UNIVERSITAT POLITÈCNICA DE VALÈNCIA

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Tesis Doctoral

Estudio y análisis del comportamiento de un Sistema constructivo para arquitectura sostenible.

Study and analysis of the behavior of a construction system for sustainable architecture.

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Abstract

From the First World War up until nowadays the UN still adopt the same technology when faced with an emergency which got us questioning the reason behind that. Many well studies, well-structured and even amazingly effective projects were presented and yet the tent is still the first choice and that puts up a series of questions: why is the tent option still unmatched? And more importantly, is an alternative really needed?

The tents present a lot of negative aspects but none of which is of importance for the refugees during the first period and therefore it seems the most logical that they dominate the field. It is known that the intervention to any crisis should be executed into at least three phases if not more, so the real question to be answered here is where should the focus and research and development be useful the most? What follows is a brief explanation on each of the phases which will help justifying the choice taken in this thesis.

The first phase of which is without a doubt is the research and planning work that each and every country should do before such events occur in order to be ready. This would help to save many lives since the first 48 hours are the most critical for a crisis.

The second step would occur either throughout the emergency or directly after it and it would be the construction in the fastest way possible of the structures in order to try to shelter as many people as possible.

The third step is to program the evolution of the camp based on estimates on the duration of the crisis. Once the primary objective of putting a roof on top of the refugees is secured the work and focus needs to be shifted into how to manage the camp as a whole in order to guide its life.

So, here comes the time for the architects to intervene introducing all that which they had studied from sociology to geography, from interior to exterior, into the metamorphosis of the camp from a first response camp onto mid of long range refugee camp and thus introducing what shall be defined as “ PHASE II”.

PHASE II consists of eliminating the necessity for the refuges to stay or use their tents except for sleeping which would give them the feeling of being in one big home. Hence is why the focus will be to the structure which form will be defined once the knowledge of the structural limits of the technology chosen has been reached.

For this structure MERO space frame technology was adopted as it allows us to exploit the maximum out of the interior of the structure since it is simple to build and allows big spans without the need to have columns in the middle of the structure. It can work as both an open space terrace and as a multipurpose building depending on the needs of the settlements.

Abstracto

Desde la Primera Guerra Mundial hasta hoy la ONU sigue adoptando la misma tecnología ante una emergencia que nos hace cuestionar el motivo. Se presentaron muchos estudios bien estudiados, proyectos bien estructurados e incluso sorprendentemente eficaces y, sin embargo, la tienda de campaña sigue siendo la primera opción y esto plantea una serie de preguntas: ¿por qué la opción de tienda de campaña sigue siendo inigualable? Y lo que es más importante, ¿realmente se necesita una alternativa?

Las tiendas presentan muchos aspectos negativos pero ninguno de los cuales es de importancia para los refugiados durante el primer período y por lo tanto parece lo más lógico que dominen el campo. Se sabe que la intervención en cualquier crisis debe ejecutarse en al menos tres fases, si no más, por lo que la verdadera pregunta que debe responderse aquí es ¿dónde deberían ser más útiles el enfoque y la investigación y el desarrollo? A continuación se ofrece una breve explicación de cada una de las fases que ayudará a justificar la elección tomada en esta tesis.

La primera fase es, sin duda, el trabajo de investigación y planificación que todos y cada uno de los países deberían realizar antes de que ocurran tales eventos para estar preparados. Esto ayudaría a salvar muchas vidas ya que las primeras 48 horas son las más críticas de una crisis.

El segundo paso se produciría durante la emergencia o inmediatamente después de ella y sería la construcción lo más rápida posible de las estructuras para intentar albergar a la mayor cantidad de personas posible.

El tercer paso es programar la evolución del campo en función de estimaciones sobre la duración de la crisis. Una vez asegurado el objetivo principal de poner un techo sobre los refugiados, el trabajo y la atención deben centrarse en cómo gestionar el campamento en su conjunto para guiar su vida.

Entonces, llega el momento de que los arquitectos intervengan introduciendo todo lo que habían estudiado desde la sociología hasta la geografía, desde el interior al exterior, en la metamorfosis del campo de un campo de primera respuesta a un campo de refugiados de medio largo alcance y presentando así lo que se definirá como “FASE II”.

La FASE II consiste en eliminar la necesidad de que los refugios permanezcan o utilicen sus tiendas de campaña excepto para dormir, lo

que les daría la sensación de estar en una gran casa. Es por ello que la atención se centrará en la estructura cuya forma se definirá una vez que se haya alcanzado el conocimiento de los límites estructurales de la tecnología elegida.

Para esta estructura se adoptó la tecnología MERO space frame ya que nos permite aprovechar al máximo el interior de la estructura ya que es simple de construir y permite grandes luces sin necesidad de tener columnas en el medio de la estructura. Puede funcionar tanto como terraza diáfana como como edificio polivalente en función de las necesidades de los asentamientos.

Resum

Des de la Primera Guerra Mundial hasta hoy la ONU sigue adoptant la misma tecnología ante un emergencia que nos hace cüestionar el motiu. Se presentaron molt estudios bé estudiats, proyectos bien estructuraados i incluso sorprendentemente eficaces y, embargament de pecat, la tienda de campaña siendo la primera opció i esto planta una sèrie de preguntas: ¿per a l'opció de l'agenda de campaña siendo inigualable? I que és més important, ¿realmente se necesita un alternativa?

Les tiendas presents molt aspectes negatius per a l'any de les taxes són d'importació per als refugis durant el primer período i per tant de por que es faci més que l'any que domina el campo. Se sap que la intervenència en la crisi actual de ser ejecutrose en els menos tres gerros, si no hi ha més, que la veredera pregunta que respongui a allò que és ¿dónde deberían ser més útils el enfroc i la investigació del desarrollo? Una continuació que es produeix una aplicació de cada una de les bases que ayudará a un justificat de l'elecció tomada en esta tesis.

La primera fase es, sin duda, el treball d'investigació i la planificació que els todos i la cada un dels papísos de l'autèntic realizar anties de que orurran contes esdeveniments per a estar preparatos. Esto ayudaría a salvar molt com les millors 48 horas son les més crutices d'una crisi.

El segundo paso es produciría durant la emergència o l'inmediatament d'ella i sería la construcció del món que és possible de les estructures per a la seva intenció a l'alcalde de la ciutat de les persones posables.

El tercer pas es programa a l'evolució del camp en la diversió d'estimacions sobre la durada de la crisi. Un vez assegurado el objetivo principal de poner un techo sobre els refugis, el treball i l'estat deben centrinces en el moment de fer el campament en el seu conjunt per a la seva vida.

Entonces, llega el moment que els arquitectes intervenen introductoris van presentar el que habían estudiado des de la sociologia hata la geografía, des del interior de l'exterior, a la metamorfosi del camp d'un camp de la primera respuesta un camp de refugiats de medio largo alcance i presentando com a definit " FASE II ".

La FASE II consisteix en eliminar la necsidad de que els refugis permanents o utilitzar les seves tiendas de campaña excepte per a dormir, que les daría la sensació d'estar en un gran cas. Es per al mateix que l'acència se centrarà en l'estructura de la forma que es defineix a la seva

vida que es pot al·canzado el concocient de l’estructura de les estructures de la tecnologia elegida.

Para estructura s’adopta per la tecnologia MERO marc espacial ja que no permet l’aprovechar al máximo l’interior de l’estructura ja que és senzill de construir i permetre grans les luces sin necsiad de la estructura tendre columnas en el medi de l'estructura. Puede funcionar teto com terraza diáfana com a edificio polivalent en la diversió de les necesidades dels asentamientos.

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Acronyms

CwC	Communication with Communities
FGD	focus group discussion
GSO	General Security Office
ICRC	International Committee of the Red Cross
IFRC	International Federation of Red Cross and Red Crescent Societies
INGO	international NGO
ISF	Internal Security Forces
LCRP	Lebanon Crisis Response Plan
NGO	non-governmental organisation
OCHA	UN Office for the Coordination of Humanitarian Affairs
SRP	Syria Response Plan
RRP	Regional Response Plan
UNDP	UN Development Programme
UNHCR	UN High Commissioner for Refugees
UNICEF	UN Children's Fund
UNRWA	UN Relief and Works Agency for Palestine Refugees in the Near East
UNSC	UN Security Council
WASH	water, sanitation and hygiene
WFP	World Food Programme

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EMERGENCY ARCHITECTURE

1.1. History of emergency architecture

Wars, earthquakes, tsunamis, climate change … are few words that have, unfortunately, defined this century and overtaken the full attention of everyone, especially with the non-stop growth of social media which empower, on a daily basis, the reach of the suffering of the victims of these emergency situations to the rest of the world.

It is therefore of no surprise that each day more people take the decision to join many of fellow specialists, whether volunteers, architects and engineers…, in their humanitarian quest to help out to limiting the ever-rising number of victims in whichever way they can. Architects have seen their profession grow and evolve throughout time and therefore their main role has passed from design to add a series of heavy social, geographical, sustainable and many more studies in order to be able to give a better more complete project. This research will follow the same approach in the hopes of being able to reach a sustainable structure that can be used in these situations or maybe even help in treating and resolving some if not all the problems identified throughout the research.

In order to be able to better plan ahead one must look at the past and learn from both the mistakes and the achievements and that especially goes in a field that is new and low on resources as ours. So the first and biggest problem encountered was the lack of organization of the information and the very important research done by fellow colleagues and that is why this matter will be treated in this thesis through a summary of the "Emergency Architecture" notion starting from its history up until its current situation nowadays in order to better organize all that important information. The initial aim was to be able to understand the topic of this research and look at its evolution throughout the years in order to be able to take note of what were the positive and negative conclusions that fellow architects have reached and try to start from their work and improve it. But considering the hard work and the time it took, time that could have been put to better use, it was decided to take it a step further and try to also create a clear and easy pathway that hopefully future researchers will follow in the aim to be able to further improve this argument or maybe even treat problems that were not apparent to us. But since these objectives are too big to be able to fit them all in with the deserving details, which can be crucial depending on the aim of the future research, only a summary of these problems will be introduced in the thesis and the rest of the information shall be contemporarily published in a book that will treat the subjects in full details and act as separate guideline for the future researchers.

The book will handle all there is to handle when it comes to the history of emergency architecture and hopefully will become a guideline, or a manual of sort, for this argument. After all, in order to be able to make a successful project one needs to understand the successes and failures of past projects similar to his and seek the results of fellow researchers who have put time and effort into sharing that information hoping that it will form part in future researches.

And so due to the rise of people in need of shelter because of the rise of disasters whether natural or mankind created, many specialists have decided to join the humanitarian cause of emergency architecture in hope to be able to reach a sustainable structure that can be used in these situations.

"What is Emergency Architecture?

Where did the notion come from?

How did it develop throughout the year's?

In what state is it nowadays?"

These questions represent the main notions which be introduced in order to be able to answer the biggest and most important question of them all:

What is required for the future of emergency architecture?

1.1.1. What is the objective of emergency architecture?

Although many definitions were given for this notion and although they might vary a little, they all agree on one very important fact and that is that the main objective is and will always be to put a roof on top of every person that has found itself on the streets because of either a natural or mankind created disaster. The lack of shelter in a post-disaster situation can lead to loss of life from exposure and disease that can be in excess of that caused by the disaster itself. It is essential that people caught in these situations are helped within a very short period, 48 hours of less, if that help is to be effective.

1.1.2. When did society become aware of the necessity of emergency architecture?

The earliest examples of architectural response were brought back to during the world wars, the first to deal with these types of houses was Jean Prouvé, French blacksmith (a failed architect, who could not study due to financial problems) that in 1939 proposed to the Ministry of Arms the construction of 300 barracks in two modules, square of 4x4m and rectangular of 4x6m, both removable with the backbone covered in wood paneling; these modules represent the first series production of houses realized with the aim of creating temporary accommodation for the soldiers.

Figure 1 Jean Prouvé, removable house[1]

The first emergency faced by the design world, dates back to the First World War. In 1917, in France, were erected wooden houses (dismountable wooden house) fully assembled dry for refugees of the Great War. These efforts continued to expand and especially during World War II, when there were many emergency houses built for the displaced. And the most important thing about this period was the contribution and participation of many well extraordinary architects, who have built or designed emergency houses, like for instance the Finnish architect Alvar Aalto [1] who designed a temporary emergency shelter that can be carried and used by four families with a central heating system.

[1] https://www.dezeen.com/2013/12/08/8x8-demountable-house-1945-by-jean-prouve-galerie-patrick-seguin/ (March 2020)

1.1.3. How did emergency architecture develop throughout the years?

With the passage of the century, there was a distortion of the concept of emergency. During the first wars, its role was to create temporary housing for soldiers, housing for displaced persons and refugees of war. It concerned the accommodation of war refugees, especially faced with the scenario of increased destruction caused by the rise in weapon technologies. Scenarios that were presented in the form of cities razed, buildings gutted, burned, rendered completely unusable by the man who found himself in hostile environments, inhospitable and downright unhealthy. Despite the length of the catastrophic situation that was created, this kind of emergency could be considered temporary and solvable with the rebuilding and resettlement of urban land, recreating from the basis that which is the city, repeating a constructive building process based on the same characteristics as before and then remarking those that could be project gaps already highlighted.

But as time passed by, the concept of emergency architecture has seen itself go through the following evolution: Its concept started out as temporary buildings to evolve a few years later to portable buildings and then after the introduction of design it became known as portable architecture to finally be classified as Emergency Architecture with the intensification of the emergencies alongside the creation of the UN and therefore a common effort of all the countries in the world to help out in such crisis. This shows that with the evolution of the lifestyles, so did the basic needs and therefore so did the architecture which explains the evolution of the concept from a basic shelter to a shelter with minimum lifestyles requirements and the main objective of putting a roof on top of the refugees' heads to inserting all the basic modern life needs into an emergency prefabricated concept in the cheapest way in order for it to be considered acceptable by the newly defined emergency crisis measures.

That can be noticed in the final part where the concept made a switch from portable building to portable architecture and that was the moment when design was introduced. But here a new question arises, even though many amazing and really well thought projects were presented throughout the years how come the UN and many NGOs, how come the UN still tends to adapt the simple tents as the optimum solution?

1.1.4. In what state is emergency architecture nowadays?

Ever since the creation of the United Nations, several statements by high end officials[2,3] criticize the fact that there wasn't a major breakthrough in the shelter for the post-disaster department. Many prototypes were built, and many designs were developed in coordination between architects and the industry itself, yet none of them have managed to make the necessary impact to be called revolutionary and create a new standard. Millions of dollars are spent yearly on shelter, yet all of the proposed solutions keep falling short of expectations, for logistical and/or design purposes.

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[2] "*It can be said with some assurance that relief management in the fields of medicine, health, and nutrition has … significantly improved over the last decade. The benefits of the lessons learned from the major disasters during the 1970s and early 1980s are beginning to show. However, there remains one particular sector in which too little progress has been made, and in which many conservative and obsolescent attitudes survive, that is: emergency shelter, and shelter after disaster in a more general sense.*"

United Nations Disaster Relief Coordinator (UNDRO), 1982

[3] "*Once again, it should be pointed out that a suitable shelter concept to match, in particular, larger-scale emergency measures was not at hand. In addition, the lack of experienced agencies to deal with shelter issues was badly felt … what is needed is a comprehensive shelter strategy with appropriately developed standards, supply methods, specifications for shelter units and industries to make the right products available in time …*"

United Nations High Commission for Refugees (UNHCR), 1993

This has led with the passing of time of the creation or more and more disaster relief agencies who have different goals and different ways of thinking. Each of them treats the subject that they believe the UN is neglecting or is unable to treat. Even though this was very beneficial for the humanitarian cause and has helped save countless lives, it has proven that the isn't much effectiveness in the use of the resources at hand. This is due to the fact that the solutions have been donor-led which limited their objectivity and made them stray from the main purpose.

All the solutions presented answer the call for shelter although they do differ by their special typological and technological solutions. These solutions can be put together into three groups: Low tech, Hybrid, High Tech Light. The low-tech solutions are structures that normally aim to the maximum simplification, whereas the low high-tech are light and strong structures highly based on technology but still within a humanitarian context. The high-tech structures are often disliked due to their imposing appearance which is almost always disconnected with the context. And of course, the most targeted group would be the Hybrid where new solutions try to balance between the other two groups in order to come up with a hybrid solution aiming to take the best of both ends and eliminating their weaknesses.

1.1.5. What is required for the future of emergency architecture?

Having reached this point, one can say that the background research was performed when it comes to emergency architecture and that it is now possible to form the important points that need to be treated when working on future structures. But before starting to work on the structure there remains to see at what point of the emergency response it needs to take part of. Almost all units and projects have been the creation of a single unit in order to host a family. But in this thesis, a different approach was taken and the desire to intervene on a different level will be applied.

From the First World War up until nowadays, the UN still adopt the same technology when faced with an emergency, which questions the reason behind that. Many well studies, well-structured and even amazingly effective projects were presented and yet the tent is still the first choice and that puts up a series of questions: **why is the tent option still unmatched? Is an alternative really needed?** Well the answer is that since the first priority in an emergency is to put a rood on top of the head of every person who found themselves homeless there is no better and more effective way than the tents. The tents present a lot of negative aspects but none of which is of importance for the refugees during the first period and therefore it can be concluded that the intervention to any crisis should be executed into many phases and this thesis will justify the need of at least three phases.

The first of which is without a doubt is the research and planning work that each and every country should do before such events occur in order to avoid the presence in doubt or the sentiment of inaptness in the leadership. This would help to save many lives since as said before the first 48 hours are the most critical for a crisis. It is believed for instance that there should be at least different locations identified and studied to withhold the refugee camp. The location should be easy to reach and should allow the organizers to provide at least the basic needs using the nearby natural resources in order to avoid the delay and the costs that the transportation of such needs would require. It should also be a location with no risk of getting hit by the emergency situation either directly or through aftershock. It should also be studied in base of the weather of the location and avoid any future problems that might be caused by some minor climate change. As far as the material to build up the habitation unit comes, although it may not be present directly, experience has taught that through air support from the UN they can reach the country within a matter of hours once the green light has been given. The plan also needs to be planned with the help of the law enforcement agencies in order to insure the safety and fill the most probable need for volunteers in order to either help with the construction and management directly or in order to guide the refugees throughout the construction process. Alongside many other factors that if prepared in advance even and handful of people can avoid chaos and panic throughout the ranks of the refugees and help save lives.

The second step would occur either throughout the emergency or directly after it and it would be the construction in the fastest way possible of the structures in order to try to shelter as many people as possible. That is a step that is best suited for tents that can easily be manufactured, transported and constructed and that have a lifespan that is suitable for almost all emergency cases. It is to be considered that many people when found in cases of emergency tend to build their own shelter out of the debris left through the emergency and it is of extreme important to point out that, although it might seem as a good idea at first not all people are equipped to handle such structures and therefore many have had to pay it with their lives and when possible these cases should be avoided.

The third step is to program the evolution of the camp based on estimates on the duration of the crisis. Once the primary objective of putting a roof on top of the refugees is secured the work and focus needs to be shifted into how to manage the camp as a whole in order to guide its life. After the series of interviews performed it was understood that it will not take long for the refugees to pass from the “grateful for whatever is given to them” status into the demanding one and that is mainly due because of the difference between the minimum life needs of nowadays and what the camps have to offer. From a psychological point of view and through the series of interviews held with the refugees in Lebanon, who were being chosen from different ages, backgrounds and sex in order to try to include as many points of views in order to summarize a global point view, it was possible to reach a common point in between all of them and that is the following: ¨when they left their homes people were only thinking of getting to a safe place and put a roof on top of their heads and that specially applied for the parents and heads of families, so when they are first given a tent they are all very grateful and thankful. But as time passed, they become aware of their situation and feel impotent and that is where the problems start because at this point they are unable to enjoy the good stuff they have and start focusing on the negatives of their situations."

And so, here comes the time for the architects to intervene introducing all that which they had studied from sociology to geography, from interior to exterior, into the metamorphosis of the camp from a first response camp onto mid of long range refugee camp and thus introducing what shall be defined as " PHASE II". And that is the heading that chosen for this thesis, where through the introduction of the notion of multiple phases, the focus shall be put on PHASE II through the study of the construction of one or more multiuse, multifunction, sustainable structures capable of grouping all of the life of the camp into them. The biggest problem people encountered is routine and the feeling of being isolated when in need of company and in public when in need of privacy. But that can be easily fought, since just like most interior architects know, sometimes the smallest changes in a person's home can have a huge impact on their mood and life in general.

The main idea of this research is to eliminate the necessity for the refuges to stay or use their tents except for sleeping which would give them the feeling of being in one big home. This idea has come to light thanks to the personal experiences encountered while living throughout the university years in dorms in Italy where the use of such well-studied structures made the life in a dormitory much more desired than the life in an apartment. The idea is the make the rooms smaller in order for them to be able to cover the basic needs of a student and therefore a desk to study a closet to put his stuff in, a bed to sleep in and in some cases a private bathroom. Whereas the kitchen, the living room and all the remainder of activities that can be done in groups were put in common areas which gave the effect that the whole dorms were just one big home and that is the desired effect for PHASE II.

Having defined the heading this thesis will take when it comes to emergency architecture, the focus will now be shifted to the structure which form will be defined once the knowledge of the structural limits of the technology chosen has been reached. For this structure it was decided to use the MERO space frame technology which provide maximum usage of the interior of the structure since it needs no central columns and has a very big span allowing it to work as both a terrace and as a multipurpose building depending on the project.

1.1.6. What are the guidelines for the design of a shelter?

When thinking of designing a shelter, it is essential to consider at first how to proceed. There are several scenarios that can be adopted and depending on the choice the workload can be divided into the three phases of a disaster: pre-disaster, During the disaster, Post-disaster.

Once these have been defined, focus can be shifted into the design of the actual structure and for which, it is advisable to follow the series of proposed guidelines for the design. Even though the guidelines apply to all three phases of a disaster, it is always recommended that they be considered during the initial design.

<u>Defining scenarios</u>

Scenario 01: Design a prefabricated structure adaptable for all possible terrains and scenarios.

- Pre-disaster:
  - Digital prefabrication with necessary studies
  - Construction of a certain amount of prototypes
  - Packing and storage in facilities with easy access to airports for fast delivery
  - wait for shipping orders
- During disaster:
  - Ship
  - Deploy team for assistance with construction
- Post-disaster:
  - Monitor regularly until dismantling
  - Maintenance in case needed

Scenario 02: Design a prefabricated structure and wait for disaster to adapt design and produce

- Pre-disaster:
  - Digital prefabrication with necessary studies
  - wait for disaster to adapt to location and emergency type
- During disaster:
  - Construction of a certain number of prototypes based on demand
  - Packing and shipping
  - Deploy team for assistance with construction
- Post-disaster:
  - Monitor regularly until dismantling
  - Maintenance in case needed

Scenario 03: Design a prefabricated structure and wait for disaster to know which adaptive parts to produce

- Pre-disaster:
  - Digital prefabrication, with necessary studies, into 2 parts: core and adjustments based on situation
  - Design for rapid combinations and easy packing
  - Construction of core and of adjustments elements separately
  - Storage in facilities with easy access to airports for fast delivery
- During disaster:
  - Adaptive packing of core and selective elements based on demand and situation
  - Shipping
  - Deploy team for assistance with construction
- Post-disaster:
  - Monitor regularly until dismantling
  - Maintenance in case needed

Note: the added adjustment elements can be built once the disaster occurs in order to avoid waste.

Scenario 04: Design is based on materials present in situ

- Pre-disaster:
  - Digital prefabrication into several parts with necessary studies
  - Design should include different possible materials covering majority if not all primary materials present all over the world
  - Prepare manual with instructions for each material and area
  - Prepare packages containing all possible essential lacking elements and tools with manual in all languages

- During disaster:
  - Shipping
  - Deploy team for assistance with construction
- Post-disaster:
  - Monitor regularly until dismantling
  - Maintenance in case needed

1.1.7. Project guidelines:

When it comes to the project itself, the main focus should be not to stray from the general idea of designing, in the pre-disaster phase, the structure to be as flexible as possible and to try and cover as many disasters and territories as possible.

In other terms the universality of the project is what will define it as a breakthrough or just another good but below the expectations project.

What follows are a series of guidelines gathered from the past projects, and that every future shelter project should try to follow:

A. Pre-disaster preparation work

The pre-disaster preparation work is the most crucial for the design phase as a good design leads to good manufacturing which in the end leads to a good product. The focus of the pre-disaster

A.a. Design

A.a.1. Digital prefabrication

- Digital Prefabrication makes the project economic in its production speed and also easy to assemble because of the precision of its construction.
- It allows for Simulation and testing the structure in different ambient factors

- It allows easy access for construction supervision
- It allows easy upgrades and modifications to be applied
- Taking it a step further would be to create a parametric design which would allow full control and maximum flexibility.
- It allows the customization process of the unit possible
- When possible, the usage of user-friendly tool can go a long way with people who are not familiar with the various programs used by the engineers and architects.

A.a.2. Mock-up

- If possible, it would be beneficial to build prototypes or at least parts of it for testing
- easy tool in case needs to be shared with non-experienced people or not familiar with the programs used by the architects and the engineer

A.a.3. Economical

- It is essential and vital to the shelter that it is economical
- Emergency shelters normally require big quantities and the more costly they are the less efficient they become
- There can be two main topics to focus upon when speaking about the reducing the cost: the material and the technology.

A.a.3.1. Materials

- It is advisable to use cheap materials available locally.
- Materials should always be replaceable, and focus should be put on performance rather than aesthetics.
- There should be a possibility to replace with different kind of material present locally and with similar performances.

A.a.3.2. Technology:

- It is advisable to use simple construction techniques
- It is advisable to use as little imported material and tools as possible
- The best designs are the ones that require the least know-how possible

A.a.4. Universality

- The project should aim to be usable in any part of the world
- It would be best if this could be arranged through a simple modification
- Take into consideration that a project usable everywhere with no need for changes normally implies waste and in most cases overdesign since it must be designed to the worst possible climates.

A.a.5. Performance

- The project's performance will be defined by a simple cost/result graph.
- The structural analysis should take no risk and should take into consideration the different climates with their circumstances
- The structure must have excellent thermophysical specifications as the cost of heating or cooling might be too high to bare.

A.a.6. Flexibility

- The project should be as flexible as possible both on the interior and the exterior
- The interior flexibility allows for a multipurpose use and maybe some personal customization
- The exterior flexibility allows for the different units to complementary on an urban scale creating a usable space in between them.
- The project should be able to integrate with other structures already on site.

A.b. Manufacturing

- The simpler the production the faster the manufacturing process will become
- Limiting the know-how needed can help both speed up the process and limit the need for an on-site team to monitor any adjustments needed.
- Production is limited to budget and storage capabilities
- The prefabrication should process should be sustainable and, if possible, consider using already existing refugee settlements as manpower

A.c. Packaging

- It is essential that the packaging be robust to avoid any items to be damaged before reaching the destination
- Packaging should be designed to allow easy unpackaging and erection
- In case of reusable structures, the initial packaging should take into consideration a smooth re-packaging and the know-how needed.

- It is advisable to avoid the need for a specialized team for both packaging and unpackaging.

A.d. Storage

- Items should be contained in a storage place with proper ambient specifications in order to avoid any damages to the product especially since they can be stored for a long period depending on the crises needs.

- It is advisable that the location of the storage be near the airports or docks where the shipping will take place.

B. During-disaster work

B.a. Shipping

B.a.1. Mobility of the structure

- It is essential that the shelter be easily transportable

- All parts should be easily packed and transported.

B.a.2. Transportation

- Transportation if the shelter should be done with the fastest mean available as time is crucial and especially the first 48 hours post-disaster.

- Special attention should be made in case accessibility to refugee site isn’t easily achieved

- Study the possibility of usage of extreme measures to ensure delivery, such as aerial parachuting

B.b. Erection

- Assembly should be as easy and simple as possible
- Special attention should be put into all connections since they are normally the trickiest part of the construction and where most problems were found.
- Connections are the parts that require the most know-how and hence working on simplifying them, reduces or even removes the need to have a specialized team on site.
- Consider the possibility to use modern technology for remote erection or online assistance of local inexperienced manpower
- Consider making an Ikea style detailed manual, also in the objective of reducing the need of an onsite team or the need of experienced people to erect which would speed up the time and amount of shelters erected and therefore help saving more lives.

C. Post-Disaster work

C.a. Supervision

Onsite supervision can be divided into the following:

- Full time presence of a team on site: preferable in case of availability funding and in case safety measures allow it
- Part-time presence of a team on site: team visit on demand or through a series of routine checkups in order to make sure structures are still intact or that there is no need for any adjustments of modifications
- No presence of a team on site: due to the simplicity of the design or in case it is fully prefabricated and easily erected.

This could also be due to the fact that online assistance would suffice.

- In all three cases, it would be extremely helpful to plan the project in order for it to be personalized at a later stage, once safety is insured.

C.b. No more need for shelter

- The design of the unit should account for the post-disaster period when the need for the shelter units is gone
- If designed as only temporarily and recoverable, then the structure should be dismantled, and the materials reused of recycled
- If designed as only temporarily and non-recoverable, then the structure should be dismantled, and the materials put to waste
- If designed as Portable and Reusable, then the structure should be re-packaged and shipped to a new location
- In all retrievable cases, the structure should undergo a status check in order to confirm its performance is still up to standards.

1.2. History of emergency Architecture in Lebanon

1.2.1. Why Lebanon?

After studying the history of emergency architecture and learning how it evolved, and when looking at the current projects being planned and presented, it becomes clearer that there is a huge gap between the projects proposed and the projects executed. In order to complete the research and better understand the reason behind it, there was a need for a thorough study and analysis of the current states of the refugee's settlements. This study was performed in through all the refugee settlements present in Lebanon.

In case some of the readers were wondering **"Why Lebanon?"**, a series of facts will be exposed showing what makes Lebanon the perfect place to be called "Ground 0" for not only this research but also for all future research to be conducted on emergency architecture: [2]

- Lebanon has the biggest refugee's percentage in all the world almost one third of its actual population are refugees divided between Palestinians and Syrians. And as anyone can imagine that has had many effects upon the social life in the country, more negative than positive. This will also provide an answer to the following question: **Where does a country draw the line upon accepting refugees?** Faced with the risk of death one will always look to flee the country and no nearby country with a minimum of common sense would block the border and let people die but when faced with such a situation and with such a big mass of refugees **how must a country act?** The Lebanese are very familiar with this situation considering that due to its dark history full of wars there are currently 16 million Lebanese outside Lebanon compared to the mere 4 million present in Lebanon. And considering that during the Lebanon-Israel war in 2006 Syria opened its borders and hosted many thousands Lebanese with the mere difference that the latter war lasted only 30 days compared to the 5 years of the ongoing Syrian civil war, the Lebanese government had no choice but to open their borders and that was the beginning of many problems. The biggest and most dangerous problem of them all was the presence of terrorist cells that hid themselves amongst the refugees in order to infiltrate the country. It took the Lebanese army almost 2 years to stop them from sending car bombs at the cost of hundreds of civilian casualties and in some parts of the border still reside a few terrorist cells that are in constant conflict with the Lebanese army. The cost for saving many lives was also the cost of many more… and so without going further into details at this stage and faced with these facts one must ask himself did the Lebanese government do well by opening the borders or not? But more importantly**, how can someone wager the hosting country's national security with the humanitarian duty that one has when faced with such a cruel situation?** One thing is definitely certain and that is that many innocent lives were lost due to the choice the countries had to make when faced upon such a wager…

- It has been the host of refugees for more than 50 years now making it the host to one of the oldest and longest ongoing refugee camps in the history of emergency architecture. This gives an important view upon how refugee camps evolve and what is the impact that these camps have on a country especially when they last for so long past their expected duration. Thanks to the location and with the help of the responsible parties present there this study will alternate between a subjective and objective study depending on the argument treated. That will give this thesis a much desired and lacking point of view to the long scale camps. This fact brings up a very important series of questions that will be discussed and analyzed well further ahead in the research: **What is it that defines the expiry date of a refugee camp? How can the length of the crisis be predicted? What should be done when the camp exceeds its planned duration?**

- And due to recent events in Syria, Lebanon is now also the host for the most recent refugee settlements which combined with the camps present before will show the evolution of the interventions and once again the effects that these settlements have had to the hosting country.

- Due to the extremely big amount of refugees that the country had to take in, the UN were unable to handle the settlements and even with the help of the Lebanese government's help there was still a deficit and so in some parts the locals organized settlements, in others some NGO's rose to the occasion and finally in some locations the refugees themselves had to create the settlements from the locally present material and with the help of nearby villages. Taking a look at various refugee settlements and comparing them will lead to draw some important conclusions on how the first response settlements can be improved in order to avoid the creation of so many different settlements.

- Lebanon's weather makes it a perfect location to test the behavior of one's structure in all 4 seasons. Additionally, thanks to the various interviews performed during all 4 seasons, conclusions were presented through the refugees themselves to what is lacking and what is needed and how to prioritize future projects. This is the perfect situation for an architect, because most flaws in a project are unanticipated and that is mainly because the architect cannot anticipate the lifestyle nor the climate change in an area. Having this intel will allow future proposed projects to avoid many problems faced by past even present projects since it is not possible for everyone to go on site and discuss the problems whether it is for security reasons or economical or even communication problems. Having the knowledge of the Arabic language, it was possible to have a conversation with refugees from all ages especially considering that majority of the old and/or the young do not all know a different language.

- The presence of many very active NGO's and architecture offices that showed interest in such a project and have given their support to the research by sharing some of their experiences and have expressed their interest in helping in the future in the case of the construction of some prototypes or even doing some on the ground testing.

- The presence of a strong UN Habitat office considering the history of Lebanon seems logical. They have showed their support to the research by allowing a series of interviews not only with the refugees but even with some of the staff who had to work with refugees.

As part of the study of the current state of the settlements, the need to visit them has proven essential and it is through only through them that it was possible to confirm the initial theories and thoughts concerning the state of the settlements and that they are in dire need of modifications and improvements and in some cases they are way past that and are in dire need of closure. But in order to fully understand what is needed and mainly prioritize the needs, a series of interviews were performed in order to get a subjective perspective to this matter and the results were astonishingly rich. It was possible to conduct a heavy and important social study of the refugee settlements throughout the various interviews held with all parties involved in the settlements from refugees to staff members.

1.2.2. Past: Palestinians

As introduced earlier, the history of the Lebanese with hosting refugees dates back to more than 70 years back and starts with the Palestinians. The Palestinian refugee camps are still ongoing and current estimates show that around half a million refugees are currently residing on Lebanese soil. These refugees have been attended and supported by the United Nations through the UNRWA.

In order to fully understand the situation, a brief introduction to the history of these camps will be presented showing their evolution and important dates as well as the important role the UNRWA has played throughout the years.

1.2.2.1. Immigration waves:

Lebanon currently hosts around half a million Palestinian refugees and for a country with a population of merely 6 million people it is interesting to understand how such a big number of refugees came to be found on its soil. The Palestinians are currently present

To fully understand the history of these camps, it is important to first understand that the refugees did not come all at once and came through various immigration waves in different periods during the past 70 years. After which, when considering the emergency architecture concerning the Palestinians, it is of absolute importance to study the role and the impact of the UNRWA on the field. All of the above will guide the evolution of these camps throughout the years and will draw many conclusions of essential importance when considering emergency architecture.

The immigration waves can be summarized with the following events:

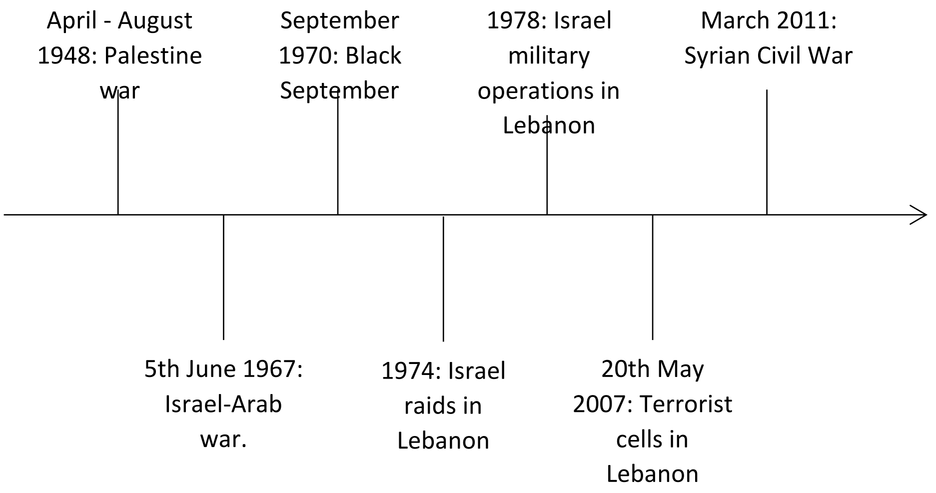


Figure 2 Diagram showing all related events

- **April - August 1948: Palestine war.**

  Due to the hostility between the Israelis and the Palestinians, more than 700,000 Palestine refugees have found themselves refugees in the surrounding Arab countries and estimates show that around 100.000 wounded up in Lebanon.

Figure 3 Picture showing the Israeli tanks [4]

[4] https://www.history.com/topics/middle-east/six-day-war (March 2020)

- **5th June 1967: Israel-Arab war.**

  Due to the hostilities between Israel and the surrounding Arab countries, an additional 120.000 Palestinians found themselves are refugees and were once more divided amongst the surrounding Arab countries.

- **September 1970: Black September**

  Due to conflicts between the Palestinians and the Jordanian Armed Forces, several thousands of refugees are expelled from the country and move to Lebanon.

- **1974: Israel raids in Lebanon**

  Israel raids Palestine refugee camps in the southern part of Lebanon, displacing several thousands of Palestinians to other camps.

- **1978: Israel military operations in Lebanon**

  Due to the continuous military operations by the Israeli army targeting Palestinians in southern Lebanon, UNRWA estimates that around 67.000 refugees were displaced.

Figure 4 Picture showing the Israeli army marching next to a destroyed building[5]

- **20th May 2007**

  Due to the actions of a Palestinian terrorist group by the name of

[5] https://www.aljazeera.com/focus/2010/05/201051992011673189.html (March 2020)

Fatah al-Islam, conflicts erupt between them and the Lebanese Armed Forces in Nahr el-Bared camp, leading to the destruction of most of it and the emigration of almost all the refugees there.

Figure 5 Picture showing the amount of destruction suffered from the military offensive [6]

- **March 2011**

  Due to the start of the Syrian civil war, around half a million Palestine refugees were affect and around 65.000 were estimated to have entered the Lebanese soil to be directed into the newly found settlements and to the already overcrowded camps.

Figure 6 Picture showing the bombardments near the border[7]

[6] https://en.wikipedia.org/wiki/Palestinians_in_Lebanon (March 2020)
[7] https://www.unrwa.org/who-we-are?tid=93#slideshow-2(March 2020)

1.2.2.2. UNRWA:

Figure 7 Picture showing the logo of the UNRWA[8]

The *United Nations Relief and Works Agency for Palestine Refugees (UNRWA*) was created on the 8th December 1949 through the *Resolution 302* in order to take over the *United Nations Relief for Palestine Refugees (UNRPR)*, and assist the Palestine refugees directly through programmes in order to attend urgent matters like the prevention of starvation and distress. The agency's services expanded throughout the years to cover education, health care, relieve and social services, camp infrastructures and improvement, microfinance and emergency assistance, including in times of armed conflict.[9] UNRWA focuses mainly achieving the basic human rights for the refugees while trying to give them long and healthy lives and the most basic decent standards of living.

The UNRWA initially defined the Palestine refugees as follows: "*persons whose normal place of residence was Palestine during the period 1 June 1946 to 15 May 1948, and who lost both home and means of livelihood as a result of the 1948 conflict."* Even though the descendants of these refugees do not fit in the description, an exception was done due the ongoing conflict and therefore were considered eligible for registration. This has led the agency to jump from assisting around

[8] https://www.unrwa.org/who-we-are?tid=93#slideshow-2(March 2020)
[9] Ibid.

750.000 Palestine refugees back in 1950 to assisting around 5.6 million nowadays.

When it comes to camps, the UNRWA's role is limited to providing services and administering its installation and does not interfere with the administration and security of the camps which is left to the host authorities. It is present in all camps through a camp services office on site which handles the communication between the residents and the UNRWA administration in the area.

What follows are a series of important dates in the UNRWA history in Lebanon:

- **1948:**

  Creation of the United Nations Relief for Palestine Refugees (UNRPR)
- **8th December 1949 :**

  Creation of the United Nations Relief and Works Agency for Palestine Refugees (UNRWA)
- **1st May 1950**

  UNRWA officially begins its operations.
- **1955**

  UNRWA works on improving the refugee camps by gradually substituting the tents with pre-fabricated shelters or cinderblock dwellings.

Figure 8 Picture showing the first camps set up by the UN[10]

- **1976**

  Due to the start of the Lebanese civil war, UNRWA leaves its headquarters in Beirut, moving first to Amman and then to Vienna,
- **2005**:

  UNRWA establishes its Infrastructure and Camp Improvement Programme to address deteriorating living conditions in the Palestine refugee camps
- **2009**

  UNRWA begins reconstruction work for Nahr el-Bared camp. (Note: With a budget of around US$ 345 million, it is considered UNRWA's largest project.

[10] https://www.unrwa.org/who-we-are?tid=93#slideshow-2(March 2020)

Figure 9 Picture showing the reconstruction process of the camp[11]

[11] https://www.unrwa.org/who-we-are?tid=93#slideshow-2(March 2020)

1.2.2.3. Refugee Camps

1.2.2.3.1. Location

There are currently 12 official Palestinian camps hosting over 50 % of the refugees in the country, located as follows:

- Four around the capital **Beirut**
  - Burj al-Barajne
  - Shatila
  - Dbayeh
  - Mar Elias
- Two in **Tripoli**
  - Beddawi
  - Nahr al-Bared
- Three near **Tyre**
  - Burj Shemali
  - El-Bass
  - Rashidiyeh
- Two near **Saida**
  - Ein el-Helwe
  - Mieh Mieh
- One near **Baalbek**
  - Wavel

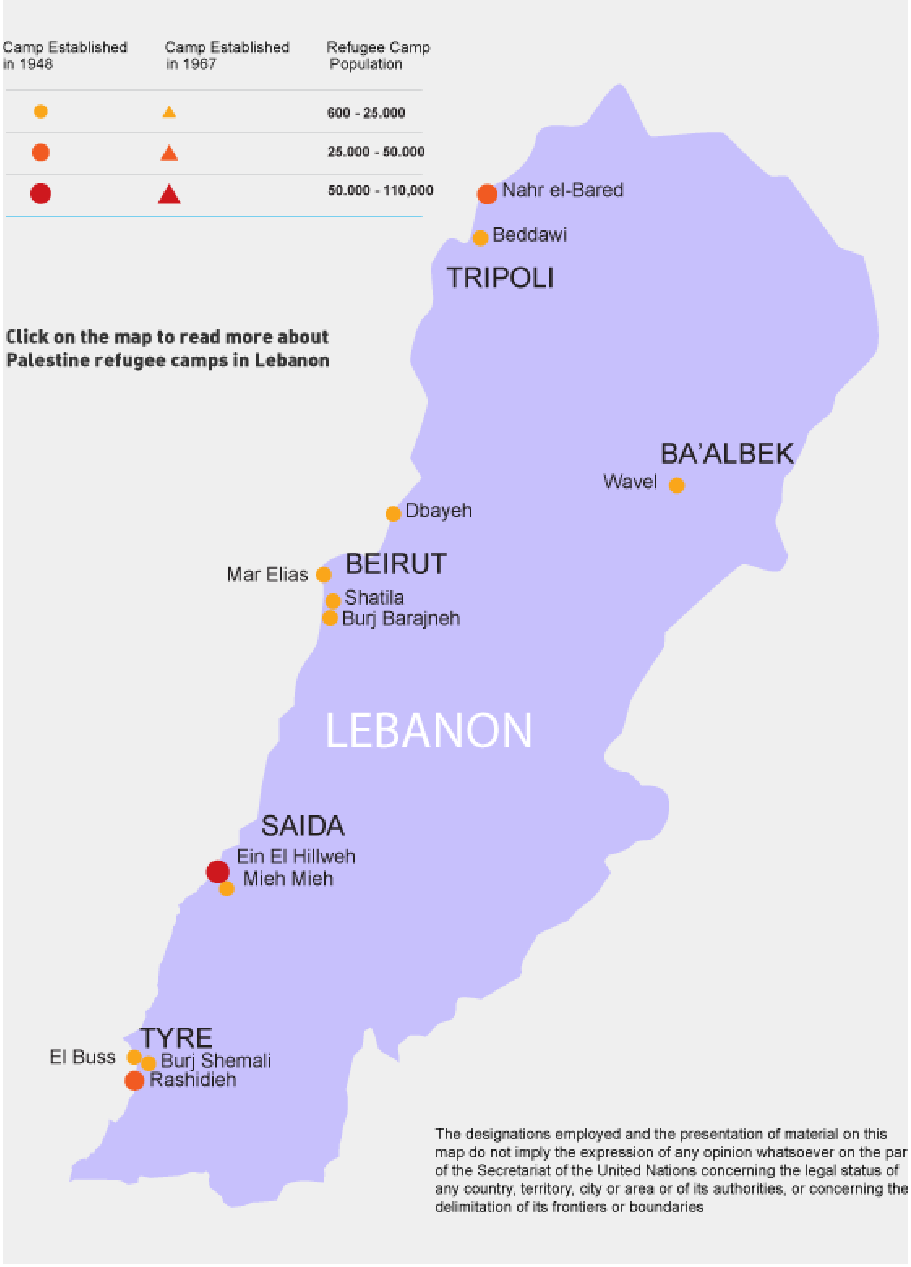


Figure 10 Map showing the location of the Palestinian camps[12]

[12] https://www.unrwa.org/where-we-work/lebanon(March 2020)

1.2.2.3.2. Current situation:

Initially these camps were thought to be temporary and most camps were made of tent, but with the passing of time and the help of UNRWA the camps started evolving with cements and brick taking over the tents which has led to the camps appearing like poor cities rather than refugee camps. The camps nowadays have houses built of bricks and concrete, streets, shops and sometimes paved roads.

It is important to note that most of the Palestinians do not possess Lebanese Identity cards therefore cannot access health, education and other government services. In order to receive them, they must live in the twelve refugee camps set up by UNRWA.

All the camps face the following serious problems:

- **Overcrowding**

  Combining the lack of infrastructure, the limitation of expansion imposed by the Lebanese government and the never-ending waves of immigration it is logical to consider that most camps are overcrowded.
- **Poor housing conditions**

  Considering that the population inside the camps has grown 5 times from the first wave of immigration, it remains a shocking fact to most analysts that the actual perimeter of all 12 camps remains mostly unchanged from their creation. This has led to the inhabitants building additional rooms and additional floors to their houses. According to Amnesty international, in 2005 some families had up to 10 people sharing a single room.

- **Unemployment**

  In order the Palestinians to be able to work in Lebanon they must obtain a government-issued work permit. But due to the armed conflicts and the political wish to halt the settlement of the Palestinians, very few permits were handed out to Palestinians with the government giving priority to other foreigners. This has forced many Palestinians to work in black and mostly to work within the camps themselves which has limited their potential and their economical status and helped into deepening the poverty in the camps.
- **Poverty**

  Between the political limitations posed by the Lebanese government, the armed clashes and the high unemployment rate, it is of no surprise that most of the families rely heavily on the UNRWA to satisfy their most basic needs with most families considered poor and some even severely poor.
- **Education**
  - The UNRWA is also the main provider of education in Lebanon and has established around 65 schools across Lebanon for that purpose. They try to focus the education to prepare their students to the employment opportunities available in the local market.
  - One of the most important roles of education is facilitating the integration of the Palestinians within the Lebanese society through their acquired skills and trainings.
- **Local politics**
  - Due to the various armed conflicts caused by the refugees, the local Lebanese authorities keep putting ever growing restrictions on the camps which are handicapping the camps' growth. Considering that these camps look more like cities rather than

refugee camps and considering the local discontent with the current situation and the refusal of allowing local integration of the refugees, the government has taken a series of political choices to limit the settlement of the refugees. For instance, since the late 1990s, it is prohibited the entry of building materials into the official camps, which has halted the expansion of the camps but at the same time has led to the deterioration of the camps' housing and infrastructure.[13]

- The situation is even worse in non-official camps, where the current technology is more basic and is constitutes of iron sheets for roofing. In those camps the government has prohibited the change of the roofing into bricks and when some of the residents attempt to do so, they are met with strict measures from severe fines to demolition to arrest.
- In 2001, a legislation was introduced to prohibit Palestinians from owning properties in Lebanon. This is part of the ongoing ever-growing movement denying all attempts of settlement of the Palestinians in Lebanon.

- **Health centers**

All health care for the Palestinians in Lebanon is handled by UNRWA. They mainly cover the cost of primary health care services as well as curative care with consultations and free medication. They are working on improving their support to the secondary and tertiary levels of health care in order to reduce the dependence on private hospitals and reduce the costs. The UNRWA has around 27 health centers spread across the country in order to perform their duties alongside contracting with some governmental and private hospitals for support when needed.

[13] https://www.fmreview.org/palestine/elsayedali(March 2020)

- **Environmental health**

  Due to the overcrowdings of the camps there is a high demand on water-supply sources as well as added pressure on sewerage and drainage systems. The UNRWA trying its best to upgrade the infrastructures of the camps by providing additional water sources and rehabilitating and upgrading the existing sources. [14]

- **Shelter rehabilitation**
  - Shelter rehabilitation has been a major source of concern for the UNRWA. Aside of the problems exposed previously there were many security issues during these 70 years that pushed the rehabilitation process back a lot. Here follows one the most important ones:
    - **1974**

      Israeli raids on Palestine refugee camps in southern lebanon destroying almost 80% of the UNRWA concrete-block shelters.
    - **2007**

      Due to a 3 months or armed conflict between the Lebanese Armed Forces and the terrorist Palestinian factions who went by the name of Fatah Al-Islam, around 95% of the Tripoli based camp was destroyed.
  - One of the most adopted approaches in recent history has been that of rehabilitation through self-help in order to promote self-reliance and therefore create a sensation of empowerment and control over their houses.

[14] https://www.unrwa.org/sites/default/files/overview_30-5-2019.pdf(March 2020)

- **Security[15]**
    - On the 2nd November 1969, the Cairo Agreement was signed between a delegation of the Palestinians and a delegation of the Lebanese Armed forces which has led to the security and control of the camps to be passed from the Lebanese Armed forces to the Palestinian Armed Struggle Command.
    - Even though on the 21st of May 1987, the Lebanese parliament declared this agreement as not valid, the internal security of the camps is autonomous but the Lebanese government holds the right to enter the camps and perform any necessary operations to secure the safety of the Lebanese citizens.
    - This has proven useful when considering the numerous terrorist cells that were created within the camps themselves.

1.2.2.4. Guidelines for project:

The Palestinian cause being the complex situation that it is puts each of the refugees in front of the following possibilities:[16]

- **Voluntary repatriation**

  When asked if they wish to return to their home and land, almost every Palestinian refugee answers the same way stating that they would but they fear to do so due to the persecution. To add to their problems, it is unclear if they would be allowed to enter the Palestinian lands by the Israeli authorities. So far, experience has shown that this route is the most difficult one especially with the ongoing restrictions being put in place by the Israelis.

[15] https://www.unrwa.org/where-we-work/lebanon(March 2020)
[16] https://www.fmreview.org/palestine/elsayedali(March 2020)

- **Local integration in the country of asylum.**

  Arab countries, and especially the hosts, have defended and expressed their desire for the Palestinians to return while assuring they will ensure their safety and wellbeing until they do. However due to the large numbers present and the disastrous impact local integration would have on the hosting country from an economic, sociological, demographical and cultural point of view this option has been halted by almost all Arab hosting countries. In addition, some of the Palestinian factions have caused numerous problems and, in some cases, clashed with the host country's armed forces which has led to the country expelling some refugees and in other cases more restrictions.

- **Resettlement in a third country**

  Due to the incapacity to proceed with either of the previous options, many refugees find themselves seeking asylum in other countries with a more open minded and inviting mentality which would allow them to live a better life and even in some cases move on their tough pasts.

The Palestine refugee camps in Lebanon definitely bear the title the longest emergency camps to modern history. As was shown during the description of the current situations in the camps, it is unsustainable and can even be described at times as dramatic. Through the, important and highly recommended, study of these camps the following conclusions can be drawn and used as guidelines for future projects:

Social impact:

- First and foremost, the armed conflicts have created an irreparable distance between the Lebanese and the Palestinians and therefore it is recommended that the refugees do not bear any weaponry.

- The security of the camps being autonomous has caused the camps to be seen as independent areas and therefore have set back the settlement as well as created further social barriers between the host country and the refugees. It is recommended that the security of the camps be handled by either the host country of the United Nations but definitely not by the refugees themselves.
- Social integration is essential for the refugees to be able to settle in and slowly get out of the refugee camps seeking a better life but if a country refuses the settlement of the refugees, it is advisable to proceed with the resettlement in a third country as the social and political limitations imposed by the host country will provide to be strongly severe and in some cases lead to worse living conditions than those caused by the crisis itself.

Proper planning:

- When the crisis' duration exceeds the initial expectations, it is important to proceed to a concrete change in the strategy and share and divide the burden on more than one country. Leaving the burden on one single country will create the feeling the abandonment by the international community and will fuel the refusal of the host country of the continuation of the camps which will create tensions between the host population and the refugees.
- The use of bricks and cement from the UNRWA has led to improving the housing quality of the camps from the tents but at the same time it has completely removed the qualification of temporary on the camps. It is essential to preserve the temporality of the camps through a thorough study of the impact of the actions of the help provided. The use of technology must remain that or temporary or demountable or relocatable structures no matter the difference in costs as the use of

more lasting technology has proven to have more negative effects rather than good.

- It can be concluded that these camps are no longer considered temporary and can be considered as small independent regions within the country itself and this leads to disastrous consequences on top of which can be found racial hatred between the hosting population and the refugees as well enormous economic and security impacts to the hosting country and social and economic impact to the refugees which find themselves in a closed and limited lifestyle.
- Additionally, this leads to the attraction of more and more refugees whenever surrounding circumstances forced the Palestinians to fled the other countries. This contributed to enlarging the burden on the host country. It is essential to maintain the focus on the temporary factor of the camps and plan how to react when the crisis exceeds its expected duration. There should not be this many waves of immigrations present in 1 single country as the humanitarian need no longer applies when speaking of such big numbers and such low-quality limited camps.
- The UNRWA, by abiding to their humanitarian role, have provided essential services and improved the quality of life within the camps which has proved to be a fueling point in the transformation of the camps from temporary settlements into a more long term solutions and exposed the true weakness of emergency architecture in the face of long term crisis'. The role of the humanitarian associations is to assist but at the same time not to create problems to the host countries. The help should be proportional to the expected duration of the camps and when the crisis extends to long periods, alternate solutions should be presented instead of maintaining the help.

- Resettlement in third countries can be very beneficial given that these third countries would have time to prepare and build proper long term camps with a decent infrastructure and housing.

Security impact

- The independent security of the camps has allowed the creation of many terrorist cells causing a security issue to which the hosting country cannot attend without severe consequences as was the case of Nahr el-Bared camp which has led to several hundred deaths between military and civilians.
- It is difficult to control the borders of these camps and this helps wrong doers and criminals to take shelter within these areas.
- In times of internal conflicts in between the different armed Palestinian factions present in the camps, the army cannot interfere and this has led to many times the conflicts to affect surrounding areas and causing casualties because of misfired bullets.

Economic impact:

- The cost of maintaining these camps for a long duration exceeds that of resettlement in a third country
- The fact the Palestinians find themselves working in black affects the economy of the host country as they are taking job opportunities from others by getting paid less and giving the job providers chance to do some tax evasion.
- Due to the presence of these camps, the areas around them find themselves heavily affected from a real estate point of view
- Additionally, whenever internal conflicts occur, the fighting often causes economic damages to the surrounding areas that fall on the Lebanese government to handle.

1.2.3. Present: Syrians

1.2.3.1. Lebanese-Syrian history

The Syrians have always been connected to the Lebanese due to their connected history through all the phases of history. It is to be noted that Syria only officially recognized Lebanon as an independent country in October 2008 when Syria established official diplomatic relations with Lebanon.

In order to fully understand the relationship between both countries it is essential to take a look at the history tying them together. This background research is key to identifying many of the political issued faced by the Syrian refugees and by the United Nations when interfering in between these two countries.

The history being so vast will not to be discussed in details within this thesis but instead what follows will be a brief description of the main phases.

- **1299-1914 Ottoman Empire**

  Lebanon and Syria used to be part of the Ottoman Empire and were known as one country under the name of Ottoman Syria. During that time, a part of Ottoman Syria, known by the name of Mount Lebanon, was politically autonomous from the Ottoman Empire due to its geographic isolation. It is to be noted that the Europeans had always felt closer to the Lebanese due to the fact that during that period the Europeans would use Beirut as the main trading port. Additionally, due to its isolation many religious minorities moved to Mount Lebanon, mainly Druze and Maronite Christians. Later on, this sparked several feuds between these minorities with the Christians backed by the Europeans and the Druze backed by the ottomans.

These religious tensions led to further isolation of Mount Lebanon from the Ottoman Syria up until the first world war.

Figure 11 Picture showing the borders during the ottoman empire[17]

- **1914-1920 World War I and its aftermath**

  During World War I, the Ottoman Empire allied itself with Germany which led to its eventual collapse and mainly due to the Arab Revolt. This was the beginning a new era for both countries as they fell under the ruling of the French. Under the French, the Ottoman Syria was divided into Greater Lebanon and Greater Syria, two French territorial mandate. Ever since the separation, many parties from both mandates still pushed for the reunification and recreation of the greater Syria but all their efforts were halted by the persistent French who vowed to defend the Christians in Lebanon.

[17] http://da2ottomanempire.weebly.com/(March 2020)

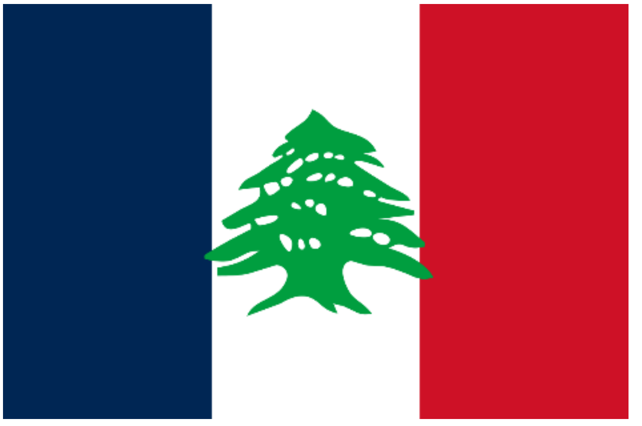


Figure 12 Picture showing the Lebanese flag under the French mandate[18]

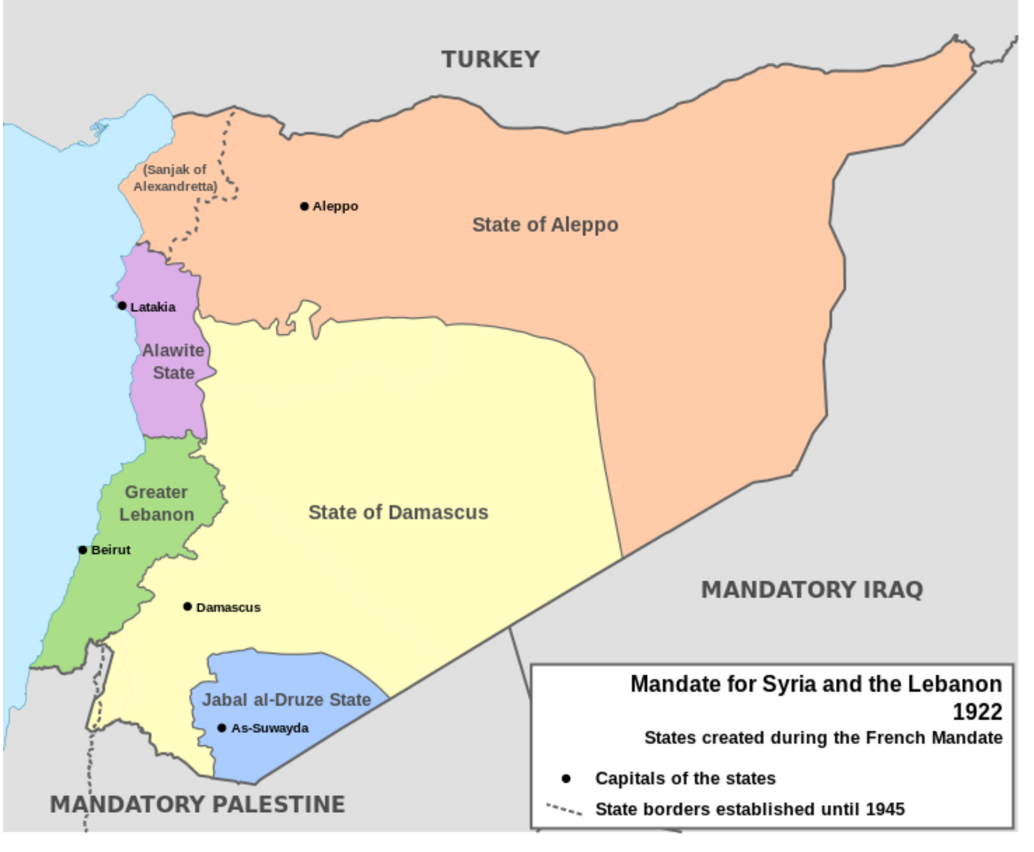


Figure 13 Map showing both Lebanon and Syria under the French Mandate[19]

[18] https://en.wikipedia.org/wiki/Greater_Lebanon(March 2020)

[19] https://en.wikipedia.org/wiki/File:French_Mandate_for_Syria_and_the_Lebanon_map_en.svg(March 2020)

- **1943-1946 Independence**

  In 1943, governments of both countries formed a united front and asked for independence from the French and got a partial one. Although the process was full both internal conflicts and armed conflicts with the French, it was not until 1946, after the withdrawal of all foreign troops that the actual independence was achieved. During the post French era the politics of both countries were always connected, and emphasis was put to the importance of collaborating for a better economical purpose.

Figure 14 Picture showing the Lebanese flag after the independence[20]

- **1975-1990 Lebanese civil war**

  During the Lebanese civil war, the Syrians entered the country to assist the Christian militias with their fight against the Palestinians which led to a cease-fire after escalated fighting. From that point on there was stationing of Syrian troops withing Lebanon. After political disagree the Syrians turned on the Christian militias and engaged in armed conflicts with them. This is the main reason of why many of modern-day Christians in Lebanon do not approve of the presence of any relationship with Syria. The civil war ended with the Taif Agreement and in it was cited the need for the Syrians to leave

[20] https://en.wikipedia.org/wiki/Lebanon (March 2020)

Lebanon, but this was not the case and later on came the Syrian occupation.

Figure 15 Picture showing the downtown of Beirut during the civil war[21]

- **1989-2005 Syrian occupation**

  As of 1989, around 40.000 Syrian troops were stationed in Lebanon and this has led into the non-official occupation of Lebanon by Syria. This has led into a period of direct interference of the Syrians in Lebanese politics as well as a series of political assassinations on top of which we have in 2005 the assassination of prime minister Rafic Hariri.

[21] https://en.wikipedia.org/wiki/File:Green_Line,_Beirut_1982.jpg(March 2020)

- **2005 Hariri assassination and Cedar Revolution**

  In 2005 the assassination of Prime Minister Rafic Hariri and 21 others, caused a nationwide manifestation against the Syrian presence in the country especially since suspicions led to the involvement of the Syrian government in it. On the 30th of April 2005, the Syrians withdrew from Lebanon giving what the Lebanese call "the Cedar Revolution".

Figure 16 Picture showing Syrian troops retreating from Lebanon[22]

Figure 17 Picture showing the popular demonstration demanding the exit of the Syrian troops[23]

[22] https://www.chinadaily.com.cn/english/doc/2005-04/26/content_437651.htm(March 2020)

[23] http://twofriedeggs.blogspot.com/2005/03/half-population-of-lebanon.html(March 2020)

- **2006 Israeli war**

  During the 2006 Israeli war on Lebanon, the Syrians stood by the Lebanese by opening the borders for the refugees and hosting the families for the entire duration of the conflict. During that time the aerial and maritime borders were closed by the Israeli warships and all connection to the outside world was only possible through Syria. This act was heavily appreciated by the Lebanese and has helped to mend the relationship between both countries.

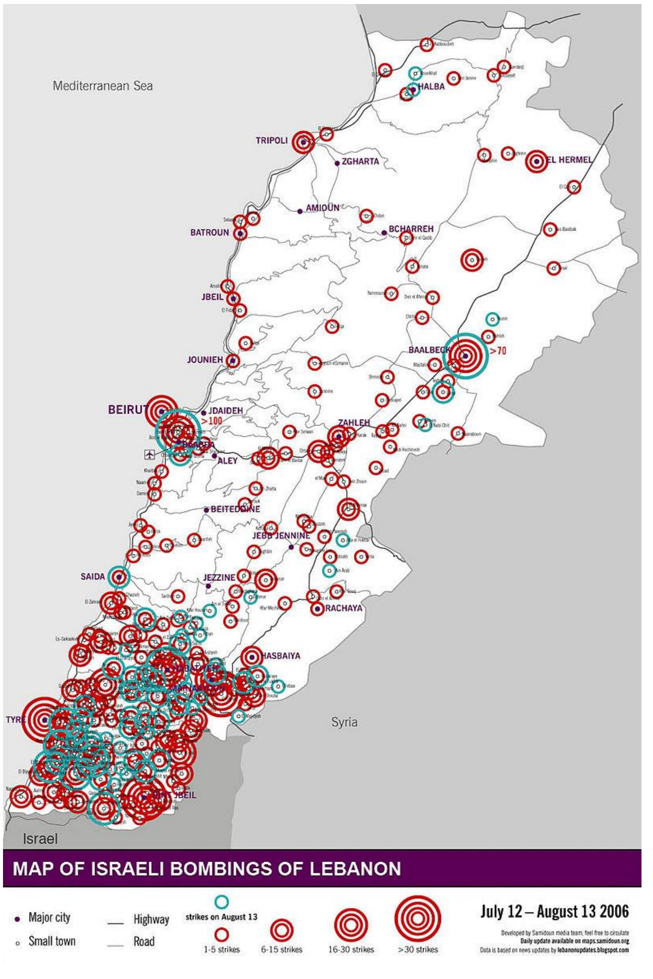


Figure 18 Map showing the bombardments suffered during the war[24]

[24] Public Domain, https://commons.wikimedia.org/w/index.php?curid=1474398 (March 2020)

- **2008 establishment of Diplomatic relations**

  Although never apart on the political scale, it was not until the 13th of August 2008 that both countries officially established diplomatic relations. It was not until December 2008 that the Syrian embassy opened in Beirut and not until March 2009 that the Lebanese embassy opened in Damascus.

Figure 19 Picture showing the Syrian embassy in Lebanon[25]

[25] http://www.dailystar.com.lb/News/Politics/2011/Oct-13/151203-isf-personnel-syrian-embassy-had-role-in-kidnappings-officials.ashx (March 2020)

- **2011 Syrian civil War**

  On 15th of March 2011, the Syrian civil unrest developed into an official civil war. The Lebanese government tried its best to stay unbiased and offer support to the refugees from day one. The borders were kept the first few years but as the numbers kept rising and with no foreseeing end to the crisis the Lebanese government closed its borders after having accepted over 1 million Syrian refugee with severe implications on the Lebanese on all fronts.

Figure 20 Picture showing the level of destruction due to the civil war[26]

[26] https://www.aa.com.tr/en/middle-east/syrian-civil-war-in-its-9th-year/1418892 (March 2020)

1.2.3.2. Settlements

1.2.3.2.1. Current situation

The Syrian refugees in Lebanon constitute the primary focus of this research and what follows are the results of on-site visits and various interviews performed with UNHCR officials as well as refugees, staff members..

One of the most important interviews performed during this research took place in the UNHCR headquarters in Beirut with a high official who requested that their ID remain confidential.

From that interview, it was possible to discover that when the crisis first started, the UNHCR began very lightly assisting various municipalities as they were initially vetoed by the Lebanese government to help the refugees because the government wanted to avoid another camps crisis, such as the situation of Palestinian camps currently in Lebanon.

This situation quickly changed after the government became aware of the huge number of refugees who entered the Lebanese territory and allowed the various NGOs and UNHCR to help. But this time they were asked to emphasize and focus on the temporary purpose of these settlements and hence it was decided to focus on the most basic stuff like, for instance, the use the term "informal settlements" instead of camps in order to clarify and insist that this situation is only temporary.

Moreover, the Lebanese government has prevented the use of concrete in construction as in the case of Palestinian camps that now look more like a city with a bad or even absent urban organization. It has allowed all sorts of temporary, reusable, relocatable, demountable structures only.

As it stands the refugees are distributed as follows:

- Only 18% present in informal settlements.
  - These receive the SHELTER KIT every month
- THE SHELTER KIT is a package designed to cover the primary needs of refugees.

o Sometimes, depending on the budget, these settlements receive maintenance work

- Mainly in WASH healthcare systems.
- 24% in SSBs, buildings qualified by them as SUB-STANDARDS
  - Over populated apartments
  - Apartments that have undergone basic rehabilitation.
  - Apartments where you do not pay rent in exchange for various forms of renovation or work specifically handled by UN member teams.
  - Apartments with a very low rent (up to 80% reduction)
- The rest of the refugees are distributed without UN control or monitoring.

In a more detailed approach according to the UNHCR, the types of shelters can be grouped as per the following table:

Shelter Type	Subsets	Definition
Residential structure	-	Structure designed for human residence
	Apartment/house Concierge's room in residential building	Single room with likely rudimentary toilet/kitchen facilities
Non-residential structure	-	Not designed for human inhabitance
	Factory Workshop Farm Active construction site Garage Shop Agricultural/engine/pump room Warehouse Hotel room School	Room without toilet and kitchen area
Non-permanent structure	-	A structure erected in an ad-hoc manner that could be quickly dismantled and moved
	Tent Prefab unit Other	

Table 1 Table showing different shelter types

It is important to focus on the non-permanent structures as the UNHCR qualify the other structures as a losing investment since every year the rents grow and especially with growing demand.

In order to better understand how the UNHCR qualifies and rates each of these types of shelter it is essential to keep in mind the following table:

Rating factor:	Subsets	Definition
Collectivity	Collective	>=6 HHs living in same structure
	Non-collective	<6 HHs living in same structure
Communality	Communal	>=6 HHs sharing facilities
	Non-communal	<6 HHs sharing facilities
Management	Managed	Managed by an agency, charity, committee, etc.
	Not-managed	
Adequacy	Adequate	According to shelter technical guidelines (shelter and WASH) standards, not taking into account overcrowding. Does not need a technical intervention
	Inadequate/substandard	Requires shelter/WASH intervention. Could be a residential, non-residential or non-permanent structure.
Sealing	Unsealed / no walls	Exposed to the elements; absence of most doors/windows

Table 2 Table showing shelter rating system according to UNHCR

Using the above table should allow the designer to understand better how their structure is qualified and what can be done to improve it in case needed.

1.2.3.2.2. Formal settlements

The formal settlements are the most used settlements by the refugees and are comprised of the all residential and non-residential structures:

Residential structures

Considering that these structures were targeted for human inhabitance, therefore renders them the most targeted solutions by distance by the refugees. Lebanon has a very active real estate market based on the fact that many of the Lebanese currently residing abroad own at least 1 or more properties. The downside was the high rent charges, but thankfully the UNHCR alongside the Lebanese government adopted a series of actions that allowed to make these apartments accessible for the refugees:

- Whenever possible target all apartments in villages and suburbs where rent is relatively cheaper than within the cities

Figure 21 Picture showing a typical residential building used by the refugees[27]

[27] https://data2.unhcr.org/en/documents/details/62289 (March 2020)

- Talking with owners to allow them to overcrowd the houses by applying the rule of 1 family per bedroom which allows the heavy rent's burden
- Targeting apartments that need rehabilitation and offering to rehabilitate them for free if owner accepts a huge rent reduction for the upcoming 2 years or more based on case by case
- It is common withing the Lebanese culture to have a concierge for the building. The job normally is underpaid and requires the concierge to live in the building and be available 24/7. One of the perks of this job is that the concierge can have his entire family to move with him and of course in this case as well we are talking about overcrowding the room. The capacity of the overcrowding always depends on the understanding of the building's owners.

Figure 22 Picture showing a Syrian family sleeping in a janitor's room[28]

[28] https://data2.unhcr.org/en/documents/details/62289(March 2020)

Non-Residential structures

There is no better way to put the saying “desperate times call for desperate measures” than by treating this part of the thesis. In this part we will be treating the numerous structures not designed for human inhabitance that have been adopted by the refugees as a shelter due to the lack of alternatives.

Factory

Figure 23 Picture showing Syrian refugees in an abandoned factory [29]

Many refugees have found themselves end up in abandoned factories which provide a solid shelter through its tough structure and although it can help keep most of the climate factors away like the wind and the rain and the snow… but it also provides with immense difficulty to heat up during the winter season rendering life in it very difficult.

The winter packages delivered by the UNHCR help out a great deal and gives the refugees a fighting chance but are obviously not enough.

[29] https://data2.unhcr.org/en/documents/details/62289(March 2020)

This option is deemed by many Syrians as more appealing than the tent as they feel safer and more autonomous.

However, it is to be noted that in many cases the presence of old equipment has caused many injuries and it is not a recommended solution. Not to consider that most of these do not have any water or sanitary installations

Workshop

Figure 24 Picture showing Syrian refugees in an abandoned workshop[30]

This is a similar situation to the abandoned factories, with a major downside that most of these workshops are not fully closed and most of them require the refugees to build a shelter within the structures. And as stated before it is highly not advised for refugees to build their own

[30] https://data2.unhcr.org/en/documents/details/62289(March 2020)

shelters due the risks that come with it. Not to consider that most of these do not have any water or sanitary installations

Old abandoned buildings

Figure 25 Picture showing a typical old abandoned building used by Syrian refugees[31]

There are many old abandoned buildings in the middle of farms that have been used by the refugees for shelter. This option presents the same characteristics as the factories with a slightly easier task of being heated. Consider that these buildings are not to be considered insulated. Not to consider that most of these do not have any water or sanitary installations

[31] https://data2.unhcr.org/en/documents/details/62289(March 2020)

Active construction site

Figure 26 Picture showing a typical active construction site used by the Syrian refugees[32]

With the construction sites lasting years many Syrians have found refuge in unfinished active construction sites. There are considered extremely dangerous and highly difficult to heat up during the winter seasons. Not to consider that most of these do not have any water or sanitary installations

Garage and Shops

Figure 27 Picture showing Syrian refugees using a garage as shelter[33]

[32] https://data2.unhcr.org/en/documents/details/62289(March 2020)
[33] Ibid.

Figure 28 Picture showing Syrian refugees using abandoned shops as shelter[34]

In the smaller cities or villages there can be found many empty garages and shops due to the economical crisis or the fact that their owners have left the country. In some cases, these were given by the municipalities and in others they were aggressively occupied by the refugees. In most cases the shops and the garages do not have a façade rendering them to be considered as open spaces. Where the shops do have a glass façade these options have proven themselves to be quite efficient as most shops are easy to heat up and have installations for showers and water access.

[34] https://data2.unhcr.org/en/documents/details/62289(March 2020)

Agricultural/engine/pump room

Figure 29 Picture showing a typical engine room used by some refugees as shelter[35]

These options have been used in extreme cases and especially at the beginning of the crisis. Seeing as though they are extremely difficult to live in, many efforts were put into relocating the inhabitants of these rooms into different locations.

[35] https://data2.unhcr.org/en/documents/details/62289(March 2020)

1.2.3.2.3. Informal settlements

Description

Due the already discussed policy adopted by the Lebanese government, no official camps were allowed to be set up for Syrian refugees and restrictions were put on the types of shelter materials that can be used by those affected. Instead most of them were forced into the previously described formal settlements. But since the numbers at stake here are too big, a series of informal tented settlements have been spread across the country.

Figure 30 Picture showing an informal settlement used by the Syrian refugees[36]

[36] https://data2.unhcr.org/en/documents/download/45642(March 2020)

Mapping

At the beginning of the crisis many agencies used to collect data independently which causing a lot of problems when it comes to the naming of the settlements and the distribution of the help. A few years into the crisis, an inter-agency project for mapping these informal settlements was placed and resulted into a much more organized contribution of all the agencies and hence helped the refugees get access to help equally and in a more organized way giving them the sensation of tranquility. Before there used to be panic as the refugees were always afraid, they might be overlooked and had to make initiatives themselves in order to get the different agencies to provide them with assistance.

The mapping helped identify areas that used to be previously invisible as well as monitor and collect data on a monthly basis. It also allowed to monitor the population changes and prioritize the help to the most vulnerable communities. It also created a network allowing the teams to have designated contact persons in each IF.

A series of PCodes were given to the various settlements tents and IF in order for everyone to be working with same coding system rendering the communication easier, faster and clearer. During the winter season or even in cases of emergency it became easier for the response team to directly arrive on site since all that was necessary was to know the Pcode in order to identify their location and status in order to find out who and how many people to send.

Thanks to the help and work of the InterAgency Mapping Partners (IAMP) it was possible to map the informal settlements as follows:

- What follows is a table showing informal settlements above 4 tents:

District	Nb Tents	Nb individuals	Nb Informal Settlements
Akkar	4,768	26,807	452
Aley	61	324	9
Baalbek	13,707	74,383	712
Batroun	54	296	5
Bcharre	36	260	2
Beirut	15	50	1
Chouf	111	570	10
El Metn	34	153	3
Hasbaiya	110	593	13
Hermel	261	1,282	31
Jezzine	7	26	1
Jubail	58	329	7
Kasrouane	21	58	3
Koura	177	961	17
Marjaayoun	599	3,152	31
Minieh-Danieh	1,004	6,102	93
Rachiaya	21	97	4
Saida	273	1,389	32
Sour	113	641	11
Tripoli	13	50	1
West Bekaa	4,303	25,276	206
Zahle	11,485	69,153	592
Zgharta	59	364	8
Grand Total	37,290	212,316	2,244

Table 3 Table showing informal settlements above 4 tents[37]

[37] https://data2.unhcr.org/en(March 2020)

- What follows is a table showing informal settlements less than 4 tents:

District	Nb Tents	Nb individuals	Nb Informal Settlements
Akkar	732	4,577	387
Aley	15	83	7
Baalbek	1	8	1
Batroun	995	5,534	542
Bcharre	36	196	24
Beirut	1	8	1
Chouf	57	294	39
El Metn	19	123	11
Hasbaiya	7	41	3
Hermel	45	242	25
Jezzine	8	37	4
Jubail	22	122	15
Kasrouane	58	282	32
Koura	36	225	25
Marjaayoun	21	112	11
Minieh-Danieh	171	1,184	95
Rachiaya	13	56	10
Saida	195	987	114
Sour	6	43	3
Tripoli	4	18	2
West Bekaa	469	2,666	275
Zahle	852	5,127	483
Zgharta	44	265	27
Grand Total	3,807	22,230	2,136

Table 4 Table showing informal settlements less than 4 tents [38]

- What follows is a map showing informal settlements across Lebanon:

[38] https://data2.unhcr.org/en(March 2020)

Legend

Informal Settlements Less Than 4 Tents [2,136]

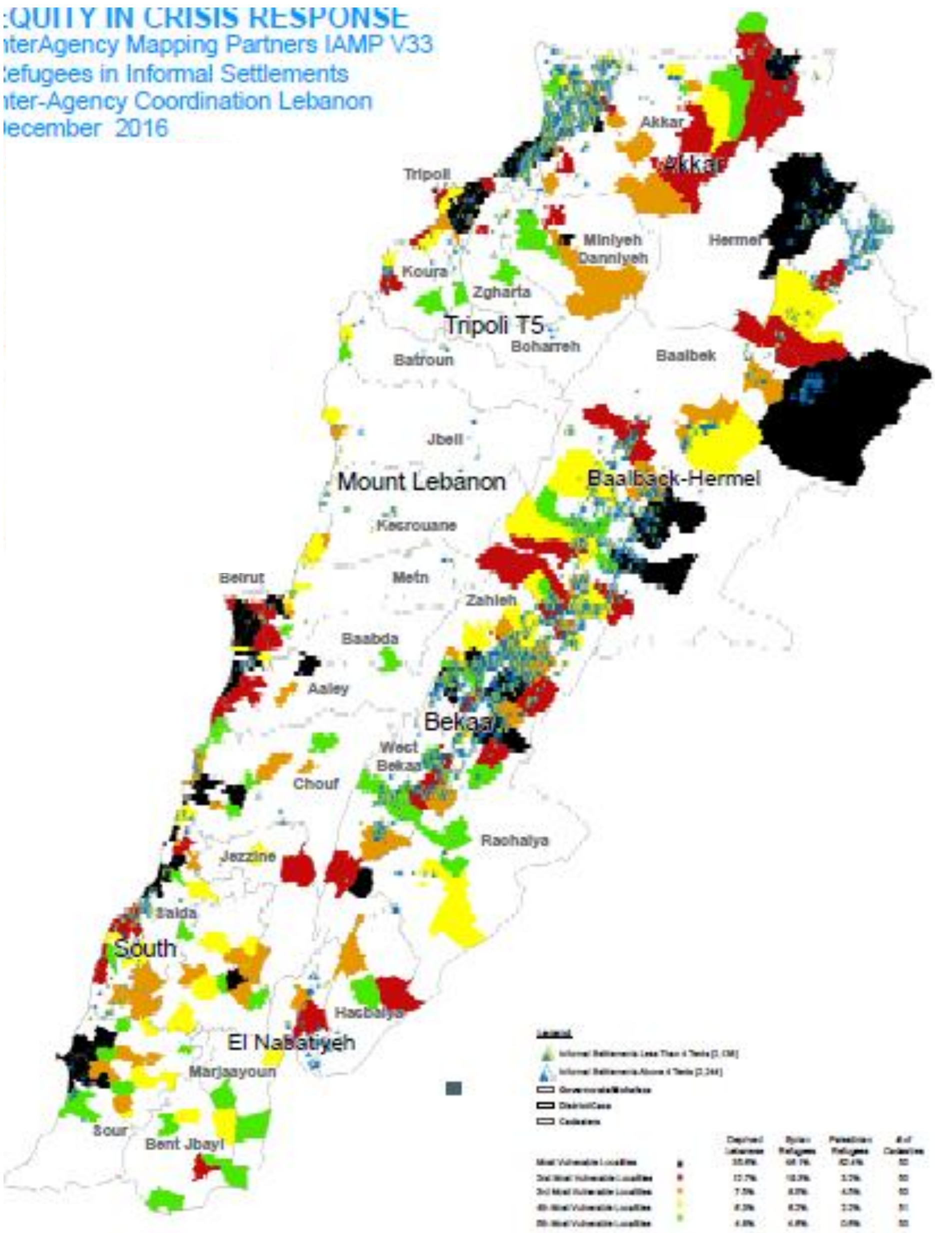
Informal Settlements Above 4 Tents [2,244]

Governorate/Mohafaza

District/Caza

Cadasters

		Deprived Lebanese	Syrian Refugees	Palestinian Refugees	# of Cadastres
Most Vulnerable Localities	■	35.6%	46.1%	82.4%	50
2nd Most Vulnerable Localities	■	12.7%	19.3%	3.2%	50
3rd Most Vulnerable Localities	■	7.5%	8.5%	4.5%	50
4th Most Vulnerable Localities	■	6.3%	6.2%	2.2%	51
5th Most Vulnerable Localities	■	4.8%	4.6%	0.6%	50



[39]

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[39] https://data2.unhcr.org/en(March 2020)

1.2.3.2.4. UNHCR

Figure 31 Picture showing the logo of the UNHCR[40]

The *United Nations High Commissioner for Refugees (UNHCR)* first established its office in Lebanon in 1964, and spent the first few decades doing rather modest work. It was not up until the Syrian crisis that the role the UNHCR had become essential with over a million refugee being put under their responsibility. Aside from assisting the refugees the UNHCR also provides financial and managerial assistance to the hosting country, especially considering the increasing strains on the economy and infrastructure. The UNHCR offers assistance in a variety of fields:

Protection

Having entered the 9th year of Syrian conflict, the hospitality of Lebanon is being continuously tested, with Lebanese feeling saturated with the current situation and expressing their desire for it to reach an end.

The UNHCR coordinates with governmental and non-governmental organizations to ensure the basic human rights to the those seeking asylum and making sure that there are no cases where the refugees are made to return to their countries therefore putting their lives at risk. In Lebanon, and due the already expressed objection of the Lebanese government for local integration, the UNHCR provides assistance to those wishing to either willingly head back to their country or those seeking resettlement in a third country. This resettlement operation is increasingly difficult in

[40] https://data2.unhcr.org/en(March 2020)

Lebanon due to the big numbers of refugees and more focus is being put on providing the needed services for them in Lebanon.

Basic assistance

Due to the large number of refugees, the fact that the Lebanese markets have the capacity to satisfy the basic refugee needs, and the exceptional banking system present, the UNHCR have pioneered a cash system allowing the refugees to meet their basic needs while giving autonomy to prioritize their expenses. By doing so the UNHCR would also be contributing into the local economy and helping to reduce the opposition to the refugees within the Lebanese politicians. The expenses are of course targeted and monitored in order to avoid any embezzlement or misuse.

Additionally, food assistance is provided by the World Food Programme through the help of the government and its National Poverty Targeting Programme (NPTP) which allows the deposit of a certain amount each month into e-cards which can be used to buy food supplies from local shops.

Considering the rough winter seasons in Lebanon, the UNHCR also provides winter aid to those in need and in some cases these helps reach Lebanese families in need.

Education

Having around 488.000 school-aged Syrian refugee in Lebanon, the UNHCR provided financial and personnel assistance to the Ministry of Education and Higher Education (MEHE) in order to accommodate as many children as possible. This was possible by the usage of 2 shifts for the schools, the creation of additional schools when needed and the rehabilitation and expansion of many MEHE schools equipping them for children with disabilities as well. A lot of focus and attention were put into encouraging the children not to drop out of schools and many programs with education sector partners were put to place and applied.

Public health

The UNHCR collaborates continuously with the Ministry of Public Health (MoPH) in order to provide services to the refugees. It supports the salaries of several staff members working for the MoPH as well as donating equipment and helping in increasing the capacities of the hospitals in order to ease the load of the Syrian refugees on the Lebanese health care system.

Support to host communities

The UNHCR has contributed through its donations to the various ministries affected with this crisis. In addition to the financial donations there were the various equipment, trainings, supplies, operational staffing cost coverages. This has helped to improve the country's infrastructure and assist with the community support projects.

Water sanitation and hygiene

The UNHCR helps to ease the load the high number of refugees has had on the existing Lebanese water and waste water infrastructure by strengthening and rehabilitating existing systems or even by the implementation of new systems in both formal and informal settlements. The interventions included the rehabilitation of storm water channels, the construction of reservoirs and drilling and equipping of boreholes.

Coordination:

All the above required heavy coordination between the various ministries of the Lebanese government as well as Inter-Agency coordination between all the various NGOs present. each sector is required to coordinate with all others. According to the "LEBANON CRISIS RESPONSE PLAN 2015-2016", the coordination also extends into an Inter-Sectorial one where for examples the following is required from the shelter field:

1. Regularly meeting with other sectors (e.g. energy and water, protection), especially at field level.
2. Encouraging shelter partners to also attend the meetings of other sectors, such as energy and water, and facilitating attendance by organizing them on the same day in the same location.
3. Exchanging information, for example on achieved or planned activities, lessons learned and more, with the other sectors.
4. Including relevant sectors in the process of elaboration guidelines and clarifying how to report on shelter activities.
5. Including all sectors in the process of profiling neighborhoods and articulating their needs for upgrades.
6. Coordinating the implementation of select portions of improvements of gatherings and neighborhood upgrades (e.g. energy and water).

Shelter

The UNHCR provides shelter assistance to all kind of settlements the refugees find themselves in while prioritizing improving the shelter conditions of families living in insecure conditions:

- The help for informal settlements is limited to providing temporary shelter kits which have to be in line with the guidelines imposed by the Lebanese government.
- As for those in formal settlements such as residential and non-residential structures, things are simpler as the help can be through the rehabilitation, the performance of necessary repairs as well as site improvement and fire prevention operations.

1.2.3.3. Guidelines for project.

Through the analysis done above, the following conclusions can be drawn and used as guidelines for future projects:

- After taking a look at the heavy and rich history between the Lebanon and Syria it becomes easier to understand how the heavy political baggage is influencing the ever rising movement requesting the end of the refugees situation in Lebanon with many considering that there are some areas within the Syrian territory that can host these refugees settlements. It is essential to understand the history of the neighboring countries while planning the emergency situation as the humanitarian priority of hosting refugees from an emergency crisis is bound to expire faster when the hosting country holds grudges against the refugees themselves.
- The duration of the crisis, having entered its 9^{th} year, is growingly leaving a saturation feeling within the Lebanese community which makes both the lives or the refugees and the work of the agencies harder as the cooperation in increasingly diminishing. As with the Palestinians, the current situation is no longer sustainable, and alternatives must be presented, or the situation will only keep getting worse and worse to an already suffering refugees.
- The history of the Lebanese with the Palestinian refugees has highly affected the performance of the humanitarian agencies during this crisis as there was a refusal for camps to be set up and limitations to the materials used in the informal settlements. It goes to show that it would have been much easier on everyone to have proceeded with the relocation to a third country. It is essential not to overload the hosting country above its capacity as

no amount of international aid can help in these situations and the aftermath can result with severe hatred between both the refugees and the hosting communities. Additionally, this shows that most of the solutions presented by the scientific community for alternative housing units might be met with the same rejection as was the case with the Lebanese government promoting that these efforts be put on different areas.

- Informal settlements make the job of the humanitarian agencies much more difficult as for instance it has taken many years for an inter-agency effort just to be able to do the mapping in order to coordinate in between them for the most efficient way to help.
- It is clear to everyone that Lebanon should have closed its borders much sooner than it has, as the number of refugees has proven to be too big to handle and has severely affected the country on all levels. When hosting the refugees, it is in everyone’s interest to understand the capacity of the host country and developing a strategy allowing the host country’s system not to fail while at the same time allowing the evacuation of as many refugees as possible.
- The adoption of a multiple shifts in the common areas has proven to be very useful and should be adopted in all future emergency situations.
- The different shelter types used by the Syrians show that the need to put a roof on top of one’s head is a priority no matter where they end up or how uncomfortable the shelter proves to be. Many refugees have preferred abandoned factories over tents due to the extra space they have gotten, and this shows that more efforts should be put into concentrating on providing them with more common areas rather than on the housing units.

2

SOCIOLOGICAL RESEARCH

In order for this research to be complete, it was indispensable to go on site and visit these informal settlements as well perform a series of interviews and see at first-hand what are the true needs of the refugees. This was the only way possible to be able to take a look at the settlements through the eyes of the persons who know them best: the refugees and the staff members.

It is essential to point out that this would not have been possible if it wasn't for the vital cooperation and support of all parties involved with this humanitarian cause from the Lebanese government to the UNHCR as well other active NGOs.

2.1.Preparation work

The first point to start with was the most important one and that was the definition of the objectives to be achieved from this study. From that point on the focus was on choosing the most befitting methodology to be adopted in order to achieve these objectives. Once that defined, the questionnaires needed to be prepared based on the methodology chosen and the "Guiding principles for working with survivors" developed and presented by the UNHCR in order to get their approval to proceed with the interviews.

2.1.1. Objectives

The following have been defined as the objectives to achieve from this study:

1. Develop a series of guidelines to be used for this project and future projects through a qualitative research performed in the Syrian Informal settlements.
2. Present the “Phase II” principles and study the reactions in order to justify the need for it.

2.1.2. Methodology

In order to achieve the above objectives, the methodology adopted was a qualitative research[41] performed as follows:

1. Direct observation of the Informal settlements through site visits in order to take a look at life there from an observer point of view
2. In-depths interviews and open-ended surveys with the refugees in order to better understand their lifestyles, primary needs and their points of view on “Phase II”
3. In-depths interviews and focus groups with the humanitarian crew in order to better understand what they redeem should be the primary needs of future projects and their points of view on “Phase II”
4. Participant observation in the monthly meeting for inter-agency coordination in order to get first-hand experience of the problems and how they are being dealt with.
5. Content analysis of the vast information gathered during this work and elaboration of the results.

What defines a qualitative research is that is allows the investigation, through your own eyes, ears, and intelligence to collect in-depth perceptions, descriptions of meanings. interpretations, symbols, and the processes and relations of social life. The results constitute descriptive data that must be interpreted using proper methods to achieve the desired conclusions. Special attention must be put into ensuring that the researchers do not influence the recollected data in ways which might affect it and that there is no undue personal bias used in the interpretation of the findings.

[41] https://www.thoughtco.com/qualitative-research-methods-3026555(March 2020)

Through this method, it was possible to better understand what influences the everyday life of the refugee in the Informal Settlements such as all kinds of social forces.

What follows are the tools that were used in this process:

- Direct observation

  The act of studying people through direct observation of their daily lives without any interference or participation from the researcher. Most of the times, the people are unaware that they are being studied and this is why these studies normally take place in public settings.

- Open-ended surveys:

  Unlike most surveys where the objective is to get quantitative data in order to prove a point with numbers, these are composed of open-ended questions that lead to qualitative data.

- Focus group:

  A focus group is a small group of 5 to 15 participants that engage in a conversation with the researcher to help him generate necessary data to be used in his research.

- In-depth interviews:

  These constitute the typical one-on-one setting where the researcher speaks with the participants with a pre-organized list of questions but is not limited to them and gives space for the participants to lead the evolvement of the conversation.

- Participant observation:

  Similar to the direct observation with the addition that the researcher participates in order to gain the first-hand experience discussed through the participants.

- Content analysis:

  This consists in the interpretation of all content received whether words, pictures, films, art, etc… in order to analyze the social life of the persons attached to the content analyzed.

2.1.3. Subject pool selection

Before starting the interview, it was essential to identify the targets subject pool needed in order to be able to give the research a valid representation of the current situation of the refugees.

Based on the need to understand the refugees at their full extent it essential to manage to interview subjects as diverse possible trying to cover all genders, ages and backgrounds. At the same time, encountering subjects with similar files allowd the confirmation of the accuracy of the results achieved. In case of the presence of too many differences, the case study will proceed with the majority.

The subjects were chosen based on the following criteria:

- Age
  - Under 10
  - Between 10 and 25
  - Between 25 and 60
  - Above 60

- Gender
  - Male
  - Female

- Profession Before camp (if applicable)
  - Employed
  - Unemployed
    - Looking for a job
    - Not looking for a job

- Profession In camp (if applicable)
  - Employed
  - Unemployed
    - Looking for a job
    - Not looking for a job
  - Volunteering
- Education
  - University
  - School

- Social Background
  - Low class
  - Middle class
  - High and upper class

- Grade of illiteracy
  - Capable to read but not write
  - Capable to write but not read
  - Incapable to read not to write
  - Capable to read and write.

- Knowledge of languages
    - Native language
    - 2 or more

- Capacity to use technology
    - Computer
    - Smartphone
    - Tablets
    - Internet

When it came to the humanitarian activists, the aim was to try and interview as many as possible and, when given the opportunity, try to pick persons from different cultural background as well as different role and grade within the agencies themselves.

All the preparation work done here was used as a guideline since one on site the interviews followed more a snowballing effect and there hardly time to pick the participants.

2.1.4. International guidelines for interviews:42

In order to best prepare for the interviews, it was deemed necessary to have some international references on the matter. For that purpose, the book entitled **“***Field Guide to Consulting and Organizational Development: A Collaborative and Systems Approach to Performance, Change and Learning Paperback – 2006- By Carter McNamara”* was used and the following guidelines were deducted from it:

[42] https://managementhelp.org/businessresearch/interviews.htm(March 2020)

- The following series of considerations and actions should be taken into account before starting the interview:
  - There should be the need to pick a comfortable setting with little to no distractions in order to keep the interview going smoothly and be able to finish faster and perform as many interviews as possible within the given timeline
  - There should be an introduction at the beginning of the interview to explain to the participants the purpose of the interview
  - In order to be as clear as possible, the terms of confidentiality should be addressed as soon as possible by specifying who will be entitled to access to their answers and analyze them.
  - It is essential to explain the flow of the interview in order to guide the participants on how they should behave.
  - Although difficult to determine, some indications should be given regarding the expected timeline of the interview
  - Depending on the subject at hand, it might be useful to give the participants means to contact the interviewer in case they have more information to give.
  - In order to make things clearer and break the ice between both parties, it would be helpful to ask the participants if they have any questions before engaging with the interview.
  - Whenever possible, it is always advisable to record the interview. It is essential in this case to first declare that intention to the participants and give them the final say in it.
- The type of interview should be defined and clear to both parties. The choice should be made between the following types:
  - Informal

    There are no predetermined questions and the interviewer has to go with flow.

- Guide approach

  There are no predetermined questions and the interviewer has a series of information that he has to collect from all interviewees by guiding the conversation.
- Open-ended

  All interviewees are asked the same open-ended questions.
- Closed

  All interviewees are asked the same questions and are asked to pick between the predefined answers.

➢ The questions chosen can be grouped into the following types :

- Behaviors

  Questions regarding an action performed by the interviewee
- Opinions/values

  Questions regarding the thoughts of the interviewee concerning a topic
- Feelings

  Questions regarding the feelings of the interviewee concerning a topic
- Knowledge

  Questions regarding to get facts from the interviewee about a topic
- Sensory

  Questions regarding information that can be helpful to the topic through the sensory system of the interviewee
- Background/demographics

  Questions regarding the profile of the interviewee

➢ The sequence of the questions controls the interview's flow and there it is essential to consider the following:

- Getting the interviewee involved as soon as possible

- Ask generic questions before treating the more controversial questions
- Space out the fact-based in order to keep the interviewee engaged
- It is essential to ask questions concerning the present ahead of the questions concerning the future
- When possible, the final questions should allow the interviewee to add any information they might redeem important.

➢ The wording of the questions can affect the interviewee on a psychological level and therefore it is essential to consider the following:

- Wording should not be closed and restrict the interviewees from using their own words
- It is essential that the questions be as neutral as possible
- Avoid asking multiple questions simultaneously
- Choice of words should avoid ambiguity
- Pay extra attention when using “why” questions as they may cause the interviewees to go into defensive mode which will influence the information transmitted.

➢ It is important to always be in control of the flow of the interview and therefore it is essential to consider the following while conducting the interview:

- In case recording is used, constantly verify the recording device is working.
- Avoid asking multiple questions simultaneously
- It is essential that remain as neutral as possible both when asking and when reacting to the answers. Same applies when taking notes.
- All responses must be accompanied by encouragement from the interviewer

- It might be useful to guide the conversation by using transitional expressions when jumping between important topics
- Avoid straying from the topic at hand by always keeping the conversation under control.

➢ Finally, it is important to write all notes as it is not advisable to rely on the memory especially when performing back to back interviews. And in case of tape recorder always quickly verify the recording made in between interviews and in case the recording was not made attempt to take a break and recover as much data as possible by writing it down before proceeding with the next interview.

2.1.5. UNHCR recommendations for interviews:

Before starting with the compilation of the questionnaires, it was advisable to check out the guiding principles for working with survivors established by the UNHCR. The Survivor Centered Approach prioritizes the rights, needs and wishes of the refugees above all and although it was thought out for the victims of Gender Based Violence (GBV), many of the items can be applied to this thesis' study case as well. It focusses on the need to create a supportive and empowering environment while making sure the refugee is treated with dignity and respect at all times.

Through the analysis of these guidelines, that have been put out for all humanitarian actors who are in contact with the refugees, the following rules were established to guide the making of the questionnaires:

- Ensure the safety of the refugee at all times
- A respect for the confidentiality was achieved by ensuring anonymity and making sure that all which was said cannot be

traced back to any of the participants of the surveys, interviews or focus groups.

- When requested by the refugee, ensure that the interview is done in private settings protecting his confidentiality.
- It was made clear that the information can be shared only through a written consent of the refugee himself, and the researcher should stick only to the pertinent and relevant information. It is to be noted that for the purpose of this research there was no need for any consent. No specific or personal data gathered was used and instead the data was presented through collective results.
- As it was advised, a coding system was adopted for filing therefore removing any identifying information which can lead to giving away information about the refugees.
- Respect the wishes, choices and decisions, rights, and dignity of the survivor at all times.
- In the case the researcher feels and intervention is needed, it is imperative that the researcher should only advise the refugee on where to seek help if they wish it and not to push or take decisions on their behalf.
- Maintain a non-judgmental and respectful attitude throughout the entire process.
- Let the participants guide the information flow of the conversation and never press for more information if they are not ready to speak about their experiences.
- Ask only relevant questions
- Use a language they would fully understand as the answers can only be used if the questions were fully understood by the participants.

- Never make any promises and especially never raise expectations.
- Obtaining an informed consent has to be done through the rules set by UNHCR. For more information refer to their website.

2.1.6. Questionnaires

Having finished with the background research and gathered the guidelines it was time to proceed with the questionnaires. The main focus was how to proceed with interview, and how to maintain a healthy and productive flow of information while maintaining all of what was mentioned above. It was thought to start with the easy and simple questions to reach a comfort zone and establish a warm relationship with participants and then proceed with the rest of the questions by order of complexity. It was therefore smartest to start with some easy personal questions in order to be able to qualify their background and get a lead on how to proceed and which questions to dodge since they might be irrelevant.

However, in order to assure the objectivity and considering the purpose of the research no record of the personal information will be held and if desired the subject has the right to remain anonymous since, as previously said, preserving confidentiality is a must. Also fully understand the background of the subjects allows us to see how the life in the camp has affected the people from different background.

The questions have been divided into different subgroups leaving the choice of the series of questions to be adopted to decided based on the nature and background of the subject whether a refugee, a volunteer or an activist. Some of the questions are successive and based on the answers of the subject the series of questions should be used or not. In order to make things more conformable, it was decided to alternate between simple "Yes of No" questions and open-ended ones that require more time. Since it was not possible to know the amount of people that would participate of how much time it would take interviewing each person, it was decided to put as many questions as possible and prioritizing them. This would allow as much flexibility as possible to the researcher rendering the conversations as close to natural ones as possible. The "yes or no" questions were not prioritized as they are not regarded as time consuming and more focus was put into the open-ended ones.

Due to the sensitivity of the subject, the interviewer should at all time take into consideration the feelings and comfort of the subjects and in case an argument disturbs the subject it should be dropped directly and avoid it coming up throughout the other questions. For as much effort as could be put into planning the interview, these matters can only be avoided throughout experience gained from the interviews themselves and therefore a lot of attention should be put into the first interviews as they will pave the way for the rest.

It is to be noted that the questions themselves are far too big to be put within the thesis itself and can be found in the end within the annexes.

2.2.Site visits and interviews

With the preparation work done and having taken into consideration all the requirements set by the UNHCR and the agencies handling the aid in the Informal settlements, it was time to get in contact with them and set up the interviews.

After presenting my interests it was agreed between al parties that the site visits will occur on 2 full days divided by 1 day per settlement and visiting in the end 2 settlements:

- One being aided by the NGO MEDAIR and located in the Bekaa valley to the Eastern part of Lebanon. (referred to as **Settlement A**)
- One being aided by the UNHCR and located in the southern parts of Lebanon near the city of Tyr (referred to as **Settlement B**)

It was agreed not perform additional visits for safety purposes and considering that all the required information can be gathered within these 2 days from the refugees and as for the staff, the interviews would occur on different days when they are not under pressure and within the headquarters of each agency accordingly. During that year, 2015, the Lebanese army was performing operations to remove terrorist cells within the settlements and therefore safety measures were very strict.

2.2.1. Interviews with the refugees:

The exact names and locations of the settlements will not be disclosed based on the request of the humanitarian actors but instead they shall be reported on the following map in an approximate manner:

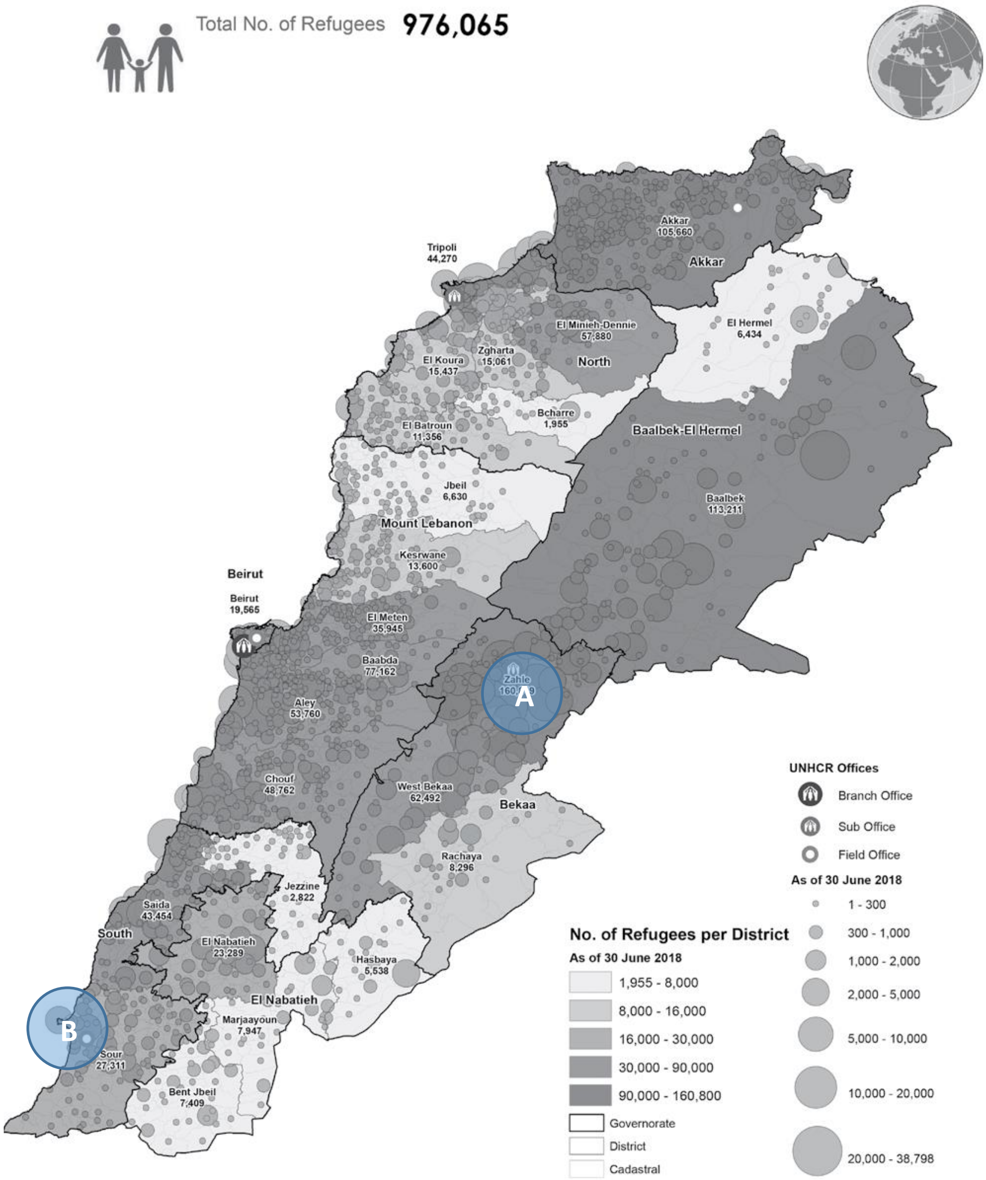


Figure 32 Map showing the studied settlements[43]

[43] *Source: UNHCR Lebanon, 2018*

During the settlement's visits, the agencies were kind enough to assign each a designated staff member to help with the tour around the settlements. The role was also to avoid creating unnecessary panic amongst the refugees when seeing a new face amongst them. The dress code was requested not to be formal and on top of which it was asked to wear UNHCR caps and MEDAIR depending on which settlement accordingly.

