is a finite resource intrinsically linked to energy. Energy is required to pump and move water throughout the building system. Additional energy is consumed by treatment processes that result in water which meets acceptable quality standards. Similarly, water cannot be infinitely pumped from potable sources to meet victims needs. Sustainable solutions are required that meet current and projected need as well as preserve natural and human cycles. Responsible water management increases water efficiency and both indoor and outdoor environments benefit from it. Through the implementation of water management strategies, such as water reclamation, conservation, or decentralized water reuse, the issues associated with water need may be alleviated. Various water strategies can be implemented to increase water use efficiency such as conservation, recycling, reclaimed water, green roof, and native landscaping [9].

3.7. Flexible Of Capacity

As we know, every family is a unique case and has her own properties, average of privacy and a different number of persons. Therefore and as architects, we should find a best solution to save this family's properties.

In post-disaster cases, some people think that this is not an important principle because we have to find roofs for a huge number of families. This could be excisable in emergency relief stage but since we are moving toward temporary stage, which could continue for long period as we said, so it is meaningless to deal with all the families as they share the same conditions. One of the best ways to achieve our goal is to make a design with flexible of capacity that allow us to build according to the family.

4. TEMPORARY ARCHITECTURE SYSTEMS AND TECHNIQUES

4.1. Tents

Tents are the oldest and most enduring form of housing. Early nomadic societies required housing they could move from place to place in order to find food. This often meant moving from moderate to extreme environments (Figure 2). Any shelter used by these people needed to be robust and flexible. One such shelter is the Yurt. Used by Turkish and Mongolian tribes, this shelter was and is the primary dwelling of the tribesmen. It is disassembled and carried across long distances.Tents are temporary enclosures used to house people or goods. Their uses vary to include recreation, refugee housing, and military shelters [10].

Figure 2. View of the tent structures [11]

The emergency tents are not intended to be a permanent solution, but a movable foundation that could be upgraded over time by residents [12]. Nevertheless, if these tents are used for a longer period than foreseen, the devastating and inhuman situation increases. Sheltering not only concerns the provision of a physical structure; it also has to satisfy a number of other requirements [13]. These structures range in size from single-person dwellings to warehouses. The wide variations in both use and size make tent structure design a considerable challenge.

4.1.1. Sustainability assessment

Budget: Generally, these types of shelters do not cost a lot of money as capital budget. Simple tent could even be made by the humans with simple equipment. It just could cost a little if we have to transfer them for a long distance.

Processing period: We can construct these shelters with couple of hours and we could work with the victims to process it. It is just constructing the structure then holding the cover to it, and this consequently taking a very short period.

Usage duration: One of the main disadvantages of lightweight shelter is being short lifespan. It is very affected with environmental effects. Neither the structure nor the cover could resist the rain or storms or other external effects. The cover could worn out by the time. Moreover, and by considering the lack of privacy or any other social needs for the family, we should not let the victims accommodate in such environment for a long period.

Materials: The structure material could be steel or PVC and both of them are reusable and recyclable, after the finishing of using it we can disassemble it and store it for the next mission or we can recycle it be melting and reduce it for other uses. Nevertheless, main problem here is the cover; it is neither reusable nor recyclable and farther more the life span of it is short. These materials has a lack of thermal insulation and it cannot resist the environmental and climate effects. All what we can do after few months is to throw it away and bring a new one to cover the main structure and that is the worth part in tents.

Energy: Basically, in this system there is no any consideration about energy. The heating could be by gas or firewood, and however this heat will leak by the cover of tent.

Water: In an organized camp from these tents, we cannot talk about any type of water reaching or getting out from the tent by pipes. Normally the water is brought from main sources in the camp by gallons. The WC and bathrooms are combined in some points and regardless of privacy it is normally stay unclean and unhealthy.

Flexible of Capacity: We can achieve this property by producing a number of models considering the number of persons who will accommodate in this tent; that could be achievable before producing. However, normally the tent produced as standard for five person's family and we cannot add any additional spaces. Therefore, we cannot consider it as flexible theoretically.

Table 2. The conclusion of tents sustainability

Tents						
Budget	Possessing period	Usage duration	Materials	Energy	Water	Flexible of capacity
√	√	χ	χ	χ	χ	√

4.2. Earth buildings

The mud, and because of its plasticity, is the first used building material. There is no problem about finding or producing it and it could be formed easily. Earth and muddy mixtures are used as a building material in a variety of ways for ancient times. Around the world, there are a lot of refugee families, who find in traditional techniques ways to build dwellings that meets their basic needs. Many refugees use building techniques that have evolved for years taking into consideration their specific environmental surroundings, in order to build functional houses. These techniques are usually based on cheap building materials, easily found in the area and frequently long lasting (Figure 3).