The day started very early as we arrived around 8AM to the settlements. After quickly touring around the settlements, we were allowed to accompany them during their morning tasks for a couple of hours at the end of which the agencies were kind enough to free the space normally used by them to interview the victims of Sexual and Gender-based Violence, stating that by now this is considered a safe space and it would allow for the participants to feel more at ease. In order not to change the standard procedure, it was requested that no filming or photography be taken and that as spoken before confidentiality we assessed case by case. During our tour, the designated person kept pointing out people who are normally very cooperative and we went together and asked them if they would be interested in participating in this research and it was shocking to see that every single person, we had encountered was very delighted to help out.

Once our tour ended, I stayed in the designated space for the remainder of the time while the designated person kept calling for the refugees one after the other. The interviews lasted around 7 straight hours with a 30 min lunch break during which we were invited to join the team present on site and got to know them better and shared some thoughts about the research and since they showed interest, it was agreed that they would later on participate in the interviews help at the headquarters. The average time per interview was around 15 min in which the objective was to give 10 min to the background of the refugee and 5 min to talk about the proposed project. The most difficult part was having to stop them as their enthusiasm led them to wanting to stay more. Since no recordings were allowed, I took around 1 to 2 min to write down special notes about each refugee when needed. Engaging in the interview, the most difficult part was maintaining an eye contact while trying to keep up with the notes and that task proved extremely difficult with the open-ended questions. That was why in most times only notes were taken and that has led me to continue working late on the same day and the following day in order to avoid missing out or forgetting any information given by the refugees. The results would have definitely been richer had the conversations been recorded but the overall result was more than satisfying.

In the end, a total of 50 refugees were interviewed in between both settlements. The experience by itself was super fulfilling and enriching and it is advisable for anyone who wishes to follow in this humanitarian field to perform at least one site visit.

2.2.2. Interviews with staff members

Due to the limited time available on the settlements, the interviews with the staff members were conducted within their premises. The interviews were held on several meetings during the month of August of the same year, 2015, depending on their availability as there was no wish to burden them and it was of course impossible to hold interviews all day.

Interviews were done one by one with staff members of different ranks and roles, as per instance, team leader, project leader, wash team leader, assessment team leader. These interviews were performed either within the meeting room in case available or on their desks or even post work in some cases.

In order to further validate this research, the NGO's team also agreed to perform a focus group that was done after work hours for a period of maximum 30 min during which the topic discussed was a presentation of all the areas they are involved in.

2.3.Detailed results of the work performed on site

2.3.1. Observations

During the brief visits to the settlements, the following was deducted from observing the life there:

- No material was used aside from tents and parts of scrapped metal as well as old used tires to add wind resistance to the tents.
- The lack of proper foundation and flooring causes flooding whenever it rains in most of the tents
- Many tents bare the Pcodes assigned to them by the IMAP giving some sort of urban design to a chaotic environment
- Most of the refugees stay within the tents and only 1 designated person per family proceeds to get the food when new packaged arrive. In addition, some of the refugees have volunteered to help out in the settlements and therefore their presence is noted and they are shown respect.
- The volunteers are shown more respect than the humanitarian agencies and through observation it is mainly due to the language barrier
- When the refugees see a new person, they start asking around to find out if a new agency is offering some help in order to register and get precedence.
- Even though they are assured everyone will get an aid there are always fears of missing out and that is due to the pre-mapping phase where many refugees saw their neighbors get packages and

when they went to pick up theirs, in some cases they were met with the disappointment of depletion

- Kids are the first to introduce themselves and are the ones with the highest presence outside the tents as they are playing or just observing everything around them trying to satisfy their curiosity
- At the time of visit the security members amongst the team were always tense and on the lookout for any possible danger which were met by some looks of disgust by the males present there.
- The old people are by far the best connection between all members present in campus as they are respected by everyone and that could be due to the cultural respect present in Arabic communities where the families are normally led by the oldest male member.

2.3.2. Interview results

Here follows are the statistics and summaries of the results of the questionnaires. The analysis was done according to *ICC/ESOMAR International Code on Market, Opinion and Social Research and Data Analytics*[44] and have been treated for every single question and the conclusions were gathered in the point 3.4. under Guidelines for the project.

In order to maintain confidentiality all Identification and Background Data collected will not enter the following results as they do not influence the project. The age and genders were summarized in the generic charts in order to preserve the anonymity of the participants.

We will start with the tables showing how each person answered the questions, which can be found in the annexes with their corresponding codes, in order to later on analyze and summarize them with the charts that will be used to draw the necessary conclusions.

[44] https://www.esomar.org/uploads/pdf/professional-standards/ICCESOMAR_Code_English_.pdf(March 2020)

2.3.2.1.Refugees

<u>Tables showing the collected data:</u>

#	data			Answers											
	location	time	code	History in the settlement (H)											
				H1	H2	H2.1	H2.2[3]	H2.3[4]	H3	H3.1	H4[9]	H4.1	H4.2	H5	H5.1
1	SA	10:00	A-01	7	yes	PUB[1]	2	1	FR[6]	GOV[8]	SAF	BOR[10]	MOV[12]	YES	N[13],W
2	SA	10:15	A-02	7	yes	PRV[2]	1	3	FA[5]	GOV	SAF	BOR	MOV	YES	N,W[14]
3	SA	10:30	A-03	7	yes	PUB	5	2	FA	GOV	SAF	BOR	MOV	YES	N,W
4	SA	10:45	A-04	7	no	PUB	1	1	FA	GOV	SAF	BOR	MOV	YES	N,W
5	SA	11:00	A-05	9	no	PUB	2	4	FA	GOV	SAF	BOR	MOV	YES	N,W
6	SA	11:15	A-06	9	yes	PUB	3	4	FA	GOV	SAF	BOR	HOM[11]	YES	N,W
7	SA	11:30	A-07	9	no	PUB	4	4	FA	GOV	SAF	BOR	MOV	YES	N,W
8	SA	11:45	A-08	9	yes	PUB	5	12	FR	GOV	SAF	BOR	MOV	YES	N,W
9	SA	12:00	A-09	9	yes	PRV	5	1	FR	GOV	SAF	BOR	HOM	YES	N,W
10	SA	12:15	A-10	7	yes	PUB	5	2	FR	GOV	SAF	BOR	HOM	YES	N,W
11	SA	13:00	A-11	7	no	PRV	5	3	AG[7]	GOV	SAF	BOR	HOM	YES	N,W
12	SA	13:15	A-12	7	no	PUB	2	2	AG	GOV	SAF	BOR	HOM	YES	N,W
13	SA	13:30	A-13	6	no	PUB	2	12	AG	GOV	SAF	BOR	HOM	YES	N,W
14	SA	13:45	A-14	6	no	PUB	2	1	FR	GOV	SAF	BOR	HOM	YES	N,W
15	SA	14:00	A-15	6	yes	PUB	1	4	FR	GOV	SAF	BOR	HOM	YES	N,W
16	SA	14:15	A-16	6	yes	PUB	4	2	FR	GOV	SAF	BOR	MOV	YES	N,W
17	SA	14:30	A-17	6	yes	PUB	5	4	FA	GOV	SAF	BOR	MOV	YES	N,W
18	SA	14:45	A-18	6	yes	PRV	6	5	FA	GOV	SAF	BOR	MOV	YES	N,W
19	SA	15:00	A-19	7	yes	PRV	2	2	FA	GOV	SAF	BOR	MOV	YES	N,W
20	SA	15:15	A-20	8	yes	PRV	12	1	FA	GOV	SAF	BOR	HOM	YES	N,W
21	SA	15:30	A-21	6	no	PRV	2	4	FA	GOV	SAF	BOR	HOM	YES	N,W
22	SA	15:45	A-22	6	no	PUB	1	1	FA	GOV	SAF	BOR	MOV	YES	N,W
23	SA	16:00	A-23	6	no	PUB	6	1	FA	GOV	SAF	BOR	HOM	YES	N,W
24	SA	16:15	A-24	5	no	PUB	3	1	FA	GOV	SAF	BOR	HOM	YES	N,W
25	SA	16:30	A-25	8	yes	PRV	4	1	AG	GOV	SAF	BOR	MOV	YES	N,W

(1) Public (2) Private (3) Days (4) Weeks (5) Family (6) Friends (7) Agencies (8) Government (9) Safety (10) After passing the border (11) Going back home (12) Moving on (13) Numbers (14) Wash systems

Table 5 Table showing collected data in settlement A for the questions of "History in the settlement (H)"

#	data			Answers											
	location	time	code	History in the settlement (H)											
				H1	H2	H2.1	H2.2(3)	H2.3(4)	H3	H3.1	H4	H4.1	H4.2	H5	H5.1
26	SB	10:00	B-01	8	no	PUB(1)	6	2	AG(7)	GOV(8)	SAF(9)	BOR(10)	MOV(11)	YES	N(13), W
27	SB	10:15	B-02	8	yes	PUB	2	3	FA(5)	GOV	SAF	BOR	HOM	YES	N,W(14)
28	SB	10:30	B-03	8	yes	PRV(2)	2	4	FA	GOV	SAF	BOR	MOV	YES	N,W
29	SB	10:45	B-04	8	no	PUB	2	5	FA	GOV	SAF	BOR	HOM	YES	N,W
30	SB	11:00	B-05	6	yes	PRV	1	2	FA	GOV	SAF	BOR	MOV	YES	N,W
31	SB	11:15	B-06	5	yes	PUB	2	1	FR(6)	GOV	SAF	BOR	MOV	YES	N,W
32	SB	11:30	B-07	6	yes	PRV	4	5	FR	GOV	SAF	BOR	HOM	YES	N,W
33	SB	11:45	B-08	6	yes	PUB	5	4	FR	GOV	SAF	BOR	MOV	YES	N,W
34	SB	12:00	B-09	6	yes	PRV	5	5	AG	GOV	SAF	BOR	HOM	YES	N,W
35	SB	12:15	B-10	8	no	PUB	5	2	AG	GOV	SAF	BOR	HOM	YES	N,W
36	SB	13:00	B-11	8	no	PUB	5	3	AG	GOV	SAF	BOR	MOV	YES	N,W
37	SB	13:15	B-12	9	no	PUB	2	4	AG	GOV	SAF	BOR	HOM	YES	N,W
38	SB	13:30	B-13	8	no	PUB	2	1	AG	GOV	SAF	BOR	MOV	YES	N,W
39	SB	13:45	B-14	8	yes	PUB	1	12	AG	GOV	SAF	BOR	MOV	YES	N,W
40	SB	14:00	B-15	9	yes	PUB	2	2	AG	GOV	SAF	BOR	HOM	YES	N,W
41	SB	14:15	B-16	8	no	PUB	1	2	FA	GOV	SAF	BOR	MOV	YES	N,W
42	SB	14:30	B-17	9	yes	PUB	1	2	FA	GOV	SAF	BOR	HOM	YES	N,W
43	SB	14:45	B-18	7	no	PUB	1	2	FA	GOV	SAF	BOR	HOM	YES	N,W
44	SB	15:00	B-19	8	yes	PUB	1	2	FA	GOV	SAF	BOR	HOM	YES	N,W
45	SB	15:15	B-20	8	yes	PRV	1	1	FA	GOV	SAF	BOR	MOV	YES	N,W
46	SB	15:30	B-21	9	yes	PUB	1	1	FA	GOV	SAF	BOR	MOV	YES	N,W
47	SB	15:45	B-22	9	no	PUB	2	1	FR	GOV	SAF	BOR	MOV	YES	N,W
48	SB	16:00	B-23	8	no	PUB	3	4	FR	GOV	SAF	BOR	MOV	YES	N,W
49	SB	16:15	B-24	7	no	PRV	3	4	FR	GOV	SAF	BOR	MOV	YES	N,W
50	SB	16:30	B-25	7	yes	PUB	4	12	FA	GOV	SAF	BOR	MOV	YES	N,W

(1) Public (2) Private (3) Days (4) Weeks (5) Family (6) Friends (7) Agencies (8) Government (9) Safety (10) After passing the border (11) Going back home (12) Moving on (13) Numbers (14) Wash systems

Table 6 Table showing collected data in settlement B for the questions of "History in the settlement (H)"

#	data			Answers										
				Current situation: (group into subgroups) (C)										
				Hygiene (H)										
	location	time	code	CH1	CH1.1	CH1.2	CH2	CH3	CH4	CH5	CH5.1	CH5.2	CH6	CH6.1
1	SA	10:00	A-01	DEC[2]	AG[3]	YES	AID	AG	DEC[2]	SHB[4]	YES	YES	AID[5]	SHA[6]
2	SA	10:15	A-02	GD[1]	AG	YES	AID	AG	DEC	SHB	YES	YES	AID	SHA
3	SA	10:30	A-03	GD	AG	YES	AID	AG	DEC	SHB	YES	YES	AID	SHA
4	SA	10:45	A-04	GD	AG	YES	HOM	AG	DEC	SHB	YES	YES	AID	SHA
5	SA	11:00	A-05	GD	AG	YES	HOM	AG	DEC	SHB	YES	YES	AID	SHA
6	SA	11:15	A-06	GD	AG	YES	HOM	AG	DEC	SHB	YES	YES	AID	SHA
7	SA	11:30	A-07	GD	AG	YES	HOM	AG	DEC	SHB	YES	YES	AID	SHA
8	SA	11:45	A-08	GD	AG	YES	HOM	AG	DEC	SHB	YES	YES	AID	SHA
9	SA	12:00	A-09	GD	AG	YES	HOM	AG	DEC	SHB	YES	YES	AID	SHA
10	SA	12:15	A-10	GD	AG	YES	HOM	AG	DEC	SHB	YES	YES	AID	SHA
11	SA	13:00	A-11	GD	AG	YES	HOM	AG	DEC	SHB	YES	YES	AID	SHA
12	SA	13:15	A-12	GD	AG	YES	HOM	AG	DEC	SHB	YES	YES	AID	SHA
13	SA	13:30	A-13	DEC	AG	YES	HOM	AG	DEC	SHB	YES	YES	AID	SHA
14	SA	13:45	A-14	GD	AG	YES	HOM	AG	DEC	SHB	YES	YES	AID	SHA
15	SA	14:00	A-15	GD	AG	YES	HOM	AG	DEC	SHB	YES	YES	AID	SHA
16	SA	14:15	A-16	GD	AG	YES	HOM	AG	DEC	SHB	YES	YES	AID	SHA
17	SA	14:30	A-17	DEC	AG	YES	HOM	AG	DEC	SHB	YES	YES	AID	SHA
18	SA	14:45	A-18	DEC	AG	YES	HOM	AG	DEC	SHB	YES	YES	AID	SHA
19	SA	15:00	A-19	DEC	AG	YES	HOM	AG	DEC	SHB	YES	YES	AID	SHA
20	SA	15:15	A-20	DEC	AG	YES	HOM	AG	DEC	SHB	YES	YES	AID	SHA
21	SA	15:30	A-21	DEC	AG	YES	HOM	AG	DEC	SHB	YES	YES	AID	SHA
22	SA	15:45	A-22	DEC	AG	YES	HOM	AG	DEC	SHB	YES	YES	AID	SHA
23	SA	16:00	A-23	GD	AG	YES	HOM	AG	DEC	SHB	YES	YES	AID	SHA
24	SA	16:15	A-24	GD	AG	YES	HOM	AG	DEC	SHB	YES	YES	AID	SHA
25	SA	16:30	A-25	DEC	AG	YES	AID	AG	DEC	SHB	YES	YES	AID	SHA

(1) Good (2) Decent (3) Agency guided (4) Shared Bath (5) Aids: Either used clothing or tools for knitting (6) Shared Areas

Table 7 Table showing collected data in settlement A for the questions of " Hygiene (CH)"

	data			Answers										
#	location	time	code	Current situation: (group into subgroups) (C)										
				Hygiene (H)										
				CH1	CH1.1	CH1.2	CH2	CH3	CH4	CH5	CH5.1	CH5.2	CH6	CH6.1
26	SB	10:00	B-01	GD[(1)]	AG[(3)]	YES	HOM	AG	DEC[(2)]	SHB[(4)]	YES	YES	AID[(5)]	SHA[(6)]
27	SB	10:15	B-02	DEC[(2)]	AG	YES	HOM	AG	DEC	SHB	YES	YES	AID	SHA
28	SB	10:30	B-03	DEC	AG	YES	HOM	AG	DEC	SHB	YES	YES	AID	SHA
29	SB	10:45	B-04	DEC	AG	YES	HOM	AG	DEC	SHB	YES	YES	AID	SHA
30	SB	11:00	B-05	GD	AG	YES	HOM	AG	DEC	SHB	YES	YES	AID	SHA
31	SB	11:15	B-06	GD	AG	YES	HOM	AG	DEC	SHB	YES	YES	AID	SHA
32	SB	11:30	B-07	GD	AG	YES	HOM	AG	DEC	SHB	YES	YES	AID	SHA
33	SB	11:45	B-08	GD	AG	YES	HOM	AG	DEC	SHB	YES	YES	AID	SHA
34	SB	12:00	B-09	DEC	AG	YES	HOM	AG	DEC	SHB	YES	YES	AID	SHA
35	SB	12:15	B-10	DEC	AG	YES	HOM	AG	DEC	SHB	YES	YES	AID	SHA
36	SB	13:00	B-11	DEC	AG	YES	HOM	AG	DEC	SHB	YES	YES	AID	SHA
37	SB	13:15	B-12	GD	AG	YES	AID	AG	DEC	SHB	YES	YES	AID	SHA
38	SB	13:30	B-13	GD	AG	YES	AID	AG	DEC	SHB	YES	YES	AID	SHA
39	SB	13:45	B-14	GD	AG	YES	AID	AG	DEC	SHB	YES	YES	AID	SHA
40	SB	14:00	B-15	GD	AG	YES	HOM	AG	DEC	SHB	YES	YES	AID	SHA
41	SB	14:15	B-16	GD	AG	YES	HOM	AG	DEC	SHB	YES	YES	AID	SHA
42	SB	14:30	B-17	GD	AG	YES	HOM	AG	DEC	SHB	YES	YES	AID	SHA
43	SB	14:45	B-18	GD	AG	YES	HOM	AG	DEC	SHB	YES	YES	AID	SHA
44	SB	15:00	B-19	DEC	AG	YES	HOM	AG	DEC	SHB	YES	YES	AID	SHA
45	SB	15:15	B-20	DEC	AG	YES	AID	AG	DEC	SHB	YES	YES	AID	SHA
46	SB	15:30	B-21	GD	AG	YES	HOM	AG	DEC	SHB	YES	YES	AID	SHA
47	SB	15:45	B-22	GD	AG	YES	HOM	AG	DEC	SHB	YES	YES	AID	SHA
48	SB	16:00	B-23	DEC	AG	YES	HOM	AG	DEC	SHB	YES	YES	AID	SHA
49	SB	16:15	B-24	DEC	AG	YES	AID	AG	DEC	SHB	YES	YES	AID	SHA
50	SB	16:30	B-25	GD	AG	YES	HOM	AG	DEC	SHB	YES	YES	AID	SHA

[(1)] Good [(2)] Decent [(3)] Agency guided [(4)] Shared Bath [(5)] Aids: Either used clothing or tools for knitting [(6)] Shared Areas

Table 8 Table showing collected data in settlement B for the questions of "Hygiene (CH)"

#	data			Answers									
	location	time	code	Current situation: (group into subgroups) (C)									
				Organization (O)									
				CO1	CO1.1	CO2	CO3	CO3.1	CO3.2	CO3.3	CO4	CO5	CO6
1	SA	10:00	A-01	GD[1]	YES	AID	WD[3]	GASOIL	NTHG[4]	BAS[5]	YES	AID	NP[6]
2	SA	10:15	A-02	GD	YES	AID	WD	GASOIL	NTHG	BAS	YES	AID	NP
3	SA	10:30	A-03	GD	YES	AID	WD	GASOIL	NTHG	BAS	YES	AID	NP
4	SA	10:45	A-04	GD	YES	AID	WD	GASOIL	NTHG	BAS	YES	AID	NP
5	SA	11:00	A-05	GD	NO	AID	WD	GASOIL	NTHG	BAS	YES	AID	NP
6	SA	11:15	A-06	GD	YES	AID	WD	GASOIL	NTHG	BAS	YES	AID	NP
7	SA	11:30	A-07	GD	YES	AID	WD	GASOIL	NTHG	BAS	YES	AID	NP
8	SA	11:45	A-08	GD	YES	AID	WD	GASOIL	NTHG	BAS	YES	AID	NP
9	SA	12:00	A-09	GD	YES	W[2]	WD	GASOIL	NTHG	BAS	YES	AID	NP
10	SA	12:15	A-10	GD	YES	AID	WD	GASOIL	NTHG	BAS	YES	AID	NP
11	SA	13:00	A-11	GD	NO	AID	WD	GASOIL	NTHG	BAS	YES	AID	NP
12	SA	13:15	A-12	GD	YES	AID	WD	GASOIL	NTHG	BAS	YES	AID	NP
13	SA	13:30	A-13	GD	NO	AID	WD	GASOIL	NTHG	BAS	YES	AID	NP
14	SA	13:45	A-14	GD	YES	W	WD	GASOIL	NTHG	BAS	YES	AID	NP
15	SA	14:00	A-15	GD	NO	AID	WD	GASOIL	NTHG	BAS	YES	AID	NP
16	SA	14:15	A-16	GD	YES	AID	WD	GASOIL	NTHG	BAS	YES	AID	NP
17	SA	14:30	A-17	GD	NO	AID	WD	GASOIL	NTHG	BAS	YES	AID	NP
18	SA	14:45	A-18	GD	YES	AID	WD	GASOIL	NTHG	BAS	YES	AID	NP
19	SA	15:00	A-19	GD	NO	AID	WD	GASOIL	NTHG	BAS	YES	AID	NP
20	SA	15:15	A-20	GD	YES	AID	WD	GASOIL	NTHG	BAS	YES	AID	NP
21	SA	15:30	A-21	GD	YES	W	WD	GASOIL	NTHG	BAS	YES	AID	NP
22	SA	15:45	A-22	GD	YES	W	WD	GASOIL	NTHG	BAS	YES	AID	NP
23	SA	16:00	A-23	GD	YES	W W	WD	GASOIL	NTHG	BAS	YES	AID	NP
24	SA	16:15	A-24	GD	YES	AID	WD	GASOIL	NTHG	BAS	YES	AID	NP
25	SA	16:30	A-25	GD	YES	AID	WD	GASOIL	NTHG	BAS	YES	AID	NP

(1) Good (2) Work (3) Winter is very difficult (4) Nothing (5) Basic (6) No preferences

Table 9 Table showing collected data in settlement A for the questions of "Organization (CO)"

#	data			Answers									
				Current situation: (group into subgroups) (C)									
				Organization (O)									
	location	time	code	CO1	CO1.1	CO2	CO3	CO3.1	CO3.2	CO3.3	CO4	CO5	CO6
26	SB	10:00	B-01	GD[1]	YES	AID	WD[3]	GASOIL	NTHG[4]	BAS[5]	YES	AG	NP[6]
27	SB	10:15	B-02	GD	YES	AID	WD	GASOIL	NTHG	BAS	YES	AID	NP
28	SB	10:30	B-03	GD	YES	AID	WD	GASOIL	NTHG	BAS	YES	AID	NP
29	SB	10:45	B-04	GD	YES	W[2]	WD	GASOIL	NTHG	BAS	YES	AID	NP
30	SB	11:00	B-05	GD	YES	AID	WD	GASOIL	NTHG	BAS	YES	AID	NP
31	SB	11:15	B-06	GD	YES	AID	WD	GASOIL	NTHG	BAS	YES	AID	NP
32	SB	11:30	B-07	GD	YES	AID	WD	GASOIL	NTHG	BAS	YES	AID	NP
33	SB	11:45	B-08	GD	YES	AID	WD	GASOIL	NTHG	BAS	YES	AID	NP
34	SB	12:00	B-09	GD	YES	AID	WD	GASOIL	NTHG	BAS	YES	AID	NP
35	SB	12:15	B-10	GD	NO	AID	WD	GASOIL	NTHG	BAS	YES	AID	NP
36	SB	13:00	B-11	GD	NO	AID	WD	GASOIL	NTHG	BAS	YES	AID	NP
37	SB	13:15	B-12	GD	NO	AID	WD	GASOIL	NTHG	BAS	YES	AID	NP
38	SB	13:30	B-13	GD	YES	AID	WD	GASOIL	NTHG	BAS	YES	AID	NP
39	SB	13:45	B-14	GD	YES	W	WD	GASOIL	NTHG	BAS	YES	AID	NP
40	SB	14:00	B-15	GD	YES	AID	WD	GASOIL	NTHG	BAS	YES	AID	NP
41	SB	14:15	B-16	GD	YES	AID	WD	GASOIL	NTHG	BAS	YES	AID	NP
42	SB	14:30	B-17	GD	YES	AID	WD	GASOIL	NTHG	BAS	YES	AID	NP
43	SB	14:45	B-18	GD	YES	AID	WD	GASOIL	NTHG	BAS	YES	AID	NP
44	SB	15:00	B-19	GD	YES	AID	WD	GASOIL	NTHG	BAS	YES	AID	NP
45	SB	15:15	B-20	GD	YES	AID	WD	GASOIL	NTHG	BAS	YES	AID	NP
46	SB	15:30	B-21	GD	YES	AID	WD	GASOIL	NTHG	BAS	YES	AID	NP
47	SB	15:45	B-22	GD	YES	AID	WD	GASOIL	NTHG	BAS	YES	AID	NP
48	SB	16:00	B-23	GD	NO	AID	WD	GASOIL	NTHG	BAS	YES	AID	NP
49	SB	16:15	B-24	GD	YES	AID	WD	GASOIL	NTHG	BAS	YES	AID	NP
50	SB	16:30	B-25	GD	YES	AID	WD	GASOIL	NTHG	BAS	YES	AID	NP

[1] Good [2] Work [3] Winter is very difficult [4] Nothing [5] Basic [6] No preferences

Table 10 Table showing collected data in settlement B for the questions of "Organization (CO)"

#	data			Answers									
				Current situation: (group into subgroups) (C)									
				Social life (S)									
	location	time	code	CS1	CS1.1	CS1.2	CS2[7]	CS3[8]	CS3.1	CS3.2	CS4[9]	CS4.1	CS5
1	SA	10:00	A-01	FAM[1]	BAS[6]	YES	YES	NO	NO	NO	LOW	LOW	BAS
2	SA	10:15	A-02	FAM	BAS	YES	YES	NO	NO	NO	LOW	LOW	BAS
3	SA	10:30	A-03	NEWS[2]	BAS	YES	YES	NO	NO	NO	LOW	LOW	BAS
4	SA	10:45	A-04	NEWS	BAS	YES	YES	NO	NO	NO	LOW	LOW	BAS
5	SA	11:00	A-05	NTHG[4]	BAS	NO	YES	NO	NO	NO	LOW	LOW	BAS
6	SA	11:15	A-06	NTHG	BAS	YES	YES	NO	NO	NO	LOW	LOW	BAS
7	SA	11:30	A-07	NEWS	BAS	YES	YES	NO	NO	NO	LOW	LOW	BAS
8	SA	11:45	A-08	HO[3]	BAS	YES	YES	NO	NO	NO	LOW	LOW	BAS
9	SA	12:00	A-09	HO	BAS	NO	YES	NO	NO	NO	LOW	LOW	BAS
10	SA	12:15	A-10	HO	BAS	YES	YES	NO	NO	NO	LOW	LOW	BAS
11	SA	13:00	A-11	ST[5]	BAS	YES	YES	NO	NO	NO	LOW	LOW	BAS
12	SA	13:15	A-12	ST	BAS	YES	YES	NO	NO	NO	LOW	LOW	BAS
13	SA	13:30	A-13	ST	BAS	YES	YES	NO	NO	NO	LOW	LOW	BAS
14	SA	13:45	A-14	ST	BAS	NO	YES	NO	NO	NO	LOW	LOW	BAS
15	SA	14:00	A-15	ST	BAS	NO	YES	NO	NO	NO	LOW	LOW	BAS
16	SA	14:15	A-16	ST	BAS	NO	YES	NO	NO	NO	LOW	LOW	BAS
17	SA	14:30	A-17	ST	BAS	YES	YES	NO	NO	NO	LOW	LOW	BAS
18	SA	14:45	A-18	HO	BAS	YES	YES	NO	NO	NO	LOW	LOW	BAS
19	SA	15:00	A-19	HO	BAS	YES	YES	NO	NO	NO	LOW	LOW	BAS
20	SA	15:15	A-20	HO	BAS	YES	YES	NO	YES	NO	LOW	LOW	BAS
21	SA	15:30	A-21	HO	BAS	YES	YES	NO	NO	NO	LOW	LOW	BAS
22	SA	15:45	A-22	HO	BAS	YES	YES	NO	NO	NO	LOW	LOW	BAS
23	SA	16:00	A-23	HO	BAS	YES	YES	NO	NO	NO	LOW	LOW	BAS
24	SA	16:15	A-24	HO	BAS	NO	YES	NO	YES	NO	LOW	LOW	BAS
25	SA	16:30	A-25	HO	BAS	NO	YES	NO	NO	NO	LOW	LOW	BAS

[1] Spend time with family [2] Listen the news [3] Help out in the settlements [4] Nothing [5] Study [6] Basic [7] In an attempt for moral boost from the agencies [8] All refugees from same religion [9] People are closed

Table 11 Table showing collected data in settlement A for the questions of " Social life (CS)"

	data			Answers									
				Current situation: (group into subgroups) (C)									
				Social life (S)									
#	location	time	code	CS1	CS1.1	CS1.2	CS2[7]	CS3[8]	CS3.1	CS3.2	CS4[9]	CS4.1	CS5
26	SB	10:00	B-01	HO[3]	BAS[6]	YES	YES	NO	NO	NO	LOW	LOW	BAS
27	SB	10:15	B-02	HO	BAS	YES	YES	NO	NO	NO	LOW	LOW	BAS
28	SB	10:30	B-03	HO	BAS	YES	YES	NO	NO	NO	LOW	LOW	BAS
29	SB	10:45	B-04	HO	BAS	YES	YES	NO	NO	NO	LOW	LOW	BAS
30	SB	11:00	B-05	HO	BAS	YES	YES	NO	NO	NO	LOW	LOW	BAS
31	SB	11:15	B-06	NTHG[4]	BAS	YES	YES	NO	NO	NO	LOW	LOW	BAS
32	SB	11:30	B-07	NTHG	BAS	YES	YES	NO	NO	NO	LOW	LOW	BAS
33	SB	11:45	B-08	NTHG	BAS	YES	YES	NO	YES	NO	LOW	LOW	BAS
34	SB	12:00	B-09	NTHG	BAS	YES	YES	NO	NO	NO	LOW	LOW	BAS
35	SB	12:15	B-10	FAM[1]	BAS	YES	YES	NO	NO	NO	LOW	LOW	BAS
36	SB	13:00	B-11	FAM	BAS	YES	YES	NO	NO	NO	LOW	LOW	BAS
37	SB	13:15	B-12	NTHG	BAS	YES	YES	NO	NO	NO	LOW	LOW	BAS
38	SB	13:30	B-13	FAM	BAS	YES	YES	NO	NO	NO	LOW	LOW	BAS
39	SB	13:45	B-14	FAM	BAS	YES	YES	NO	NO	NO	LOW	LOW	BAS
40	SB	14:00	B-15	NTHG	BAS	YES	YES	NO	NO	NO	LOW	LOW	BAS
41	SB	14:15	B-16	NTHG	BAS	YES	YES	NO	NO	NO	LOW	LOW	BAS
42	SB	14:30	B-17	NTHG	BAS	YES	YES	NO	NO	NO	LOW	LOW	BAS
43	SB	14:45	B-18	NEWS[2]	BAS	YES	YES	NO	NO	NO	LOW	LOW	BAS
44	SB	15:00	B-19	NEWS	BAS	YES	YES	NO	NO	NO	LOW	LOW	BAS
45	SB	15:15	B-20	FAM	BAS	YES	YES	NO	NO	NO	LOW	LOW	BAS
46	SB	15:30	B-21	NEWS	BAS	YES	YES	NO	NO	NO	LOW	LOW	BAS
47	SB	15:45	B-22	FAM	BAS	YES	YES	NO	NO	NO	LOW	LOW	BAS
48	SB	16:00	B-23	NEWS	BAS	YES	YES	NO	NO	NO	LOW	LOW	BAS
49	SB	16:15	B-24	NTHG	BAS	YES	YES	NO	NO	NO	LOW	LOW	BAS
50	SB	16:30	B-25	NTHG	BAS	YES	YES	NO	NO	NO	LOW	LOW	BAS

(1) Spend time with family (2) Listen the news (3) Help out in the settlements (4) Nothing (5) Study (6) Basic (7) In an attempt for moral boost from the agencies (8) All refugees from same religion (9) People are closed

Table 12 Table showing collected data in settlement B for the questions of "Social life (CS)"

#	data			Answers				
	location	time	code	Current situation: (group into subgroups) (C)				
				Education (E)				
				CE1	CE2	CE3	CE3.1	CE3.2
1	SA	10:00	A-01	NO	YES	SSB[(1)]	YES	YES
2	SA	10:15	A-02	NO	YES	SSB	YES	YES
3	SA	10:30	A-03	NO	YES	SSB	YES	YES
4	SA	10:45	A-04	NO	YES	SSB	YES	YES
5	SA	11:00	A-05	NO	YES	SSB	YES	YES
6	SA	11:15	A-06	NO	YES	SSB	YES	YES
7	SA	11:30	A-07	NO	YES	SSB	YES	YES
8	SA	11:45	A-08	NO	YES	SSB	YES	YES
9	SA	12:00	A-09	NO	YES	SSB	YES	YES
10	SA	12:15	A-10	NO	YES	SSB	YES	YES
11	SA	13:00	A-11	YES	YES	SSB	YES	YES
12	SA	13:15	A-12	YES	YES	SSB	YES	YES
13	SA	13:30	A-13	YES	YES	SSB	YES	YES
14	SA	13:45	A-14	YES	YES	SSB	YES	YES
15	SA	14:00	A-15	YES	YES	SSB	YES	YES
16	SA	14:15	A-16	YES	YES	SSB	YES	YES
17	SA	14:30	A-17	YES	YES	SSB	YES	YES
18	SA	14:45	A-18	NO	YES	SSB	YES	YES
19	SA	15:00	A-19	NO	YES	SSB	YES	YES
20	SA	15:15	A-20	NO	YES	SSB	YES	YES
21	SA	15:30	A-21	NO	YES	SSB	YES	YES
22	SA	15:45	A-22	NO	YES	SSB	YES	YES
23	SA	16:00	A-23	NO	YES	SSB	YES	YES
24	SA	16:15	A-24	NO	YES	SSB	YES	YES
25	SA	16:30	A-25	NO	YES	SSB	YES	YES

[(1)] Sub-Standard buildings [(2)] Only in non-conflict areas

Table 13 Table showing collected data in settlement A for the questions of "Education (CE)"

#	data			Answers				
	location	time	code	Current situation: (group into subgroups) (C)				
				Education (E)				
				CE1	CE2	CE3	CE3.1	CE3.2[2]
26	SB	10:00	B-01	NO	NO	SSB[1]	YES	YES
27	SB	10:15	B-02	NO	NO	SSB	YES	YES
28	SB	10:30	B-03	NO	NO	SSB	YES	YES
29	SB	10:45	B-04	NO	NO	SSB	YES	YES
30	SB	11:00	B-05	NO	NO	SSB	YES	YES
31	SB	11:15	B-06	NO	NO	SSB	YES	YES
32	SB	11:30	B-07	NO	NO	SSB	YES	YES
33	SB	11:45	B-08	NO	NO	SSB	YES	YES
34	SB	12:00	B-09	NO	NO	SSB	YES	YES
35	SB	12:15	B-10	NO	NO	SSB	YES	YES
36	SB	13:00	B-11	NO	NO	SSB	YES	YES
37	SB	13:15	B-12	NO	NO	SSB	YES	YES
38	SB	13:30	B-13	NO	NO	SSB	YES	YES
39	SB	13:45	B-14	NO	NO	SSB	YES	YES
40	SB	14:00	B-15	NO	NO	SSB	YES	YES
41	SB	14:15	B-16	NO	NO	SSB	YES	YES
42	SB	14:30	B-17	NO	NO	SSB	YES	YES
43	SB	14:45	B-18	NO	NO	SSB	YES	YES
44	SB	15:00	B-19	NO	NO	SSB	YES	YES
45	SB	15:15	B-20	NO	NO	SSB	YES	YES
46	SB	15:30	B-21	NO	NO	SSB	YES	YES
47	SB	15:45	B-22	NO	NO	SSB	YES	YES
48	SB	16:00	B-23	NO	NO	SSB	YES	YES
49	SB	16:15	B-24	NO	NO	SSB	YES	YES
50	SB	16:30	B-25	NO	NO	SSB	YES	YES

(1) Sub-Standard buildings (2) Only in non-conflict areas

Table 14 Table showing collected data in settlement B for the questions of "Education (CE)"

#	data			Answers						
	location	time	code	Current situation: (group into subgroups) (C)						
				Work (W)						
				CW1	CW1.1	CW1.2	CW2	CW2.1	CW3	CW3.1
1	SA	10:00	A-01	NO	NO	LH[2]	YES	DNA	ASAP[4]	NO
2	SA	10:15	A-02	NO	NO	LH	YES	DNA	ASAP	NO
3	SA	10:30	A-03	NO	NO	LH	YES	DNA	ASAP	NO
4	SA	10:45	A-04	NO	NO	LH	YES	DNA	ASAP	NO
5	SA	11:00	A-05	NO	NO	LH	NO	DIG[3]	ASAP	NO
6	SA	11:15	A-06	NO	NO	LH	NO	DIG	ASAP	NO
7	SA	11:30	A-07	NO	NO	LH	NO	DIG	ASAP	NO
8	SA	11:45	A-08	NO	NO	LH	YES	DNA	ASAP	NO
9	SA	12:00	A-09	NO	YES	DNA[1]	YES	DNA	ASAP	NO
10	SA	12:15	A-10	NO	NO	LH	YES	DNA	ASAP	NO
11	SA	13:00	A-11	NO	NO	LH	YES	DNA	ASAP	NO
12	SA	13:15	A-12	NO	NO	LH	YES	DNA	ASAP	NO
13	SA	13:30	A-13	NO	NO	LH	YES	DNA	ASAP	NO
14	SA	13:45	A-14	NO	YES	DNA	YES	DNA	ASAP	NO
15	SA	14:00	A-15	NO	NO	LH	YES	DNA	ASAP	NO
16	SA	14:15	A-16	NO	NO	LH	NO	DIG	ASAP	NO
17	SA	14:30	A-17	NO	NO	LH	YES	DNA	ASAP	NO
18	SA	14:45	A-18	NO	NO	LH	YES	DNA	ASAP	NO
19	SA	15:00	A-19	NO	NO	LH	NO	DIG	ASAP	NO
20	SA	15:15	A-20	NO	NO	LH	YES	DNA	ASAP	NO
21	SA	15:30	A-21	NO	YES	DNA	YES	DNA	ASAP	NO
22	SA	15:45	A-22	NO	YES	DNA	YES	DNA	ASAP	NO
23	SA	16:00	A-23	NO	YES	DNA	YES	DNA	ASAP	NO
24	SA	16:15	A-24	NO	NO	LH	YES	DNA	ASAP	NO
25	SA	16:30	A-25	NO	NO	LH	YES	DNA	ASAP	NO

(1) Does not apply (2) Lost Interest (3) Dignity (4) As soon as possible

Table 15 Table showing collected data in settlement A for the questions of "Work (CW)"

#	data			Answers						
	location	time	code	Current situation: (group into subgroups) (C)						
				Work (W)						
				CW1	CW1.1	CW1.2	CW2	CW2.1	CW3	CW3.1
26	SB	10:00	B-01	NO	NO	LH[2]	YES	DNA	ASAP[4]	NO
27	SB	10:15	B-02	NO	NO	LH	YES	DNA	ASAP	NO
28	SB	10:30	B-03	NO	NO	LH	NO	DIG[3]	ASAP	NO
29	SB	10:45	B-04	NO	YES	DNA[1]	YES	DNA	ASAP	NO
30	SB	11:00	B-05	NO	NO	LH	YES	DNA	ASAP	NO
31	SB	11:15	B-06	NO	NO	LH	YES	DNA	ASAP	NO
32	SB	11:30	B-07	NO	NO	LH	YES	DNA	ASAP	NO
33	SB	11:45	B-08	NO	NO	LH	YES	DNA	ASAP	NO
34	SB	12:00	B-09	NO	NO	LH	YES	DNA	ASAP	NO
35	SB	12:15	B-10	NO	NO	LH	YES	DNA	ASAP	NO
36	SB	13:00	B-11	NO	NO	LH	YES	DNA	ASAP	NO
37	SB	13:15	B-12	NO	NO	LH	NO	DIG	ASAP	NO
38	SB	13:30	B-13	NO	NO	LH	NO	DIG	ASAP	NO
39	SB	13:45	B-14	NO	YES	DNA	YES	DNA	ASAP	NO
40	SB	14:00	B-15	NO	NO	LH	YES	DNA	ASAP	NO
41	SB	14:15	B-16	NO	NO	LH	YES	DNA	ASAP	NO
42	SB	14:30	B-17	NO	NO	LH	YES	DNA	ASAP	NO
43	SB	14:45	B-18	NO	NO	LH	YES	DNA	ASAP	NO
44	SB	15:00	B-19	NO	NO	LH	YES	DNA	ASAP	NO
45	SB	15:15	B-20	NO	NO	LH	NO	DIG	ASAP	NO
46	SB	15:30	B-21	NO	NO	LH	NO	DIG	ASAP	NO
47	SB	15:45	B-22	NO	NO	LH	NO	DIG	ASAP	NO
48	SB	16:00	B-23	NO	NO	LH	NO	DIG	ASAP	NO
49	SB	16:15	B-24	NO	NO	LH	NO	DIG	ASAP	NO
50	SB	16:30	B-25	NO	NO	LH	NO	DIG	ASAP	NO

(1) Does not apply (2) Lost Interest (3) Dignity (4) As soon as possible

Table 16 Table showing collected data in settlement B for the questions of "Work (CW)"

#	data			Answers		
	location	time	code	Current situation: (group into subgroups) (C)		
				Volunteering (V)		
				CV1	CV1.1	CV2[(2)]
1	SA	10:00	A-01	YES	DNA[(1)]	YES
2	SA	10:15	A-02	YES	DNA	YES
3	SA	10:30	A-03	YES	DNA	YES
4	SA	10:45	A-04	YES	DNA	YES
5	SA	11:00	A-05	YES	DNA	YES
6	SA	11:15	A-06	YES	DNA	YES
7	SA	11:30	A-07	YES	DNA	YES
8	SA	11:45	A-08	YES	DNA	YES
9	SA	12:00	A-09	YES	DNA	YES
10	SA	12:15	A-10	YES	DNA	YES
11	SA	13:00	A-11	YES	DNA	YES
12	SA	13:15	A-12	YES	DNA	YES
13	SA	13:30	A-13	YES	DNA	YES
14	SA	13:45	A-14	YES	DNA	YES
15	SA	14:00	A-15	YES	DNA	YES
16	SA	14:15	A-16	YES	DNA	YES
17	SA	14:30	A-17	YES	DNA	YES
18	SA	14:45	A-18	YES	DNA	YES
19	SA	15:00	A-19	YES	DNA	YES
20	SA	15:15	A-20	YES	DNA	YES
21	SA	15:30	A-21	YES	DNA	YES
22	SA	15:45	A-22	YES	DNA	YES
23	SA	16:00	A-23	YES	DNA	YES
24	SA	16:15	A-24	YES	DNA	YES
25	SA	16:30	A-25	YES	DNA	YES

(1) Does not apply (2) People help to fill up their time and feel useful

Table 17 Table showing collected data in settlement A for the questions of "Volunteering (CV)"

#	data			Answers		
	location	time	code	Current situation: (group into subgroups) (C)		
				Volunteering (V)		
				CV1	CV1.1	CV2[2]
26	SB	10:00	B-01	YES	DNA[1]	YES
27	SB	10:15	B-02	YES	DNA	YES
28	SB	10:30	B-03	YES	DNA	YES
29	SB	10:45	B-04	YES	DNA	YES
30	SB	11:00	B-05	YES	DNA	YES
31	SB	11:15	B-06	YES	DNA	YES
32	SB	11:30	B-07	YES	DNA	YES
33	SB	11:45	B-08	YES	DNA	YES
34	SB	12:00	B-09	YES	DNA	YES
35	SB	12:15	B-10	YES	DNA	YES
36	SB	13:00	B-11	YES	DNA	YES
37	SB	13:15	B-12	YES	DNA	YES
38	SB	13:30	B-13	YES	DNA	YES
39	SB	13:45	B-14	YES	DNA	YES
40	SB	14:00	B-15	YES	DNA	YES
41	SB	14:15	B-16	YES	DNA	YES
42	SB	14:30	B-17	YES	DNA	YES
43	SB	14:45	B-18	YES	DNA	YES
44	SB	15:00	B-19	YES	DNA	YES
45	SB	15:15	B-20	YES	DNA	YES
46	SB	15:30	B-21	YES	DNA	YES
47	SB	15:45	B-22	YES	DNA	YES
48	SB	16:00	B-23	YES	DNA	YES
49	SB	16:15	B-24	YES	DNA	YES
50	SB	16:30	B-25	YES	DNA	YES

[1] Does not apply [2] People help to fill up their time and feel useful

Table 18 Table showing collected data in settlement B for the questions of "Volunteering (CV)"

#	data			Answers					
	location	time	code	Current situation: (group into subgroups) (C)					
				Safety (SA)					
				CSA1	CSA1.1	CSA2	CSA2.1	CSA2.2	CSA2.3
1	SA	10:00	A-01	YES	DNA[1]	SIC[2]	YES	OCC[3]	VS[4]
2	SA	10:15	A-02	YES	DNA	SIC	YES	OCC	VS
3	SA	10:30	A-03	YES	DNA	SIC	YES	OCC	VS
4	SA	10:45	A-04	YES	DNA	SIC	YES	OCC	VS
5	SA	11:00	A-05	YES	DNA	SIC	YES	OCC	VS
6	SA	11:15	A-06	YES	DNA	SIC	YES	OCC	VS
7	SA	11:30	A-07	YES	DNA	SIC	YES	OCC	VS
8	SA	11:45	A-08	YES	DNA	SIC	YES	OCC	VS
9	SA	12:00	A-09	YES	DNA	SIC	YES	OCC	VS
10	SA	12:15	A-10	YES	DNA	SIC	YES	OCC	VS
11	SA	13:00	A-11	YES	DNA	SIC	YES	OCC	VS
12	SA	13:15	A-12	YES	DNA	SIC	YES	OCC	VS
13	SA	13:30	A-13	YES	DNA	SIC	YES	OCC	VS
14	SA	13:45	A-14	YES	DNA	SIC	YES	OCC	VS
15	SA	14:00	A-15	YES	DNA	SIC	YES	OCC	VS
16	SA	14:15	A-16	YES	DNA	SIC	YES	OCC	VS
17	SA	14:30	A-17	YES	DNA	SIC	YES	OCC	VS
18	SA	14:45	A-18	YES	DNA	SIC	YES	OCC	VS
19	SA	15:00	A-19	YES	DNA	SIC	YES	OCC	VS
20	SA	15:15	A-20	YES	DNA	SIC	YES	OCC	VS
21	SA	15:30	A-21	YES	DNA	SIC	YES	OCC	VS
22	SA	15:45	A-22	YES	DNA	SIC	YES	OCC	VS
23	SA	16:00	A-23	YES	DNA	SIC	YES	OCC	VS
24	SA	16:15	A-24	YES	DNA	SIC	YES	OCC	VS
25	SA	16:30	A-25	YES	DNA	SIC	YES	OCC	VS

(1) Does not apply (2) Some internal conflicts (3) Occasionally (4) Very safe since distant from society

Table 19 Table showing collected data in settlement A for the questions of "Safety (CSA)"

#	data			Answers					
	location	time	code	Current situation: (group into subgroups) (C)					
				Safety (SA)					
				CSA1	CSA1.1	CSA2	CSA2.1	CSA2.2	CSA2.3
26	SB	10:00	B-01	YES	DNA(1)	SIC(2)	NO	OCC(3)	VS(4)
27	SB	10:15	B-02	YES	DNA	SIC	NO	OCC	VS
28	SB	10:30	B-03	YES	DNA	SIC	NO	OCC	VS
29	SB	10:45	B-04	YES	DNA	SIC	NO	OCC	VS
30	SB	11:00	B-05	YES	DNA	SIC	NO	OCC	VS
31	SB	11:15	B-06	YES	DNA	SIC	NO	OCC	VS
32	SB	11:30	B-07	YES	DNA	SIC	NO	OCC	VS
33	SB	11:45	B-08	YES	DNA	SIC	NO	OCC	VS
34	SB	12:00	B-09	YES	DNA	SIC	NO	OCC	VS
35	SB	12:15	B-10	YES	DNA	SIC	NO	OCC	VS
36	SB	13:00	B-11	YES	DNA	SIC	NO	OCC	VS
37	SB	13:15	B-12	YES	DNA	SIC	NO	OCC	VS
38	SB	13:30	B-13	YES	DNA	SIC	NO	OCC	VS
39	SB	13:45	B-14	YES	DNA	SIC	NO	OCC	VS
40	SB	14:00	B-15	YES	DNA	SIC	NO	OCC	VS
41	SB	14:15	B-16	YES	DNA	SIC	NO	OCC	VS
42	SB	14:30	B-17	YES	DNA	SIC	NO	OCC	VS
43	SB	14:45	B-18	YES	DNA	SIC	NO	OCC	VS
44	SB	15:00	B-19	YES	DNA	SIC	NO	OCC	VS
45	SB	15:15	B-20	YES	DNA	SIC	NO	OCC	VS
46	SB	15:30	B-21	YES	DNA	SIC	NO	OCC	VS
47	SB	15:45	B-22	YES	DNA	SIC	NO	OCC	VS
48	SB	16:00	B-23	YES	DNA	SIC	NO	OCC	VS
49	SB	16:15	B-24	YES	DNA	SIC	NO	OCC	VS
50	SB	16:30	B-25	YES	DNA	SIC	NO	OCC	VS

(1) Does not apply (2) Some internal conflicts (3) Occasionally (4) Very safe since distant from society

Table 20 Table showing collected data in settlement B for the questions of "Safety (CSA)"

	data			Answers				
				Current situation: (group into subgroups) (C)				
				Personal Evaluation (P)				
#	location	time	code	CP1	CP2	CP2.1	CP3	CP4
1	SA	10:00	A-01	VG[1]	YES	EUR[2]	TEMP[3]	AOH[4]
2	SA	10:15	A-02	VG	YES	EUR	TEMP	AOH
3	SA	10:30	A-03	VG	YES	EUR	TEMP	AOH
4	SA	10:45	A-04	VG	YES	EUR	TEMP	AOH
5	SA	11:00	A-05	VG	NO	EUR	TEMP	AOH
6	SA	11:15	A-06	VG	YES	EUR	TEMP	AOH
7	SA	11:30	A-07	VG	YES	EUR	TEMP	AOH
8	SA	11:45	A-08	VG	YES	EUR	TEMP	AOH
9	SA	12:00	A-09	VG	YES	EUR	TEMP	AOH
10	SA	12:15	A-10	VG	YES	EUR	TEMP	AOH
11	SA	13:00	A-11	VG	YES	EUR	TEMP	AOH
12	SA	13:15	A-12	VG	YES	EUR	TEMP	AOH
13	SA	13:30	A-13	VG	NO	EUR	TEMP	AOH
14	SA	13:45	A-14	VG	NO	EUR	TEMP	AOH
15	SA	14:00	A-15	VG	NO	EUR	TEMP	AOH
16	SA	14:15	A-16	VG	YES	EUR	TEMP	AOH
17	SA	14:30	A-17	VG	YES	EUR	TEMP	AOH
18	SA	14:45	A-18	VG	YES	EUR	TEMP	AOH
19	SA	15:00	A-19	VG	YES	EUR	TEMP	AOH
20	SA	15:15	A-20	VG	YES	EUR	TEMP	AOH
21	SA	15:30	A-21	VG	YES	EUR	TEMP	AOH
22	SA	15:45	A-22	VG	YES	EUR	TEMP	AOH
23	SA	16:00	A-23	VG	YES	EUR	TEMP	AOH
24	SA	16:15	A-24	VG	YES	EUR	TEMP	AOH
25	SA	16:30	A-25	VG	NO	EUR	TEMP	AOH

(1) Very good when compared locally and very bad when compared to Europe (2) Europe (3) Temporary (4) Appreciation of the way things were back home

Table 21 Table showing collected data in settlement A for the questions of "Personal Evaluation (CP)"

#	data			Answers				
				Current situation: (group into subgroups) (C)				
				Personal Evaluation (P)				
	location	time	code	CP1	CP2	CP2.1	CP3	CP4
26	SB	10:00	B-01	VG(1)	NO	EUR(2)	TEMP(3)	AOH(4)
27	SB	10:15	B-02	VG	NO	EUR	TEMP	AOH
28	SB	10:30	B-03	VG	NO	EUR	TEMP	AOH
29	SB	10:45	B-04	VG	YES	EUR	TEMP	AOH
30	SB	11:00	B-05	VG	YES	EUR	TEMP	AOH
31	SB	11:15	B-06	VG	YES	EUR	TEMP	AOH
32	SB	11:30	B-07	VG	YES	EUR	TEMP	AOH
33	SB	11:45	B-08	VG	YES	EUR	TEMP	AOH
34	SB	12:00	B-09	VG	YES	EUR	TEMP	AOH
35	SB	12:15	B-10	VG	YES	EUR	TEMP	AOH
36	SB	13:00	B-11	VG	YES	EUR	TEMP	AOH
37	SB	13:15	B-12	VG	YES	EUR	TEMP	AOH
38	SB	13:30	B-13	VG	YES	EUR	TEMP	AOH
39	SB	13:45	B-14	VG	YES	EUR	TEMP	AOH
40	SB	14:00	B-15	VG	YES	EUR	TEMP	AOH
41	SB	14:15	B-16	VG	YES	EUR	TEMP	AOH
42	SB	14:30	B-17	VG	YES	EUR	TEMP	AOH
43	SB	14:45	B-18	VG	YES	EUR	TEMP	AOH
44	SB	15:00	B-19	VG	NO	EUR	TEMP	AOH
45	SB	15:15	B-20	VG	NO	EUR	TEMP	AOH
46	SB	15:30	B-21	VG	YES	EUR	TEMP	AOH
47	SB	15:45	B-22	VG	YES	EUR	TEMP	AOH
48	SB	16:00	B-23	VG	YES	EUR	TEMP	AOH
49	SB	16:15	B-24	VG	YES	EUR	TEMP	AOH
50	SB	16:30	B-25	VG	YES	EUR	TEMP	AOH

(1) Very good when compared locally and very bad when compared to Europe (2) Europe (3) Temporary (4) Appreciation of the way things were back home

Table 22 Table showing collected data in settlement B for the questions of "Personal Evaluation (CP)"

#	data			Answers			
	location	time	code	Current situation: (group into subgroups) (C)			
				What is lacking in the Settlement? (Wh)			
				W1	W1.1	W1.2	W2
1	SA	10:00	A-01	FUND(1)	MS(3)	CA(5)	CA
2	SA	10:15	A-02	FUND	MS	CA	CA
3	SA	10:30	A-03	FUND	MS	CA	CA
4	SA	10:45	A-04	FUND	NTHG(2)	CA	CA
5	SA	11:00	A-05	FUND	NTHG	CA	CA
6	SA	11:15	A-06	FUND	NTHG	CA	CA
7	SA	11:30	A-07	FUND	NTHG	CA	CA
8	SA	11:45	A-08	FUND	NTHG	CA	CA
9	SA	12:00	A-09	FUND	NTHG	CA	CA
10	SA	12:15	A-10	FUND	MS	CA	CA
11	SA	13:00	A-11	FUND	MS	CA	CA
12	SA	13:15	A-12	FUND	WC(4)	CA	CA
13	SA	13:30	A-13	FUND	WC	CA	CA
14	SA	13:45	A-14	FUND	WC	CA	CA
15	SA	14:00	A-15	FUND	WC	CA	CA
16	SA	14:15	A-16	FUND	MS	CA	CA
17	SA	14:30	A-17	FUND	MS	CA	CA
18	SA	14:45	A-18	FUND	MS	CA	CA
19	SA	15:00	A-19	FUND	MS	CA	CA
20	SA	15:15	A-20	FUND	MS	CA	CA
21	SA	15:30	A-21	FUND	NTHG	CA	CA
22	SA	15:45	A-22	FUND	NTHG	CA	CA
23	SA	16:00	A-23	FUND	NTHG	CA	CA
24	SA	16:15	A-24	FUND	NTHG	CA	CA
25	SA	16:30	A-25	FUND	NTHG	CA	CA

(1) Funding (2) Nothing (3) More Space (4) Better shower and wc conditions (5) Common area (6) Lights

Table 23 Table showing collected data in settlement A for the questions of "What is lacking in the Settlement? (CWh)''

#	data			Answers			
	location	time	code	Current situation: (group into subgroups) (C)			
				What is lacking in the Settlement? (Wh)			
				W1	W1.1	W1.2	W2
26	SB	10:00	B-01	FUND[1]	MS[3]	CA[5]	CA
27	SB	10:15	B-02	FUND	MS	CA, LI[6]	CA
28	SB	10:30	B-03	FUND	MS	CA, LI	CA
29	SB	10:45	B-04	FUND	MS	CA, LI	CA
30	SB	11:00	B-05	FUND	MS	CA, LI	CA
31	SB	11:15	B-06	FUND	MS	CA, LI	CA
32	SB	11:30	B-07	FUND	NTHG[2]	CA, LI	CA
33	SB	11:45	B-08	FUND	NTHG	CA, LI	CA
34	SB	12:00	B-09	FUND	NTHG	CA, LI	CA
35	SB	12:15	B-10	FUND	NTHG	CA, LI	CA
36	SB	13:00	B-11	FUND	NTHG	CA, LI	CA
37	SB	13:15	B-12	FUND	NTHG	CA, LI	CA
38	SB	13:30	B-13	FUND	NTHG	CA, LI	CA
39	SB	13:45	B-14	FUND	MS	CA, LI	CA
40	SB	14:00	B-15	FUND	MS	CA, LI	CA
41	SB	14:15	B-16	FUND	WC[4]	CA, LI	CA
42	SB	14:30	B-17	FUND	WC	CA, LI	CA
43	SB	14:45	B-18	FUND	MS	CA, LI	CA
44	SB	15:00	B-19	FUND	MS	CA, LI	CA
45	SB	15:15	B-20	FUND	MS	CA, LI	CA
46	SB	15:30	B-21	FUND	MS	CA, LI	CA
47	SB	15:45	B-22	FUND	MS	CA, LI	CA
48	SB	16:00	B-23	FUND	MS	CA, LI	CA
49	SB	16:15	B-24	FUND	NTHG	CA, LI	CA
50	SB	16:30	B-25	FUND	MS	CA, LI	CA

(1) Funding (2) Nothing (3) More Space (4) Better shower and wc conditions (5) Common area (6) Lights

Table 24 Table showing collected data in settlement B for the questions of "What is lacking in the Settlement? (CWh)"

#	data			Answers							
	location	time	code	PHASE II (PH)							
				Ph1	Ph2	Ph3	Ph4	Ph5	Ph6	Ph7	Ph8
1	SA	10:00	A-01	YES	YES	MF SEP(2)	LAST	LS(8)	YES	YES	AYL(10)
2	SA	10:15	A-02	YES	YES	MF SEP	FIRST	LS	YES	YES	AYL
3	SA	10:30	A-03	YES	YES	CIN(7)	FIRST	LS	YES	YES	AYL
4	SA	10:45	A-04	YES	YES	CIN	FIRST	LS	YES	YES	AYL
5	SA	11:00	A-05	YES	YES	MF SEP	FIRST	LS	YES	YES	AYL
6	SA	11:15	A-06	YES	YES	MF SEP	FIRST	LS	YES	YES	AYL
7	SA	11:30	A-07	YES	YES	MF SEP	FIRST	LS	YES	YES	AYL
8	SA	11:45	A-08	YES	YES	HOSP(6)	FIRST	ES(9)	YES	YES	AYL
9	SA	12:00	A-09	YES	YES	SCH(3)	FIRST	ES	YES	YES	AYL
10	SA	12:15	A-10	YES	YES	SCH	LAST	ES	YES	YES	AYL
11	SA	13:00	A-11	YES	YES	MF SEP	FIRST	LS	YES	YES	AYL
12	SA	13:15	A-12	YES	YES	MF SEP	FIRST	LS	YES	YES	AYL
13	SA	13:30	A-13	YES	YES	MF SEP	FIRST	LS	YES	YES	AYL
14	SA	13:45	A-14	YES	YES	MF SEP	FIRST	LS	YES	YES	AYL
15	SA	14:00	A-15	YES	YES	SS(5)	LAST	ES	YES	YES	AYL
16	SA	14:15	A-16	YES	YES	MF SEP	FIRST	LS	YES	YES	AYL
17	SA	14:30	A-17	YES	YES	MF SEP	FIRST	LS	YES	YES	AYL
18	SA	14:45	A-18	YES	YES	MS	FIRST	ES	YES	YES	AYL
19	SA	15:00	A-19	YES	HP(1)	MS	FIRST	ES	YES	YES	AYL
20	SA	15:15	A-20	YES	HP	MF SEP	FIRST	LS	YES	YES	AYL
21	SA	15:30	A-21	YES	YES	MF SEP	FIRST	LS	YES	YES	AYL
22	SA	15:45	A-22	YES	YES	MSMN(4)	FIRST	ES	YES	YES	AYL
23	SA	16:00	A-23	YES	YES	MF SEP	FIRST	LS	YES	YES	AYL
24	SA	16:15	A-24	YES	YES	MF SEP	FIRST	LS	YES	YES	AYL
25	SA	16:30	A-25	YES	YES	MSMN	LAST	LS	YES	YES	AYL

(1) Consider other stuff with higher priority (2) Separate Men and Women (3) Schools (4) Moderate space and more numbers (5) Safer structure (6) Hospitals (7) Cinema (8) Lifestyle (9) Essential services (10) All year long

Table 25 Table showing collected data in settlement A for the questions of "PHASE II (PH)"

#	data			Answers							
				PHASE II (PH)							
	location	time	code	Ph1	Ph2	Ph3	Ph4	Ph5	Ph6	Ph7	Ph8
26	SB	10:00	B-01	YES	YES	MSMN(4)	LAST	LS(8)	YES	YES	AYL(10)
27	SB	10:15	B-02	YES	YES	MSMN	FIRST	LS	YES	YES	AYL
28	SB	10:30	B-03	YES	YES	MSMN	FIRST	LS	YES	YES	AYL
29	SB	10:45	B-04	YES	YES	MSMN	FIRST	LS	YES	YES	AYL
30	SB	11:00	B-05	YES	YES	MSMN	FIRST	LS	YES	YES	AYL
31	SB	11:15	B-06	YES	YES	MSMN	FIRST	LS	YES	YES	AYL
32	SB	11:30	B-07	YES	YES	MSMN	FIRST	LS	YES	YES	AYL
33	SB	11:45	B-08	YES	YES	SCH(3)	FIRST	ES(9)	YES	YES	AYL
34	SB	12:00	B-09	YES	YES	SCH	LAST	ES	YES	YES	AYL
35	SB	12:15	B-10	YES	YES	SCH	LAST	ES	YES	YES	AYL
36	SB	13:00	B-11	YES	YES	SCH	LAST	ES	YES	YES	AYL
37	SB	13:15	B-12	YES	YES	SCH	FIRST	ES	YES	YES	AYL
38	SB	13:30	B-13	YES	YES	SCH	FIRST	ES	YES	YES	AYL
39	SB	13:45	B-14	YES	YES	SCH	FIRST	ES	YES	YES	AYL
40	SB	14:00	B-15	YES	HP(1)	MF SEP(2)	FIRST	LS	YES	YES	AYL
41	SB	14:15	B-16	YES	YES	MF SEP	FIRST	LS	YES	YES	AYL
42	SB	14:30	B-17	YES	YES	MF SEP	FIRST	LS	YES	YES	AYL
43	SB	14:45	B-18	YES	YES	MF SEP	FIRST	LS	YES	YES	AYL
44	SB	15:00	B-19	YES	YES	MF SEP	FIRST	LS	YES	YES	AYL
45	SB	15:15	B-20	YES	YES	MF SEP	FIRST	LS	YES	YES	AYL
46	SB	15:30	B-21	YES	YES	MF SEP	FIRST	LS	YES	YES	AYL
47	SB	15:45	B-22	YES	YES	MF SEP	FIRST	LS	YES	YES	AYL
48	SB	16:00	B-23	YES	YES	MF SEP	LAST	LS	YES	YES	AYL
49	SB	16:15	B-24	YES	YES	MF SEP	LAST	LS	YES	YES	AYL
50	SB	16:30	B-25	YES	YES	MF SEP	FIRST	LS	YES	YES	AYL

(1) Consider other stuff with higher priority (2) Separate Men and Women (3) Schools (4) Moderate space and more numbers (5) Safer structure (6) Hospitals (7) Cinema (8) Lifestyle (9) Essential services (10) All year long

Table 26 Table showing collected data in settlement B for the questions of "PHASE II (PH)"

	data			Answers		
#	location	time	code	Dreams and hopes? (D)		
				D1	D2	D3
1	SA	10:00	A-01	MOLNL(1)	LEB(2)	WORK
2	SA	10:15	A-02	MOLNL	LEB	WORK
3	SA	10:30	A-03	MOLNL	SYR(3)	WORK
4	SA	10:45	A-04	MOLNL	SYR	WORK
5	SA	11:00	A-05	MOLNL	SYR	WORK
6	SA	11:15	A-06	MOLNL	SYR	WORK
7	SA	11:30	A-07	MOLNL	SYR	WORK
8	SA	11:45	A-08	MOLNL	SYR	WORK
9	SA	12:00	A-09	MOLNL	SYR	WORK
10	SA	12:15	A-10	MOLNL	SYR	WORK
11	SA	13:00	A-11	MOLNL	SYR	WORK
12	SA	13:15	A-12	MOLNL	SYR	WORK
13	SA	13:30	A-13	MOLNL	SYR	WORK
14	SA	13:45	A-14	MOLNL	SYR	WORK
15	SA	14:00	A-15	MOLNL	SYR	WORK
16	SA	14:15	A-16	MOLNL	SYR	WORK
17	SA	14:30	A-17	MOLNL	LEB	WORK
18	SA	14:45	A-18	MOLNL	LEB	WORK
19	SA	15:00	A-19	MOLNL	LEB	WORK
20	SA	15:15	A-20	MOLNL	LEB	WORK
21	SA	15:30	A-21	MOLNL	LEB	WORK
22	SA	15:45	A-22	MOLNL	LEB	WORK
23	SA	16:00	A-23	MOLNL	LEB	WORK
24	SA	16:15	A-24	MOLNL	LEB	WORK
25	SA	16:30	A-25	MOLNL	LEB	WORK

(1) Move on and live a normal life (2) Lebanon (3) Syria

Table 27 Table showing collected data in settlement A for the questions of "Dreams and hopes? (D)"

	data			Answers		
#	location	time	code	Dreams and hopes? (D)		
				D1	D2	D3
26	SB	10:00	B-01	MOLNL(1)	LEB(2)	WORK
27	SB	10:15	B-02	MOLNL	LEB	WORK
28	SB	10:30	B-03	MOLNL	LEB	WORK
29	SB	10:45	B-04	MOLNL	LEB	WORK
30	SB	11:00	B-05	MOLNL	LEB	WORK
31	SB	11:15	B-06	MOLNL	LEB	WORK
32	SB	11:30	B-07	MOLNL	LEB	WORK
33	SB	11:45	B-08	MOLNL	LEB	WORK
34	SB	12:00	B-09	MOLNL	LEB	WORK
35	SB	12:15	B-10	MOLNL	LEB	WORK
36	SB	13:00	B-11	MOLNL	LEB	WORK
37	SB	13:15	B-12	MOLNL	LEB	WORK
38	SB	13:30	B-13	MOLNL	LEB	WORK
39	SB	13:45	B-14	MOLNL	LEB	WORK
40	SB	14:00	B-15	MOLNL	LEB	WORK
41	SB	14:15	B-16	MOLNL	LEB	WORK
42	SB	14:30	B-17	MOLNL	LEB	WORK
43	SB	14:45	B-18	MOLNL	LEB	WORK
44	SB	15:00	B-19	MOLNL	LEB	WORK
45	SB	15:15	B-20	MOLNL	LEB	WORK
46	SB	15:30	B-21	MOLNL	LEB	WORK
47	SB	15:45	B-22	MOLNL	LEB	WORK
48	SB	16:00	B-23	MOLNL	LEB	WORK
49	SB	16:15	B-24	MOLNL	LEB	WORK
50	SB	16:30	B-25	MOLNL	LEB	WORK

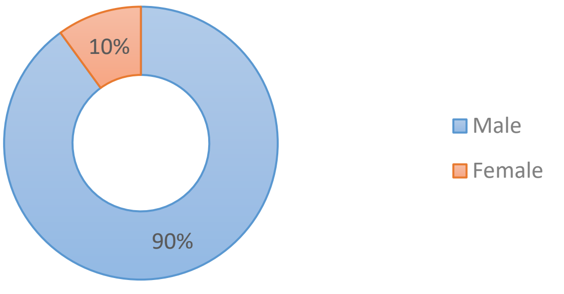
(1) Move on and live a normal life (2) Lebanon (3) Syria

Table 28 Table showing collected data in settlement B for the questions of "Dreams and hopes? (D)"

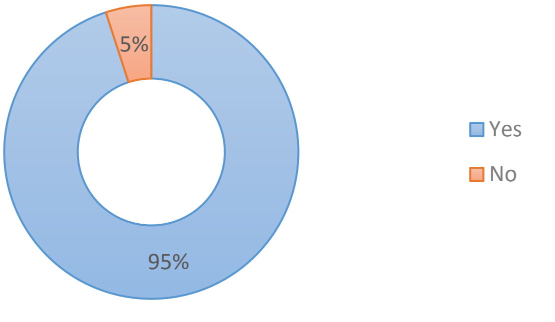
<u>Charts showing the data analysis:</u>

Background questions:

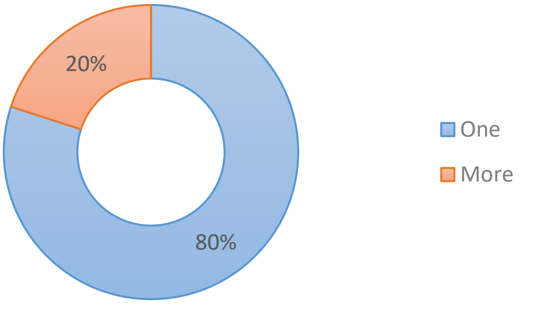
- Gender of participants:



- Familiar with technology:

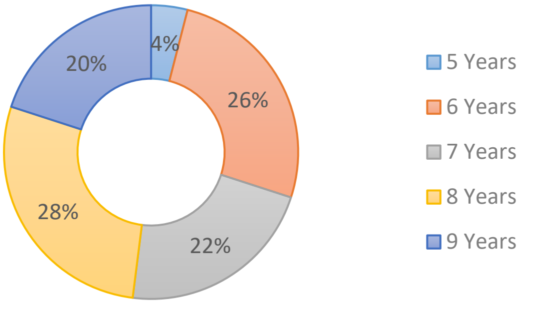


- Languages spoken:

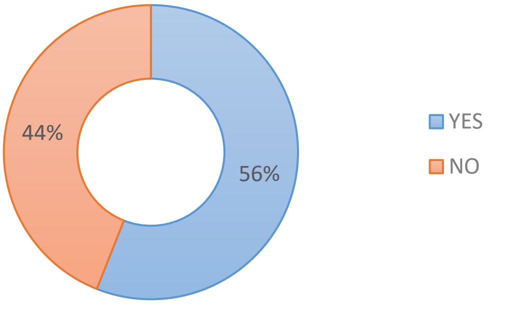


History in the settlement: (H)

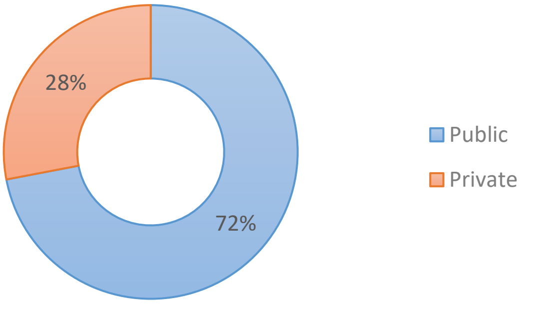
- How long have you been here? (H1)



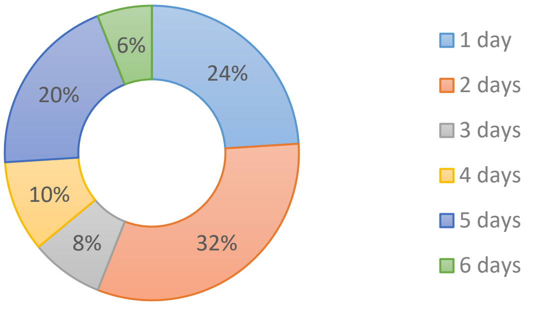
- Was it easy for you to flee and come here? (H2)



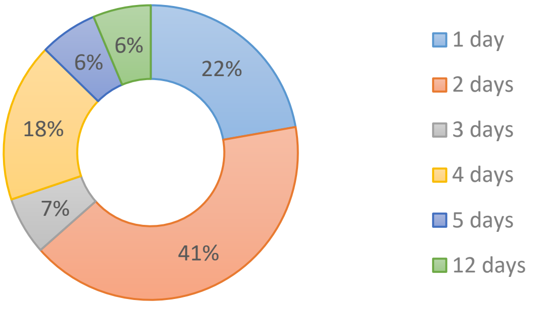
  - How did you get here? (H2.1)



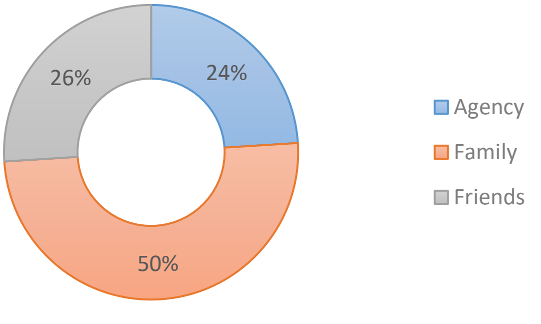
- How long did it take you to get a tent? (H2.2)



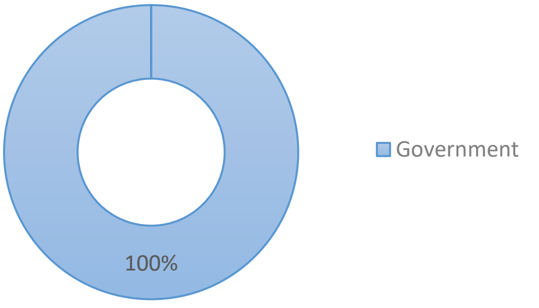
- How long would you say it took you to settle in? (H2.3)



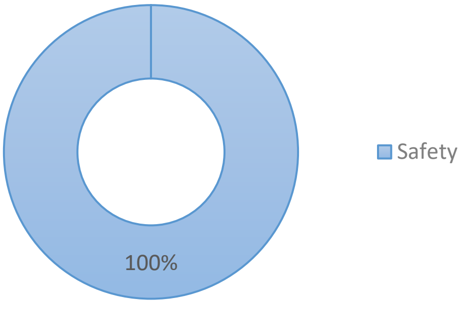
- How did you know about this camp? (H3)



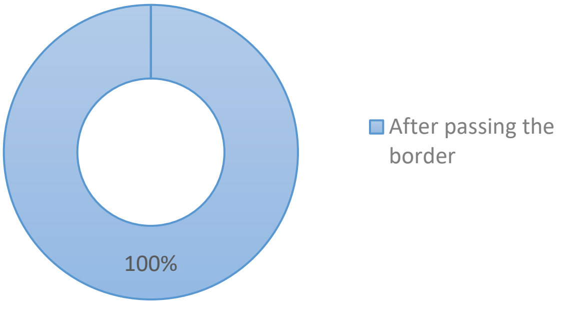
- In your opinion what is the best way to inform people about it? (H3.1)



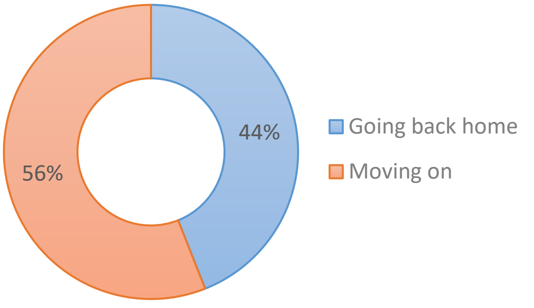
- What was your first priority when leaving home? (H4)



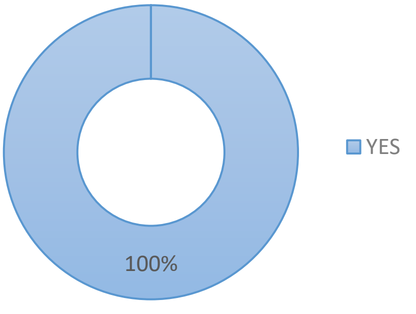
- How long did it take you to achieve it? (H4.1)



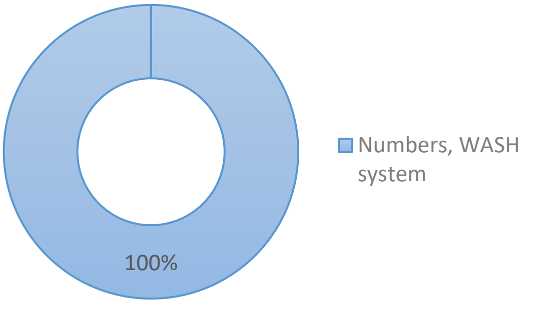
- What is your priority now? (H4.2)



- Has the camp evolved? (H5)



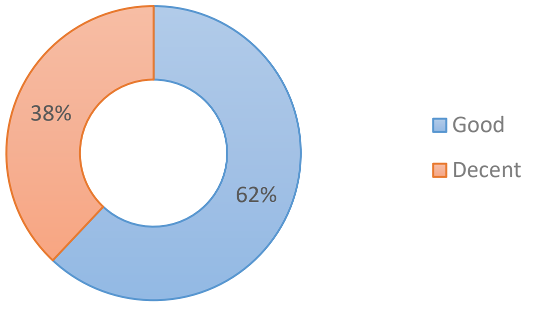
- What has changed since you first came here? (H5.1)



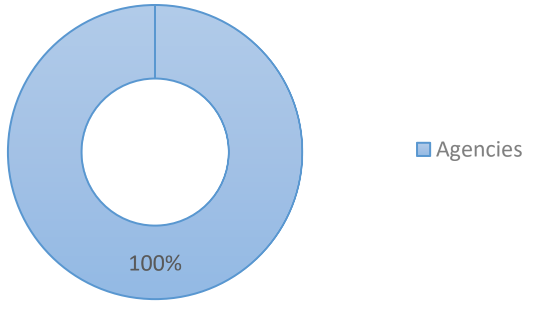
Current situation: (group into subgroups) (C)

Hygiene (CH)

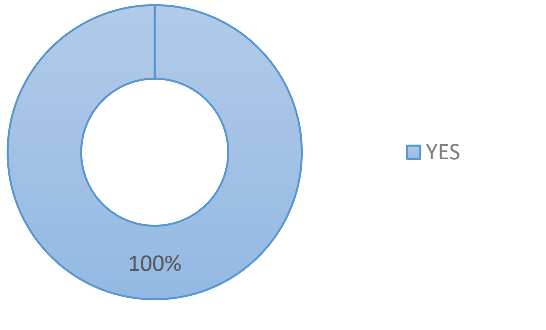
- How would you describe the hygiene situation? (CH1)



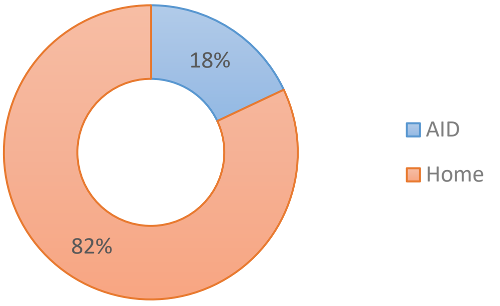
  - Where do you get your water from? (CH1.1)



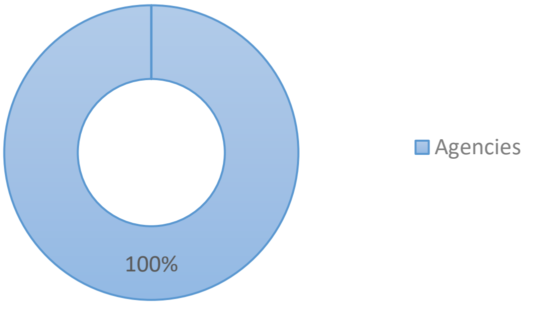
  - Is it clean? (CH1.2)



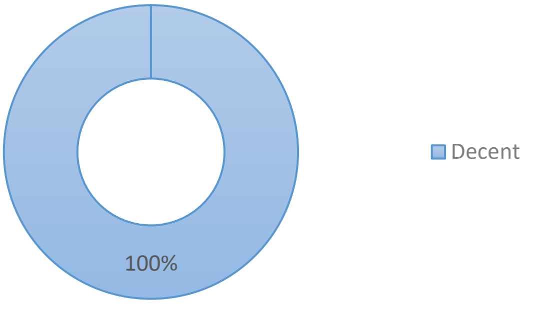
- Where do you do all the cooking? (CH2)



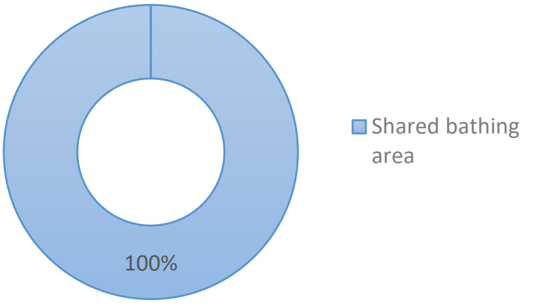
- How and where do you dispose of the garbage? (CH3)



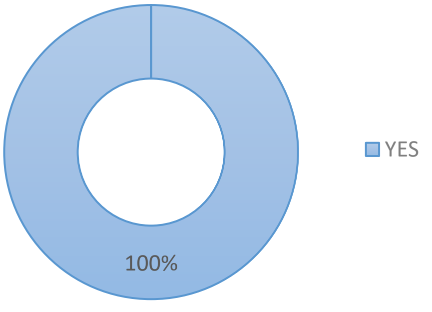
- How are the toilets? (CH4)



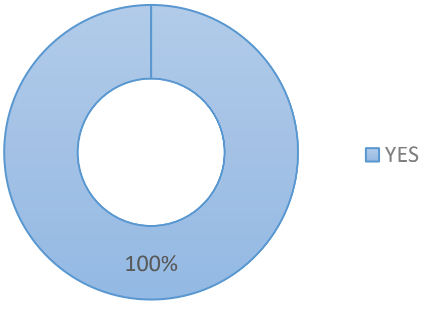
- Where do you take showers? (CH5)



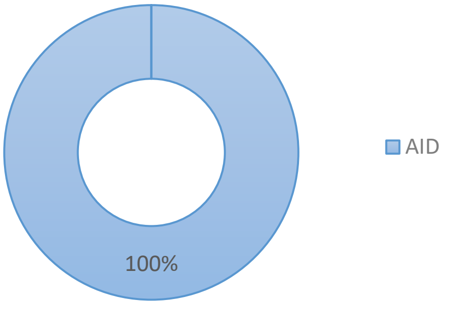
  - Are you provided with soap? (CH5.1)



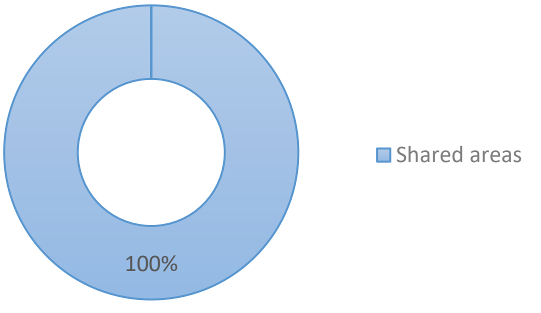
  - Towels? (CH5.2)



- Where do you get the clothes? (CH6)

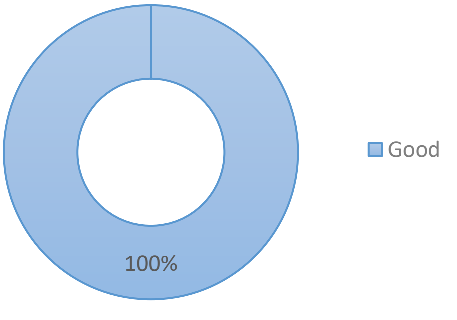


    ○ How do you wash them? (CH6.1)

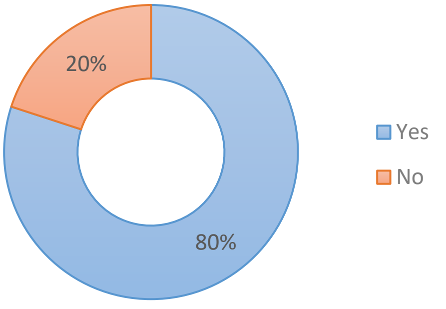


Organization (O)

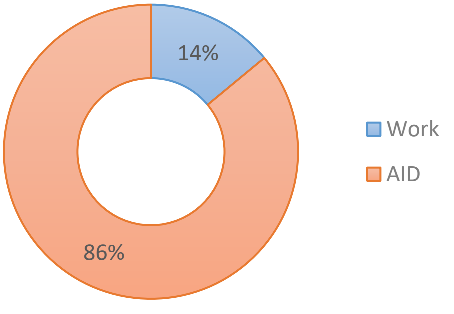
- What do you think about the camp's organization? (CO1)



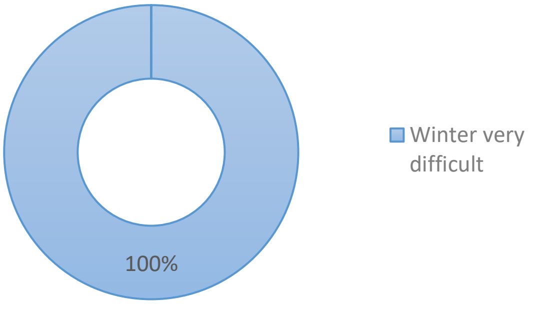
- Do you help out in the camp organization? (CO1.1)



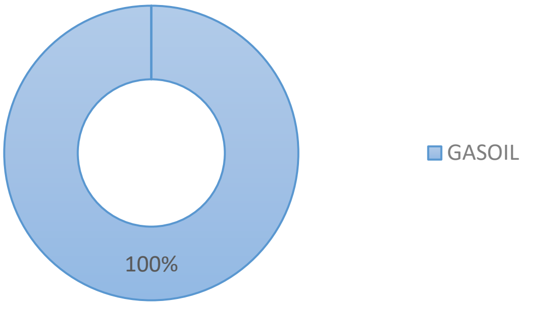
- How do you ensure main life requirements? (CO2)



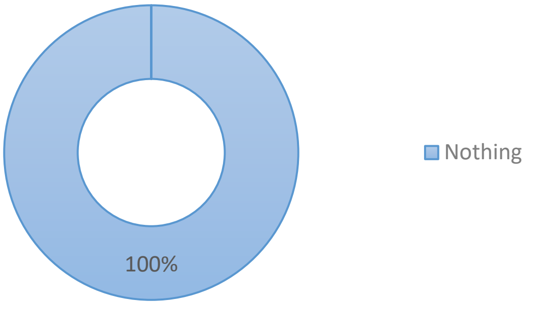
- Being in Lebanon you are exposed to all 4 seasons; how do you adapt to it? (CO3)



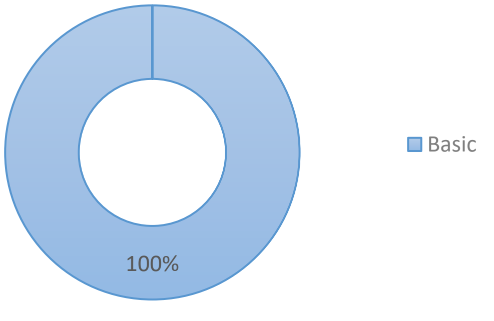
- What do you use for heating? (CO3.1)



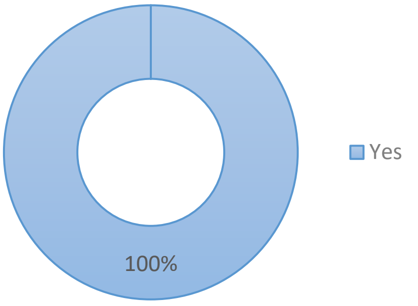
- And for cooling? (CO3.2)



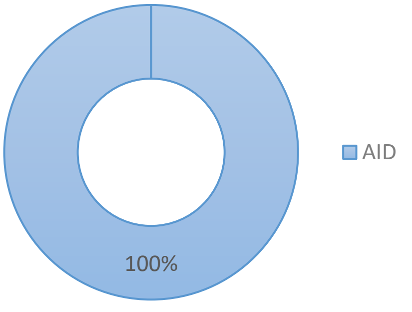
- What is the electricity situation? (CO3.3)



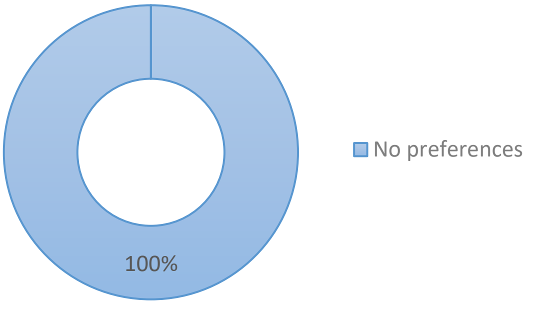
- Are the streets muddy? (CO4)



- What do you do in case of a medical emergency? (CO5)

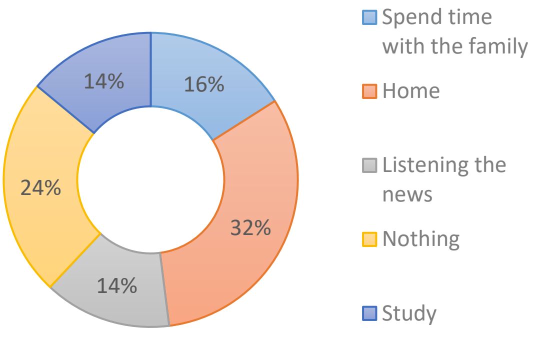


- Are there preferences or is everyone treated in the same way? (CO6)

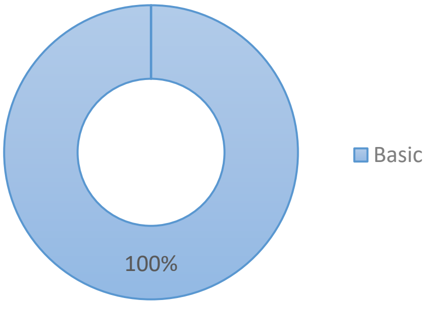


Social life (S)

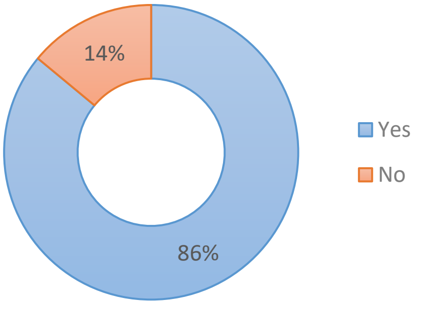
- How do you fill up your time? (CS1)



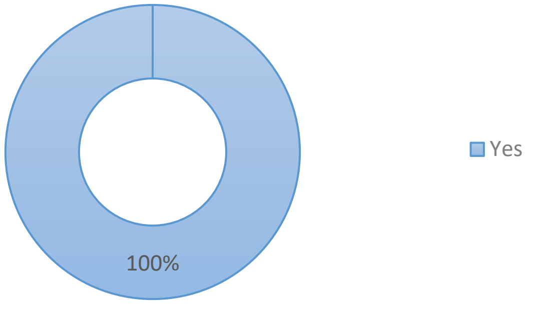
  - How is the social life here? (CS1.1)



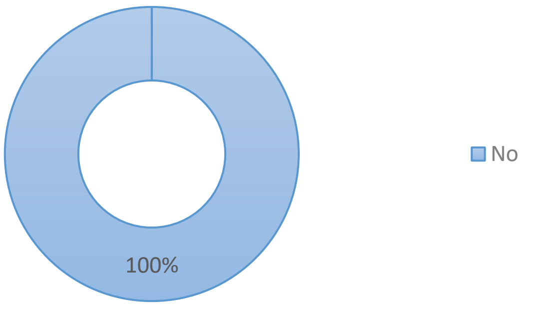
  - Do you get along with the others? (CS1.2)



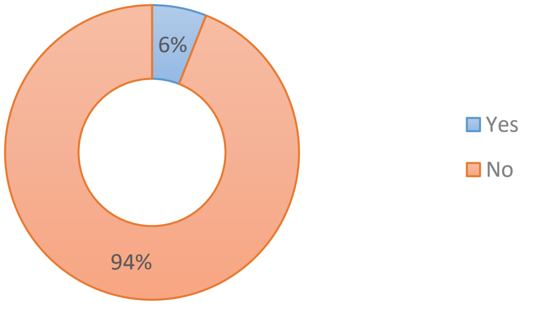
- During the festivities, is there anything special being done? (CS2)



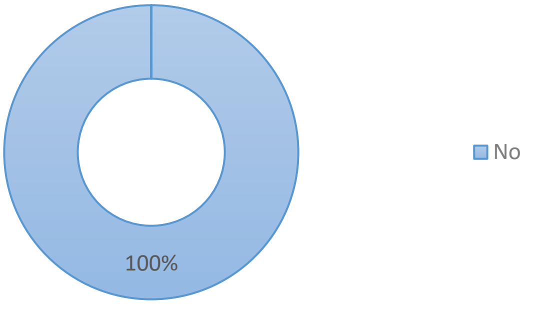
- Are there any religion conflicts? (CS3)



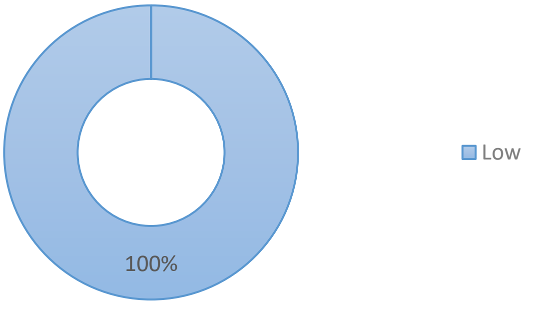
  - Were you used to living in a mixed religion society? (CS3.1)



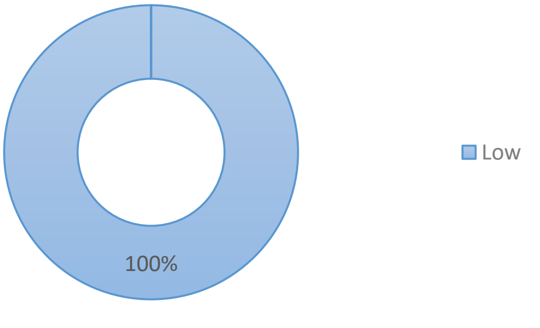
- Does it bother you? (CS3.2)



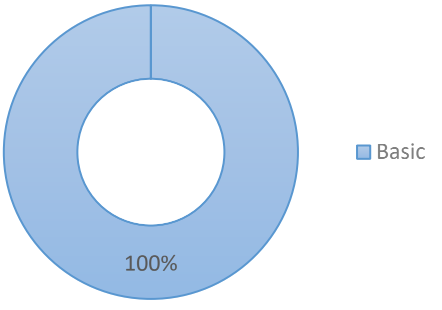
- What are the possibilities to have a social encounter here? (CS4)



- How would you define the possibility to meet a partner and get married here? (CS4.1)

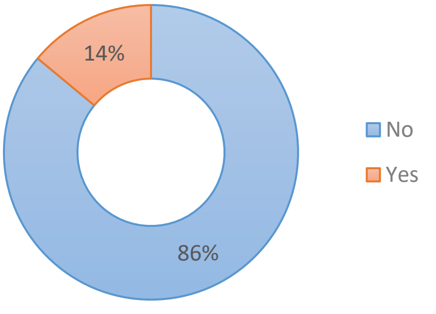


- Can you describe your typical day here in the camp? (CS5)

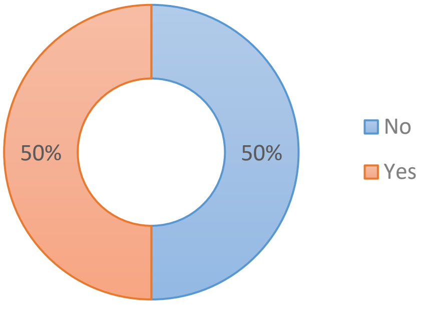


Education (E)

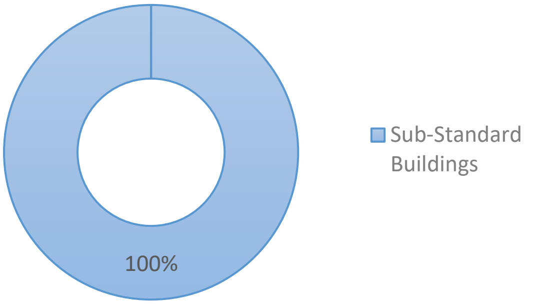
- Do you study? (CE1)



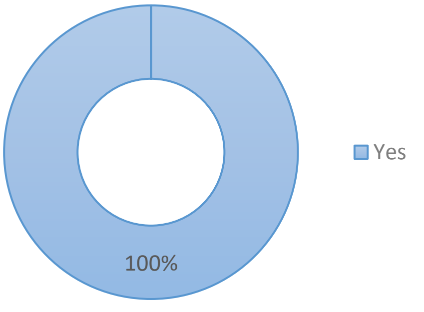
- Are there any schools? (CE2)



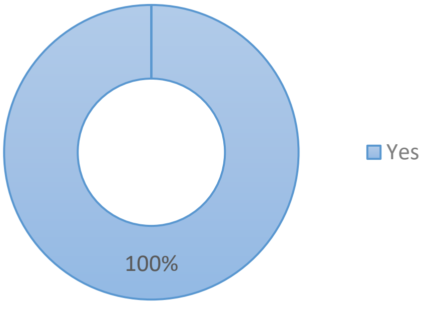
- What is the situation of the students who went to university? (CE3)



  - Were there public universities in Syria? (CE3.1)

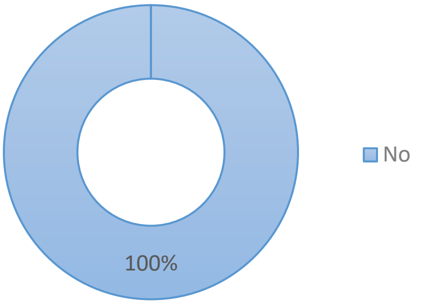


  - Are there still universities open in Syria? (CE3.2)

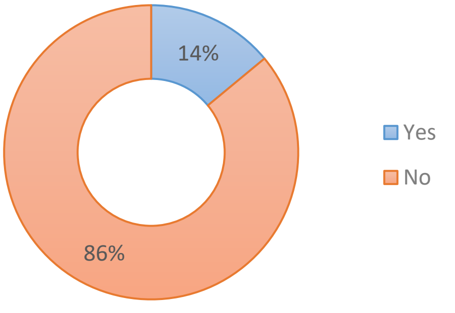


Work (W)

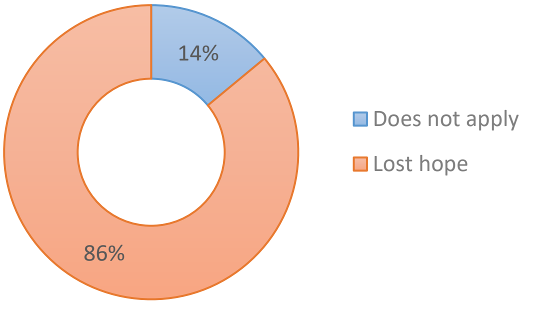
- Do you work? (CW1)



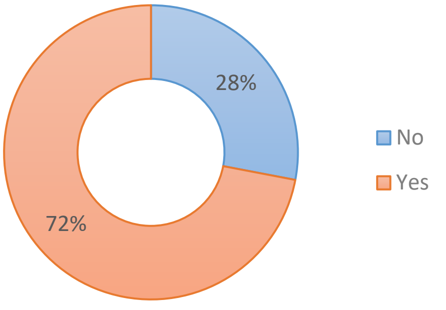
  - If unemployed, are you looking for work? (CW1.1)



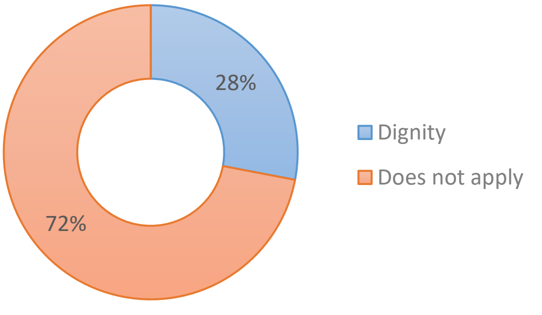
  - If not, why? (CW1.2)



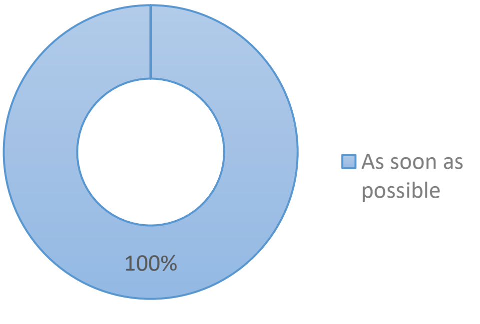
- Would you accept any kind of work? (CW2)



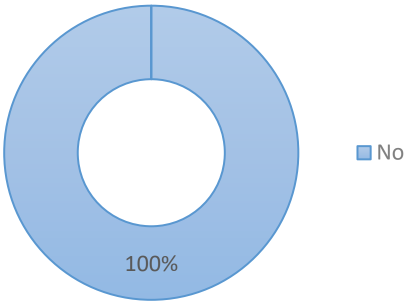
  - Where would you say you would draw the line? (CW2.1)



- If you were working would you move out of the camp? (CW3)

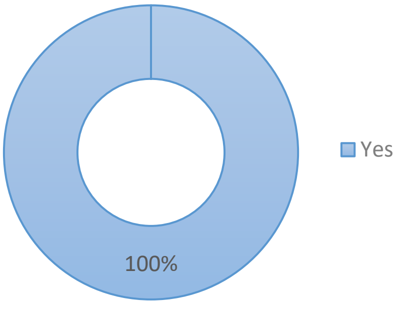


- Or would you save up the money and stay here? (CW3.1)

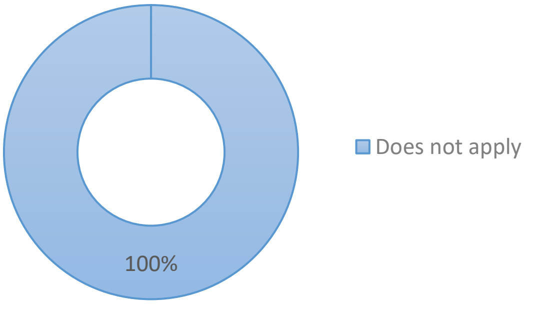


Volunteering (V)

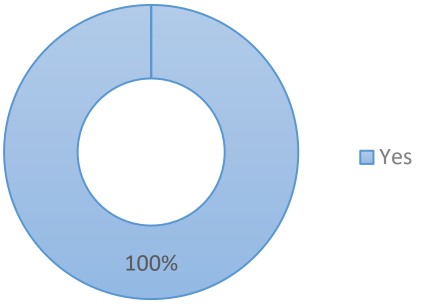
- Have you ever participated in helping out with the camp organization? (CV1)



- If not, why? (CV1.1)

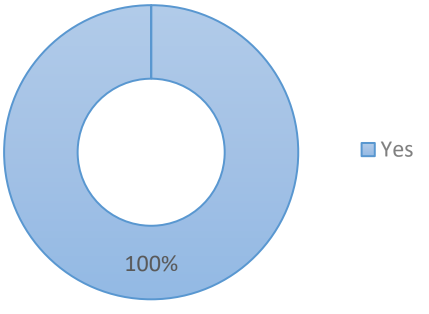


- Are there a lot of volunteers here? (CV2)

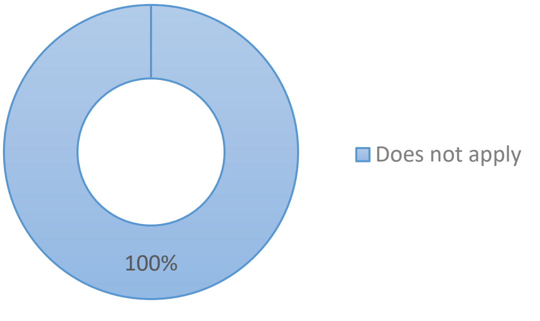


Safety (SA)

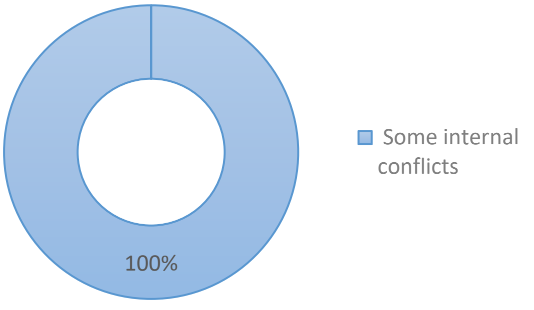
- Do you feel safe? (CSA1)



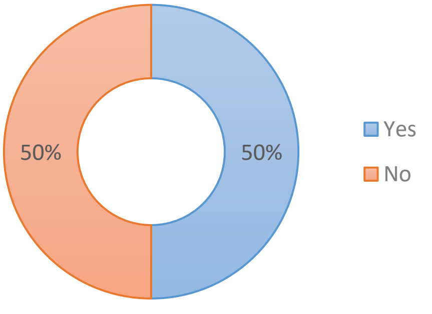
  - If not, what is the main reason for that? (CSA1.1)



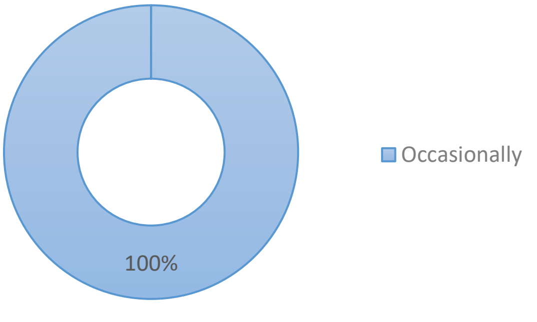
- Were there any security problems? (CSA2)



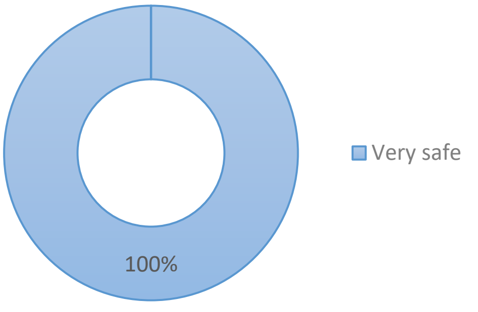
  - Are there any lights in the night? (CSA2.1)



  - Was there any animal presence inside the camp? (CSA2.2)

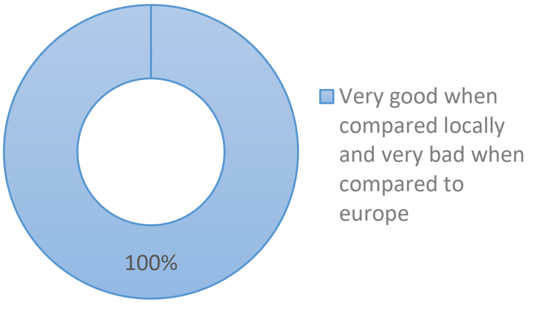


- Kids' safety? (CSA2.3)

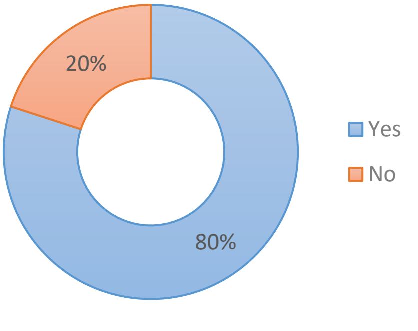


Personal Evaluation (P)

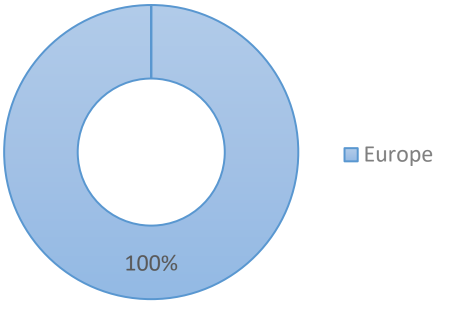
- If you had to evaluate the work done here, what would you say? (CP1)



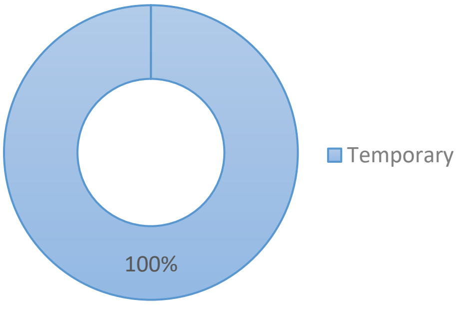
- If you were given another chance would you still leave your country and come here? (CP2)



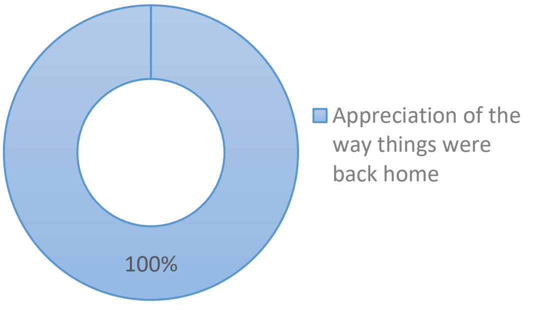
- If you were given the choice, where would you go? (CP2.1)



- If you could define life here in 1 word, what would it be? (CP3)

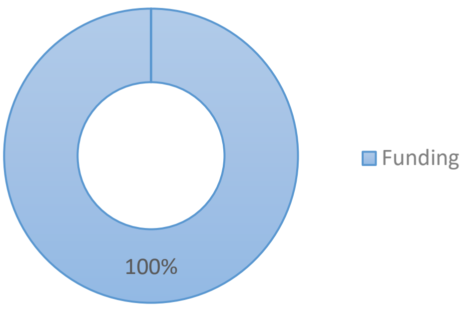


- If you had to choose something positive you gained from this experience what would it be? (CP4)

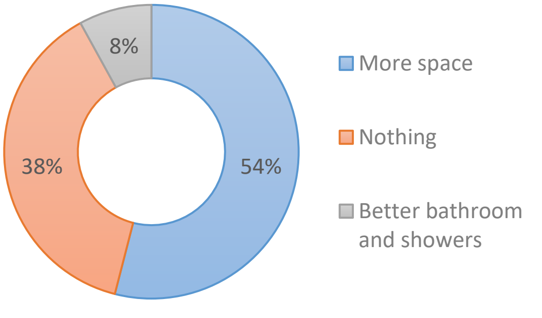


What is lacking in the camp? (Wh)

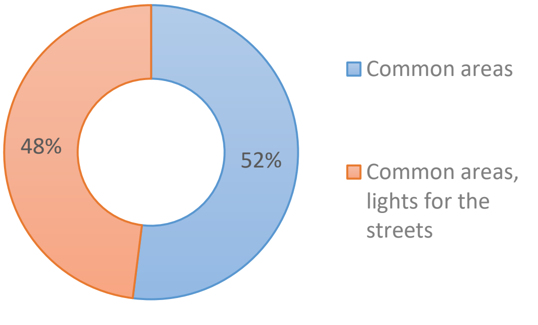
- What do you think lacks in this camp? (Wh1)



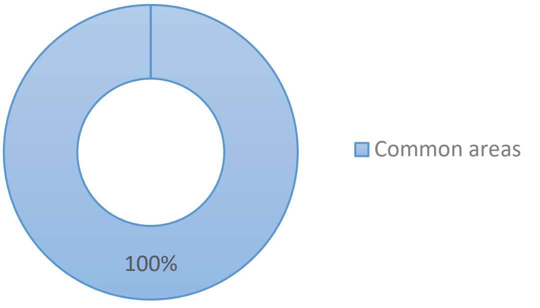
  - On a single unit scale (Wh1.1)



  - On an urban scale (Wh1.2)

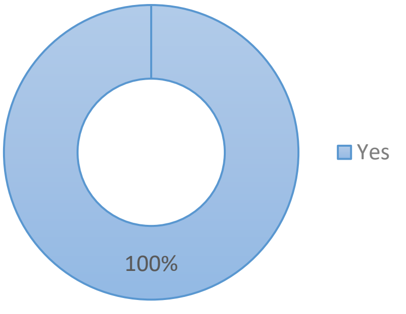


- Group them by priority, starting from the most essential (W2)

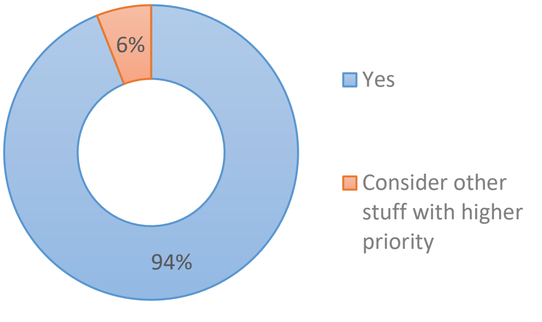


PHASE II (PH)

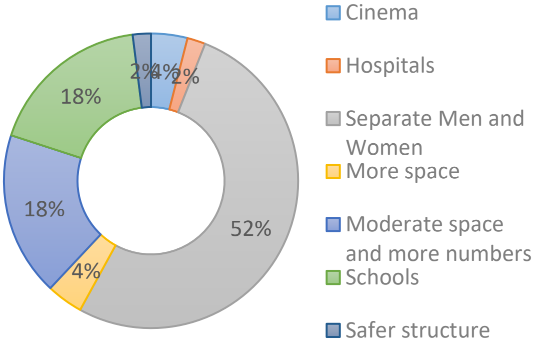
- Will it work? (PH-1)



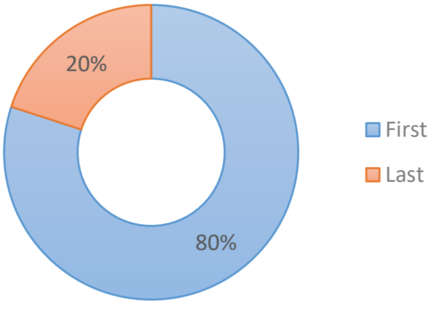
- Is it necessary? (PH-2)



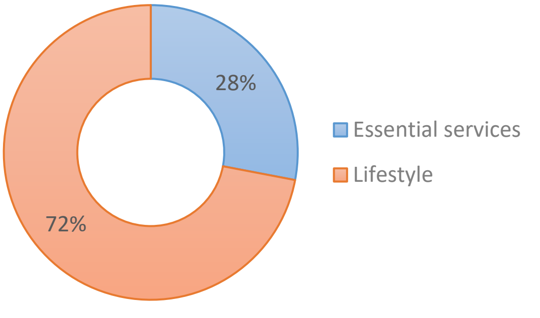
- Any modifications come up to your mind? What do you think are the most important activities to put in this multifunctional project? (PH-3)



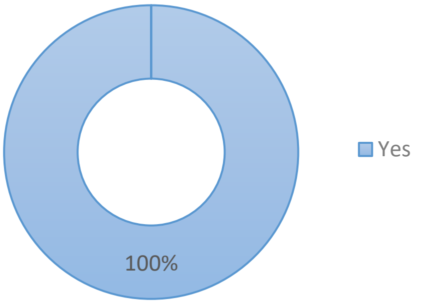
- Where does it fit in your priority list? (PH-4)



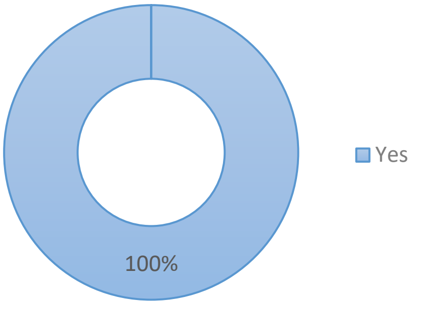
- In what way do you think it would help out the most? (PH-5)



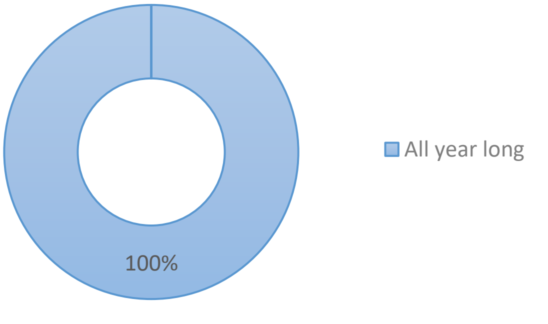
- Do you think we will be able to find support from the refugees? (PH-6)



- Were there volunteers for similar past projects? (PH-7)

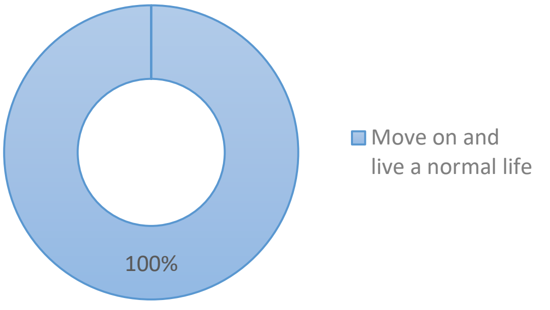


- In what season do you think it our project will be most crucial? (PH-8)

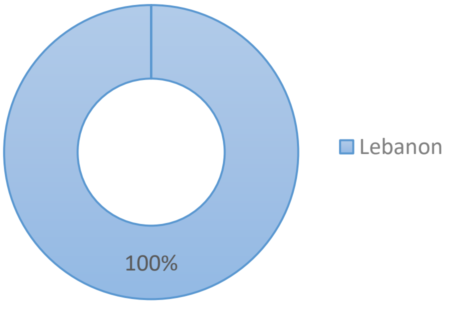


Dreams and hopes? (D)

- What are your dreams and hopes for the future? (D1)



- Do you prefer to go back to Syria or stay in Lebanon if you were capable to settle in? (D2)



- What is the first thing you would do when back in Syria? (D3)

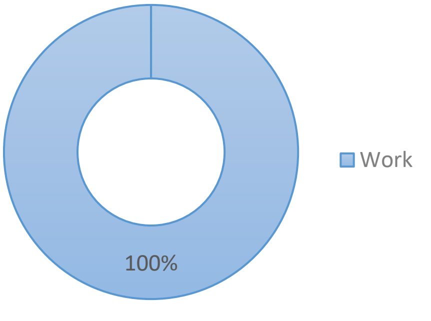


Table summarizing all of the above results:

Question	Results					
Gender of participants:	Male	Female				
%	90	10				
Familiar with technology	Yes	No				
%	95	5				
Languages spoken	One	More				
%	80	20				
How long have you been here?	5 years	6 years	7 years	8 years	9 years	
%	4	26	22	28	20	
Was it easy for you to flee and come here?	Yes	No				
%	56	44				
How did you get here?	Public	Private				
%	72	28				
How long did it take you to get a tent?	1 day	2 days	3 days	4 days	5 days	6 days
%	24	32	8	10	20	6
How long would you say it took you to settle in?	1 day	2 days	3 days	4 days	5 days	12 days
%	22	41	7	18	6	6
How did you know about this camp?	Agency	Family	Friends			
%	24	50	26			
In your opinion what is the best way to inform people about it?	Government					
%	100					
What was your first priority when leaving home?	Safety					
%	100					
How long did it take you to achieve it?	After passing the border					
%	100					

What is your priority now?	Going back home	Moving on
%	44	56
Has the camp evolved?	Yes	
%	100	
What has changed since you first came here?	Numbers, WASH system	
%	100	
How would you describe the hygiene situation?	Good	Decent
%	62	38
Where do you get your water from?	Agencies	
%	100	
Is it clean?	Yes	
%	100	
Where do you do all the cooking?	AID	Home
%	18	82
How and where do you dispose of the garbage?	Agenies	
%	100	
How are the toilets?	Decent	
%	100	
Where do you take showers?	Shared bathing area	
%	100	
Are you provided with soap?	Yes	
%	100	
Towels?	Yes	
%	100	
Where do you get the clothes?	AID	
%	100	
How do you wash them?	Shared areas	
%	100	

What do you think about the camp's organization?	Good						
%	100						
Do you help out in the camp organization?	Yes	No					
%	80	20					
How do you ensure main life requirements?	Work	AID					
%	14	86					
Being in Lebanon you are exposed to all 4 seasons; how do you adapt to it?	Winter very difficult						
%	100						
What do you use for heating?	GASOIL						
%	100						
And for cooling?	Nothing						
%	100						
What is the electricity situation?	Basic						
%	100						
Are the streets muddy?	Yes						
%	100						
What do you do in case of a medical emergency?	AID						
%	100						
Are there preferences or is everyone treated in the same way?	No preferenc es						
%	100						
How do you fill up your time?	Family	Home	Listening to the news	Nothing	Study		
%	16	32	14	24	14		
How is the social life here?	Basic						
%	100						

Do you get along with the others?	Yes	No
%	86	14
During the festivities, is there anything special being done?	Yes	
%	100	
Are there any religion conflicts?	No	
%	100	
Were you used to living in a mixed religion society?	Yes	No
%	6	94
Does it bother you?	No	
%	100	
What are the possibilities to have a social encounter here?	Low	
%	100	
How would you define the possibility to meet a partner and get married here?	Low	
%	100	
Can you describe your typical day here in the camp?	Basic	
%	100	
Do you study?	Yes	No
%	86	14
Are there any schools?	Yes	No
%	50	50
What is the situation of the students who went to university?	Sub-Standard Buildings	
%	100	
Were there public	Yes	

universities in Syria?							
%	100						
Are there still universities open in Syria?	Yes						
%	100						
Do you work?	No						
%	100						
If unemployed, are you looking for work?	Yes	No					
%	14	86					
If not, why?	Does not apply	Lost hope					
%	14	86					
Would you accept any kind of work?	Yes	No					
%	72	28					
Where would you say you would draw the line?	Dignity	Does not apply					
%	28	72					
If you were working would you move out of the camp?	As soon as possible						
%	100						
Or would you save up the money and stay here?	No						
%	100						
Have you ever participated in helping out with the camp organization?	Yes						
%	100						
If not, why?	Does not apply						
%	100						
Are there a lot of volunteers here?	Yes						
%	100						
Do you feel safe?	Yes						
%	100						

If not, what is the main reason for that?	Does not apply						
%	100						
Were there any security problems?	Some internal conflicts						
%	100						
Are there any lights in the night?	Yes	No					
%	50	50					
Was there any animal presence inside the camp?	Occasiona lly						
%	100						
Kids' safety?	Very safe						
%	100						
If you had to evaluate the work done here, what would you say?	Very good when compared locally and very bad when compared to europe						
%	100						
If you were given another chance would you still leave your country and come here?	Yes	No					
%	80	20					
If you were given the choice, where would you go?	Europe						
%	100						
If you could define life here in 1 word, what would it be?	Temporar y						
%	100						
If you had to choose something positive you gained from this experience	Appreciati on of the way things were back home						

what would it be?							
%	100						
What do you think lacks in this camp?	Funding						
%	100						
On a single unit scale	More Space	Nothing	Better Bathroom and showers				
%	54	38	8				
On an urban scale	Common areas	Common areas, lights for the streets					
%	52	48					
Group them by priority, starting from the most essential	Common areas						
%	100						
Will Phase II work?	Yes						
%							
Is it necessary?	Yes	Consider other stuff with higher priority					
%	94	6					
Any modifications come up to your mind? What do you think are the most important activities to put in this multifunctional project?	Cinema	Hospitals	Separate Men and Women	More Space	Modera te space and more number s	School s	Safer structure
%	4	2	52	4	18	18	2
Where does it fit in your priority list?	First	Last					
%	80	20					
In what way do you think it would help out the most?	Essential services	Lifestyle					

%	72	28					
Do you think we will be able to find support from the refugees?	Yes						
%	100						
Were there volunteers for similar past projects?	Yes						
%	100						
In what season do you think it our project will be most crucial?	All year long						
%	100						
What are your dreams and hopes for the future?	Move on and live a normal life						
%	100						
Do you prefer to go back to Syria or stay in Lebanon if you were capable to settle in?	Lebanon						
%	100						
What is the first thing you would do when back in Syria?	Work						
%	100						

Table 29 Table summarizing the chart results

2.3.2.2.Staff

Tables showing the collected data:

#	data			Answers				
	location	Agency	code	History in the settlement (H)				
				H1[1]	H2	H3	H4	H4.1
1	SA	UNHCR	SA-01	1	Int[2]	MO[3],HO	NO	DNA[6]
2	SA	UNHCR	SA-02	2	Int	HO[4]	NO	DNA
3	SA	UNHCR	SA-03	3	Int	MO,HO	YES	W[7]
4	SA	UNHCR	SA-04	3	Int	MO,HO	YES	W
5	SA	UNHCR	SA-05	2	Int	HO	NO	DNA
6	SB	MEDAIR	SB-01	4	Int	TW[5]	YES	W,FS[8],N
7	SB	MEDAIR	SB-02	5	Int	MO,HO,TW	YES	W,FS,N[9]
8	SB	MEDAIR	SB-03	6	Int	MO,HO	YES	W,FS,N
9	SB	MEDAIR	SB-04	5	Int	MO,HO	YES	W,FS,N
10	SB	MEDAIR	SB-05	6	Int	MO,HO	YES	W,FS,N

[1] Years [2] Internet [3] Money [4] Helping others less fortunate [5] Travel the world [6] Does not apply [7] WASH systems [8] Fire Safety [9] Numbers

Table 30 Table showing collected data from the staff for the questions of "History in the settlement (H)"

#	data			Answers					
	location	Agency	code	Current situation (C)					
				Hygiene (Hy)					
				CHy1	CHy1.1	CHy2	CHy2.1[3]	CHy3	CHy3.1
1	SA	UNHCR	SA-01	GD[1]	AG[2]	AG	NO	YES	NO
2	SA	UNHCR	SA-02	GD	AG	AG	NO	YES	NO
3	SA	UNHCR	SA-03	GD	AG	AG	YES	YES	NO
4	SA	UNHCR	SA-04	GD	AG	AG	YES	YES	NO
5	SA	UNHCR	SA-05	GD	AG	AG	NO	YES	NO
6	SB	MEDAIR	SB-01	GD	AG	AG	YES	YES	NO
7	SB	MEDAIR	SB-02	GD	AG	AG	YES	YES	NO
8	SB	MEDAIR	SB-03	GD	AG	AG	YES	YES	NO
9	SB	MEDAIR	SB-04	GD	AG	AG	YES	YES	NO
10	SB	MEDAIR	SB-05	GD	AG	AG	YES	YES	NO

[1] Good [2] Agency [3] Mostly with kids

Table 31 Table showing collected data from the staff for the questions of "Hygiene (CHy)"

#	data			Answers									
				Current situation (C)									
	location	Agency	code	Organization (O)									
				CO1	CO1.1	CO2	CO3	CO4	CO5	CO5.1	CO6	CO6.1	CO6.2
1	SA	UNHCR	SA-01	VG[1]	CM[2]	AID	TP[6],CLRT	NP[8]	Yes	Yes	VFT[9]	ST[10]	W[11]
2	SA	UNHCR	SA-02	VG	AT[3]	AID	TP,CLRT[7]	NP	Yes	Yes	NO	ST	W
3	SA	UNHCR	SA-03	VG	AT	AID	TP,CLRT	NP	Yes	Yes	NO	ST	W
4	SA	UNHCR	SA-04	VG	SS[5]	AID	TP,CLRT	NP	Yes	Yes	NO	ST	W
5	SA	UNHCR	SA-05	VG	WT[4]	AID	TP,CLRT	NP	Yes	Yes	VFT	ST	W
6	SB	MEDAIR	SB-01	VG	AT	AID	TP,CLRT	NP	Yes	Yes	VFT	ST	W
7	SB	MEDAIR	SB-02	VG	CM	AID	TP,CLRT	NP	Yes	Yes	VFT	ST	W
8	SB	MEDAIR	SB-03	VG	AT	AID	TP,CLRT	NP	Yes	Yes	VFT	ST	W
9	SB	MEDAIR	SB-04	VG	AT	AID	TP,CLRT	NP	Yes	Yes	VFT	ST	W
10	SB	MEDAIR	SB-05	VG	AT	AID	TP,CLRT	NP	Yes	Yes	VFT	ST	W

(1) Very good especially considering the funding limitations and the numbers (2) Community mobiliser (3) Assessment team (4) WASH team (5) Shelter Support (6) Trained personnel always present on site (7) Coordination with local emergency response teams (8) No preferences (9) Very few times
(10) Security teams handle it according to international procedure (11) Always welcome

Table 32 Table showing collected data from the staff for the questions of "Organization (CO)"

#	data			Answers								
				Current situation (C)								
	location	Agency	code	Social life (S)								
				CS1	CS1.1	CS1.2	CS1.3	CS1.4	CS2	CS3	CS3.1	CO4
1	SA	UNHCR	SA-01	YES	YES	S[1]	VC[2]	YES[3]	YES[4]	S	YES	O[5],Se
2	SA	UNHCR	SA-02	YES	YES	S	VC	YES	YES	S	YES	Se[6]
3	SA	UNHCR	SA-03	YES	YES	S	VC	YES	YES	S	YES	Se
4	SA	UNHCR	SA-04	YES	YES	S	VC	YES	YES	S	YES	O,Se
5	SA	UNHCR	SA-05	YES	YES	S	VC	YES	YES	S	YES	O,Se
6	SB	MEDAIR	SB-01	YES	YES	S	VC	YES	YES	S	YES	O,Se
7	SB	MEDAIR	SB-02	YES	YES	S	VC	YES	YES	S	YES	O,Se
8	SB	MEDAIR	SB-03	YES	YES	S	VC	YES	YES	S	YES	Se
9	SB	MEDAIR	SB-04	YES	YES	S	VC	YES	YES	S	YES	Se
10	SB	MEDAIR	SB-05	YES	YES	S	VC	YES	YES	S	YES	O,Se

(1) Sometimes (2) Very close, like a family (3) There is always a group that volunteers to stay and do an event for refugees (4) From the refugee's part
(5) Office hours (6) Settlement

Table 33 Table showing collected data from the staff for the questions of "Social life (CS)"

#	data			Answers						
	location	Agency	code	Current situation (C)						
				Education (V)						
				CV1	CV2	CV3	CV3.1	CV3.2	CV3.3	CV4
1	SA	UNHCR	SA-01	YES	PM(1), TL	NO	NO	NO	DNA(3)	YES
2	SA	UNHCR	SA-02	YES	PM, TL(2)	NO	NO	NO	DNA	YES
3	SA	UNHCR	SA-03	YES	PM, TL	NO	NO	NO	DNA	YES
4	SA	UNHCR	SA-04	YES	PM, TL	NO	NO	NO	DNA	YES
5	SA	UNHCR	SA-05	YES	PM, TL	NO	NO	NO	DNA	YES
6	SB	MEDAIR	SB-01	YES	PM, TL	NO	NO	NO	DNA	YES
7	SB	MEDAIR	SB-02	YES	PM, TL	NO	NO	NO	DNA	YES
8	SB	MEDAIR	SB-03	YES	PM, TL	NO	NO	NO	DNA	YES
9	SB	MEDAIR	SB-04	YES	PM, TL	NO	NO	NO	DNA	YES
10	SB	MEDAIR	SB-05	YES	PM, TL	NO	NO	NO	DNA	YES

(1) Project manager (2) Team leader (3) Does not apply

Table 34 Table showing collected data from the staff for the questions of "Education (CV)"

#	data			Answers					
	location	Agency	code	Current situation (C)					
				Safety (Sa)					
				Csa1	Csa1.1	Csa2	Csa2.1	Csa2.2	Csa2.3
1	SA	UNHCR	SA-01	YES	DNA(1)	S(2)	ST(3)	NO	R(4)
2	SA	UNHCR	SA-02	YES	DNA	S	ST	NO	R
3	SA	UNHCR	SA-03	YES	DNA	S	ST	NO	R
4	SA	UNHCR	SA-04	YES	DNA	S	ST	NO	R
5	SA	UNHCR	SA-05	YES	DNA	S	ST	NO	R
6	SB	MEDAIR	SB-01	YES	DNA	S	ST	NO	R
7	SB	MEDAIR	SB-02	YES	DNA	S	ST	NO	R
8	SB	MEDAIR	SB-03	YES	DNA	S	ST	NO	R
9	SB	MEDAIR	SB-04	YES	DNA	S	ST	NO	R
10	SB	MEDAIR	SB-05	YES	DNA	S	ST	NO	R

(1) Does not apply (2) Sometimes (3) Security team is in constant coordination with the local authorities to ensure the safety of everyone (4) Mostly refugees handle these problems

Table 35 Table showing collected data from the staff for the questions of "Safety (CSa)"

#	data			Answers		
	location	Agency	code	Current situation (C) Personal Evaluation (PE)		
				CPE1	CPE2	CPE3
1	SA	UNHCR	SA-01	VG[1]	S[2]	H[4]
2	SA	UNHCR	SA-02	VG	T[3]	H
3	SA	UNHCR	SA-03	VG	T	VL[5]
4	SA	UNHCR	SA-04	VG	S	H
5	SA	UNHCR	SA-05	VG	T	H
6	SB	MEDAIR	SB-01	VG	T	VL
7	SB	MEDAIR	SB-02	VG	S	H
8	SB	MEDAIR	SB-03	VG	T	H
9	SB	MEDAIR	SB-04	VG	T	H
10	SB	MEDAIR	SB-05	VG	T	H

(1) Very good especially considering the funding limitations and the high numbers (2) Safe (3) Temporary (4) Helping out the needed (5) Visiting Lebanon

Table 36 Table showing collected data from the staff for the questions of "Personal Evaluation (CPE)"

#	data			Answers			
	location	Agency	code	Current situation (C) What is lacking in the camp? (W)			
				CW1	CW1.1	CW1.2	CW1.2
1	SA	UNHCR	SA-01	F[1]	Sh[2],Q,PF	I[5],F	I,F,Sh,Q,PF
2	SA	UNHCR	SA-02	F	Sh,Q[3],PF	I,F[6]	I,F,Sh,Q,PF
3	SA	UNHCR	SA-03	F	Sh,Q,PF[4]	I,F	I,F,Sh,Q,PF
4	SA	UNHCR	SA-04	F	Sh,Q,PF	I,F	I,F,Sh,Q,PF
5	SA	UNHCR	SA-05	F	Sh,Q,PF	I,F	I,F,Sh,Q,PF
6	SB	MEDAIR	SB-01	F	Sh,Q,PF	I,F,L[7]	I,L,F,Sh,Q,PF
7	SB	MEDAIR	SB-02	F	Sh,Q,PF	I,F,L	I,L,F,Sh,Q,PF
8	SB	MEDAIR	SB-03	F	Sh,Q,PF	I,F,L	I,L,F,Sh,Q,PF
9	SB	MEDAIR	SB-04	F	Sh,Q,PF	I,F,L	I,L,F,Sh,Q,PF
10	SB	MEDAIR	SB-05	F	Sh,Q,PF	I,F,L	I,L,F,Sh,Q,PF

(1) Funding (2) Showers (3) Quantities (4) Protection from fluddings (5) Infrastructure (6) Fences (7) Lights

Table 37 Table showing collected data from the staff for the questions of "What is lacking in the camp? (CW)"

#	data			Answers								
	location	Agency	code	PHASE II (PH)								
				PH1	PH2	PH3	PH4	PH5	PH6	PH7	PH8	PH9
1	SA	UNHCR	SA-01	YES	YB(1)	S(2)	LAST	SO(3)	YES	YES	Sch,Cl,Au(6)	AYL(7)
2	SA	UNHCR	SA-02	YES	YB	S	LAST	SO	YES	YES	Sch(4)	AYL
3	SA	UNHCR	SA-03	YES	YB	S	LAST	SO	YES	YES	Sch,Cl(5)	AYL
4	SA	UNHCR	SA-04	YES	YB	S	LAST	SO	YES	YES	Sch,Cl	AYL
5	SA	UNHCR	SA-05	YES	YB	S	LAST	SO	YES	YES	Sch,Cl	AYL
6	SB	MEDAIR	SB-01	YES	YB	S	LAST	SO	YES	YES	Cl	AYL
7	SB	MEDAIR	SB-02	YES	YB	S	LAST	SO	YES	YES	Sch,Cl,Au	AYL
8	SB	MEDAIR	SB-03	YES	YB	S	LAST	SO	YES	YES	Cl,Au	AYL
9	SB	MEDAIR	SB-04	YES	YB	S	LAST	SO	YES	YES	Cl	AYL
10	SB	MEDAIR	SB-05	YES	YB	S	LAST	SO	YES	YES	Sch,Cl,Au	AYL

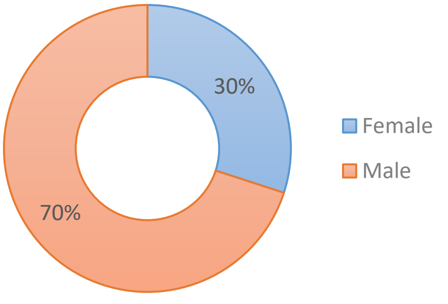
(1) Yes, but other things seem more prior (2) If structure is simpler it would better (3) Socially (4) Schools (5) Doctor clinics (6) Auditorium for trainings (7) All year long

Table 38 Table showing collected data from the staff for the questions of "PHASE II (PH)"

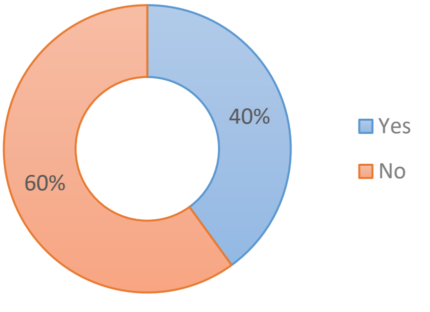
Charts showing the data analysis:

Background questions:

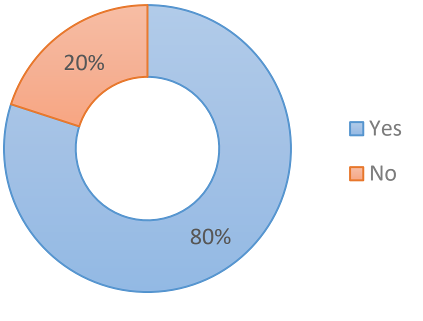
- Gender of participants:



- Speaks Arabic:

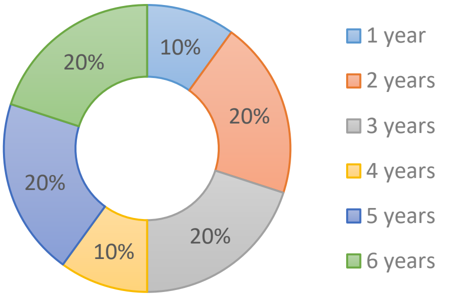


- Understands Arabic:

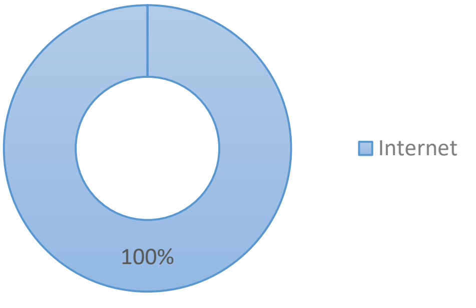


History in the camp: (H)

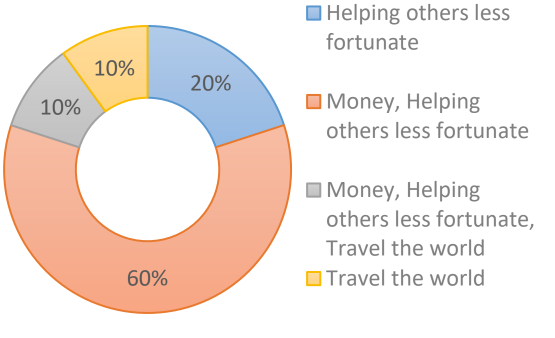
- How long have you been here? (H1)



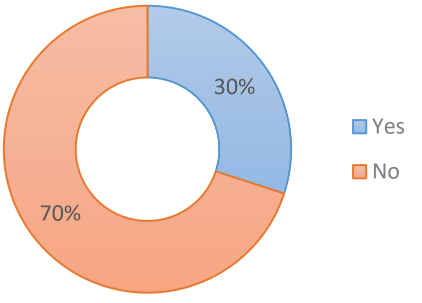
- How did you know about this job? (H2)



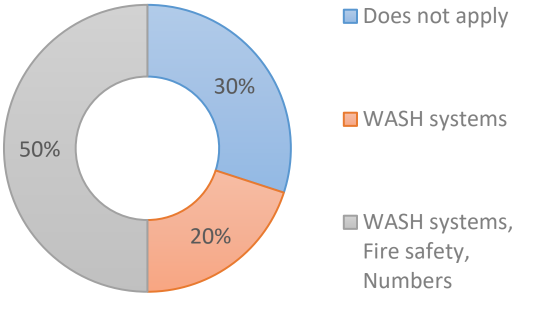
- What did you hope to gain from this job? (H3)



- Has the camp evolved since you first came? (H4)



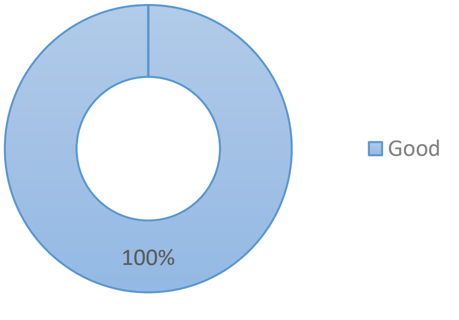
  - What has changed since you first came here? (H4.1)



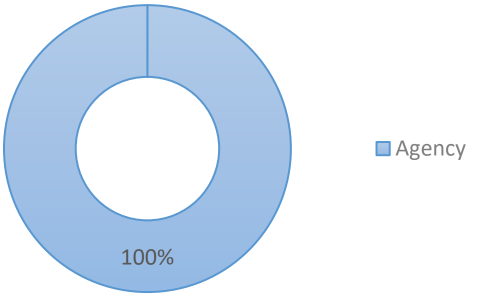
Current situation: (group into subgroups) (C)

Hygiene (Hy)

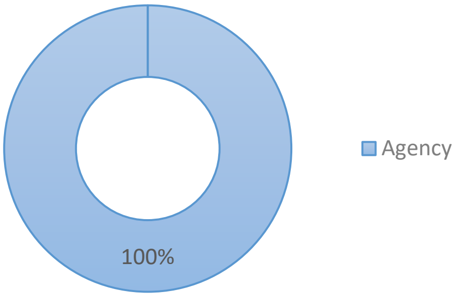
- How would you describe the hygiene situation? (CHy1)



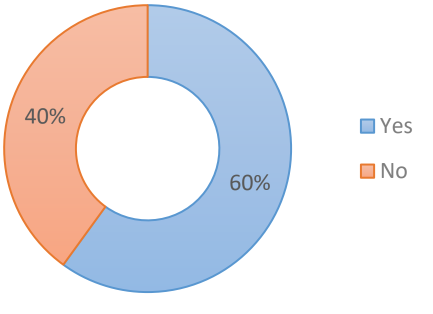
- Where do you get your water from? (CHy1.1)



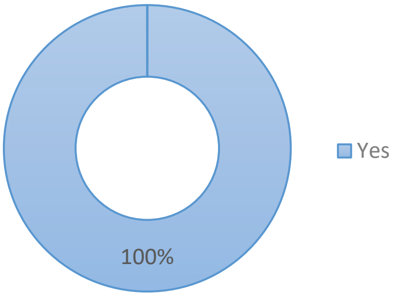
- Who provides the food? (CHy2)



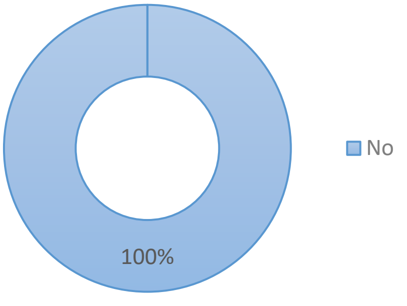
- Do you sometimes share meals with the refugees? (CHy2.1)



- Do you guys have private toilets on site? (CHy3)

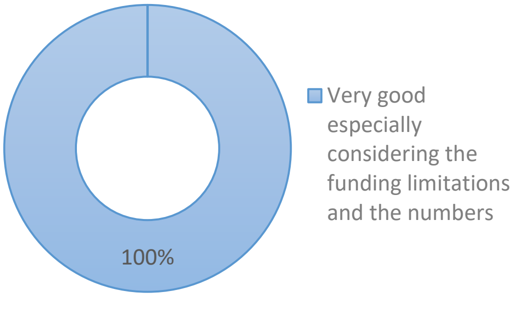


  - Do the refugees trespass? (CHy3.1)

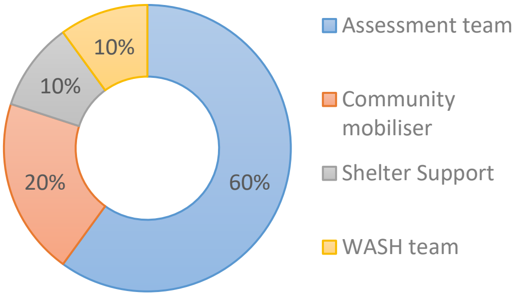


Organization (O)

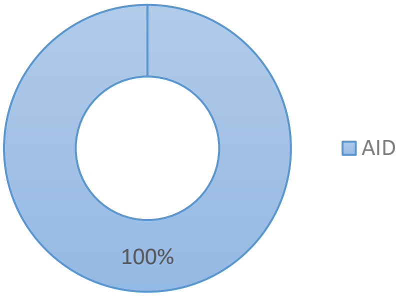
- What do you think about the camp's organization? (CO1)



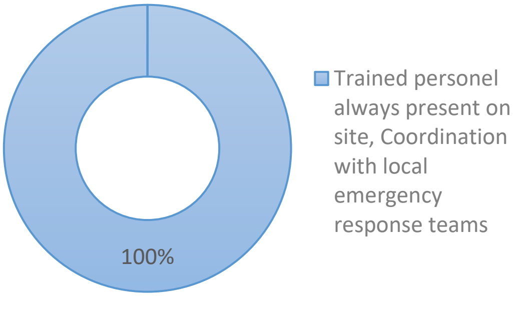
- What is your role in the camp organization? (CO1.1)



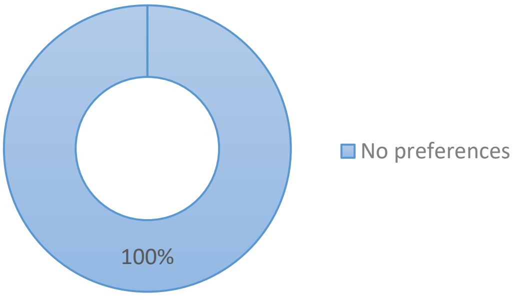
- How do you ensure main life requirements for the refugees? (CO2)



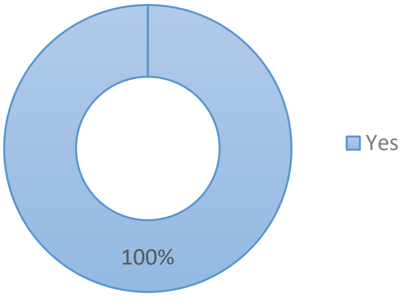
- What do you do in case of a medical emergency? (CO3)



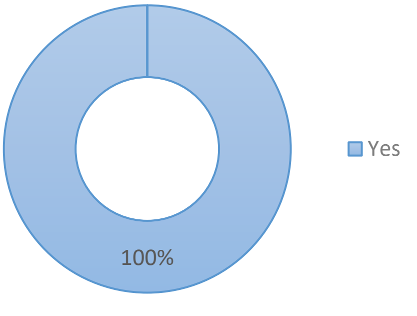
- Are there preferences or is everyone treated in the same way? (CO4)



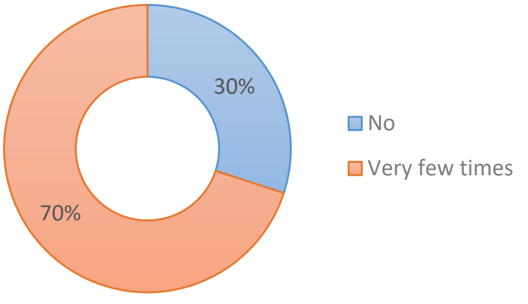
- Do you have to do some field work? (CO5)



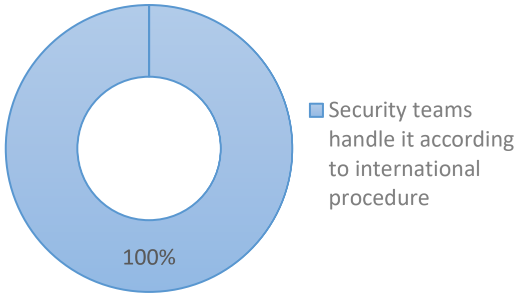
  - Do you have to do handwork? (CO5.1)



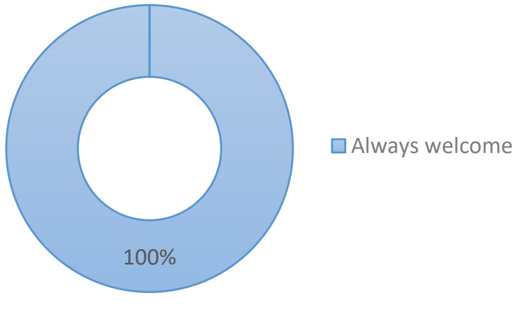
- Do you find problems applying authority? (CO6)



  - How do you solve riots? (CO6.1)

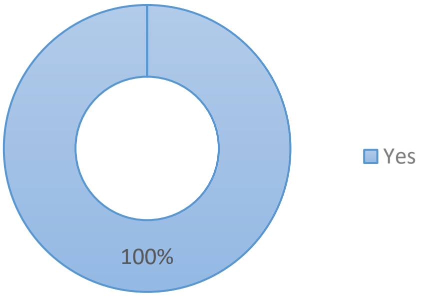


  - How do you handle critics? (CO6.2)

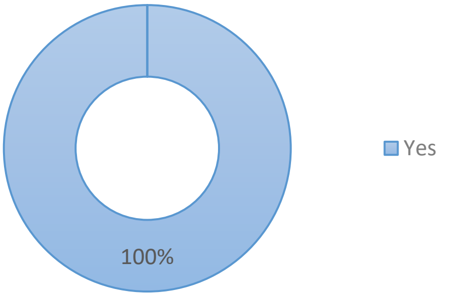


Social life (S)

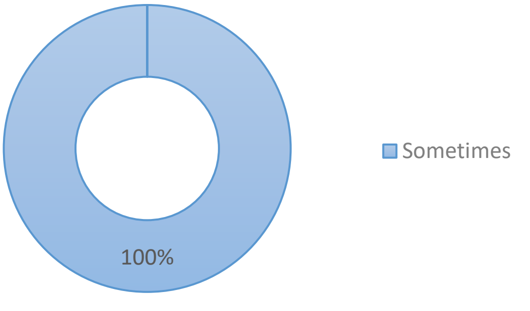
- Do you live nearby? (CS1)



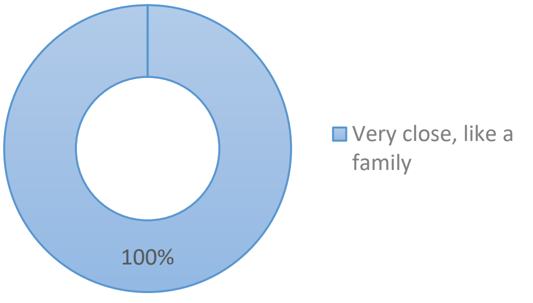
  - Do you feel like going to work? (CS1.1)



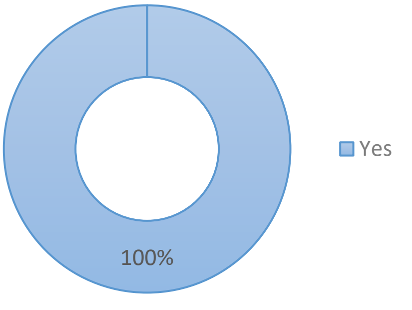
  - Does it seem like volunteering? (CS1.2)



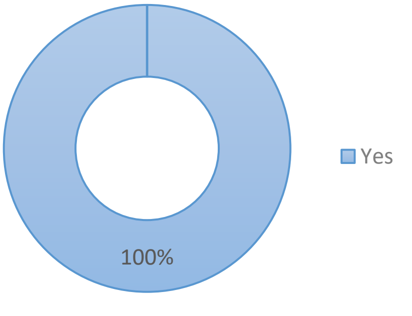
- How is the social life in the office? (CS1.3)



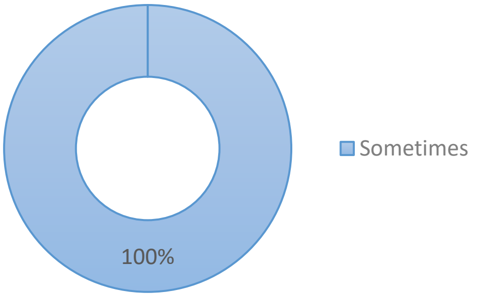
- Do you get along with the others? (CS1.4)



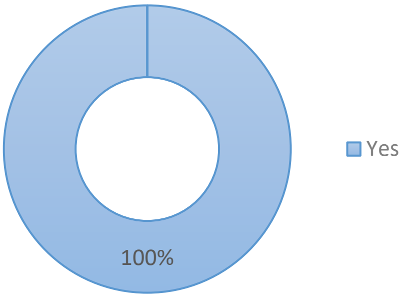
- During the festivities, is there anything special being done? (CS2)



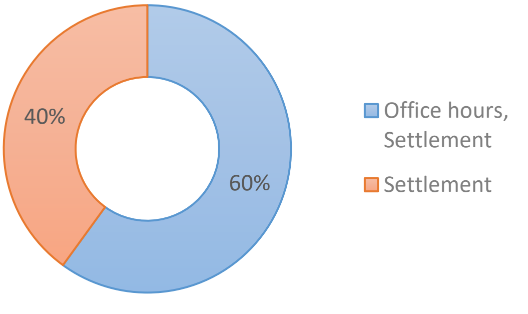
- Are there any religion conflicts between you and the refugees? (CS3)



    - Are you used to being in a multicultural environment? (CS3.1)

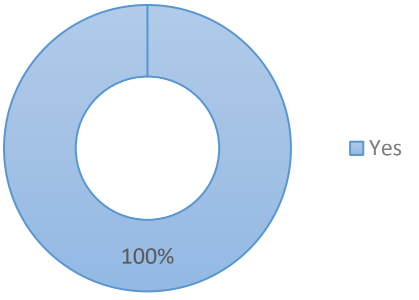


- Can you describe your typical day at work? (CS4)

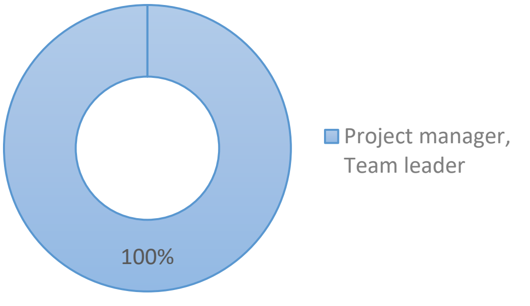


Volunteering (V)

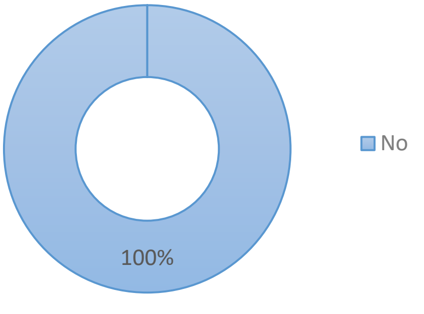
- Are there a lot of volunteers here? (CV1)



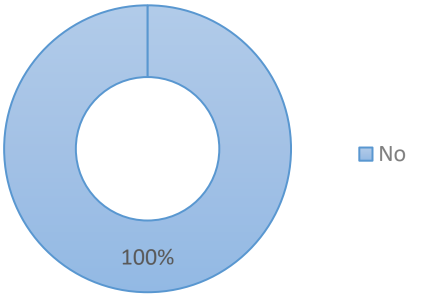
- Who assigns the chores? (CV2)



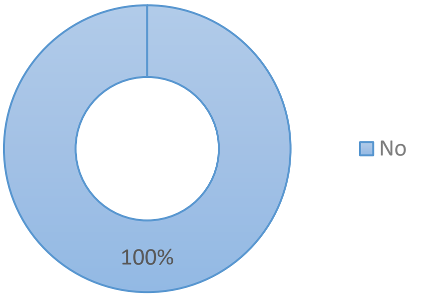
- Is there any conflict amongst volunteers and refugees? (CV3)



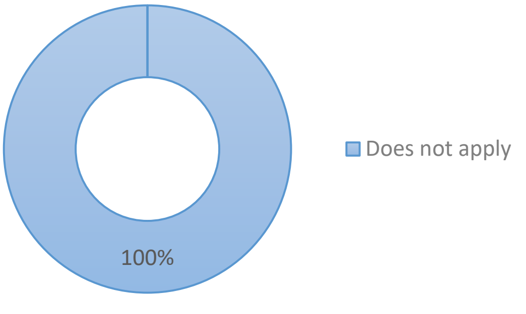
- Amongst the volunteers themselves? (CV3.1)



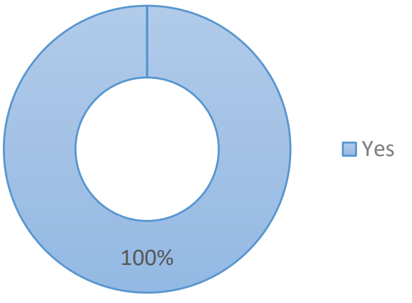
- Amongst the volunteers and the organizers? (CV3.2)



- And in case of yes, how are the conflicts resolved? (CV3.3)

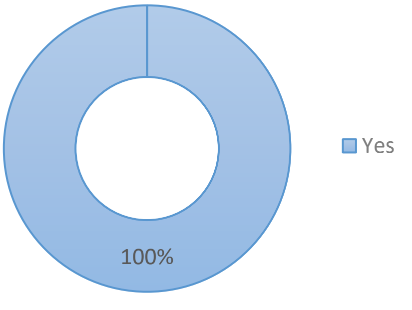


- Is the role that the volunteers play essential in your opinion? (CV4)

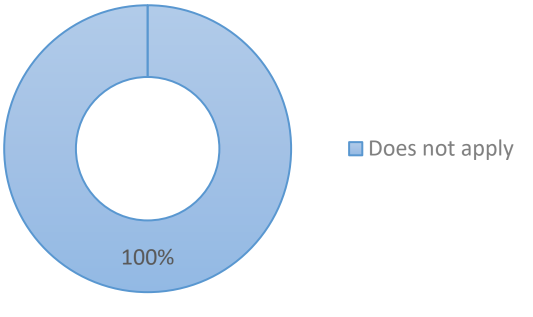


Safety (Sa)

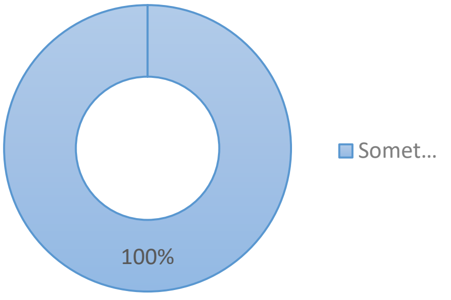
- Do you feel safe? (CSa1)



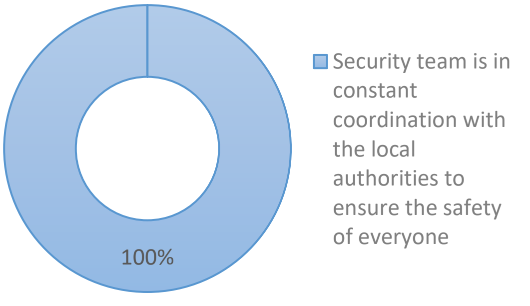
  - If not, what is the main reason for that? (CSa1.1)



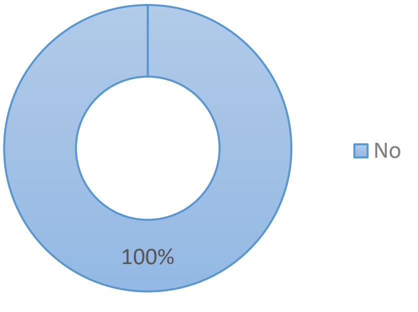
- Were there any security problems? (CSa2)



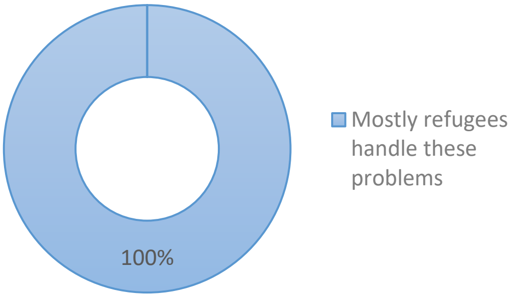
  - How do you deal with the threat of terrorist cells living in the settlements? (CSa2.1)



  - Do you work during the night? (CSa2.2)

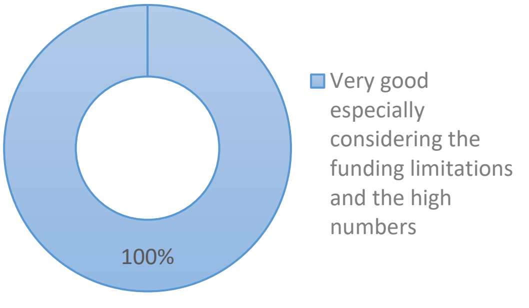


- Do you deal with any animal presence inside the settlements? (CSa2.3)

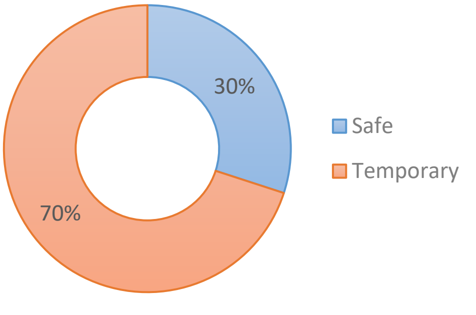


Personal Evaluation (PE)

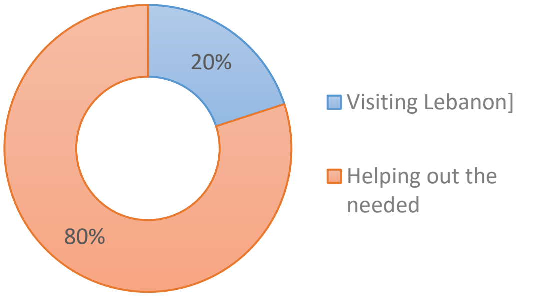
- If you had to evaluate the work done here, what would you say? (CPE1)



- If you could define life in the settlements in 1 word, what would it be? (CPE2)

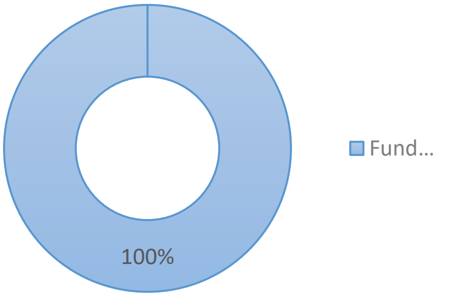


- If you had to choose something positive you gained from this experience what would it be? (CPE3)

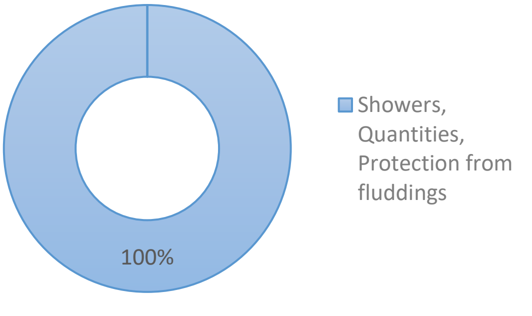


What is lacking in the camp? (W)

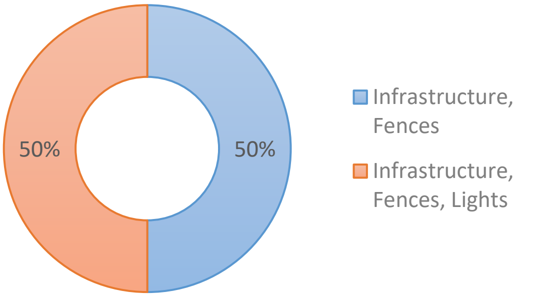
- What do you think lacks in this camp? (CW1)



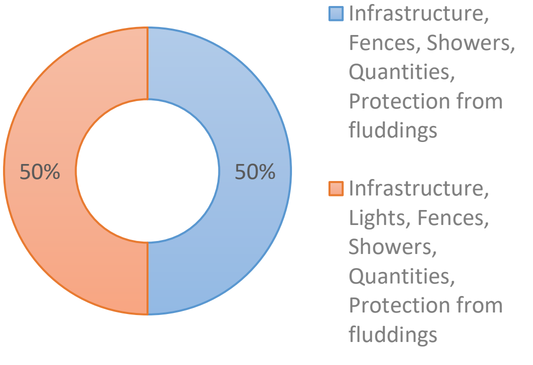
  - On a single unit scale (CW1.1)



- On an urban scale (CW1.2)

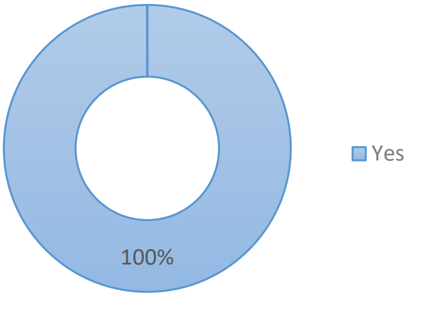


- Group them by priority, starting from the most essential. (CW1.3)

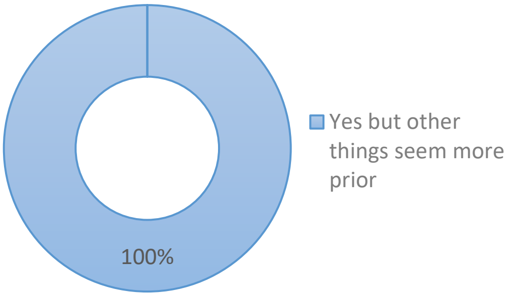


PHASE II (PH)

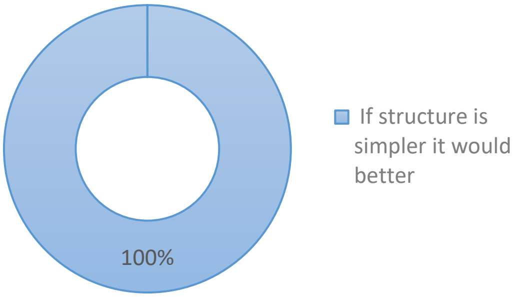
- Will it work? (Ph1)



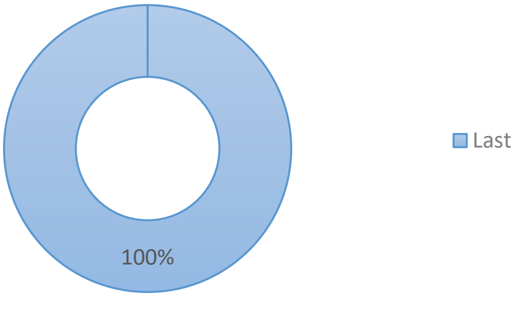
- Is it necessary? (Ph2)



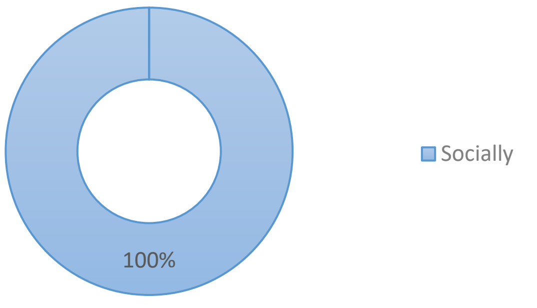
- Any modifications come up to mind? (Ph3)



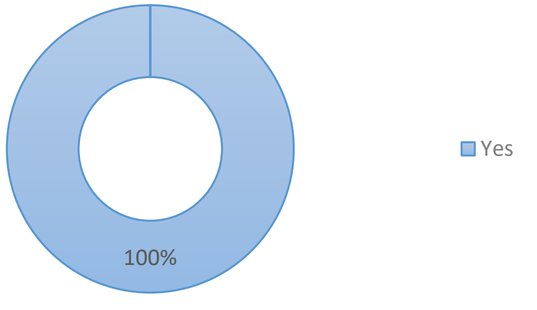
- Where does it fit in your priority list? (Ph4)



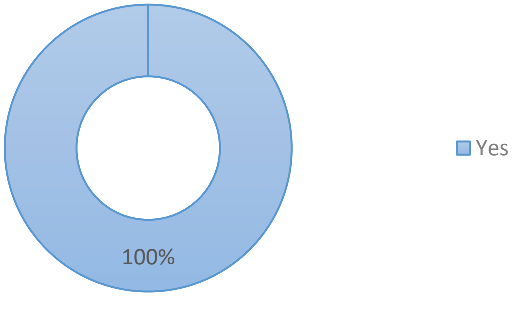
- In what way do you think it would help out the most? (Ph5)



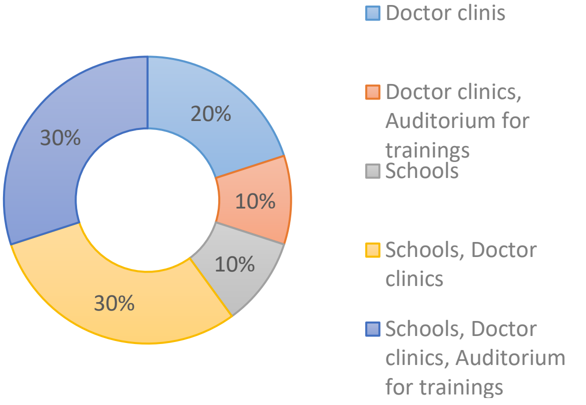
- Do you think we will be able to find support from the refugees? (Ph6)



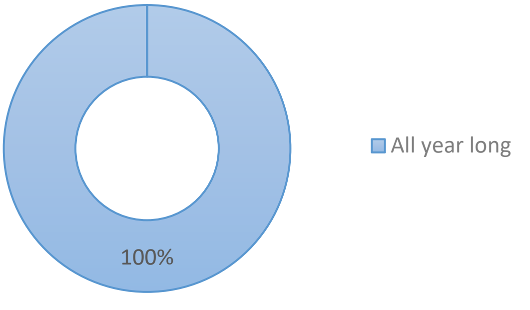
- Were there volunteers for similar past projects? (Ph7)



- What do you think are the most important activities to put in this multifunctional project? (Ph8)



- In what season do you think it our project will be most crucial (Ph9)



<u>Table summarizing the chart results:</u>

Question	Results					
Gender of participants:	Male	Female				
%	70	30				
Speaks Arabic	Yes	No				
%	40	60				
Languages spoken	One	More				
%	80	20				
Understands Arabic	Yes	No				
%	80	20				
How long have you been here?	1 Year	2 Years	3 Years	4 Years	5 Years	6 Years
%	10	20	20	10	20	20
How did you know about this job?	Internet					
%	100					
What did you hope to gain from this job?	Helping others less fortunate	Money, Helping others less fortunate	Money, Helping others less fortunate, Travel the world	Travel the world		
%	20	60	10	10		
Has the camp evolved since	Yes	No				

you first came?						
%	30	70				
What has changed since you first came here?	Does not apply	WASH systems	WASH systems, Fire Safety, Numbers			
%	30	20	50			
How would you describe the hygiene situation?	Good					
%	100					
Where do you get your water from?	Agency					
%	100					
Who provides the food?	Agency					
%	100					
Do you sometimes share meals with the refugees?	Yes	No				
%	60	40				
Do you guys have private toilets on site?	Yes					
%	100					

Do the refugees trespass?	No						
%	100						
What do you think about the camp's organization?	Very good, especially considering the funding limitations and the numbers						
%	100						
What is your role in the camp organization?	Assessment team	Community mobiliser	Shelter Support	WASH team			
%	60	20	10	10			
How do you ensure main life requirements for the refugees?	AID						
%	100						
What do you do in case of a medical emergency?	Trained personnel always present on site, Coordination with local emergency response team						
%	100						

Are there preferences or is everyone treated in the same way	No preferences						
%	100						
Do you have to do some field work?	Yes						
%	100						
Do you have to do handwork?	Yes						
%	100						
Do you find problems applying authority?	No	Very few times					
%	30	70					
How do you solve riots?	Security teams handle it according to international procedure						
%	100						
How do you handle critics?	Always welcome						
%	100						
Do you live nearby?	Yes						
%	100						
Do you feel like going to work?	Yes						

%	100						
Does it seem like volunteering?	Sometimes						
%	100						
How is the social life in the office?	Very close, like a family						
%	100						
Do you get along with the others?	Yes						
%	100						
uring the festivities, is there anything special being done?	Yes						
%	100						
Are there any religion conflicts between you and the refugees?	Sometimes						
%	100						
Are you used to being in a multicultural environment?	Yes						
%	100						
Can you describe your	Office hours, Settlement	Settlement					

typical day at work?						
%	60	40				
Are there a lot of volunteers here?	Yes					
%	100					
Who assigns the chores?	Project manager, Team leader					
%	100					
Is there any conflict amongst volunteers and refugees?	No					
%	100					
Amongst the volunteers themselves?	No					
%	100					
Amongst the volunteers and the organizers?	No					
%	100					
And in case of yes, how are the conflicts resolved?	Does not apply					
%	100					
Is the role that the volunteers	Yes					

play essential in your opinion?						
%	100					
Do you feel safe?	Yes					
%	100					
If not, what is the main reason for that?	Does not apply					
%	100					
Were there any security problems?	Sometimes					
%	100					
How do you deal with the threat of terrorist cells living in the settlements?	Security team is in constant coordination with local authorities to ensure the safery of everyone					
%	100					
Do you work during the night?	No					
%	100					
Do you deal with any animal presence	Mostly refugees handle these problems					

inside the settlements?						
%	100					
If you had to evaluate the work done here, what would you say?	Very good, especially considering the funding limitations and the numbers					
%	100					
If you could define life in the settlements in 1 word, what would it be?	Safe	Temporary				
%	30	70				
If you had to choose something positive you gained from this experience what would it be?	Visiting Lebanon	Helping out the needed				
%	20	90				
What do you think lacks in this camp?	Funding					
%	100					
On a single unit scale	Showers, Quantities, Protection					

	from fluddings					
%	100					
On an urban scale	Infrastructure, Fences	Infrastructure, Fences, lights				
%	50	50				
Group them by priority, starting from the most essential.	Infrastructure, Fences, Showers, Quantities, Protection from fluddings	Infrastructure, Lights, Fences, Showers, Quantities, Protection from fluddings				
%	50	50				
Will PHASE II work?	Yes					
%	100					
Is it necessary?	Yes but other things seem more prior					
%	100					
Any modifications come up to mind?	If structure is simpler it would be better					
%	100					
Where does it fit in your priority list?	Last					
%	100					
In what way do you think it	Socially					

would help out the most?							
%	100						
Do you think we will be able to find support from the refugees?	Yes						
%	100						
Were there volunteers for similar past projects?	Yes						
%	100						
What do you think are the most important activities to put in this multifunctional project?	Doctor clinics	Doctor clinis, Auditorium for trainings	Schools	Schools, Doctor clinics	Schools, Doctor clinics, Auditorium for trainings		
%	20	10	10	30	30		
In what season do you think it our project will be most crucial	All year long						
%	100						

Table 39 Table summarizing the chart results

2.3.3. Focus Groups results:

Aside from the interview with the staffs, a focus group with members of the NGO was conducted, during which the entire roles of the organization were covered in an attempt to better enlighten where the NGOs intervene.

The discussion was held at their premises for a duration of 30 min during which the following was highlighted:

- The NGO deals with the distribution of tents and their construction.
- It cooperates directly with the municipality and not with the government.
- In 2014, it distributed 125 tents, while in 2015 only 20 and things seem to be to worsening
- With the scarcity of resources, a proposal to join the different funds of different NGOs under the name of one was presented and that was how URDA was created.
- URDA works directly with the UN in search of important commitments and resolutions. It was an attempt to convince the Lebanese government to allow the usage of relocatable demountable housing which would create up until decommission a better quality of life for the refugees

Figure 33 Picture showing URDA's proposed shelters- view 01[45]

Figure 34 Picture showing URDA's proposed shelters- view 02[46]

[45] Pictures taken from the site of the housing units proposed without being populated yet.
[46] Ibid.

Figure 35 Picture showing URDA's proposed shelters- view 03[47]

The main current work of the NGO is:

- Improvement of settlements.
- Distribution of different kits
- Training for refugees
    - How to Use the different Kits
    - Extinction of fire
    - How to have hot water with electricity in order to avoid the usual gas use in order to avoid major damage
- Distribution and/or construction of tents
- Social work with the refugees, mainly with children.
- Opening and managing health clinics
- Participation in the civil community, CSMC collective management committee[48]

[47] Pictures taken from the site of the housing units proposed without being populated yet.
[48] More detailed information on the placement of objects found on site

The composition of the NGO is as follows:

- Community Mobilizers
    - They are in constant dialogue with the community to improve work, reduce distances, and avoid cultural confrontation issues.
- Evaluation teams
    - The first to come on site in case of problems
    - They analyze problems and assign the problem to the appropriate team.
    - They take photos and collect all necessary information to properly prepare the assigned team
- Mapping team
    - They are concerned with creating a map of all informal settlements
        - Especially that the refugees keep creating new illegal settlements that require constant monitoring
        - Coordinate with other agencies
- Technical teams
    - They handle the Database
- CASH Team
    - They deal mainly with refugees residing in SUB-STANDARD buildings
- WASH team
    - They handle the implants and the infrastructure

"https://www.medair.org/what-we-do/lebanon/"(March 2020)

2.4.Refugees in Europe:

Alongside what was said before, a minor site study was performed in various countries Europe in order to compare the difference situations.

According to Eurostat, in 2015 Europa has around 1.321.560, asylum claims located as per the below picture:

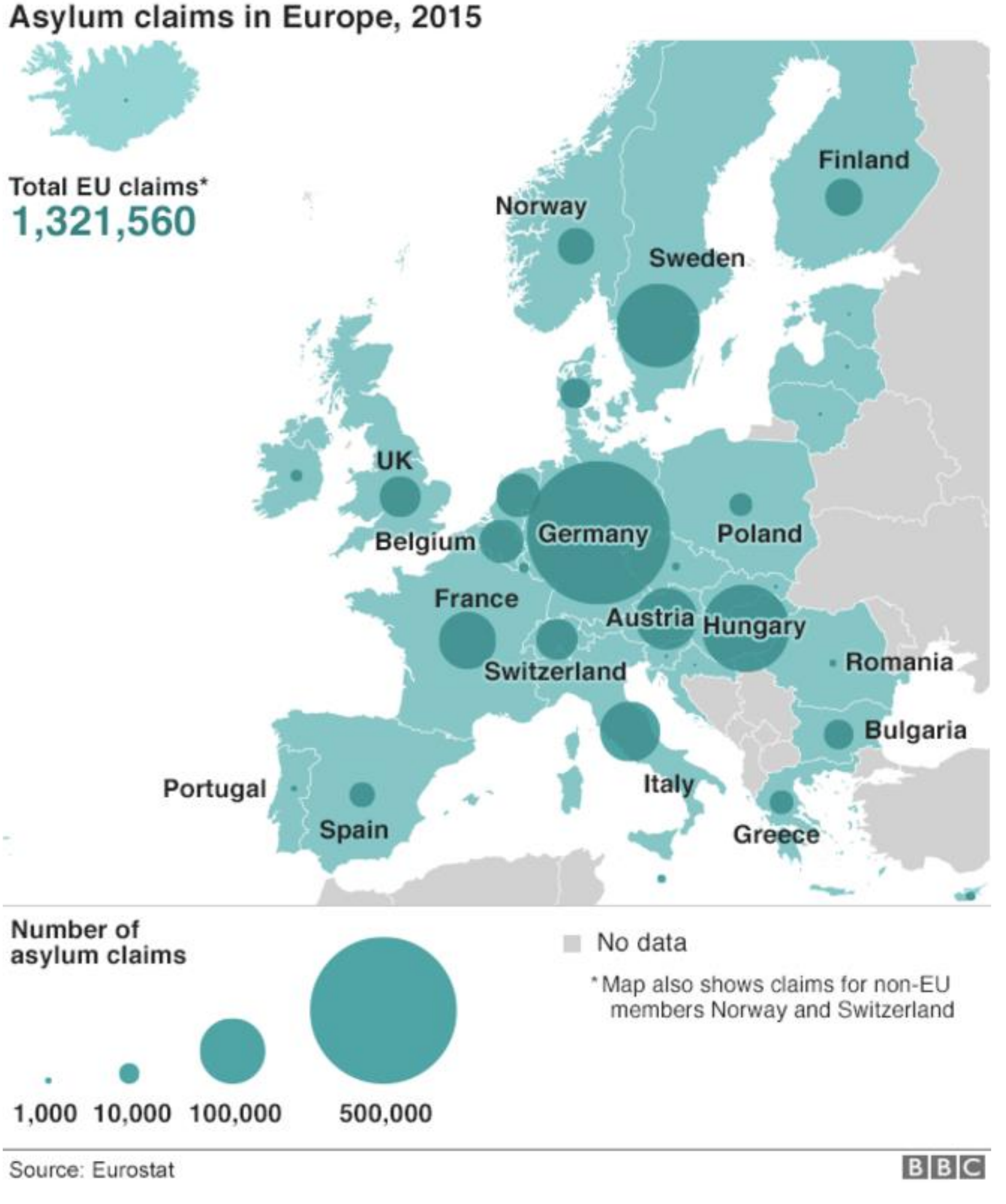


Figure 36 Picture showing the distribution of asylum claims in Europa in 2015

Italy

The study took place also back in 2015 directly after the site visits in Lebanon in an attempt to compare both levels during the same timeframe. It was conducted in three main countries: Italy, Germany and France.

In Italy, the study was conducted in the northern city of Turin, and more specifically in their Olympic city. During the 2006 winter Olympics the city hosted by turin, there was an entire area built to host the media staff as well as the athletes. After the end of the games, that area was abandoned with parts of it sold to privates as well a big area decommissioned and left to be used in big events. For a period of time some of these buildings were used as student residence. But with the European decision to open their borders to host refugees, these areas were reassigned for the refugees.

These modern buildings were fully equipped and sadly during the visit of 2015 it was noticed that they were left in a very bad condition due to the irresponsibility or unawareness of the refugees.

It is to be noted that these houses were not exclusive to the Syrian refugees but also for others which also created conflicts due to cultural differences.

Figure 37 Picture showing the Olympic village – view 01[49]

Figure 38 Picture showing the Olympic village – view 02[50]

49 https://torino.repubblica.it/cronaca/2016/08/03/news/la_sindaca_promette_svuoteremo_le_ex_case_del_villaggio_olimpico_senza_le_ruspe_-145278855/(March 2020)

50 https://www.lastampa.it/torino/quartieri/lingotto/2019/10/01/news/camerana-alla-fine-dei-giochi-le-case-degli-atleti-potevano-essere-vendute-al-quadruplo-1.37598469(March 2020)

Figure 39 Picture showing the Olympic village during the games[51]

51 https://www.agi.it/cronaca/olimpiadi_invernali_giochi_torino_2026_opere_abbandonate-3628316/news/2018-03-14/(March 2020)

Figure 40 Picture showing the Olympic village in 2015 after the refugees arrived - view 01[52]

Figure 41 Picture showing the Olympic village in 2015 after the refugees arrived - view 02[53]

[52] http://www.ansa.it/sito/notizie/topnews/2019/03/11/ex-moi-torino-si-sgombera-palazzina-blu_de363ac7-e968-4a14-8e66-fcb42d06d399.html(March 2020)
[53] https://www.lumsanews.it/torino-inziato-lo-sgombero-dellex-villaggio-olimpico/(March 2020)

Germany

In Germany, the study was performed in the northwestern area of Germany near the city of Aachen. During a 1 month stay there, many differences were noted with the situation in Lebanon:

- The first and most important one, is the difference between controlled and uncontrolled immigration
- In the first, people receive the immigrants with affection and in a positive vibe.
- The preparation for their stay is done beforehand rendering their arrival easier and more reassuring
- No pressure is felt by everyone involved, from refugees to organizers to hosting cities
- Number of refugees studied in order not to influence the lifestyle of the camp areas
- Background checks and filtering of the bad elements infiltrated within the refugees, which has led to a safer environment within the settlements

In Germany, the country adopted a two-step plan with the objective of turning these refugees from a burden to an asset:

- Step 1: Receive them in determined camps
- Step 2: Slowly encourage them to blend in the society through a determined plan

The idea is that once relieved and settled in the camps, the staff starts to introduce the families to the German culture and after a determined period of time, depending on a case by case status, the government would then help them move into the cities into apartments and assign to each of them a job based on their interests and availability.

Figure 42 Picture showing how the Germans welcomes the refugees[54]

Figure 43 Picture showing how grateful the refugees were upon their arrival[55]

[54] https://www.theguardian.com/world/2015/sep/02/refugees-welcome-uk-germany-compare-migration(March 2020)
[55] https://syrianobserver.com/EN/features/54579/germany-syrian-refugees-face-new-restrictions.html(March 2020)

France, Germany and the terrorist cells

Whether it was due to hard luck or not, I was located in France and in Germany during 2 terrorist attacks.

First it was during the 2015 attacks in Paris, while I was visiting a friend and ended up staying for 2 weeks. It was during that attack that ISIS had declared its arrival to Europe putting with in doubt the screening process that was performed by the European border control teams.

Later on that year, in an attempt to flee from the targeted big cities at the time, during the New Year's Eve of 2015, I was in Munich in Germany, where at midnight alarms were sound due to a possible bomb threat received and witnessed first hand, the panic in the plazas.

These events were brought up, since sadly they also created a new situation within the Europeans and the number of refugees given Asylum was reduced with the ever-growing opposition to it from the hurt societies as well as the extremists in each country.

In some countries, calls to send the refugees back to their countries were being called for but thankfully they were met with rejection. But due to the events of the terrorist cells in Europe, racism grew and it could be noted everywhere from big social events to the small house parties.

This matter remains far from resolved and in end it has resulted to the creation of two opposing points of views:

- Those demanding the refugees being sent back to their countries
- Those who are demanding the countries help out the Syrians having felt a small piece of the horror they are living in their countries.

2.5.Guidelines for the project

It is important to point out that the interviews and site visits were done according to the international and UNHCR standards in order to remain as professional as possible and getting the desired results while respecting the refugees.

The most relevant conclusion that can be extracted from the site visits is the confirmation of the poor conditions of the informal settlements and the lack of public space or common areas making the social life in the IF limited to the tents of the outdoor.

Through the interviews, it was possible to reach the following conclusions which can be relevant to the project of this thesis:

Regarding their background:

- As it was expected, the settlements aided by the UNHCR are more organized and better equipped than those of the NGOs, who due to funding limitations put all their focus by prioritizing the most essential.
- The biggest barrier remains the language one, as it distances the humanitarian activists from the refugees. The interviews have shown that most of the refugees spoke only their native language.
- Due to the Arabic Muslim culture, the women are still a bit more distant than the men.

Regarding the history in the settlement:

- The primary objective of seeking a roof within the first 48 hours was confirmed during the research.
- Large numbers of refugees affect that data drastically as it took some refugees up to 6 days to get tent and 12 days to settle in.

Although during these periods they were hosted by friends or families in their already overpopulated tents

- Most of the refugees tend to feel safe only when having left the disaster area, so it would be advisable not to plan a camp of a settlement near the disaster area
- Most of the refugees wish to move on and start a new life rather than wait for the crisis to end and go back home, which is why it is crucial to maintain the idea that the settlements are temporary and avoid using materials that send mixed signals as was the case with the Palestinians.
- Informal settlements are highly dependent on aids and function with the same logic as an organized camp except that it does maintain its temporary status. This is a confirmation that the Lebanese government did handle this crisis better than the one with the Palestinians from that perspective.
- According to the refugees, the settlements have experienced slight to no evolving during the past 4 years aside from an increase in numbers, which shows the importance of adopting a strategy similar of the one proposed in this thesis. The majority of the agencies staff agree with the refugees but that depends on their roles. For instance, the WASH systems have seen radical change throughout the years but that is not something easily seen by the refugees.

Regarding the Hygiene:

- The hygiene situation seems to be good and the only problem exposed by the refugees are the shared bathing areas and they would have preferred something more private or within the single housing unit but they were grateful and did not nag about it considering their situation. It might be helpful to consider a bathing area within the structure with a locker like system for commodity.

- The biggest problem from a shelter design perspective is the WASH systems, and they can be highlighted as the biggest downside to the tents. It is entirely handled and monitored by the agencies and they encounter a big problem when it comes to connecting to the local network. Presenting a sustainable solution built within the structure could be studied.
- The agencies have special toilets reserved to them which the refugees respect and do not trespass. If the structures plans allow it, these toilets can be included within the structure.

Regarding the Organization:

- Refugees always willing to help and volunteer in case a project aims to make their life conditions better. This is a confirmation that the refugees can be used a manpower for the construction of the structure
- The winter season has been defined by all the refugees as the toughest and between the constant need for heating as well as the flooding their life gets really complicated and the workload on the agencies becomes incredibly high. The heating and cooling of the structure should be paid special attention as the bigger the structure is the more difficult achieving proper temperature will become.
- All the staff agrees that considering the numbers and the limited funding nothing more can be done. With the situation entering its 9th year the funders’ number are increasingly dropping and some

of the staff believe that such projects could get the necessary media attention to get the necessary funding.

- According to the staff, many medical emergencies require clinics be located on site but that cannot be achieved so far as the products cannot be left there for security reasons. As it stands the clinics are at the agencies' headquarters and therefore it would be much more effective if an area can be designated on site and in case of emergency the medical team arrives with the necessary equipment and treat them on site.

Regarding the Social life:

- In the study done it was highlighted that most of the refugees are hit when it comes to the social life and that is a founding point for this thesis' project. The improvement of the social life within these settlements should be paid more attention.
- During the festivities, the agencies go out of their way to try and help out by brightening up the mood and having big structures to accommodate these events would be extremely helpful.
- As it stands the youngsters have no common areas to have social encounter and meeting up on the streets, they always feel like they are being watched so the ambience is that of a closed society. The proposed structure can become a meeting point for the youngsters and render the social encounters possible.

Regarding the Education:

- It is hard for the refugees to seek education due to the lack of schools and in some cases lack of interest as they seek to work at a very early age. The adoption of a multipurpose structure for common areas could be used schools.

- There are no university refugees in the settlements, as it seems they managed to adapt better and faster than the others and find themselves an underpaid job in order to cover their expenses. The schools are destined for the kids mainly but some technical schools can be made for the adults which would give them needed expertise to be able to find work and start being independent again

Regarding the Work:

- The extremely high rate of unemployment is another factor that is affecting the social life of the refugees. The strict policies imposed by the Lebanese government have rendered it almost impossible for the Syrians to find job which on the other has led an extremely high cases of lost hope.
- These people have found themselves in a situation where they are not productive in life and have lost hope in looking for a job. By giving them things to do within these structures, they would be productive again even if they don’t get paid for it.

Regarding the Safety:

- On the other hand, safety is a factor that was expressed from all the refugees. So, the structures should be careful not to disrupt that factor.
- Adding lights in a camp at night seems to be highly regarded and should be considered in the structure presented in PHASE II.

Putting up strong projectors in a central position could fix this problem.

- Special security teams are constantly coordinating with the local authorities to ensure no terrorist cells are being harbored within the settlements. Having cameras installed around the structure with the purpose of securing it could provide to be useful in this fight.

Regarding what they feel is lacking in the settlements:

- On a single housing unit scale, all requests were about making things better and less about essential lacking. Priority was given to having showers and bathrooms within the single unit, but they understand it not being a priority for the agencies.
- On an urban scale, more common areas were requested by both the refugees and the staff members
- The staff believe everything can be solved with proper funding, including the proposed PHASE II as they state that in order to reach that point the funding has to be able to cover all primary needs beforehand. This is why the funding of these structures must be thought to come from different sources as to not conflict with the priorities.

Regarding Phase II:

- All the interviewees confirmed that they believe such a project will work and profit the refugees as well as the agencies
- Although almost everyone confirmed it is necessary a minority did point out that there are other things with higher priority. The priority scale has to be treated case by case.

- When asked about modifications, the multipurpose use of the structure received a lot of success with many of the refugees pointing out different uses for the structures. It is of course essential to best coordinate the purposes of the structure based each emergency type and situation.
- Many staff members were concerned by the design and advised that the structure be simpler and stronger.
- There was a difference in opinion as to the size of the project. Some thought it would be better to make it as big as possible while others thought it would be better to create something of a moderate scale and build more than one structure. This shows that the best solution is the create something moderate that can be complementary with other identical units to create a bigger structure.
- The majority of the refugees have put the project on top of their current priority list as they redeem the current social life being the heaviest burden they have.
- Everyone on the staff members expressed the project being at the bottom of their priority lists as they each have so many problems to deal with in their respective areas that they believe are more essential than treating the social lifestyle of the refugees.
- Everyone confirms that the project will fund support from the refugees
- The project should be planned to be useful throughout the entire year and hence special attention should be put to withstanding the different weather conditions.

3

TECHNOLOGIES AND MATERIAL STUDIED

In the following chapter shall be developed the studies performed on both technologies and materials on both the theoretical and practical point of view.

The entire study process shall be described, starting from all the possible options studied leading to the chosen ones.

It is important to note that this thesis is the expansion to the masters' thesis project in which the chosen technologies were Gridshell for structure with tensile structures for the envelope, all of which were made from sustainable materials found on site. Therefore, these options were the natural starting point of research. After analyzing the pros and cons of that technology, the research will lead the project to a similar yet more convenient one.

With the structural technology defined, the research will then move on the exterior partitions and decide the most opportune one.

With the technology decided, the research will proceed with the materials to be used and in order to achieve the best possible solution, a thorough study of the all materials used in the emergency architecture field will be conducted at the end of which the most advantageous materials will be picked.

In order to make the research more accurate, a more technical approach was needed to the already covered theoretical parts. In order to achieve that, a 2 years collaboration was performed with construction giants DAR GROUP[56], and more specifically, alongside their textile structure experts MAFFEIS ENGINEERING SPA[57] based in Solagna, Italy. During those 2 years, immeasurable technical information was gathered which in the end led to the choice of the material and technology chosen.

[56] https://www.dargroup.com/ (April 2020)
[57] http://www.maffeis.it/(April 2020)

3.1.Technologies studied

3.1.1. Gridshell

3.1.1.1.Description of Gridshell technologies

The Gridshell as its name suggests it is based is a structure designed of a grid or lattice. The shell name is given to it due to the fact that its strength is based on its double curvature which in most cases results in shell like giant structures.

The Gridshell offers a series of much desired characteristics:

- Free-form architecture

  Its composition allows the achievement of any desired form and especially ones that hard or even impossible to achieve with traditional technologies
- Long-span

  The shell design allows long span areas with no intermediate interruptions from structural elements like pillars
- Light-weight

  The strength of the double curvature alongside the light envelope material used make it a light-weight solution especially compared with alternatives or traditional building materials and technologies.
- Affordable

  All of the above amount to incredible savings in material costs making it a much-desired affordable option
- Sustainable

  Most of the Gridshell structures built so far are timber based which gives it is sustainable appeal. But aside from the material chosen, the fact that is requires smaller quantities or material than traditional buildings and diverse materials renders it sustainable by definition.

The Gridshell structures constructed up until today were of the following materials:

- Aluminum

  Used mainly in modern glass façades and glass shell skylights

Figure 44 Aichi University Campus, Japan58

[58] https://iass-structures.org/resources/Documents/WG%20Publications%20and%20Reports/WG_0

- Steel

  Ex.: British Museum Great CourtRoof, London, UK

Figure 45 Picture showing the steel skylight of the Museum59

- Timber

  Ex.: Mannheim Multihalle,Mannheim, Germany

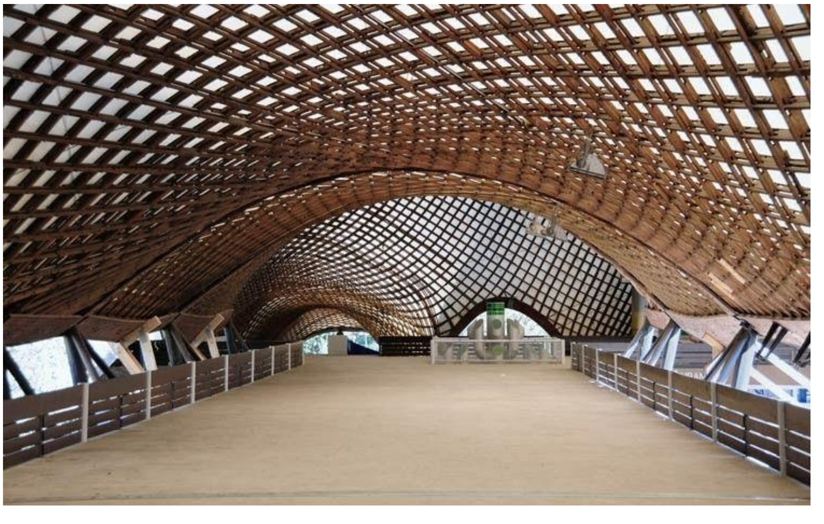


Figure 46 Picture showing the interior of the Mannheim Multihalle60

8/Draft-Guide-to-Buckling-Load-Evaluation-of-Metal-Reticulated-Roof-Structures_WG08_v20180103.pdf (April 2020)

[59] https://www.arch2o.com/great-court-british-museum-foster-partners/(April 2020)

[60] https://co.pinterest.com/pin/397161260887602744/(April 2020)

- Cardboard

  Ex.: Japan Pavilion, Hannover,Germany

Figure 47 Picture of the interior of the Japan Pavilion[61]

- Glass-fibre composites.

  Ex.: Solidays music pavilion,Paris, France

Figure 48 Pictures showing Gridshell in composite materials for Solidays festival in Paris62

[61] https://en.wikiarquitectura.com/building/japan-pavillion-expo-2000-hannover/(April 2020)

[62] https://www.researchgate.net/figure/Gridshell-in-composite-materials-for-Solidays-festival-in-Paris_fig2_266208563(April 2020)

Each different material brought with it a different construction and assembly process. These processes can be qualified as follows:

- Continuous grid members

  In this case, the grid members are continuous from one end to the other throughout the entire structure. These laths overlap each other at the nodes.
- Discrete grid members

  In this case, the grid members are of smaller dimensions and span from node to node in a reticular shape.

The first design of a Gridshell dates back to 1896, during the “All-Russia industrial and art exhibition 1896 in Nizhny Novgorod”, when Russian engineer Vladimir Shukov designed the steel Gridshell which can be still found nowadays, abandoned, standing showing the strength of such structures.

Figure 49 The double curvature Diagrid Shell by Vladimir Shukhov in Vyksa near Nizhny Novgorod during construction, 1897[63]

[63] https://en.wikipedia.org/wiki/File:Double_curvature_steel_lattice_Shell_by_Shukhov_in_Vyksa_1897_shell.jpg (April 2020)

However, it was Professor Frei Otto who first developed the timber Gridshell technique that we still use nowadays. That technique consists into putting straight timber laths into a flat grid on the ground and then, in a later stage, pushing them up until they form the desired double curved surface by using the material's flexibility. It is thanks to the timber's low torsional stuffiness that nodal rotations are allowed rendering the final shape achievable. Another way of reaching the desired shape would be to assemble the grid above ground and lowering it thanks to the gravity.

The grid is formed by arranging a series of laths in two perpendicular directions overlapping, it can be of both a single layer and a double layer as per the picture below:

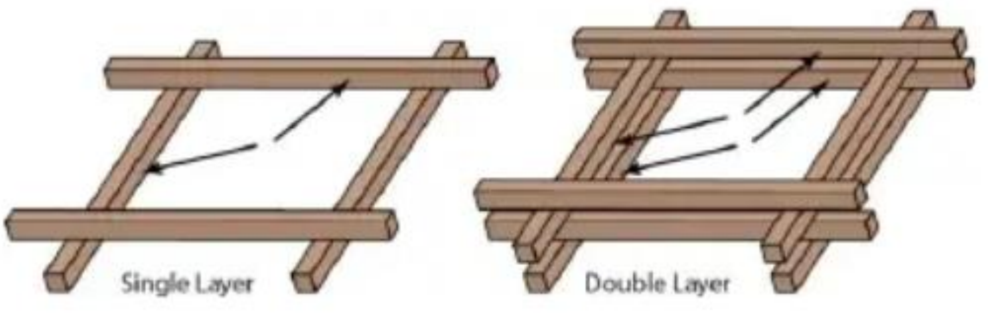


Figure 50 Sketches showing the alignment of the laths in both cases[64]

It is to be noted that for the double-layered option, shear blocks are added to provide shear transfer between both layers additionally to the nodal connection as per the picture below:

[64] https://www.academia.edu/8615523/Timber_Gridshells_-_Design_methods_and_their_application_to_a_temporary_pavilion(April 2020)

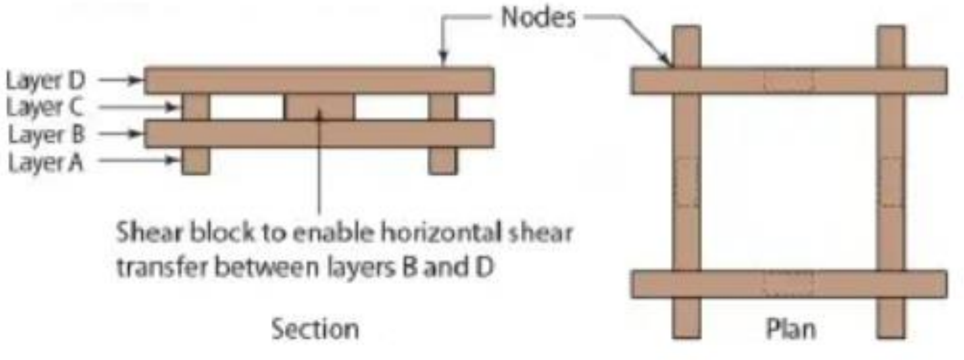


Figure 51 Sketches showing the shear blocks in between layers[65]

The most important element to solve and the most critical is located at the joints, and although numerous solutions were presented, the following are considered the most common and simplest:

- Option A:
  Slotted holes on the joints with bolts that would allow the shaping of the structure. The bolts are fully tightened only after achieving the desired shape

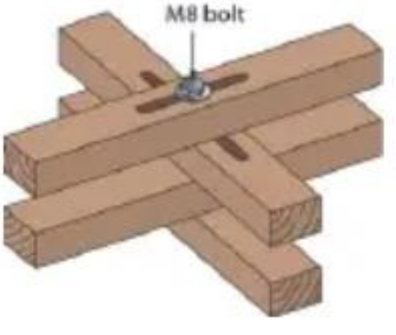


Figure 52 Sketches showing slotted holes at the nodes[66]

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[65] https://www.academia.edu/8615523/Timber_Gridshells_-_Design_methods_and_their_application_to_a_temporary_pavilion(April 2020)
[66] Ibid.

- Option B:

  Through the usage of steel plates between the overlapping laths with a series of four bolts connecting the plates. In this option there is no need to penetrating the laths which saves up on the cost of slotting the laths as well as gives them a stronger characteristic.

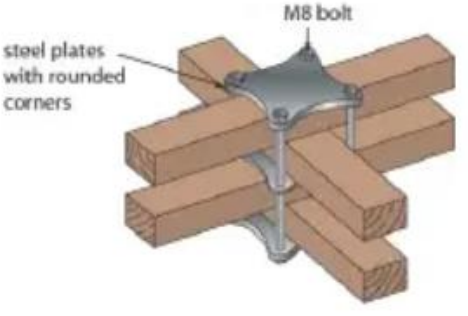


Figure 53 Sketches showing the steel plates at the nodes[67]

This option allows the addition of stiffeners in case needed as well as a connection allowing the incorporation of the envelope layer.

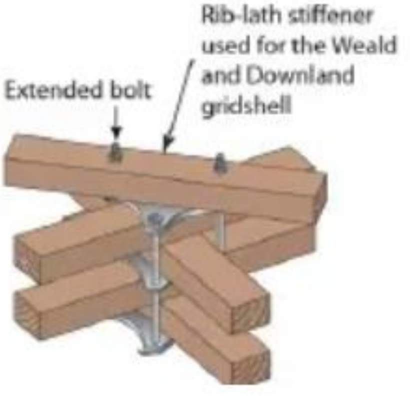


Figure 54 Sketches showing the added stiffeners at node[68]

[67] https://www.academia.edu/8615523/Timber_Gridshells_-_Design_methods_and_their_application_to_a_temporary_pavilion (April 2020)
[68] Ibid.

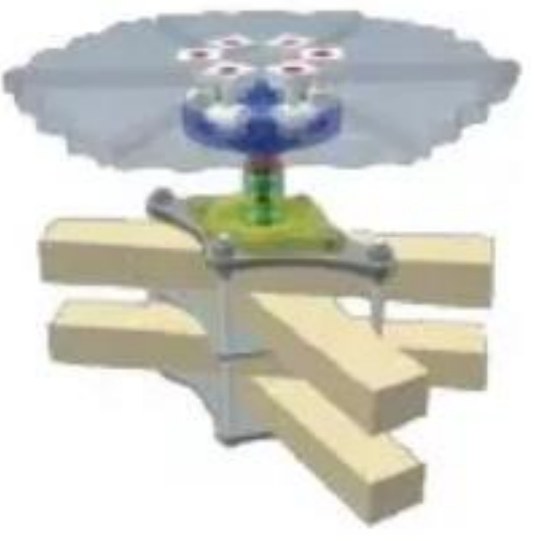


Figure 55 Sketches showing the added adaptable connections for the glazing[69]

In order to create the continuous laths alongside the entire structure, it is essential to decide on a typical module, usually easily transportable and then proceed with connecting the models one with another.

The connection process can be done in one of two ways:

- Maintaining the linearity of the laths through the addition of pieces on the splice joint:

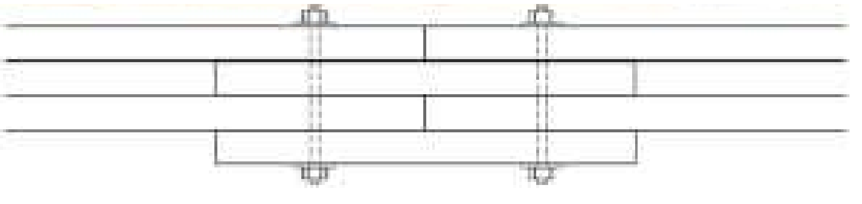


Figure 56 Sketches showing the linearity of the laths at connection level[70]

[69] https://www.academia.edu/8615523/Timber_Gridshells_-_Design_methods_and_their_application_to_a_temporary_pavilion (April 2020)
[70] Ibid.

- Not maintaining the linearity, but avoiding the need for additional material, through alternative splice joint by overlapping the modules.

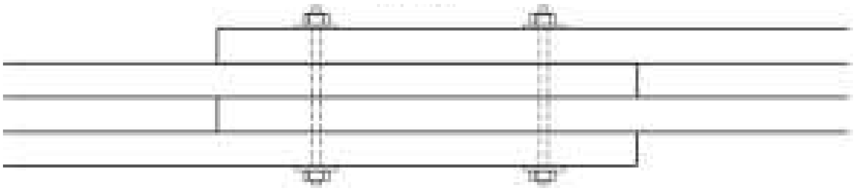


Figure 57 Sketches showing the non-linearity of the laths at connection level [71]

The Gridshell design process is a rather complicated one as it goes through the following stages:

A. Form finding

   Form-finding can be done in four different ways depending on the design intent and on the method that puts the designer most at ease.

   a) Funicular approach

      The form is achieved by inverting the shape of a hanging chain model on the desired perimeter. The chain being under pure tension, gives a pure compression structure under its own weight.

[71] https://www.academia.edu/8615523/Timber_Gridshells_-_Design_methods_and_their_application_to_a_temporary_pavilion(April 2020)

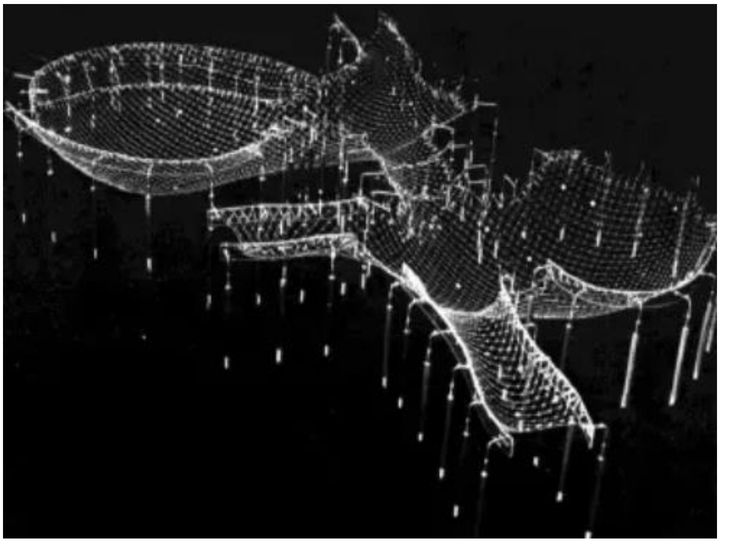


Figure 58 Picture showing hanging chain model used by Frei Otto for the Mannheim Multihalle[72]

b) Analytic approach

In this case, the approach is reversed as the surface is defined, and then on it is applied a grid with a series of nodes and lines through a series of calculations done with the help of computers.