Figure 3. Earthen buildings, Syria [14]

Earth buildings may constitute an intermediate technology and offer an alternative to both modern and traditional technologies, since it uses natural materials that are readily available, it is durable, and gives good and healthy indoor characteristics improving the comfort of its inhabitants; such a technique can possibly be easily transmitted and used by local people [15].

4.2.1. Sustainability assessment

Budget: Building materials is just soil, straw and wood and those are normally located in most of conditions. They are cheap and available for every one. It is a common and traditional technique so it does not need a very experience and the manpower could be the inhabitance themselves.

The owner can build furniture, such as benches and beds or even niches or bookshelves that may help reduce costs since there is no need to buy them elsewhere, and they can be made even after the house is finished. It is possible to add cob furniture to the building or to create niches or bookshelves after the wall has been built [15].

Processing period: Despite we do not have a loss of time about transferring materials or any other equipment which could be made locally, but the construction operation of these buildings often take long period relatively, vary depending on the type of construction.

Usage duration: This system provide a very long of usage duration and we could mention here that there are a lot of people around the world from old history until now living in such earth buildings as a permanent house. Because of its sensitivity of water, it may needs some repair every now and then and

that depends on the environmental conditions. Therefore, we can say that it will be a good choice for sheltering in dry regions.

Materials: There are several advantages over compared to other building materials such as: affordable, low-priced, providing healthy lifestyle, natural local resources, minimal of waste generated during the production fire resistance.

Energy: This type of shelters is very effective from energy point. Initially, we can fulfil the main construction operation without any need for energy. In the other hand, the design of earth homes, and their usually thick walls make the atmosphere comfortable, and the interior temperatures quite stable.

Water: Since these dwellings could have many rooms and could contain even bathrooms so we can do water infrastructure and apply many techniques for conservation and water recycling. Moreover, in earth dwelling especially dome roof ones, we can add some simple equipment, which allow us to harvest rainwater, storing and reusing it in different ways.

Flexible of Capacity: Actually, the flexibility of earth buildings depends on the technique of building. Some techniques allow adding another spaces even after the finishing of construction and others need to be rebuild to change the design. However, in both cases that will not costs more than additional amount of soil and that is a big advantage here.

Table 3. The conclusion of earth building sustainability

Earth Buildings						
Budget	Possessing period	Usage duration	Materials	Energy	Water	Flexible of capacity
√	χ	√	√	√	√	---

4.3. Prefabricated Shelters

"Prefabrication" literally means carrying out work earlier (typically moving it from the site to a controlled work environment), aiming for a better use of resources and improved control, and reducing skill requiring operations on site - all in the interest of speed and profit. All building work uses materials (like sand, concrete, earth, formed on site) and components (units like bricks, sections like joists or assemblies like windows, necessarily prefabricated). Conventional prefabrication in high-tech and industrialized environments involves centralized factories, novel materials and stable organizations, but this is not necessarily the case in other environments (Figure 4, 5) [16].

Typically, four stages make up a modular construction project. First, design development by the developer and plan approval by any regulating authorities; second, assembly of module components in a factory; third, transportation of modules to the project site; and fourth, erection of modular units to form the building [19].

A form of prefabrication already exists in developing countries, which uses local materials and avoids high-tech industrialized operations, and which is based on a multiplication of resources such as small-scale local entrepreneurs. Facilitating a decentralized, low-tech, homegrown prefabrication capability of this sort may significantly contribute to post-disaster reconstruction [16].