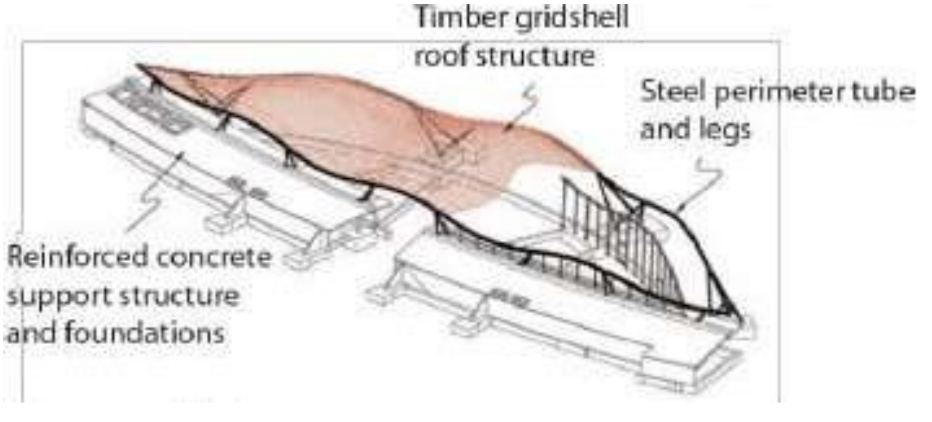


Figure 59 Picture showing the roof structure of the Savill Garden Gridshell [73]

[72] https://www.academia.edu/8615523/Timber_Gridshells_-_Design_methods_and_their_application_to_a_temporary_pavilion (April 2020)
[73] Ibid.

c) Combined approach

In this approach the design is developed from a concept point of view architecturally and then implemented using physical models.

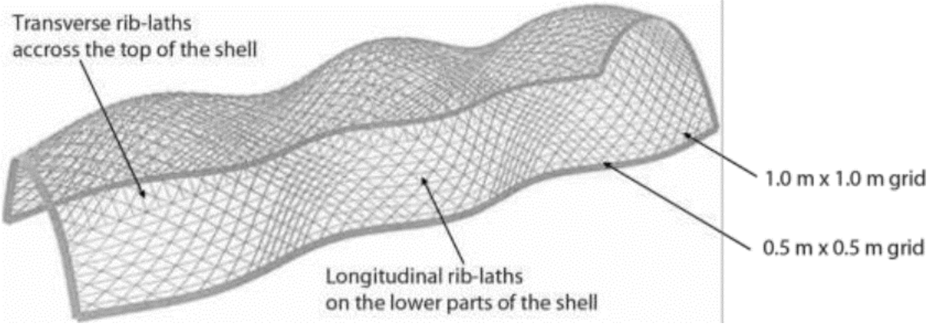


Figure 60 Picture showing the rood structure of the Weald & Downland Gridshell[74]

d) Construction based-approach

In this case, the entire concept is focused on the construction process which in its turn is due to the limitations of the contracting firm.

[74] https://www.academia.edu/8615523/Timber_Gridshells_-_Design_methods_and_their_application_to_a_temporary_pavilion (April 2020)

Figure 61 Picture showing the interior of the Pavilion ZA Gridshell [75]

B. Engineering assessment and validation

   Once the form-finding process is done, a heavy structural design phase has to be done in order to be able to size members, provide detail connection design and all necessary structural calculations.

C. construction details

   The last phase consists in providing all necessary construction details in order to be able to proceed with the project.

In order to make things easier to relate to, all the previous stages will be discussed more in details in the following chapter in a case study concerning one of the most important projects in the timber Gridshell history: the Mannheim Multihalle.

[75] https://www.academia.edu/8615523/Timber_Gridshells_-_Design_methods_and_their_application_to_a_temporary_pavilion (April 2020)

3.1.1.2.Case study: Mannheim Multihalle Gridshells

The Mannheim Multihalle which was inaugurated in 1975, is considered by many to be the project that got the interest of the world back into the Gridshell technology. The architects "Carl Mutschler & Partners" of Mannheim were assigned to the project and due to their design intention, they went and seeked out Frei Otto who, at the time, was famous for his interest in the technology.

3.1.1.2.1. Form finding:

The form finding was achieved through the usage of a physical model and more specifically a 1:100 wire mesh model of the design intent of the architects consisting of two large dome structures connected by covered walkways. The chain grid dimension was 1.5 cm and it represented the third lath of proposed structure.

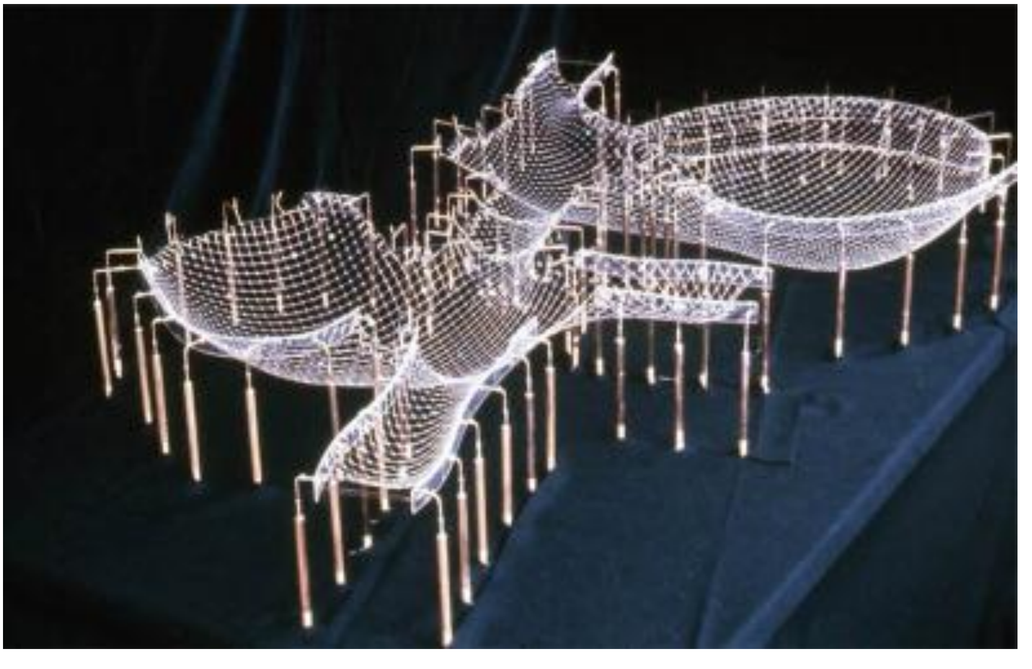


Figure 62 Picture showing the chain model for Mannheim [76]

[76] https://www.sciencedirect.com/science/article/pii/S2214399815300011 (April 2020)

That model served as the basis of the project as it was studied through stereo photography and the following was achieved:

- Each of the nodes were assigned relative coordinates
- Quantities, drawings and specifications were all extracted from that model and were used a basis to get the necessary pricing of the project.

In order to better prepare the engineers, a preliminary Method of Statement (MoS) was developed, indicating that the construction would be done as follows:

A. Construction of the grid on ground level with all the node bolts inserted by not tightened to allow the needed elasticity in order to achieve the desired form.
B. The laths were lifted into the desired shell shape with proper support
C. Once the desired form is attained, the bolts were tightened
D. Removal of the temporary support after making sure it is capable of withstanding its own weight.

3.1.1.2.2. Engineering assessment and validation:

With all of the above information, the engineering assessment and validation was ready to be done. In order to achieve the desired results, the initial assessment focus on the following four points:

- Investigations into the design loads
- Desk studies and hand calculations on shell buckling
- Model testing
- Hand calculations to get a approximation of the member forces

With the above results proving the structure could be done from a theoretical point of view the engineers then proceed into the validation of the load carrying capacities of that structure through the following:

- Load/rotation tests on the grid intersections
- Creep bending tests of the laths
- Testing the capacity of the boundary connections
- Testing for shear stiffness

Figure 63 Shear stiffness testing [77]

- Computer modelling of the buckling load

[77] https://www.sciencedirect.com/science/article/pii/S2214399815300011 (April 2020)

- Model load tests per performed on both the Essex and the Multihalle Gridshells in order to compare the behavior of both structures.

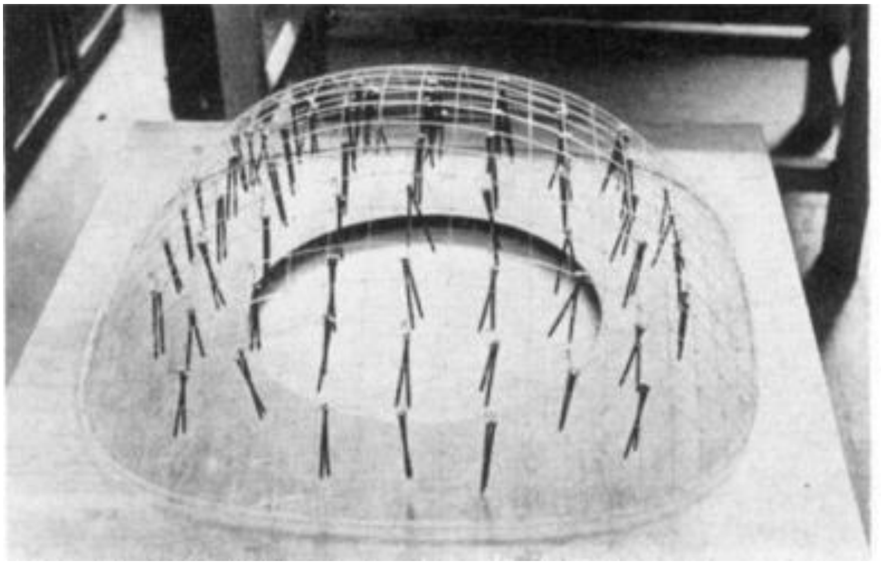


Figure 64 Essen Gridshell load testing model [78]

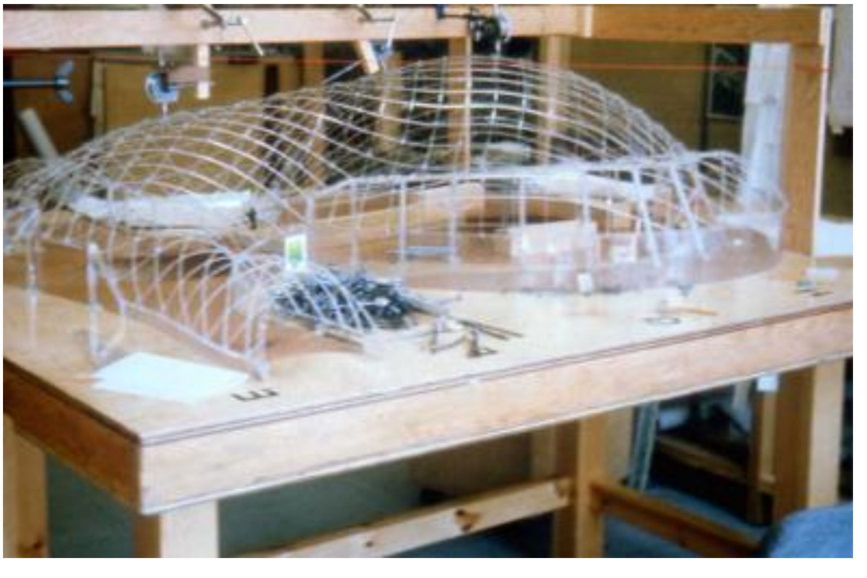


Figure 65 Mannheim Gridshell load testing model [79]

3.1.1.2.3. Construction details:

[78] https://www.sciencedirect.com/science/article/pii/S2214399815300011 (April 2020)
[79] Ibid.

With the mechanism and the design confirmed, the last step was finalizing the construction details of the following essential elements:

- Node joints
- The lower laths has single holes every 0.5m capable of withstanding the 8mm threaded rod
- The upper laths had slotted holes allowing them to slide during the lifting and shaping process.
- Disc springs were used to protect from shrinkage and expansion due to seasonal moisture, 3 on the top and 1 below as per the picture below:

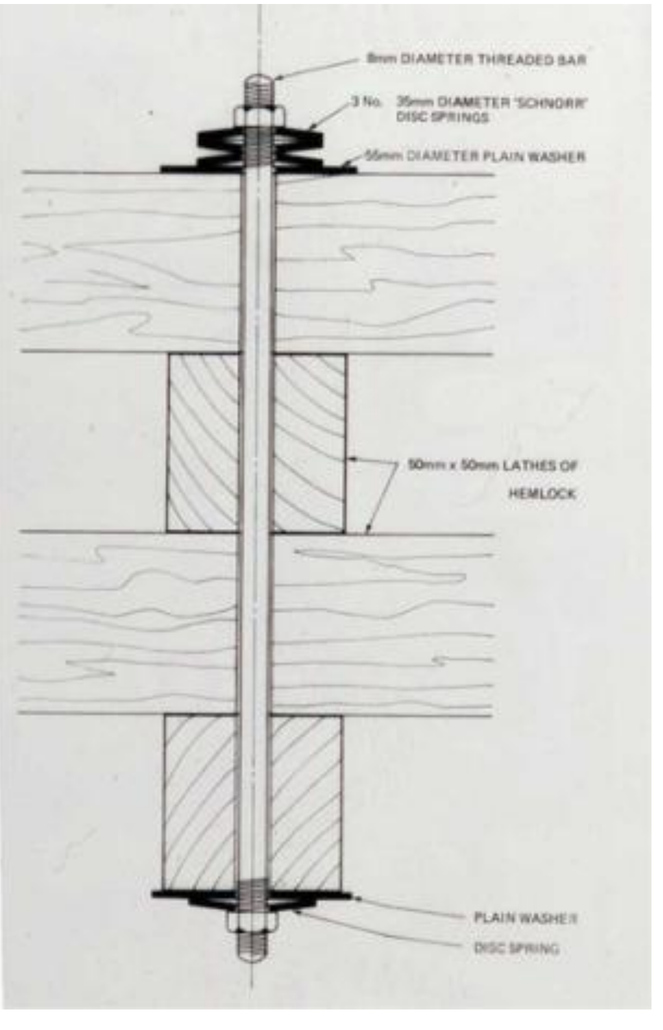


Figure 66 Connection bolting details [80]

- Folding wedges were added whenever additional shear capacity
- Cable ties

  Cables were added every sixth node in both directions in order to provide adequate stiffness.

Figure 67 Picture showing the cables at the nodes [81]

- Boundary connections

  There were four different types of boundary structures:
- Concrete wall
- Arched openings
- Laminated timber beams connected to stell columns
- Cable structures supported on steel columns.

  All of the boundaries connection details were based on the detail presented by Frei Otto and then modified by the engineers as needed and adapted as deemed necessary to get the best possible results.

[80] https://www.sciencedirect.com/science/article/pii/S2214399815300011 (April 2020)
[81] Ibid.

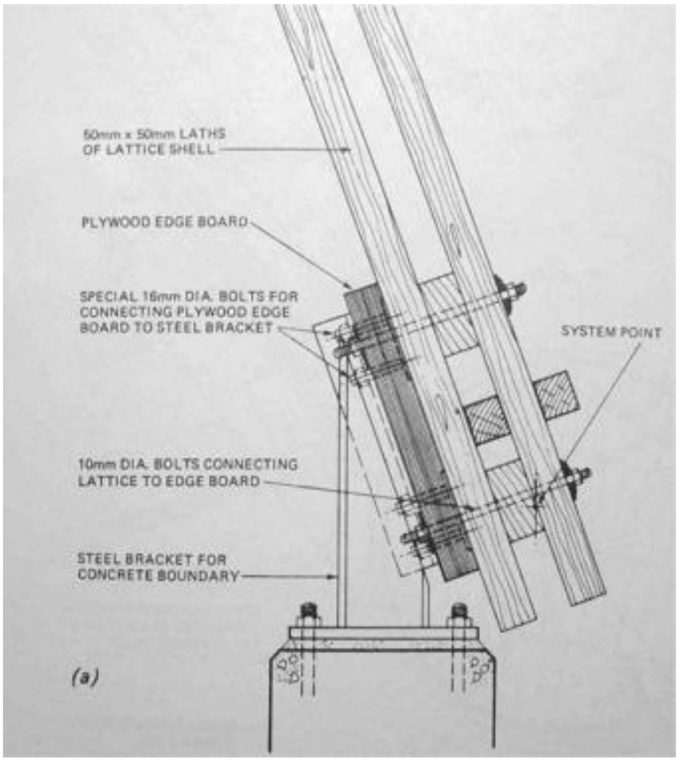


Figure 68 Sketch showing the boundary connection detail [82]

[82] https://www.sciencedirect.com/science/article/pii/S2214399815300011 (April 2020)

Figure 69 Picture showing the arched opening boundary[83]

- Installation on site

The contractors were given a wire mesh model in order to help them understand the bending stiffness and self-weight.

Figure 70 Picture showing the lifting positions model presented to the contractors [84]

Basing their studies on the required spacing, the contractors opted to start with a scaffolding tower system with timber spreaders to distribute the loads. These towers would be lifted slowly by adding 33cm parts where needed. Once sufficient height was reached, forklift trucks were used for bolt tightening and tower jack up where height limitation required.

[83] https://www.sciencedirect.com/science/article/pii/S2214399815300011 (April 2020)
[84] Ibid.

Figure 71 Picture showing the lifting arrangements on site [85]

- Covering
- The grid was covered with translucent PVC coated mesh fabric.
- The grid weave's yarns were also coated with black PVC
- Waterproofing on the joint between the sheets of fabric was obtained through heat sealing

Figure 72 Picture showing the PVC translucent covering [86]

[85] https://www.sciencedirect.com/science/article/pii/S2214399815300011 (April 2020)
[86] Ibid.

3.1.1.3.Conclusions

As it must now seem clear, the Gridshell technology has numerous advantages and only few disadvantages but considering the background and the humanitarian effect of this study, these disadvantages have had a severe impact.

The Gridshell was always going to be a challenging technology but it provided a much-desired attractive designs and so the aim was to try and make it work.

- From a technical point of view, the collaboration period with DAR group made it possible to provide the design but it did not make it easier, if anything it actually made it harder. During that collaboration period, it was noted that special programs are to be used in order to achieve the proposed project and even once the design is completed it required constant monitoring and a team of experts on site. That renders this project very costly and overlaps its cost benefits.
- The main idea through this project is to use the presence of the refugees to reduce the number of required manpower. Due to the expertise required and the difficulty in making the design simple, the impact of the available manpower on site is significantly reduced rendering one of the most valuable elements of this project useless.
- In order not to use heavy and costly machinery it was thought to use simpler scaffoldings for the hoist made from local materials. The problem is that this option requires heavy level of precision and constant monitoring in order to compensate the lack of the heavy machinery.

- The biggest and most important problem and definite blow to the Gridshell came from the site visits and interview results. Throughout the numerous interviews performed, the complexity of the design gave away a fragile impression which rendered the design, which is the primary target behind this technology, its biggest obstacle. This would hinder the hosting capabilities of the project and go against making it a place to monopolize the social activities of the settlements. It was explicitly requested to make the structure simpler by both interviewed refuges and staff members of the agencies.

All of the above reasons have made the option of Gridshell not valid for this project as a simpler design and structure was needed. During the collaboration at the DAR group office, a sister shell technology was brought up when discussing this matter and it was the space frame. At this point the study shifted and the technology adopted was the spaceframe one for reasons which shall be discussed further in the upcoming part.

3.2.Space frame

3.2.1. Description of technology

3.2.1.1.Introduction

Definition

In order to best define the space frame technology, it is best to quote the official definitions given to it be the International Association on Shell and Spatial Structures:

“A space frame is a structure system assembled of linear elements so arranged that forces are transferred in a three-dimensional manner. In some cases, the constituent element may be two-dimensional. Macroscopically a space frame often takes the form of a flat or curved surface.”

History

The notion of space frame was first introduced by Alexander Graham Bell in 1900 for their use in nautical and aeronautical engineering. but it was not until 1959 when the notion came introduced into the world of architecture through Buckminster Fuller’s geodesic dome.

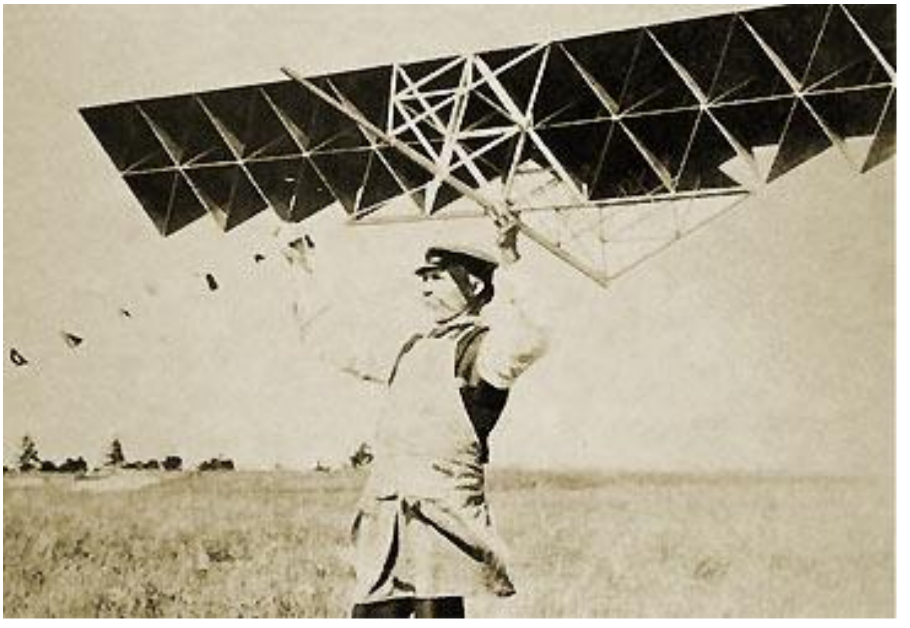


Figure 73 Bell Tetradic kite -1904[87]

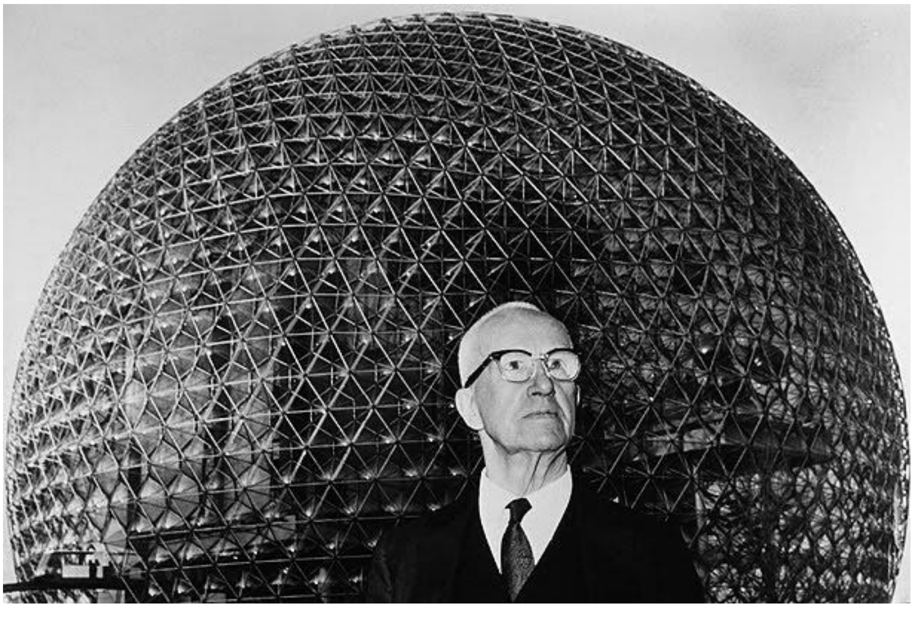


Figure 74 Buckminster fuller's geodesic dome [88]

[87] http://histoire-cerf-volant.com/Bell/kite.html (April 2020)
[88] https://www.arquine.com/buckminster-fuller/ (April 2020)

Basic concept

The most important concept of the space frame is the omnidirectional spread of the load which makes the structure take the load as whole thus allowing its members to be of the same size unlike traditional structures where the size of the members is bigger depending on the sequence of flow of forces.

In a normal planar structure, the roof load is transferred from lighter class to the heavier class as it transferred from secondary structure to primary to foundation. Whereas in the space frame system, all the elements participate equally in handling the roof load thus removing any ranking system.

Due to the fact that the corresponding forces in a space frame are usually less than those in a traditional trusses system, the depth of the structure can be reduced.

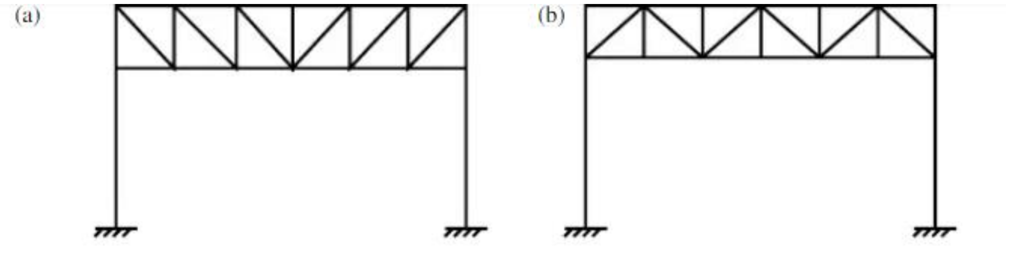


Figure 75 Sketch showing the lineup and depth of a traditional structure (a) compared to a space frame one (b)[89]

89 https://www.academia.edu/6244542/24_Space_Frame_Structures_24.1_Introduction_to_Space_Frame_Structures (April 2020)

Applications

The space frame is applied wherever a structure that spans large distances with no need for internal support is needed. ever since its introduction into architecture, the space frame technology was applied mainly in the following building types:

- Airport terminals
- Sports arenas
- Pavilions
- Big halls
- Hangars for big machinery from airports to boats
- Workshops
- Warehouses
- Mid and short span enclosures for the building envelope.

Preliminary Planning Guidelines

When considering to use space frame technology, it would be wise to consider the following factors before reaching the point of undergoing any structural analysis and design:

A. It is advisable to start by choosing the shape of the building and the type of space frame that would best accommodate that shape.
B. Decide on the geometry of the space frame to be adopted and from deduce the module size to be developed.
C. Pick the desired and most opportune joint design based on the structure, expertise, investment and material availability.
D. Prepare a method of statement explaining the desired construction process.

3.2.1.2.Different types

The different types of space frames can be grouped as follows:

- According to curvature
    - Flat covers

      Structures made of planar substructures.

Figure 76 Picture showing a flat cover structure[90]

[90] https://www.flickr.com/photos/nichitecture/6815523100/in/photostream/ (April 2020)

- Barrel vaults

  Vaults with a cross section of a simple arch.

Figure 77 Picture showing a barrel vault structure[91]

- Spherical domes

Figure 78 Picture showing a spherical dome structure[92]

[91] https://www.dezeen.com/2014/06/30/zaha-hadid-heydar-aliyev-center-wins-design-of-the-year-2014/ (April 2020)
[92] http://www.gsmt.noao.edu/book/ch4/4_3.html (April 2020)

- According to grid layers
    - Single-layer

Elements organized on 1 layer located usually at the surface.

Figure 79 Picture showing a single layer space frame structure[93]

- Double-layer

Elements organized on 2 separate parallel layers connected by diagonal bars giving the space frame5 its 3d geometrical strength.

Figure 80 Picture showing a double layer space frame structure[94]

[93] https://www.arthurbest.uk.com/single-layer-free-form-structures-design/ (April 2020)
[94] http://ultraatechsteelbuildings.com/space-frames.php (April 2020)

- Triple-layer

Elements organized on 3 separate parallel layers connected by diagonal bars with lower length than the 2 layered ones.

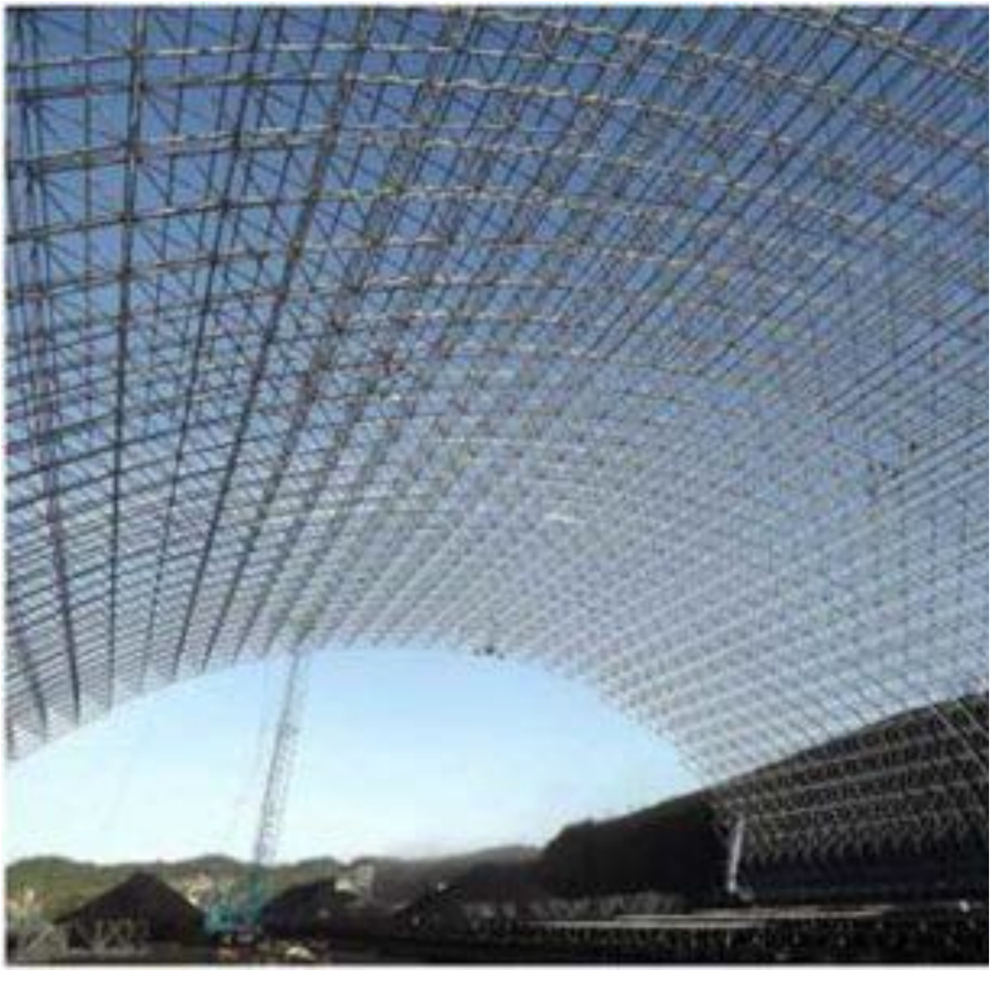


Figure 81 Picture showing a double layer space frame structure[95]

[95] https://www.constrofacilitator.com/space-frame-structure-an-analysis-of-its-benefit/ (April 2020)

3.2.1.3.Double layered space frame

When deciding on which type to go with, the aim should be to pick the most opportune type to contain long tension members and shot compression members while taking into consideration the following factors:

Shape of the building plan
- Size of span
- Supporting conditions
- Magnitude of loading
- Roof construction
- Architectural requirements.

For this project, the structure shall have a double layered flat space frame in order to balance between feasibility and simplicity while maintaining the benefits of the 3d geometry of the space frame.

Therefore, a more detailed study was performed on the different types of double layered space frame.

When using double-layer space frames it is useful to consider that all members have to resist only tension or compression as the grids are supported by hinged joints with no moment or torsional resistance. And in case the joints are rigid the bending or torsional moment can be considered insignificant.

Although there are many types of doube-layer space frames present, all of them are formed of the same following basic components:

- Planar latticed truss
- A pyramid with a square base
- A pyramid with a triangular base

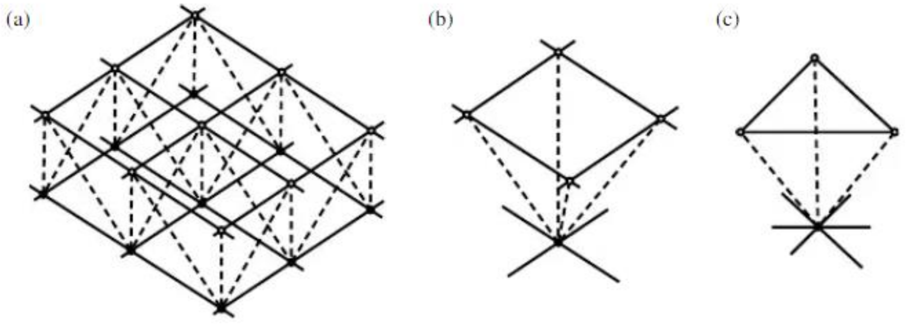


Figure 82 Sketch showing the basic elements of a double-layer space frame[96]

The differences between a type and another come from creating different combinations of the previous elements by changing the following:

- The direction of the top and bottom-layers compared to each other
- The alignment between the top layer and bottom layer nodal points.
- The size of the top and bottom layer grids

Using the previous logic, a list of most commonly used double-layer space frames has been established. It is to be noted that for the sketches that will follow, the following logic has been considered:

- The entire system has been represented at the top left side of the sketches.
- top chord members have been represented with heavy solid lines (top right)
- bottom chords members have been represented with light solid lines (bottom left)

96 https://www.academia.edu/6244542/24_Space_Frame_Structures_24.1_Introduction_to_Space_Frame_Structures (April 2020)

- Web members have been represented with dashed lines (bottom right)
- The upper joints and the bottom joints have been represented by solid circles.

Two-way orthogonal latticed grids

- Simple configuration and joint detail
- All chord members are of equal length
- All chord members lie in two planes that intersect at 90 to each other.
- Horizontal bracings are usually established along the perimeters due to its weak torsional strength

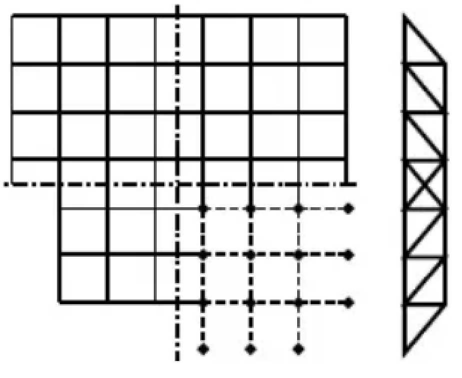


Figure 83 Sketch showing the Two-way orthogonal latticed grid[97]

Two-way diagonal latticed grids

- Same layout as previous grid with the addition that it is offset by 45 degrees from the edges.
- Different spans for trusses along two directions at each intersecting joint.
- Stiffness of truss varies according to its span.

97 https://www.academia.edu/6244542/24_Space_Frame_Structures_24.1_Introduction_to_Space_Frame_Structures (April 2020)

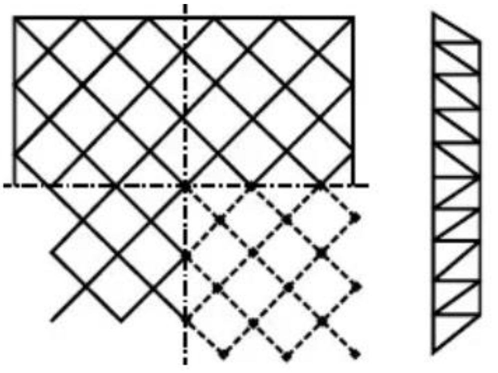


Figure 84 Sketch showing the Two-way diagonal latticed grid[98]

Three-way latticed grids

- Chord members form equilateral triangular grids.
- Adaptable to odd shapes like circular and hexagonal plans.
- Joint detail can be complicated considering various members can intersect at the same joint.

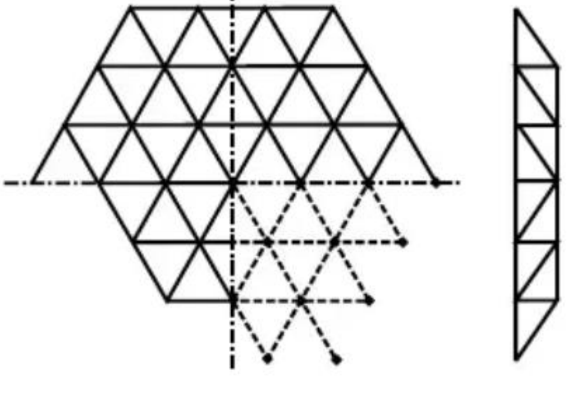


Figure 85 Sketch showing the Three-way latticed grid[99]

98 https://www.academia.edu/6244542/24_Space_Frame_Structures_24.1_Introduction_to_Space_Frame_Structures (April 2020)
99 Ibid.

One-way latticed grids

- A series of mutually inclined latticed trusses give it its folded shape.
- Chord members present only along the spanning direction
- One-way action is predominant.
- Horizontal bracings are necessary along the perimeters

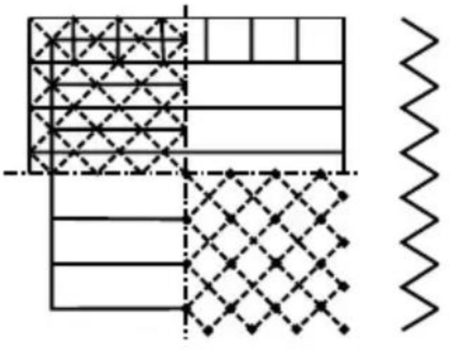


Figure 86 Sketch showing the One-way latticed grid[100]

Orthogonal square pyramid space frames

- Top-layer square grids offset over bottom-layer grids.
- Top and bottom chord members have equal length
- All members can be of equal length in case the angle between the diagonal and chord members is 45 degrees
- The basic element is a square pyramid

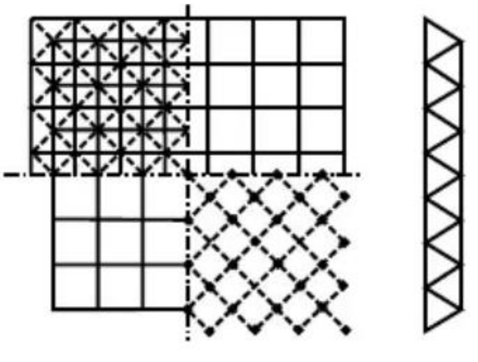


Figure 87 Sketch showing the Orthogonal square pyramid space frame[101]

[100] https://www.academia.edu/6244542/24_Space_Frame_Structures_24.1_Introduction_to_Space_Frame_Structures (April 2020)

[101] Ibid.

Orthogonal square pyramid space frames with openings

- Similar framing pattern as previous type, with the exception that inner square pyramids are removed in order to form openings on the bottom-layer.
- The number of members and the weight is reduced.
- This system is used for skylights.

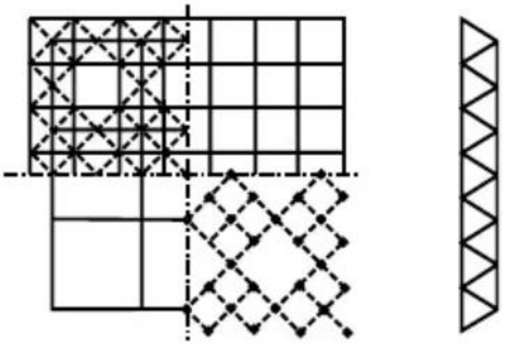


Figure 88 Sketch showing the Orthogonal square pyramid space frame with openings[102]

Differential square pyramid space frames

- The two planes of the space frames are at 45 degrees to each other
- Increased torsional stiffness
- The grids are arranged orthogonally in the top-layer and diagonally in the bottom-layer.
- Shorter top chord members to resist compression and longer bottom chords to resist tension

102 https://www.academia.edu/6244542/24_Space_Frame_Structures_24.1_Introduction_to_Space_Frame_Structures (April 2020)

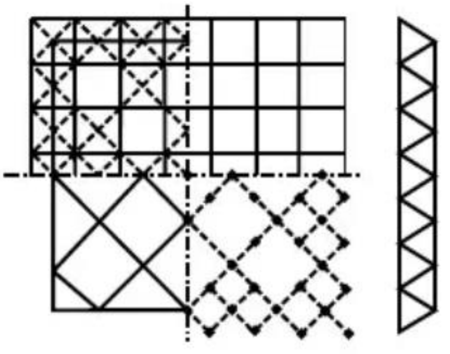


Figure 89 Sketch showing the Differential square pyramid space frame[103]

Diagonal square pyramid space frames

- Similar layout as previous type with inverted top and bottom patterns
- Composed of square pyramids
- Simple joint detail

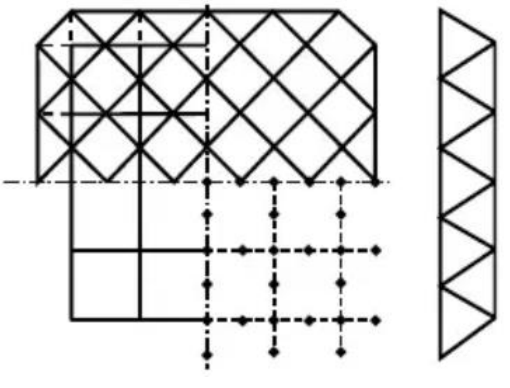


Figure 90 Sketch showing the Diagonal square pyramid space frame[104]

Triangular pyramid space frames

- Composed of Triangular pyramids
- Top-layer triangular grids are offset over bottom-layer grids.

103 https://www.academia.edu/6244542/24_Space_Frame_Structures_24.1_Introduction_to_Space_Frame_Structures (April 2020)

104 Ibid.

- All members can have same length if the depth of the space frames is equal to chord length.

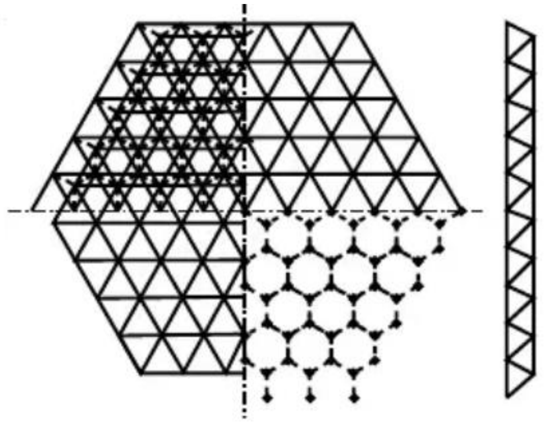


Figure 91 Sketch showing the Triangular pyramid space frame[105]

Triangular pyramid space frames with openings

- Inner triangular pyramids can be removed in order to create openings.
- Top-layer grid is triangular, while bottom-layer grids are triangular and hexagonal
- The manner in which the parts will be removed may influence the bottom-layer pattern.

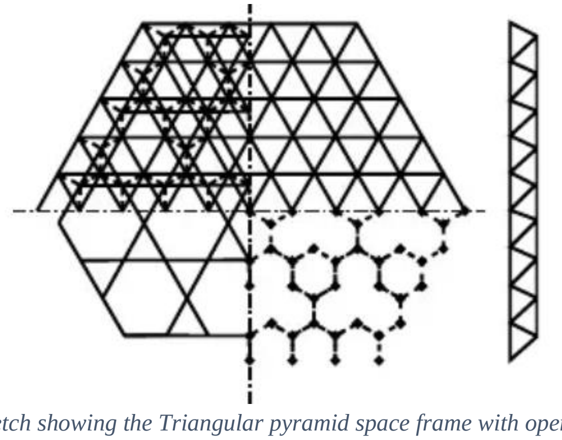


Figure 92 Sketch showing the Triangular pyramid space frame with openings [106]

105 https://www.academia.edu/6244542/24_Space_Frame_Structures_24.1_Introduction_to_Space_Frame_Structures (April 2020)

106 Ibid.

3.2.1.4.Components

3.2.1.4.1. Members

Members of the space frame be either rectangular or circular hollow tubes depending on design. Most of them are made of steel and some can be found of aluminum, wood and carbon tubes.

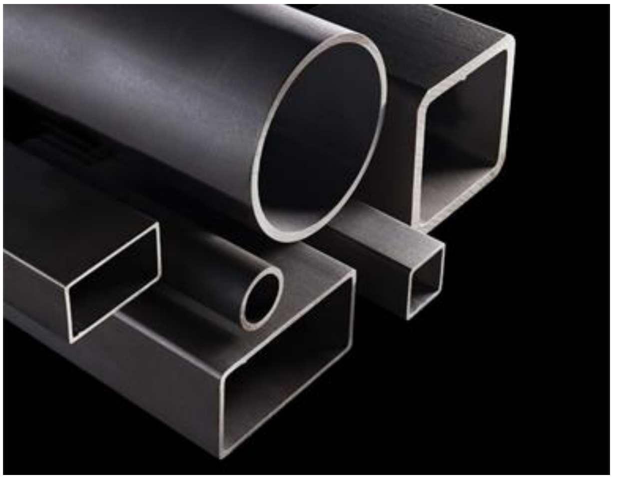


Figure 93 Picture showing circular and rectangular hollow tubes[107]

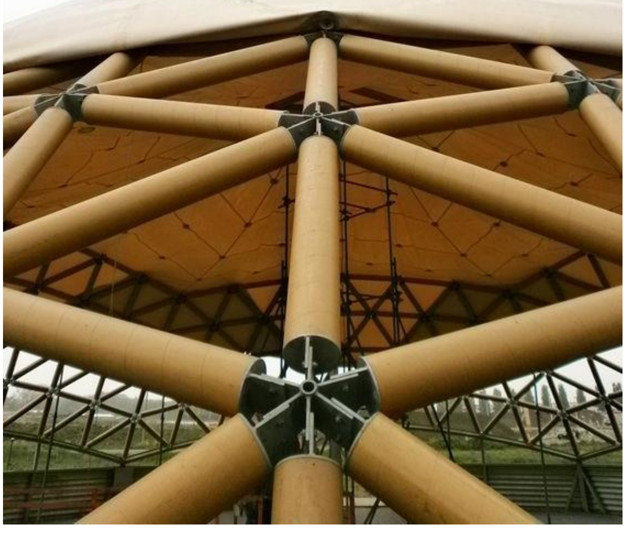


Figure 94 Picture showing Shigeru Ban's paper tower made of carton tube space frame[108]

[107] https://www.bimobject.com/en-au/tata-steel/product/celsius-355-chs (April 2020)
[108] https://www.dezeen.com/2009/09/20/paper-tower-by-shigeru-ban/ (April 2020)

3.2.1.4.2. Joints

Joints constitute the most important parts in space frame mechanism. They constitute between 15 to 30% of total steel consumption of a structure which is why designing the most adequate joints will affect the final cost of the structure.

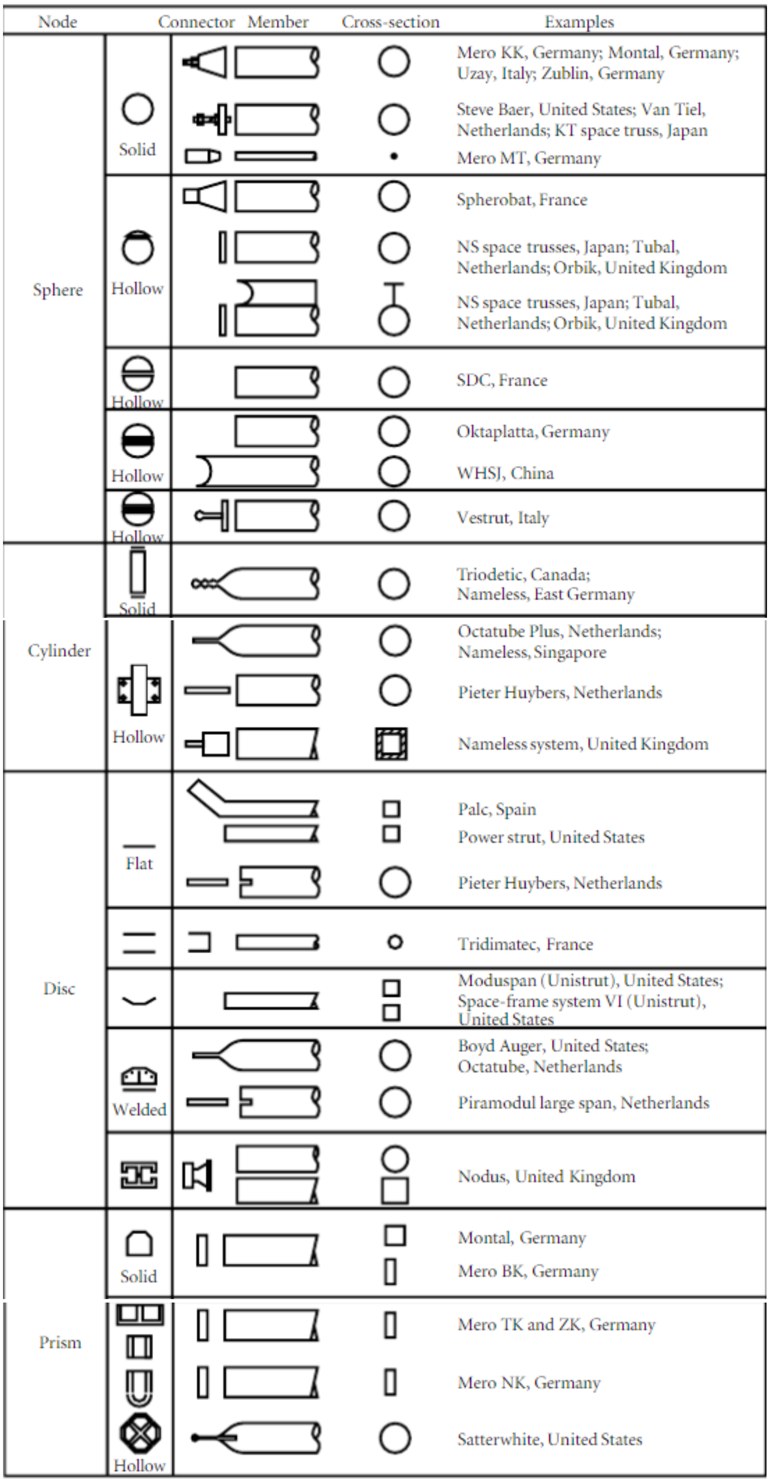
When designing a jointing system, the following factors should be taken into consideration:

- Strength and stiffness
- Simplicity both on a structural and mechanical level
- Easy fabrication, and when possible avoid the need for specialized advanced technology
- Reduce eccentricity to bare minimum
- Withstand construction process tolerances
- Maintenance

An international study has shown that there are over 250 joint types present in the world and that they can be divided into the following three groups:

- With a node
- Without a node
- With prefabricated units.

In the following pages will be presented a series of tables which will give a more detailed look into each of these groups showing different combinations of nodes connectors and members as well giving case studies for each of these options.



Node	Connector	Member	Cross-section	Examples
Sphere	Solid			Mero KK, Germany; Montal, Germany; Uzay, Italy; Zublin, Germany
				Steve Baer, United States; Van Tiel, Netherlands; KT space truss, Japan
				Mero MT, Germany
	Hollow			Spherobat, France
				NS space trusses, Japan; Tubal, Netherlands; Orbik, United Kingdom
				NS space trusses, Japan; Tubal, Netherlands; Orbik, United Kingdom
	Hollow			SDC, France
	Hollow			Oktaplatta, Germany
				WHSJ, China
	Hollow			Vestrut, Italy
Cylinder	Solid			Triodetic, Canada; Nameless, East Germany
	Hollow			Octatube Plus, Netherlands; Nameless, Singapore
				Pieter Huybers, Netherlands
				Nameless system, United Kingdom
Disc	Flat			Palc, Spain
				Power strut, United States
				Pieter Huybers, Netherlands
				Tridimatec, France
				Moduspan (Unistrut), United States; Space-frame system VI (Unistrut), United States
	Welded			Boyd Auger, United States; Octatube, Netherlands
				Piramodul large span, Netherlands
				Nodus, United Kingdom
Prism	Solid			Montal, Germany
				Mero BK, Germany
	Hollow			Mero TK and ZK, Germany
				Mero NK, Germany
				Satterwhite, United States

Table 40 Table showing different connection types with a node[109]

109 https://www.academia.edu/6244542/24_Space_Frame_Structures_24.1_Introduction_to_Space_Frame_Structures (April 2020)

Node	Connector	Member	Cross-section	Examples
Form of member	Forming			Buckminster Fuller
				Nonadome, Netherlands
	Flattened and bending			Radial, Australia
				Harley, Australia
Addition of member	Plate(s)			Mai Sky, United States
	Member end			Pieter Huybers, Netherlands
				Pierce, United States
				Buckminster Fuller

Table 41 Table showing different connection types without a node[110]

Node	Prefabricated unit	Member cross-section top / bracing / bottom	Example
Geometrical solid			Space deck, United Kingdom
			Mero DE, Germany
			Unistrut, France
			Nameless system, Italy
2D components			Ruter, Germany
			Nameless system, Italy
3D components			Cubic, United Kingdom

Table 42 Table showing different connection types with prefabricated units[111]

110 https://www.academia.edu/6244542/24_Space_Frame_Structures_24.1_Introduction_to_Space_Frame_Structures (April 2020)
111 Ibid.

With the above combinations, a series of the most successful joint types will be presented:

Mero

- First introduced 50 years ago by Dr. Mengeringhausen, it constitutes the most used joint system for biggest space frame structures.
- It consists of a spherical node with flat facets and tapped holes
- Members are usually circular hollow sections
- Members are connected to the joint by bolts that are tightened by dowel pin arrangement.
- A joint can be used to connect up to 18 members while maintaining no eccentricity

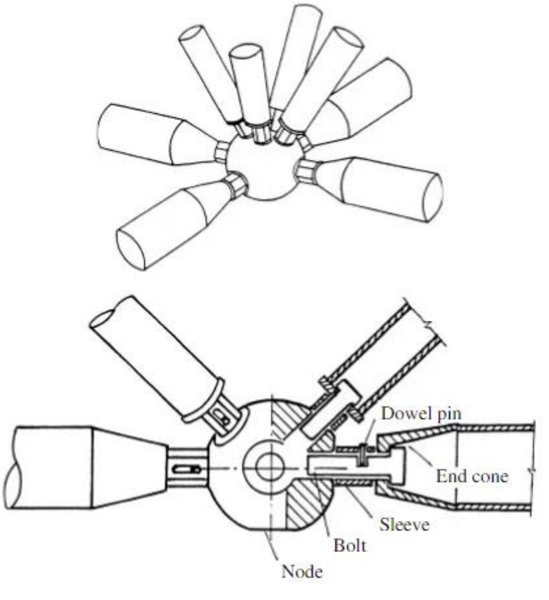


Figure 95 Sketch showing the Mero joint[112]

112 https://www.academia.edu/6244542/24_Space_Frame_Structures_24.1_Introduction_to_Space_Frame_Structures (April 2020)

Disk Node (Type TK)

- It consists of a planar ring-shaped joint
- Members are usually square or rectangular sections
- Node and member are connected by a single bolt
- A joint can be used to connect 5 to 10 members
- Angle between 2 members of the same node varies between 30 to 80 degrees
- Angle between the member axis and the normal in the plane of the node varies between 0 and 10 degrees

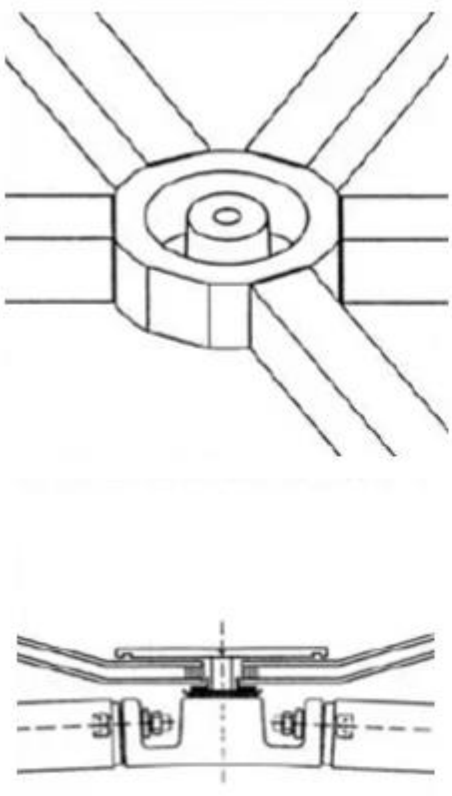


Figure 96 Sketch showing the Disk Node (Type TK) joint[113]

113 https://www.academia.edu/6244542/24_Space_Frame_Structures_24.1_Introduction_to_Space_Frame_Structures (April 2020)

Bowl Node (Type NK)

- It consists of a hemispherical joint joining top chord with the diagonal members.
- Each member is connected to the node through a single bolt
- It is combined with regular Mero system for the bottom chord and diagonal members

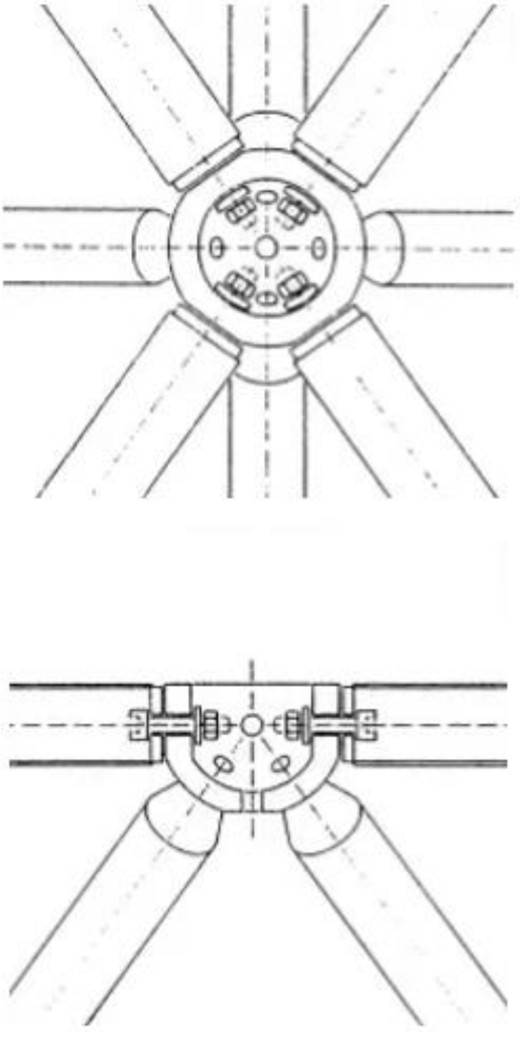


Figure 97 Sketch showing the Bowl Node (Type NK) joint[114]

114 https://www.academia.edu/6244542/24_Space_Frame_Structures_24.1_Introduction_to_Space_Frame_Structures (April 2020)

Cylinder Node (Type ZK)

- It consists of a cylindrical joint connected with the members through bolts
- Members are usually square or rectangular hollow sections
- Angle between 2 members of the same node varies between 30 to 100 degrees
- Angle between the member axis and the normal in the plane of the node varies between 0 and 10 degrees

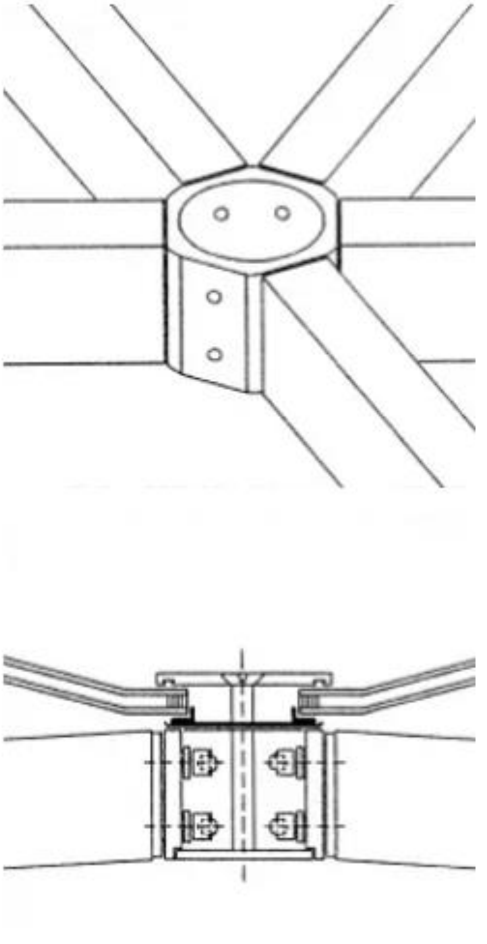


Figure 98 Sketch showing the Cylinder Node (Type ZK) joint[115]

115 https://www.academia.edu/6244542/24_Space_Frame_Structures_24.1_Introduction_to_Space_Frame_Structures (April 2020)

Block Node (Type BK)

- It consists of a block or prism shaped joint
- It is of simple geometry and used mainly for small dimensions
- Members are usually square or rectangular hollow sections
- Angle between 2 members of the same node varies between 70 to 120 degrees
- Angle between the member axis and the normal in the plane of the node varies between 0 and 10 degrees

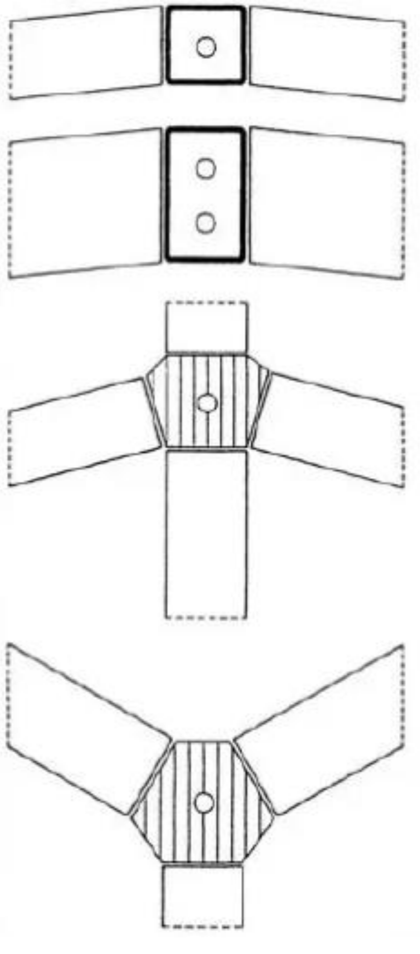


Figure 99 Sketch showing the Block Node (Type BK) joint[116]

116 https://www.academia.edu/6244542/24_Space_Frame_Structures_24.1_Introduction_to_Space_Frame_Structures (April 2020)

Space Deck

- It was first introduced in the 1950s in England
- It consists of pyramidal prefabricated joints.
- It is constituted of rods or bars welded at the edges of a squared angled frame which used to connect the units together with bolts on the field
- Tie bars are used to connect the apexes of the various units
- This system is normally used for structures of a less than 40m span
- Standard module and depth are of 1.2m.

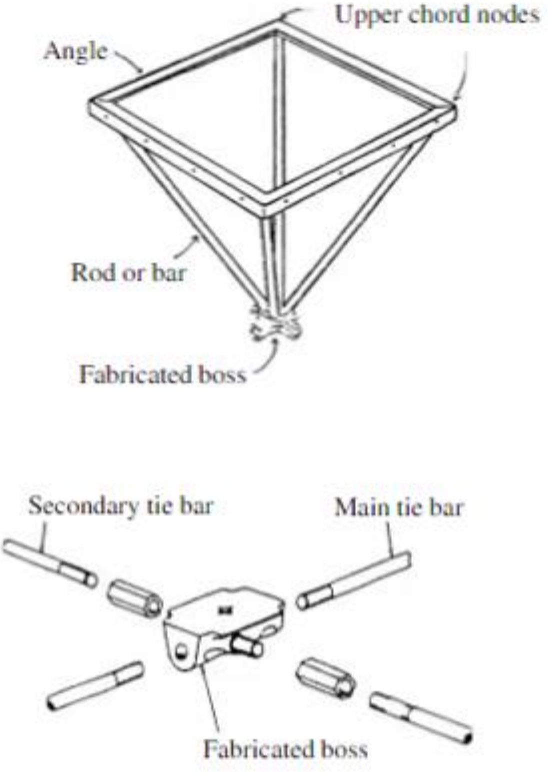


Figure 100 Sketch showing the Space Deck joint[117]

117 https://www.academia.edu/6244542/24_Space_Frame_Structures_24.1_Introduction_to_Space_Frame_Structures (April 2020)

Triodetic

- It consists of an extruded hub with serrated keyways.
- The members have a coined edge allowing the connection with the joint through simple insertion
- Once the members are inserted into the hub, the joint is completed by washers placed at both ends and a bolt inserted through the center of the hub.
- The maximum module size is of around 2.7m2
- The depth is equal to 70% of the module size

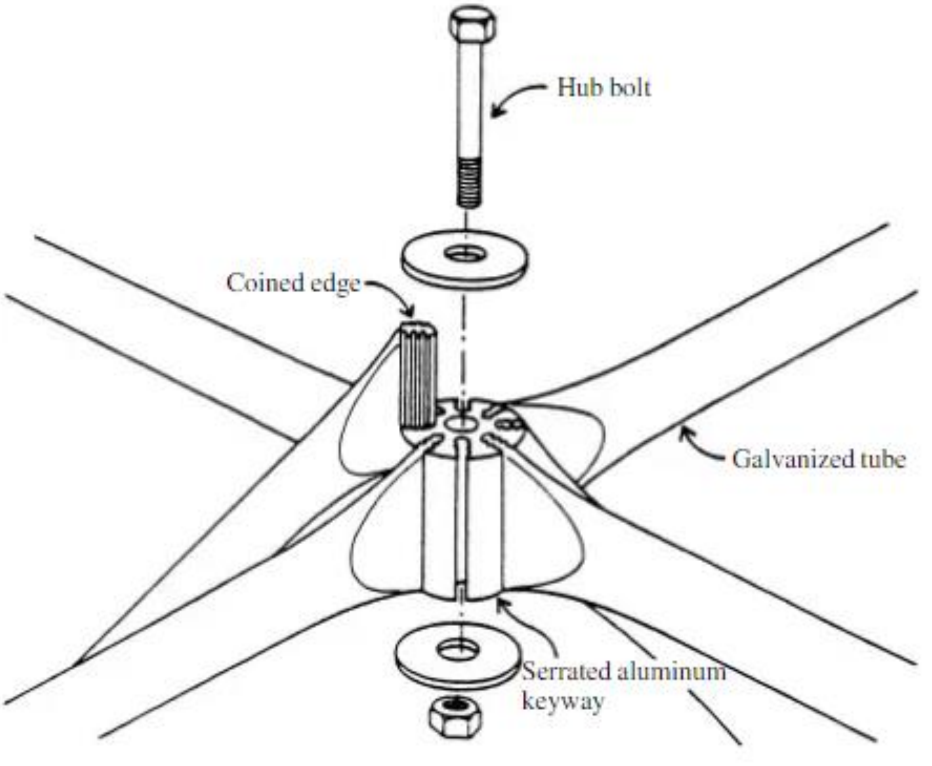


Figure 101 Sketch showing the Triodetic joint[118]

118 https://www.academia.edu/6244542/24_Space_Frame_Structures_24.1_Introduction_to_Space_Frame_Structures (April 2020)

Unistrut

- It was first introduced in the 1950s in the United States
- It consists of press-formed steel plate joints.
- The channel-shaped members are bolted to the joint
- The maximum span is of around 40m with modules pf 1.2 and 1.5m

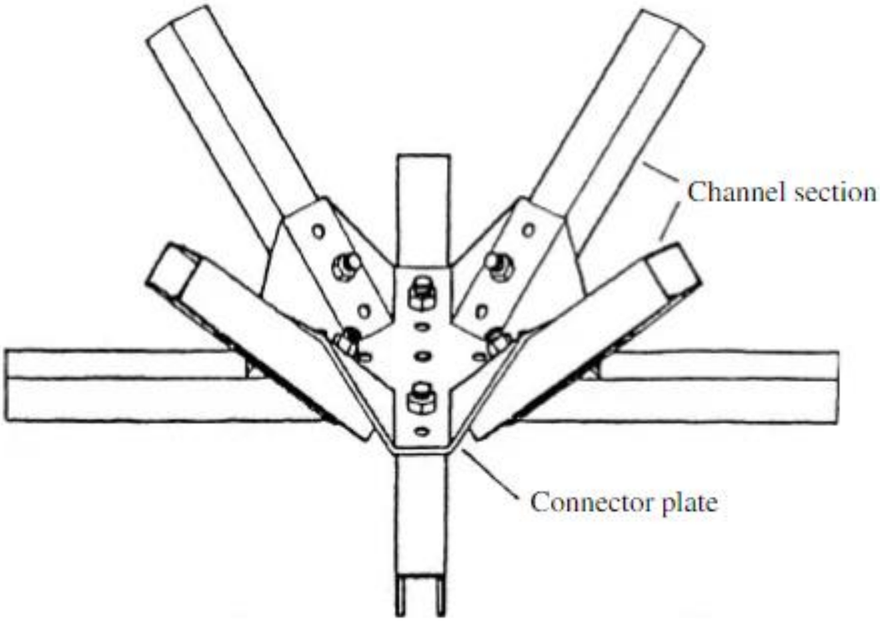


Figure 102 Sketch showing the Unistrut joint[119]

119 https://www.academia.edu/6244542/24_Space_Frame_Structures_24.1_Introduction_to_Space_Frame_Structures (April 2020)

Oktaplatte

- It consists of a hollow steel sphere joint
- Members are usually circular hollow sections
- Members are welded with the joint
- The joint is composed of two hemispherical shells welded together.
- The joint can be reinforced with an annular diaphragm

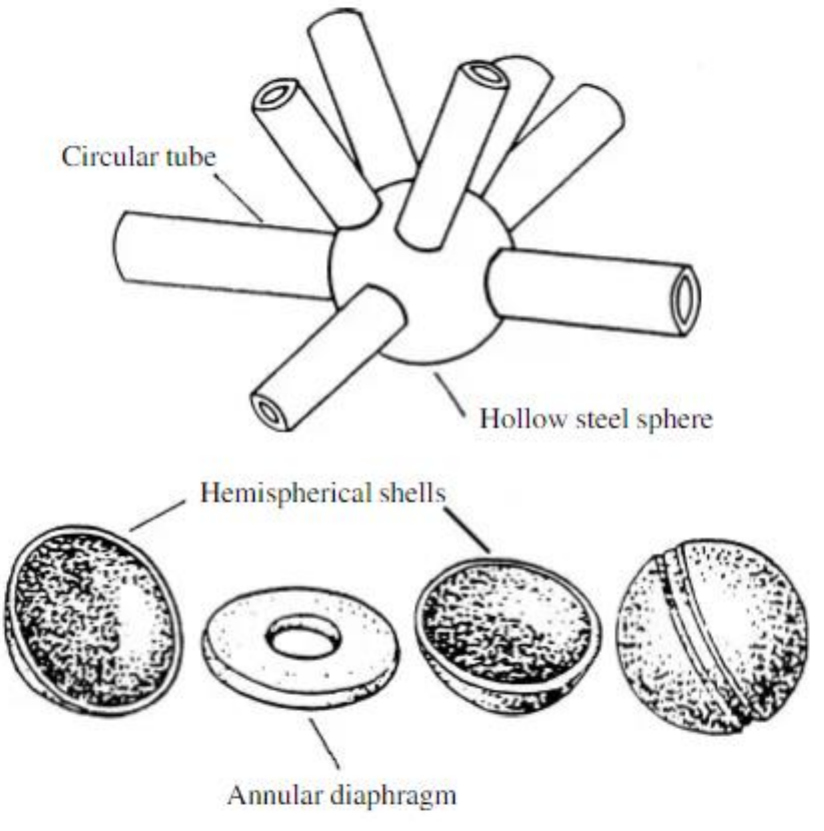


Figure 103 Sketch showing the Oktaplatte joint [120]

120 https://www.academia.edu/6244542/24_Space_Frame_Structures_24.1_Introduction_to_Space_Frame_Structures (April 2020)

Unibat

- It was first introduced in France and became widely used in large span roofs in the 1970s
- It consists of a pyramidal steel unit joint
- The design of the top chord members results in material savings.
- These units are connected to each other by a bolt at each upper corner.

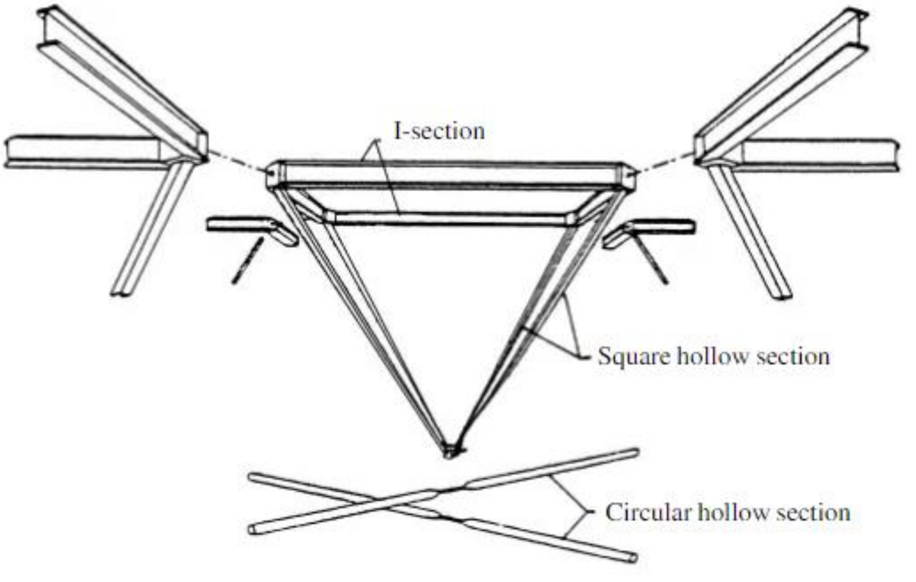


Figure 104 Sketch showing the Unibat joint[121]

121 https://www.academia.edu/6244542/24_Space_Frame_Structures_24.1_Introduction_to_Space_Frame_Structures (April 2020)

Nodus

- It was first introduced in England in the 1970s
- It consists of half-casing steel joint with machine drilled holes for bolted connections
- Members consist of circular hollow tubes with machined teeths at their ends allowing proper engagement.
- Diagonal members have steel forked connectors welded to their end allowing connection with joint.
- All parts are prefabricated allowing simple and fast erection on site

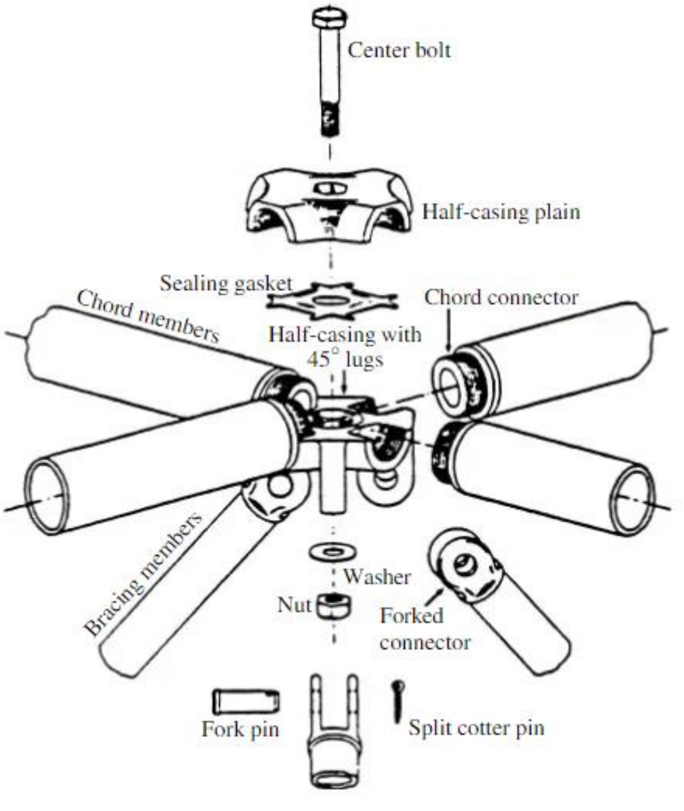


Figure 105 Sketch showing the Nodus joint[122]

122 https://www.academia.edu/6244542/24_Space_Frame_Structures_24.1_Introduction_to_Space_Frame_Structures (April 2020)

NS Space Truss

- First introduced in the 1970 by Nippon Stell corporation.
- It consists of thick spherical steel joints open at the bottom for bolt insertion.
- Members are circular hollow steel tube with cones at the ends
- Members and joint are connected by bolts

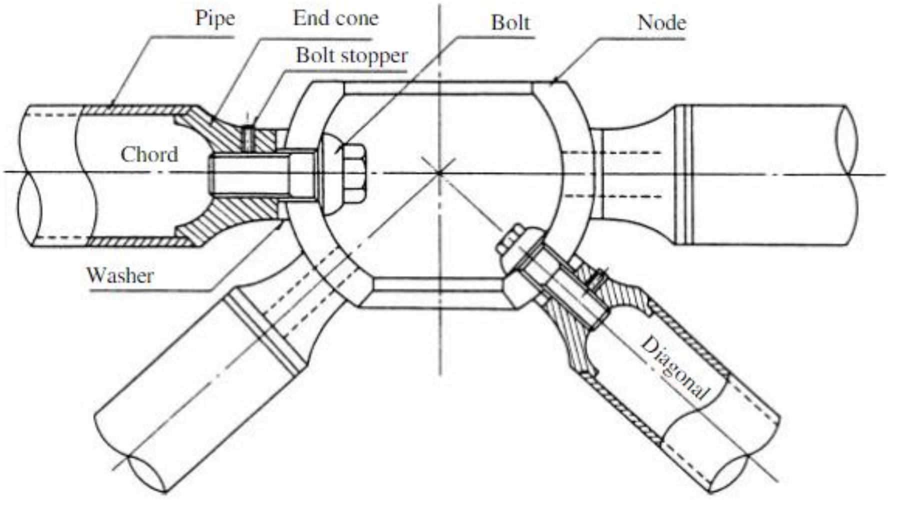


Figure 106 Sketch showing the NS Space Truss joint [123]

Bearing Joints

- These joints are used to connect the space frame to the support
- They must be strong and stiff enough to transmit safely the reactions to the support
- There are a multitude of options for the bearing joints and the most commonly used being the ones used in the picture below:
  -

123 https://www.academia.edu/6244542/24_Space_Frame_Structures_24.1_Introduction_to_Space_Frame_Structures (April 2020)

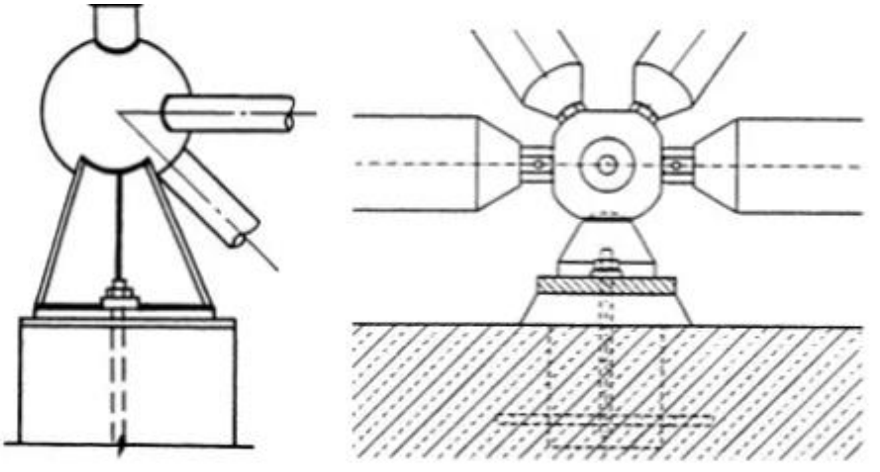


Figure 107 Sketch showing Bearing joint established on flat plate and anchored by bolts [124]

- Bearing joint resting on curved bearing block allowing rotation along the surface

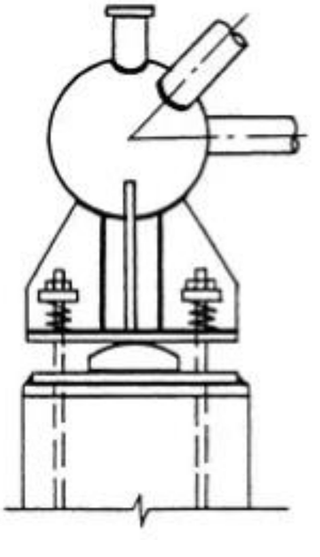


Figure 108 Sketch showing the Bearing joint resting on curved bearing block [125]

- Bearing joint resting on a laminated elastomeric pad allowing both rotation and horizontal movements

124 https://www.academia.edu/6244542/24_Space_Frame_Structures_24.1_Introduction_to_Space_Frame_Structures (April 2020)

125 Ibid.

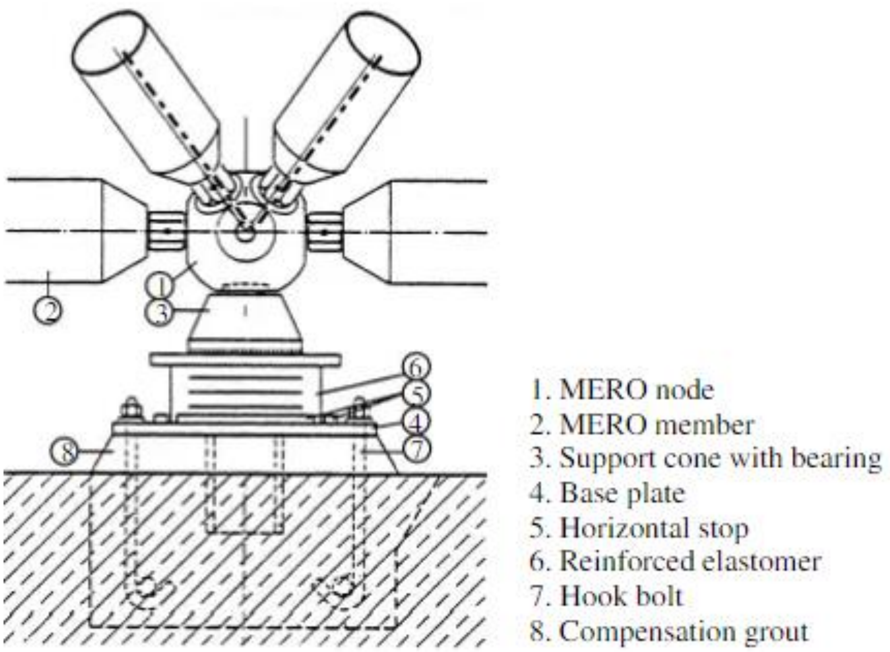


Figure 109 Sketch showing the Bearing joint resting on a laminated elastomeric pad [126]

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126 https://www.academia.edu/6244542/24_Space_Frame_Structures_24.1_Introduction_to_Space_Frame_Structures (April 2020)

3.2.1.4.3. Supports

Although it is preferable that the space frame is designed out of simple shapes with perimetral supports, it is not always possible due to build or surroundings limitations. Therefore, when designing a space frame, there three possible support layouts come to mind:

Support along perimeters

The first is the most common and most recommended support location. Supports are located on the perimeter of the space frame and should match the module size of the grids.

Multicolumn supports.

In this case, intermediary columns are present through several possible layouts:

- Space frame is supported by four intermediate columns, this is mainly used for single-span buildings

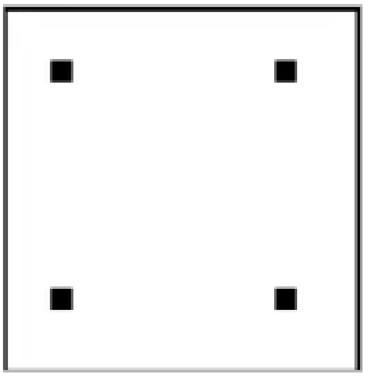

Figure 110 Sketch showing the Space frame supported by four intermediate columns [127]

127 https://www.academia.edu/6244542/24_Space_Frame_Structures_24.1_Introduction_to_Space_Frame_Structures (April 2020)

- Space frame is supported by more than four intermediate columns, this is mainly used for multispan buildings.

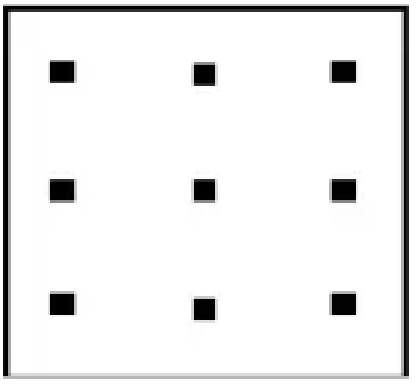

Figure 111 Sketch showing the Space frame supported by more than four intermediate columns [128]

- Space frame is supported by more than four intermediate columns with support at the perimeters.

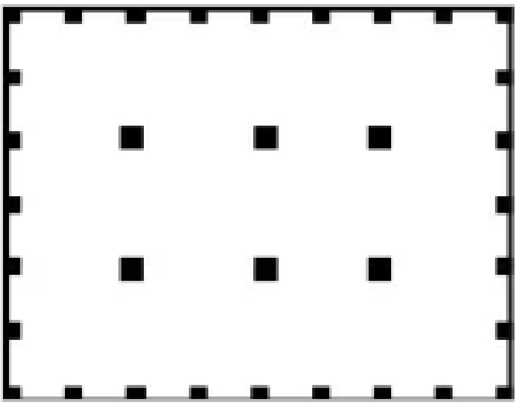

Figure 112 Sketch showing the Space frame supported by more than four intermediate columns with support at the perimeters [129]

- When using intermediate columns, it is advisable to use overhangs and avoid corner supports whenever possible.

128 https://www.academia.edu/6244542/24_Space_Frame_Structures_24.1_Introduction_to_Space_Frame_Structures (April 2020)

129 Ibid.

- In case only four columns are being employed, it is advisable to locate them in the middle and not at the corners.

Support along perimeters on three sides and free on the other side.

In most rectangular shaped structures, it will be necessary to have one side of the space frame open. In these cases, it is advisable to use a triple layer grid on the free side and place supports on the other three sides and no supports on the free side. In case span is not too big, maintaining a double layer space frame and only increasing its depth is possible.

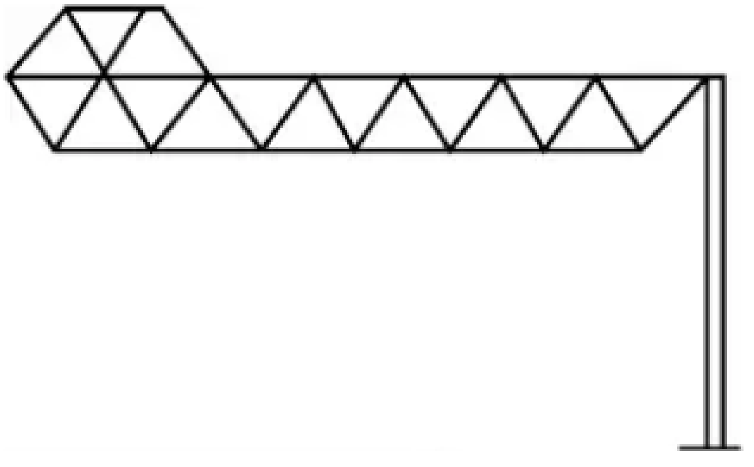

Figure 113 Sketch showing the Space frame supported along perimeters on three sides and free on the other side using triple layer at free edge [130]

130 https://www.academia.edu/6244542/24_Space_Frame_Structures_24.1_Introduction_to_Space_Frame_Structures (April 2020)

Column shape

The columns for the double layer space frame must be designed to support the gravity loads as well as possible lateral forces. This can be done using the following options:

- Using an inverted pyramid

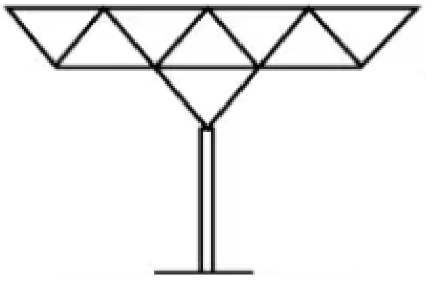

Figure 114 Sketch showing the column shape using and inverted pyramid [131]

- Using a triple-layer grid

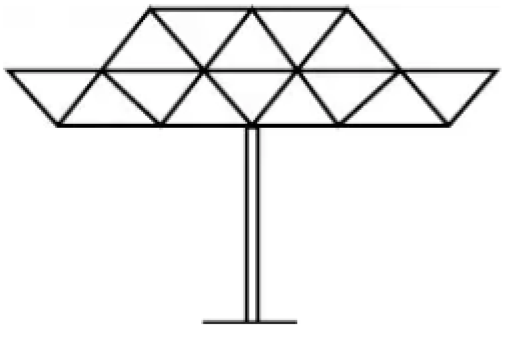

Figure 115 Sketch showing the column shape using a triple-layer grid [132]

131 https://www.academia.edu/6244542/24_Space_Frame_Structures_24.1_Introduction_to_Space_Frame_Structures (April 2020)

132 Ibid.

- Using an inverted pyramid extended to the ground level

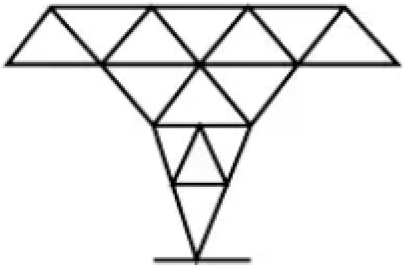

Figure 116 Sketch showing the column shape using an inverted pyramid extended to the ground level [133]

- Using vertical strut on column tops

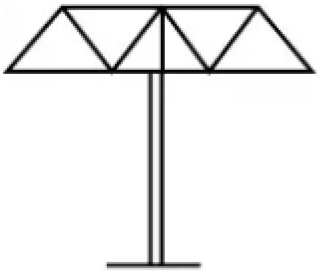

Figure 117 Sketch showing the column shape using vertical strut on column tops [134]

- Using crosshead beams on column tops

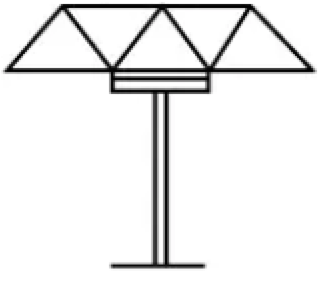

Figure 118 Sketch showing the column shape using crosshead beams on column tops [135]

133 https://www.academia.edu/6244542/24_Space_Frame_Structures_24.1_Introduction_to_Space_Frame_Structures (April 2020)
134 Ibid.
135 Ibid.

3.2.1.5.Notions for design consideration

3.2.1.5.1. Design parameters

When considering designing a space frame, the most important things to determine are the module size and the depth:

- The depth is determined by the distance between the top and bottom layers
- The module is determined by the distance separating two joints on the same grid

The angle between the center line of web members and the plane of the top and bottom chord members should be less than 30 degrees, to avoid excessive forces and length web members, or greater than 60 degrees, to avoid excessive web members density.

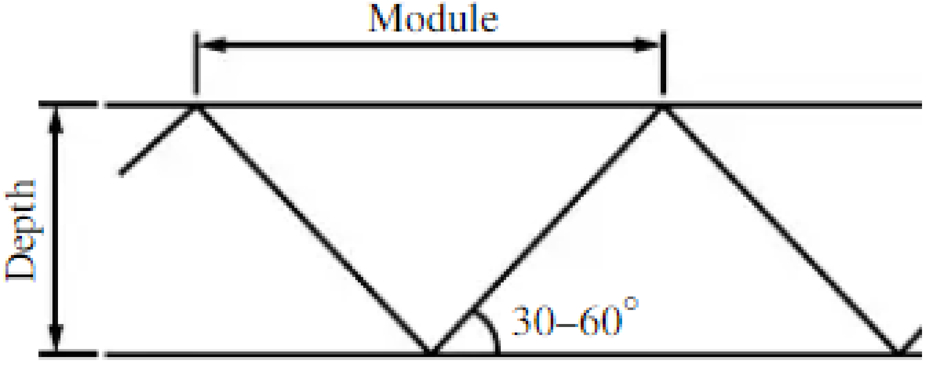

Figure 119 Sketch showing the column shape using vertical strut on column tops [136]

136 https://www.academia.edu/6244542/24_Space_Frame_Structures_24.1_Introduction_to_Space_Frame_Structures (April 2020)

3.2.1.5.2. Geometry

Designing a space frame can be brought down to the following basic geometric operations:

- Define the grid based on the plan of the structure

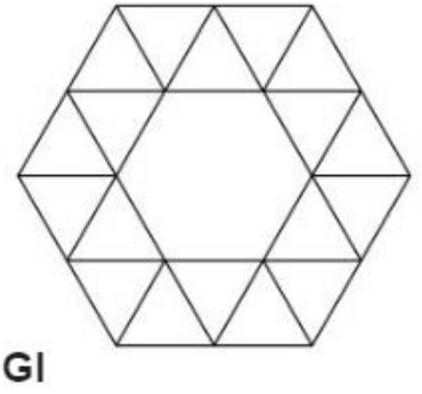

Figure 120 Sketch showing the grid based on the plan of the structure [137]

- Define the vertex connections

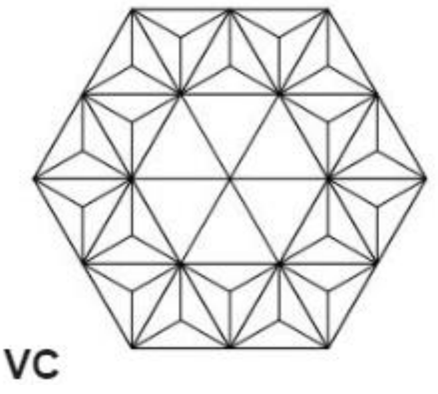

Figure 121 Sketch showing the vertex connections [138]

[137] https://issuu.com/kadimalasady/docs/spaceframe (April 2020)
[138] Ibid.

- Define the Nodes

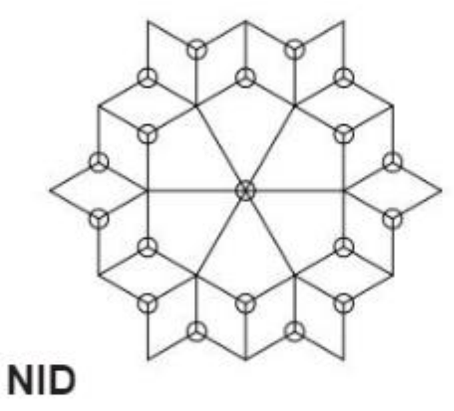

Figure 122 Sketch showing the nodes [139]

- Define the 3-dimensional joints

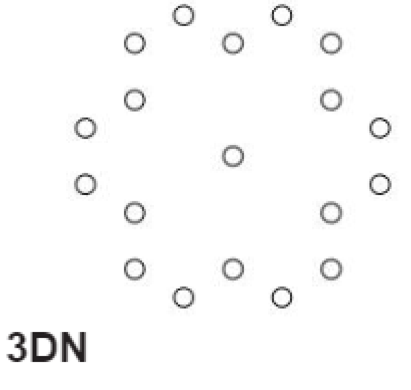

Figure 123 Sketch showing the 3-dimensional joints [140]

[139] https://issuu.com/kadimalasady/docs/spaceframe (April 2020)
[140] Ibid.

- Define the semi-regular grid by connecting the 3d joints

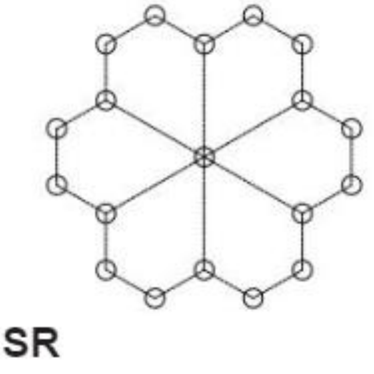

Figure 124 Sketch showing the semi-regular grid [141]

- Define the structural members of the space frame by overlay all previous systems

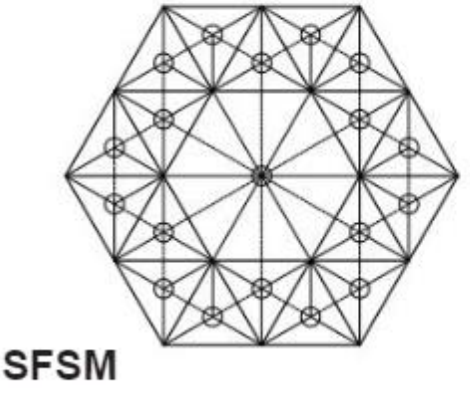

Figure 125 Sketch showing the structural members [142]

[141] https://issuu.com/kadimalasady/docs/spaceframe (April 2020)
[142] Ibid.

3.2.1.5.3. Method of erection

When considering the method of statement for a space frame, the following factors must be thought off:

- Load transmission
- Construction details
- Quality of construction
- Speed of construction
- Safety
- Cost of construction
- Scale of the structure
- Elements jointing
- Insuring the strength and rigidity of structure until end of construction

That said, there are 6 possible construction methods that can be adopted and they are the following:

Assembly of space frame elements in the air

- In this situation all members and sub-assembled elements are fabricated and transported to the site removing the need for heavy lifting equipment.
- These elements are then connected in the air directly at their correct final position with the help of partial or full scaffoldings.
- In this process it is advisable to use bolted connections.

Erection of space frame by strips or blocks

- The structure is prefabricated on the gound level in small parts which are then hoisted up into their final position to be assembled using temporary supports.
- Most assembly work is done on the ground reducing the work to be done on air making the process easier.
- It is essential that the space frame type withstands being divided into smaller parts
- The size of the small blocks is directly depended on hoisting capacities

Assembly of space frame by sliding element in the air

- This technique is used in the case that the space frame is being mounted on a pre-existing building in which case the building's structure can be used as support.
- Building rails on each side of the building to transport the parts of the space frame into position.
- Small parts of the space frame can be assembled at roof level and then put into position by sliding on rails
- This operation leaves the area underneath the space frame free to be used for construction works which saves up time
- There is no need for scaffoldings
- There is no need for special lifting equipment.

Hoisting of whole space frame by derrick masts or cranes

- The space frame is assembled entirely at ground level and then hoisted using heavy lifting equipment.
- This process presents increased efficiency and better quality
- Although depending on the size of the space frame, this option might end up being extremely costly due to the special lifting equipment needed
- In this process, the space frame can be rotated into position

Lifting up the whole space frame

- Same process and the previous one except that in this case the structure cannot move horizontally during lifting.
- Hydraulic jacks and special lifting machines for lift-slab construction are used

Jacking-up the whole space frame

- Columns are used as supports for jacking-up the space frame structure.
- This process allows for additional work to be done before lifting up, such as adding roof claddings, ceilings, mechanical installations, etc.

3.2.2. Case study

3.2.2.1.Plans, section and views:

The Aspen Art Museum was selected as a case study as it constitutes one of the most successful wood space frame projects in modern history.

Figure 126 Picture of the Aspen Art Museum front facade[143]

Figure 127 Picture of the Aspen Art Museum from an angle view[144]

[143] https://www.woodworks.org/wp-content/uploads/2015-NW-WSF-KINGSLEY-Aspen-Art-Museum.pdf (April 2020)
[144] Ibid.

The project was designed by architect Shigeru Ban and opened in 1979. The roof spans for over 15m with 4m of cantilevers and a depth of little less than a meter deep.

The space frame consists of 2 squared grids on top and bottom connected, with no visible connectors, by a series of intersecting diagonal webs made of original and unique curved members.

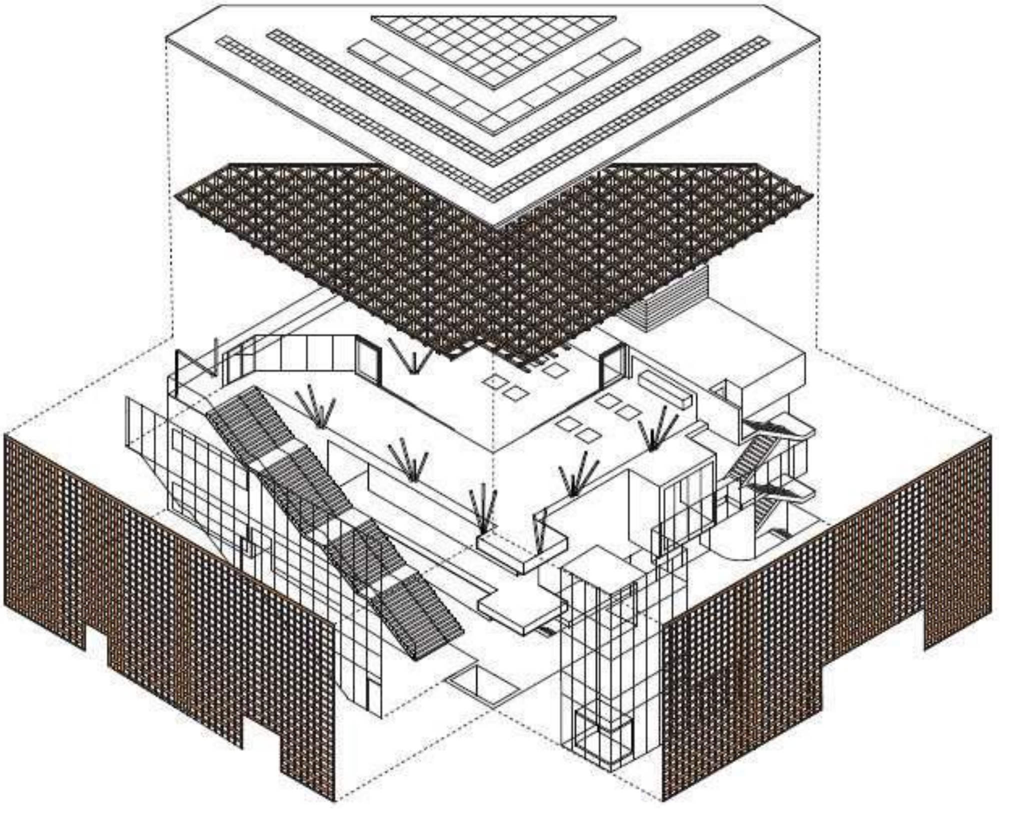

Figure 128 Sketch showing a projection of the projects' different parts[145]

[145] https://www.woodworks.org/wp-content/uploads/2015-NW-WSF-KINGSLEY-Aspen-Art-Museum.pdf (April 2020)

Figure 129 Picture of a model showing a section of the roof structure [146]

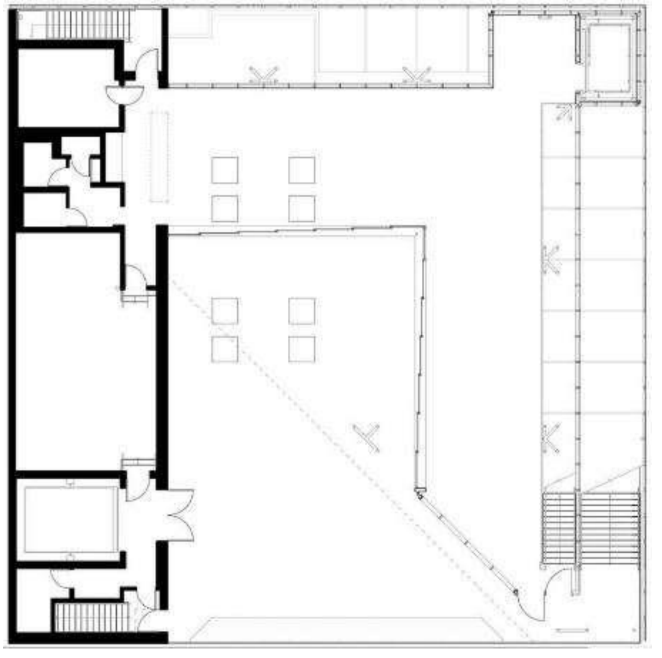

Figure 130 Plan view of the top floor showing the multiple rood structure supports [147]

146 https://www.woodworks.org/wp-content/uploads/2015-NW-WSF-KINGSLEY-Aspen-Art-Museum.pdf (April 2020)
147 Ibid.

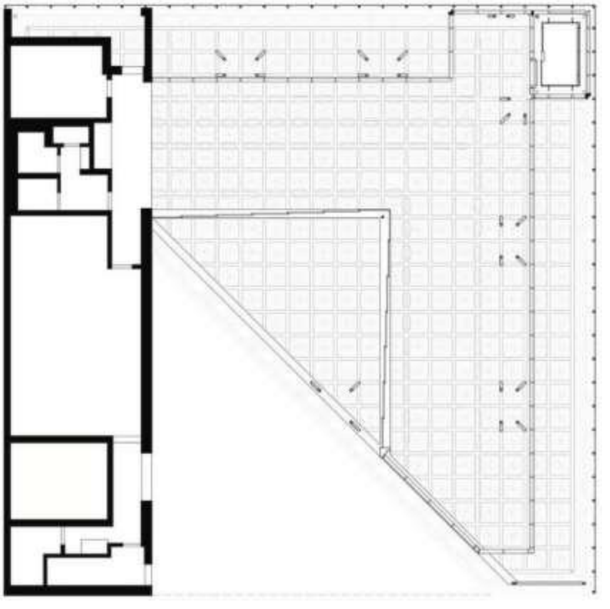

Figure 131 Plan view of the top floor showing the connection between the rood structure support and the space frame grids [148]

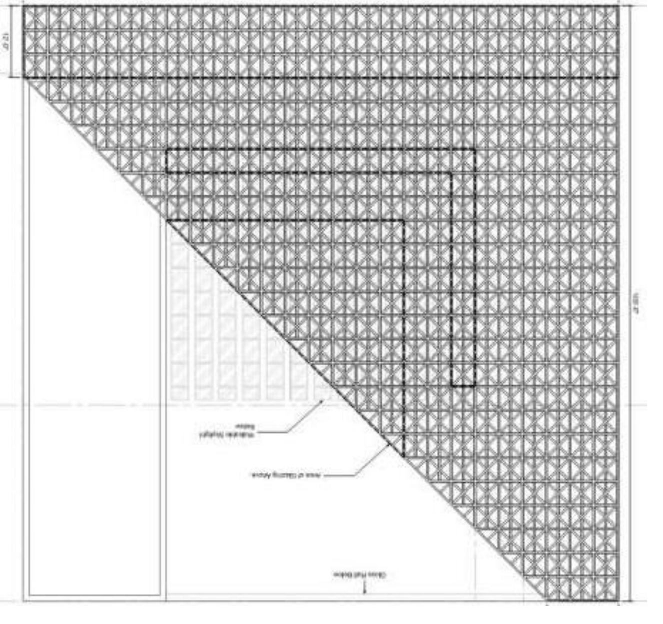

Figure 132 Plan view showing the top bottom grids with the diagonal connections.[149]

148 https://www.woodworks.org/wp-content/uploads/2015-NW-WSF-KINGSLEY-Aspen-Art-Museum.pdf (April 2020)
149 Ibid.

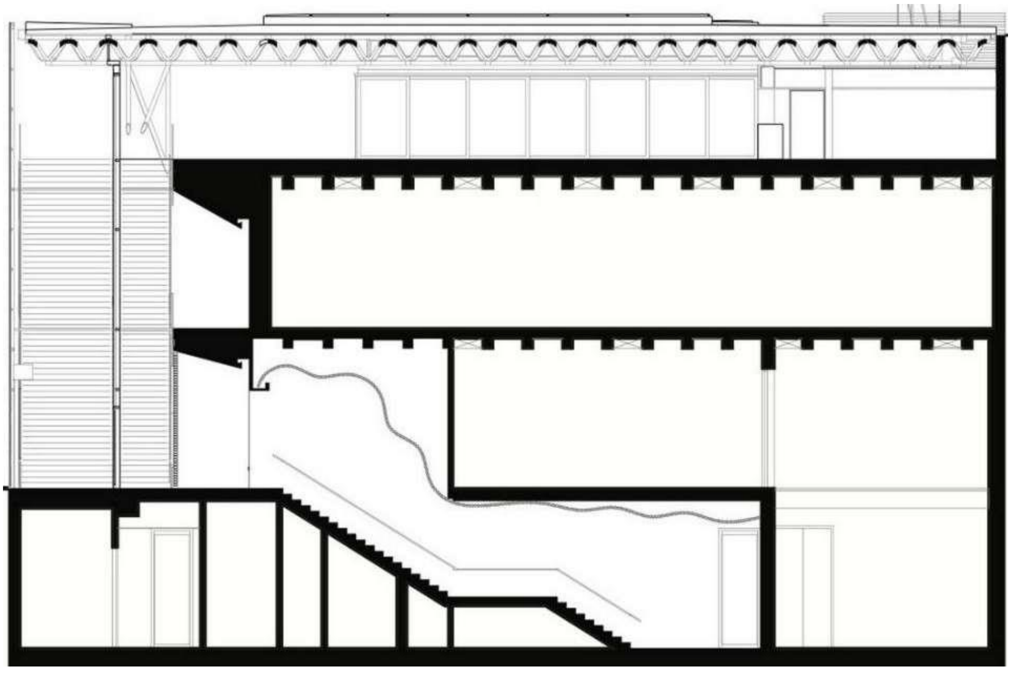

Figure 133 Section view of the building showing the space frame roof structure[150]

3.2.2.2.The space frame composition:

The concept of the space frame can be explained through the different layers it is composed of, from bottom to top:

- Layer 01: Align parallelly the Kerto Bottom Chord with special crafting at the node for proper insertion with orthogonal chord.

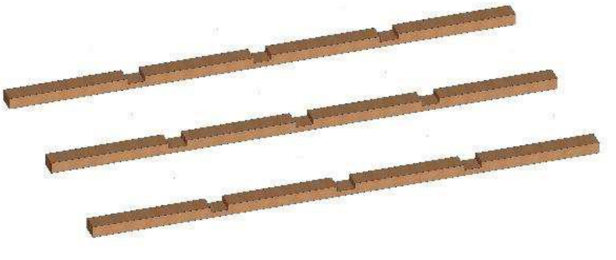

Figure 134 3D model showing layer 01 of the space frame[151]

[150] https://www.woodworks.org/wp-content/uploads/2015-NW-WSF-KINGSLEY-Aspen-Art-Museum.pdf (April 2020)
[151] Ibid.

- Layer 02: Addition of Kerto Bottom Chord orthogonally orientated

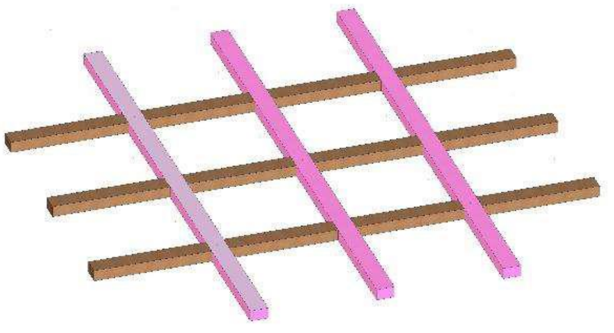

Figure 135 3D model showing layer 02 of the space frame [152]

- Layer 03: Addition of Birch Plywood bottom layer in diagonal web also with special crafting for proper insertion with orthogonal web layer at a 45-degree angle from bottom grid alignment.

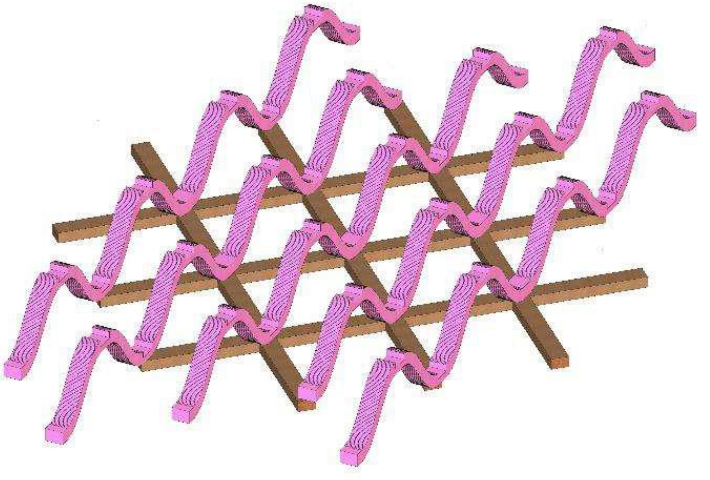

Figure 136 3D model showing layer 03 of the space frame [153]

[152] https://www.woodworks.org/wp-content/uploads/2015-NW-WSF-KINGSLEY-Aspen-Art-Museum.pdf (April 2020)
[153] Ibid.

- Layer 04: Addition of Birch Plywood upper layer orthogonally orientated

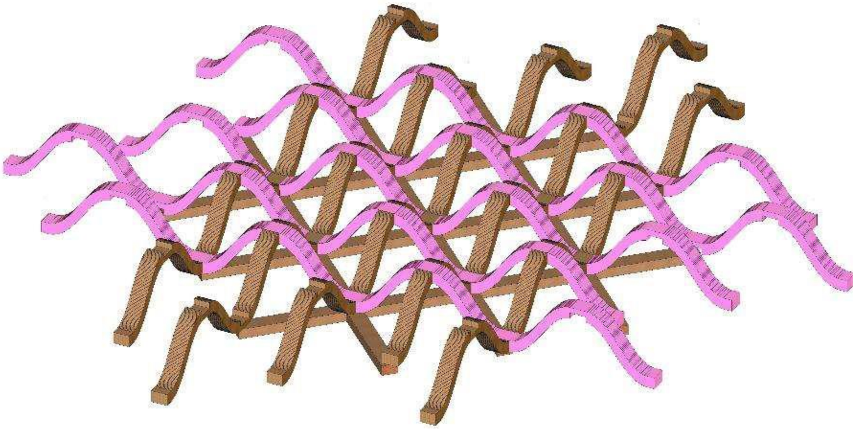

Figure 137 3D model showing layer 04 of the space frame [154]

- Layer 05: Addition of Kerto Upper Chord in same direction as bottom chord but with an offset. Upper chords are also with special crafting at the node for proper insertion with orthogonal chord.

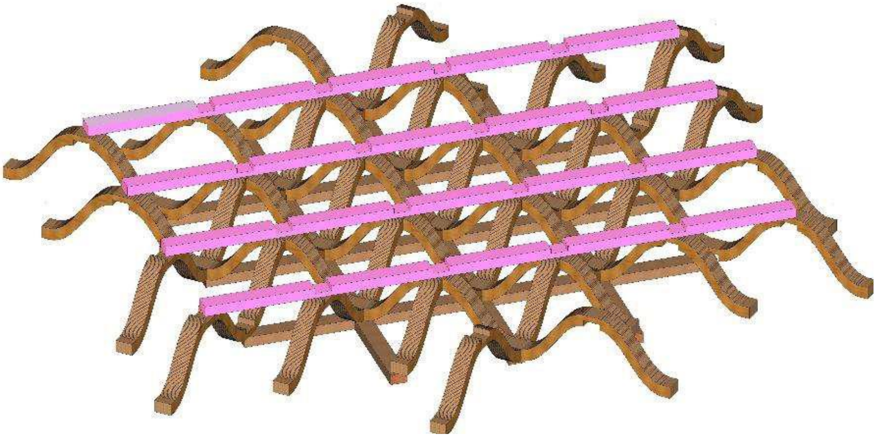

Figure 138 3D model showing layer 05 of the space frame [155]

[154] https://www.woodworks.org/wp-content/uploads/2015-NW-WSF-KINGSLEY-Aspen-Art-Museum.pdf (April 2020)
[155] Ibid.

- Layer 06: Addition of Kerto Upper Chord orthogonally orientated

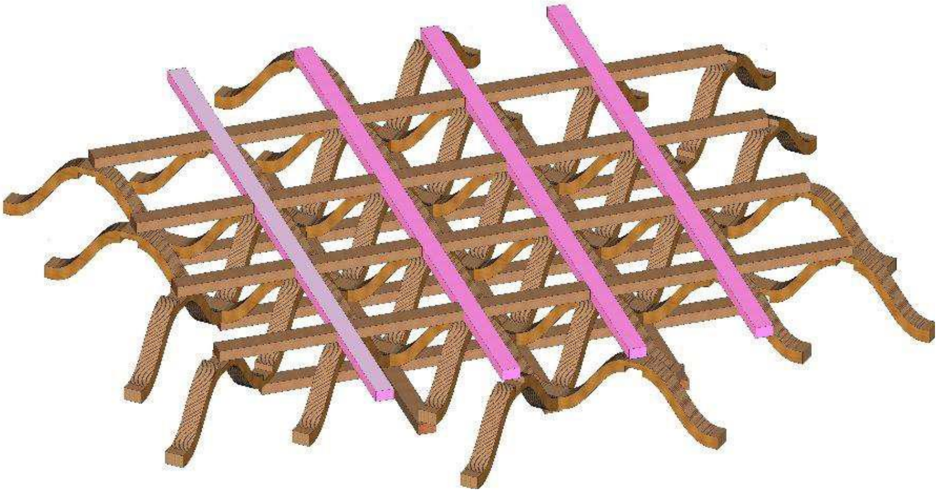

Figure 139 3D model showing layer 06 of the space frame [156]

- The joints were screwed together as per the below sketch (15 screws)

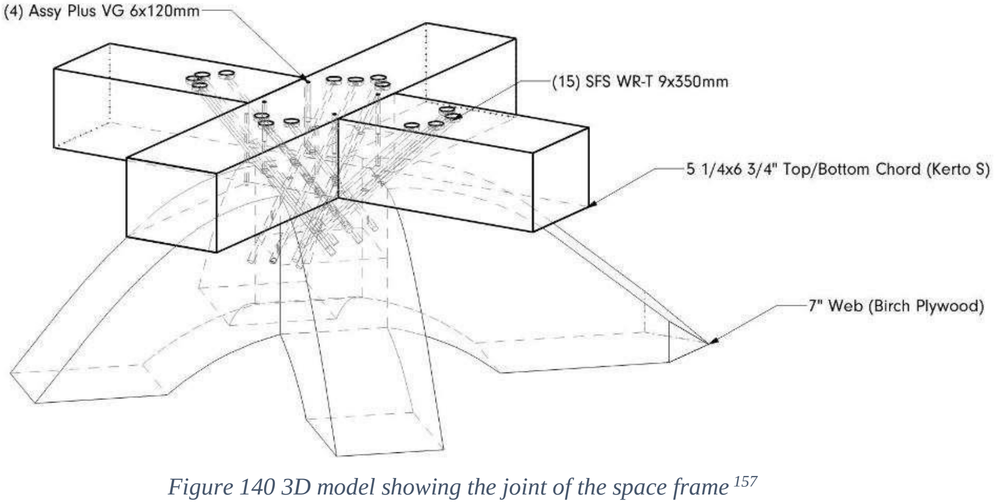

Figure 140 3D model showing the joint of the space frame [157]

[156] https://www.woodworks.org/wp-content/uploads/2015-NW-WSF-KINGSLEY-Aspen-Art-Museum.pdf (April 2020)
[157] Ibid.

3.2.2.3.The components fabrication:

The different components were prefabricated at the shop before being shipped to site. The curved wood members were made of 31 layers 1.5 mm Birch plywood sheets which thanks to their characteristics allowed for the desired wavy shape. Once cut the layers would be then placed together into the desired shape and glued together and then packed for shipping.

Here follow a few pictures concerting the fabrication process:

Figure 141 Picture showing the multilayered Brich plywood [158]

[158] https://www.woodworks.org/wp-content/uploads/2015-NW-WSF-KINGSLEY-Aspen-Art-Museum.pdf (April 2020)

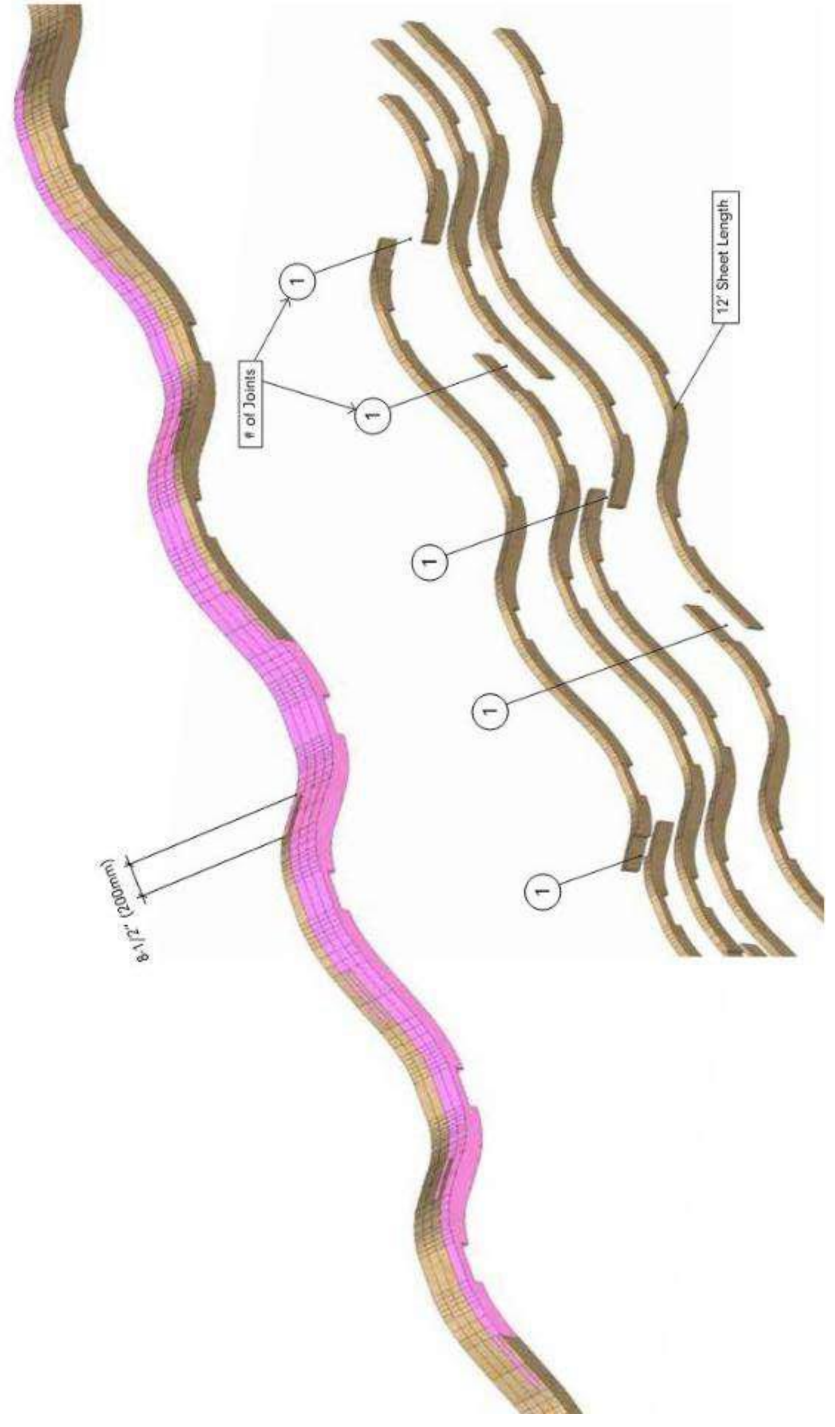

Figure 142 Picture showing the wood splicing pattern[159]

[159] https://www.woodworks.org/wp-content/uploads/2015-NW-WSF-KINGSLEY-Aspen-Art-Museum.pdf (April 2020)

Figure 143 Picture showing the plywood laser cutting process [160]

[160] https://www.woodworks.org/wp-content/uploads/2015-NW-WSF-KINGSLEY-Aspen-Art-Museum.pdf (April 2020)

Figure 144 Picture showing the plywood laser cut pieces being joined together before the gluing process[161]

[161] https://www.woodworks.org/wp-content/uploads/2015-NW-WSF-KINGSLEY-Aspen-Art-Museum.pdf (April 2020)

Figure 145 Picture showing the plywood clamped during the gluing process [162]

[162] https://www.woodworks.org/wp-content/uploads/2015-NW-WSF-KINGSLEY-Aspen-Art-Museum.pdf (April 2020)

Figure 146 Picture showing the space frame web connection [163]

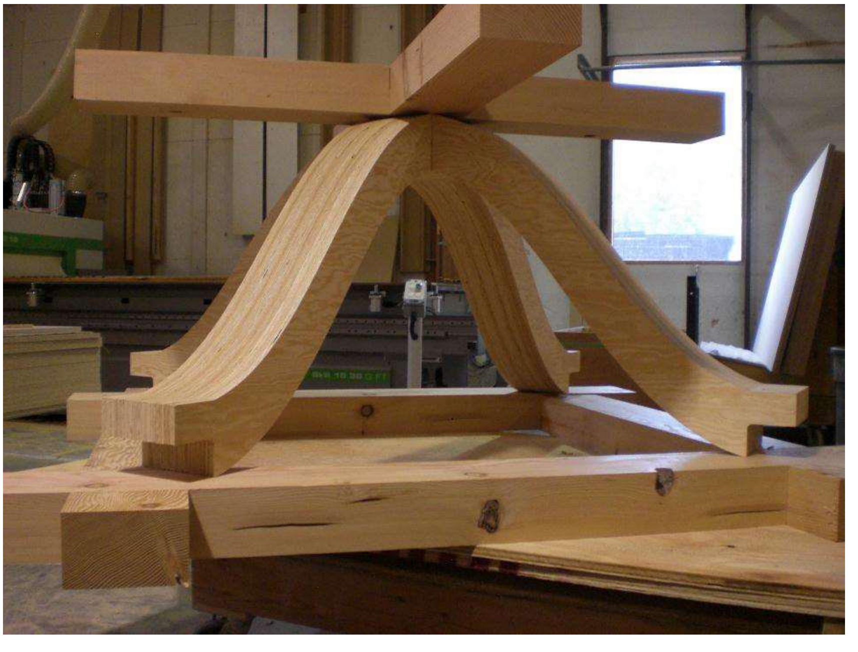

Figure 147 Picture showing a prototype with all layers[164]

3.2.2.4.The construction site:

[163] https://www.woodworks.org/wp-content/uploads/2015-NW-WSF-KINGSLEY-Aspen-Art-Museum.pdf (April 2020)
[164]Ibid.

Thanks to the pictures provided by "KL&A Inc., Structural Engineers and Builders", the following important details were noted during the construction process:

- The space frame was constructed thanks to scaffolding and heavy lifting equipment:

Figure 148 Picture showing scaffolding[165]

Figure 149 Picture showing crane being used for heavy lifting[166]

- Additional on-site adjustments were needed for grid fitting:

[165] https://www.woodworks.org/wp-content/uploads/2015-NW-WSF-KINGSLEY-Aspen-Art-Museum.pdf (April 2020)
[166] Ibid.

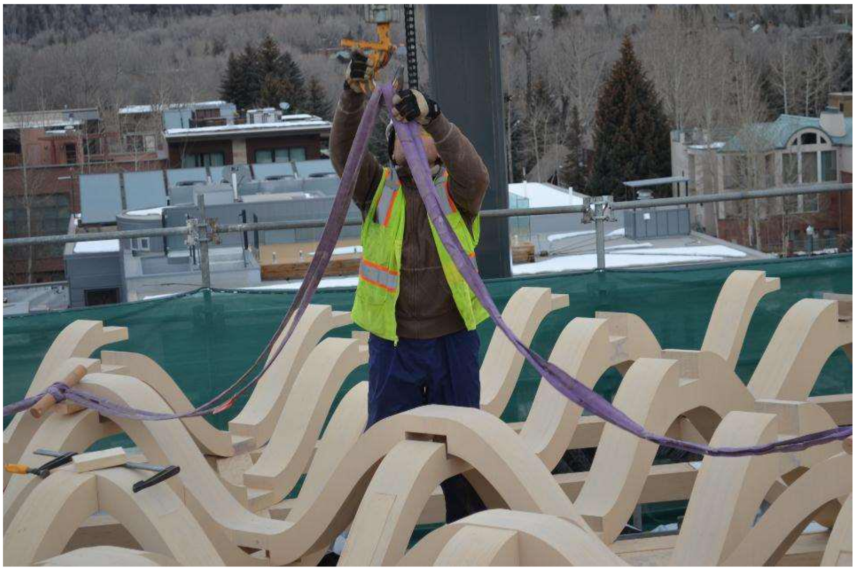

Figure 150 Picture showing fitting between layers was not always smooth[167]

- Column support connection detail:

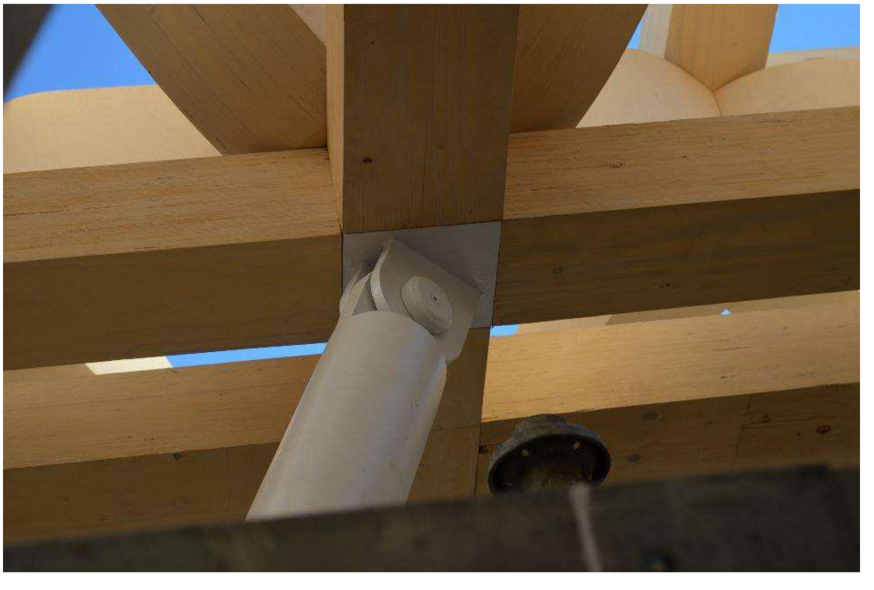

Figure 151 Picture showing Column support connection detail [168]

- Additional structural reinforcement was needed in some nodes:

[167] https://www.woodworks.org/wp-content/uploads/2015-NW-WSF-KINGSLEY-Aspen-Art-Museum.pdf (April 2020)

[168] Ibid.

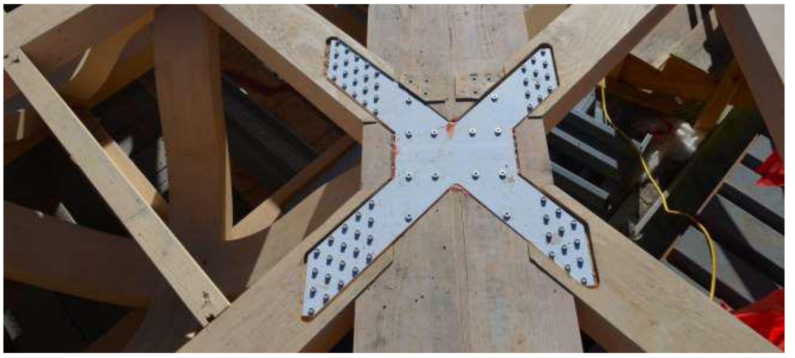

Figure 152 Picture showing additional node structural reinforcement[169]

3.2.2.5.Guidelines for wood space frame:

Through the study and analysis of the case study project, the following guidelines were deduced:

- Nodes and connections constitute the biggest challenge
- Considering that wood is orthotropic by nature, special attention should be put to the wood fibers orientation.
- The cost of knife plates and bolts can overcome the savings of using an entirely wooden space frame.
- Using notches in half-lap joints have a severe impact on the wood strength
- Using screws at the joints provide a strong connection.
- The more the design is complicated the more limited are the manufacturing capabilities which will influence the overall project cost.
- 3d modelling is crucial
- It is advisable to involve the manufacturers in the design process as early as possible

[169] https://www.woodworks.org/wp-content/uploads/2015-NW-WSF-KINGSLEY-Aspen-Art-Museum.pdf (April 2020)

3.2.3. Conclusions

The space frame technology presents the following advantages:

- Lightweight:
  The spatial distribution of the space frame allows it to use each element to the fullest thus reducing the required material to the bare minimum while maintaining excellent strength and stiffness. It is to be noted that the materials used for the space frame are also light weighted when compared to the alternatives thus further justifying this quality with the technology.

- Mass productivity
  The fact that most space frames are based on repetitive units alongside a grid, makes most if not all of its members of standard size and shape thus allowing easy, cost efficient mass production in factories. This also improves the quality of the elements provided.

- Transportation
  The components of a space frame are of relatively small size, especially when compared to the span covered by the structure. This allows easy stacking, transportation & storage of the components and helps heavily with cost reduction.

- Assembly
  The repetitiveness of the units and the fact that they follow a grid makes the assembly process if the space frame to be relatively easy and require minimal erection time.

- Stiffness

  The three-dimensional structural behavior of the space frame allows the full engagement of all its components and therefore give the structure a very desirable and important stiffness allowing more freedom with support location.

- Versatility

  Given the fact that various modules, and repetitive units, can be used in the design process, the space frames are considered to be extremely versatile in shape and form.

- Maintenance

  One of the most important factors when considering the space frame would be the easy maintenance. The space between the top and bottom cord allows for easy and practical passage of the ducts and catwalks in the case of very big structures.

The space frame presents numerous advantages that can all be used with the proposed project and most importantly it provides the same benefits of the Gridshell and answers to all the highlighted problems both from a technical and sociological point of view:

- From a technical point of view, the collaboration period with DAR group has proven that it is simpler to calculate, design and build a space frame than it is a Gridshell as no special programs are needed.

- The construction process is very simple and depending on span and design, may not need heavy lifting machinery nor a high level of monitoring. The also allows the manpower present on site to be very effective and therefore reduce costs.

- Expertise on site are limited and there is no need for constant presence as periodical control and supervision suffice.

- The geometries formed by space frame are of simple nature and with proper design and cladding, should give away a simple desirable and safe project.

- the joints are simpler, the members are of the same size and the repetitiveness of the grid unit makes the calculations much

3.3.Tensile structures

3.3.1. History

Unlike tents, the notion of tensile structure was first introduced in the nineteenth century with several important structures as follows:

- It was first used in circus tents like the “Chapiteau”, who had a diameter of 50m and were made from woven linen. From these structures were founded two of the modern techlonogies’ features:
    - The deformable shape
    - Pretension

Figure 153 Picture showing a circus tent "Chapiteau" [170]

- Once more, Russian engineer Vladimir Suchov became a reference due to his design for exhibition halls for the Pan-Russian exhibition of 1896, in which he used a two-way network of thin steel strips to form the world’s first steel tensile structure. This

[170] https://circus-collection.blogspot.com/2013/04/journee-mondiale-du-cirquecirque.html (April 2020)

showed the importance of the surface shape in the stiffness, stability and load baring capacities of the structure.

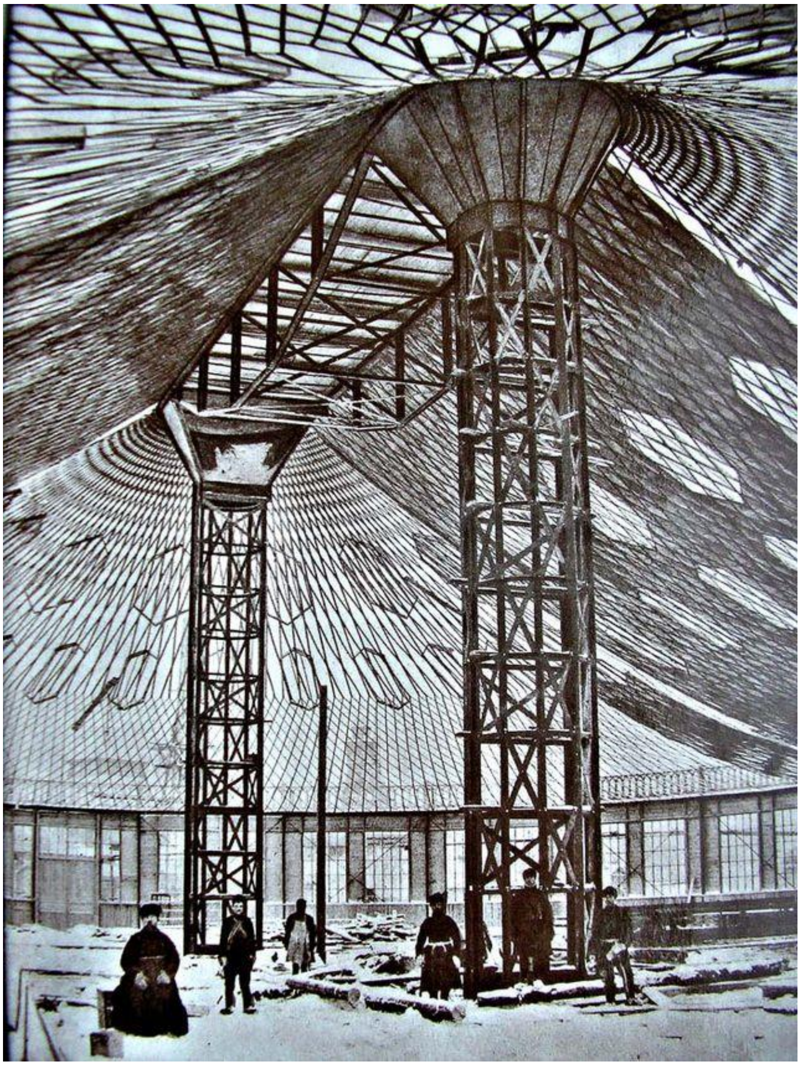

Figure 154 Picture showing network of steel fins used by V.Suchov [171]

- The next big step required 50 years, with the introduction of the “saddle” shaped roof with the Raleigh Livestock Arena by engineer Fred Severud and architect Matthew Nowicki. With this

[171] https://circus-collection.blogspot.com/2013/04/journee-mondiale-du-cirquecirque.html (April 2020)

building, another two very important features of tensile structures were introduced:

- The arch boundaries' capacities to contain the forces coming out of the cable network
- The formation of the "anticlastic" double curvature roof type

Figure 155 Picture showing network of steel fins used by V.Suchov [172]

- From that point on a series of new ideas and techniques were developed worldwide with the Expos becoming the ideal testing ground for these structures. Every single one of these projects contributed in developing new ideas and notions about the various features of the tensile structure:
    - Shape
    - Erection
    - Stressing technique
    - Material
    - Jointing methods
- The last important notion leading the world of tensile structure as we know it, is the cable net roofing designed by architect Frei Otto for the 1972 Olympic Games in Munich. This project's importance comes from the fact that it symbolizes the official shift from

[172] https://www.architecturelab.net/one-best-examples-modern-architecture-former-livestock-pavilion-north-carolina/ (April 2020)

physical model testing to computer software which allowed a better design of the surface geometry and the cutting patterns and dimensions for production.

Figure 156 Picture showing network of steel fins used by Vladimir Suchov [173]

[173] https://en.wikipedia.org/wiki/Venues_of_the_1972_Summer_Olympics (April 2020)

3.3.2. Qualities of membrane arc

The tensile structures were initially considered due to their complementarity with the shell technology. However, once analyzed, they presented the following interesting and important qualities making them even more ideal:

- Lightweight structures
  Due to the fact that their structural performance comes from their shape and not their mass

- Translucency
  The materials offer an important translucency thus allowing important gains on the structure’s energy efficiency.

- Flexibility
  The materials and design allow for important displacements to occur with no permanent damage.

- Safety
  Aside from the existent strict regulations that make these structures very safe, it is to be noted that they perform much better than traditional technologies in case of earthquakes.

- Functions
  This technology can be used for a variety of functions as will be seen successively

- Expressive architectural forms
  The free-form designs that ca be produced with this technology presents an attractive interest from architects worldwide.

- Weather protection

  These structures remain truthful to their tent ancestors and provide excellent shelters for almost all-weather conditions.

- Mobile and temporary

  The lightness and packaging process make them ideal mobile and temporary structures.

- Convertible and adaptive

  Combined with modern day engineering and mechanical processes these structures have proven to be extremely useful when convertible and can easily adapt to any project requirement.

Figure 157 Picture showing architect Mahmoud Bodo Rasch's convertible shading tensile structure[174]

[174] https://en.wikipedia.org/wiki/Mahmoud_Bodo_Rasch (April 2020)

3.3.3. TYPES

Tensile structures are usually chosen in order to use the free form advantage they allow the architects which makes it possible for them to achieve esthetically pleasing double curvatures. These curvatures can be divided into two main groups: The Synclastic and the Anticlastic.

3.3.3.1.ANTICLASTIC

The anticlastic membrane structures are:

- Saddle-shaped mechanically prestressed membranes.
- They rely purely on tension forces for stability.
- Their resistance to extreme loads comes from their form and not their mass.
- The structure is balanced by using edge reinforcements connecting the structure to either supporting or suspending elements.
- When designing for large spans, linear internal boundaries must be used.

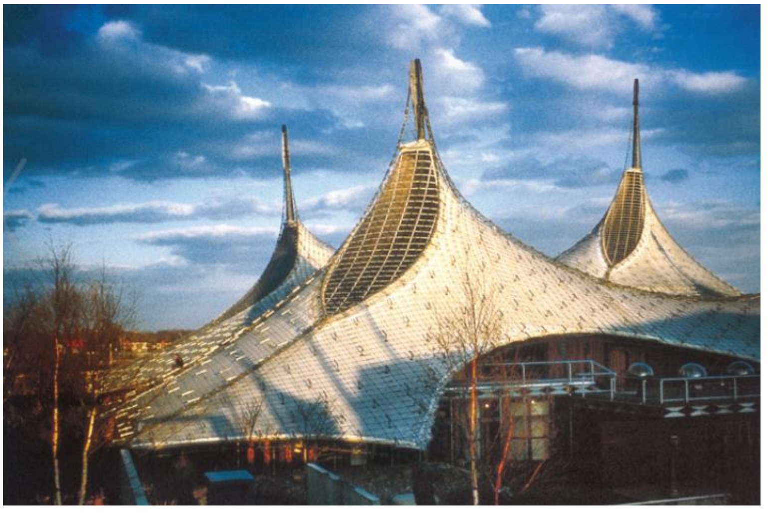

Figure 158 Picture showing the anticlastic structure of the German pavilion in the world exhibition of 1967 [175]

[175] https://www.archdaily.com/623689/ad-classics-german-pavilion-expo-67-frei-otto-and-rolf-gutbrod (April 2020)

3.3.3.2.SYNCLASTIC

The synclastic membrane structures are:

- Spherical-shaped air inflated structures
- They rely purely on difference in fluid or gas pressure for prestressing and stability.

Figure 159 Picture showing synclastic structure of Walter Bird's Exhibition pavilion at the 1964 World Fair New York [176]

[176] https://www.e-flux.com/architecture/structural-instability/208703/environmental-wind-baggery/ (April 2020)

They can be divided into three groups

- Air supported structures

  They are stabilized by pressure difference produced by air being pushed by fans into their airtight membrane. These structures have no need for supports making them the simplest and lightest structures made by man, and allowing them to span for big distances.

Figure 160 Picture showing an air supported Synclastic structure [177]

[177] https://www.e-flux.com/architecture/structural-instability/208703/environmental-wind-baggery/ (April 2020)

- Inflated cushions structures

  Similar to the previous type except it is used for building envelopes and is usually made out of ETFE and PTFE layers, with the number of layers depending on environmental requirements.

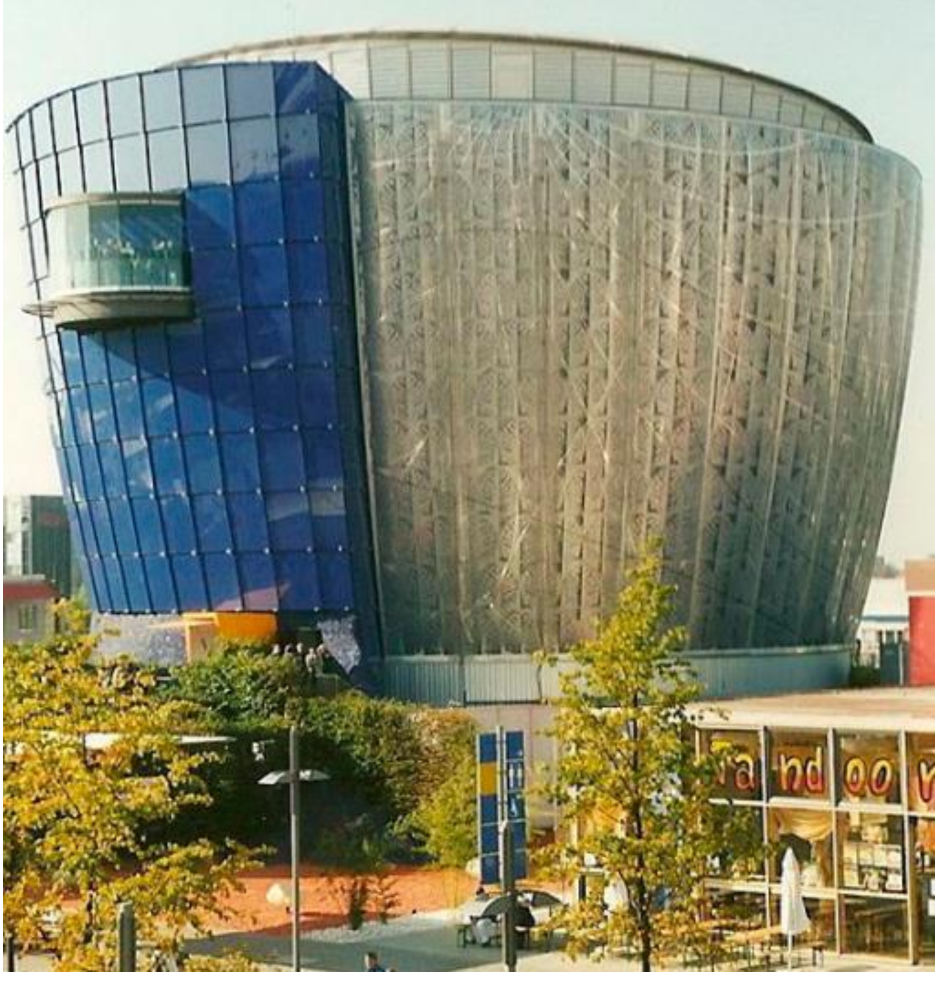

Figure 161 Picture showing an air supported Synclastic structure [178]

[178] https://www.archiexpo.es/prod/vector-foiltec/product-68767-1911832.html (April 2020)

- Hydrostatically shaped structures

  They are stabilized by hydrostatic pressure and are normally shaped like water droplets and are mainly used for containing liquids.


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Figure 162 Picture showing an air supported Synclastic structure [179]

[179] https://www.tensinet.com/files/Design_Guide/03-tensinet-A.pdf (April 2020)

3.3.4. LOCATION: APPLICATION AND CLASSIFICATION

As it can be deduced from the existing projects, there are infinite design applications for textile constructions which is also what makes it so desirable. While looking at these projects, a certain pattern was noted that showed that these applications can be grouped by function as follows:

- Open

  The function is to provide shelter from rain and sunshine while maintaining the surrounding environmental conditions and continuity with its surroundings.

- Enclosed

  Same as previous with the addition that it creates an internal environment that improves and separates from the outdoor weather conditions

- Convertible

  A mix of the above functions made capable through both a mechanical and analogue system that allow the closed roof to be opened in short time to accommodate with different weather conditions or/and building purposes.

These can also be grouped by location as follows:

- Covering

  The textile membrane has its independent structure and is the last layer of the envelope of the structure
- Internal

  The textile membrane is located within the building

- Attached

  The textile membrane is located in the outdoors and is partially attached to the building

Each textile construction can be classified by using a combination of the above stated functions and locations as per the following table:

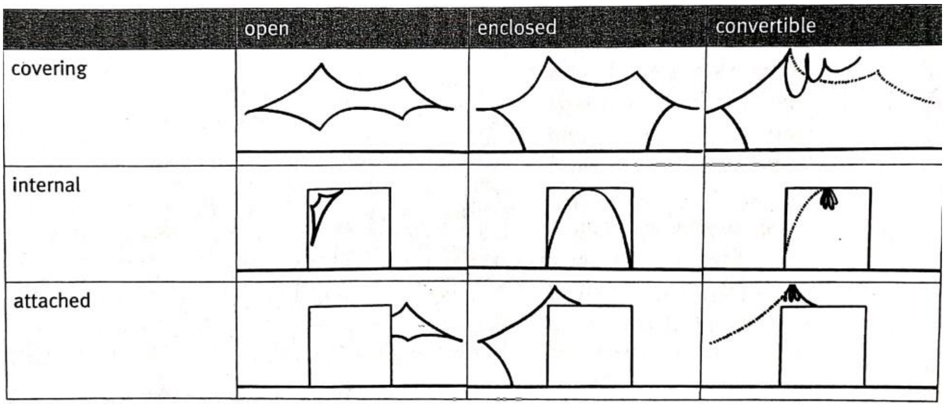

Figure 163 Picture showing an air supported Synclastic structure [180]

[180] https://www.tensinet.com/ (April 2020)

3.3.5. MEMBRANE SUPPORT

When considering the support for a lightweight structure such as the tensile structures, two very important notions come to mind:

- Curvilinear reinforcements between supports
- Forming a continuous boundary from stiff elements and rigid structures.

The above can be achieved by applying one or a combination of the following solutions:

- Soft membrane reinforcements
  It consists of using linear continuous reinforcements, preferably from the same fibers as the fabric composing the structure.

- Soft ridges, valleys and loops
  Used primarily for large span roofs that have a flat perimeter edge. The linear reinforcement is achieved by alternating between ridges and valley cables with internal support.

- Stiff membrane edges
  This system allows for more freedom in design as the edge can be regularly adjusted in order to handle the forces applied through the membrane. Special attention should be given to the connection detail between the membrane and the edge in order to properly handle the difference in stiffness coming from the different materials.

- Stiff linear supports

  Provides similar advantages as the previous option with the exception that in this case we are talking about arches and angular frames.

- Humped membrane supports

  This system consists in using spherical supports for large span structures.

- Masts

  Masts are used to support the tensile structure at its key points and can be divided as follows:

  - Boundary masts

    Used to provide support at the edge and corner points

  - Internal masts

    Used to support the top internal membrane fortification.

  - Airborne masts

    Used to reduce the structural supports on the ground and provide more open areas. They are usually composed of steel cable systems.

  - External masts

    Used for maximum inner space freedom and where the design of the structure impedes it from having inner structural elements.

- Cables

  Cables and ropes can be used for the following:
    - Soft linear edges
    - Internal linear reinforcements
    - Anchoring
    - Aerial support of single points.

- Foundations

  All the above supports have a variety of foundation systems available. They vary from size to function to timeline to loads. Crucial studies should be performed as high forces are transferred through them.

3.3.6. DESIGN AND FORM FINDING

The design process for a tensile structure unit requires the following:

- Form-finding process
- Defining the cutting pattern for the design
- This process requires special computer programs that are not commonly known.
- Designing the proper seams after picking out of the most opportune technology out of the following:
    - Stitched seams
    - Welded seams
    - Combination seams
    - Glued seams
    - Laced seams
    - Clamped seams

- Designing the proper edges after picking out of the most opportune technology out of the following:
  - Flexible edges
  - Rigid edges

- Designing the proper corners after picking out of the most opportune technology out of the following:
  - Corner plate separated from fabric
  - Corner plate clamped to fabric using adjustable cables
  - Corner plate using keder profiles for connection to fabric
  - Corner plate clamped to fabric using a continuous edge cable
  - Corner plate connected to fabric through the usage of belts

- Designing the proper base plates after picking out of the most opportune technology out of the following:
  - Mast base plates
  - Cable base plates

- Designing the proper anchorage after picking out of the most opportune technology out of the following:
  - Prestressed or active anchorage
  - Deadload or passive anchorage

3.3.7. Fabrication process

The fabrication process is a rather complicated one, as it goes through all of the following operations:

- Patterning through the usage of special programs
- Plotting the patterns onto to the cloth using special machines
- Cutting by hand or using laser guided systems
- Welding through using appropriate machinery
- Quality inspection prior to shipping
- Packaging and transportation
- On site assembling, installation, adjustments
- Quality control and testing

3.3.8. Cleaning and maintenance

During the design phase a special study should be made to the following:

- Cleaning procedures and guidelines
- Maintenance procedures and guidelines
- Corrosion protection
- Water drainage and ponding
- Prestress and restress monitoring
- Components repair
- Components replacement

A manual is normally requested to be presented for each of the above arguments as this is essential to maintain the structure’s quality and prolong the life expectancy as much as possible.

3.3.9. Conclusion

Although this technology presents numerous advantages, it was rejected for the following reasons:

- It requires a level of detailing that is too complex thus making it hard to build from locally present materials.
- The fabrication process is too specialized rendering importation the only possible solution to be adopted thus raising the costs and requiring specialized personnel on site thus removing the advantage of the manpower present on site.
- Being minimally shaped structures leaves no room for any mistake thus further requiring experts during the entire process.
- Supporting technology heavily reliant on steel and loses plenty of its benefits for switching to alternative technologies further raising the complexity of this technology.
- The maintenance and cleaning process requires constant monitoring from specialized personnel thus increasing costs and making it very difficult to exchange the knowledge with the refugees in order to provide a much desired and essential autonomy.

Instead an adaptive roofing technology shall be used while trying to maintain on many of the desirable benefits of this technology which shall be treated in the next chapter.

4

MATERIAL STUDIED

4.1.Process description leading to chosen material

With the technology chosen, it was time to choose the materials that will be used for the project on two main levels:

- Structural level
  - Foundation
  - Structure

- Envelope level
  - Roof material
  - Wall covers materials
  - Floor materials
  - Doors material
  - Foundation materials

The first step was to eliminate materials which based on the research done so far have proven incompatible:

- From the sociological study and based on the experience gained from the experience with the Lebanese government, the material must be temporary thus eliminating any possibility to use the cement and traditional brick walls.

- Steel is the most optimum choice considering the technology but it is too costly and might prove to be unavailable in the area or also give away a non-desired durable structure.

- Although the possibility to use a hybrid system with steel in it will be studied. The point might be use steel joints with alternative available sustainable materials for members.

In order not to waste time, and to limit the vast possibilities, a thorough study was performed of the technologies adopted already by the United Nations. From that study, the materials to be used for the project were chosen and a more detailed study was performed on them in order to develop the last needed guidelines before developing and finalizing the project.

4.2.UNHCR reference projects:

According to the UNHCR, the shelter should be able to adapt to its context which means no universal design can be applied everywhere. Especially since the modern strategies focus highly on using sustainable materials and preferably local materials, skills and technology.

The UNHCR divide their shelters into 4 groups:

- Global Shelter Designs
- Emergency Shelter Designs
- Transitional Shelter Designs
- Durable Shelter Designs

4.2.1. Global Shelter Designs

4.2.1.1. UNHCR family tent

Location:	Deployable in soft surface areas with temperature between 5 and 40 °C
Description:	- Deployable family tent for up to 5 persons - Comes in a complete package with no need for local materials - Easily deployable and erection process can be performed by 2 persons with no required expertise in 10 minutes. - Double layered tent with outer tent providing protection against environmental agents. - Minimum 1-year lifespan
Materials:	- The tents' layers are made of polyester-cotton blend - Flooring is made of standard plastic sheeting
Special features:	- A shade net can be added in hot climate areas allowing the tent to resist from 5 to 45 °C - A winterization kit can be used in cold climate areas allowing the tent to resist up to 0 to 40°C. - The kit contains the following: o Winterization liner o Partition o Chimney sleeve o Insulating mats o Floor protection (for the wooden stove) - Assembly instructions reveal the presence of an outer tent mud flap that can be covered in mud to further strengthen the tent.

Figure 164 Picture showing UNHCR family tent [181]

Figure 165 Picture showing outer tent mud flap covered up [182]

[181] https://www.shelterinventory.org/sites/default/files/2019-06/Shelter%20Design%20Catalogue%20January%202016.pdf (April 2020)
[182] Ibid.

4.2.1.2.Frame tent

Location:	Deployable in hard surface areas with temperature between 5 and 40 °C
Description:	- Deployable family tent for up to 5 persons - Comes in a complete package with no need for local materials - Easily deployable and erection process can be performed by 2 persons with no required expertise in 10 minutes. - Double layered tent with outer tent providing protection against environmental agents. - Minimum 1-year lifespan
Materials:	- The tents' layers are made of polyester-cotton blend - Flooring is made of standard plastic sheeting
Special features:	- Ideal to be used in urban areas - A shade net can be added in hot climate areas allowing the tent to resist from 5 to 45 °C - A winterization kit can be used in cold climate areas allowing the tent to resist up to 0 to 40°C. - The kit contains the following: o Winterization liner o Partition o Chimney sleeve o Insulating mats o Floor protection (for the wooden stove) - Tent has a self-standing frame

Figure 166 Picture showing the UNHCR frame tent[183]

[183] https://www.shelterinventory.org/sites/default/files/2019-06/Shelter%20Design%20Catalogue%20January%202016.pdf (April 2020)

4.2.1.3.UNHCR Self-standing family tent

Location:	Deployable in soft surface areas with temperature between 5 and 45 °C
Description:	- Deployable family tent for up to 5 persons - Comes in a complete package with no need for local materials - Easily deployable and erection process can be performed by 3 persons with no required expertise in 10 minutes. - Double layered tent with outer tent providing protection against environmental agents. - Minimum 1-year lifespan - Dome shape provides better inner space and more comfort. - More privacy is insured with the presence an inner partition
Materials:	- The inner tent is made of polyester-cotton blend - The outer tent is made of woven high-density polyethylene (HDPE) - Flooring is made of standard plastic sheeting
Special features:	- Includes shade net in initial package. - A winterization kit can be used in cold climate areas allowing the tent to resist up to 0 to 40°C. - The kit contains the following: o Winterization liner o Partition o Chimney sleeve o Insulating mats o Floor protection (for the wooden stove) - Tent is self-standing and self-tensioning

Figure 167 Picture showing the UNHCR Self-standing family tent [184]

Figure 168 Picture showing the interior of the tent[185]

[184] https://www.shelterinventory.org/sites/default/files/2019-06/Shelter%20Design%20Catalogue%20January%202016.pdf (April 2020)
[185]Ibid.

4.2.1.4.Refugee Housing Unit

Location:	Deployable in soft surface areas with temperature between 5 and 45 °C
Description:	- Deployable family tent for up to 5 persons - Comes in a complete package with no need for local materials - Fairly deployable erection process can be performed by 4 persons with no required expertise in 5 to 6 hours - Minimum 1.5-year lifespan - Very durable - More privacy is insured with the presence an inner partition
Materials:	- The entire shelter is composed of lightweight steel including: ○ Frame ○ Roof ○ Wall panels ○ Doors ○ Windows ○ Flooring
Special features:	- Includes a photovoltaic system. - Includes a solar energy system (lamp and telephone charger)

Figure 169 Picture showing the UNHCR Refugee Housing Unit[186]

Figure 170 Picture showing the interior of the unit[187]

[186] https://www.shelterinventory.org/sites/default/files/2019-06/Shelter%20Design%20Catalogue%20January%202016.pdf (April 2020)
[187] Ibid.

4.2.2. Emergency Shelter Designs

4.2.2.1. Wooden Gable frame

Location:	Ajuong Thok, South Sudan
Description:	- Shelter using local materials - Erection process can be performed by 1 skilled person and 2 persons with no required expertise in 6 hours - Minimum 1-year lifespan

Materials:	- Foundation materials
	  o Plain concrete
	  o Compacted earth
	- Structural materials
	  o Bushwood
	  o Timber
	  o Bamboo
	- Roof materials
	  o Tarpaulin
	  o Thatch
	  o Corrugated iron
	- Wall materials
	  o Tarpaulin
	  o Grass cladding
	  o Mud plastering
	  o Bamboo
	- Flooring materials
	  o Tarpaulin
	  o Local natural material mat
	  o Platform

Special features:	- The structure performed differently depending on the material used but a common minimum specification was maintained in all solutions.

Figure 171 Picture showing the shelter unit with wooden structure and tarpaulin for the envelope[188]

Figure 172 Picture showing the shelter unit with wooden structure, tarpaulin for roof and flooring and thatch for wall cladding [189]

Figure 173 Picture showing the shelter unit with wooden structure, tarpaulin for flooring, corrugated iron sheets for roofing and thatch for wall cladding [190]

188 https://www.shelterinventory.org/sites/default/files/2019-06/Shelter%20Design%20Catalogue%20January%202016.pdf (April 2020)
189 Ibid.
190 Ibid.

Figure 174 Picture showing the shelter unit with wooden structure, tarpaulin for flooring, corrugated iron sheets for roofing and mud cladding for wall cladding [191]

Figure 175 Picture showing the shelter unit with wooden structure, tarpaulin for flooring, corrugated iron sheets and thatch for roofing and adobe plastering for wall cladding [192]

[191] https://www.shelterinventory.org/sites/default/files/2019-06/Shelter%20Design%20Catalogue%20January%202016.pdf (April 2020)
[192] Ibid.

4.2.2.2.Tuareg shelter

Location:	Burkina Faso
Description:	- Shelter using local materials - Maintained the role women played in the tribe by building the shelters. - Erection process can be performed by 3 persons with no required expertise in 1 day - Minimum 2-years lifespan - Easily relocatable
Materials:	- Nodes materials o Synthetic or local rope - Structural materials o Eucalyptus poles - Roof materials o Tarpaulin o Goat skin whenever available - Wall materials o Straw mats o Synthetic mats o Plastic sheeting
Special features:	- The structure performed differently depending on the material used but a common minimum specification was maintained in all solutions.

Figure 176 Picture showing the shelter unit with wooden structure and tarpaulin for the rest of the envelope [193]

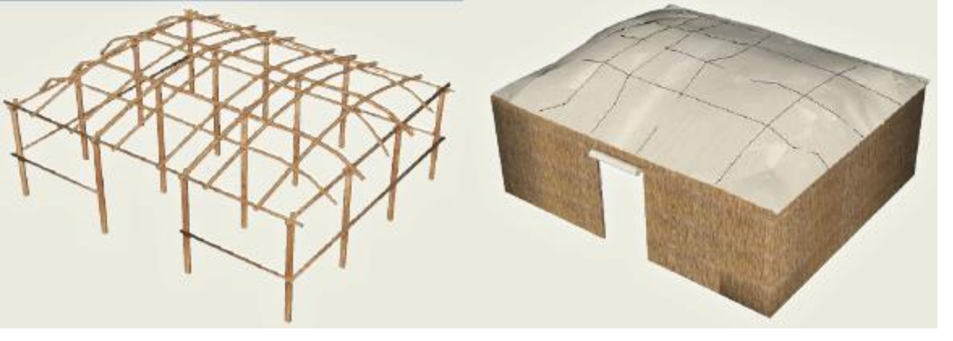

Figure 177 Picture showing the shelter unit with wooden structure, tarpaulin for roofing and straw mats for wall cladding [194]

[193] https://www.shelterinventory.org/sites/default/files/2019-06/Shelter%20Design%20Catalogue%20January%202016.pdf (April 2020)
[194] Ibid.

4.2.2.3.Tuareg tent

Location:	Algeria
Description:	- Shelter using local materials - Erection process can be performed by 3 persons with no required expertise in 1 day - Minimum 2-year lifespan
Materials:	- Nodes materials o Synthetic or local rope - Foundation materials o Plain concrete o Compacted earth - Structural materials o Metal o Timber o Bamboo - Envelope materials o Canvas sheet for exterior - Internal partitions materials o Blended cloth for interior - Flooring materials o Tarpaulin o Local natural material mat
Special features:	- The usage of local materials was highly appreciated by the refugees.

Figure 178 Picture showing the Tuareg tent[195]

Figure 179 Picture showing the bamboo poles [196]

[195] https://www.shelterinventory.org/sites/default/files/2019-06/Shelter%20Design%20Catalogue%20January%202016.pdf (April 2020)
[196] Ibid.

4.2.2.4.Tukul, South Sudan

Location:	South Sudan
Description:	- Shelter using local materials and traditional simple techniques. - Erection process can be performed by 3 persons with no required expertise in 1 day - Accommodates 4 to 6 persons - Minimum 2-year lifespan
Materials:	- Nodes materials o Synthetic or local rope - Foundation materials o Plain concrete o Compacted earth - Structural materials o Bushwood o Timber o Bamboo - Roof materials o Tarpaulin o Thatch - Walls materials o Tarpaulin o Grass cladding o Mud plastering o Bamboo sticks - Flooring materials o Tarpaulin o Local natural material mat o Platform
Special features:	- The structure performed differently depending on the material used but a common minimum specification was maintained in all solutions.

Figure 180 Picture showing the shelter unit with wooden structure, thatch for roofing and tarpaulin for wall cladding [197]

Figure 181 Picture showing the shelter unit with wooden structure, thatch for roofing and adobe plastering for wall cladding [198]

Figure 182 Picture showing the shelter unit[199]

[197] https://www.shelterinventory.org/sites/default/files/2019-06/Shelter%20Design%20Catalogue%20January%202016.pdf (April 2020)
[198] Ibid.
[199] Ibid.

4.2.2.5.Tent Shelter

Location:	Sozma Qala, Afghanistan

Description:	- 2-layer shelter
	  ○ Core living area composed of standard UNHCR tent
	  ○ Outer layer composed of typical local technologies creating a covered outer space allowing the continuity of household activities.
	- Erection process can be performed by 1 skilled person and 3 persons with no required expertise in 4 hours
	- Minimum 2-year lifespan

Materials:	- For the inner layer refer to the previously discussed UNHCR tent design
	- The outer layer is composed of the following:
	  ○ Connection materials
	    ▪ Plywood gusset plates
	    ▪ Bolts
	  ○ Structural materials
	    ▪ Bamboo
	  ○ Envelope materials
	    ▪ Tarpaulin
	    ▪ Plastic sheet cladding

Special features:	- The usage of bolts allows for easy dismantling and relocation.

Figure 183 Picture showing the 2 layered shelter unit [200]

Figure 184 Picture showing the shelter unit with wooden structure and Tarpaulin for roofing and wall cladding [201]

[200] https://www.shelterinventory.org/sites/default/files/2019-06/Shelter%20Design%20Catalogue%20January%202016.pdf (April 2020)
[201] Ibid.

4.2.3. Transitional Shelter Designs

4.2.3.1.T Shelter

Location:	Jordan, Azraq Camp
Description:	- Protect against severe weather conditions - Erection process can be performed by 4 persons with no required expertise in 16 hours - Minimum 2-year lifespan
Materials:	- Structural materials o Steel - Envelope materials o double layer of IBR (Inverted Box Rib) cladding o with aluminum foam insulation walls materials - Flooring materials o reinforced concrete
Special features:	- 13,500 shelter units were built hosting around 67,000 refugees - The gable roof design provides an improved ventilation than a traditional flat roof

Figure 185 Picture showing the T-shelter unit [202]

Figure 186 Picture showing a blow-up model of the T-Shelter unit [203]

[202] https://www.shelterinventory.org/sites/default/files/2019-06/Shelter%20Design%20Catalogue%20January%202016.pdf (April 2020)
[203] Ibid.

4.2.3.2.Compact Bamboo shelter

Location:	Ethiopia, Dollo Ado camp
Description:	- Characterized by the usage of local available materials - Erection process can be performed by 1 skilled person and 3 persons with no required expertise in 4 hours - Minimum 2-year lifespan
Materials:	- Roofing materials o Corrugated sheet - Structural materials o Eucalyptus - Wall materials o Bamboo cladding
Special features:	- Training of local laborers were submitted to trainings to help with the construction.

Figure 187 Picture showing the Compact Bamboo shelter unit [204]

Figure 188 Picture showing a blow-up model of the Compact Bamboo shelter unit [205]

[204] https://www.shelterinventory.org/sites/default/files/2019-06/Shelter%20Design%20Catalogue%20January%202016.pdf (April 2020)
[205] Ibid.

4.2.3.3.Twin elevated shelters

Location:	Kachin, Myanmar
Description:	- Characterized by the usage of local available materials - Use of local construction method - Erection process can be performed by 3 persons with no required expertise in 2 days - Minimum 2-year lifespan
Materials:	- Roofing materials o Corrugated galvanized iron (CGI) - Structural materials o Timber - Wall materials o Bamboo mat - Flooring materials o Bamboo mat
Special features:	- Characterized by the elevation from ground level in order to maintain local habits. - Local population participated in the making of the shelters which created livelihood opportunities.

Figure 189 Picture showing the Twin elevated shelter unit [206]

Figure 190 Picture showing a blow-up model of the Twin elevated shelter unit [207]

[206] https://www.shelterinventory.org/sites/default/files/2019-06/Shelter%20Design%20Catalogue%20January%202016.pdf (April 2020)
[207] Ibid.

4.2.4. Durable Shelter Designs

4.2.4.1. One room shelter

Location:	Sindh province, Pakistan
Description:	- Characterized by the fact that the shelters were safe, durable, cost efficient and sustainable - Use of local construction method - Erection process can be performed by 3 persons with no required expertise in 2 days - Minimum 2-year lifespan
Materials:	- Roofing materials o ceramic tiles - Structural materials o Self-supporting brick walls o Steel structure for roofing - Wall materials o unreinforced fire burned brick - Foundation materials o stone durable
Special features:	- Characterized by an important contribution from the community

Figure 191 Picture showing the one room shelter unit [208]

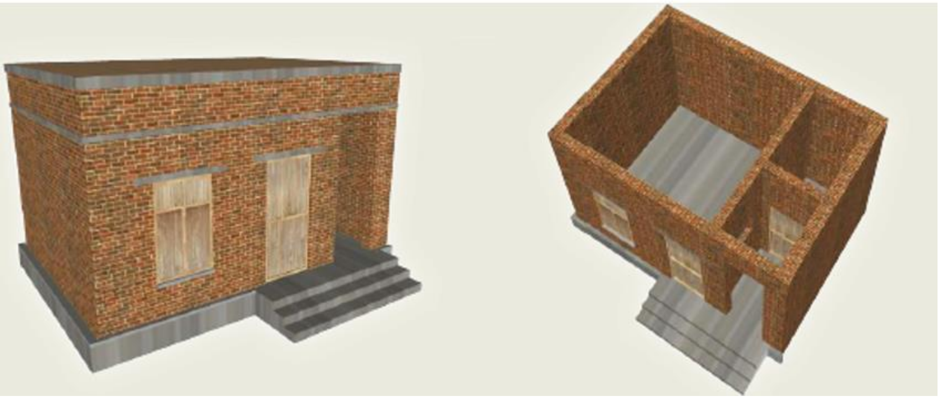

Figure 192 Picture showing a blow-up model of the one room shelter unit [209]

[208] https://www.shelterinventory.org/sites/default/files/2019-06/Shelter%20Design%20Catalogue%20January%202016.pdf (April 2020)
[209] Ibid.

4.2.4.2.L Shape Shelter

Location:	Iraq
Description:	- Characterized by the fact that the shelters were safe, durable, cost efficient and sustainable - Use of local construction method - Erection process can be performed by 5 persons with no required expertise in 3 weeks days - Minimum 10-years lifespan
Materials:	- Roofing materials ○ Sandwich panel - Structural materials ○ Self-supporting walls ○ Steel structure for roofing - Wall materials ○ concrete hollow blocks - Foundation materials ○ Raft foundation of plain concrete
Special features:	- Each shelter has: ○ Two rooms ○ One kitchen ○ One toilet

Figure 193 Picture showing the L-Shape shelter unit [210]

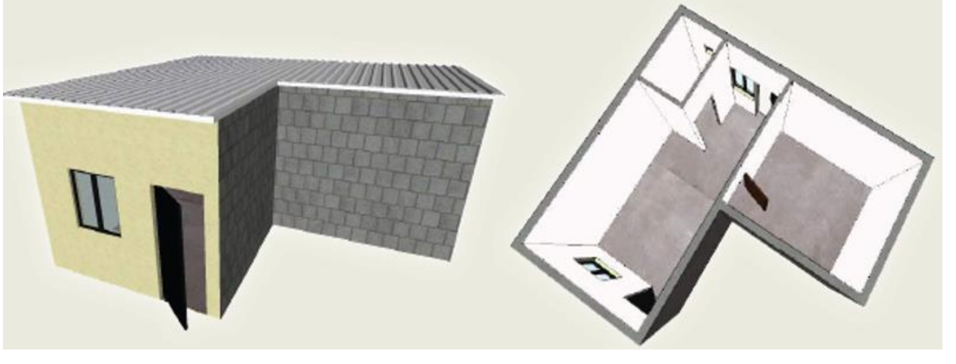

Figure 194 Picture showing a blow-up model of the L-Shape shelter unit [211]

[210] https://www.shelterinventory.org/sites/default/files/2019-06/Shelter%20Design%20Catalogue%20January%202016.pdf (April 2020)
[211] Ibid.

4.2.5. Guidelines for the project:

4.2.5.1. Summary of all materials encountered:

First step, was to sum up the materials used by the UNHCR reference projects as follows:

Structural materials:

- Brushwood
- Timber
- Bamboo
- Eucalyptus poles
- Metal
- Self-supporting brick walls
- Steel structure for roofing
- High-density polyethylene (HDPE)

Flooring materials:

- Standard plastic sheeting
- Lightweight steel
- Reinforced concrete
- Timber
- Bamboo

Roofing materials:

- Lightweight steel
- Tarpaulin
- Thatch
- Corrugated iron sheet
- Goat skin whenever available

- Corrugated galvanized iron (CGI)
- Ceramic tiles
- Sandwich panel
- Polyester-cotton blend
- High-density polyethylene (HDPE)
- Canvas sheet for exterior
- Plastic sheet cladding
- Double layer of IBR (inverted box rib) cladding

Wall materials:

- Lightweight steel
- Tarpaulin
- Grass cladding
- Mud plastering
- Bamboo mat
- Straw mats
- Synthetic mats
- Plastic sheeting
- Blended cloth for interior
- Unreinforced fire burned brick
- Concrete hollow blocks
- Polyester-cotton blend
- High-density polyethylene (HDPE)
- Canvas sheet for exterior
- Double layer of IBR (inverted box rib) cladding
- Timber

Foundation materials:

- Plain concrete
- Compacted earth
- Stone durable
- Raft foundation of plain concrete

Flooring materials:

- Tarpaulin
- Local natural material mat
- Platform
- Timber

Nodes materials

- Synthetic or local rope
- Steel joints
- Timber

Connection materials

- Plywood gusset plates
- Bolts

4.2.5.2.List of all materials chosen:

Here follows the list of materials that were chosen taking into consideration all the previous project guidelines and circumstances and with the objective of keeping the structure as light and as sustainable as possible while maintaining its temporary identity and thus removing any durable material:

Structural materials:

- Timber
- Plastic (High-density polyethylene)

Flooring materials:

- Plastic (Standard plastic sheeting)
- Timber

Roofing materials:

- Tarpaulin
- Plastic (sheet cladding)

Wall materials:

- Tarpaulin
- Plastic (sheet cladding)
- Timber

Foundation materials:

- Plain concrete
- Compacted earth

Flooring materials:

- Tarpaulin
- Timber

Nodes materials

- Synthetic or local rope
- Steel joints
- Timber

Connection materials

- Plywood gusset plates
- Bolts

4.3. Detailed study on chosen material

4.3.1. Timber

4.3.1.1.Trees

4.3.1.1.1. Types

When considering the use of timber, it is recommended to start by understand the source behind the material, the trees.

Trees can be divided into 2 main groups:

- Softwood
  Wood obtained from plants that produce uncovered seeds that go by the name of gymnosperms

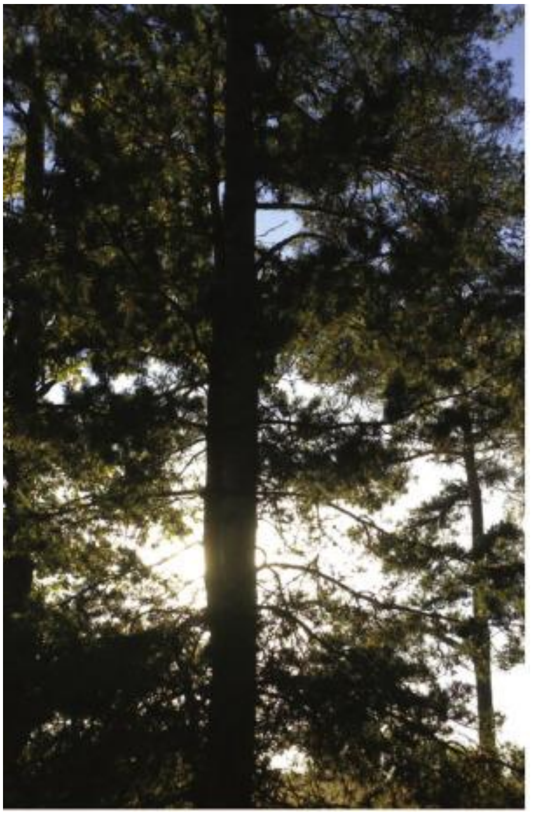

Figure 195 Picture showing a pine tree, considered a softwood [212]

[212] https://www.sciencedirect.com/science/article/pii/S1364032116306050 (April 2020)

- Hardwood

  Wood obtained from plants that produce flowers and covered seeds that go by the name of angiosperms

Figure 196 Picture showing a pine tree, considered a softwood [213]

[213] https://www.sciencedirect.com/science/article/pii/S1364032116306050 (April 2020)

4.3.1.1.2. Growth

The trees’ growth rate and biodegradability make them the ideal sustainable resource. The tree grows in 2 direction, upwards and sideways and that is due to:

- Upward growth is produced thanks to the upper part of the tree: the shoot, apical meristem,
- Sideways growth is noted by the thickening of the stems and it is produced based on the cambium. It is thanks to that growth that the oldest part of the tree is located in the center of its trunk

It is important to understand the tree’s composition as each of its parts has different mechanical properties. The trees stem is composed of the following:

- Outer bank: the last layer between the outside environment and the tree
- Phloem: the cells responsible for the nutrients’ transportation
- Cambium: the layer that defines the trunk by separating the phloem from the xylem
- Xylem: the cells responsible for the water’s conduction. When active these cells form the sapwoods. Once they die and become inactive, they go on to form the heartwood

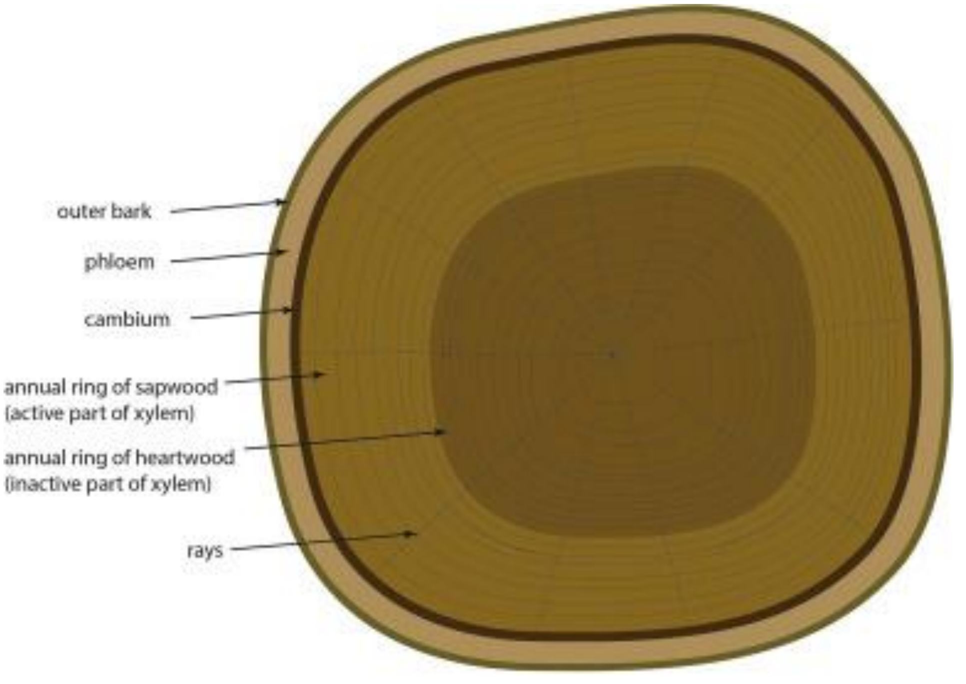

Figure 197 Picture showing a tree stem section with all its parts [214]

[214] https://www.sciencedirect.com/science/article/pii/S1364032116306050 (April 2020)

4.3.1.1.3. Knots and twists

The presence of knots and twists affects the mechanical properties of the wood. It is due to the distortion present around the knots which leads to the discontinuity within the stem wood and therefore leads to stress concentration. The impact of the knot depends the following factors making it difficult to estimate:

- Amount
- Size
- Location on length
- Location in section

Figure 198 Picture showing different types of knots [215]

[215] https://www.sciencedirect.com/science/article/pii/S1364032116306050 (April 2020)

4.3.1.2.Processing

Timber production procedures are simple and consist in 3 main phases:

- Harvesting
- Processing
- Distribution

All of the above must be done properly and according to regulations in order to avoid deforestation and inn order to maintain the process' sustainability.

4.3.1.2.1. Harvesting (why dry timber)

The harvesting is the first step of the process and it concerns what is commonly known as roundwood. Roundwood are felled trees which have passed through a primary preparation work involving removing the branches and cutting the trunks into adequate transportation size.

In order to maintain the sustainability of the process and maintain the renewable aspect if this essential primary resource, the harvesting occurs in one of the following silvicultural practices:

- Artificial regeneration
- Natural regeneration
- Mixed regeneration

Due to the large demands, this process has become automated through the use harvester heads that allow for a cleaner and faster harvesting process.

Figure 199 Picture showing a harvester head [216]

4.3.1.2.2. Sawmill processing

[216] https://www.sciencedirect.com/science/article/pii/S1364032116306050 (April 2020)

After harvesting, the roundwood is moved to the sawmill where it will be further processed.

The process is divided into 3 procedures each producing a number of used elements:

Stranding

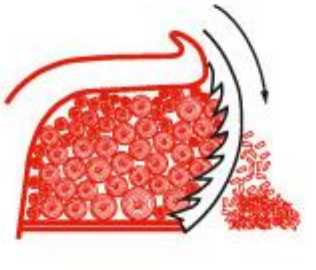

Figure 200 Sketch showing stranding[217]

The first process is the stranding which consists of the following:

- Drying
- Sorting

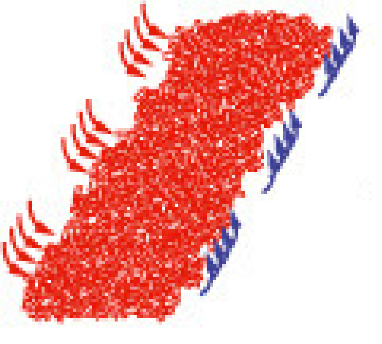

Figure 201 Sketch showing stranding processes [218]

This process produces Strands which can be used to provide the following market products:

[217] https://www.sciencedirect.com/science/article/pii/S1364032116306050 (April 2020)
[218] Ibid.

- Oriented Strand Board (OSB)

Figure 202 Sketch showing an Oriented Strand Board [219]

- Laminated-strand panels and lumber (LSL)

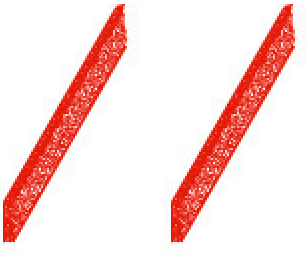

Figure 203 Sketch showing a Laminated-strand panels and lumber [220]

- I-Joists

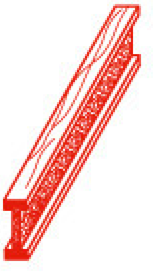

Figure 204 Sketch showing I-Joists[221]

- Structural Insulating Panel (SIPs)

[219] https://www.sciencedirect.com/science/article/pii/S1364032116306050 (April 2020)
[220] Ibid.
[221] Ibid.

Figure 205 Sketch showing a Structural Insulating Panel [222]

- Fibreboard

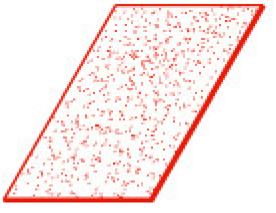

Figure 206 Sketch showing a Fibreboard [223]

Peeling

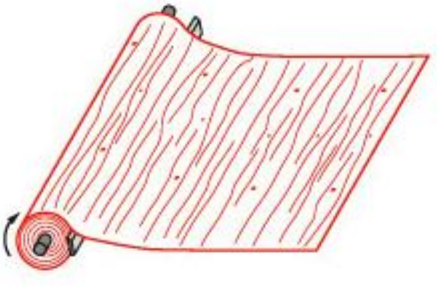

Figure 207 Sketch showing Peeling [224]

The second process is the peeling which consists of the following:

- Drying
- Cutting
- Sorting

[222] https://www.sciencedirect.com/science/article/pii/S1364032116306050 (April 2020)
[223] Ibid.
[224] Ibid.

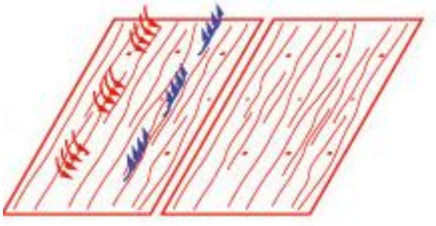

Figure 208 Sketch showing peeling processes [225]

This process produces Veneers which can be used to provide the following market products:

- Plywood

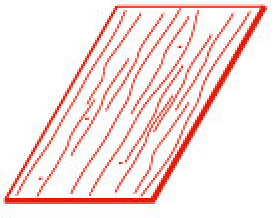

Figure 209 Sketch showing a Plywood [226]

- Parallel-stranded panels and lumber (PSL)

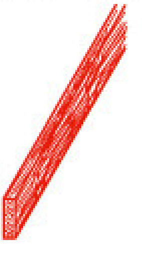

Figure 210 Sketch showing a Parallel-stranded panels and lumber [227]

[225] https://www.sciencedirect.com/science/article/pii/S1364032116306050 (April 2020)
[226] Ibid.
[227] Ibid.

- Laminated-veneer panels and lumber (LVL)

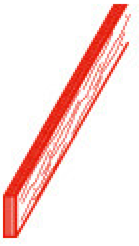

Figure 211 Sketch showing a Laminated-veneer panels and lumber [228]

Sawing

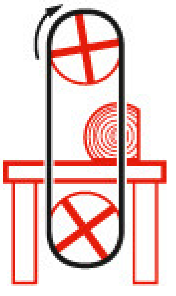

Figure 212 Sketch showing sawing [229]

The third and final process is the sawing which consists of the following:

- Drying
- Planning
- Grading

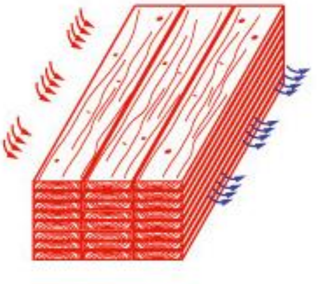

Figure 213 Sketch showing sawing processes [230]

[228] https://www.sciencedirect.com/science/article/pii/S1364032116306050 (April 2020)
[229] Ibid.
[230] Ibid.

This process produces Timber which can be used to provide the following market products:

- Treated timber (chemical treatment)

Figure 214 Sketch showing Treated timber [231]

- Nail-laminated panels

Figure 215 Sketch showing Nail-laminated panels [232]

- Stress-laminated panels

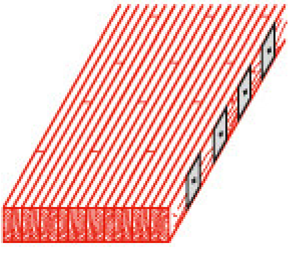

Figure 216 Sketch showing Stress-laminated panels [233]

[231] https://www.sciencedirect.com/science/article/pii/S1364032116306050 (April 2020)
[232] Ibid.
[233] Ibid.

- Brettstapel panels

Figure 217 Sketch showing Brettstapel panels [234]

- Cross-laminated timber (CLT)

Figure 218 Sketch showing Cross-laminated timber [235]

- Glue-laminated timber (Glulam)

Figure 219 Sketch showing Glue-laminated timber [236]

[234] https://www.sciencedirect.com/science/article/pii/S1364032116306050 (April 2020)
[235] Ibid.
[236] Ibid.

Here follow a few descriptions of the primary above products:

- Glulam
    - Laminated structural timber
    - Board Thicknesses range from 6 to 45 mm
    - Used for long span beams
    - Used for curved beams
- Laminated Veneer Lumber (LVL)
    - Reconstituted dimensional timber
    - Has double the strength of dimensional timber
    - Jointed end to end with a scarf thus allowing big span uses.
    - Used for beams, columns and cord
- Structural Veneer Lumber (SVL)
    - Structural component with surface layers composed of LVL
- Cross-Laminated Timber (CLT)
    - Timber panels composed of a minimum of 3 layers of softwood
    - Layers are glued together
    - Thickeness ranges from 50 to 500mm
    - Can reach 13.5m in length
    - Used for roofs, walls and floors.
- I-Joists
    - More expensive than solid timber joists
    - More dimensionally stable
    - Homogeneous OSB web
    - Used for beams and Joists
- Structural Insulating Panels (SIP)
    - Prefabricated structural insulated sandwich panel
    - Used for roofs, walls and floors.
- Brettstapel
    - Solid wood panels
    - Composed of softwood plans joined by hardwood dowels.
    - Used for roofs, walls and floors.

It is to be noted that even with all of the above procedures only 50 % of the logs are used while the rest is considered as waste and used as biomass fuel.

4.3.1.3.Drying process

Moisture heavily affects the timbers mechanical performance making it essential to dry the wood while processing it. In addition, dry timber is better for gluing and lighter thus making it easier to transport.

The drying process's efficiency depends on the following factors:

- Volumetric dimensions
- Porosity
- Green moisture

Drying can be achieved through the following methods:

- Air drying
- Solvent drying
- Microwave drying
- CO2 drying
- Kiln drying

Kiln drying is the most used in the market and especially convective drying as it is the fastest way to dry and remove moisture from the timber thus making it the most appealing from a business point of view. It is to be noted that it is however also the option with the highest energy consumption levels.

Figure 220 Picture showing an aluminum wood drying kiln [237]

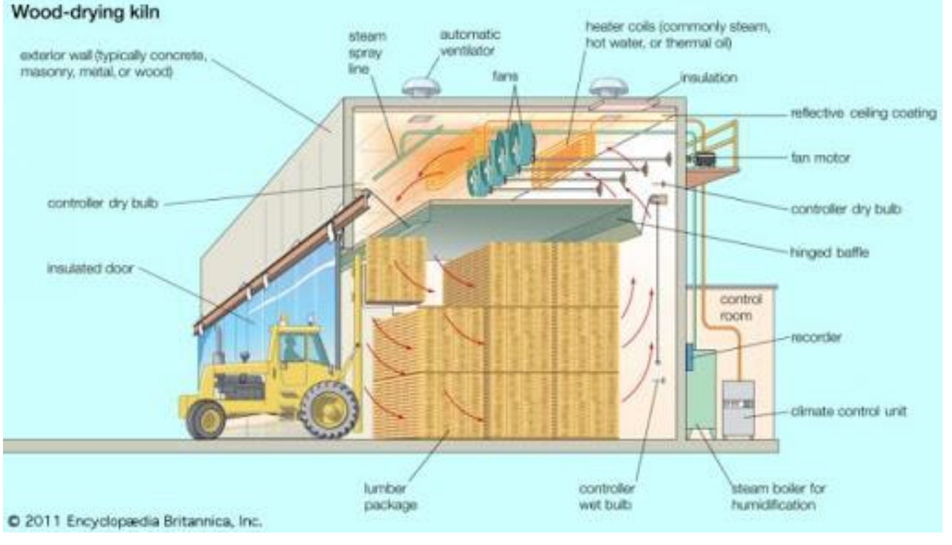

Figure 221 Picture showing a functional diagram of an aluminum wood drying kiln [238]

[237] http://www.wooddryingequipment.com/sale-11146497-reliable-high-performance-conventional-aluminum-wood-drying-kiln-from-china.html (April 2020)
[238] Ibid.

4.3.1.4. Structural capacities

Structurally the timber has the following interesting factors that have to be taken into consideration:

- Timber has an almost equal strength parallel to grain as reinforced concrete
  - hardwood being slightly stronger
  - softwood being slightly weaker
- Timber is unable to compete with concrete in compression strength
- Timber is weaker and less stiff than concrete and steel
- Timber has a lower density than traditional alternative structural materials making it ideal for long-span structures in which its own weight plays an important part of the load.
- Timber reacts better than steel and concrete when it comes to earthquake since the mass plays a big part of the force applied to the structure itself, and timber has the lowest mass out of the three options
- Since the energy cost of using a sawmill is so high, it can be avoided by using directly the green roundwood in the construction process, which allows the usage of the natural strength of the tree itself.
- Connection are most efficient when there is the use of glue involved but this comes with a high price to be paid when environmentally. Using bolts limits its efficiency to 20-30% thus making it not recommended.

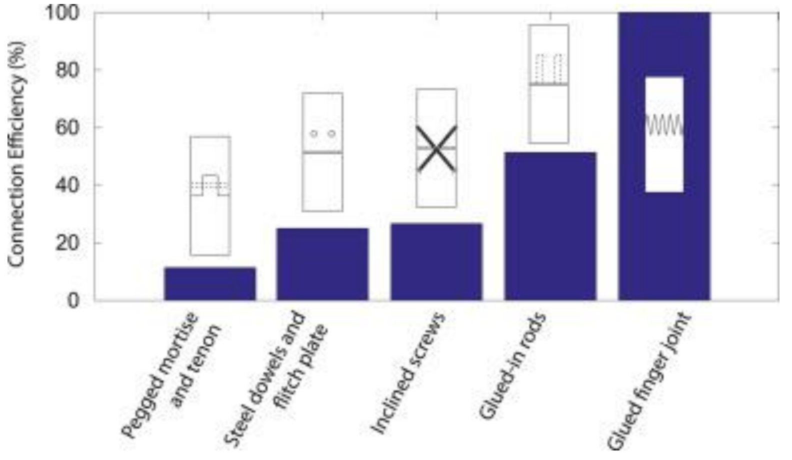

Figure 222 Graphic showing different timber connections efficiency [239]

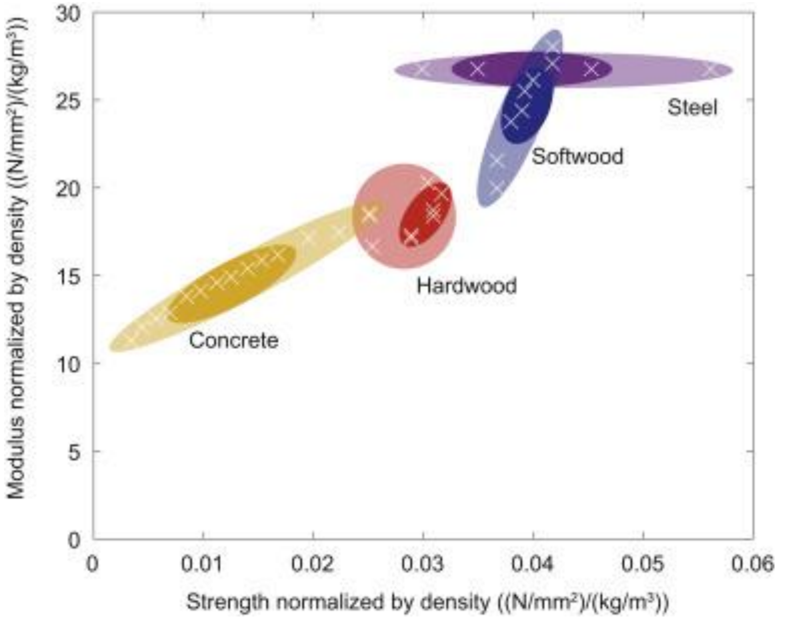

Figure 223 Graphic showing strength and modulus of construction materials normalized by density[240]

[239] https://www.sciencedirect.com/science/article/pii/S1364032116306050 (April 2020)
[240] Ibid.

4.3.1.5.Guidelines

The following guidelines can be used for the proposed project:

- Timber's growth rate and regeneration capabilities make it the perfect sustainable structural technology to use
- Use of technology makes harvesting faster and more efficient but it can be done with alternative simpler methods in case situation dictates it
- Timber has to go through a drying process as having the 4 seasons in Lebanon puts it under moisture exposure and therefore puts the structural integrity at risk.
- Cost and time reduction can be achieved by using green roundwood in case technology allows it
- Use of glue in connections is essential as bolts would bring down the efficiency.

4.3.2. Plastic in the construction field

4.3.2.1. Plastic properties

Plastic has long been used in the construction field and in a variety of ways due to its following appealing properties:

Figure 224 Picture showing plastic tubes[241]

Appearance

Plastic is found in different states and appearances as it can be transparent or colored into any desired look.

Chemical resistance

Plastics are highly resistant to chemicals and solvents thus making them ideal for resisting corrosion which why more and people are using them instead of traditional metal.

[241] https://theconstructor.org/building/plastics-construction-material/12438/ (April 2020)

Dimensional stability

Plastics offer limitless options for shaping due to their flexibility. However, not all types have the same level of flexibility which is why they can be divided into the following two groups:

- Thermo-plastic
  Easy to reshape and reuse
- Thermo-setting
  Not easy to reshape and reuse

Ductility

Plastics have a very low ductile nature.

Durability

Plastics have a very good durability overall and especially since they have no nutrition values and therefore will not be seriously affected by termites and rodents.

Electric insulation

Plastics are excellent electric insulations which is why they are the most used material with electric products like cables and electronics tools.

Finishing

One of the most appealing features of plastics is that they can given any type of finishing treatment

Fire resistance

Plastics have a good fire resistance overall but some are more resistant than others and that is directly related upon their composition.

Fixing

Plastics can be easily fixed with almost all connections from bolts to glue.

Humidity

Plastics are affected by moisture depending on their composition:

- Plastics with cellulosic materials are affected
- Plastics with poly vinyl chloride are resistant

Maintenance

Plastics are easily maintained as they do not require any surface treatment.

Melting point

Plastics must not be used in the proximity of high temperatures as they have relatively low melting point.

Optical property

Some plastics can be transparent letting light through in its original state and others can be translucent or semi-transparent thus changing the properties if the light transmitted.

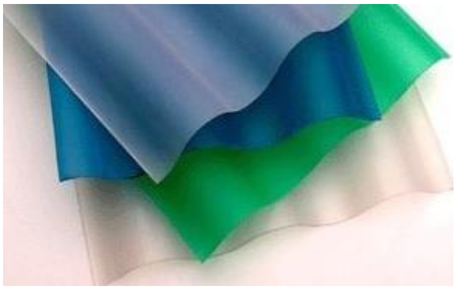

Figure 225 Picture showing plastic with different optical properties [242]

[242] https://theconstructor.org/building/plastics-construction-material/12438/ (April 2020)

Recycling

Plastics are not biodegradable and therefore not disposing of them properly is one of the main pollutions causes in the world today. Luckily they have very good recycling properties making them sustainable if properly recycled.

Sound absorption

Plastics can be used for sound insulation through acoustic boards produced by saturating the phenolic resins.

Figure 226 Picture showing sound absorbing plastic ceiling[243]

Strength

Although plastics are considered strong materials, they are not preferred to be used for structural purposes due to many factors like:

- Heavy cost
- Creep failure

[243] https://theconstructor.org/building/plastics-construction-material/12438/ (April 2020)

- Poor stiffness
- Temperature tolerance

Thermal property

Plastics have very low thermal conductivity making the foamed and expanded plastics good thermal insulators.

Figure 227 Picture showing foamed plastic[244]

Weather resistance

Most plastics are weather resistant with their biggest weakness being excessive exposure to the sunlight's ultra violet rays. That weakness was solved by the usage of fillers and pigments which help to absorb or reflect these rays.

Weight

Plastics are very light structures especially when compared to other traditional material.

[244] https://theconstructor.org/building/plastics-construction-material/12438/ (April 2020)

4.3.2.2. Uses of Plastics in Building Construction[245]

Plastics can be used almost everywhere in the building construction process:

Exterior use

- Facades Panels

The usage of plastic in façade panels is composed a variety of sandwich panels with a different combination of coverings and foam core:

  - PVC covering with polyurethane foam core.
  - Asbestos cement covering with polyurethane foam core
  - Various coverings with polystyrene foam core
  - Polyester laminated sheet covering with polyurethane foam core
  - Enameled iron covering with polyurethane foam core.
  - Polyester laminated sheet glued to asbestos cement various covering with polystyrene foam core.

- Exterior covering
- Weather Boarding
- Windows
- Rolling Shutters

Interior use

- Wall Lining
- Floor Covering
- Ceilings and Counter Ceilings
- Roof Covering
- Roof Tightness

[245] https://theconstructor.org/building/plastics-construction-material/12438/ (April 2020)

Sanitary equipment

Can be used for all sanitary equipment

Insulation

Can be used most insulation types

No.	Plastic Material	Uses	Form in which it is commonly used	Normal colour
1	Expanded polystyrene	Thermal insulation	Thin sheets in slabs 12mm thick	White
2	Expanded polyvinyl chloride (PVC)	Thermal insulation	Boards 20 to 50 mm thick	Yellow brown
3	Foamed urea formaldehyde	Thermal insulation	Foamed in situ	White
4	Foamed phenol formaldehyde	Thermal insulation	Sheets and blocks	Deep red
5	Foamed polyurethane	Thermal insulation	Sheets and blocks or foamed in situ	Brown
6	Expanded ebonite	Thermal insulation	Sheets	Brown or black
7	Polythene	Damp-proofing, plumbing	Thin sheets, pipes, cisterns	Transparent to black
8	Polypropylene	Domestic drainage, but water overflow tanks		
9	Unplasticised PVC	Rainwater goods, ventilation, ducts, pipes of water mains		
10	Acrylic resins	Sinks and baths		Various
11	Nylon	Cold water fittings, window furniture		Various
12	Phenolic resins	Adhesives for laminates		Dark

Table 43 Table shoring different use of plastic materials[246]

246 https://www.ifrc.org/PageFiles/71111/D.03.a.01.Plastic%20Sheeting_Englis.pdf (April 2020)

4.3.2.3. Plastic sheeting:

Definition:

It is a flexible, ware resistant and waterproof strong material. In the emergency architecture field, one material stands above others ad is mainly used: polyethylene. It is composed of two outer lamination sheets of polyethylene covering an inner layer of black woven polyethylene.

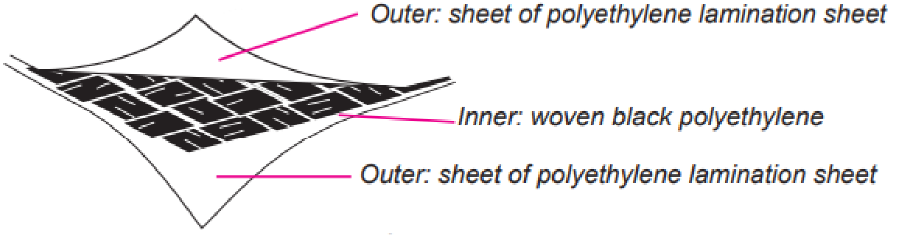

Figure 228 Picture showing different layers of a polyethylene standard sheet[247]

Important facts:

- This sheet can be used for all refugee settlement purposes from shelter units to sanitation and water supply to infrastructure.

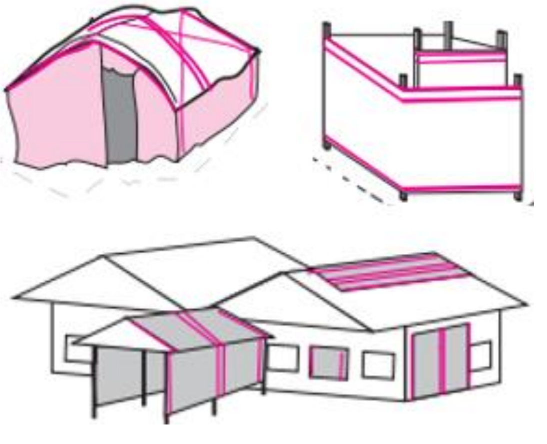

Figure 229 Sketch showing different uses of plastic sheets[248]

247 https://www.ifrc.org/PageFiles/71111/D.03.a.01.Plastic%20Sheeting_Englis.pdf (April 2020)
248 Ibid.

- Although considered as a durable and strong material it is not intended for long term use and should be used accordingly.
- Being a non-biodegradable material, it is essential to plan the proper means of its disposal in order to maintain the local environment and avoid polluting.
- When considering the amount needed, take into consideration that common guidance dictates that each person requires a minimum of $3.5m^2$ covered space.
- Plastic sheets are usually distributed with necessary items for maintenance and repairs in efforts to speed up the repairs and promote autonomy. These are distributed in repair kits

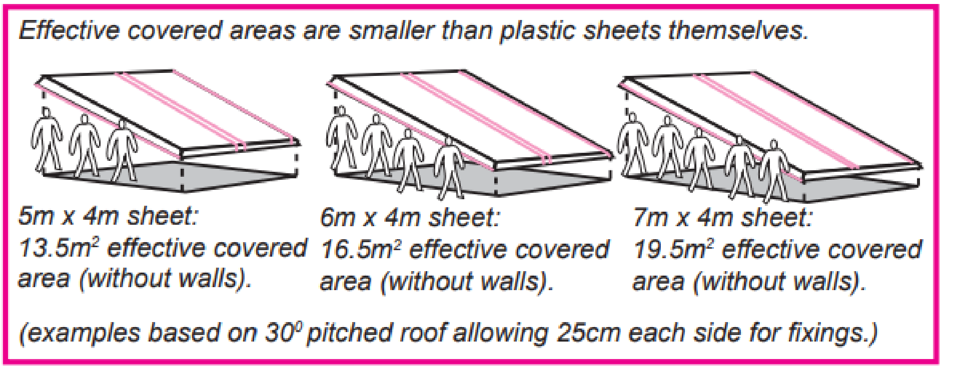

Figure 230 Sketch showing number of persons benefiting from the covered areas[249]

Transportation:

When considering transportation there are two main factors that come to mind, time and money:

- In case time is of the essence then there no better alternative than air freighting
- In case given the luxury of time, shipping should be considered as it is much cheaper than air transport.

[249] https://www.ifrc.org/PageFiles/71111/D.03.a.01.Plastic%20Sheeting_Englis.pdf (April 2020)

- Using local markets can also be an option but it will depend on availability and market inflation should be avoided.
    - In most cases, special attention should be put so that the material used is not sold by the refugees to make money from it.

Warehousing:

- Plastic sheets should be stored away from the sun, rodents and maintained dry.

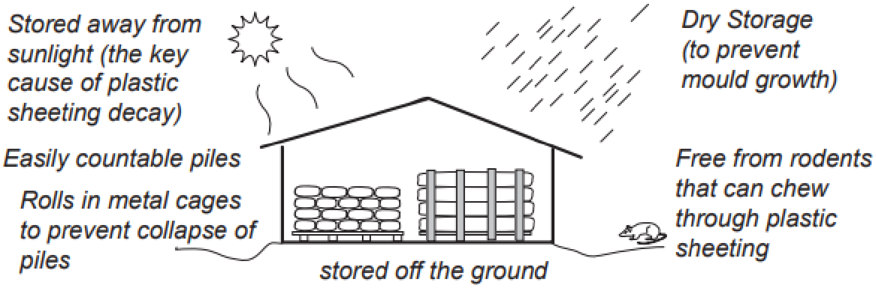

Figure 231 Sketch summarizing warehousing requirements[250]

- Since sheets are packed in rolls, special care should be taken into stacking since the rolls come usually packed in plastic and therefore are considered slippery and therefore should not be stacked too high.

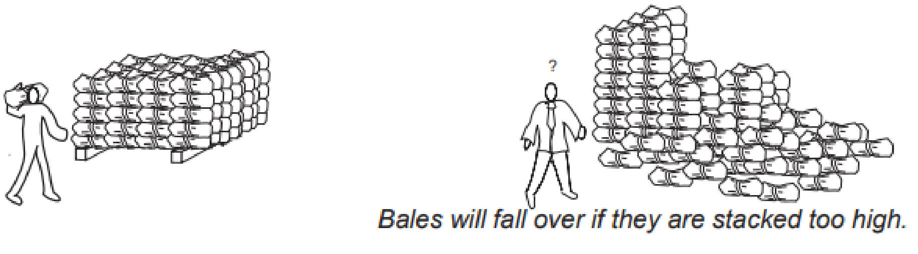

Figure 232 Sketch summarizing stacking requirements[251]

[250] https://www.ifrc.org/PageFiles/71111/D.03.a.01.Plastic%20Sheeting_Englis.pdf (April 2020)
[251] Ibid.

Distribution:

- Plastic sheets can be distributed either directly to the families or to contractors
- In case it is distributed to the families, it is advisable to have single sheets ready instead of having to cut them from a roll
- In case the use of a roll cutting cannot be avoided, it is advisable to have expert personnel perform it as it can avoid non equity situations and non-useable off cuts leading to wastage.
- Most rolls are marked every 1m for easier cutting process.
- Organizations must provide assistance with both transportation and assembly for elderly or refugees with special conditions.

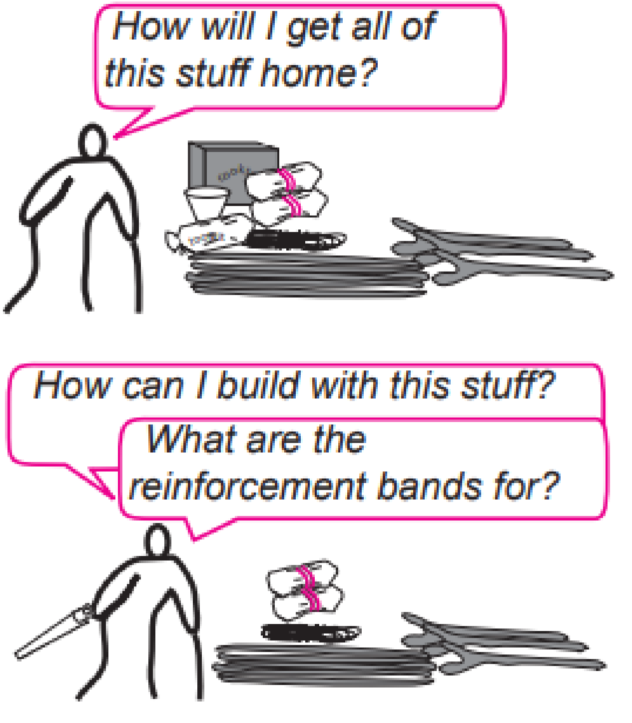

Figure 233 Sketch showing situations where special assistance is required[252]

[252] https://www.ifrc.org/PageFiles/71111/D.03.a.01.Plastic%20Sheeting_Englis.pdf (April 2020)

Fixing:

When considering fixing the plastic sheet to the support the following must be taken into consideration:

- Proper fixing between plastic sheets and supporting structure:

Fixings must be properly executed and spread over a big area in order to spread the load. Here follows are some of the most common practices when fixing plastic sheets on timber organized from weaker to stronger when using standard nails:

- Standard orthogonal application

  If applied orthogonally, the plastic will pull through their small heads

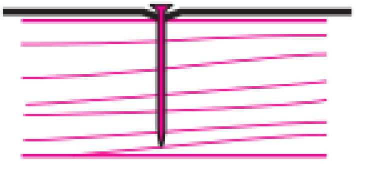

Figure 234 Sketch showing orthogonal nail fixing[253]

- Bended application

  Bending the nails improves the fixing and even more if nailed through folded plastic sheet

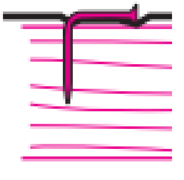

Figure 235 Sketch showing bended nail fixing [254]

[253] https://www.ifrc.org/PageFiles/71111/D.03.a.01.Plastic%20Sheeting_Englis.pdf (April 2020)
[254] Ibid.

Figure 236 Sketch showing bended nail fixing through folded plastic sheet [255]

- Using U-shaped fencing pins

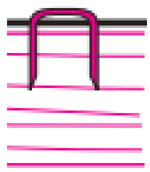

Figure 237 Sketch showing U-shaped fencing pins [256]

- Nailing through larger objects application

  Nailing through available item with a larger dimension than the nail head improves the fixings' resistance.

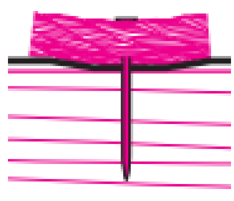

Figure 238 Sketch showing nailing through rope[257]

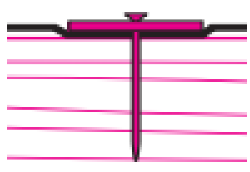

Figure 239 Sketch showing nailing through washers[258]

[255] https://www.ifrc.org/PageFiles/71111/D.03.a.01.Plastic%20Sheeting_Englis.pdf (April 2020)
[256] Ibid.
[257] Ibid.
[258] Ibid.

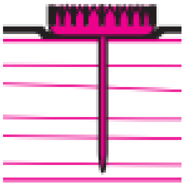

Figure 240 Sketch showing nailing through bottle caps with the sharp side up[259]

- Using domed head nails

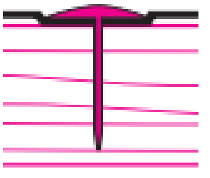

Figure 241 Sketch showing domed head nails [260]

- Using timber battening

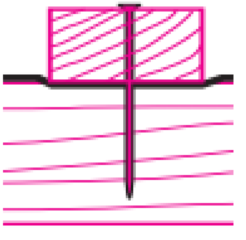

Figure 242 Sketch showing timber battening fixings[261]

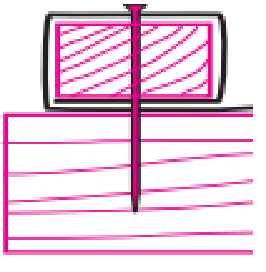

Figure 243 Sketch showing timber battening fixings with folded plastic at edges [262]

[259] https://www.ifrc.org/PageFiles/71111/D.03.a.01.Plastic%20Sheeting_Englis.pdf (April 2020)
[260] Ibid.
[261] Ibid.
[262] Ibid.