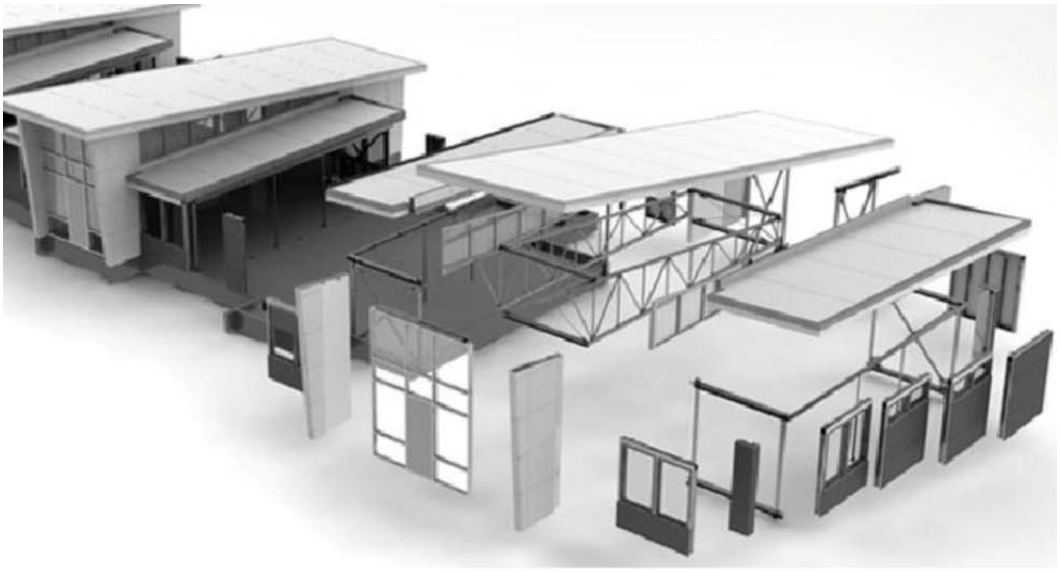


Figure 4. Prefabric structure component [17]

Figure 5. Modular prefabric structure [18]

4.3.1. Sustainability assessment

Budget: We can say that this type of shelters often cost a lot which make it difficult to offered even by charities, normally this shelters produced by supporting form governments and this is the most disadvantage here.

Processing period: As mentioned in "Types" section, we have two techniques to be applied here, however, in both of them the processing period is in the minimal stage. Of course, we have a loosing of time for shipping and transforming, but if we want to talk about the period of the processing in the site, we can say that it will not exceed a couple of hours. We have to prepare the infrastructure like the equipment of energy and water... etc., for every shelter base and then all we have to do is to place the shelter and connecting the extensions there. Naturally, it will take little more

time in the site for joining the components if we used an “unjointed modular building” type and that depending on the size of the dwelling, but it still just a little time.
Usage duration: The modular shelters have the longest usage duration cooperative to the other temporary architecture systems. Because of its good materials, it could continue for a long time without a needing of repair or to be replace. It is useful for every climate or whether, and we it could be produced to appropriate any region in the world and that make it an international choice as sustainable temporary architecture. In the other hand, when the need of it ends we can dismantled and reuse it elsewhere and that is a very important point here.

Materials: The material in modular buildings allows many innovations and that make it a very advantage point. Since we are producing the shelter in the factory so we have a large number of material to choose and that depends on the budget and the climate. Modular buildings are constructed with a range of materials similar to conventional site-built construction. We have wood, steel, concrete and the most common in post-disaster cases is the mixtures. It could achieve thermal isolation, low carbon footprint, fire resistance, zero of waste, fully recyclable and it does not affected by crack, water or any other external impacts, all what we have to do here is to choose a good material and start producing.

Energy: As we are using a thermal isolation material, so we are reducing the heating that escape by the envelope of the building. In the other hand, the energy could be reached to the shelter from external network or we can even use the green resources like solar, wind energy or any other sustainable resource. We can attach a solar system to every shelter and that make it an independent unit or apply a general green energy system and make it an external network for a complex of shelters.

Water: The water efficiency of prefabricated system does not different a lot from the earth buildings.
The shelter could be connected by pipes with a main network and be supplied by some techniques to achieve the sustainability of water like reusing the grey water and rain harvesting…. etc. We have to mention here that these dwellings do not always have their own bath or WC, it could be assembled in points in the camp and using in public and even this public baths is prefabricated and come like a module.

Flexible of Capacity: The most important and unique property of the prefabricated buildings is its great flexibility and ability to change of its design and flexibility. In this system, we can add or remove one module or more to change the space and have a variety of volumes to appropriate every family and every situation. Moreover, we have a lot of different components and we can use it like Meccano game to form the best design, dimensions and space to suite every case.

Table 4. The conclusion of Prefabricated shelters sustainability

Prefabricated Buildings						
Budget	Possessing period	Usage duration	Materials	Energy	Water	Flexible of capacity
χ	√	√	√	√	√	√

5. CONCLUSION AND ASSESSMENT

By looking to the table 5 and the previous chapter, we can conclude the following:

- The tents: are not a suitable choice as a sustainable solution but it is the best in the emergency period because of it has the shortest processing period and it could made by the victims themselves.
- The earth buildings: is very suitable for the case that there are no a high budget for building and the victims do not leave the disaster place, so the people can build their own dwellings, which can even continue as a permanent buildings.
- The prefabricated shelters: could use for building camps for a large number of displaced people, which need a large number of shelters in a short period, and this type could just apply by a governments or charities because of its high budget.

Table 5. The conclusion of temporary architecture systems and techniques

Temporary Architecture Systems And Techniques			
	Tents	**Earth Buildings**	**Prefabricated Shelters**
Budget	√	√	χ
Possessing period	√	χ	√
Usage Duration	χ	√	√
Materials	χ	√	√
Energy	χ	√	√
Water	χ	√	√
Flexible of capacity	√	---	√

As a result, prefabricated shelters option that provides most of the criteria examined in the table above. but other two options tents and earth buldings are less provide than prefabricated shelters.

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