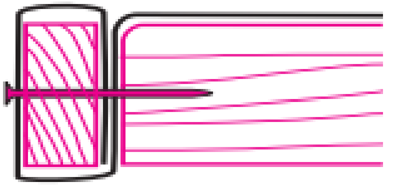

Figure 244 Sketch showing optimum positioning of timber battening fixings at edges [263]

- Frequency

The more fixings there are the longer the sheeting will last. The maximum recommended distance between fixings is 30cm.

Figure 245 Sketch showing proper fixings distancing [264]

- Proper fixing between plastic sheets and the ground directly:
  In this situation additional 50cm of plastic sheet should be planned as they are needed for the trenches. Here follows are some of the most common practices when fixing plastic directly on the ground organized from weaker to stronger:
  - Using only tent pegs

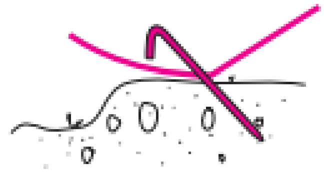

Figure 246 Sketch showing ground fixing using only tent pegs [265]

[263] https://www.ifrc.org/PageFiles/71111/D.03.a.01.Plastic%20Sheeting_Englis.pdf (April 2020)
[264] Ibid.
[265] Ibid.

- Digging a trench and covering the sheet with earth

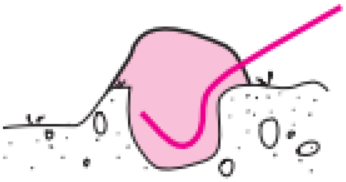

Figure 247 Sketch showing ground fixing by digging a trench and covering the sheet with earth [266]

- Digging a trench, wrapping the sheets around rocks and then covering them with earth

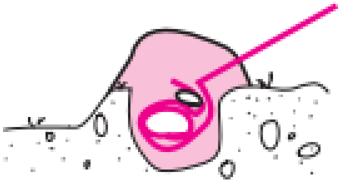

Figure 248 Sketch showing ground fixing by digging a trench, wrapping the sheets around rocks and then covering them with earth [267]

- Digging a trench, wrapping the sheets around timber and then covering them with earth and stones

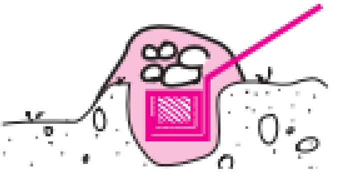

Figure 249 Sketch showing ground fixing by digging a trench, wrapping the sheets around timber and then covering them with earth and stones [268]

[266] https://www.ifrc.org/PageFiles/71111/D.03.a.01.Plastic%20Sheeting_Englis.pdf (April 2020)
[267] Ibid.
[268] Ibid.

- Wrapping sheets around timber and nailing them through pegs to the ground.

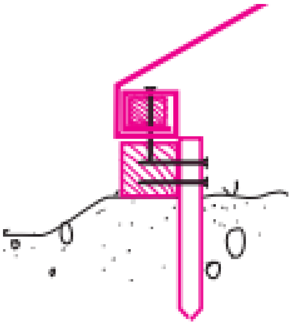

Figure 250 Sketch showing ground fixing by wrapping sheets around timber and nailing them through pegs to the ground [269]

- Proper fixing between plastic sheets and rope:

  Fixing plastic sheets on ropes should be planned ahead with the:

  - Addition of reinforcements bands

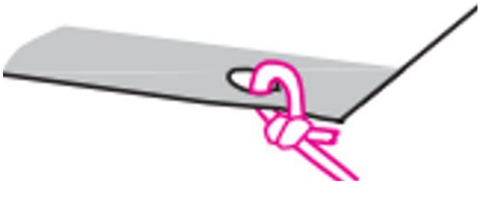

Figure 251 Sketch showing rope fixing through the addition of reinforcements bands [270]

  - Addition of eyelets

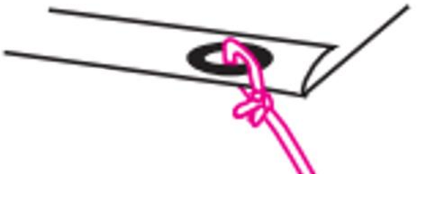

Figure 252 Sketch showing rope fixing through the addition of eyelets [271]

[269] https://www.ifrc.org/PageFiles/71111/D.03.a.01.Plastic%20Sheeting_Englis.pdf (April 2020)
[270] Ibid.
[271] Ibid.

- In case no planning was done, fixing can be achieved by wrapping the sheets upon a smooth stone of a minimum diameter of 3cm and then fixing the rope behind it.

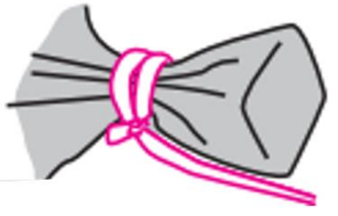

Figure 253 Sketch showing rope fixing by wrapping the sheets upon a smooth stone and fixing rope behind it [272]

- It is not recommended to cut a hole without or outside a reinforcement band

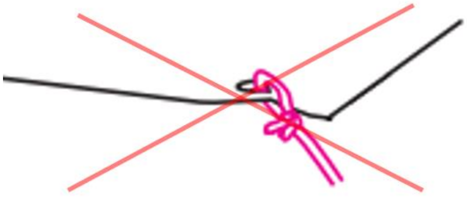

Figure 254 Sketch showing rope fixing by cutting a hole without or outside a reinforcement band [273]

- Sheets sewing

  It is recommended that sheets sewing occurs with specialized machines in order to avoid creation of holes and lateron leaks. In case unavailable, sheets can be stitched together using a strong thread and by overlapping the sheets and folding them prior to stitching as per the picture below:

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[272] https://www.ifrc.org/PageFiles/71111/D.03.a.01.Plastic%20Sheeting_Englis.pdf (April 2020)
[273] Ibid.

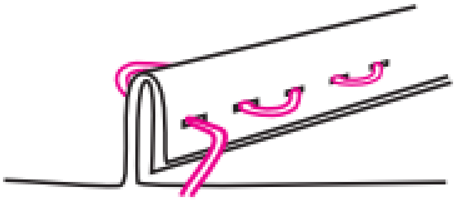


Figure 255 Sketch showing rope fixing by cutting a hole without or outside a reinforcement band [274]

- Maintaining sheet tightness:

  It is essential for the sheet to be tight, or else it will:

  - Flap in the presence of wind which will increase the probability of the fixings to detach
  - Accumulate water adding weight to the roof and causing the plastic to stretch and deteriorate which might lead to leaking. Water might form ponds which might attract mosquitos.
  - Since plastic sheets react to temperature by expanding 1% for every 40 degrees Celsius change, it would be recommended to allow for this expansion in order to avoid the sheet to expand during the day and becoming slack and to contract at night and break.

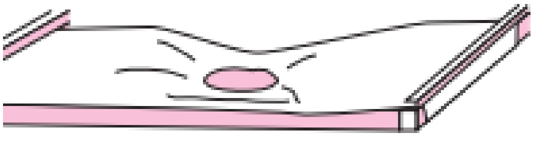


Figure 256 Sketch showing pods on the roof [275]

[274] https://www.ifrc.org/PageFiles/71111/D.03.a.01.Plastic%20Sheeting_Englis.pdf (April 2020)
[275] Ibid.

In order to avoid that it is essential to make sure of the following:

- Slope the roof
- Tighten the plastic
- Make sure supports are sufficient

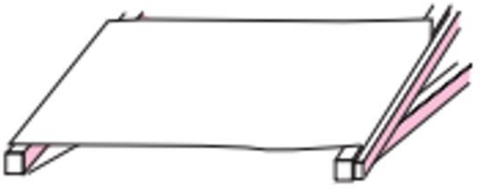


Figure 257 Sketch showing slopped roof with tight plastic sheets [276]

- Absence of sharp points

  It is essential to make sure that there are no sharp points at any point of the construction phase by:

  - Flushing the nails with the timber
  - Smoothing the edges and the rough surfaces in contact with the plastic
  - Locating the shelter away from trees which might puncture the sheets with their branches.

- Absence of hot spots

  Since heat can damage the plastic, it is essential to avoid putting the sheets in contact with hot spots in order for it not to overheat by:

  - Limiting the contact points to strict minimum
  - Adding a layer of adhesive tape on top of the sheets
  - Using aluminum or bitupostic paint at all contact points.
  - Adding a layer of insulation with light colors.

[276] https://www.ifrc.org/PageFiles/71111/D.03.a.01.Plastic%20Sheeting_Englis.pdf (April 2020)

- Fire prevention

  It absolutely essential to keep fires away from the sheets unless they contain fire retardants. Which is why the following must be applied:

  - Avoid open fires inside the building unless properly isolated
  - Candles can only be used if placed inside an isolated surface like a glass jar or a metal tin
  - All fires, lights and candles must be turned off when exiting the structures.
  - Absolutely prohibited to smoke inside the tents as the ashes can cause rapid fire especially in the presence of wind
  - All machinery that can get heated or create heat must be distant at least 15cm from the sheets and must not touch them.
  - Distancing the emergency structures is essential to avoid fire from spreading. It is usually recommended to keep a distance equal to 2.5 times the height of the structure and the use of fire breaks on the ground surrounding them.

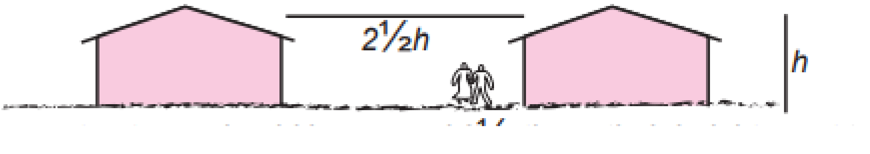


Figure 258 Sketch showing recommended distancing between structures for fire prevention [277]

[277] https://www.ifrc.org/PageFiles/71111/D.03.a.01.Plastic%20Sheeting_Englis.pdf (April 2020)

- Repair

  Repairs cannot be perfectly done on site as special machinery is required and therefore onsite repairs are limited to the following:

  - Stitching

    Stitching will probably lead to leaking and therefore it is to be resorted to as last option.

  - Taping

    It is recommended the use of UV resistant tapes and in case unavailable the traditional tapes would do the job but they will degrade due to not having any UV resistance.

- Reuse

  The reuse is depends on whether or not the sheet can be repaired or not and in all cases it should be cleaned and disinfected in a 0.2% chlorine solution before reuse. In case entire sheet cannot be recovered, it can be cut into pieces which would be used for a patch-work sheet which can be used for secondary purpose such as sun shading or indoor partitions etcc….

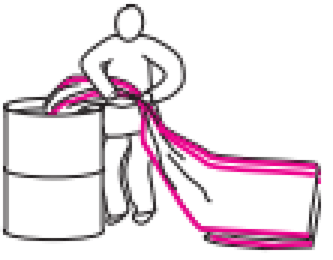


Figure 259 Sketch showing sheet disinfection procedure [278]

- Disposal

  In case sheet cannot be repaired or reused it shall be disposed off through either incineration at 1200 degrees Celsius or through burial in a proper designated ground.

[278] https://www.ifrc.org/PageFiles/71111/D.03.a.01.Plastic%20Sheeting_Englis.pdf (April 2020)

4.3.2.4.Project guidelines:

The following guidelines can be used for the proposed project:

- Plastic sheeting used shall be composed of typical polyethylene sheets used by the UNHCR
- Material is to be used on a temporary basis and then either reused or disposed of properly in a way not to hurt the environment. Planning should include post-use period.
- Transportation should be performed by shipping since there is no urgency with the proposed phase II
- Warehousing should occur within temporary fabricated storages on site meeting up with the proper environment requirements
- Material distribution and erection process is to be done under proper surveillance
- Fixings should be done with the best adequate technology within budget as they highly influence sheets durability.
- Special trainings and education should be performed to inform refugees about strict fire prevention measures.

4.3.3. Cement footing foundation

Although the aim to avoid cement was a priority, it seems that it would not be convenient to use it at least for the footing and foundation as the alternative materials would prove to be extremely expensive and put the structure's stiffness at risk. However, two alternatives were found that would limit the damage and that would maintain the structure's temporary identity.

4.3.3.1.Deck pier block:

General information

The deck pier block consists of a prefabricated mass of concrete with special designs on the top allowing it to perfectly hold timber structure elements from vertical posts to beams.

These blocks are used when concrete piers are not useable whether by choice or by other constraints. They are used for freestanding structures, such as decks and other housing additions. They have excellent compatibility with wooden structures and are very easy to arrange and make the wood structure construction much simpler.

They provide similar properties and are subject to same requirements as traditional footings bearing in mind the following:

- They must be below local frost depth
- They have to be a minimum of 30cm below grade and cannot be used at grade level.
- The blocks cannot support much load on their own and therefore should be compensated by the use of more blocks and avoiding long span
- They must not be used in areas with the presence of high wind or high uplift.

- Their dimensions normally go between 25 and 30 cm for the base square and 15 to 20 cm of height.

Construction method:

Here follows are the procedures to follow when building a deck block footing:

- Designing the structure while taking into consideration that the maximum distancing between 2 blocks should be of 120cm for heavy structures and 180cm for lighter structures.

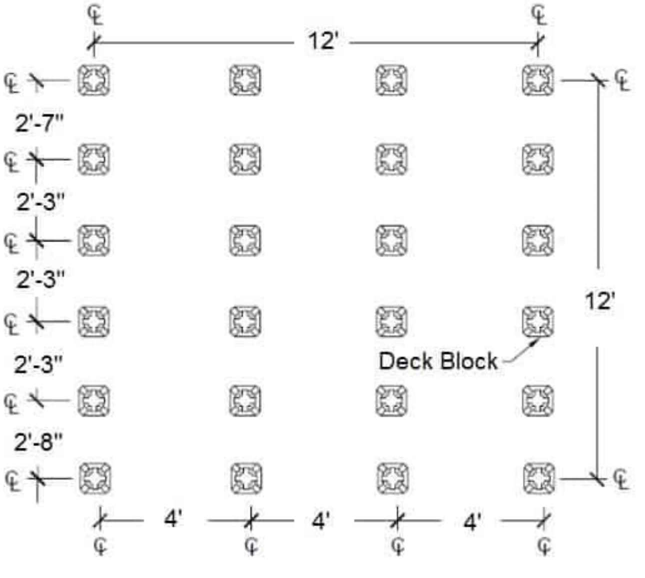


Figure 260 Sketch showing an example of block plan with proper distancing [279]

- Leveling the floor in order to reach desired heights by using available means of excavation, compaction and, if deemed necessary, placing gravel
- Highlight blocks locations on the ground

[279] https://plasticinehouse.com/building-shed-base-with-deck-blocks/ (April 2020)

- Place blocks accordingly and always make sure alignments are maintained through the use of string lines or lasers

Figure 261 Sketch showing placing blocks on a leveled area [280]

- Continue with timber structure

Figure 262 Sketch showing blocks with primary timber structure [281]

[280] https://plasticinehouse.com/building-shed-base-with-deck-blocks/ (April 2020)
[281] Ibid.

Tough ground leveling:

In case ground leveling is tough, an additional steel deck support is needed. These steel supports fit in the blocks' design and can be used as follows:

- Clean the block to eliminate any loose material

Figure 263 Picture showing clean blocks [282]

- Clean the steel supports to eliminate any oil or grease

Figure 264 Picture showing clean steel bracket[283]

[282] https://plasticinehouse.com/building-shed-base-with-deck-blocks/ (April 2020)
[283] Ibid.

- Separate the base from the bracket

Figure 265 Picture showing separated base[284]

- Close the top of the base cylinder with tape in order to avoid it being filled with concrete

Figure 266 Picture showing tapped support end [285]

[284] https://plasticinehouse.com/building-shed-base-with-deck-blocks/ (April 2020)
[285] Ibid.

- Place the base in the center hole of the block and turn it around to make sure the corners are supported on the block itself.

Figure 267 Picture showing support proper edge positioning[286]

- Remove the steel support and fill the block with concrete
- Place the steel support in the same position as it was.

Figure 268 Picture showing support positioning after cement fill[287]

[286] https://plasticinehouse.com/building-shed-base-with-deck-blocks/ (April 2020)
[287] Ibid.

- Clean the mess and make sure the concrete is smooth
- Reposition blocks
- Insert the bracket
- Place beams into brackets

Figure 269 Picture showing timber beams positioned into the brackets[288]

- Use the nut to adjust the levels

Figure 270 Picture showing nut used for level adjustment[289]

[288] https://plasticinehouse.com/building-shed-base-with-deck-blocks/ (April 2020)
[289] Ibid.

4.3.3.2.Cement anchors:

Although deck blocks allow for a faster and more economical solution than traditional onsite casted concrete footings, they offer limited structural performances and are not always subject for availability making it inevitable to study an alternative.

The study of in situ cast cement anchors was performed and two options were highlighted as the most opportune to be used in situations similar to the one proposed in this thesis.

Cement anchors directly connected to timber structure:

This option is only valid on dense soil and will require a most durable post which must be treated for moisture and especially at the area that will be buried in the ground.

The procedure for this option is a simple procedure and goes as follows:

- Prepare the wood with proper treatment and label ground contact

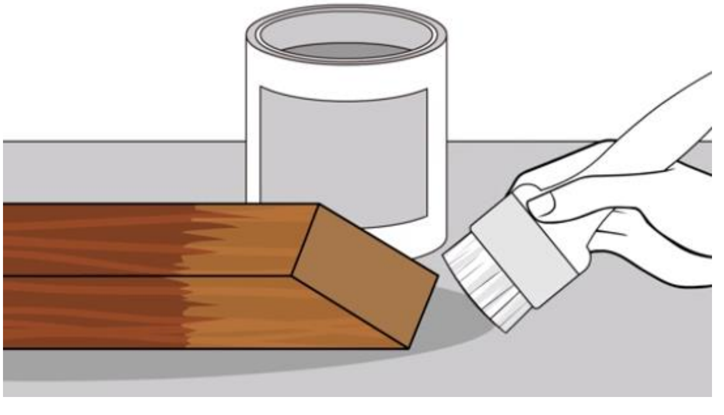


Figure 271 Sketch showing wood treatment[290]

[290] https://www.wikihow.com/Install-a-Wood-Fence-Post (April 2020)

- Design the structure and prepare plan
- Identify and mark the posts locations
- Dig a hole, wider than the post's dimensions but still relatively small, using proper tools like a clamshell digger and avoiding power tools if facing rocky soil.

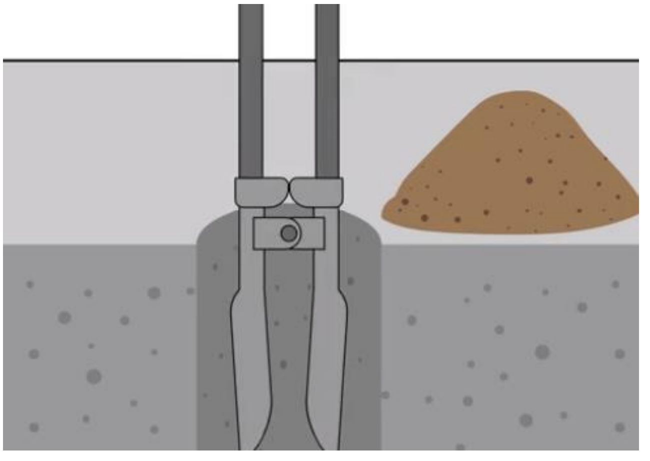


Figure 272 Sketch showing clamshell digger[291]

- Add a slim layer of gravel or crushed stone for better drainage and tamp it level

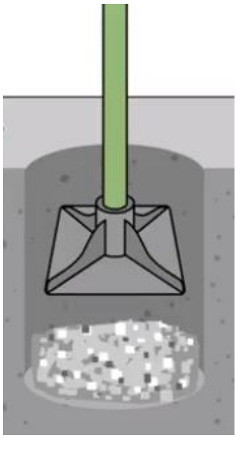


Figure 273 Sketch showing gravel tamping[292]

[291] https://www.wikihow.com/Install-a-Wood-Fence-Post (April 2020)
[292] Ibid.

- Insert the post in its central position and brace it by positioning two stakes into the ground or using temporary bracings at ground level.

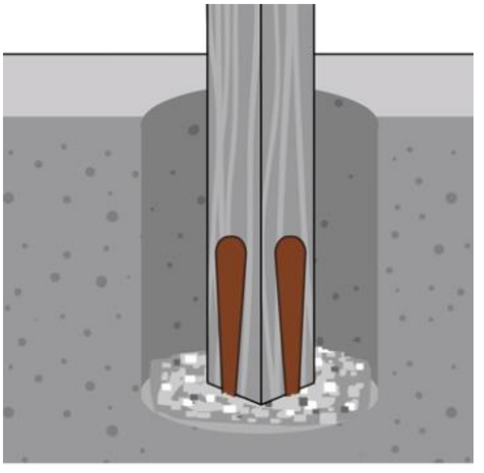


Figure 274 Sketch showing post bracing[293]

- Add another layer of gravel

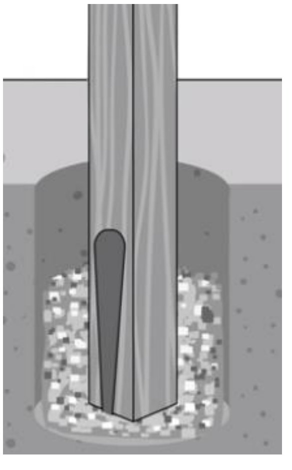


Figure 275 Sketch showing second layer of gravel[294]

[293] https://www.wikihow.com/Install-a-Wood-Fence-Post (April 2020)
[294] Ibid.

- Mix and fill the whole with concrete

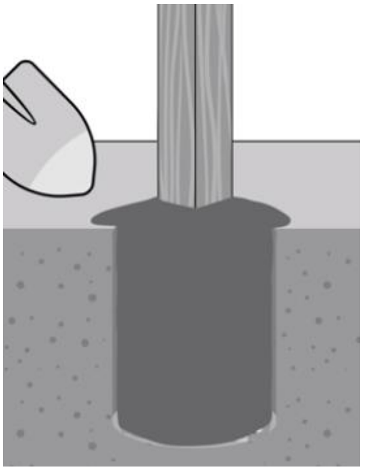


Figure 276 Sketch showing concrete filling of the whole[295]

- Adjust concrete at ground level using a trowel in order to create a small slope at ground level.

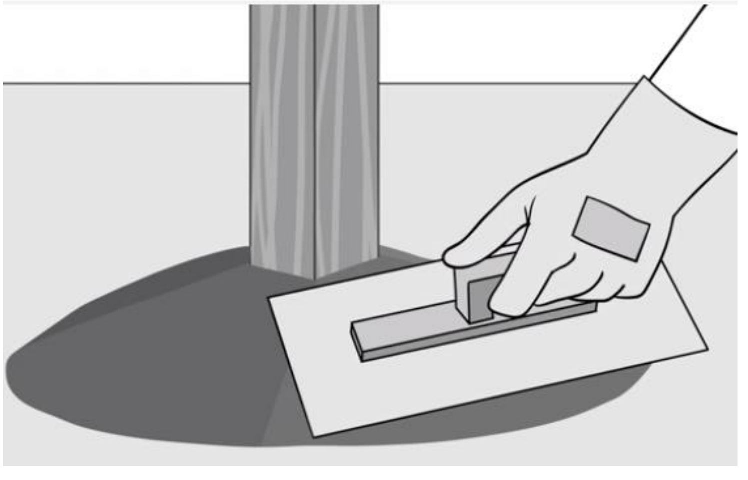


Figure 277 Sketch showing concrete troweling[296]

[295] https://www.wikihow.com/Install-a-Wood-Fence-Post (April 2020)
[296]

- Rest for three days and then seal the gap between post and concrete with proper sealant.

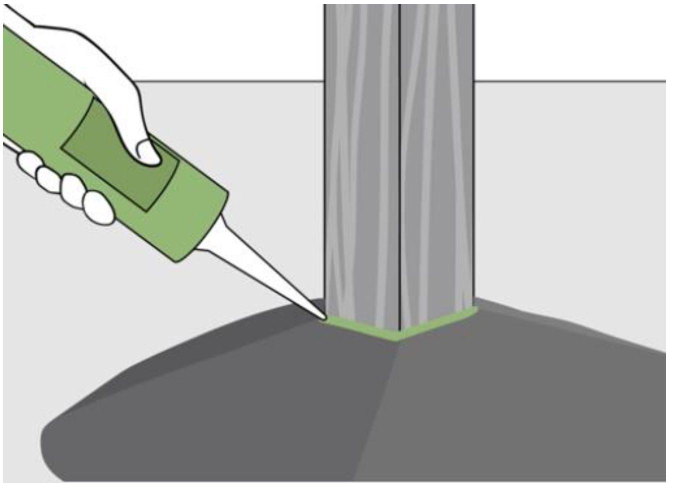


Figure 278 Sketch showing sealant treatment[297]

Cement anchors with anchor bolt:

This option is valid for most grounds and is considerably stronger than the alternative but is less sustainable and more expensive and is more aggressive to the already existing environment.

The procedure for this option is a slightly more complicated procedure and goes as follows:

- Design the structure and prepare plan
- Identify and mark the anchors' locations
- Dig a hole, based on the anchor's dimensions using proper tools like a clamshell digger and avoiding power tools if facing rocky soil. For this option, when possible, it is advisable to use an auger especially on tough grounds where the clamshell digger won't be enough. Take into consideration that the holes need to be at least 1m deep.

[297] https://www.wikihow.com/Install-a-Wood-Fence-Post (April 2020)

Figure 279 Picture showing the auger used for drilling the post anchor holes[298]

- Insert concrete tube forms and trim to desired height normally slightly above ground level.

Figure 280 Picture showing concrete tube forms [299]

[298] https://tinyhousetalk.com/life-in-120-square-feet-our-tiny-foundation/ (April 2020)
[299] Ibid.

- Mix and poor in the concrete in order to fill in holes and make sure concrete at surface if levelled

Figure 281 Picture showing filled concrete tube forms[300]

- Add steel post anchor bolts

Figure 282 Picture showing the steel post anchor bolt [301]

[300] https://tinyhousetalk.com/life-in-120-square-feet-our-tiny-foundation/ (April 2020)
[301] Ibid.

4.4.Project guidelines

The following guidelines can be used for the proposed project:

- Deck blocks are faster and more economical than concrete footings
- Deck blocks require few to no surface preparation
- Deck blocks require no digging whereas cement blocks do which creates a lot more work to be done
- Concrete footings are stronger and stiffer than deck blocks and can be considered as the better support
- The use of cement in both solutions is limited and hidden therefore keeping the overall temporary outlook of the structure imposed by the Lebanese government
- The most convenient would be the use of both solution with the concrete footings used for the roof support and the deck blocks used for the ground floor support.

5

PROPOSED PROJECT

5.1. Concept

The proposed project represents all the conclusions and guidelines discussed up until this point with a special focus on the sustainability and economic aspect of the project.

From the first two chapter, it was possible to define the status quo of the emergency architecture in general and its evolution within Lebanon and define what are the guidelines on which to base this project:

- The project needs to maintain a temporary status
- It needs to contextualize the introduced PHASE II concept
- Capable of handling all 4 seasons
- Multifunctional
- Capable of creating solutions for the social crisis
- Must not affect the existing settlements negatively and especially the WASH system

From chapters 3 and 4, both the technology and the materials were defined alongside their respective guidelines.

In this chapter shall be given the details and all necessary information such as blow ups and detail sheets in order to make it as clear and transparent as possible.

5.2. Design

For the design of this project, the square shape was chosen for the following reasons:

- It would make the project as symmetrical as possible thus allowing for mass production of the same elements and allowing fabrication cost reduction.
- Considering the desire to make it complimentary with other similar structures the square shape allows infinite combinations
- The square shaped is proven to give a secure psychological sensation.
- It allows for the interior to be easily divided at will

5.3. Method of statement:

Here follows the method of statement describing all the different construction phases of the project

a. Adjust the level of the area

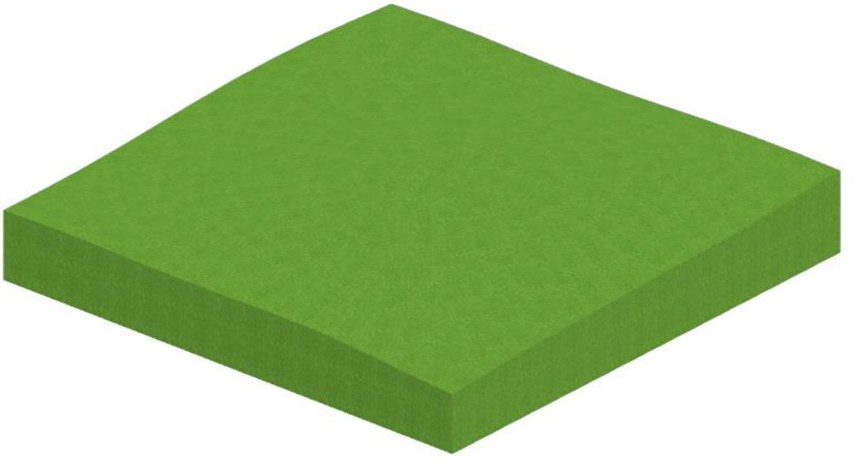


Figure 283 3D view of land before leveling

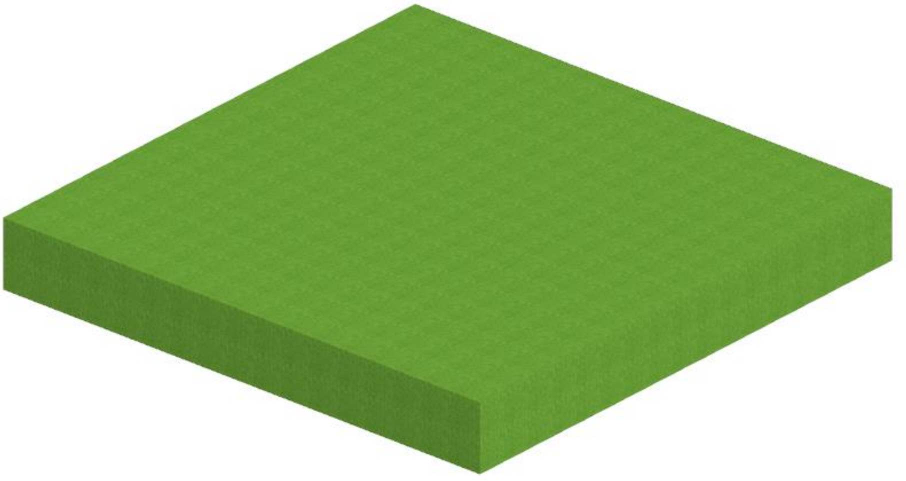


Figure 284 3D view of land after leveling

b. Topographic measurements and highlighting of the 10x10m project area.

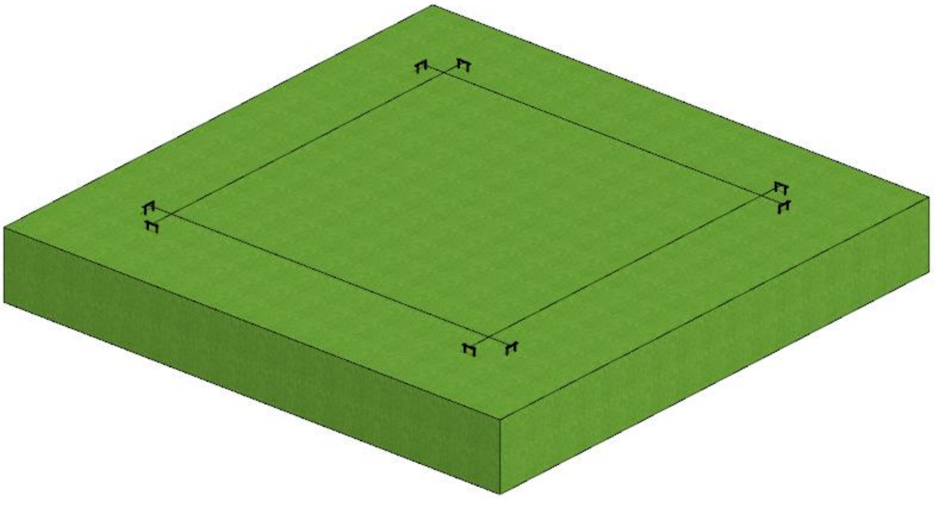


Figure 285 3D view showing topographic measurements

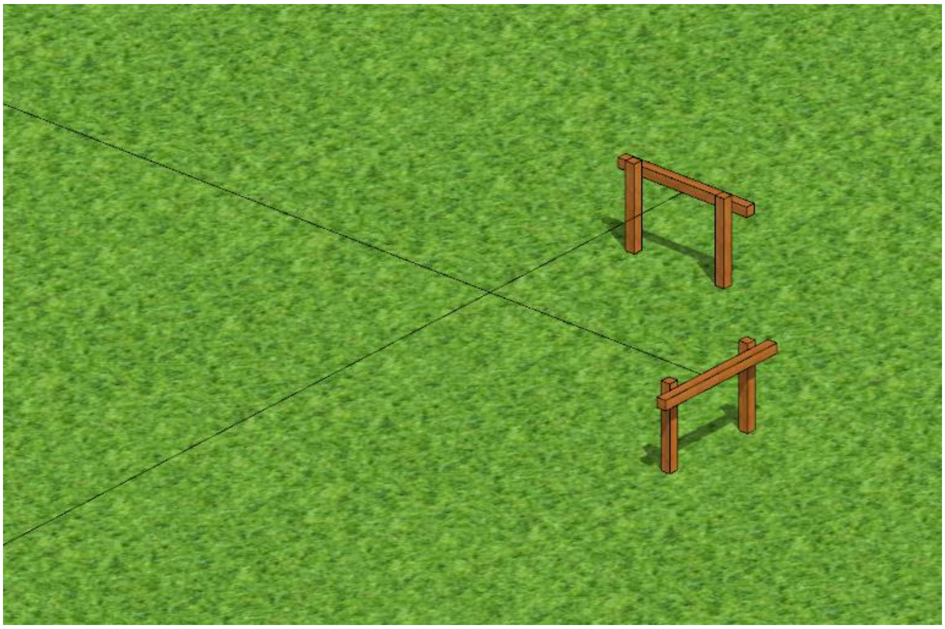


Figure 286 3D view close up of topographic markings

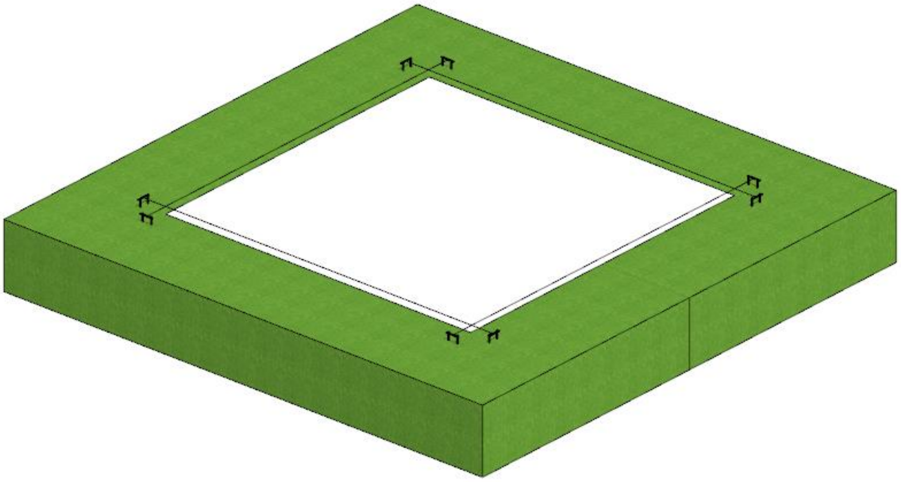


Figure 287 3D view of 10x10 highlighted area

c. Additional markings for the column cement anchor

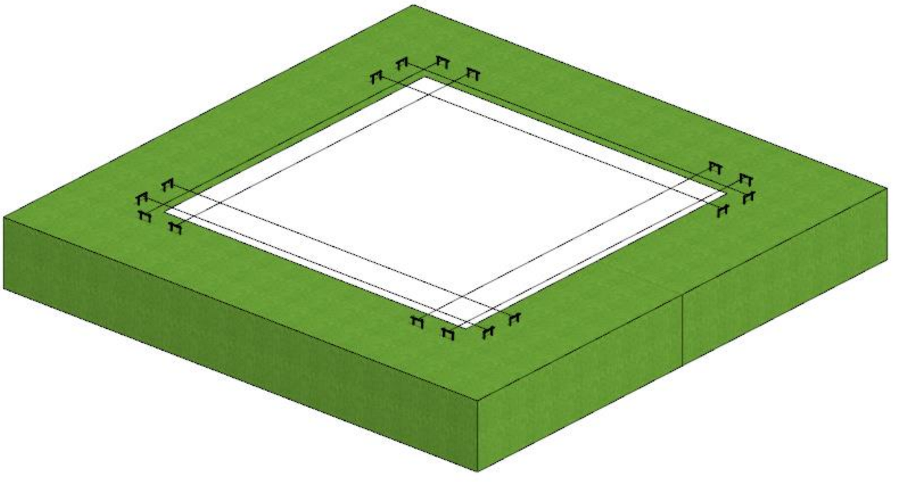


Figure 288 3D view showing cement anchors topographic highlighting

d. Dig anchor holes using most proper available tools. Holes should be of a cylindric shape with a depth of 1m and a diameter of 0.35m

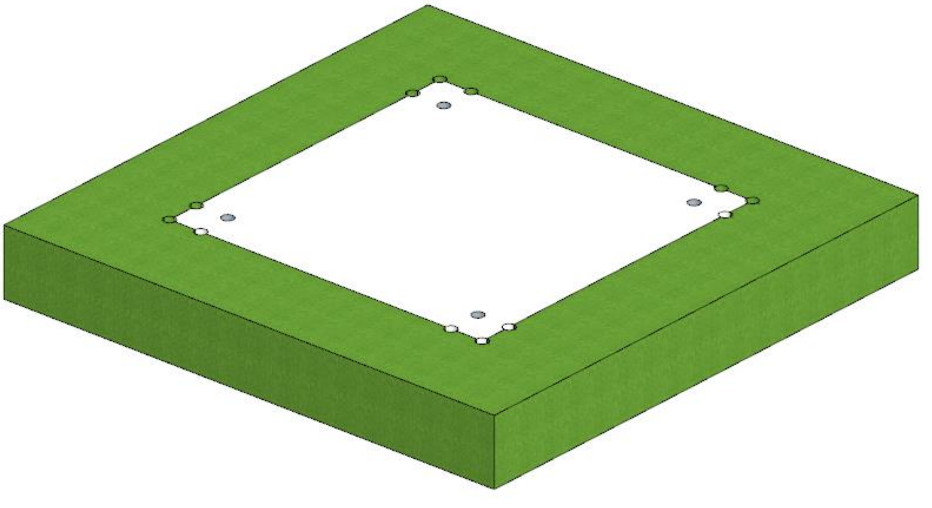


Figure 289 3D view showing cement anchors holes digging

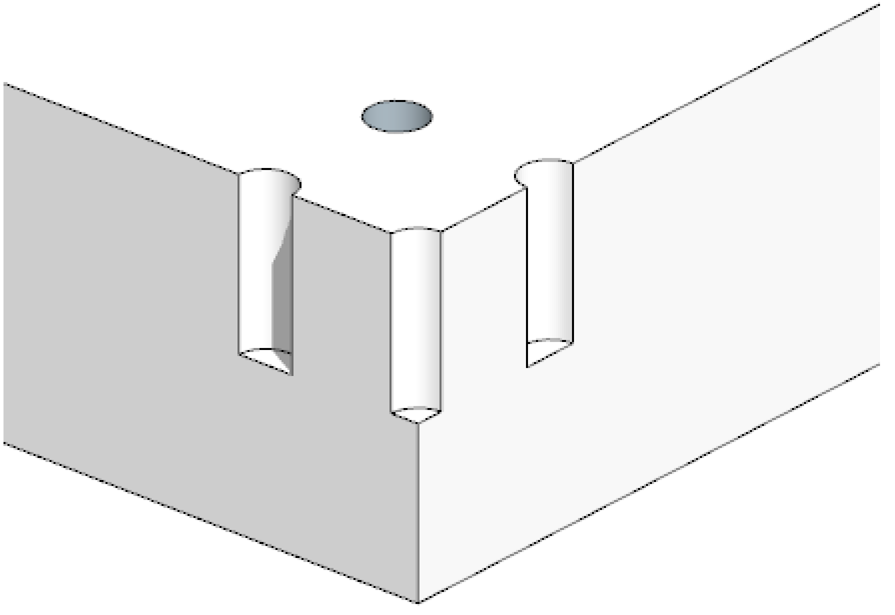


Figure 290 3D Section showing cement anchor holes

e. Insert cement tube forms

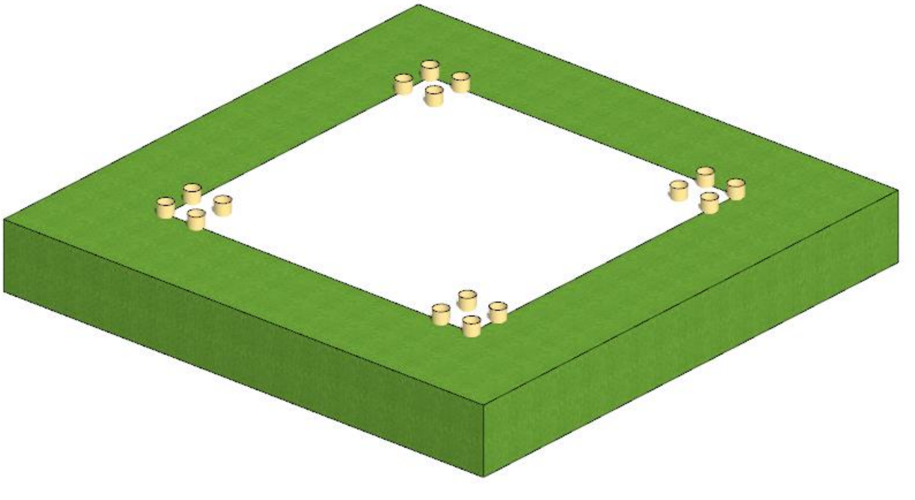


Figure 291 3D view showing cement tube forms

f. Fill in holes with a small layer of gravel and then with cement and metal anchor bolt.

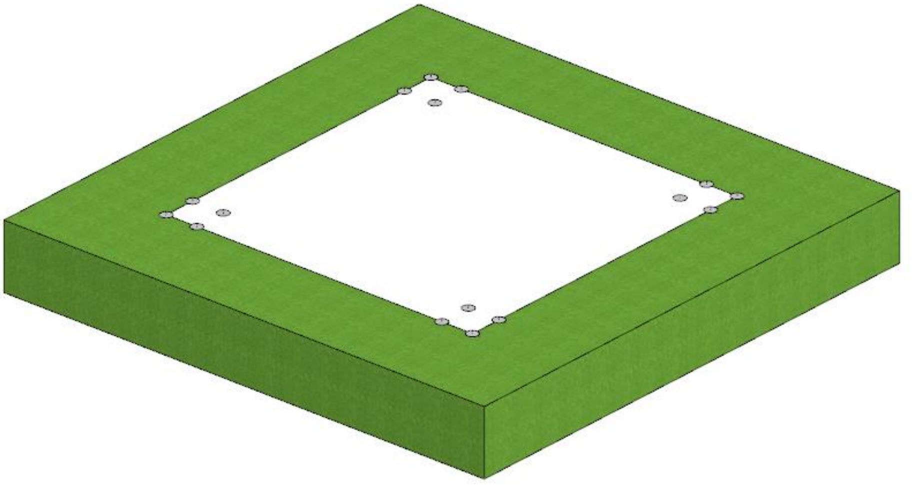


Figure 292 3D view showing the anchors

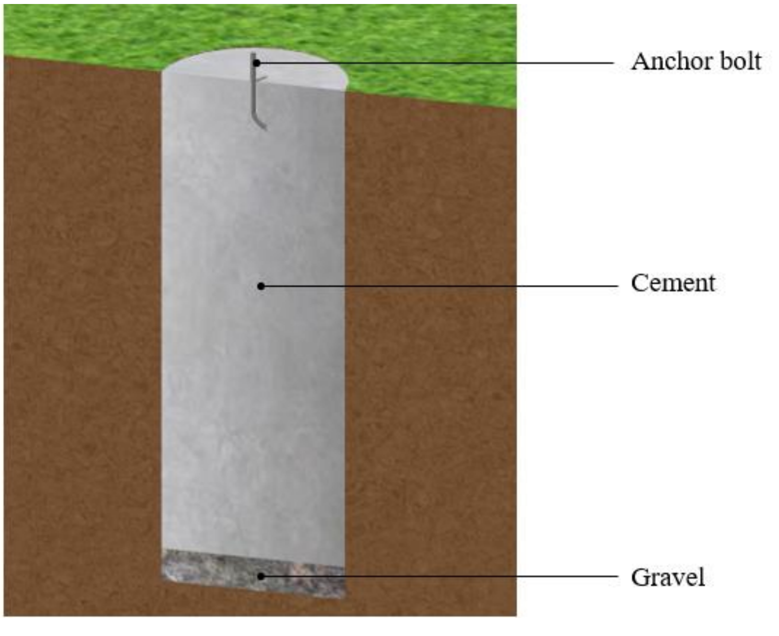


Figure 293 3D section showing the anchor's composition

g. Add metal anchor brackets

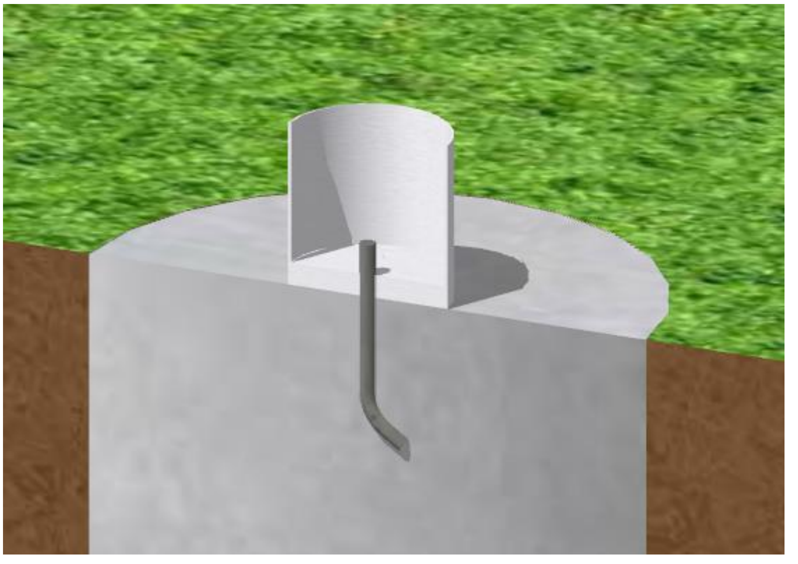


Figure 294 3D section showing the bracket

h. Start building for the support tower

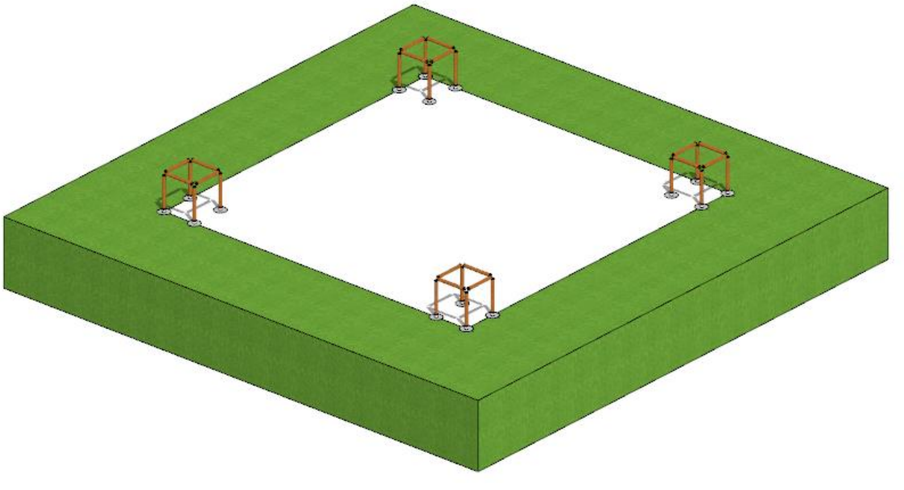


Figure 295 3D showing the construction of the 4 support towers - 1

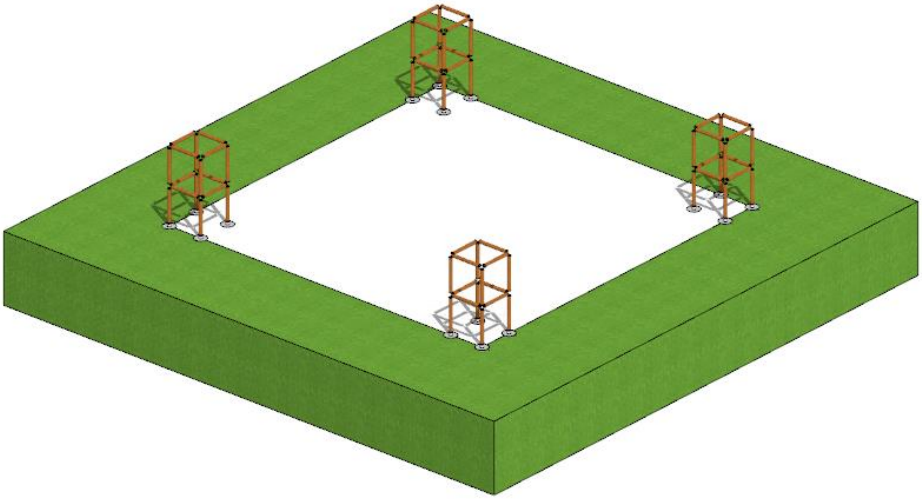


Figure 296 3D showing the construction of the 4 support towers – 2

i. Insert water recollection containers

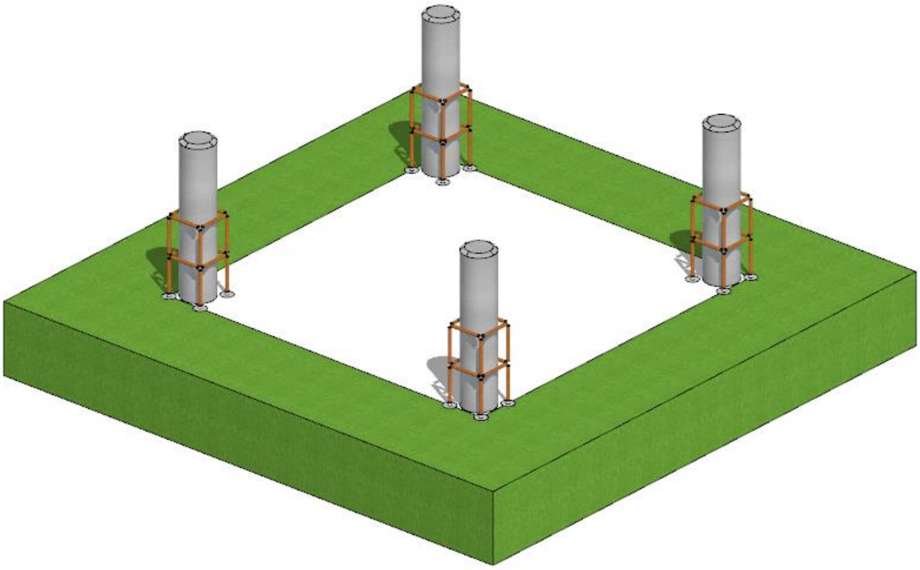


Figure 297 3D showing insertion of the water containers

j. Continue building support towers

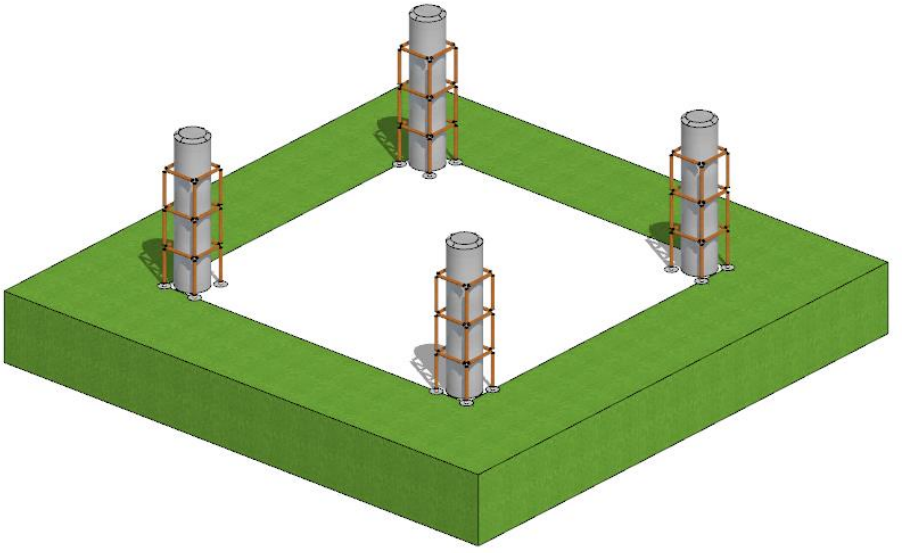


Figure 298 3D showing the construction of the 4 support towers - 3

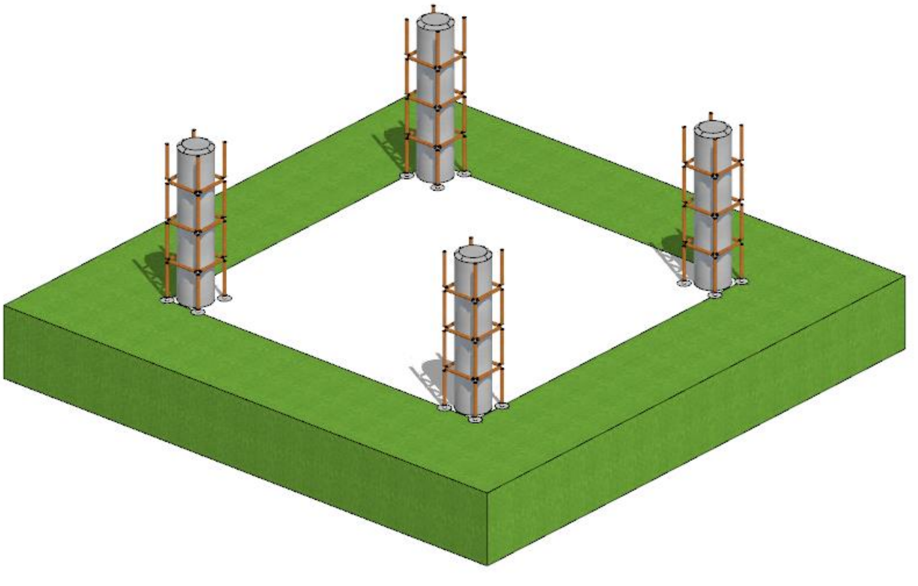


Figure 299 3D showing the construction of the 4 support towers – 4

k. Build scaffolding to support roof construction

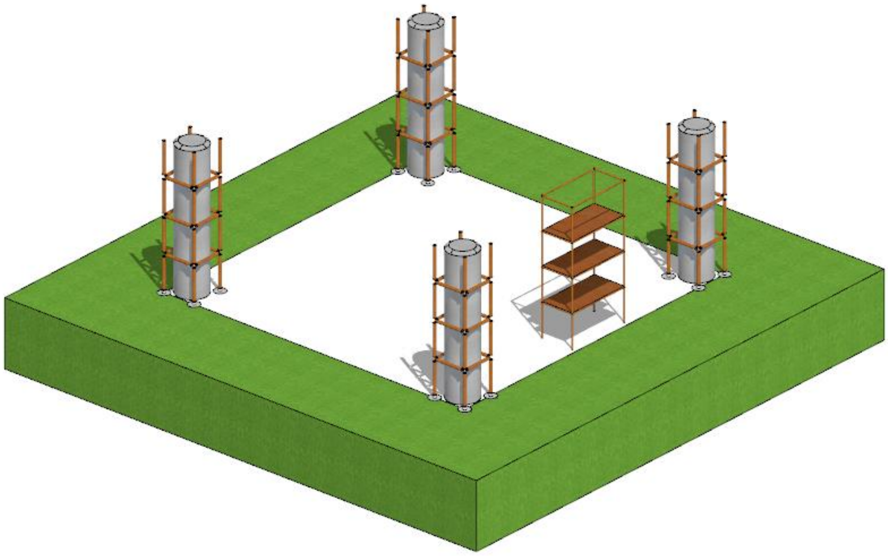


Figure 300 3D showing the construction of scaffolding

l. Build first layer of the roof space frame structure

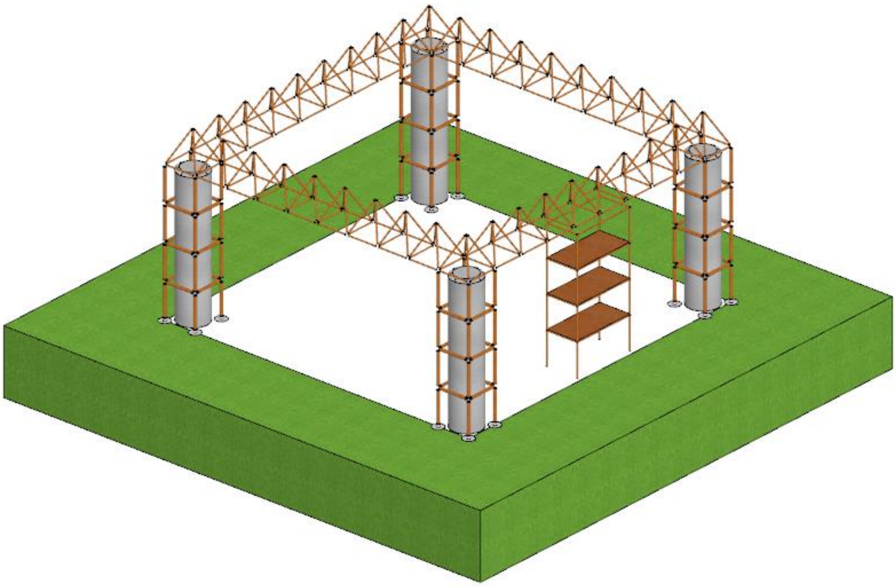


Figure 301 3D showing the construction of the first layer of the roof space frame structure

m. Build second layer of the roof space frame structure

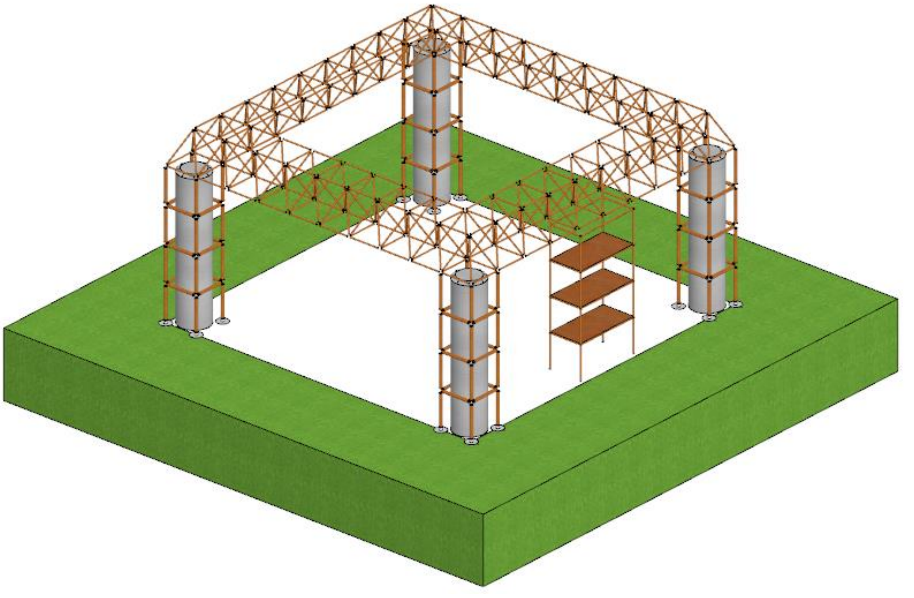


Figure 302 3D showing the construction of the second layer of the roof space frame structure

n. Build first axe of the roof space frame structure

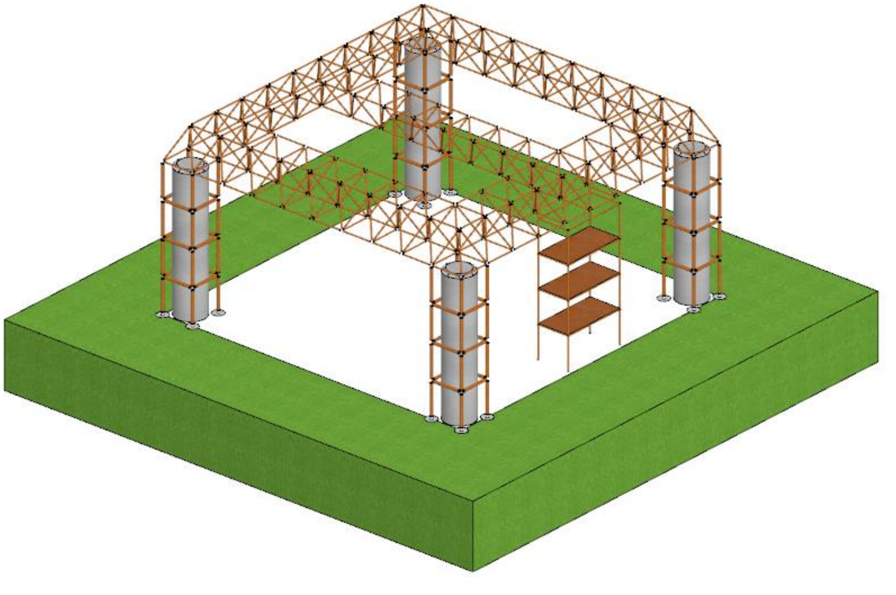


Figure 303 3D showing the construction of the first axe of the roof space frame structure

o. Build second axe of the roof space frame structure

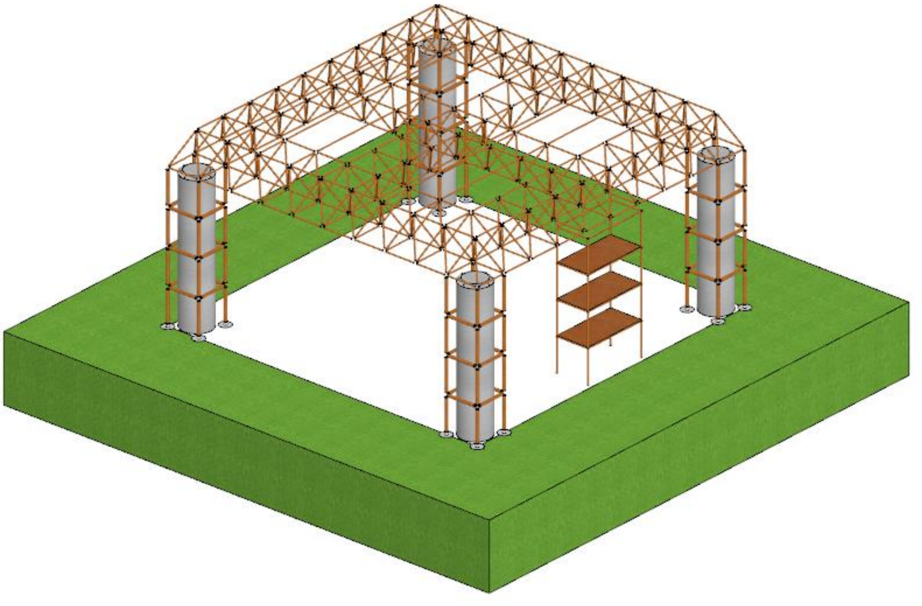


Figure 304 3D showing the construction of the second axe of the roof space frame structure

p. Install roof tarpaulin

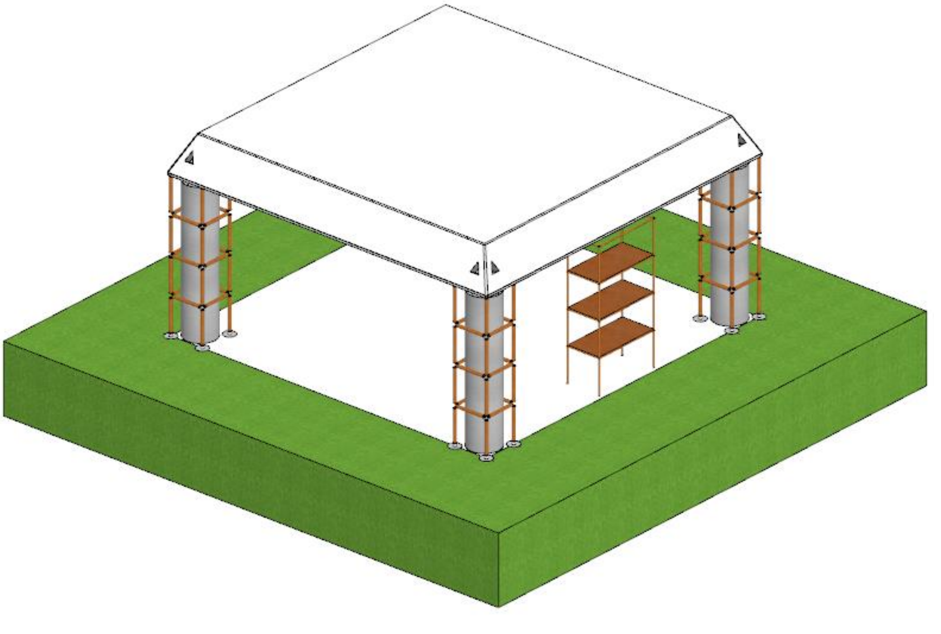


Figure 305 3D showing the installation of the roof tarpaulin

q. Position deck blocks for flooring

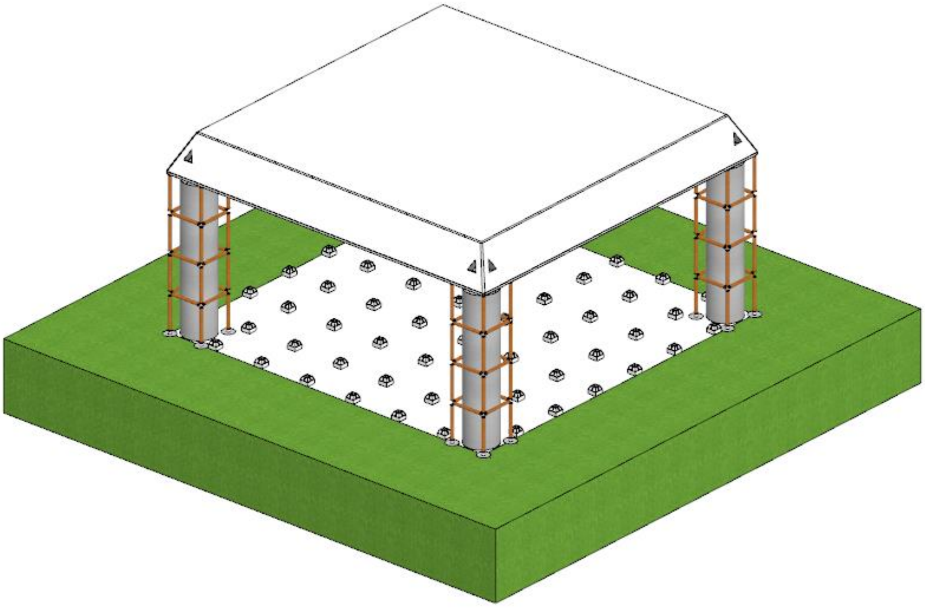


Figure 306 3D showing the positioning of the deck blocks

r. Add layer of landscape fabric to prevent weeds from growing underneath the structure.

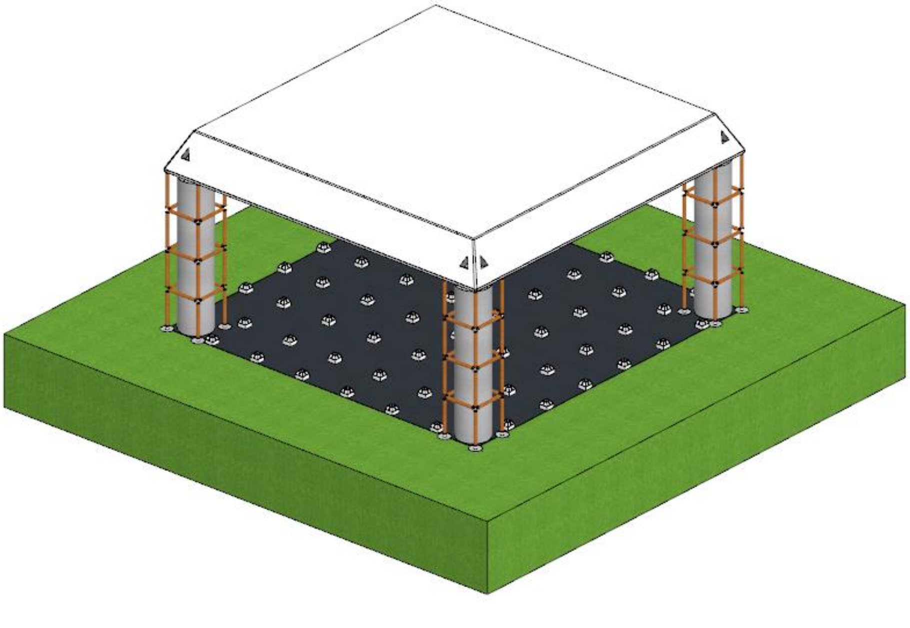


Figure 307 3D showing the adding of landscape fabric

s. Add layer of gravel

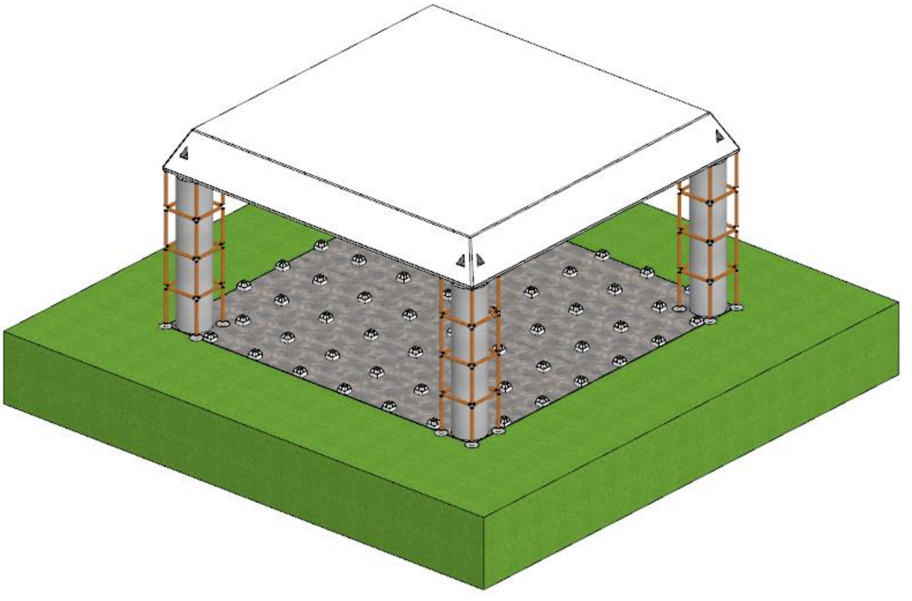


Figure 308 3D showing the adding of gravel layer

t. Build primary wooden floor structure

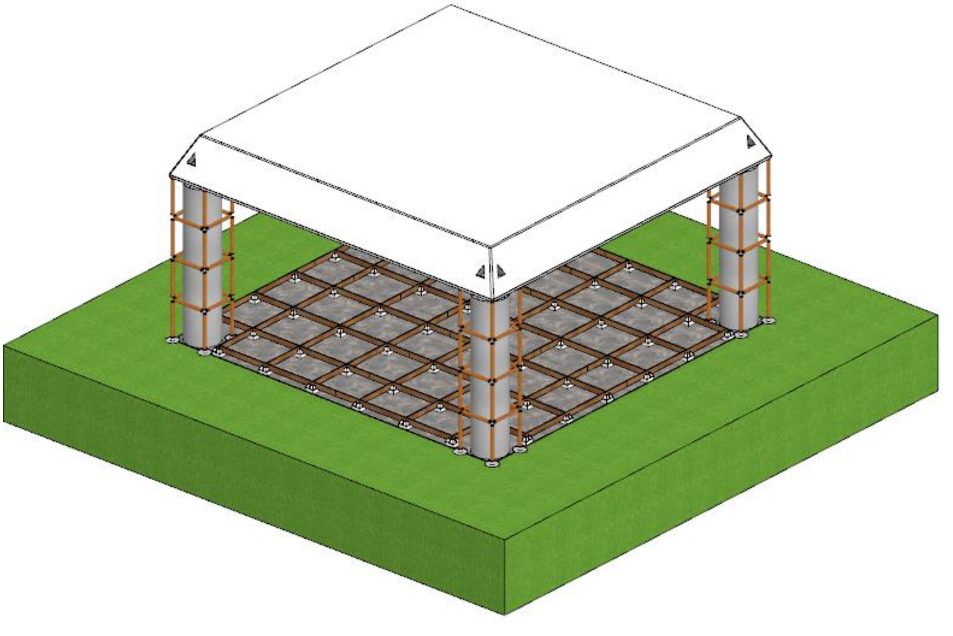


Figure 309 3D showing the construction of primary wooden floor structure

u. Build wooden floor deck

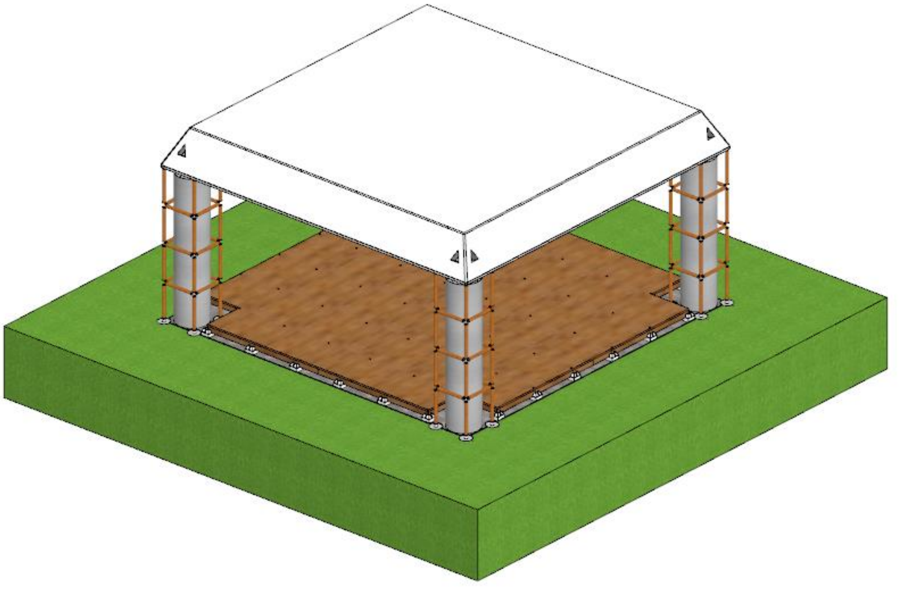


Figure 310 3D showing the construction of wooden floor deck

v. Install external walls tarpaulin

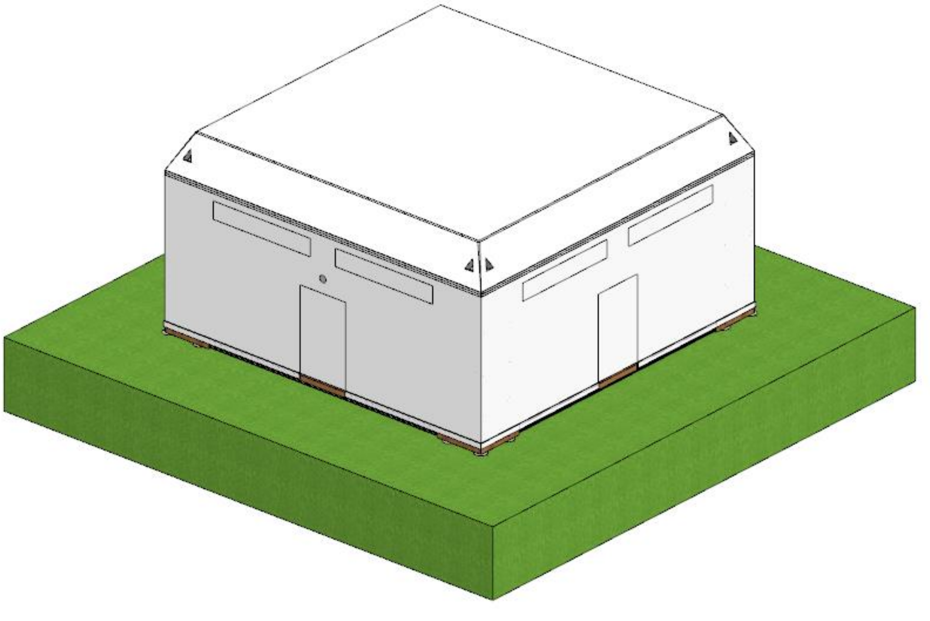


Figure 311 3D showing the installation of tarpaulin at angles

w. Install external floor covering

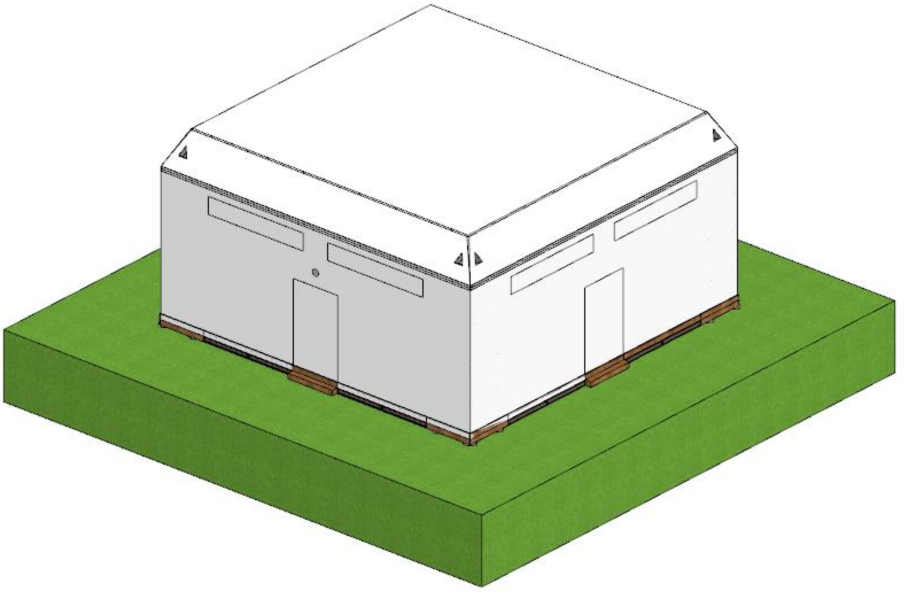


Figure 312 3D showing the installation of tarpaulin at exterior wall

5.4. Constructive details

5.4.1. Structure

5.4.1.1.Space frame construction

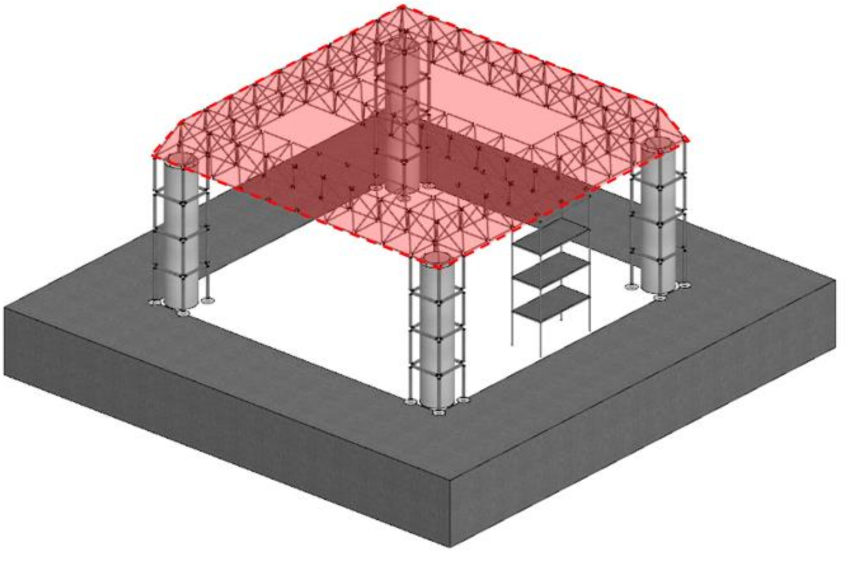


Figure 313 3D key plan highlighting the area where the following is applied

The space frame construction is quite a simple one and involves the following:

- Connecting the wooden membranes to the wooden joints by using glue and a wooden cylinder tube the goes into the pre-designed holes in both the joint and the membrane

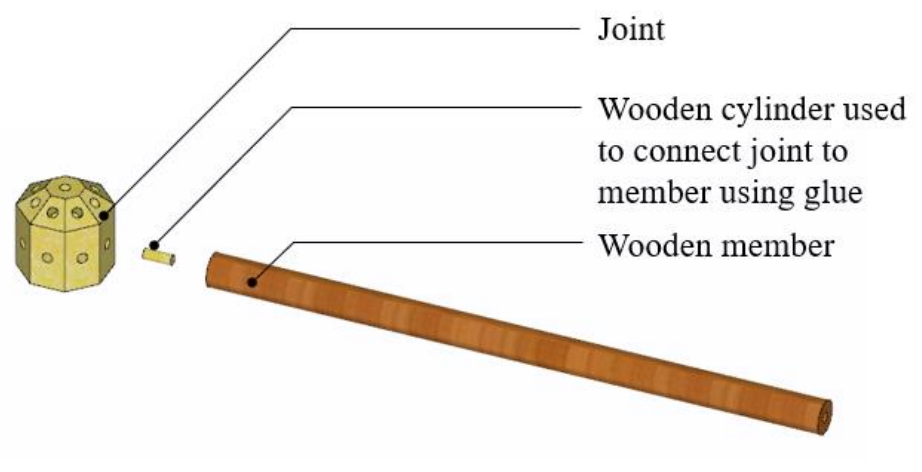


Figure 314 3D sketch showing the different elements in the space frame construction process

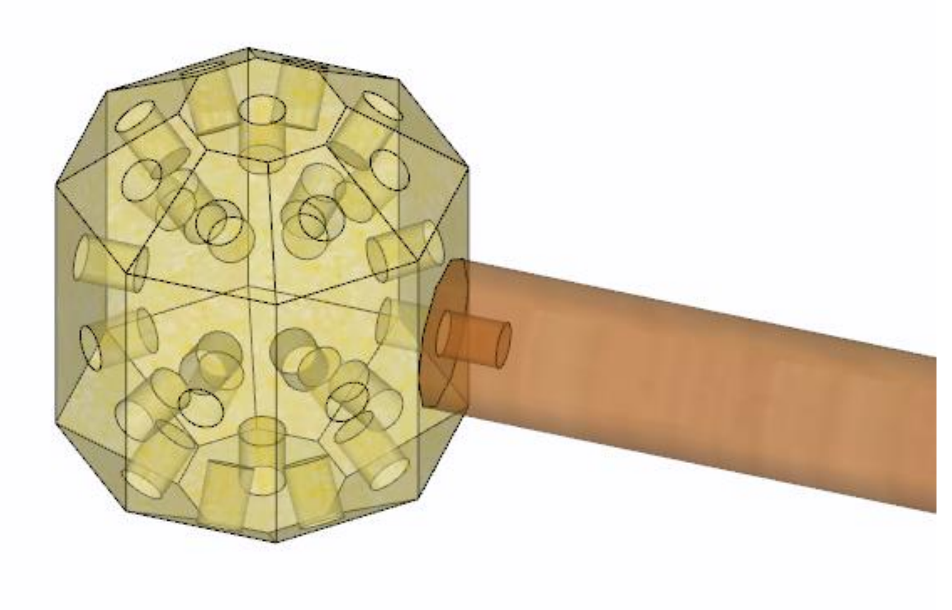


Figure 315 3D sketch showing joint membrane connection

- Connect to other joint

Figure 316 3D sketch showing the space frame base construction process – 1

- Keep applying the same until square base is done

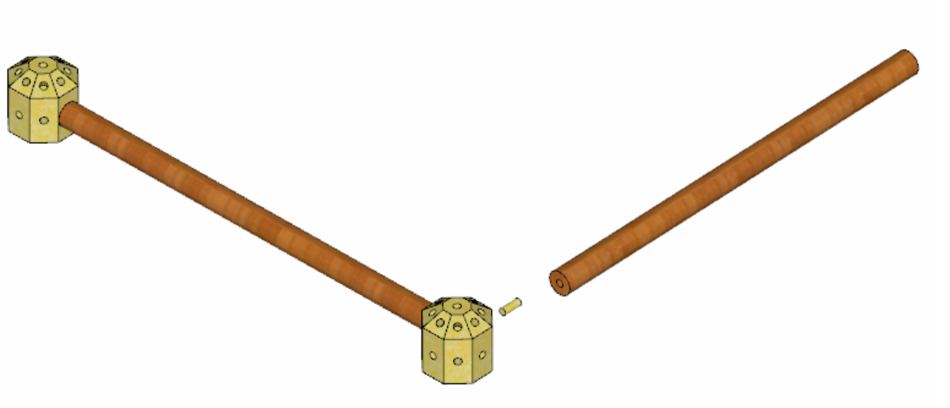


Figure 317 3D sketch showing the space frame base construction process – 2

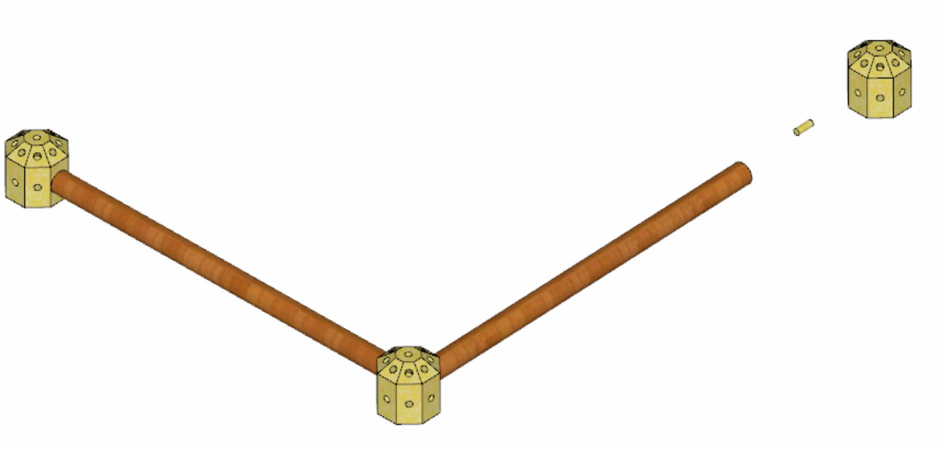


Figure 318 3D sketch showing the space frame base construction process – 3

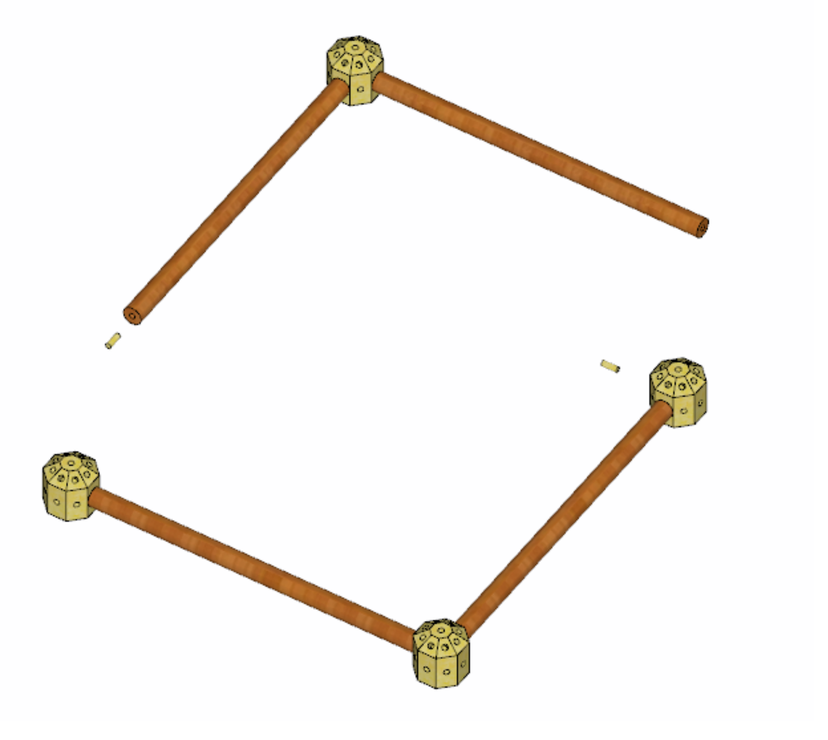


Figure 319 3D sketch showing the space frame base construction process – 4

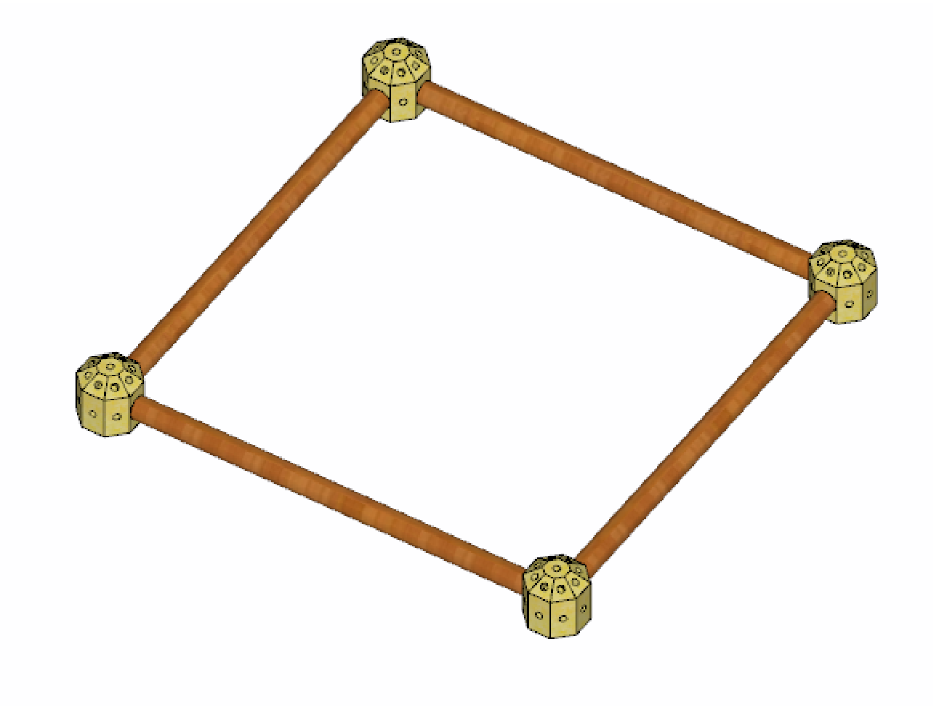


Figure 320 3D sketch showing the space frame base construction process – 5

- Build the top triangle separately in the same way as the bottom square

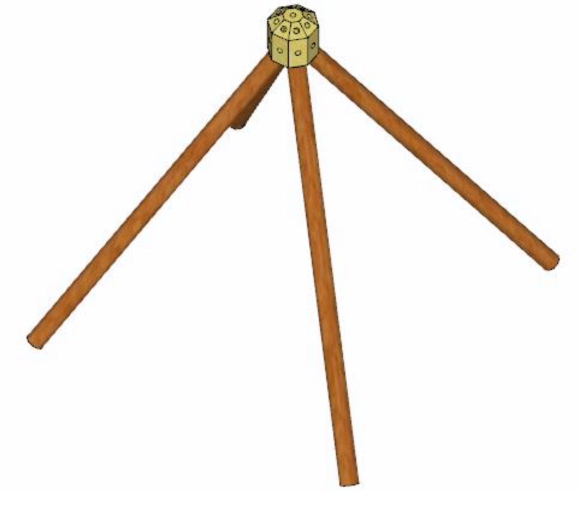


Figure 321 3D sketch showing the space frame top construction process

- Connect both parts

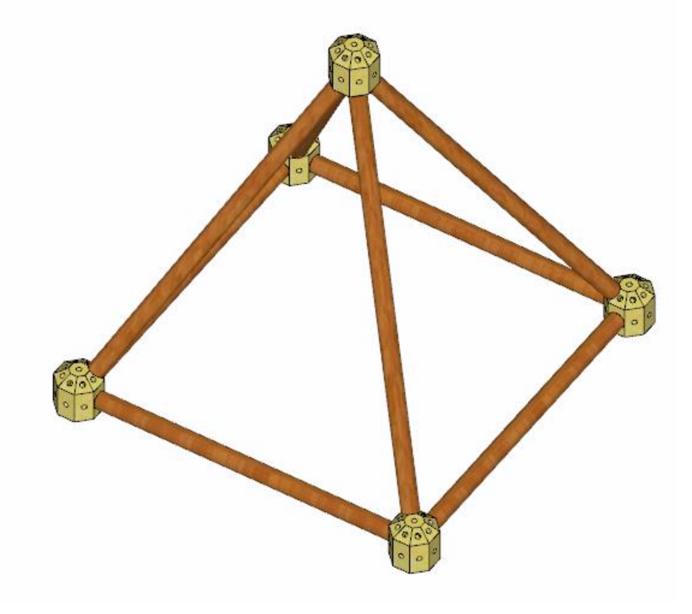


Figure 322 3D sketch showing the space frame single module

- Continue building with same logic from bottom up

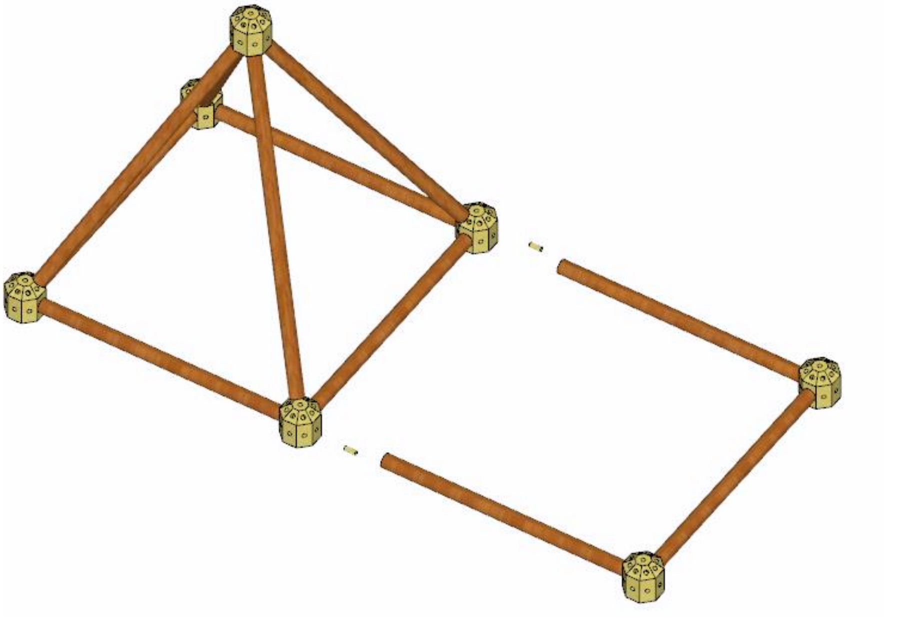


Figure 323 3D sketch showing the space frame inter module connections – 1

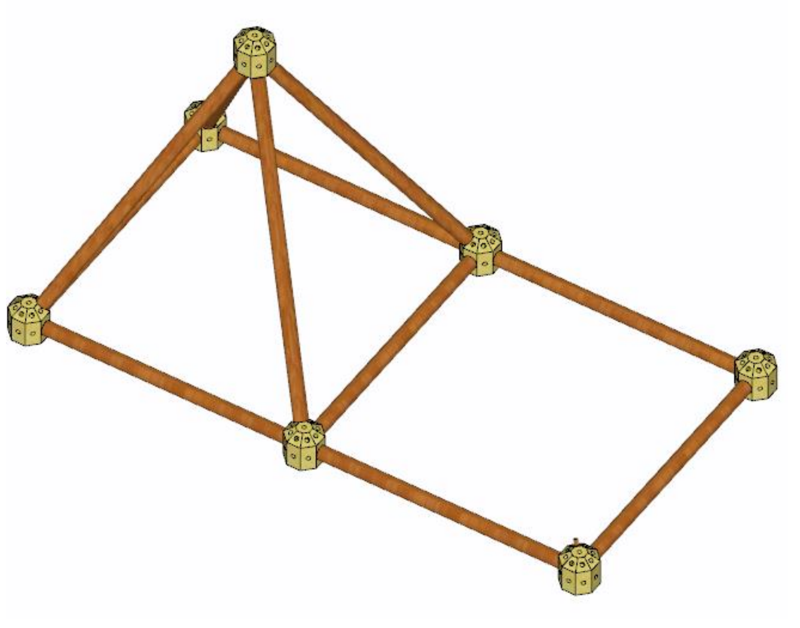


Figure 324 3D sketch showing the space frame inter module connections - 2

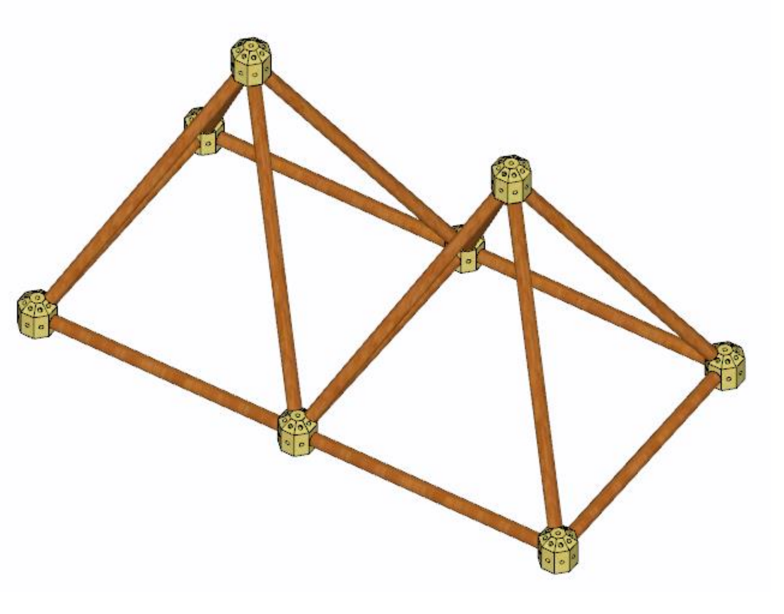


Figure 325 3D sketch showing the space frame inter module connections - 3

5.4.1.2. Joints

There are 3 different types of wooden joints present in this project:

- Roof space frame joint

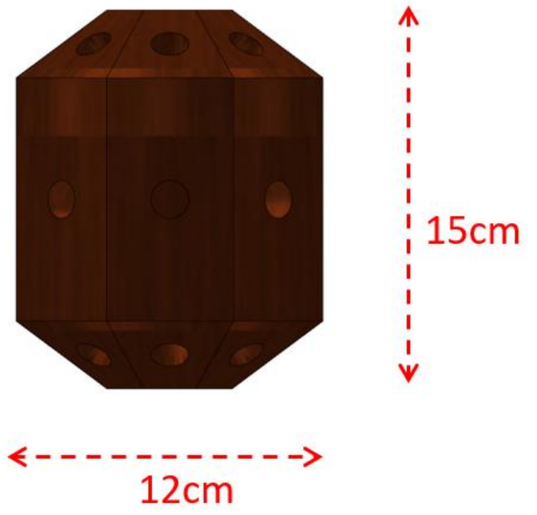


Figure 326 2D sketch showing the roof space frame joint

- Support tower joint

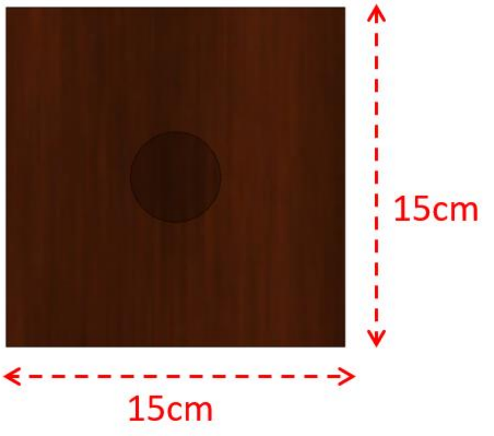


Figure 327 2D sketch showing the support tower joint

- Joint connecting roof space frame to support tower

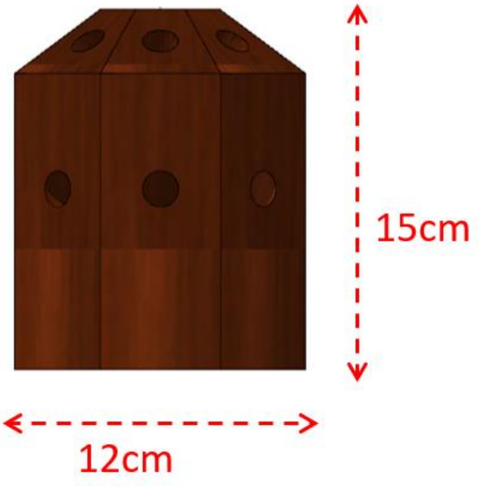


Figure 328 2D sketch showing the joint connecting roof space frame to support tower

5.4.1.3. Floor structure

In addition to what was described in the method of statement, the following must be done in order to make sure the floor structure is stiff:

- Start by installing the longest wooden beams first

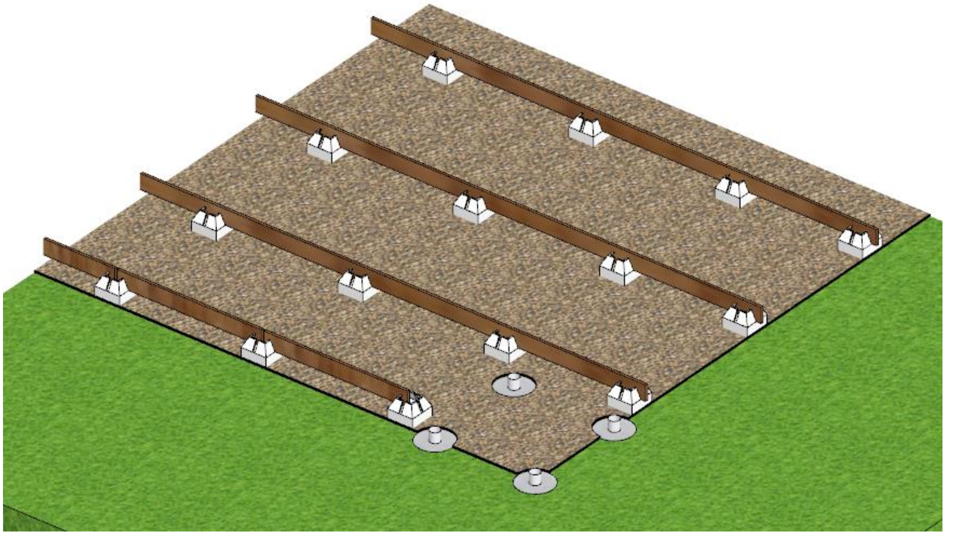


Figure 329 3D sketch showing the installation of the longest beams first

- Then position the smaller beams

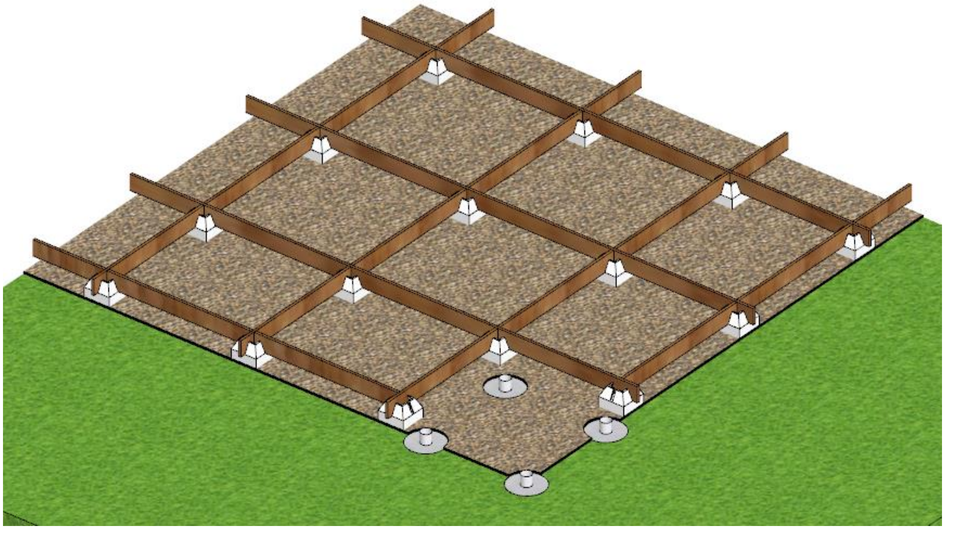


Figure 330 3D sketch showing the installation of the smaller beams

- Once positioning is finalized, reinforce the connection with metal L connections and nails

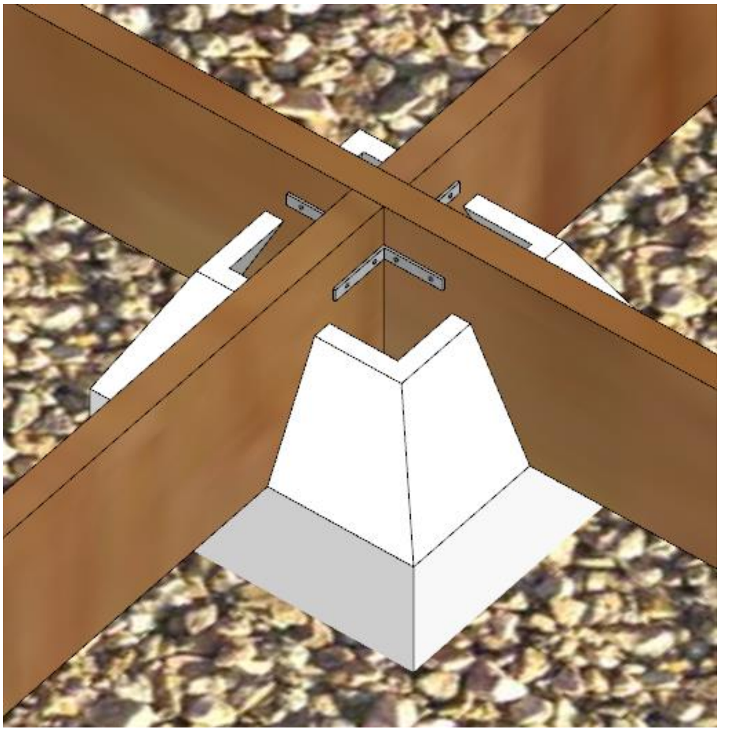


Figure 331 3D sketch showing the connection reinforcement of the inner beams

- Position the perimetral wooden beams

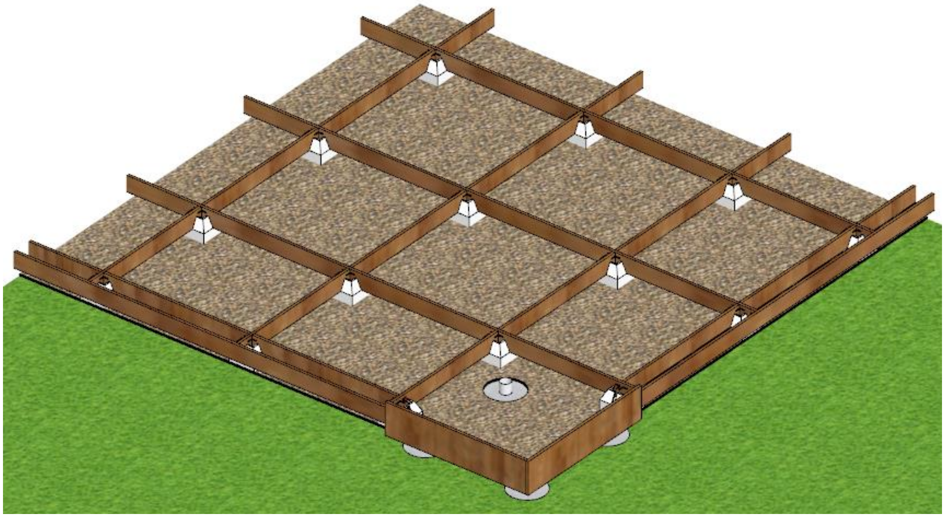


Figure 332 3D sketch showing the installation of the perimetral beams

- Once the positioning is done, reinforce with double metal L shaped connections as these beams have additional load coming from the tarpaulin of the exterior partitions

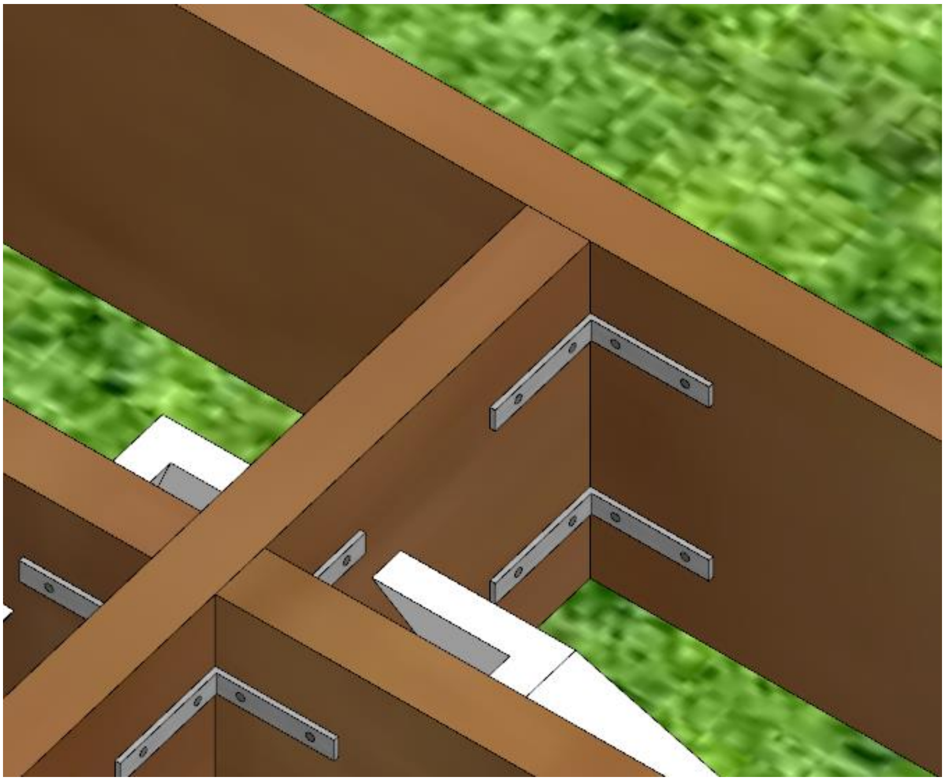


Figure 333 3D sketch showing the connection reinforcement of the perimetral beams

- Add the flooring panels

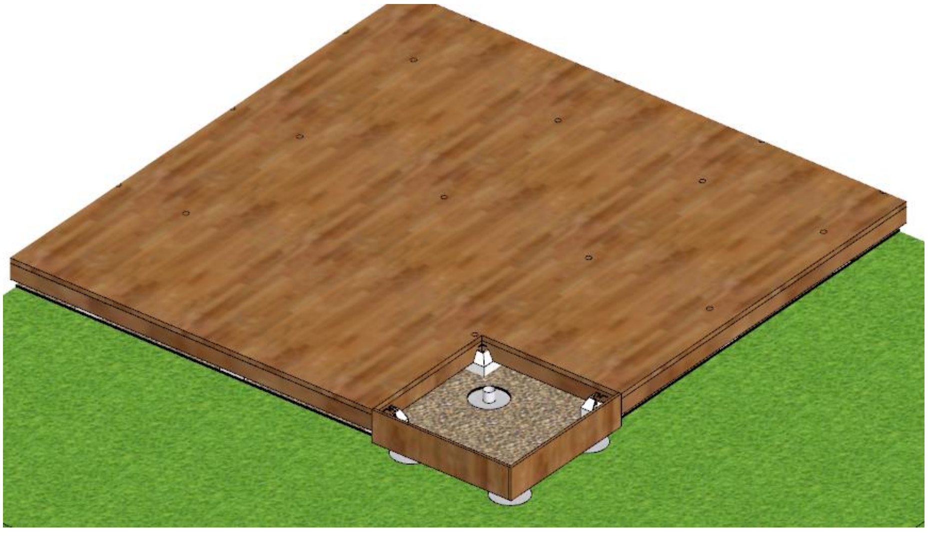


Figure 334 3D sketch showing the addition of the flooring

- Place the external partitions

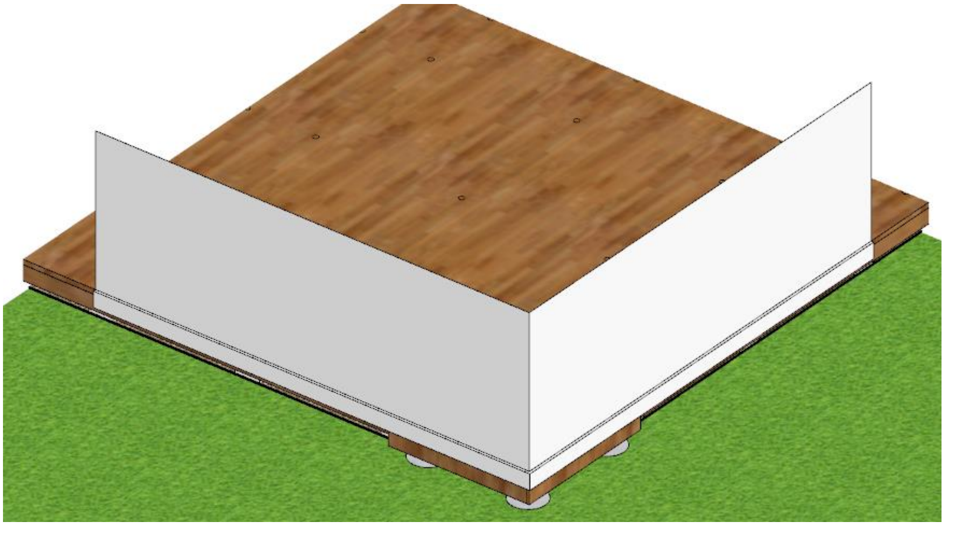


Figure 335 3D sketch showing the placing of the external partitions

- Make sure bottom support is placed at the top of the perimetral wooden beam and nailed to it with a series of 2 nails spaced apart with 30 cm maximum

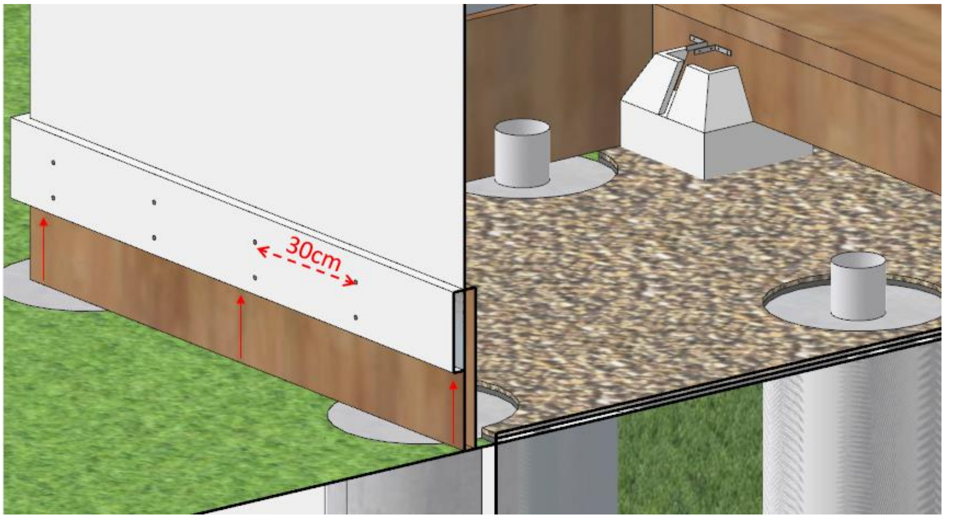


Figure 336 3D sketch showing the nailing patterns of the bottom partition support-1

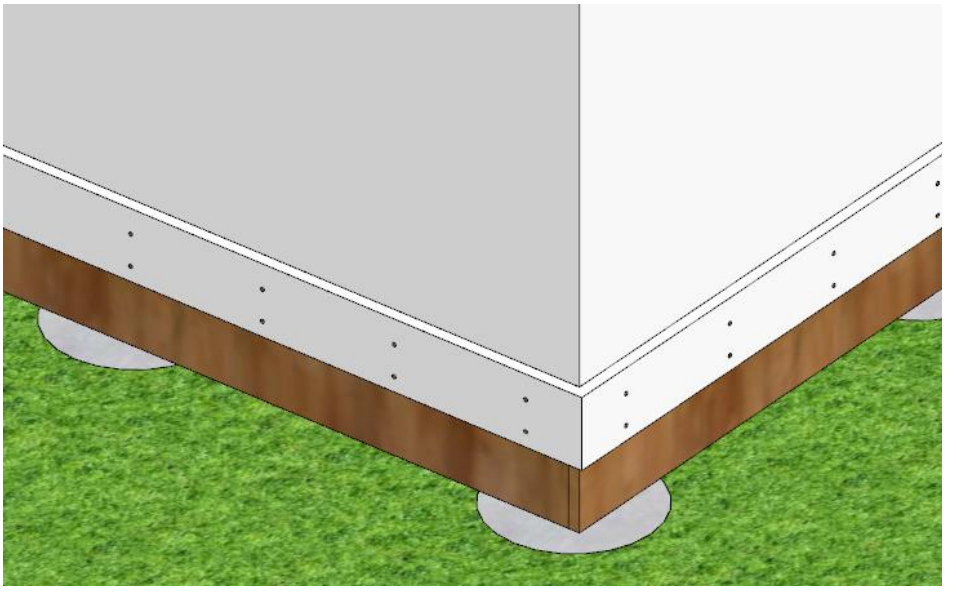


Figure 337 3D sketch showing the nailing patterns of the bottom partition support-2

- Install the floor cover layer and nail following same principle used for tarpaulin support except use one nail instead of two

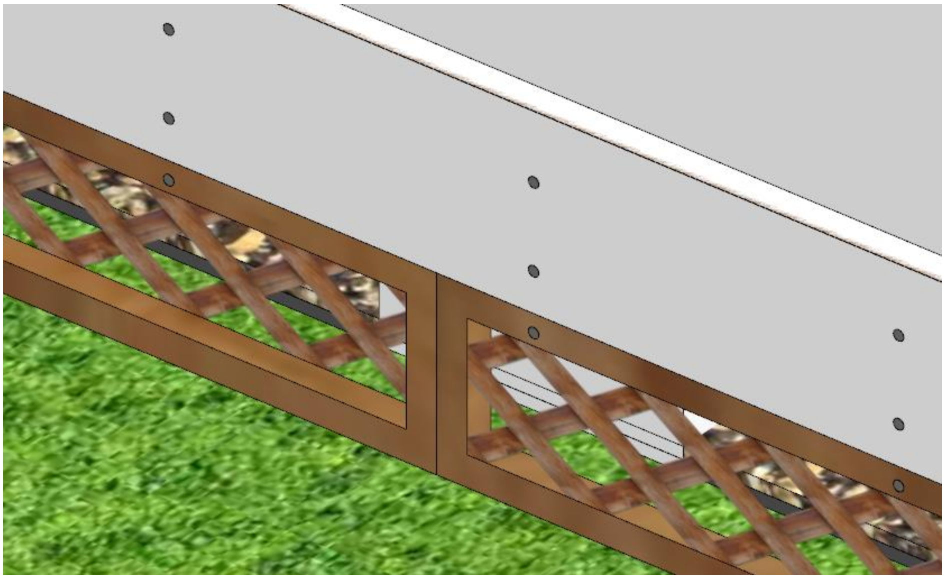


Figure 338 3D sketch showing the nailing patterns of the floor cover layer

5.4.2. Roof Edge

The roof edge is the most delicate area of the envelope as it connects the roof tarpaulin to the exterior partitions while preserving the waterproofness of the structure.

In order to achieve that, the following must be done:

- Nail the roof tarpaulin to a wooden beam while making sure that nails are maximum 30cm apart

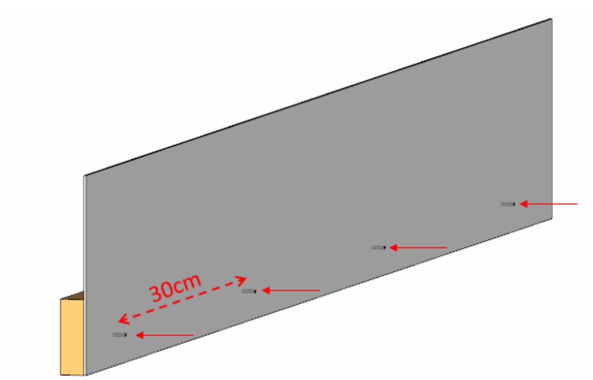


Figure 339 3D sketch showing the nailing of the roof tarpaulin to the wooden beam

- Rotate the tarpaulin sheet 360 degrees in order to cover the entire beam

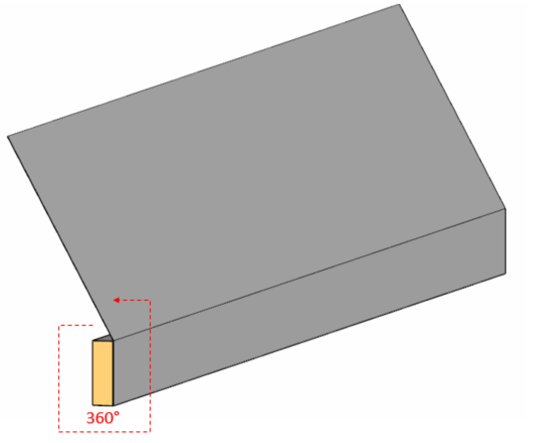


Figure 340 3D sketch showing the wrapping of the roof tarpaulin to the wooden beam

- Nail the beam to the roof structure's bottom joint while adding another layer of tarpaulin which will ensure the waterproofness of the connection. It is essential to make sure that the tarpaulin sheet is on the outside

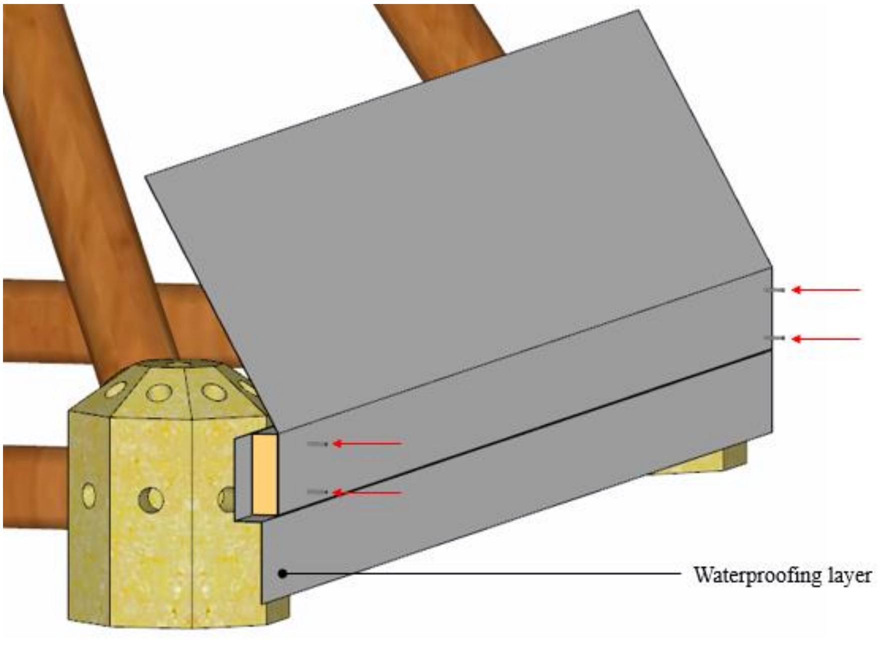


Figure 341 3D sketch showing the nailing of the roof beam to the roof structure

- Nail the external partition's tarpaulin to a wooden beam while making sure that nails are maximum 30cm apart

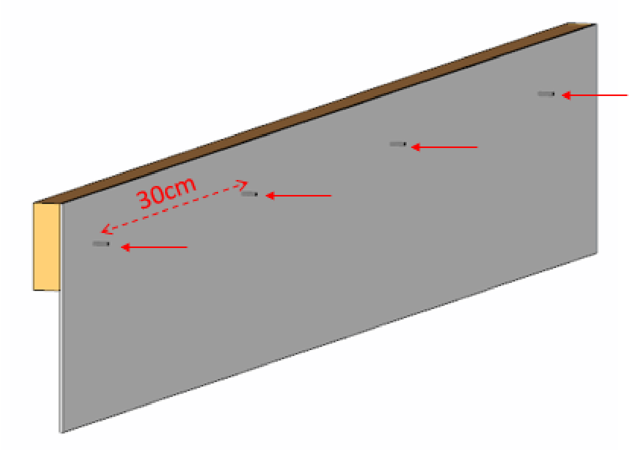


Figure 342 3D sketch showing the nailing of the external partition tarpaulin to the wooden beam

- Rotate the tarpaulin sheet 360 degrees in order to cover the entire beam

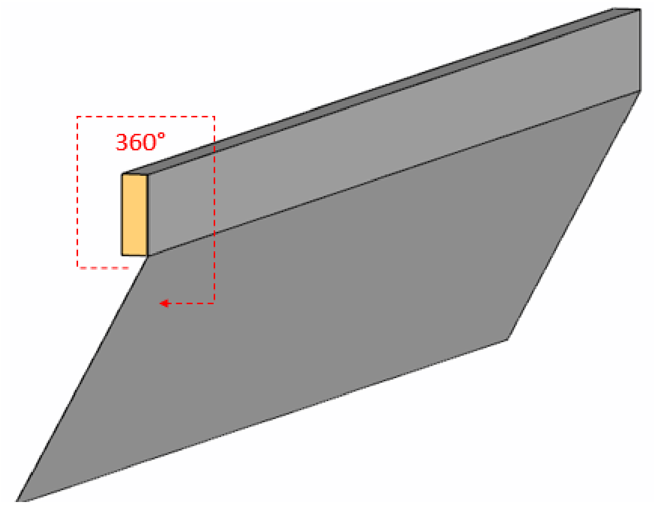


Figure 343 3D sketch showing the wrapping of the external partition tarpaulin to the wooden beam

- Nail the beam to the roof structure's bottom joint while making sure that the beam is placed under the waterproofing sheet and that the tarpaulin sheet is on the outside

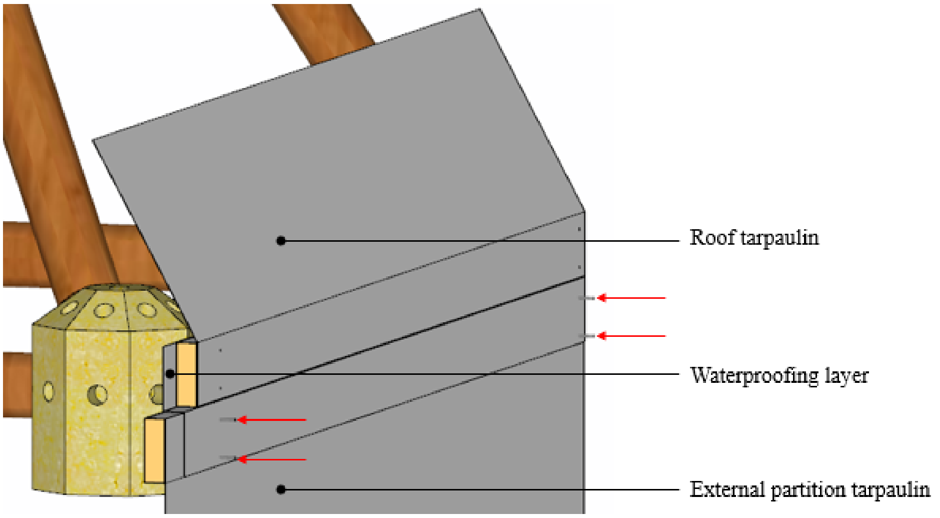


Figure 344 3D sketch showing the nailing of the external partition beam to the roof structure -1

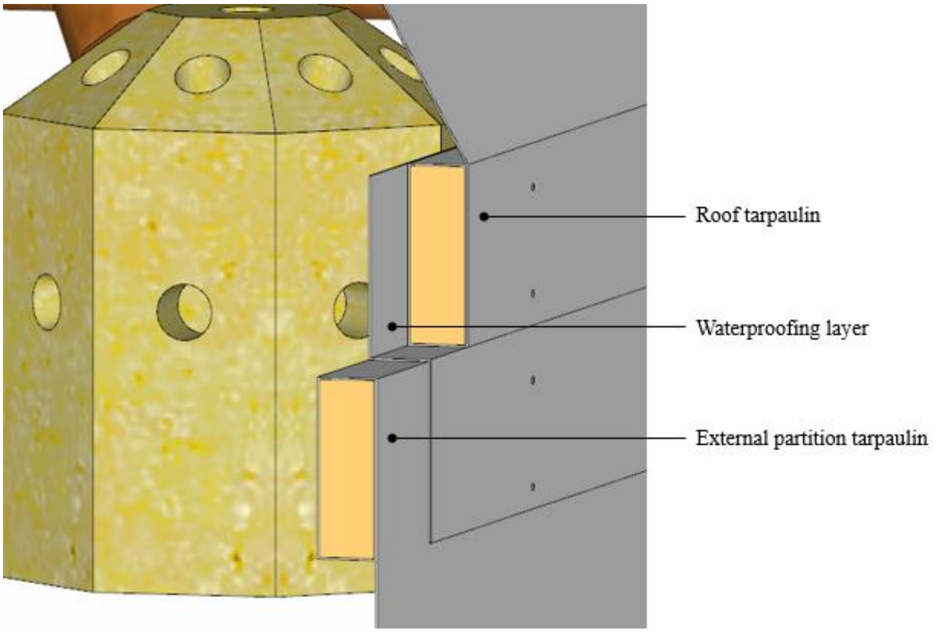


Figure 345 3D sketch showing the nailing of the external partition beam to the roof structure -2

5.4.3. Tarpaulin

It is advisable to have, if possible, the roof tarpaulin to be sewed together with proper machinery and according to the final dimensions in order to provide proper water proofing.

In case prefabrication is not possible, several tarpaulin sheets can be joined together taking into consideration the following:

- Overlap sheets and fold them prior to stitching
- Use a strong thread

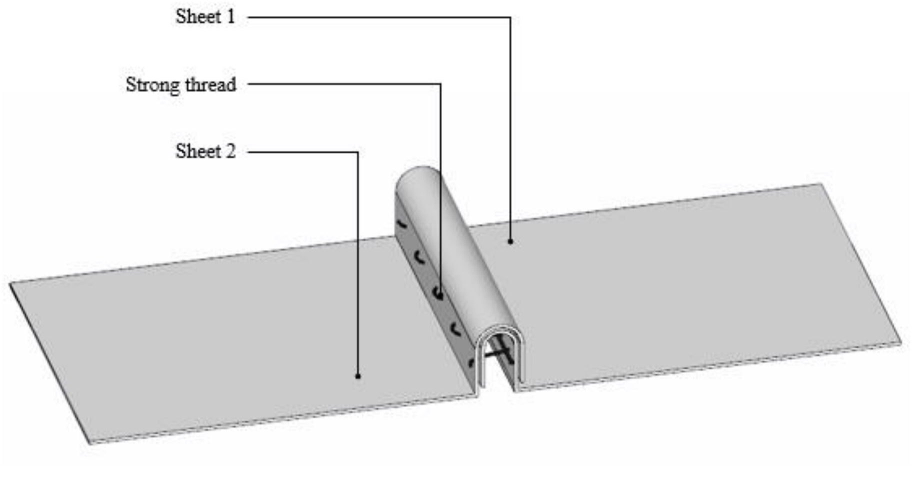


Figure 346 3D sketch showing the stitching of 2 tarpaulin sheets – 1

- Align the jointed area to the surface

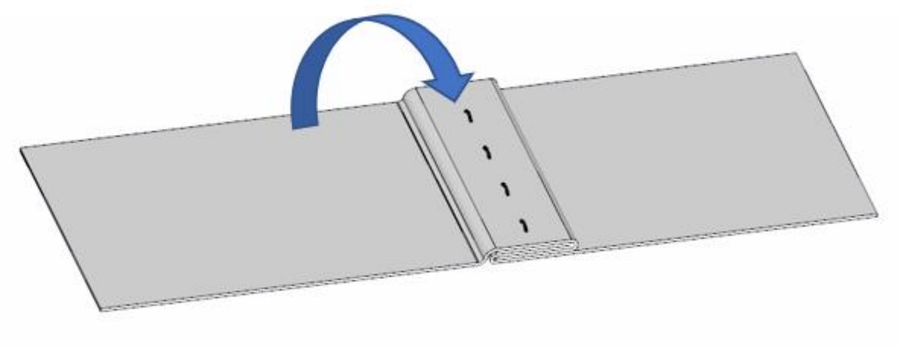


Figure 347 3D sketch showing the stitching of 2 tarpaulin sheets – 2

- Place a UV resistant water proofing tape on top of the knot

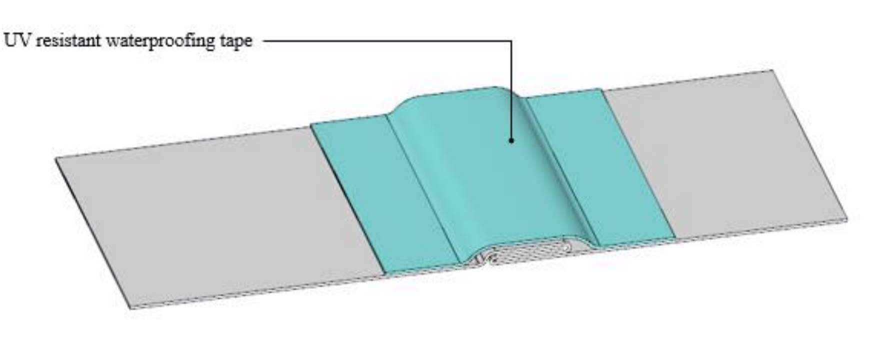


Figure 348 3D sketch showing the stitching of 2 tarpaulin sheets – 3

The roof tarpaulin is supported on its edges through timber joints but, in case deemed necessary additional also occasionally to the roof structure. This can be done through the following:

- Inserting a rope during the stitching operation thus adding stiffness at the edge connections

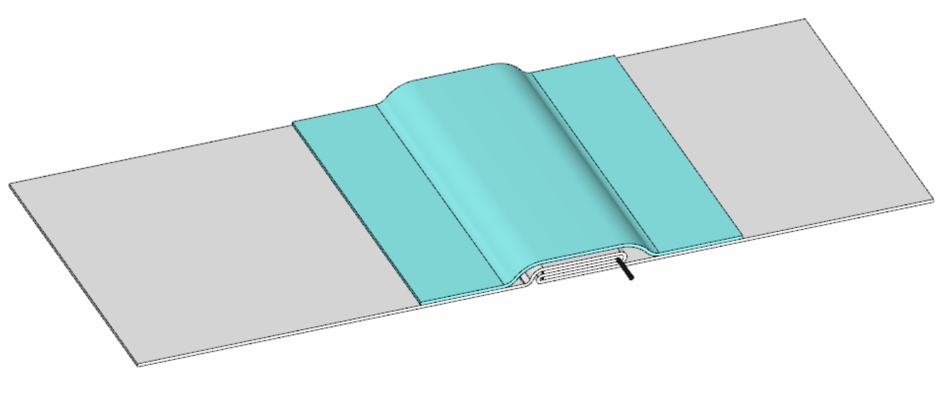


Figure 349 3D sketch showing the integration of a rope within the stitching operation

- Pre-sewed hangs for webbing loops to connect to space frame

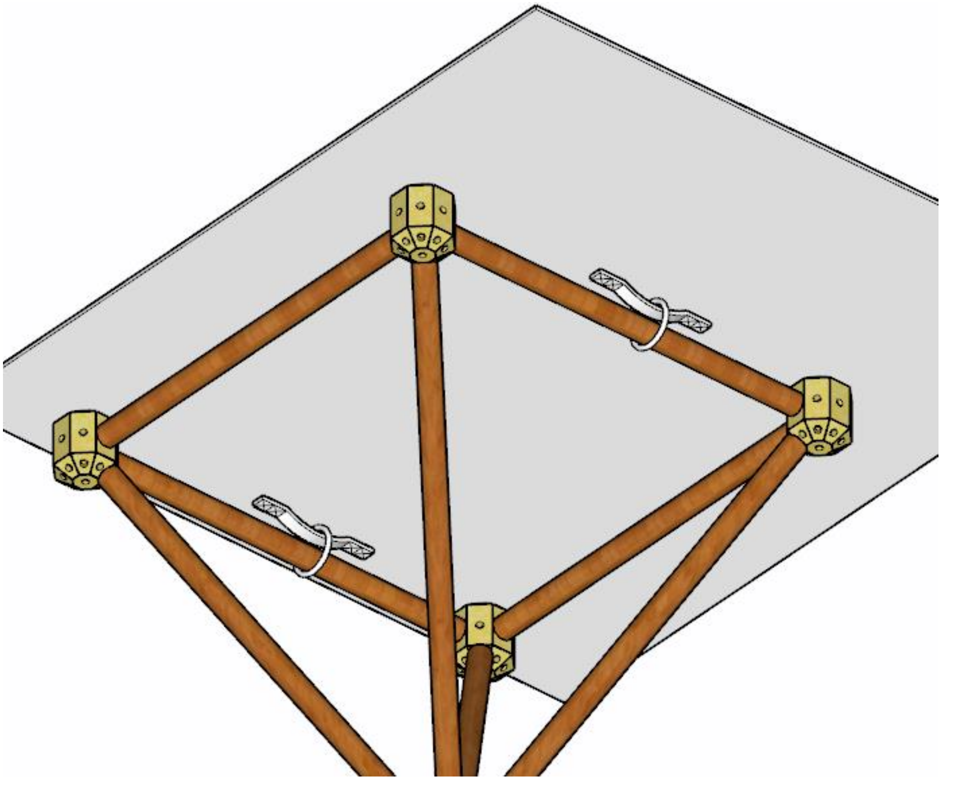


Figure 350 3D sketch showing the pre-sewed hangs

5.4.4. Partitions

5.4.4.1. Internal partitions

5.4.4.1.1. Floor detail

The floor was designed to provide as much flexibility as possible thus fortifying the multipurpose role of the proposed project.

In order to achieve that a series if tapped holes were designed following the grid of the deck blocks.

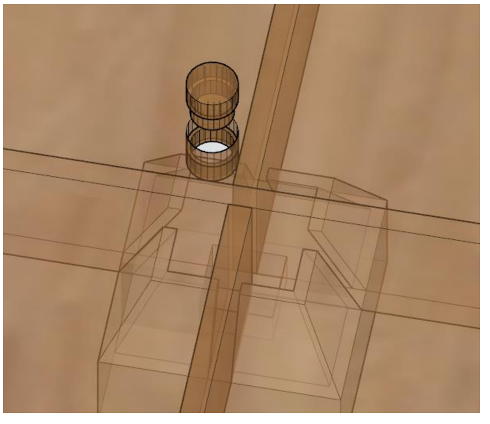


Figure 351 3D sketch showing the tapped hole location relative to the deck block beneath it

When tapped, thanks to the design, they blend in and maintain the floor's stiffness.

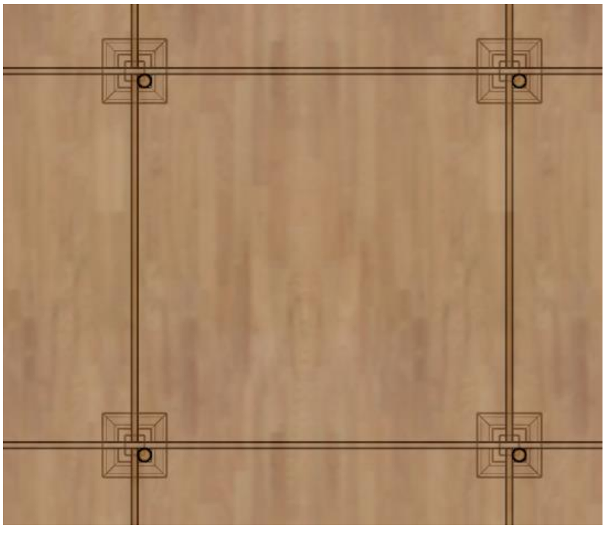


Figure 352 3D sketch showing the tapped holes following the deck block grid

But when a design change is needed these holes are untapped where deemed necessary and wooden pillars are installed in the tap's place thus providing the necessary support for internal partitions.

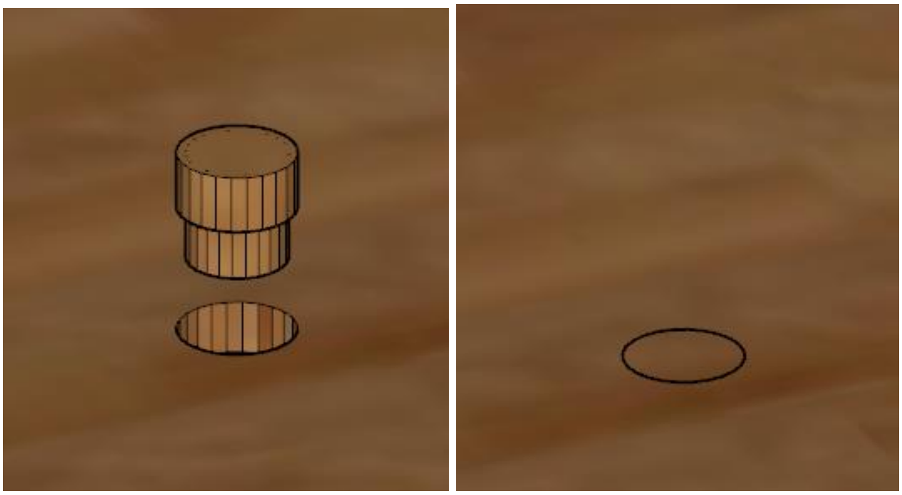


Figure 353 3D sketch showing tapped holes

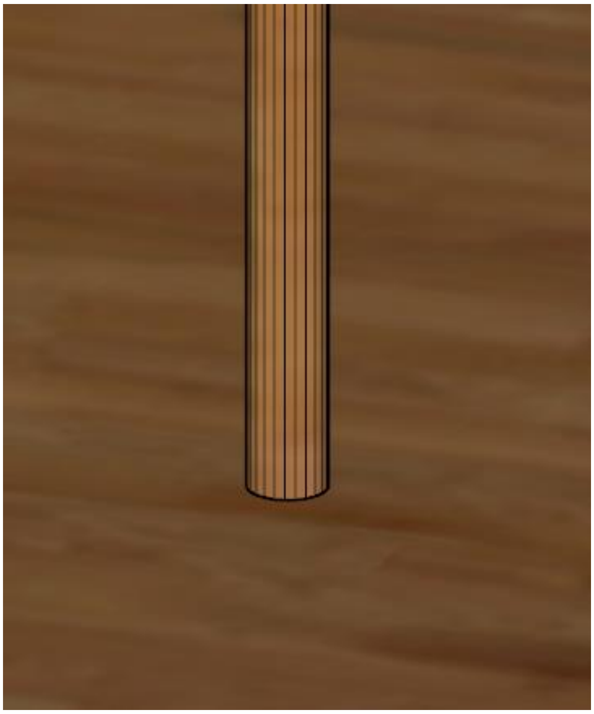


Figure 354 3D sketch showing insertion of a wooden pillar in the hole

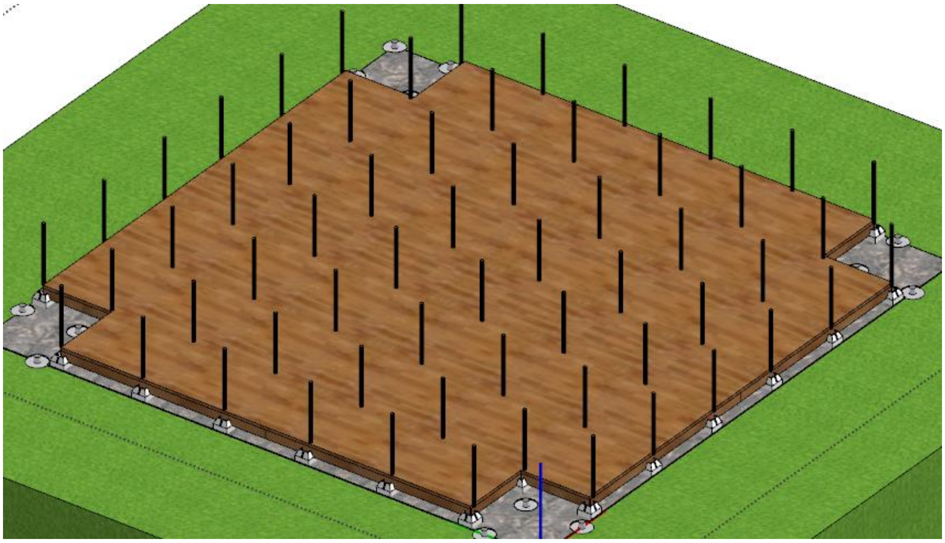


Figure 355 3D sketch showing all possible locations for the wooden pillars

5.4.4.1.2. Material

It is preferable to use old tents as partition material, the tarpaulin sheets can be cut and stitched manually as no waterproofing is needed. if recoverable the doors used for tents can be also used for the rooms that are to be created.

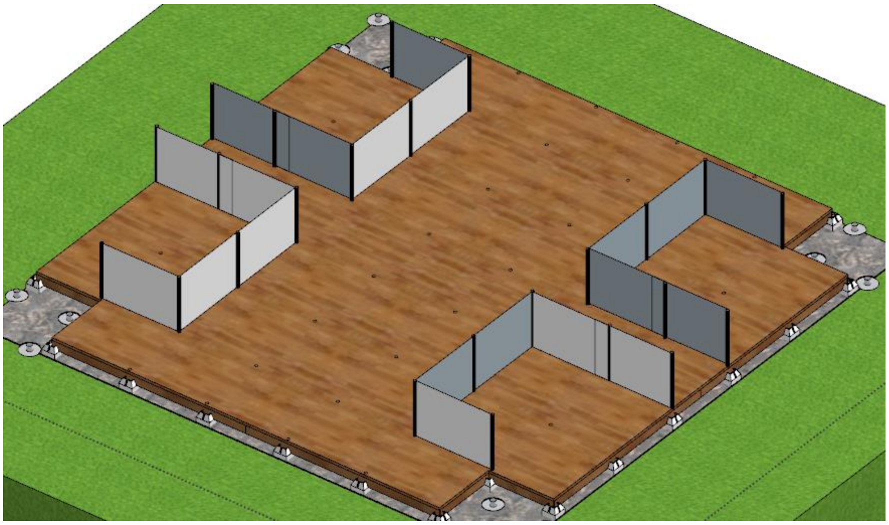


Figure 356 3D sketch showing a possible internal division – 1

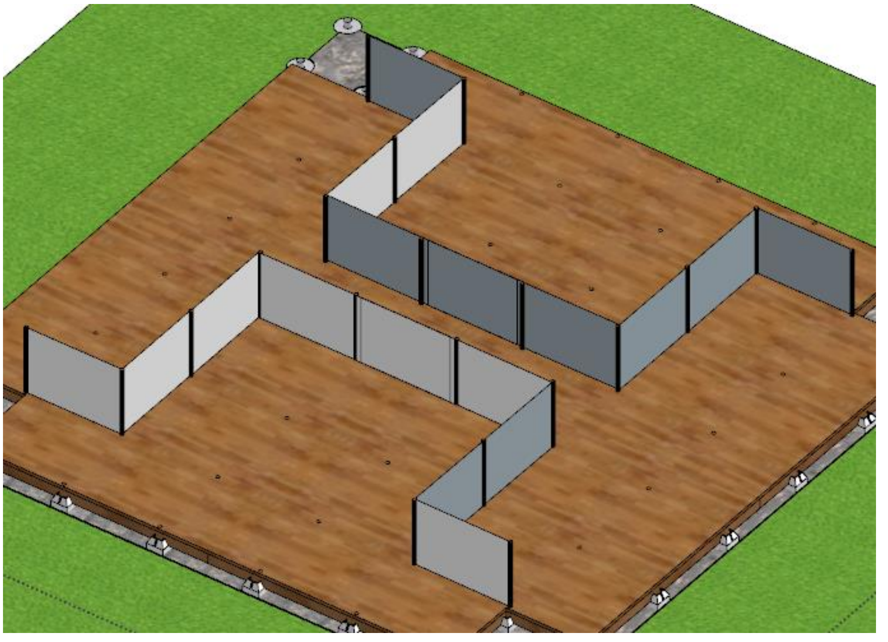


Figure 357 3D sketch showing a possible internal division – 2

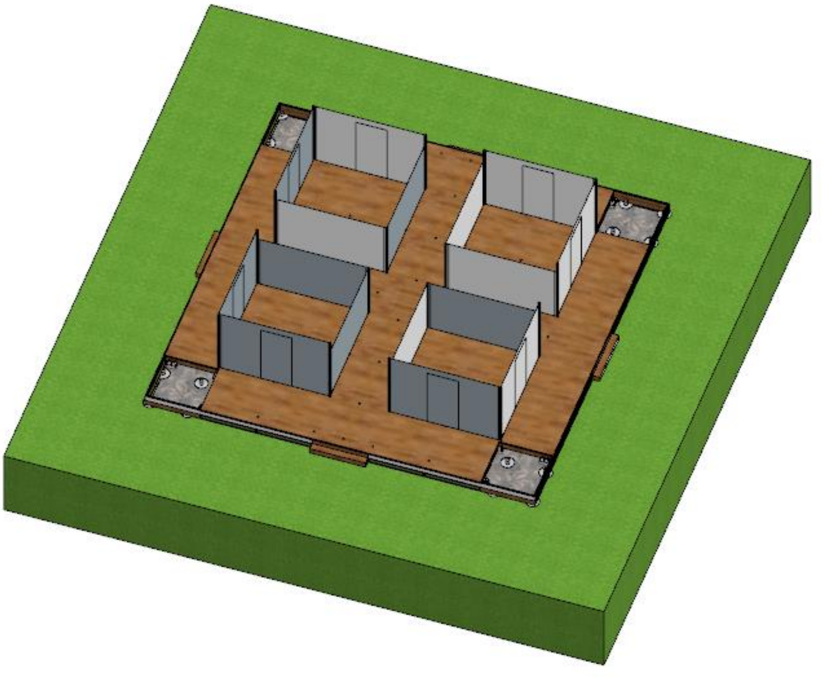


Figure 358 3D sketch showing a possible internal division – 3

5.4.4.2.External partitions

5.4.4.2.1. Windows

The design includes a set of windows, on each of the four sides of the project, that can be used during summer and heated periods for aeration and that can be closed during winter season for proper heating.

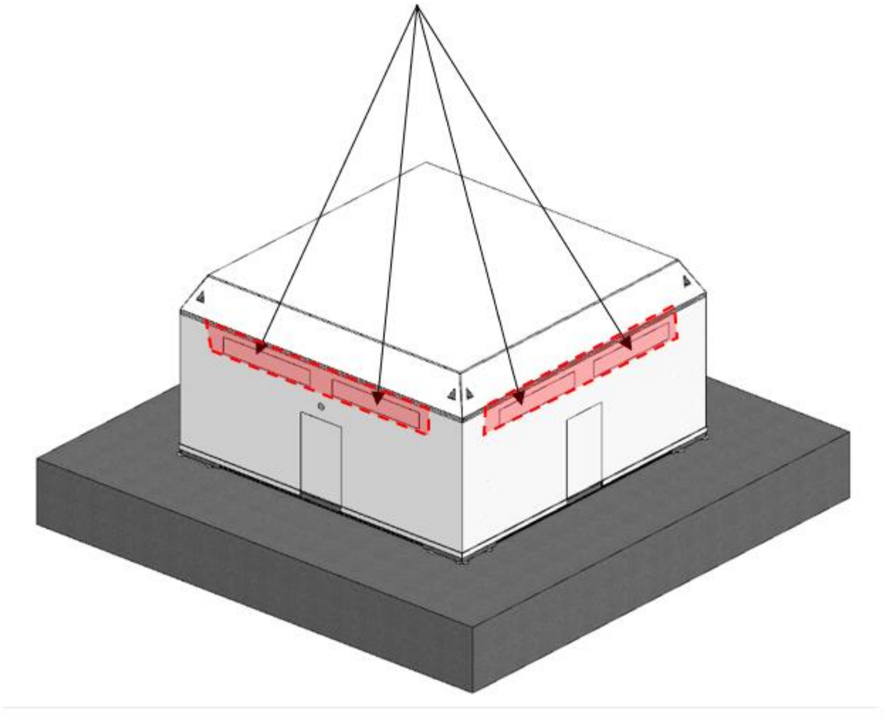


Figure 359 3D sketch showing location of windows

These windows follow the same rule and technology as the one used for traditional UNHCR tents as per the pictures that will follow.

Figure 360 Picture showing a UNHCR tent window -1 [302]

Figure 361 Picture showing a UNHCR tent window -2[303]

[302] www.unhcr.org
[303] Ibid.

5.4.4.2.2. Doors

The design includes a set of double sized doors on each of the four sides of the structure that can be used entirely or partially based on internal partition design and functions.

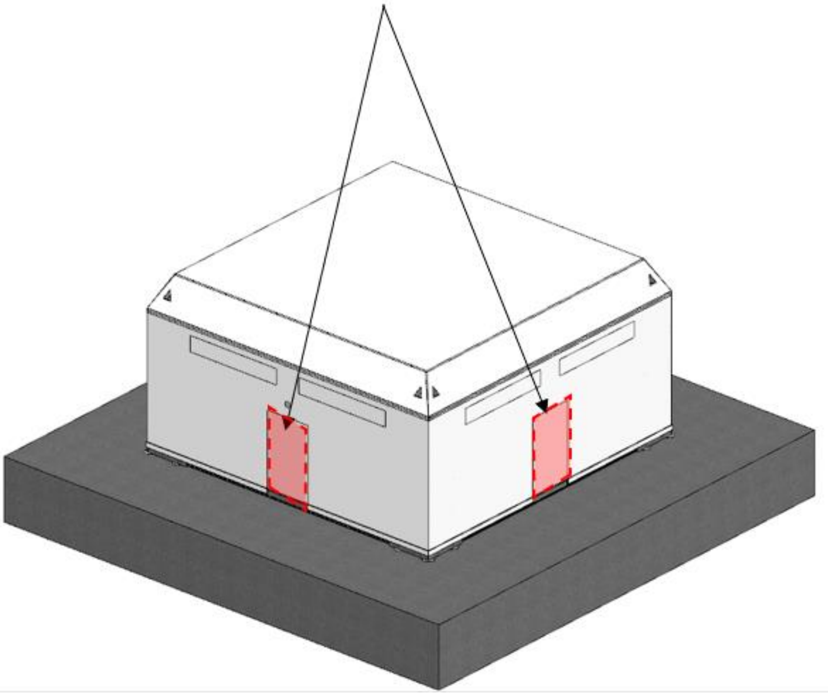


Figure 362 3D sketch showing location of doors

Doors have to be double folded from both the interior and exterior of the structure just as per standard UNHCR tent.

Figure 363 Picture showing a UNHCR tent door from the exterior [304]

Figure 364 Picture showing the zipper and the double folded door of an UNHCR tent-1 [305]

[304] www.unhcr.org
[305] Ibid.

5.4.5. Water Containers

The design includes four water tanks that are positioned inside the four support towers.

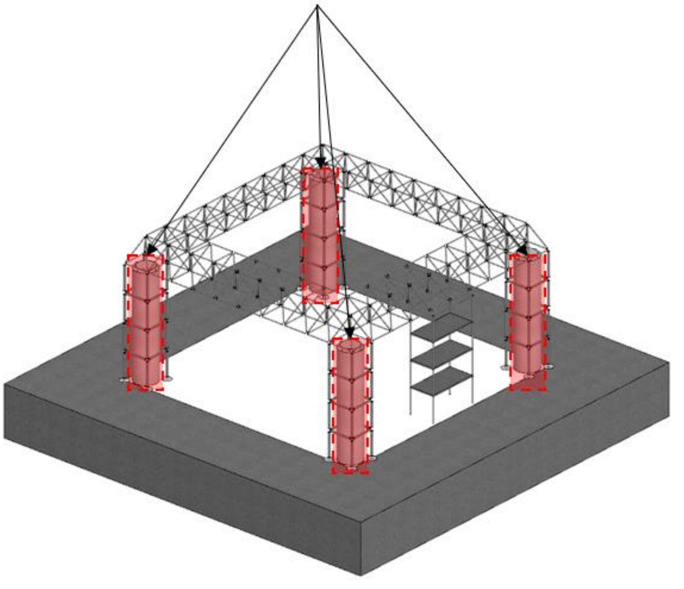


Figure 365 3D sketch showing location of water containers

These towers are meant primarily for rainwater collection or even for manual filling during extreme heat seasons in order to be used as a reserve for the settlement.

Each of these tanks are connected to 2 holes with mosquito nets located at roof level directly on top of them.

Figure 366 Picture showing chimney reinforcement material

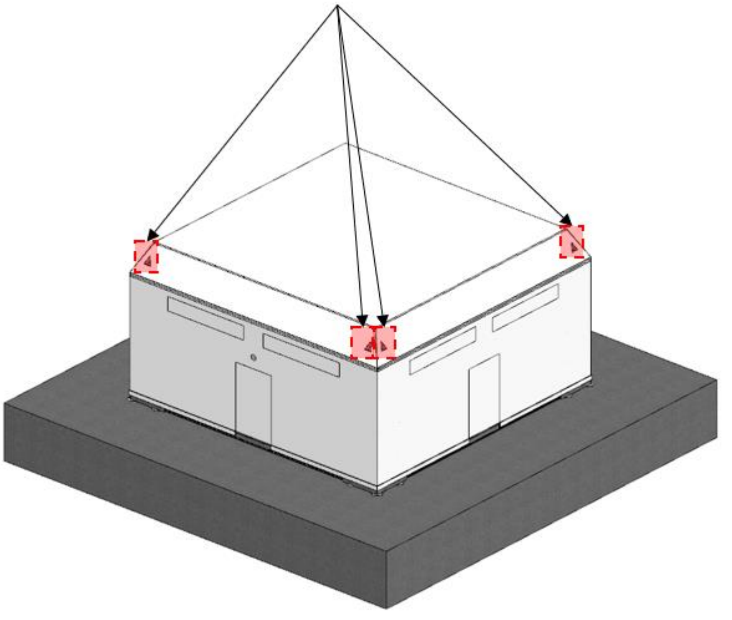


Figure 367 3D sketch showing location of water recollection holes

These connections are made of waterproof material and connected directly to the tanks with no perforations thus removing any possibility for wind to enter the structure and damage the heating during winter season.

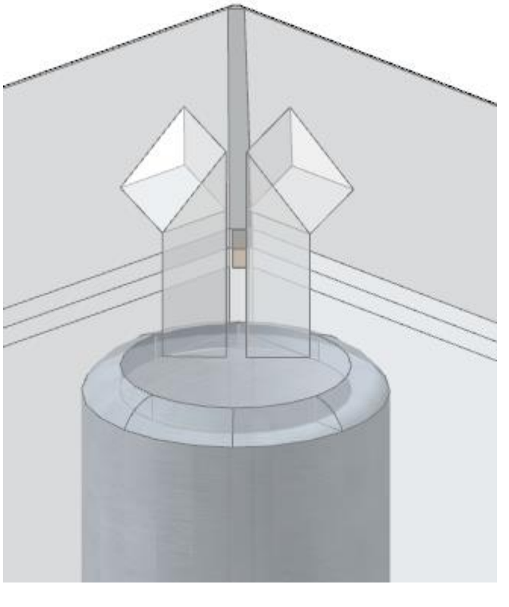


Figure 368 3D sketch showing connection between the roof holes and the water containers

5.4.6. Cooling

The project has a passive natural cooling system composed of the following:

- Elevated flooring with openings on its cover
- Built in windows on the upper part of the tarpaulin external partitions,

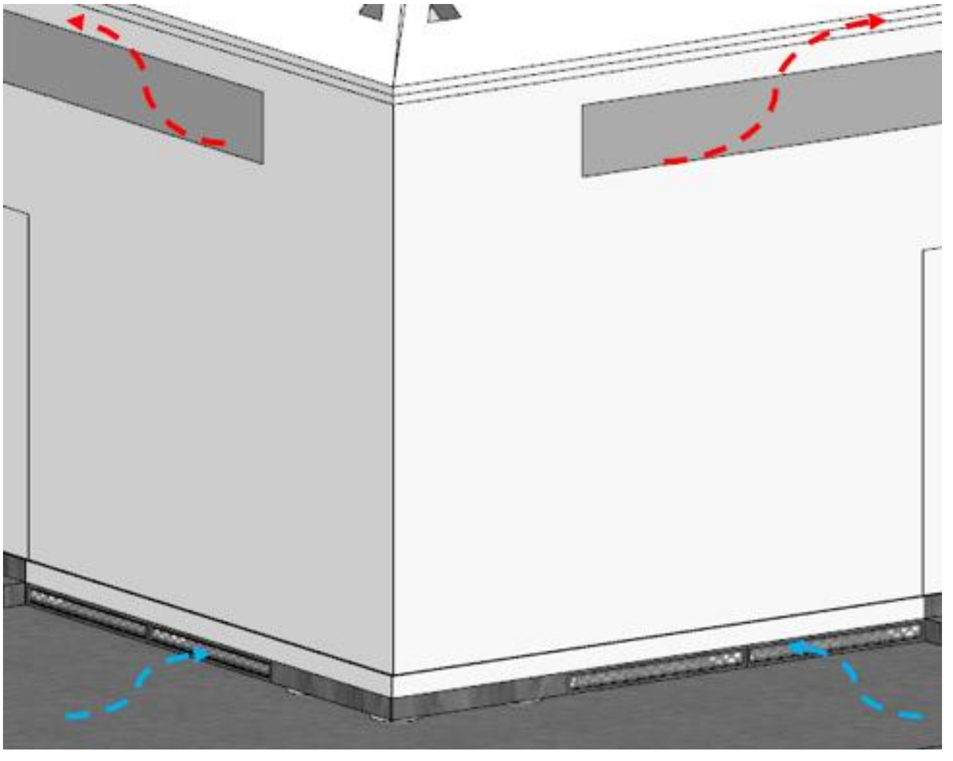


Figure 369 3D sketch showing natural passive ventilation

- If required, additional hanging supports can be added to the lower part of the roof structure in order to support external shading. Shaded areas can be used as markets and fabric can be made of old dismantled tents.
- The water containers being indoor will benefit from both shading and ventilation to keep water at good temperature

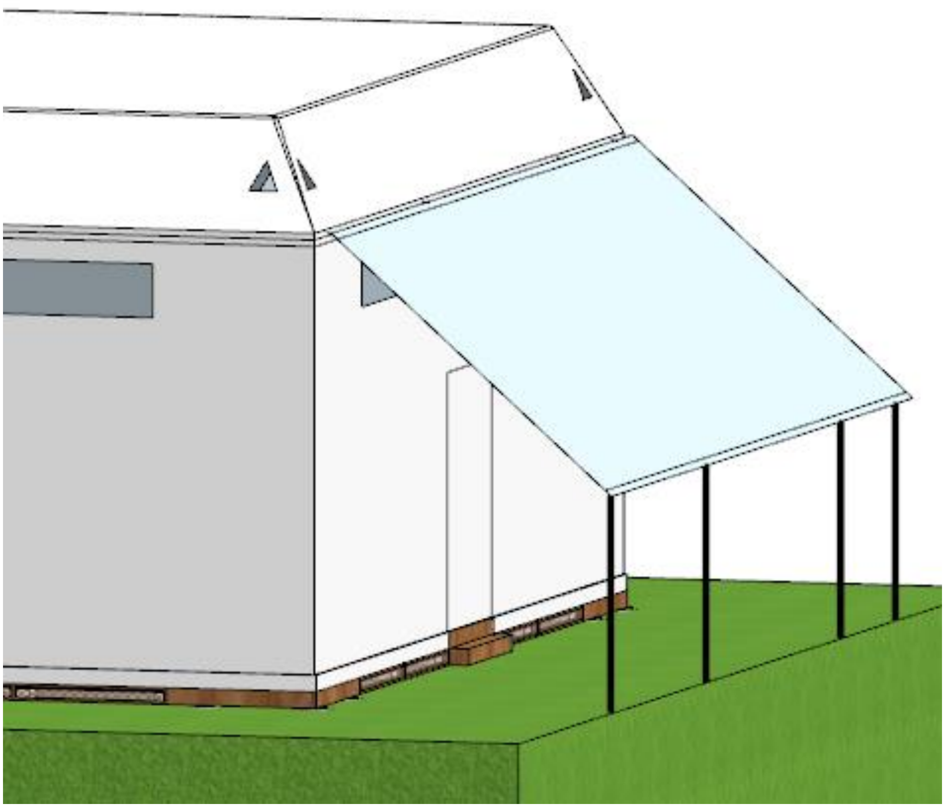


Figure 370 3D sketch showing possible shading outside the project with hangs and wooden masts.

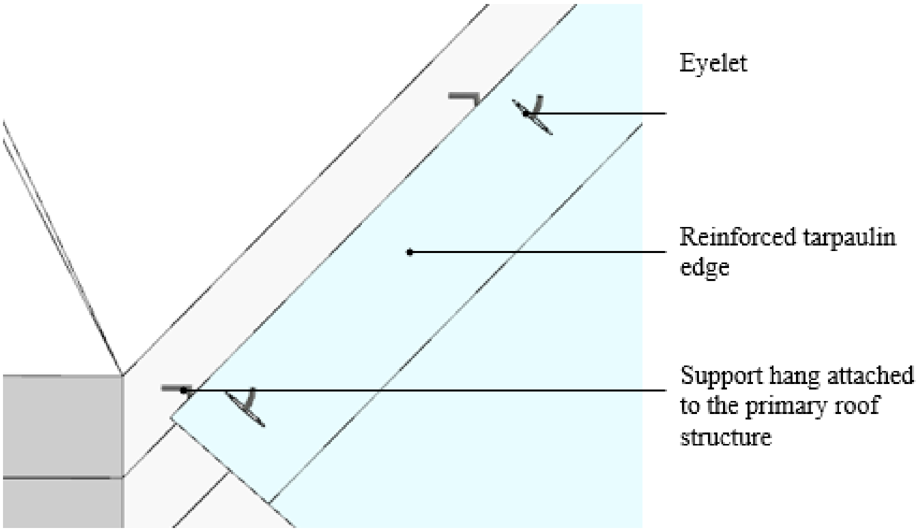


Figure 371 3D sketch showing connection details

5.4.7. Heating

During winter season it is thought to adopt a similar logic to the one used by the UNHCR and adopt a 2-layer insulation:

- The first being the proposed structure layer of tarpaulin
- The second would be composed of covering the internal partitions in order to reduce the volume to be heating thus creating massive savings.

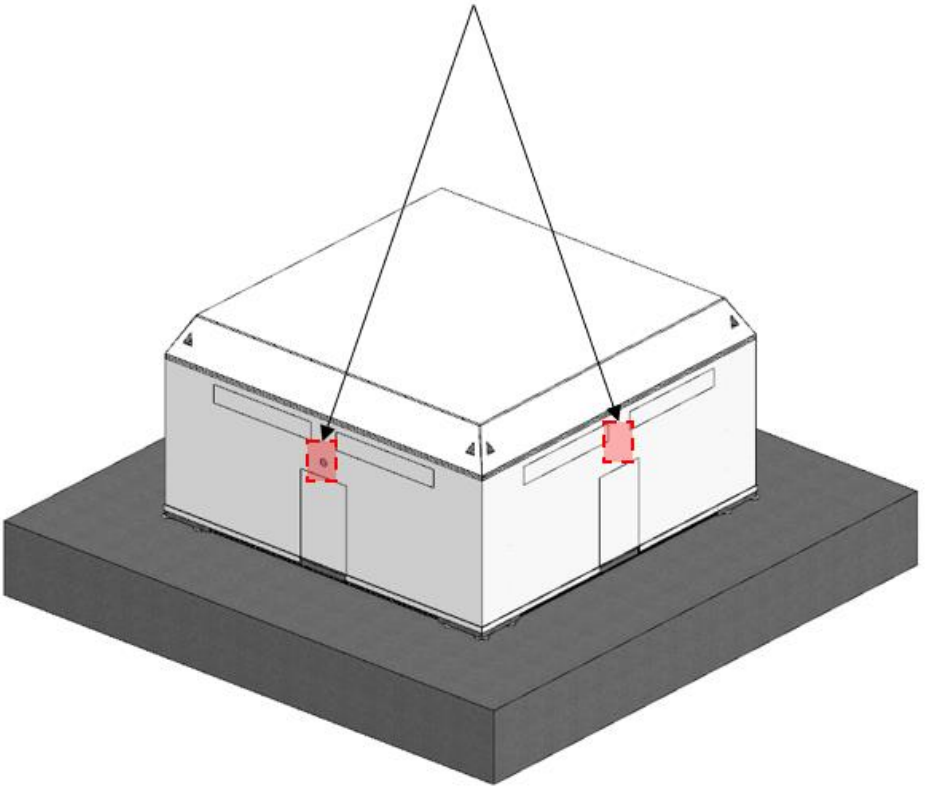


Figure 372 3D sketch showing possible location of exhaust exit area.

Figure 373 Picture showing a typical chimney reinforcement designated area in a UNHCR tent.[306]

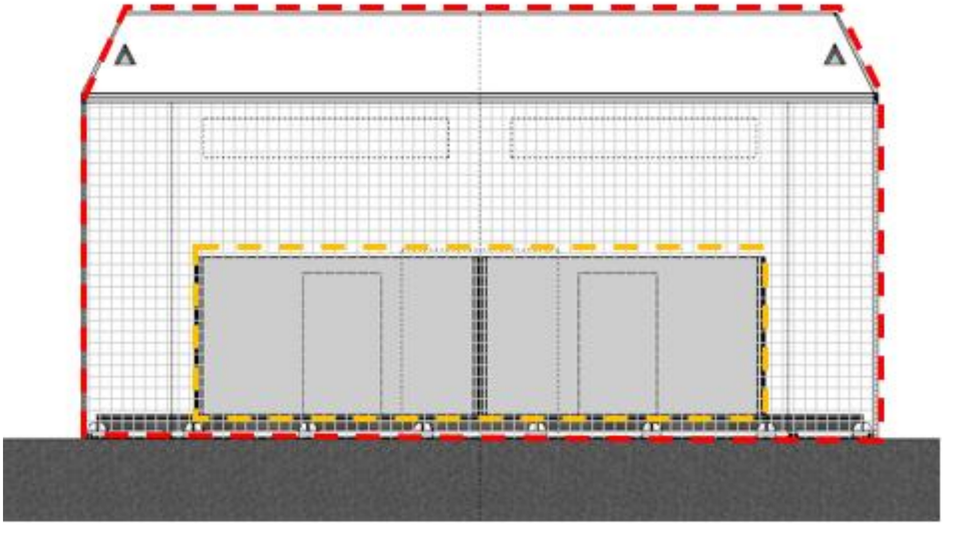


Figure 374 Sketch showing the 2 layers: in red the external existing layer and in orange the newly created one by the internal partitions

[306] www.unhcr.org

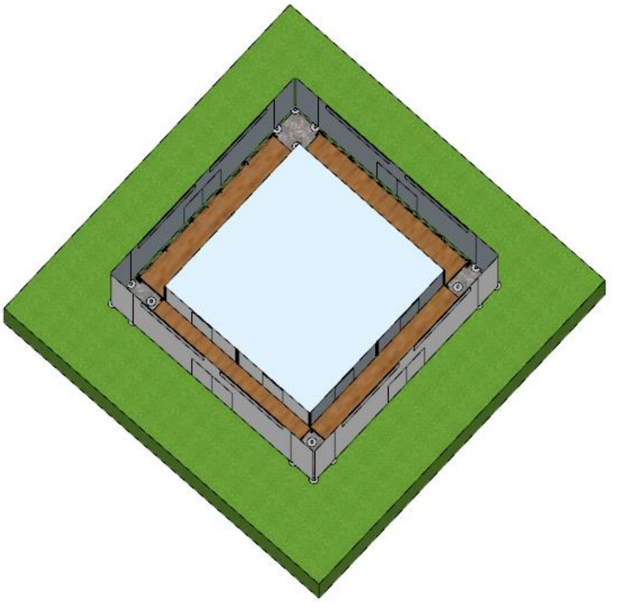


Figure 375 3D sketch showing the 2 layers

It is thought to design the internal space so that it revolves around a central focal point in which will be localized the heating unit while taking into consideration the following:

- The internal partitions within the second layer have to be lower than the boundary ones in order to allow the heat to be spread to all the area

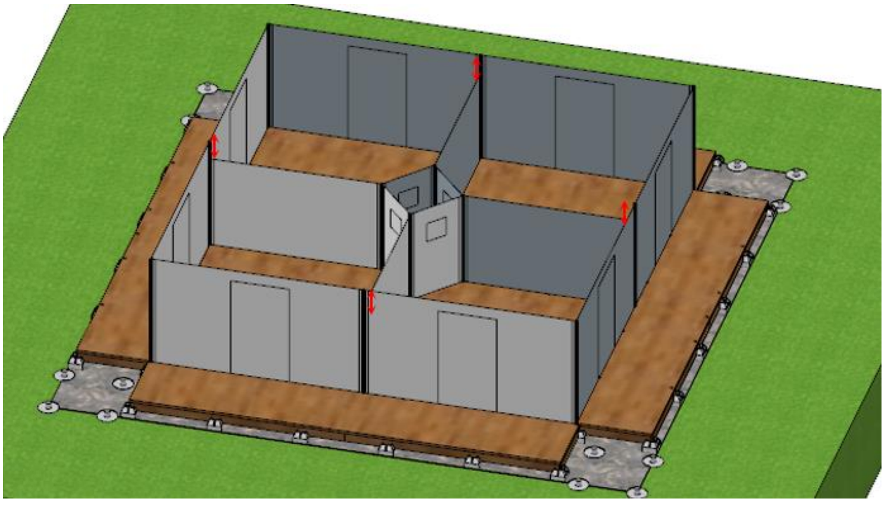


Figure 376 3D sketch showing the internal partition division with the central heating unit and the level difference between the internal partitions and boundary ones

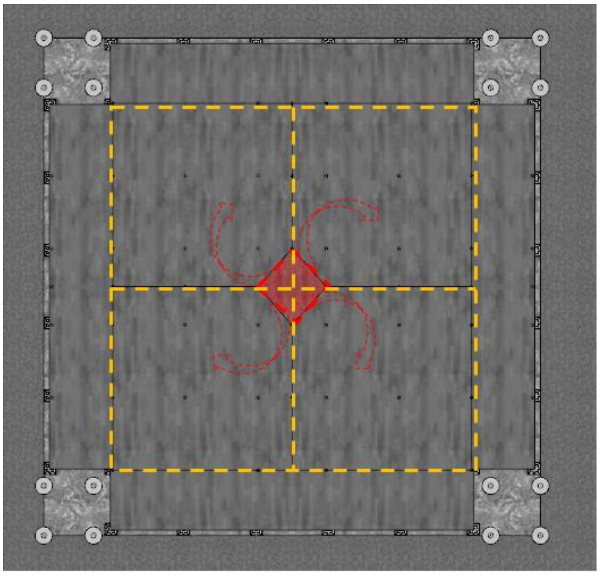


Figure 377 Plan view showing the heat transfer from the nodal heating unit, highlighted in red, to the surrounding insulated areas, highlighter in orange

- Heating unit should be easily accessible and monitorable

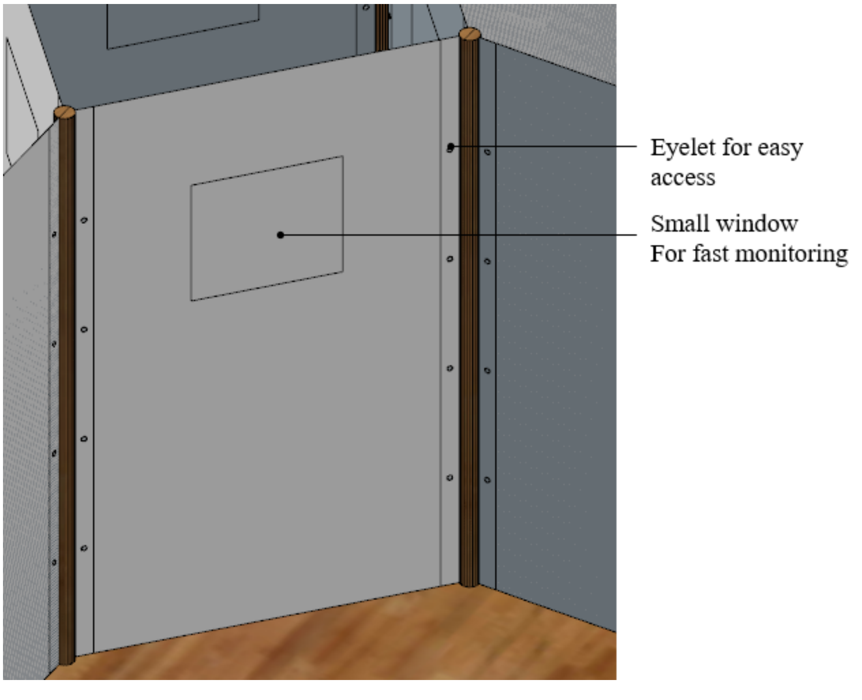


Figure 378 3D sketch showing the easy access and monitoring of the heating unit

Figure 379 Picture showing eyelet used in typical UNHCR tent[307]

- Area in between layers can be also used even if it will not be as warm as the area within layer 2.

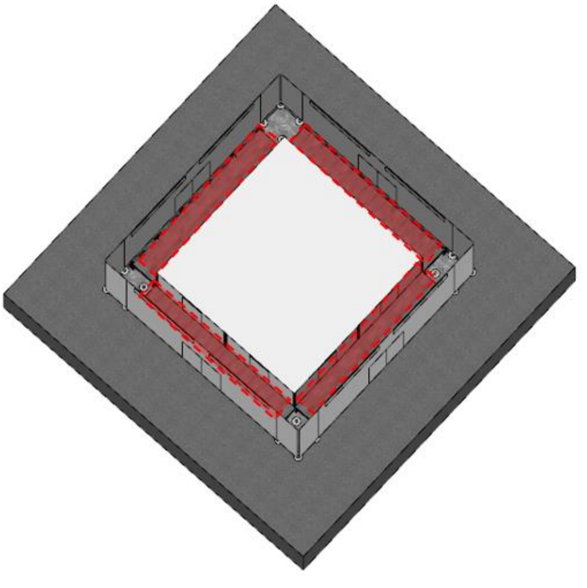


Figure 380 3D sketch showing the easy access and monitoring of the heating unit

[307] www.unhcr.org

The exhaust will be secured by proper piping leading to a designated area insulated for a safe conduct of the exhaust fumes, more commonly known as the chimney reinforcement. Its composition allows it to resist heat up to 900 degrees Celsius and keeps the fibers stiff even when cut.

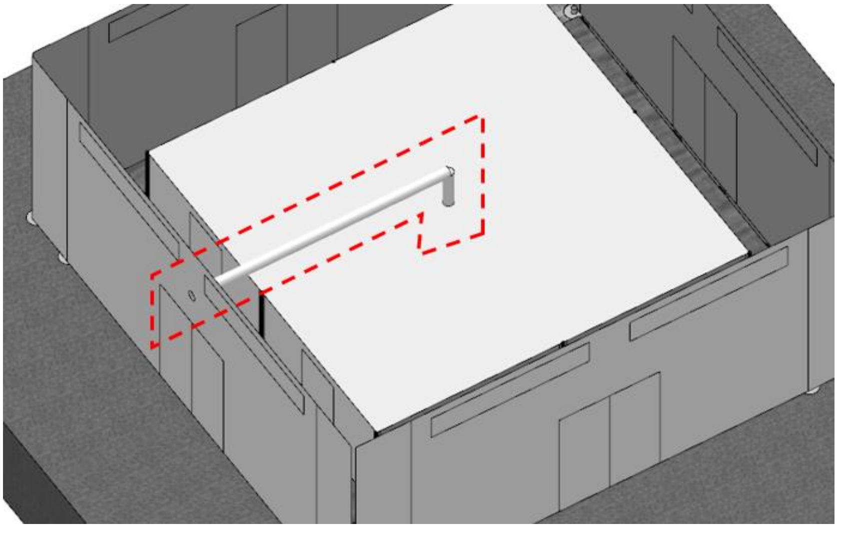


Figure 381 3D sketch showing the exhaust piping

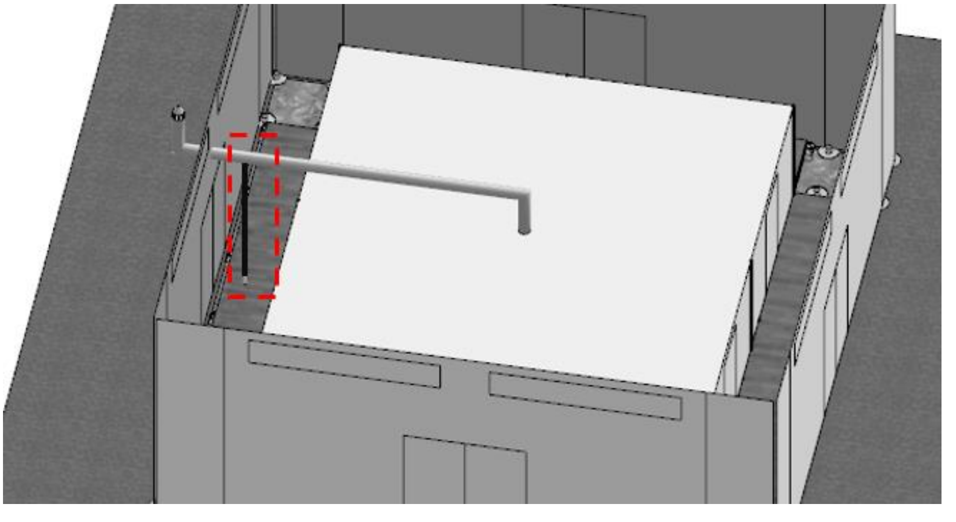


Figure 382 3D sketch showing the internal support for the exhaust piping

Figure 383 Picture showing a typical chimney reinforcement designated area in a UNHCR tent.[308]

These areas are cut and then a chimney reinforcement unit present in the winterization kit is then hemmed stitched to the tarpaulin.

308 www.unhcr.org

Figure 384 Picture showing a typical chimney reinforcement unit in a UNHCR tent.[309]

It is to essential to put proper insulation beneath the heating unit in order to avoid overheating to cause fires.

Figure 385 Picture showing the insulation of the ground beneath the heating unit[310]

It is also essential to close up the floor openings used for ventilation with a wooden piece with the fitting dimensions wrapped with tarpaulin as per the below picture.

- First make sure the grid is on the back layer of the wood covers thus allowing to add the wooden tap without having to dismantle any elements and risking damaging the structure's rigidity

[309] www.unhcr.org
[310] Ibid.

Figure 386 3D sketch showing the location of the grid at the back of the wooden cover

- Then wrap wooden tap with tarpaulin for better insulation, use leftover pieces or cut from old tents. Make sure that a small amount of tarpaulin is left unwrapped in order to easy the dismantling at a later stage.

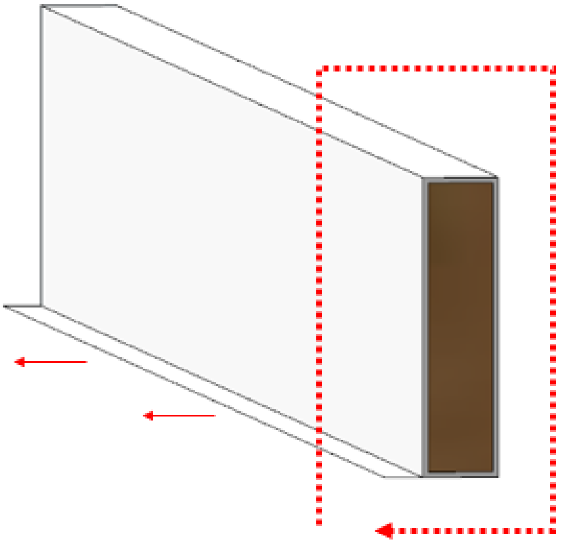


Figure 387 3D sketch showing the tarpaulin wrapping of the wooden tap

- Then place the wooden tap in front of the grid

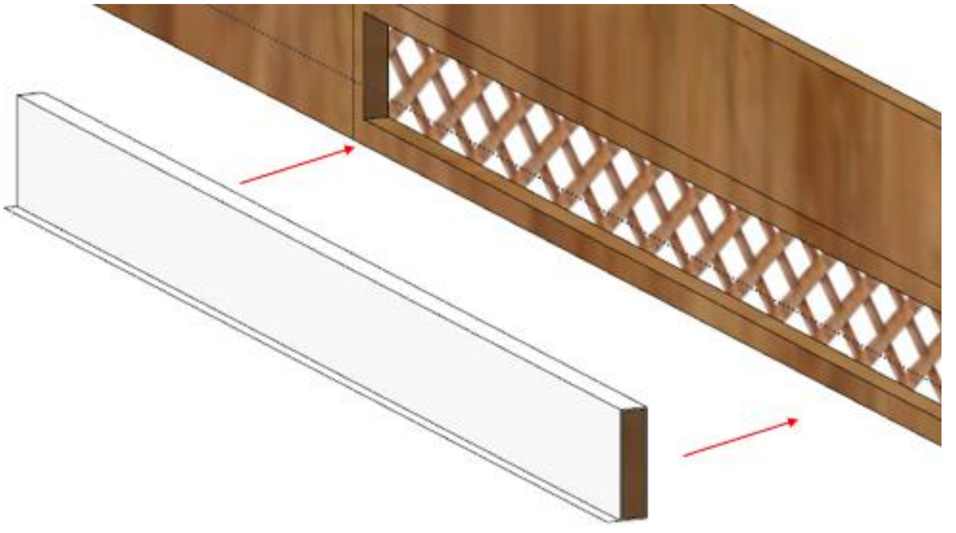


Figure 388 3D sketch showing the tapping of the floor ventilation covers - 1

Figure 389 3D sketch showing the tapping of the floor ventilation covers - 2

5.5. Plans

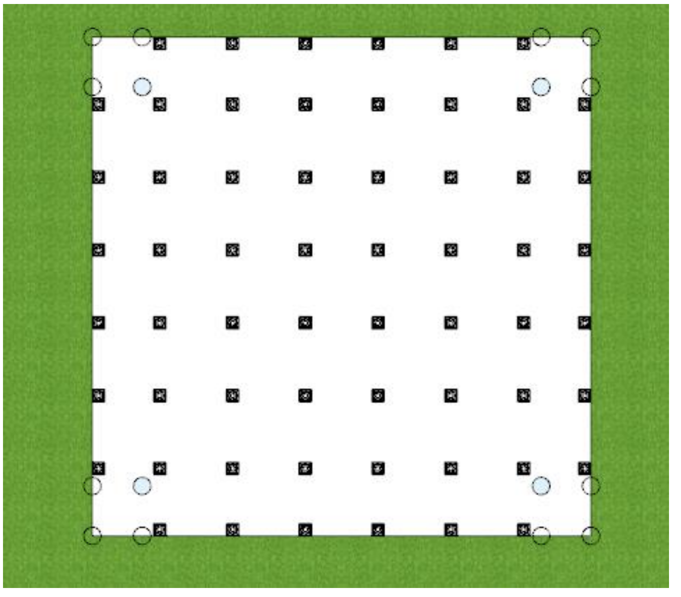


Figure 390 PLan view of proposed project

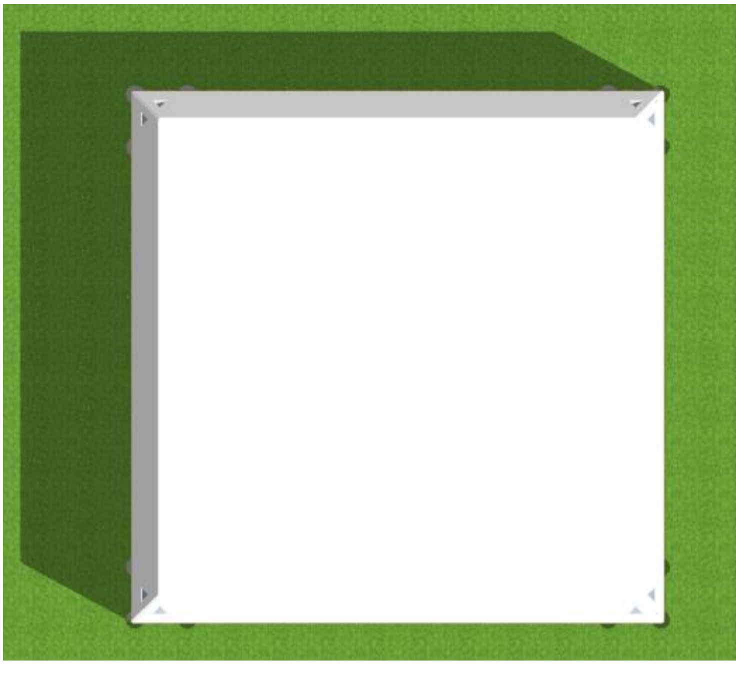


Figure 391 Top view of proposed project

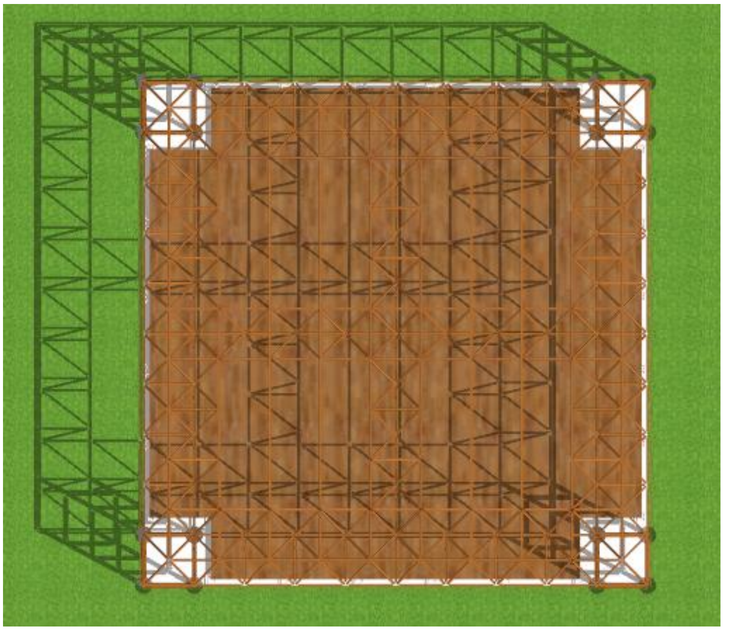


Figure 392 Top view showing the structure of the proposed project

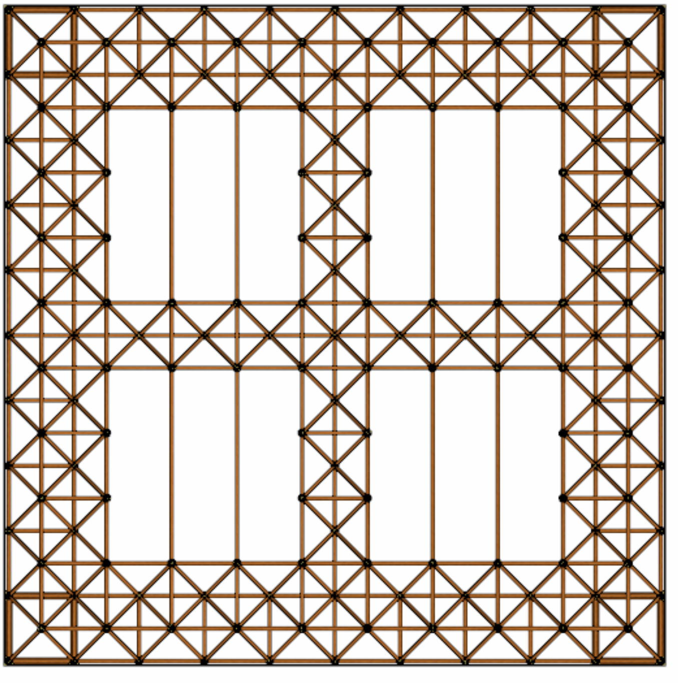


Figure 393 Space frame structure

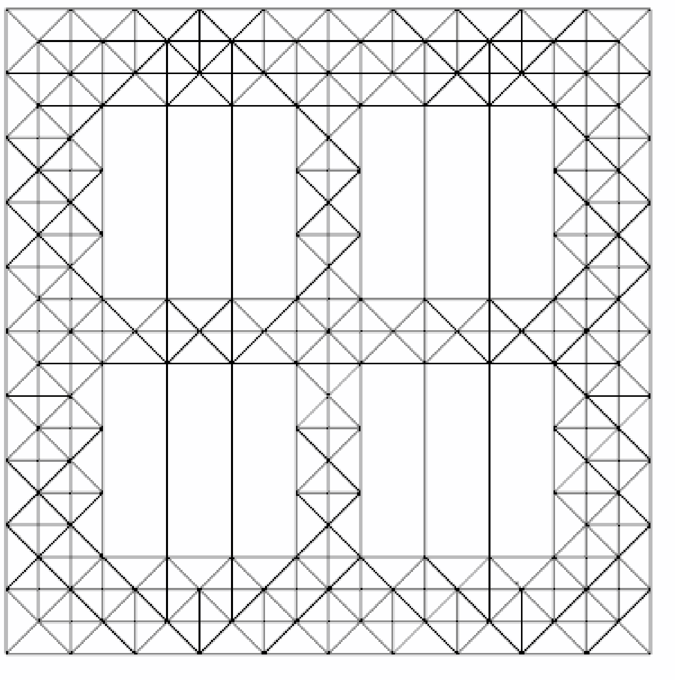


Figure 394 Space frame structure wireframe

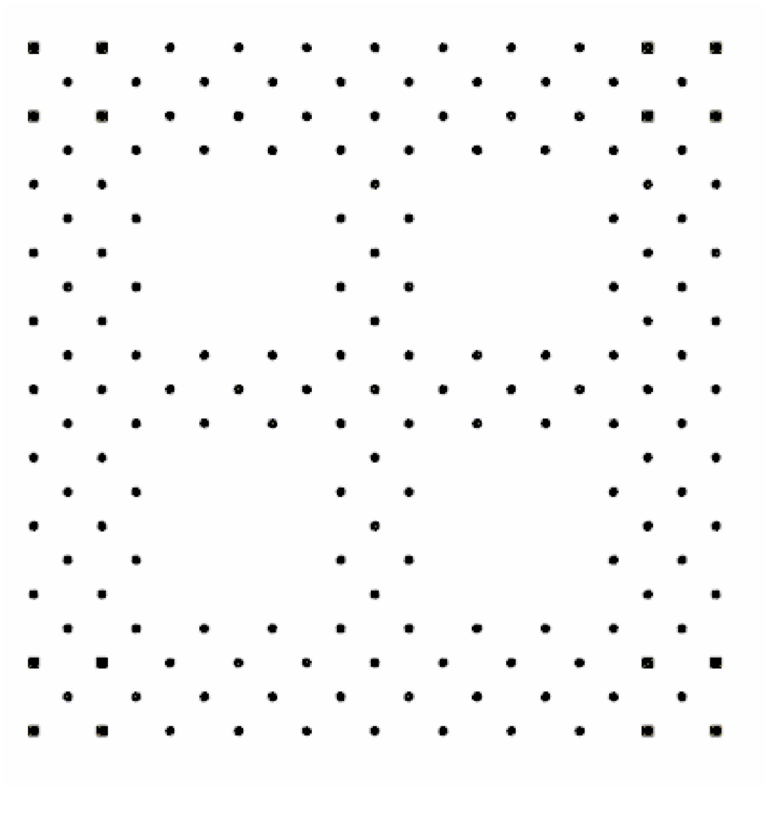


Figure 395 Plan view of structure joints

5.6. Elevations

All four elevations are identical having only the chimney reinforcement as a difference

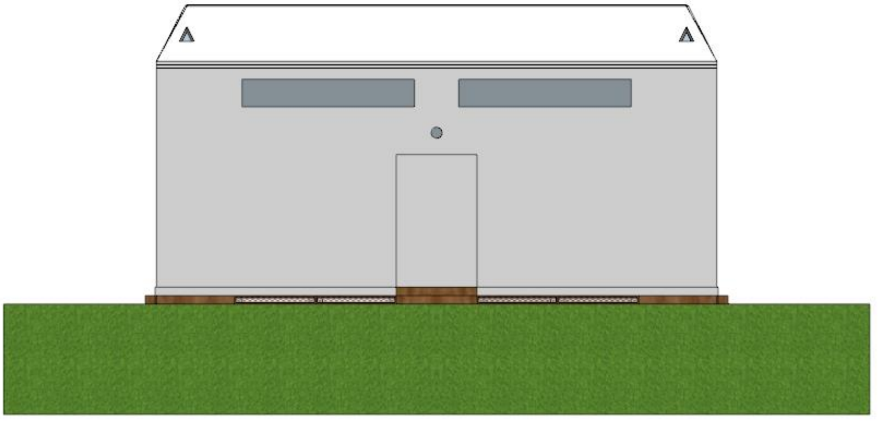


Figure 396 2D sketch showing typical elevation with chimney reinforcement

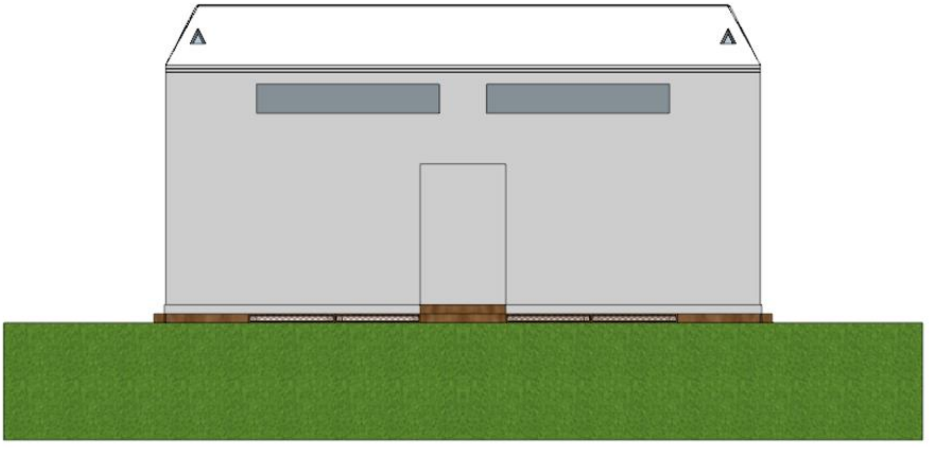


Figure 397 2D sketch showing typical elevation without chimney reinforcement

5.7. Sections

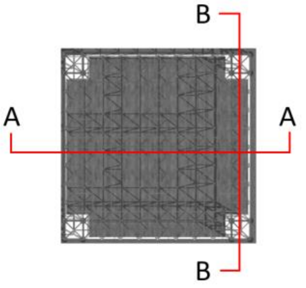


Figure 398 Key plan showing section locations

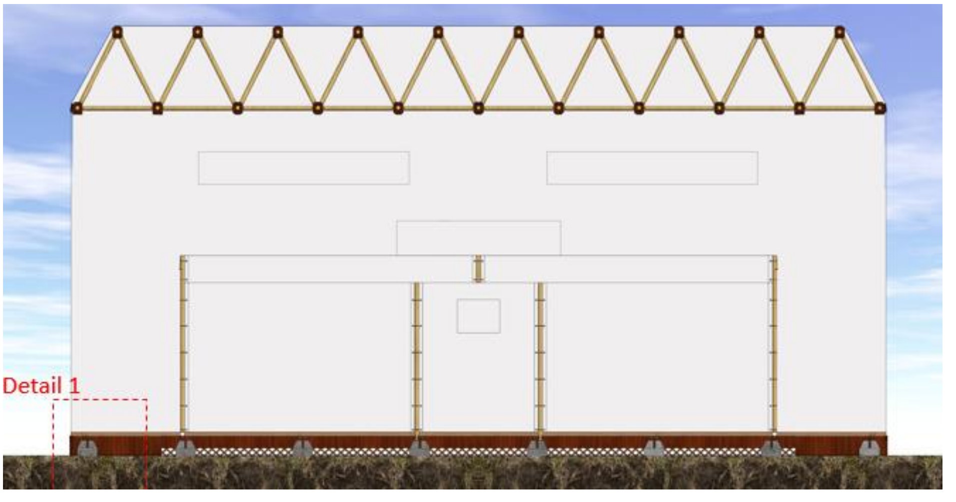


Figure 399 Section A-A

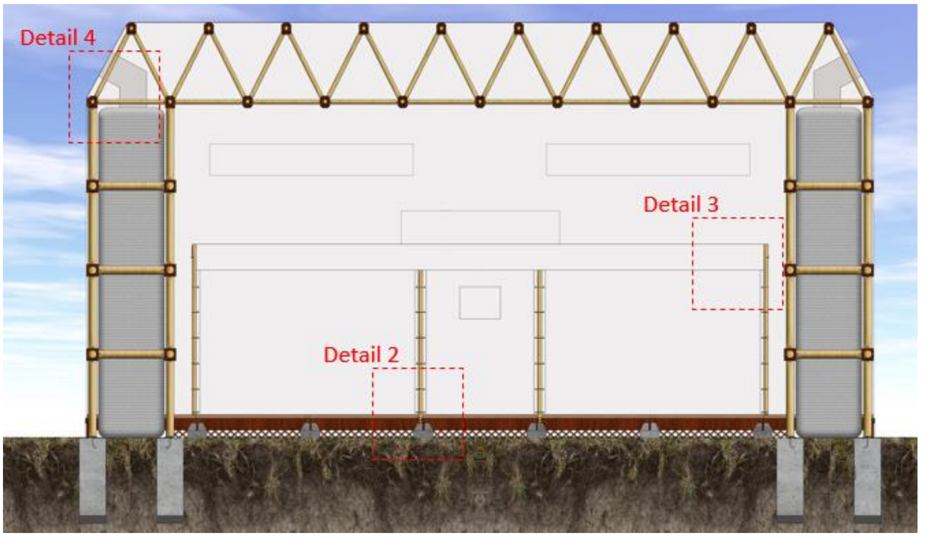


Figure 400 Section B-B

5.8. Details

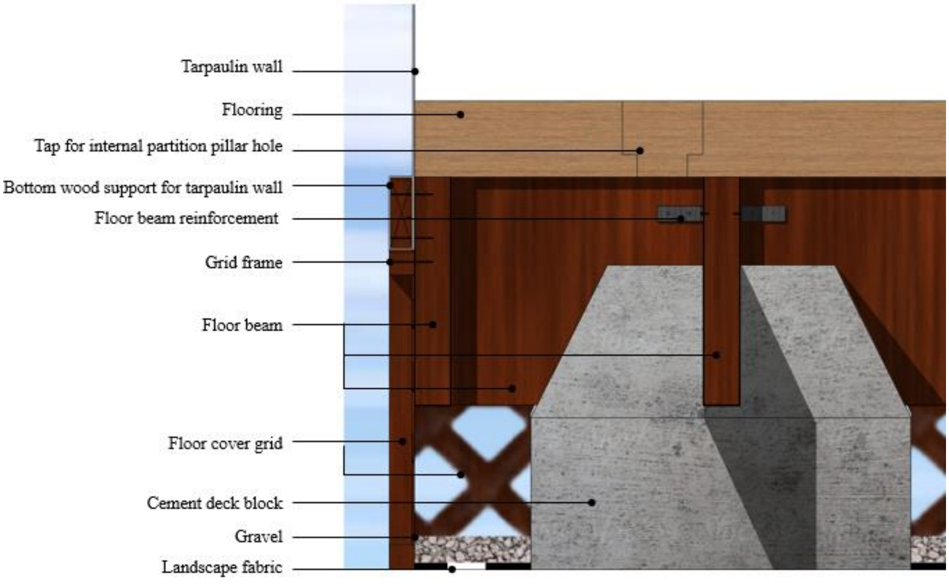


Figure 401 Detail 1

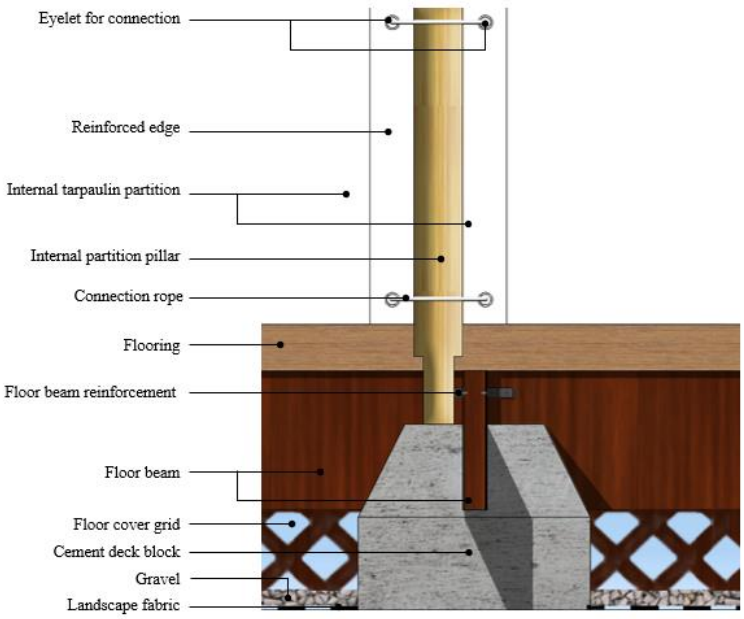


Figure 402 Detail 2

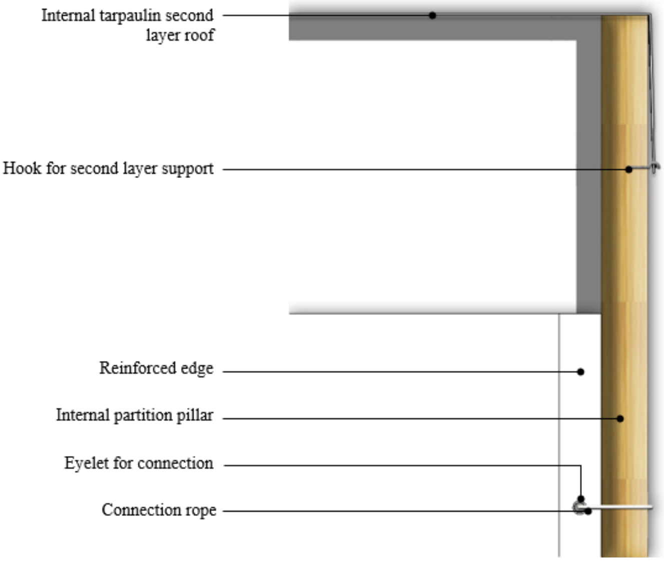


Figure 403 Detail 3

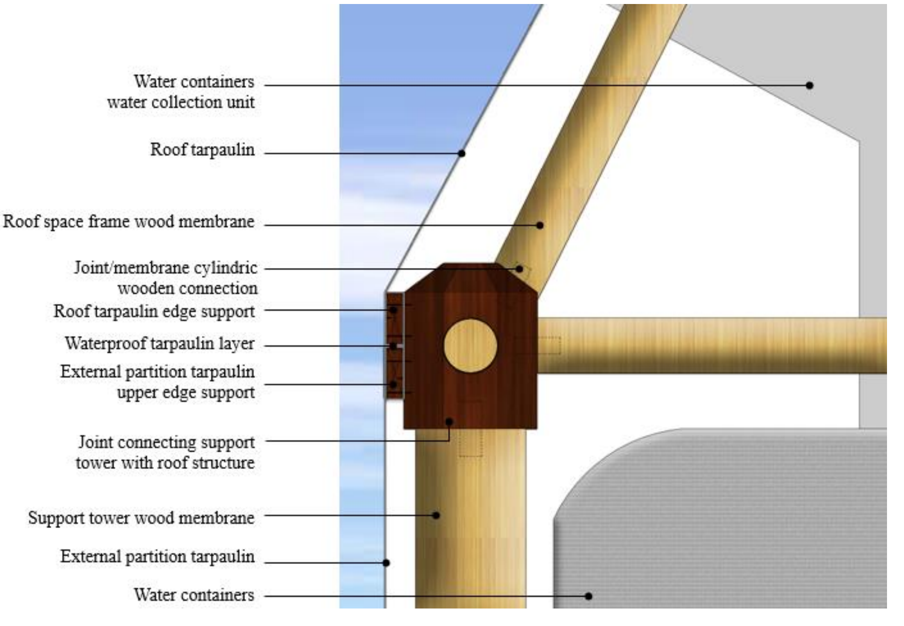
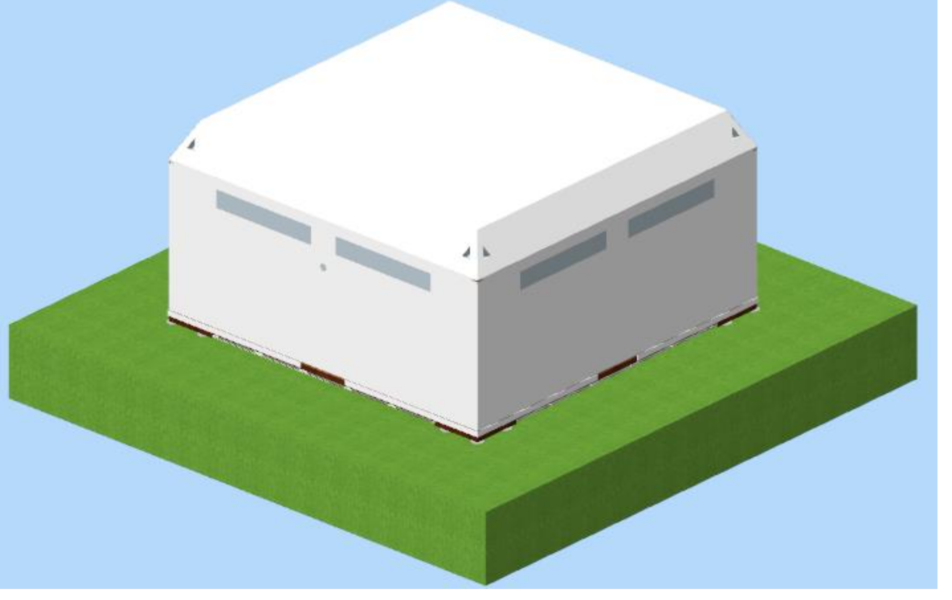
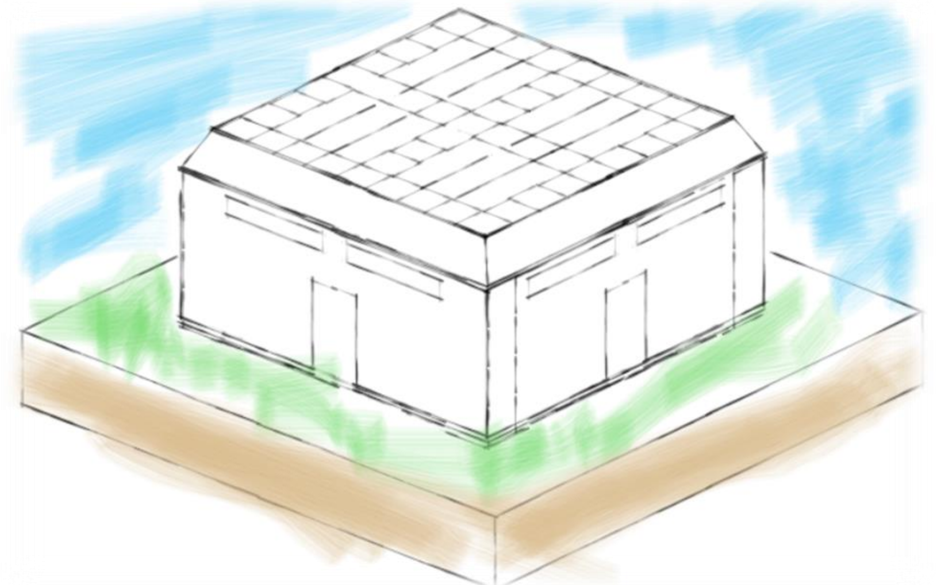


Figure 404 Detail 3

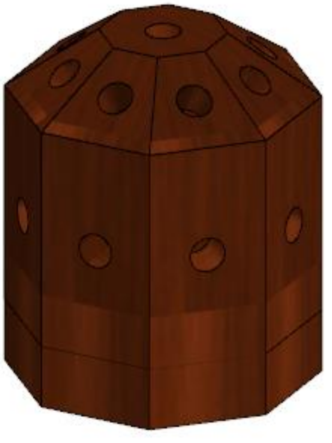
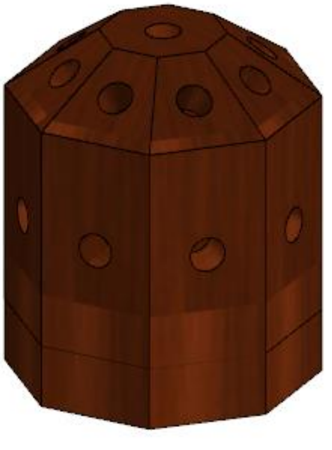
5.9. Perspectives and render

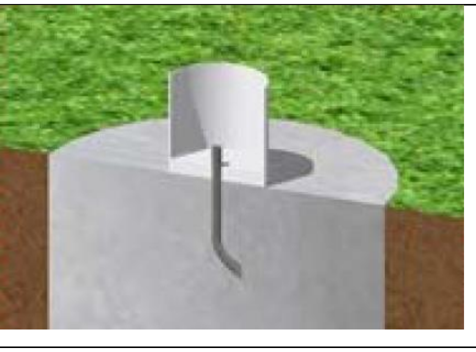


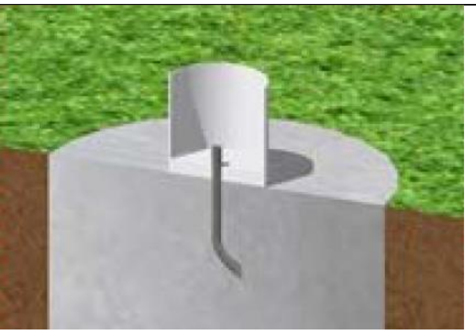


5.10. Bill of Quantities (BOQ)

Once confirmed the size of the components the Bill of quantities will be issued as per the example below:

Item	Description	Quantity
	Tower Joint Dimensions 15x15x15cm	48
	Truss Joint Dimensions 10x10x10cm	169

	Column Members Φ10cm L=85cm	112 units/ 374kg
	Column Bracing Φ5cm L=125cm	64 units/ 79 kg
	Truss Members Φ5cm L=90cm	256 units/ 226kg
	Truss Members Φ5cm L=112cm	256 units/ 282kg
	Truss Members Φ5cm L=290cm	8 units/ 23kg
	Base Plate Φ12x1cm	16
	Concrete	1.26 m^3

	Anchor Rod Φ16x180mm	16
	Roof Tarpaulin	124 m^2
	Exterior partition Tarpaulin	160 m^2

5.11. Structural study

The detailed structural analysis report has been put in the annex as "Annex 3". What follows in this part will be a summarized description of the results.

Before discussing the results, it is important to take into consideration the following:

- The project was studied using:
  - Robot Structural Analysis for seismic and wind analysis, and wood design

  - SAFE for Foundation design
  - RAM connection for base plate and anchor rod design.
- The analysis was done according to the US standards and codes as well local codes whenever applicable.
- All material properties used were verified by program database
- A soil report was used in the location desired for the camp in order for the calculations to be as accurate as possible.
- In order to ensure credibility to the study, it was supervised in collaboration with local civil engineer Fady NASR.

5.11.1. Structure members:

The project underwent 2 optimization processes due to the structural analysis results:

Stage 01:

In the initial scenario, the project was designed to have all the wood members at the truss to have a 10 cm thickness.

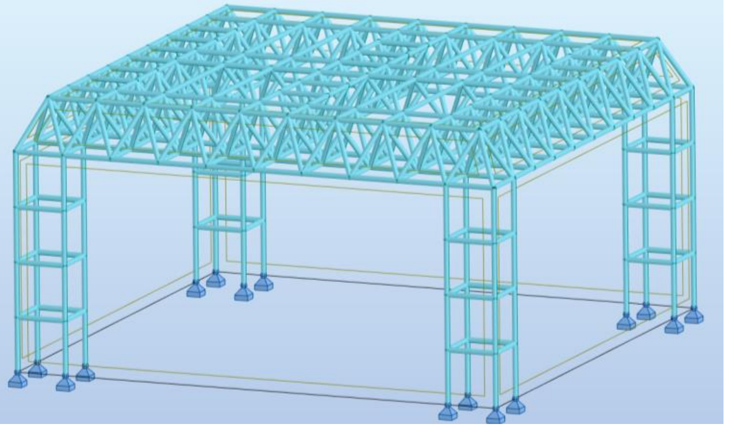


Figure 405 Stage 01 structural Model

The software analysis results showed that some members will structurally fail for a critical load combination. Thus, the original 10 cm diameter section was deemed not valid. The analysis shows the columns are carrying the most stresses due to lateral forces.

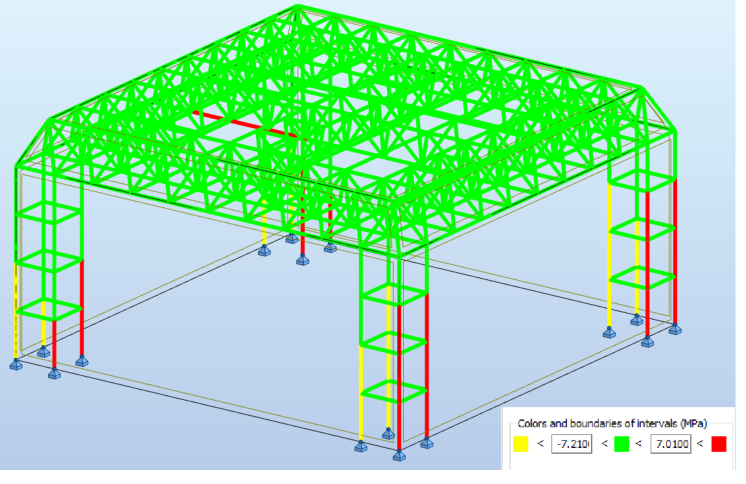


Figure 406 Model Analysis Map of Members Subjected to Ultimate Limit State

For other members, located in the upper truss system, the members are structurally valid at any given combination. However, their load/capacity ratio is too negligible, as indicated in the figure below, which shows that they are over-dimensioned.

Stage 02:

With the analysis software, many iterations were evaluated to optimize the wood sections for each category. These categories are divided into two parts, the four corner columns and the truss system. The analysis, as shown in the figure below, resulted in 19 cm diameter members for the columns, and 5 cm for the truss system.

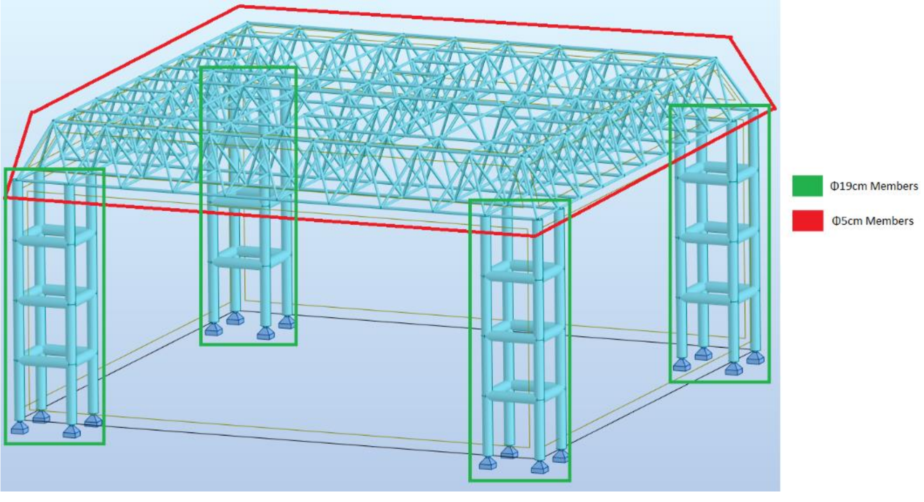


Figure 407 Stage 02 structural Model

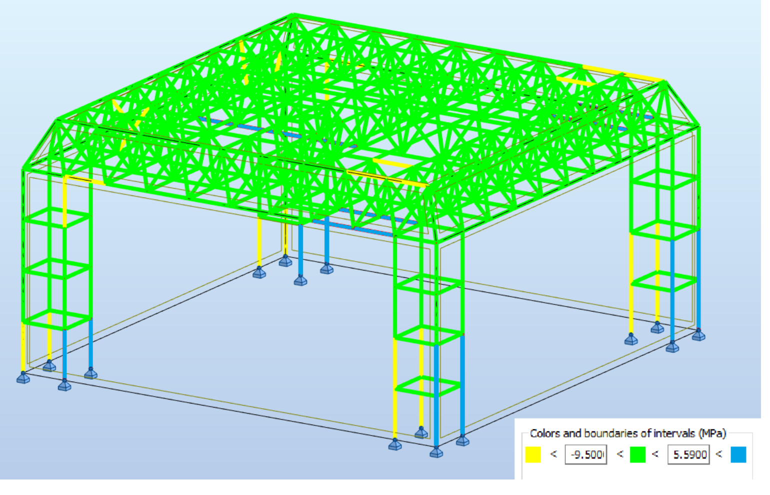


Figure 408 Model Analysis Map of Optimized Members Subjected to Ultimate Limit State

Stage 03:

The previous results showed that the columns have large dimensions. That is mainly due to the lateral forces acting upon the system, for which the stresses are taken by the columns, resulting in their large dimensions.

However, this problem can be further optimized by providing bracing to each column system. The bracing provided will thus increase the columns rigidity, and counteract the lateral forces more effectively, and therefore decreasing significantly the members dimensions.

Indeed, once added the bracing and with the help of the software, it was possible to decrease of the column members dimensions to 10 cm, with 5 cm bracing members. Additionally, this has allowed to reduce the truss members dimensions to 5cm.

This step has proven to be more economic and increases the overall stability the structure.

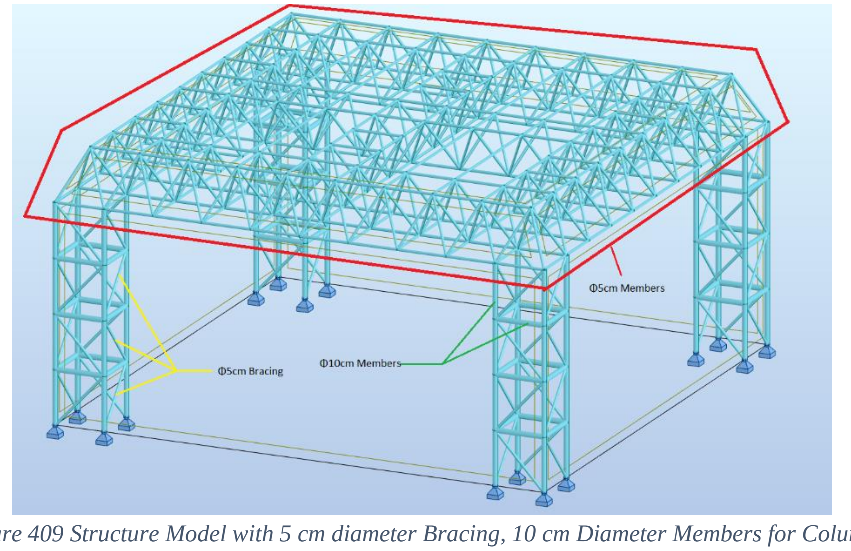


Figure 409 Structure Model with 5 cm diameter Bracing, 10 cm Diameter Members for Columns and 5 cm for Truss Members

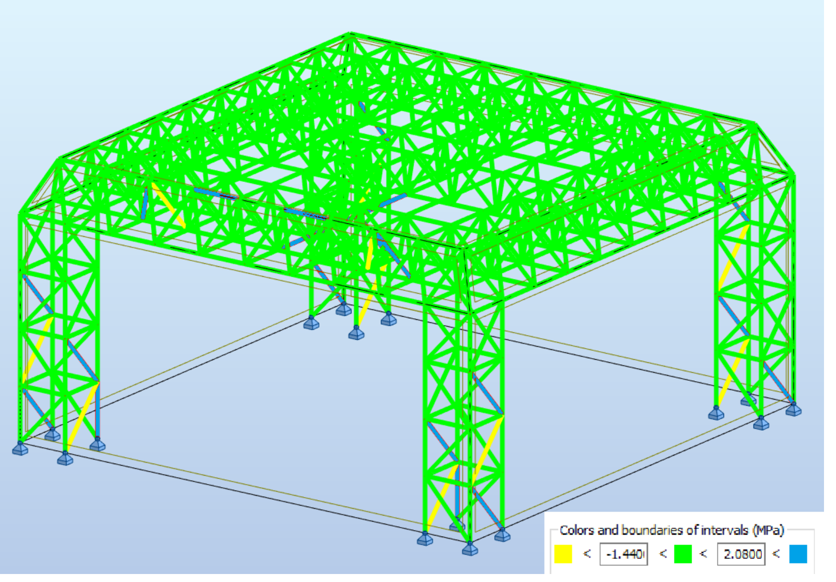


Figure 410 Model Analysis Map of Optimized Braced Members Subjected to Ultimate Limit State

The analysis shows that the bracing members are now carrying the stresses due to the lateral forces instead of the vertical elements.

Additionally, the bracing system further limited the structure displacement due to lateral forces than the previous model by 24%.

	UX (cm)	UY (cm)	UZ (cm)	RX (Rad)	RY (Rad)	RZ (Rad)
MAX	4.2	4.1	0.5	0.010	0.020	0.010
Node	[illegible]	[illegible]	424	96	61	227
Case	13	14	14	14	13	ULS/3
Mode						
MIN	-1.1	-0.8	-1.0	-0.020	-0.010	-0.010
Node	439	116	94	21	411	106
Case	ULS/7	ULS/8	ULS/4	14	13	ULS/3
Mode						

Figure 411 Maximum Lateral Displacement prior to Bracing

	UX (cm)	UY (cm)	UZ (cm)	RX (Rad)	RY (Rad)	RZ (Rad)
MAX	4.2	4.1	0.5	0.010	0.020	0.010
Node	[illegible]	[illegible]	424	96	61	227
Case	13	14	14	14	13	ULS/3
Mode						
MIN	-1.1	-0.8	-1.0	-0.020	-0.010	-0.010
Node	439	116	94	21	411	106
Case	ULS/7	ULS/8	ULS/4	14	13	ULS/3
Mode						

Figure 412 Maximum Lateral Displacement with Bracing

5.11.2. Foundation:

Considering the structure to be lightweight, the type of foundation expected is isolated footings. The concept requires cylindrical footings; therefore, a cylindrical isolated footing shall be used at each column base.

These footings have been calculated to have a 50cm diameter and a 40 cm depth.

5.11.3. Base plate

The base plate final dimensions given by the software correspond to the following:

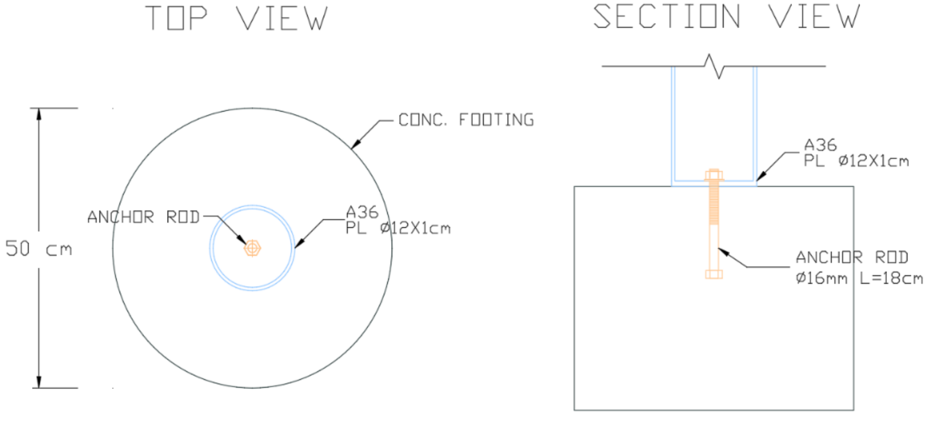


Figure 413 Final Dimensions of the Base Plate and Anchor Rod Components

5.11.4. Joints

The design of the wooden joints was divided into two categories: column connections and truss connections. Each category experiences different member dimensions and forces, thus the dimensions of the connections vary between these categories.

The analysis and design of the connections was done using a 3D volumetric design in Robot Structural Analysis software.

It is important to note that for this part, due to software limitations, the joint was simplified. A perfected study can only be achieved by building a mock-up of the joint and subjecting it to lab analysis.

Column joints:

According to the analysis, the column joint dimensions must be the following: 15x15x15 cm.

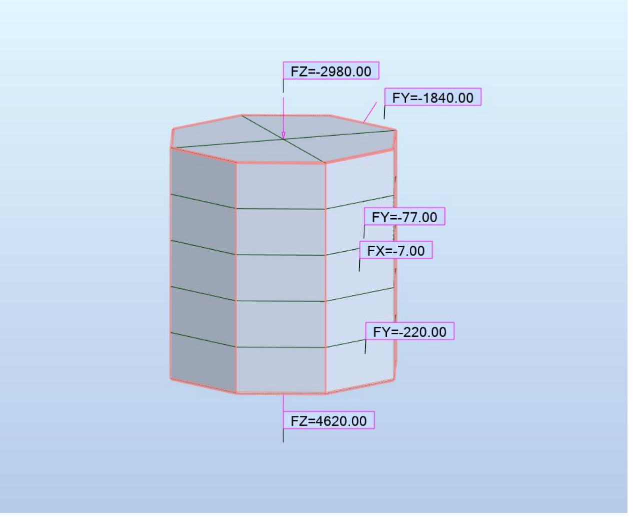


Figure 414 Robot Model of the Column Connection with Applied Forces

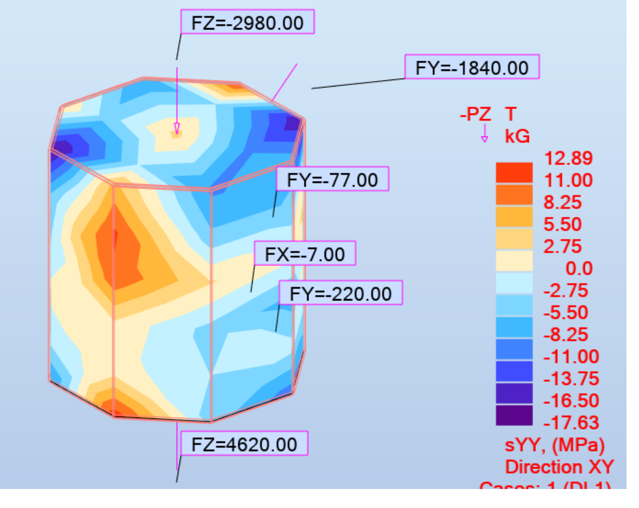


Figure 415 Results of the Internal Stresses of the Column Connection

Truss joints:

According to the analysis, the truss joint dimensions must be the following: 10x10x10 cm.

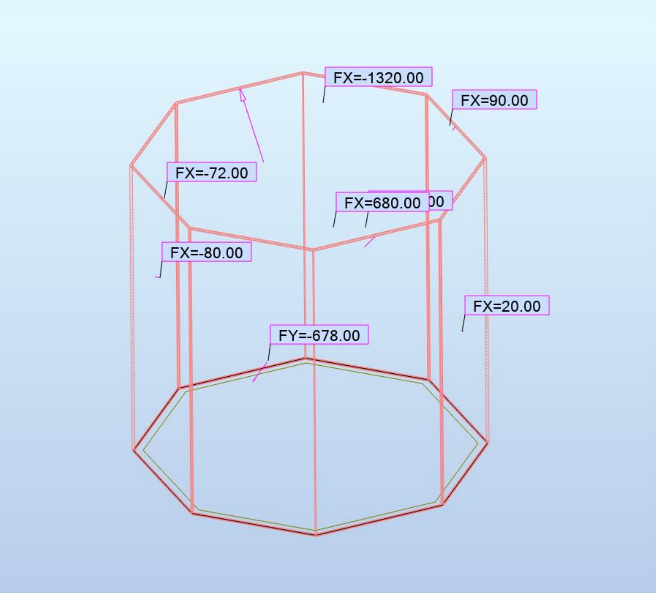


Figure 416 Robot Model of the Truss Connection with Applied Forces

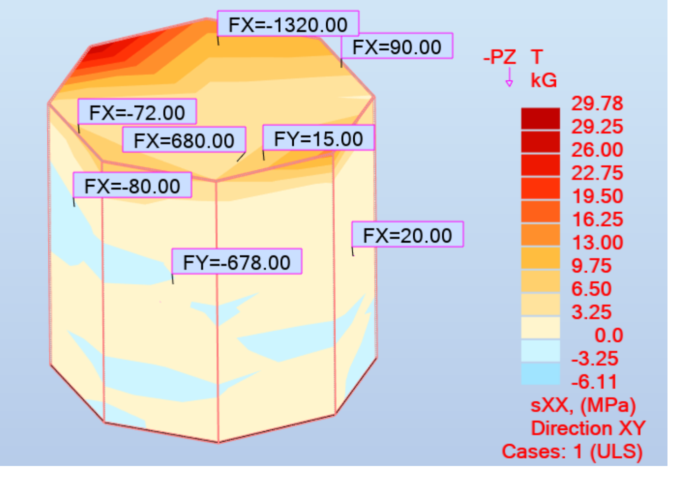


Figure 417 Results of the Internal Stresses of the Truss Connection

5

CONCLUSIONS

This thesis was developed while concentrating on the following three main levels:

- Defining the status quo
- Extracting the guidelines of the project from them
- Designing the project

For the purpose of better highlighting the conclusions, the first two parts will be summarized and treated together.

5.1. Defining the Status quo and extracting the guidelines:

The first part of the thesis concentrated on understanding the current state of things when it comes to emergency architecture in general and in Lebanon in specific.

As a result, several guidelines and conclusions were drawn and were transformed into the basis of the design criteria of the project.

5.1.1. Guidelines extracted from the study of the history of emergency architecture:

- The first part consisted in defining what is required to make this project up to date and fitting to the future visions of emergency architecture. In our case, the project is envisioned for a long-term crisis and for an intervention during what has been defined as PHASE II. Hence a project capable of improving and guiding both pre-existing and new refugee settlements.

- This project was designed to be used in the simplest of ways, in both formal and informal settlements, and it can be done both under the supervision of official organizations such as UNHCR as well as by independent agencies.
- This project was designed following a “Scenario 01” situation which consists in designing a prefabricated structure adaptable for all possible terrains and scenarios.
- The project was designed while taking into consideration all phases of the disaster: Pre-Disaster, During-Disaster and Post-Disaster. This has helped insuring the complete integration of the project during any crisis.

5.1.2. Guidelines extracted from the study of the history of emergency architecture in Lebanon:

- Proper planning was put in place in order to avoid having casualties caused by the chaos in the midst of an emergency, thus highlighting once more the importance of During-Disaster planning.
- Based on the events that occurred with the Palestinian refugees, the project was planned with the purpose of maintaining the settlements as a temporary status and avoiding, at any point, the creation of camps which will end up eventually causing clashes with the hosting population.
- Based on the events that occurred with the Syrian refugees, it has become clear that there is a need to adopt a new approach to the settlements, allowing to remove most existing obstacles on a social level. This is where the proposed PHASE II becomes a must, especially when a crisis exceeds its initial expected duration. Thus, highlighting the importance of the Post-Disaster planning.

5.1.3. Guidelines extracted from the study of the sociological research:

- The study showed high acceptance and enthusiasm towards the proposed project mainly due to the expressed importance of having common spaces and the extreme lack of them. This was highlighted even further when considering that during the warm days the refugees use the open space as common areas, but it becomes an issue during the winter season when that is not possible.
- The above also led to the importance of studying the project to be able to provide the same level of comfort during all 4 seasons and especially during winter.
- The importance of maintaining the temporary status of the settlements was highlighted during this study by the fact that most of the refugees wished to get out of the settlements and start over while forgetting about their country. This is very problematic considering the high number of refugees present in the country as well as the demographic impact it has on the country itself since the refugees reached up to 25% of the country’s population.
- It was highlighted that the infrastructure of the settlements was very poor and causes a lot of suffering to maintain, especially with the big number involved. The project was designed to help the WASH systems within the settlements by having an autonomous water collection system installed. Thus, becoming a beneficial asset and not an added problem.
- The limited funding shows the importance of the project in being sustainable and economic.

- The study has shown that the project needs to entangle the ever-rising issue of social issues within the settlements. Which is why it is essential for it to be multifunctional and active as much as possible during the day and night. The uses of different shifts will help expand its use exponentially.
- The project needs to help with the education of the refugees, especially the kids.
- The high unemployment rate creates the opportunity to recruit refugee volunteers for hand work.
- Most single unit housings have been deemed adequate to cover the basic life needs by the refugees and instead emphasis was put on the common areas.
- Humanitarian activists and staff members have all expressed their interest in the project and support of it.
- Through the interviews there was a social acceptance of the project and of Phase II.

5.2. Defining the different components of the project:

This project's design criteria are the result of the numerous guidelines extracted from the various studies performed throughout the thesis regarding the material and technology.

5.2.1. Structure

The project was initially thought of to be done through a Gridshell technology since it provided a much-desired and attractive design possibilities, but this option was then disregarded for the following reasons:

- Complexity and on-site construction difficulties.
- It requires experiences and manpower.
- It was deemed too complicated from the interviews which led for the benefits to outweigh the problems.

From the collaboration at the DAR group office, it became clear that there was a technology that offered all of the benefits of the Gridshell and none of its problems and that is why the technology chosen was the space frame. This technology provided the following benefits:

- Lightweight: It allows to cover the most area with the least amount of structural material.
- Mass productivity: Being composed of repetitive simple elements allows it to be easily mass produced.
- Transportation: Being composed of small parts, it can be easily packed and transported into any desired location.
- Assembly: The design intent was to create an IKEA like structure easily assembled following simple guidelines and with limited to no heavy machinery needed.
- Stiffness: The three-dimensional structural design and behavior give an important stiffness to the project.
- Versatility: The three-dimensional design allows extreme versatility in shape and form in the designing process.
- Maintenance: The mero design allows easy access and maintenance.

The proposed technology could have been built with a series of different materials. After thorough study, it was decided to proceed with wood for the following reasons:

- Timber’s growth rate and regeneration capabilities make it the perfect sustainable structural technology to use
- It is vastly present in the Lebanese market
- It offers very good mechanical properties which are desirable for the space frame technology

5.2.2. Façade

The project was initially thought of to be done through tensile structure but was discarded for the following reasons:

- It requires specialized on site manpower.
- It requires importation due to the complex fabrication process.
- Connection joints require steel.
- The maintenance and cleaning process requires specialized personnel.

From the study of the materials already used by most organizations and especially the UNHCR it was found that a more simple and effective technology can be adopted. Thus, the Tarpaulin was chosen for the following reasons:

- Material with limited durability that fits perfectly with the desired intent to maintain the temporary feeling of the project.
- Material with perfect specifications.
- Material present in local market.
- Material with easy maintenance process.
- Material with tested and proved efficiency on site.
- Material sold in rolls thus allowing easy transportation.
- Material can be reused or disposed of in an environment friendly manner.
- Material fixation complimentary to the mero wood structure.

- Refugees already familiar with the material.

5.2.3. Footing and decks

Both the footings and the deck blocks are going to be made from cement as they provide the following benefits:

- Using the concrete footing for the roof support as well as the deck blocks for the floor support has proven to be the most economical solution.
- Material present in local market.
- Deck blocks offer the fastest and most comfortable solution for open areas.
- Deck blocks require no digging and minimum to no surface preparation work.
- Both options will be easily covered by wooden elements and maintain the overall look and temporary status of the project.

5.3. The project:

All the above led to the proposed project with the following characteristics:

- Fully digital prefabricated with the DATA fully sharable with the package thus allowing the desiring organization the freedom to make adjustments as deemed necessary.
- Economical: This project has been designed to be as economic as possible by focusing on the following:

    - Its simple design allows it to be built with the manpower present on the emergency site and with little to no need for specialized personnel.
    - All the materials can be found locally, or economical alternatives can be used.
    - The structure has been optimized and properly re-dimensioned to avoid any waste due to overdesign.
- Universality adaptable: This project has been designed to be adjusted and built in any desired location with any weather condition. It will of course require some structural analysis based on the local area’s data.
- Sustainable: The proposed project is sustainable both passively and actively:
    - Passively through the usage of sustainable material and with as limited quantity as possible. The usage of locally present material reduces or even eliminates any transportation cost.
    - The project has been designed to have excellent thermophysical specifications requiring minimal mechanical heating and cooling.
    - Actively as the project harvests water within its big tanks allowing to reduce the load on the WASH infrastructure.
- Temporary: This is one of the most important features of this project as it was one of the most important qualifications gathered through the sociological and historical study.
    - The project can be easily assembled and disassembled.
    - The project can be relocated and reused.
    - The materials used are similar to the single housing unit thus allowing it to blend in with any existing settlement and further highlights the temporary idea.

- Flexibility: This project allows flexibility in its design subject to a structural analysis confirmation.
- Complimentary: The project can be easily connected to multiple similar units creating a bigger area for common usage.
- Multifunction: The design of the internal partitions allows infinite layouts capable of handling any of the needed functions within the settlement.

A

ATTACHMENTS

A1. Questions for the Refugees

A2. Questions for the staff

A3. Detailed structural report

1. QUESTIONS FOR REFUGEES

Before starting there will be a brief presentation the research and an assurance of the upmost confidentiality of the identity. Once that is done there will be a presentation of the interviewer throughout some personal information that will help remove the sensation of formality between the two persons in charge and that will help us by making the interviewed subject more fluid and get them into their comfort zone and get us closer to our aim which is to get them talking as if they were talking with friends.

Identification questions:

These questions should go very fast and it is very important for the interviewer not to take a formal tone in order to avoid giving the sensation of being under interrogation.

- What is your full name?
- Where do you come from?
- Are you here with family or alone?
    - What is your family composed off?
    - Who is the person responsible for the family?
    - What is your position in the family?

Background questions:

It is extremely important for the interviewer to try, when possible, to relate himself to the interviewed subject. That should put the subject further at ease and give the interview the appeal of a normal conversation. It is very important to pay attention to all details in this part because even the small ones can have a big impact on the research since it is through them that we will be able to separate the similar cases we get.

- What was your profession?
- What is your education?
- Are you familiar with technology?
- How many languages do you speak?
- Any leisure activities?
    - Physical?
    - Arts and sciences?
    - Intellectual?
    - Are still capable of performing these activities?
- Have you traveled before?
    - Been to Lebanon before the events started?

- Can you describe to us very briefly how your home was?
    - In what state was it when you left?
- Could you describe to us a typical day before the war?

History in the settlement: (H)

In order to get the most of the information about the camp we have chosen to guide the subjects through a series of questions and start with the history of the camp through their experiences. So, it is imperative for us to interview people who came to the camp in different times and it is crucial to interview, if possible, a person who was present since the beginning of the camp.

- How long have you been here? (H1)
- Was it easy for you to flee and come here? (H2)
    - How did you get here? (H2.1)
    - How long did it take you to get a tent? (H2.2)
    - How long would you say it took you to settle in? (H2.3)
- How did you know about this camp? (H3)
    - In your opinion what is the best way to inform people about it? (H3.1)
- What was your first priority when leaving home? (H4)
    - How long did it take you to achieve it? (H4.1)
    - What is your priority now? (H4.2)
- Has the camp evolved? (H5)
    - What has changed since you first came here? (H5.1)

Current situation: (group into subgroups) (C)

Once done with the history, we need to guide the subject, through a series of well-studied questions, into giving us the information that we needed in order for us to be able to better plan our project. We have decided to group the series of questions into subdivisions in order for us to be able to judge easier, based on the answers we got, which question to choose and which to ditch.

<u>Hygiene (CH)</u>

- How would you describe the hygiene situation? (CH1)
    - Where do you get your water from? (CH1.1)
    - Is it clean? (CH1.2)
- Where do you do all the cooking? (CH2)
- How and where do you dispose of the garbage? (CH3)

- How are the toilets? (CH4)
- Where do you take showers? (CH5)
    - Are you provided with soap? (CH5.1)
    - Towels? (CH5.2)
- Where do you get the clothes? (CH6)
    - How do you wash them? (CH6.1)

<u>Organization (O)</u>

- What do you think about the camp's organization? (CO1)
    - Do you help out in the camp organization? (CO1.1)
- How do you ensure main life requirements? (CO2)
- Being in Lebanon you are exposed to all 4 seasons; how do you adapt to it? (CO3)
    - What do you use for heating? (CO3.1)
    - And for cooling? (CO3.2)
    - What is the electricity situation? (CO3.3)
- Are the streets muddy? (CO4)
- What do you do in case of a medical emergency? (CO5)
- Are there preferences or is everyone treated in the same way? (CO6)

<u>Social life (S)</u>

- How do you fill up your time? (CS1)
    - How is the social life here? (CS1.1)
    - Do you get along with the others? (CS1.2)
- During the festivities, is there anything special being done? (CS2)
- Are there any religion conflicts? (CS3)
    - Were you used to living in a mixed religion society? (CS3.1)
    - Does it bother you? (CS3.2)
- What are the possibilities to have a social encounter here? (CS4)
    - How would you define the possibility to meet a partner and get married here? (CS4.1)
- Can you describe your typical day here in the camp? (CS5)

Education (E)

- Do you study? (CE1)
- Are there any schools? (CE2)
- What is the situation of the students who went to university? (CE3)
    - Were there public universities in Syria? (CE3.1)
    - Are there still universities open in Syria? (CE3.2)

Work (W)

- Do you work? (CW1)
    - If unemployed, are you looking for work? (CW1.1)
    - If not, why? (CW1.2)
- Would you accept any kind of work? (CW2)
    - Where would you say you would draw the line? (CW2.1)
- If you were working would you move out of the camp? (CW3)
    - Or would you save up the money and stay here? (CW3.1)

Volunteering (V)

- Have you ever participated in helping out with the camp organization? (CV1)
    - If not, why? (CV1.1)
- Are there a lot of volunteers here? (CV2)

Safety (SA)

- Do you feel safe? (CSA1)
    - If not, what is the main reason for that? (CSA1.1)
- Were there any security problems? (CSA2)
    - Are there any lights in the night? (CSA2.1)
    - Was there any animal presence inside the camp? (CSA2.2)
    - Kids' safety? (CSA2.3)

Personal Evaluation (P)

- If you had to evaluate the work done here, what would you say? (CP1)
- If you were given another chance would you still leave your country and come here? (CP2)
    - If you were given the choice, where would you go? (CP2.1)

- If you could define life here in 1 word, what would it be? (CP3)
- If you had to choose something positive you gained from this experience what would it be? (CP4)

What is lacking in the camp? (Wh)

- What do you think lacks in this camp? (Wh1)
  - On a single unit scale (Wh1.1)
  - On an urban scale (Wh1.2)

    Note :We are talking about all points of view:
    - *socially*
    - *architectonically*
    - *livability*
    - *management*
    - …
- Group them by priority, starting from the most essential (W2)

PHASE II (PH)

At this point, there will be a brief presentation of the project **PHASE II** and we will want to hear their reviews about it. We would like to give them the freedom to express themselves without being guided in order for us to be able to understand through the order in which they talk about the project what is in their mind the priority of the negatives or positives of the project. But we have nonetheless listed the questions that we wish to have answered and in case the subject fails to answer them on his own we will then intervene at the end by asking him the following questions:

- Will it work? (PH-1)
- Is it necessary? (PH-2)
- Any modifications come up to your mind? What do you think are the most important activities to put in this multifunctional project? (PH-3)
- Where does it fit in your priority list? (PH-4)
- In what way do you think it would help out the most? (PH-5)
- Do you think we will be able to find support from the refugees? (PH-6)
- Were there volunteers for similar past projects? (PH-7)
- In what season do you think it our project will be most crucial? (PH-8)

At the end of the interview we would also like to learn about the dreams and hopes of the subjects. This part is irrelevant for our research and is optional for both the subject and the interviewer based on how the interview went.

Dreams and hopes? (D)

- What are your dreams and hopes for the future? (D1)
- Do you prefer to go back to Syria or stay in Lebanon if you were capable to settle in? (D2)
- What is the first thing you would do when back in Syria? (D3)

2. QUESTIONS FOR STAFF MEMBERS

Before starting there will be a brief presentation the research and an assurance of the upmost confidentiality of the identity. Once that is done there will be a presentation of the interviewer throughout some personal information that will help remove the sensation of formality between the two persons in charge and that will help us by making the interviewed subject more fluid and get them into their comfort zone and get us closer to our aim which is to get them talking as if they were talking with friends.

Identification questions:

These questions should go very fast and it is very important for the interviewer not to take a formal tone in order to avoid giving the sensation of being under interrogation.

- What is your full name?
- Where do you come from?

Background questions:

It is extremely important for the interviewer to try, when possible, to relate himself to the interviewed subject. That should put the subject further at ease and give the interview the appeal of a normal conversation. It is very important to pay attention to all details in this part because even the small ones can have a big impact on the research since it is through them that we will be able to separate the similar cases we get.

- What is your profession?
- What is your education?
- How did you find out about this position?
    - Since when have you been working here?
    - How long do you plan to keep on doing it?
    - Are you paid for your work?
- How many languages do you speak?

History in the camp: (H)

In order to get the most of the information about the camp we have chosen to guide the subjects through a series of questions and start with the history of the camp through their experiences. So, it is imperative for us to interview people who came to the camp in different times and it is crucial to interview, if possible, a person who was present since the beginning of the camp.

- How long have you been here? (H1)
- How did you know about this job? (H2)

- What did you hope to gain from this job? (H3)
- Has the camp evolved since you first came? (H4)
    - What has changed since you first came here? (H4.1)

Current situation: (group into subgroups) (C)

Once done with the history, we need to guide the subject, through a series of well-studied questions, into giving us the information that we needed in order for us to be able to better plan our project. We have decided to group the series of questions into subdivisions in order for us to be able to judge easier, based on the answers we got, which question to choose and which to ditch.

<u>Hygiene (Hy)</u>

- How would you describe the hygiene situation? (CHy1)
    - Where do you get your water from? (CHy1.1)
- Who provides the food? (CHy2)
    - Do you sometimes share meals with the refugees? (CHy2.1)
- Do you guys have private toilets on site? (CHy3)
    - Do the refugees trespass? (CHy3.1)

<u>Organization (O)</u>

- What do you think about the camp’s organization? (CO1)
    - What is your role in the camp organization? (CO1.1)
- How do you ensure main life requirements for the refugees? (CO2)
- What do you do in case of a medical emergency? (CO3)
- Are there preferences or is everyone treated in the same way? (CO4)
- Do you have to do some field work? (CO5)
    - Do you have to do handwork? (CO5.1)
- Do you find problems applying authority? (CO6)
    - How do you solve riots? (CO6.1)
    - How do you handle critics? (CO6.2)

Social life (S)

- Do you live nearby? (CS1)
  - Do you feel like going to work? (CS1.1)
  - Does it seem like volunteering? (CS1.2)
  - How is the social life in the office? (CS1.3)
  - Do you get along with the others? (CS1.4)
- During the festivities, is there anything special being done? (CS2)
- Are there any religion conflicts between you and the refugees? (CS3)
  - Are you used to being in a multicultural environment? (CS3.1)
- Can you describe your typical day at work? (CS4)

Volunteering (V)

- Are there a lot of volunteers here? (CV1)
- Who assigns the chores? (CV2)
- Is there any conflict amongst volunteers and refugees? (CV3)
  - Amongst the volunteers themselves? (CV3.1)
  - Amongst the volunteers and the organizers? (CV3.2)
  - And in case of yes, how are the conflicts resolved? (CV3.3)
- Is the role that the volunteers play essential in your opinion? (CV4)

Safety (Sa)

- Do you feel safe? (CSa1)
  - If not, what is the main reason for that? (CSa1.1)
- Were there any security problems? (CSa2)
  - How do you deal with the threat of terrorist cells living in the settlements? (CSa2.1)
  - Do you work during the night? (CSa2.2)
  - Do you deal with any animal presence inside the settlements? (CSa2.3)

Personal Evaluation (PE)

- If you had to evaluate the work done here, what would you say? (CPE1)
- If you could define life in the settlements in 1 word, what would it be? (CPE2)

- If you had to choose something positive you gained from this experience what would it be? (CPE3)

What is lacking in the camp? (W)

- What do you think lacks in this camp? (CW1)
    - On a single unit scale (CW1.1)
    - On an urban scale (CW1.2)

      Note: We are talking about all points of view:
        - *socially*
        - *architectonically*
        - *livability*
        - *management*
        - …
- Group them by priority, starting from the most essential. (CW1.3)

PHASE II (PH)

At this point, there will be a brief presentation of the project **PHASE II** and we will want to hear their reviews about it. We would like to give them the freedom to express themselves without being guided in order for us to be able to understand through the order in which they talk about the project what is in their mind the priority of the negatives or positives of the project. But we have nonetheless listed the questions that we wish to have answered and in case the subject fails to answer them on his own we will then intervene at the end by asking him the following questions:

- Will it work? (Ph1)
- Is it necessary? (Ph2)
- Any modifications come up to mind? (Ph3)
- Where does it fit in your priority list? (Ph4)
- In what way do you think it would help out the most? (Ph5)
- Do you think we will be able to find support from the refugees? (Ph6)
- Were there volunteers for similar past projects? (Ph7)
- What do you think are the most important activities to put in this multifunctional project? (Ph8)
- In what season do you think it our project will be most crucial (Ph9)

3. DETAILED STRUCTURAL REPORT

1.1. Project Location

The structure shall be studied in the area of Bikfaya, Lebanon. This geological location will affect the structural design of the foundation as well as the earthquake parameters acting on the structure.

Figure 2-418 Project Location on Lebanese Map

Chapter 2: Design Criteria

2.1. Codes of Practices and Standards

- ANSI/AWC NDS-2012 National Design Specification for Wood Construction.
- AISC 360-16 Specification for Structural Steel Buildings (American Institute of Steel Construction).
- ACI 318-19 Building Code Requirement for Structural Concrete (American Concrete Institute).
- ASCE 7-10 Minimum Design Loads and Associated Criteria for Buildings and Other Structures (American Society for Civil Engineers).

2.2. Software Used

- Robot Structural Analysis for seismic and wind analysis, and wood design.
- SAFE for foundation design.
- RAM Connection for base plate and anchor rod design.

2.3. Material Properties

2.3.1. Stone Pine Wood

- Crushing Strength $F_c = 39\ MPa$
- Dried Unit Weight $w_c = 500\ kg/m^3$
- Specific Gravity $0.39, 0.50$
- Modulus of Rupture $F_b = 73\ MPa$
- Elastic Modulus $E = 8.54\ GPa$
- Shrinkage $4.5\%\ Radial$

$9.0\%\ Tangential$

$14.4\%\ Volumetric$

$T/R\ Ratio = 2.0$

2.3.2. Concrete

- Compressive Strength $f_c' = 30\ MPa$
- Unit Weight $w_c = 2.5\ T/m^3$
- Modulus of Elasticity $E_c = 4700\sqrt{f_c'} = 25{,}800\ MPa$
- Shear Modulus $G = \frac{E}{2(1+\upsilon)} = 10{,}700\ MPa$
- Poisson's Ratio $\upsilon = 0.2$
- Coefficient of Thermal Expansion $\alpha = 10 \times 10^{-6}\ ℃^{-1}$

2.3.3. Base Plates

- Type $ASTM\ A36$
- Yield Strength $F_y = 250\ MPa\ \ (36\ ksi)$
- Tensile Strength $F_u = 400\ MPa\ \ (58\ ksi)$
- Plate Thickness $10\ mm$

2.3.4. Anchor Rods

- Type $ASTM\ F1554\ \ Headed\ Bolt$
- Yield Strength $F_y = 250\ MPa$
- Tensile Strength $F_u = 400\ MPa$
- Rod Diameter $16\ mm$
- Embedment Length $Up\ to\ 50\ cm$

2.4. Soil Parameters

- Type $Limestone\ Rock$
- Allowable Net Bearing Capacity $q = 300\ kPa$
- Modulus of Subgrade Reaction $k = 36{,}000\ kN/m^3$
- Density $\gamma = 25\ kN/m^3$
- Friction Angle $\varphi = 35°$
- Cohesion $c = 15\ kPa$

2.5. Wind Parameters

- Basic Wind Speed $v_{3s} = 45\ m/s$
- Wind Directionality Factor $K_d = 0.85$
- Topography Factor $K_{zt} = 1.00$
- Gust Factor $G = 0.85$
- Importance Factor $I_w = 1.00$
- Exposure Category C

2.6. Earthquake Parameters

- Spectral response parameter at short period $S_S = 1.2$
- Spectral response parameter at period of 1 second $S_1 = 0.4$
- Seismic importance factor $I_e = 1.0$
- Response modification factor $R = 1.5$
- Deflection amplification factor $C_d = 1.5$
- System overstrength factor $\Omega_0 = 1.5$
- Long-term transition period $T_L = 8\ s$
- Site class B
- Seismic design category $SDC\ D$

Chapter 3: Loads

3.1. Dead Loads

Dead loads include permanent loads of the structure. It is mainly divided into two categories: Self-Weight (SW) and Superimposed Dead Load (SDL).

3.1.1. Self-Weight

It includes self-weight of the structure (wooden members and connections).

Self-weight is determined automatically by the software.

3.1.2. Superimposed Dead Load

Superimposed dead loads considered in the current project include the following loads

- Roof Tarpaulin 350 g/m^2
- Exterior Partition Tarpaulin 200 g/m^2

3.2. Live Load

Live loads are variable loads that depend on the usage and occupancy of each floor plan.

However, this structure doesn't carry any live loads

3.3. Load Combinations

The load combinations will be set according to Chapter 2 of the ASCE 7 code.

3.3.1. Ultimate Limit State

- $1.4D$
- $1.2D + 1.6L$
- $1.2D + 0.5W$
- $1.2D + L + W$
- $1.2D + L + E$
- $0.9D + W$
- $0.9D + E$

3.3.2. Service Limit State

- D
- $D + L$
- $D + 0.6W$
- $D + 0.7E$
- $D + 0.75L + 0.75(0.6W)$
- $D + 0.75L + 0.75(0.7E)$
- $0.6D + 0.6W$
- $0.6D + 0.7E$

Chapter 4: Wind

4.1. Design Parameters

- $v_{3s} = 45\ m/s$ Basic Wind Speed
- $K_d = 0.85$ Wind Directionality Factor
- $K_{zt} = 1.00$ Topography Factor
- $G = 0.85$ Gust Factor
- $I_w = 1.00$ Importance Factor
- C Exposure Category

Risk Category from Table 1.5-1	Snow Importance Factor, I_s	Ice Importance Factor—Thickness, I_i	Ice Importance Factor—Wind, I_w	Seismic Importance Factor, I_e
I	0.80	0.80	1.00	1.00
II	1.00	1.00	$\boxed{1.00}$	1.00
III	1.10	1.15	1.00	1.25
IV	1.20	1.25	1.00	1.50

Figure 4-1 Wind Importance Factor I_w

Structure Type	Directionality Factor K_d
Buildings	
Main Wind Force Resisting System	$\boxed{0.85}$
Components and Cladding	0.85
Arched Roofs	0.85
Circular Domes	1.0[a]
Chimneys, Tanks, and Similar Structures	
Square	0.90
Hexagonal	0.95
Octagonal	1.0[a]
Round	1.0[a]
Solid Freestanding Walls, Roof Top Equipment, and Solid Freestanding and Attached Signs	0.85
Open Signs and Single-Plane Open Frames	0.85
Trussed Towers	
Triangular, square, or rectangular	0.85
All other cross sections	0.95

Figure 4-2 Wind Directionality Factor K_d

4.2. Load

The design wind pressures for buildings of all heights can be determined by the following equation

$$W\ [T/m^2] = q\ G\ C_p - q_i\ (GC_{pi}) \qquad (4\text{-}1)$$

Where

q	$= q_z$	For windward walls evaluated at height z above the ground (T/m^2)
q_i	$= q_z$	For positive internal pressure evaluated in partially enclosed buildings (T/m^2)
C_p	$= 0.8$	External pressure coefficient
GC_{pi}	$= \pm\ 0.18$	Internal pressure coefficient

The windward pressure can be evaluated as

$$q_z = 0.613\ K_z\ K_{zt}\ K_d\ v^2 \qquad (4\text{-}2)$$

Where

q_z = Velocity pressure calculated at height z (T/m^2)

K_z = Velocity pressure coefficient evaluated at height z

$$= 2.01\ (z/z_c)^{\ 2/\alpha} \qquad (4\text{-}3)$$

Enclosure Classification	Criteria for Enclosure Classification	Internal Pressure	Internal Pressure Coefficient, (GC_{pi})
Enclosed buildings	A_o is less than the smaller of $0.01A_g$ or 4 sq ft (0.37 m) and $A_{oi}/A_{gi} \le 0.2$	Moderate	$\boxed{+0.18 \\ -0.18}$
Partially enclosed buildings	$A_o > 1.1A_{oi}$ and $A_o >$ the lesser of $0.01A_g$ or 4 sq ft (0.37 m) and $A_{oi}/A_{gi} \le 0.2$	High	+0.55 −0.55
Partially open buildings	A building that does not comply with Enclosed, Partially Enclosed, or Open classifications	Moderate	+0.18 −0.18
Open buildings	Each wall is at least 80% open	Negligible	0.00

Figure 4-3 Internal Pressure Coefficient GC_{pi}

Chapter 5: Earthquake

5.1. Design Parameters

- $S_S = 1.2$ Spectral response parameter at short period
- $S_1 = 0.4$ Spectral response parameter at period of 1 second
- $I_e = 1.0$ Seismic importance factor
- $R = 1.5$ Response modification factor
- $C_d = 1.5$ Deflection amplification factor
- $\Omega_0 = 1.5$ System overstrength factor
- $T_L = 8\ s$ Long-term transition period
- B Site class
- $SDC\ D$ Seismic design category

Risk Category from Table 1.5-1	Snow Importance Factor, I_s	Ice Importance Factor—Thickness, I_i	Ice Importance Factor—Wind, I_w	Seismic Importance Factor, I_e
I	0.80	0.80	1.00	1.00
II	1.00	1.00	1.00	$\boxed{1.00}$
III	1.10	1.15	1.00	1.25
IV	1.20	1.25	1.00	1.50

Figure 5-1 Seismic Importance Factor I_e

Seismic Force-Resisting System	ASCE 7 Section Where Detailing Requirements Are Specified	Response Modification Coefficient, R^a	Overstrength Factor, $\Omega_0{}^b$	Deflection Amplification Factor, $C_d{}^c$
5. Steel and concrete composite special concentrically braced frames	14.3	5½	2½	4½
6. Steel and concrete composite ordinary braced frames	14.3	3½	2½	3
7. Steel and concrete composite ordinary shear walls	14.3	5	3	4½
8. Ordinary reinforced concrete shear walls[g]	14.2	5½	2½	4½
F. SHEAR WALL-FRAME INTERACTIVE SYSTEM WITH ORDINARY REINFORCED CONCRETE MOMENT FRAMES AND ORDINARY REINFORCED CONCRETE SHEAR WALLS[g]	12.2.5.8 and 14.2	4½	2½	4
G. CANTILEVERED COLUMN SYSTEMS DETAILED TO CONFORM TO THE REQUIREMENTS FOR:	12.2.5.2			
1. Steel special cantilever column systems	14.1	2½	1¼	2½
2. Steel ordinary cantilever column systems	14.1	1¼	1¼	1¼
3. Special reinforced concrete moment frames[m]	12.2.5.5 and 14.2	2½	1¼	2½
4. Intermediate reinforced concrete moment frames	14.2	1½	1¼	1½
5. Ordinary reinforced concrete moment frames	14.2	1	1¼	1
6. $\boxed{\text{Timber frames}}$	14.5	$\boxed{1½}$	$\boxed{1½}$	$\boxed{1½}$

Figure 5-2 Respone Modification Coefficient R, Overstrength Factor Ω_0, and Deflection Amplification Factor C_d

5.2. Static Base Shear

5.2.1. General Provisions

The seismic base shear, *V*, in a given direction shall be determined in accordance with the following equation

$$\boldsymbol{V}\ [\boldsymbol{T}] = \boldsymbol{C_s}\, \boldsymbol{W} \qquad (5\text{-}1)$$

Where

C_s = Seismic response coefficient

W = Effective seismic weight (T)

5.2.2. Site Class

The soil report stated that the shear wave velocity of the subsurface layer at site ranges between 760 m/s (2,500 ft/s) and 1,500 m/s (5,000 ft/s). Strata with such velocities will not amplify ground shaking.

Site Class	$\bar{v}_s$	$\bar{N}$ or $\bar{N}_{ch}$	$\bar{s}_u$
A. Hard rock	>5,000 ft/s	NA	NA
B. Rock	2,500 to 5,000 ft/s	NA	NA
C. Very dense soil and soft rock	1,200 to 2,500 ft/s	>50 blows/ft	>2,000 lb/ft^2
D. Stiff soil	600 to 1,200 ft/s	15 to 50 blows/ft	1,000 to 2,000 lb/ft^2
E. Soft clay soil	<600 ft/s	<15 blows/ft	<1,000 lb/ft^2
	Any profile with more than 10 ft of soil that has the following characteristics: — Plasticity index $PI > 20$, — Moisture content $w \geq 40\%$, — Undrained shear strength $\bar{s}_u < 500$ lb/ft^2		
F. Soils requiring site response analysis in accordance with Section 21.1	See Section 20.3.1		

Figure 5-3 Site Classification

5.2.3. Spectral Acceleration Parameters

The spectral acceleration parameters are determined as follows

$$\boldsymbol{S_{MS}\ (m/s^2) = F_a S_S} \qquad (5\text{-}2)$$

$$\boldsymbol{S_{M1}\ (m/s^2) = F_v S_1} \qquad (5\text{-}3)$$

Where

S_{MS} (m/s^2) = Spectral response acceleration parameter at short periods.

S_{M1} = Spectral response acceleration parameter at period of 1s. (m/s^2)

F_a, F_v = Site coefficients

	Mapped Risk-Targeted Maximum Considered Earthquake (MCE$_R$) Spectral Response Acceleration Parameter at Short Period				
Site Class	$S_S \leq 0.25$	$S_S = 0.5$	$S_S = 0.75$	$S_S = 1.0$	$S_S \geq 1.25$
A	0.8	0.8	0.8	0.8	0.8
B	1.0	1.0	1.0	1.0	1.0
C	1.2	1.2	1.1	1.0	1.0
D	1.6	1.4	1.2	1.1	1.0
E	2.5	1.7	1.2	0.9	0.9
F	See Section 11.4.7				

Figure 5-4 Site Coefficient F_a

Site Class	Mapped Risk-Targeted Maximum Considered Earthquake (MCE_R) Spectral Response Acceleration Parameter at 1-s Period				
	$S_1 \leq 0.1$	$S_1 = 0.2$	$S_1 = 0.3$	$S_1 = 0.4$	$S_1 \geq 0.5$
A	0.8	0.8	0.8	0.8	0.8
B	1.0	1.0	1.0	1.0	1.0
C	1.7	1.6	1.5	1.4	1.3
D	2.4	2.0	1.8	1.6	1.5
E	3.5	3.2	2.8	2.4	2.4
F	See Section 11.4.7				

Figure 5-5 Site Coefficient F_v

The design response accelerations S_{DS} and S_{D1} become

$$\boldsymbol{S_{DS} = \frac{2}{3} S_{MS} = 0.8g} \tag{5-4}$$

$$\boldsymbol{S_{D1} = \frac{2}{3} S_{M1} = 0.27g} \tag{5-5}$$

5.2.4. Seismic Design Category

$S_{DS} = 0.8\ g \quad > 0.5\ g \quad \Longrightarrow SDC\ D$

$S_{D1} = 0.27\ g > 0.2\ g \quad \Longrightarrow SDC\ D$

Value of S_{DS}	Risk Category	
	I or II or III	IV
$S_{DS} < 0.167$	A	A
$0.167 \leq S_{DS} < 0.33$	B	C
$0.33 \leq S_{DS} < 0.50$	C	D
$0.50 \leq S_{DS}$	D	D

Figure 5-6 Seismic Design Category Based on Short-Period Response Acceleration Parameter

	Risk Category	
Value of S_{D1}	I or II or III	IV
$S_{D1} < 0.067$	A	A
$0.067 \leq S_{D1} < 0.133$	B	C
$0.133 \leq S_{D1} < 0.20$	C	D
$0.20 \leq S_{D1}$	$\boxed{D}$	D

Figure 5-7 Seismic Design Category Based on 1-s Period Response Acceleration Parameter

5.2.5. Fundamental Period

The approximate fundamental period, T_a, shall be determined from the following equation

$$\boldsymbol{T_a\ (s) = C_t\ h_n^x} \qquad (5\text{-}6)$$

Where

h_n = Structural height (m) $= 5.35\ m$

C_t, x = Fundamental Period Coefficients

Structure Type	C_t	x
Moment-resisting frame systems in which the frames resist 100% of the required seismic force and are not enclosed or adjoined by components that are more rigid and will prevent the frames from deflecting where subjected to seismic forces:		
Steel moment-resisting frames	0.028 $(0.0724)^a$	0.8
Concrete moment-resisting frames	0.016 $(0.0466)^a$	0.9
Steel eccentrically braced frames in accordance with Table 12.2-1 lines B1 or D1	0.03 $(0.0731)^a$	0.75
Steel buckling-restrained braced frames	0.03 $(0.0731)^a$	0.75
All other structural systems	0.02 $\boxed{(0.0488)^a}$	$\boxed{0.75}$

Figure 5-8 Values of Approximate Period Parameters C_t and x

Thus, the fundamental period will equate to

$$T_a = 0.172\ s$$

5.2.6. Seismic Response Coefficient

The seismic response coefficient, C_s, shall be determined in accordance with the following equation

$$\boldsymbol{C_s = \frac{S_{DS}}{\frac{R}{I_e}} = 0.53} \qquad (5\text{-}7)$$

The value of C_s computed need not exceed the following

$$\boldsymbol{C_{s\ max} = \frac{S_{D1}}{T\left(\frac{R}{I_e}\right)} = 1.03} \qquad (5\text{-}8)$$

C_s shall not be less than

$$\boldsymbol{C_{s\ min} = 0.044\ S_{DS}\ I_e = 0.035 \geq 0.01} \qquad (5\text{-}9)$$

Therefore, the seismic response coefficient will be taken as

$$C_s = 0.53$$

Chapter 6: Software Analysis

6.1. Software Model

The model on Robot Structural Analysis software was modeled using the original wireframe, and the wood sections was predefined as 10 cm originally. This section shall be optimized at later stages of calculations.

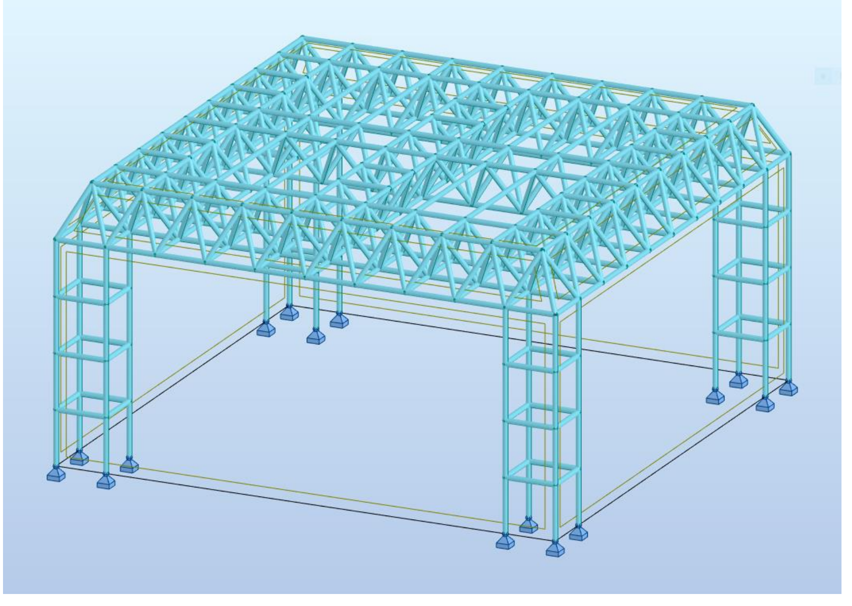


Figure 6-1 Robot Model of the Wooden Structure

6.2. Input Data

6.2.1. Wood Properties

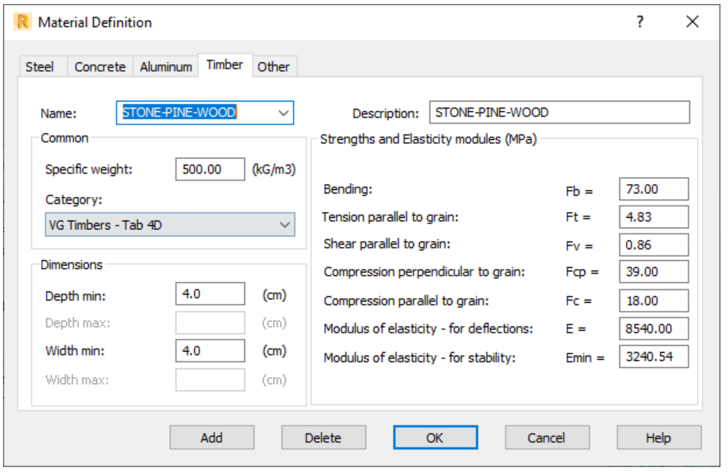


Figure 6-2 Stone Pine Wood Mechanical Properties

6.2.2. Load Definitions

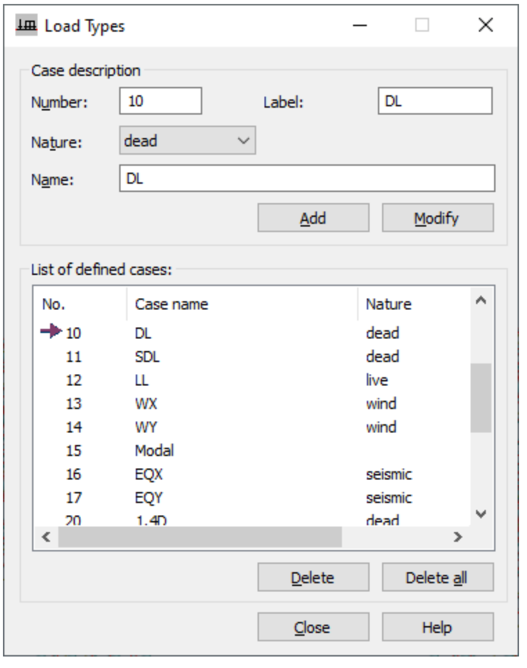


Figure 6-3 Load Types

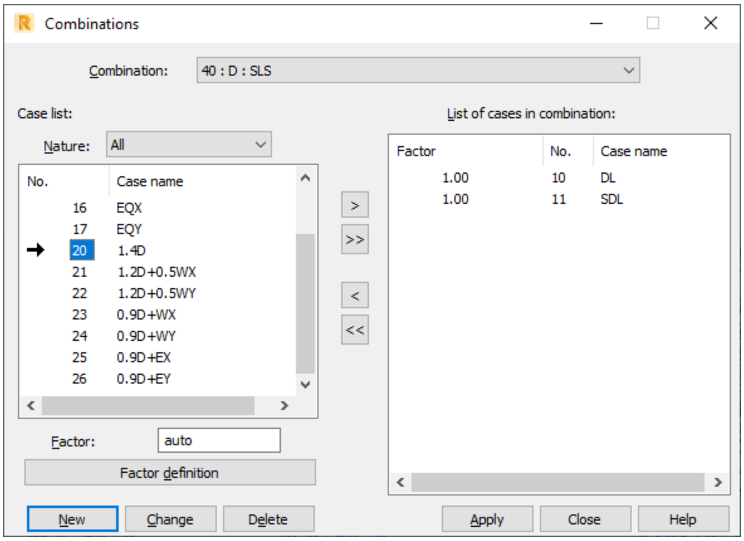


Figure 6-4 Load Combinations

6.2.3. Earthquake Parameters

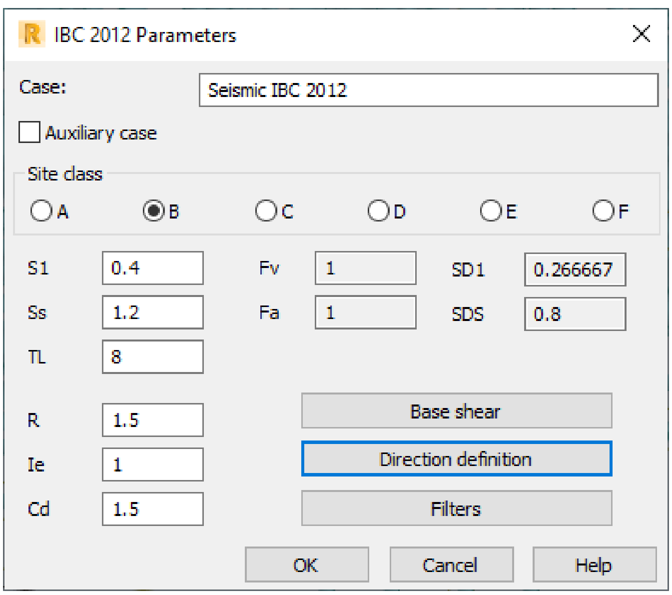


Figure 6-5 Static Earthquake Parameters

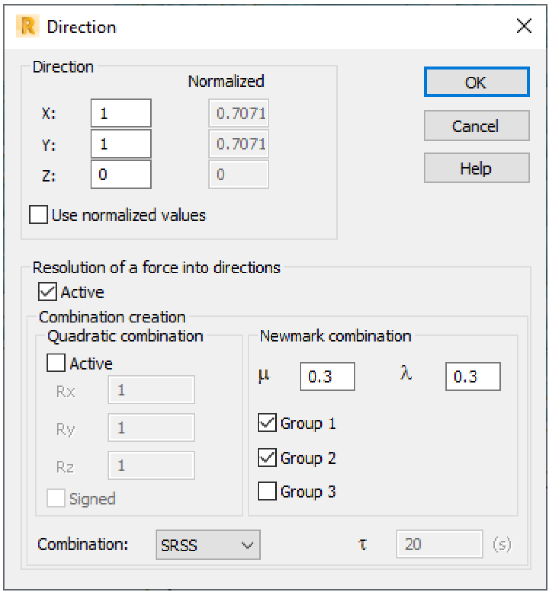


Figure 6-6 Earthquake Directionality Definition

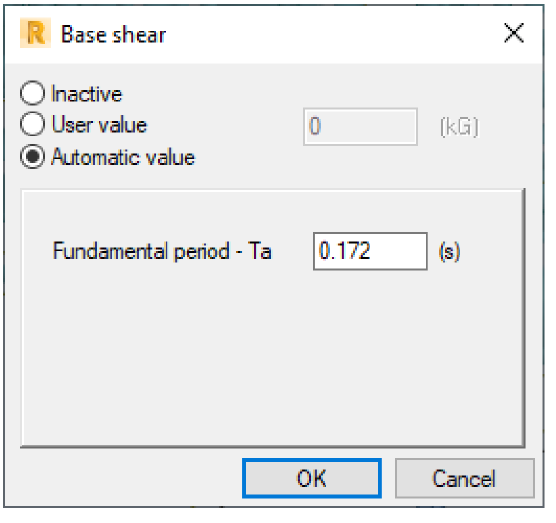


Figure 6-7 Fundamental Period Definition

6.3. Analysis Results

The software analysis results show that some members will structurally fail for a critical load combination, each specified by the figure below. Thus, the original 10 cm diameter section is not valid.

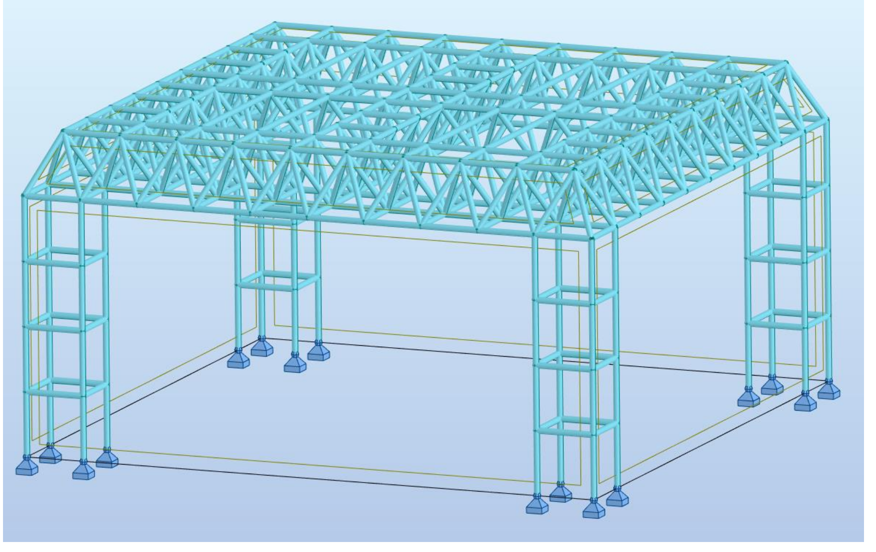


Figure 6-8 Structural Model with 10 cm Diameter for All Members

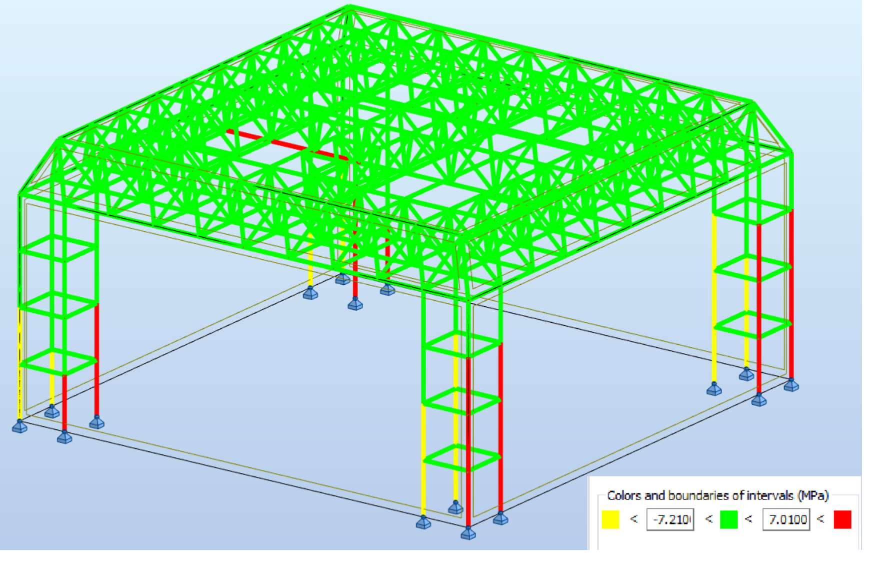
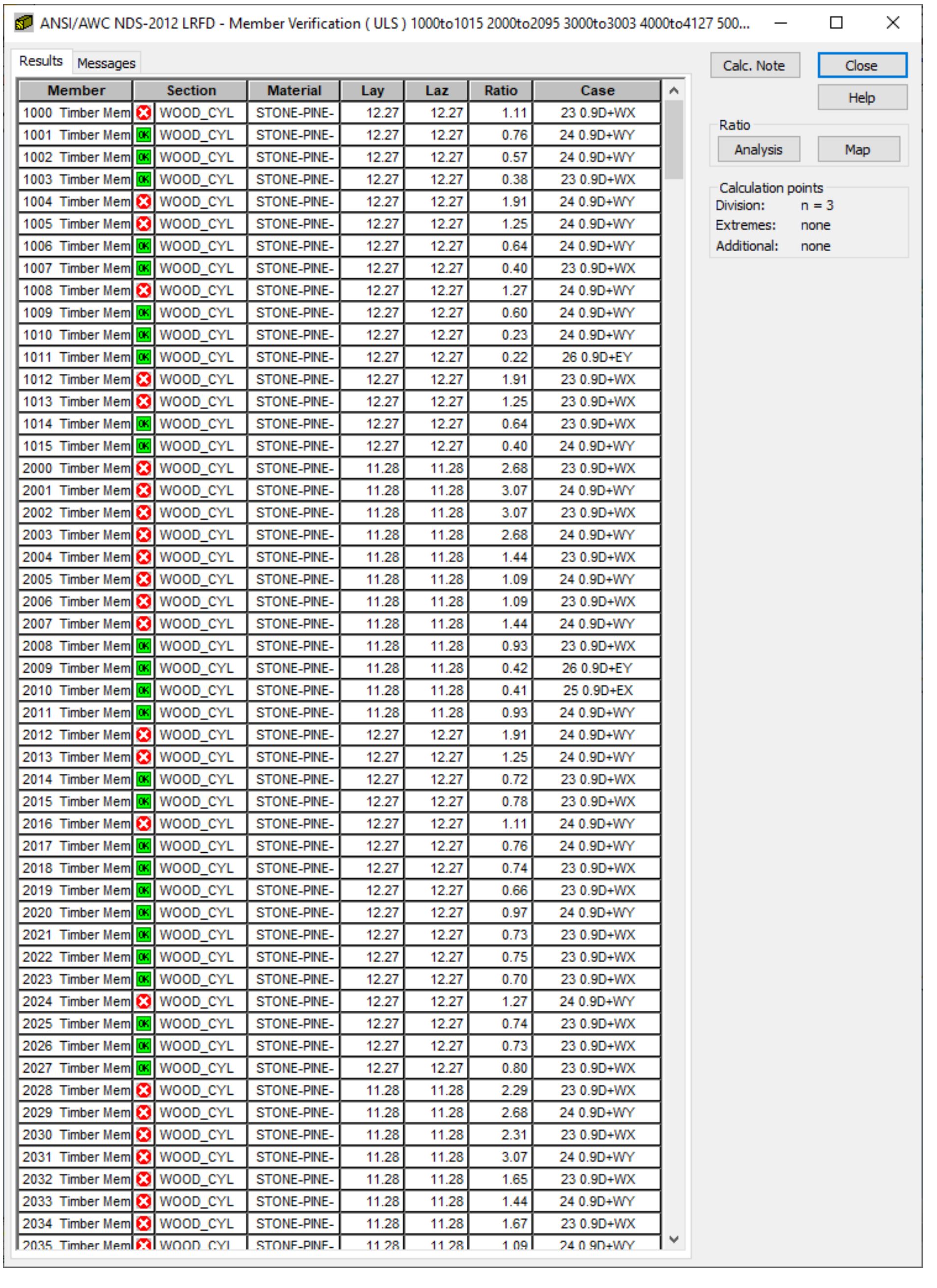


Figure 6-9 Model Analysis Map of Members Subjected to Ultimate Limit State

The analysis shows the columns are carrying the most stresses due to lateral forces.

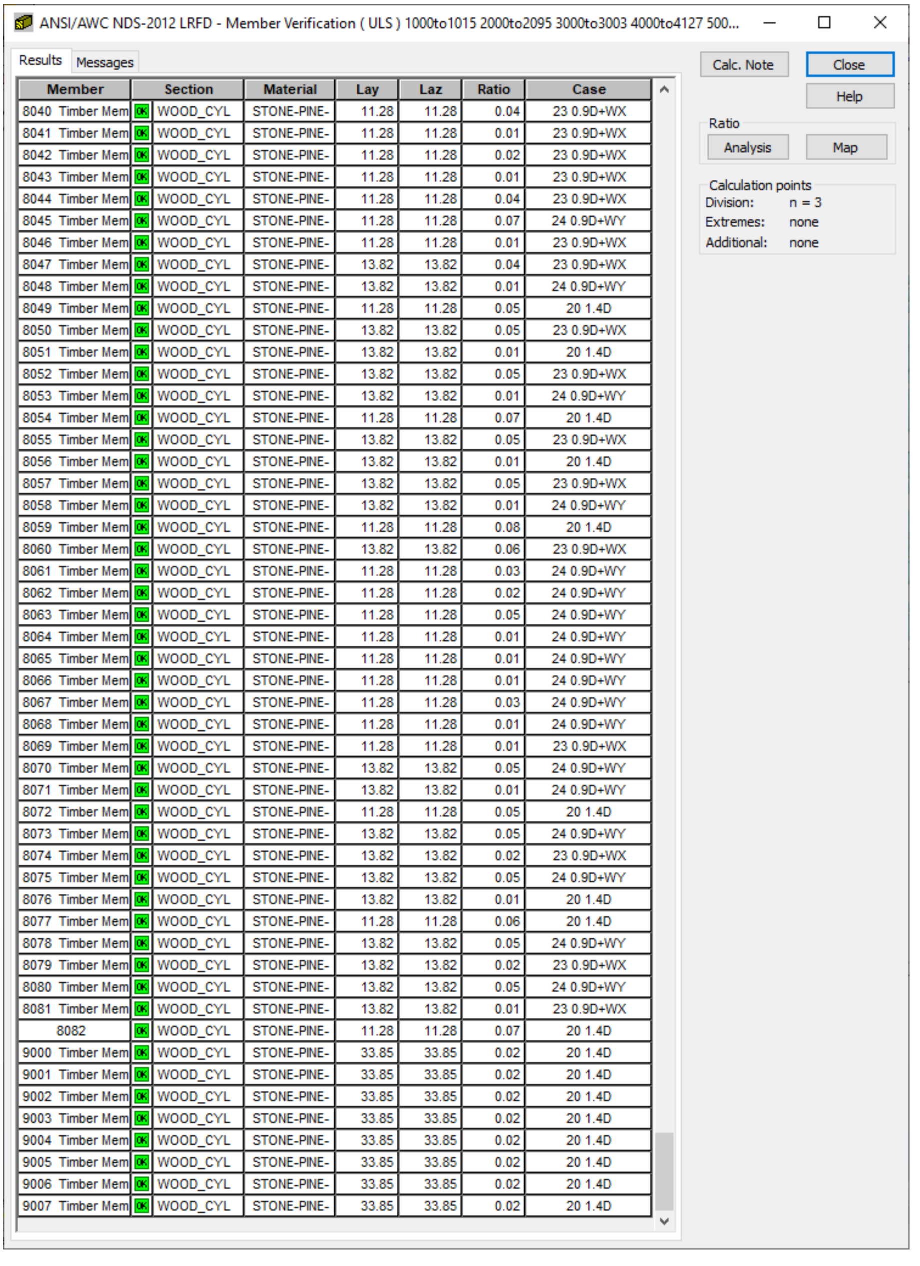
Note that red values indicate a result above a certain value, not which are failed members.



Member		Section	Material	Lay	Laz	Ratio	Case
1000 Timber Mem	✗	WOOD_CYL	STONE-PINE-	12.27	12.27	1.11	23 0.9D+WX
1001 Timber Mem	OK	WOOD_CYL	STONE-PINE-	12.27	12.27	0.76	24 0.9D+WY
1002 Timber Mem	OK	WOOD_CYL	STONE-PINE-	12.27	12.27	0.57	24 0.9D+WY
1003 Timber Mem	OK	WOOD_CYL	STONE-PINE-	12.27	12.27	0.38	23 0.9D+WX
1004 Timber Mem	✗	WOOD_CYL	STONE-PINE-	12.27	12.27	1.91	24 0.9D+WY
1005 Timber Mem	✗	WOOD_CYL	STONE-PINE-	12.27	12.27	1.25	24 0.9D+WY
1006 Timber Mem	OK	WOOD_CYL	STONE-PINE-	12.27	12.27	0.64	24 0.9D+WY
1007 Timber Mem	OK	WOOD_CYL	STONE-PINE-	12.27	12.27	0.40	23 0.9D+WX
1008 Timber Mem	✗	WOOD_CYL	STONE-PINE-	12.27	12.27	1.27	24 0.9D+WY
1009 Timber Mem	OK	WOOD_CYL	STONE-PINE-	12.27	12.27	0.60	24 0.9D+WY
1010 Timber Mem	OK	WOOD_CYL	STONE-PINE-	12.27	12.27	0.23	24 0.9D+WY
1011 Timber Mem	OK	WOOD_CYL	STONE-PINE-	12.27	12.27	0.22	26 0.9D+EY
1012 Timber Mem	✗	WOOD_CYL	STONE-PINE-	12.27	12.27	1.91	23 0.9D+WX
1013 Timber Mem	✗	WOOD_CYL	STONE-PINE-	12.27	12.27	1.25	23 0.9D+WX
1014 Timber Mem	OK	WOOD_CYL	STONE-PINE-	12.27	12.27	0.64	23 0.9D+WX
1015 Timber Mem	OK	WOOD_CYL	STONE-PINE-	12.27	12.27	0.40	24 0.9D+WY
2000 Timber Mem	✗	WOOD_CYL	STONE-PINE-	11.28	11.28	2.68	23 0.9D+WX
2001 Timber Mem	✗	WOOD_CYL	STONE-PINE-	11.28	11.28	3.07	24 0.9D+WY
2002 Timber Mem	✗	WOOD_CYL	STONE-PINE-	11.28	11.28	3.07	23 0.9D+WX
2003 Timber Mem	✗	WOOD_CYL	STONE-PINE-	11.28	11.28	2.68	24 0.9D+WY
2004 Timber Mem	✗	WOOD_CYL	STONE-PINE-	11.28	11.28	1.44	23 0.9D+WX
2005 Timber Mem	✗	WOOD_CYL	STONE-PINE-	11.28	11.28	1.09	24 0.9D+WY
2006 Timber Mem	✗	WOOD_CYL	STONE-PINE-	11.28	11.28	1.09	23 0.9D+WX
2007 Timber Mem	✗	WOOD_CYL	STONE-PINE-	11.28	11.28	1.44	24 0.9D+WY
2008 Timber Mem	OK	WOOD_CYL	STONE-PINE-	11.28	11.28	0.93	23 0.9D+WX
2009 Timber Mem	OK	WOOD_CYL	STONE-PINE-	11.28	11.28	0.42	26 0.9D+EY
2010 Timber Mem	OK	WOOD_CYL	STONE-PINE-	11.28	11.28	0.41	25 0.9D+EX
2011 Timber Mem	OK	WOOD_CYL	STONE-PINE-	11.28	11.28	0.93	24 0.9D+WY
2012 Timber Mem	✗	WOOD_CYL	STONE-PINE-	12.27	12.27	1.91	24 0.9D+WY
2013 Timber Mem	✗	WOOD_CYL	STONE-PINE-	12.27	12.27	1.25	24 0.9D+WY
2014 Timber Mem	OK	WOOD_CYL	STONE-PINE-	12.27	12.27	0.72	23 0.9D+WX
2015 Timber Mem	OK	WOOD_CYL	STONE-PINE-	12.27	12.27	0.78	23 0.9D+WX
2016 Timber Mem	✗	WOOD_CYL	STONE-PINE-	12.27	12.27	1.11	24 0.9D+WY
2017 Timber Mem	OK	WOOD_CYL	STONE-PINE-	12.27	12.27	0.76	24 0.9D+WY
2018 Timber Mem	OK	WOOD_CYL	STONE-PINE-	12.27	12.27	0.74	23 0.9D+WX
2019 Timber Mem	OK	WOOD_CYL	STONE-PINE-	12.27	12.27	0.66	23 0.9D+WX
2020 Timber Mem	OK	WOOD_CYL	STONE-PINE-	12.27	12.27	0.97	24 0.9D+WY
2021 Timber Mem	OK	WOOD_CYL	STONE-PINE-	12.27	12.27	0.73	23 0.9D+WX
2022 Timber Mem	OK	WOOD_CYL	STONE-PINE-	12.27	12.27	0.75	23 0.9D+WX
2023 Timber Mem	OK	WOOD_CYL	STONE-PINE-	12.27	12.27	0.70	23 0.9D+WX
2024 Timber Mem	✗	WOOD_CYL	STONE-PINE-	12.27	12.27	1.27	24 0.9D+WY
2025 Timber Mem	OK	WOOD_CYL	STONE-PINE-	12.27	12.27	0.74	23 0.9D+WX
2026 Timber Mem	OK	WOOD_CYL	STONE-PINE-	12.27	12.27	0.73	23 0.9D+WX
2027 Timber Mem	OK	WOOD_CYL	STONE-PINE-	12.27	12.27	0.80	23 0.9D+WX
2028 Timber Mem	✗	WOOD_CYL	STONE-PINE-	11.28	11.28	2.29	23 0.9D+WX
2029 Timber Mem	✗	WOOD_CYL	STONE-PINE-	11.28	11.28	2.68	24 0.9D+WY
2030 Timber Mem	✗	WOOD_CYL	STONE-PINE-	11.28	11.28	2.31	23 0.9D+WX
2031 Timber Mem	✗	WOOD_CYL	STONE-PINE-	11.28	11.28	3.07	24 0.9D+WY
2032 Timber Mem	✗	WOOD_CYL	STONE-PINE-	11.28	11.28	1.65	23 0.9D+WX
2033 Timber Mem	✗	WOOD_CYL	STONE-PINE-	11.28	11.28	1.44	24 0.9D+WY
2034 Timber Mem	✗	WOOD_CYL	STONE-PINE-	11.28	11.28	1.67	23 0.9D+WX
2035 Timber Mem	✗	WOOD_CYL	STONE-PINE-	11.28	11.28	1.09	24 0.9D+WY

Figure 6-10 Design Results for the Column Members

For other members, located in the upper truss system, the members are structurally valid at any given combination. However, their load/capacity ratio is too negligible, as indicated in the figure below, which shows that they are over-dimensioned.



Member		Section	Material	Lay	Laz	Ratio	Case
8040 Timber Mem	OK	WOOD_CYL	STONE-PINE-	11.28	11.28	0.04	23 0.9D+WX
8041 Timber Mem	OK	WOOD_CYL	STONE-PINE-	11.28	11.28	0.01	23 0.9D+WX
8042 Timber Mem	OK	WOOD_CYL	STONE-PINE-	11.28	11.28	0.02	23 0.9D+WX
8043 Timber Mem	OK	WOOD_CYL	STONE-PINE-	11.28	11.28	0.01	23 0.9D+WX
8044 Timber Mem	OK	WOOD_CYL	STONE-PINE-	11.28	11.28	0.04	23 0.9D+WX
8045 Timber Mem	OK	WOOD_CYL	STONE-PINE-	11.28	11.28	0.07	24 0.9D+WY
8046 Timber Mem	OK	WOOD_CYL	STONE-PINE-	11.28	11.28	0.01	23 0.9D+WX
8047 Timber Mem	OK	WOOD_CYL	STONE-PINE-	13.82	13.82	0.04	23 0.9D+WX
8048 Timber Mem	OK	WOOD_CYL	STONE-PINE-	13.82	13.82	0.01	24 0.9D+WY
8049 Timber Mem	OK	WOOD_CYL	STONE-PINE-	11.28	11.28	0.05	20 1.4D
8050 Timber Mem	OK	WOOD_CYL	STONE-PINE-	13.82	13.82	0.05	23 0.9D+WX
8051 Timber Mem	OK	WOOD_CYL	STONE-PINE-	13.82	13.82	0.01	20 1.4D
8052 Timber Mem	OK	WOOD_CYL	STONE-PINE-	13.82	13.82	0.05	23 0.9D+WX
8053 Timber Mem	OK	WOOD_CYL	STONE-PINE-	13.82	13.82	0.01	24 0.9D+WY
8054 Timber Mem	OK	WOOD_CYL	STONE-PINE-	11.28	11.28	0.07	20 1.4D
8055 Timber Mem	OK	WOOD_CYL	STONE-PINE-	13.82	13.82	0.05	23 0.9D+WX
8056 Timber Mem	OK	WOOD_CYL	STONE-PINE-	13.82	13.82	0.01	20 1.4D
8057 Timber Mem	OK	WOOD_CYL	STONE-PINE-	13.82	13.82	0.05	23 0.9D+WX
8058 Timber Mem	OK	WOOD_CYL	STONE-PINE-	13.82	13.82	0.01	24 0.9D+WY
8059 Timber Mem	OK	WOOD_CYL	STONE-PINE-	11.28	11.28	0.08	20 1.4D
8060 Timber Mem	OK	WOOD_CYL	STONE-PINE-	13.82	13.82	0.06	23 0.9D+WX
8061 Timber Mem	OK	WOOD_CYL	STONE-PINE-	11.28	11.28	0.03	24 0.9D+WY
8062 Timber Mem	OK	WOOD_CYL	STONE-PINE-	11.28	11.28	0.02	24 0.9D+WY
8063 Timber Mem	OK	WOOD_CYL	STONE-PINE-	11.28	11.28	0.05	24 0.9D+WY
8064 Timber Mem	OK	WOOD_CYL	STONE-PINE-	11.28	11.28	0.01	24 0.9D+WY
8065 Timber Mem	OK	WOOD_CYL	STONE-PINE-	11.28	11.28	0.01	24 0.9D+WY
8066 Timber Mem	OK	WOOD_CYL	STONE-PINE-	11.28	11.28	0.01	24 0.9D+WY
8067 Timber Mem	OK	WOOD_CYL	STONE-PINE-	11.28	11.28	0.03	24 0.9D+WY
8068 Timber Mem	OK	WOOD_CYL	STONE-PINE-	11.28	11.28	0.01	24 0.9D+WY
8069 Timber Mem	OK	WOOD_CYL	STONE-PINE-	11.28	11.28	0.01	23 0.9D+WX
8070 Timber Mem	OK	WOOD_CYL	STONE-PINE-	13.82	13.82	0.05	24 0.9D+WY
8071 Timber Mem	OK	WOOD_CYL	STONE-PINE-	13.82	13.82	0.01	24 0.9D+WY
8072 Timber Mem	OK	WOOD_CYL	STONE-PINE-	11.28	11.28	0.05	20 1.4D
8073 Timber Mem	OK	WOOD_CYL	STONE-PINE-	13.82	13.82	0.05	24 0.9D+WY
8074 Timber Mem	OK	WOOD_CYL	STONE-PINE-	13.82	13.82	0.02	23 0.9D+WX
8075 Timber Mem	OK	WOOD_CYL	STONE-PINE-	13.82	13.82	0.05	24 0.9D+WY
8076 Timber Mem	OK	WOOD_CYL	STONE-PINE-	13.82	13.82	0.01	20 1.4D
8077 Timber Mem	OK	WOOD_CYL	STONE-PINE-	11.28	11.28	0.06	20 1.4D
8078 Timber Mem	OK	WOOD_CYL	STONE-PINE-	13.82	13.82	0.05	24 0.9D+WY
8079 Timber Mem	OK	WOOD_CYL	STONE-PINE-	13.82	13.82	0.02	23 0.9D+WX
8080 Timber Mem	OK	WOOD_CYL	STONE-PINE-	13.82	13.82	0.05	24 0.9D+WY
8081 Timber Mem	OK	WOOD_CYL	STONE-PINE-	13.82	13.82	0.01	23 0.9D+WX
8082	OK	WOOD_CYL	STONE-PINE-	11.28	11.28	0.07	20 1.4D
9000 Timber Mem	OK	WOOD_CYL	STONE-PINE-	33.85	33.85	0.02	20 1.4D
9001 Timber Mem	OK	WOOD_CYL	STONE-PINE-	33.85	33.85	0.02	20 1.4D
9002 Timber Mem	OK	WOOD_CYL	STONE-PINE-	33.85	33.85	0.02	20 1.4D
9003 Timber Mem	OK	WOOD_CYL	STONE-PINE-	33.85	33.85	0.02	20 1.4D
9004 Timber Mem	OK	WOOD_CYL	STONE-PINE-	33.85	33.85	0.02	20 1.4D
9005 Timber Mem	OK	WOOD_CYL	STONE-PINE-	33.85	33.85	0.02	20 1.4D
9006 Timber Mem	OK	WOOD_CYL	STONE-PINE-	33.85	33.85	0.02	20 1.4D
9007 Timber Mem	OK	WOOD_CYL	STONE-PINE-	33.85	33.85	0.02	20 1.4D

Figure 6-11 Design Results for the Truss Members

Therefore, further optimization of the members dimensions will be conducted for economic reasons.

6.4. Optimization

6.4.1. Members Dimensioning

With the analysis software, many iterations were evaluated to optimize the wood sections for each category. These categories are divided into two parts, the four corner columns and the truss system. The analysis, as shown in the figure below, resulted in 19 cm diameter members for the columns, and 5 cm for the truss system.

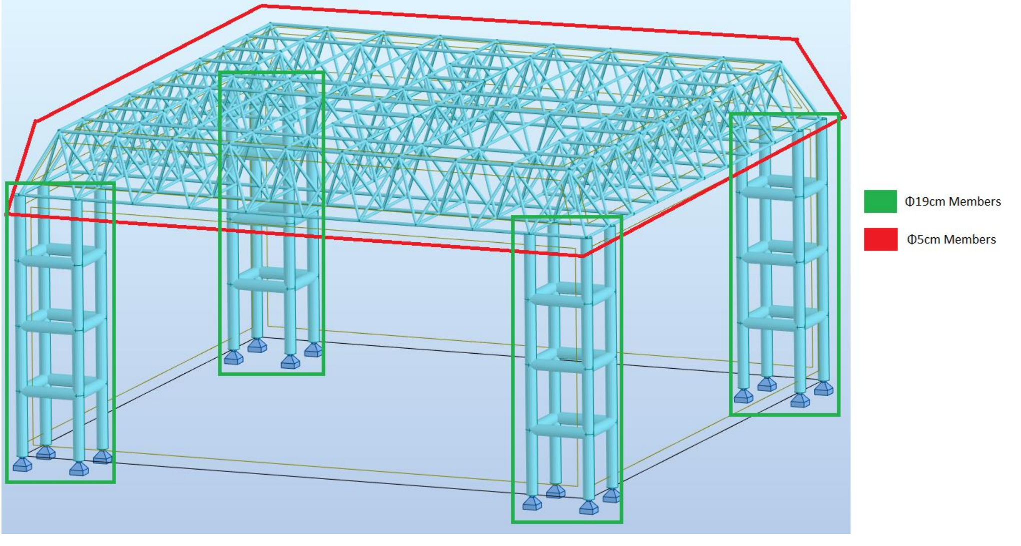


Figure 6-12 Structure Model with 19 cm Diameter Members for Columns and 5 cm for Truss Members

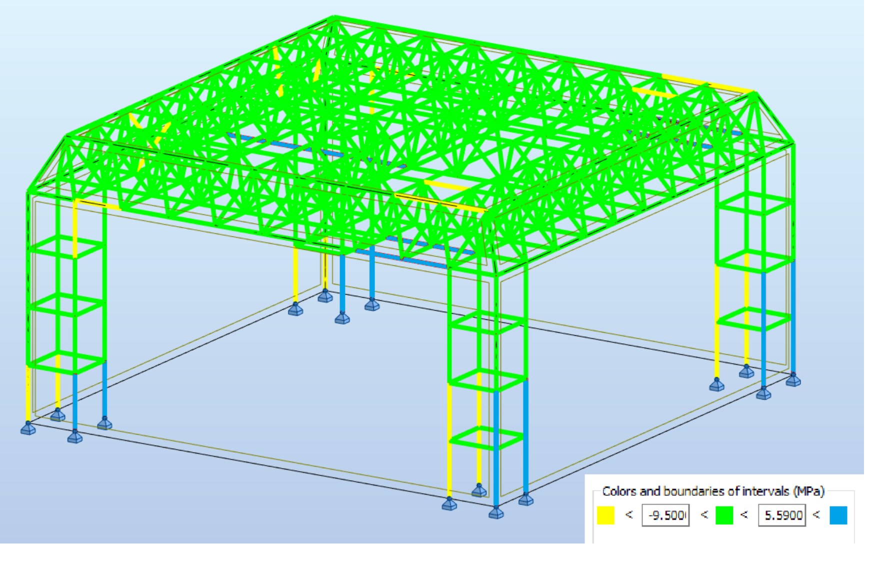


Figure 6-13 Model Analysis Map of Optimized Members Subjected to Ultimate Limit State

The analysis shows that the stresses were reduced due to the increase of the diameter of the column members.

ANSI/AWC NDS-2012 LRFD - Member Verification (ULS) 1001to1015 2000to2095 3000to3003 4000to4127 500...

Results | Messages

Member		Section	Material	Lay	Laz	Ratio	Case
1001 Timber Mem	OK	WOOD_19cm	STONE-PINE-	6.46	6.46	0.22	23 0.9D+WX
1002 Timber Mem	OK	WOOD_19cm	STONE-PINE-	6.46	6.46	0.16	23 0.9D+WX
1003 Timber Mem	OK	WOOD_19cm	STONE-PINE-	6.46	6.46	0.12	23 0.9D+WX
1004 Timber Mem	OK	WOOD_19cm	STONE-PINE-	6.46	6.46	0.56	24 0.9D+WY
1005 Timber Mem	OK	WOOD_19cm	STONE-PINE-	6.46	6.46	0.38	24 0.9D+WY
1006 Timber Mem	OK	WOOD_19cm	STONE-PINE-	6.46	6.46	0.21	24 0.9D+WY
1007 Timber Mem	OK	WOOD_19cm	STONE-PINE-	6.46	6.46	0.11	23 0.9D+WX
1008 Timber Mem	OK	WOOD_19cm	STONE-PINE-	6.46	6.46	0.38	23 0.9D+WX
1009 Timber Mem	OK	WOOD_19cm	STONE-PINE-	6.46	6.46	0.20	24 0.9D+WY
1010 Timber Mem	OK	WOOD_19cm	STONE-PINE-	6.46	6.46	0.10	24 0.9D+WY
1011 Timber Mem	OK	WOOD_19cm	STONE-PINE-	6.46	6.46	0.04	24 0.9D+WY
1012 Timber Mem	OK	WOOD_19cm	STONE-PINE-	6.46	6.46	0.56	23 0.9D+WX
1013 Timber Mem	OK	WOOD_19cm	STONE-PINE-	6.46	6.46	0.38	23 0.9D+WX
1014 Timber Mem	OK	WOOD_19cm	STONE-PINE-	6.46	6.46	0.21	23 0.9D+WX
1015 Timber Mem	OK	WOOD_19cm	STONE-PINE-	6.46	6.46	0.11	24 0.9D+WY
2000 Timber Mem	OK	WOOD_19cm	STONE-PINE-	5.94	5.94	0.77	23 0.9D+WX
2001 Timber Mem	OK	WOOD_19cm	STONE-PINE-	5.94	5.94	0.96	24 0.9D+WY
2002 Timber Mem	OK	WOOD_19cm	STONE-PINE-	5.94	5.94	0.96	23 0.9D+WX
2003 Timber Mem	OK	WOOD_19cm	STONE-PINE-	5.94	5.94	0.77	24 0.9D+WY
2004 Timber Mem	OK	WOOD_19cm	STONE-PINE-	5.94	5.94	0.43	23 0.9D+WX
2005 Timber Mem	OK	WOOD_19cm	STONE-PINE-	5.94	5.94	0.38	24 0.9D+WY
2006 Timber Mem	OK	WOOD_19cm	STONE-PINE-	5.94	5.94	0.38	23 0.9D+WX
2007 Timber Mem	OK	WOOD_19cm	STONE-PINE-	5.94	5.94	0.43	24 0.9D+WY
2008 Timber Mem	OK	WOOD_19cm	STONE-PINE-	5.94	5.94	0.37	23 0.9D+WX
2009 Timber Mem	OK	WOOD_19cm	STONE-PINE-	5.94	5.94	0.19	24 0.9D+WY
2010 Timber Mem	OK	WOOD_19cm	STONE-PINE-	5.94	5.94	0.19	23 0.9D+WX
2011 Timber Mem	OK	WOOD_19cm	STONE-PINE-	5.94	5.94	0.37	24 0.9D+WY
2012 Timber Mem	OK	WOOD_19cm	STONE-PINE-	6.46	6.46	0.56	24 0.9D+WY
2013 Timber Mem	OK	WOOD_19cm	STONE-PINE-	6.46	6.46	0.38	24 0.9D+WY
2014 Timber Mem	OK	WOOD_19cm	STONE-PINE-	6.46	6.46	0.21	24 0.9D+WY
2015 Timber Mem	OK	WOOD_19cm	STONE-PINE-	6.46	6.46	0.19	23 0.9D+WX
2016 Timber Mem	OK	WOOD_19cm	STONE-PINE-	6.46	6.46	0.29	24 0.9D+WY
2017 Timber Mem	OK	WOOD_19cm	STONE-PINE-	6.46	6.46	0.22	24 0.9D+WY
2018 Timber Mem	OK	WOOD_19cm	STONE-PINE-	6.46	6.46	0.18	23 0.9D+WX
2019 Timber Mem	OK	WOOD_19cm	STONE-PINE-	6.46	6.46	0.17	23 0.9D+WX
2020 Timber Mem	OK	WOOD_19cm	STONE-PINE-	6.46	6.46	0.27	24 0.9D+WY
2021 Timber Mem	OK	WOOD_19cm	STONE-PINE-	6.46	6.46	0.20	24 0.9D+WY
2022 Timber Mem	OK	WOOD_19cm	STONE-PINE-	6.46	6.46	0.19	23 0.9D+WX
2023 Timber Mem	OK	WOOD_19cm	STONE-PINE-	6.46	6.46	0.18	23 0.9D+WX
2024 Timber Mem	OK	WOOD_19cm	STONE-PINE-	6.46	6.46	0.38	24 0.9D+WY
2025 Timber Mem	OK	WOOD_19cm	STONE-PINE-	6.46	6.46	0.20	24 0.9D+WY
2026 Timber Mem	OK	WOOD_19cm	STONE-PINE-	6.46	6.46	0.18	23 0.9D+WX
2027 Timber Mem	OK	WOOD_19cm	STONE-PINE-	6.46	6.46	0.20	23 0.9D+WX
2028 Timber Mem	OK	WOOD_19cm	STONE-PINE-	5.94	5.94	0.58	23 0.9D+WX
2029 Timber Mem	OK	WOOD_19cm	STONE-PINE-	5.94	5.94	0.77	24 0.9D+WY
2030 Timber Mem	OK	WOOD_19cm	STONE-PINE-	5.94	5.94	0.59	23 0.9D+WX
2031 Timber Mem	OK	WOOD_19cm	STONE-PINE-	5.94	5.94	0.96	24 0.9D+WY
2032 Timber Mem	OK	WOOD_19cm	STONE-PINE-	5.94	5.94	0.43	23 0.9D+WX
2033 Timber Mem	OK	WOOD_19cm	STONE-PINE-	5.94	5.94	0.43	24 0.9D+WY
2034 Timber Mem	OK	WOOD_19cm	STONE-PINE-	5.94	5.94	0.44	23 0.9D+WX
2035 Timber Mem	OK	WOOD_19cm	STONE-PINE-	5.94	5.94	0.38	24 0.9D+WY
2036 Timber Mem	OK	WOOD_19cm	STONE-PINE-	5.94	5.94	0.52	23 0.9D+WX
2037 Timber Mem	OK	WOOD_19cm	STONE-PINE-	5.94	5.94	0.37	24 0.9D+WY

Calc. Note | Close | Help

Ratio: Analysis | Map

Calculation points
Division: n = 3
Extremes: none
Additional: none

Figure 6-14 Optimized Design Results for the Column Members

ANSI/AWC NDS-2012 LRFD - Member Verification (ULS) 1001to1015 2000to2095 3000to3003 4000to4127 5000to5027...

Results | Messages

Calc. Note | Close | Help

Ratio: Analysis | Map

Calculation points
Division: n = 3
Extremes: none
Additional: none

Member		Section	Material	Lay	Laz	Ratio	Case
8036 Timber Member1_8	OK	WOOD_5cm	STONE-PINE-	22.57	22.57	0.07	20 1.4D
8037 Timber Member1_8	OK	WOOD_5cm	STONE-PINE-	27.64	27.64	0.01	24 0.9D+WY
8038 Timber Member1_8	OK	WOOD_5cm	STONE-PINE-	22.57	22.57	0.05	25 0.9D+EX
8039 Timber Member1_8	OK	WOOD_5cm	STONE-PINE-	22.57	22.57	0.04	25 0.9D+EX
8040 Timber Member1_8	OK	WOOD_5cm	STONE-PINE-	22.57	22.57	0.17	23 0.9D+WX
8041 Timber Member1_8	OK	WOOD_5cm	STONE-PINE-	22.57	22.57	0.07	23 0.9D+WX
8042 Timber Member1_8	OK	WOOD_5cm	STONE-PINE-	22.57	22.57	0.03	25 0.9D+EX
8043 Timber Member1_8	OK	WOOD_5cm	STONE-PINE-	22.57	22.57	0.03	23 0.9D+WX
8044 Timber Member1_8	OK	WOOD_5cm	STONE-PINE-	22.57	22.57	0.25	23 0.9D+WX
8045 Timber Member1_8	OK	WOOD_5cm	STONE-PINE-	22.57	22.57	0.45	24 0.9D+WY
8046 Timber Member1_8	OK	WOOD_5cm	STONE-PINE-	22.57	22.57	0.05	25 0.9D+EX
8047 Timber Member1_8	OK	WOOD_5cm	STONE-PINE-	27.64	27.64	0.22	23 0.9D+WX
8048 Timber Member1_8	OK	WOOD_5cm	STONE-PINE-	27.64	27.64	0.02	24 0.9D+WY
8049 Timber Member1_8	OK	WOOD_5cm	STONE-PINE-	22.57	22.57	0.05	20 1.4D
8050 Timber Member1_8	OK	WOOD_5cm	STONE-PINE-	27.64	27.64	0.17	23 0.9D+WX
8051 Timber Member1_8	OK	WOOD_5cm	STONE-PINE-	27.64	27.64	0.02	20 1.4D
8052 Timber Member1_8	OK	WOOD_5cm	STONE-PINE-	27.64	27.64	0.22	23 0.9D+WX
8053 Timber Member1_8	OK	WOOD_5cm	STONE-PINE-	27.64	27.64	0.03	24 0.9D+WY
8054 Timber Member1_8	OK	WOOD_5cm	STONE-PINE-	22.57	22.57	0.07	20 1.4D
8055 Timber Member1_8	OK	WOOD_5cm	STONE-PINE-	27.64	27.64	0.16	23 0.9D+WX
8056 Timber Member1_8	OK	WOOD_5cm	STONE-PINE-	27.64	27.64	0.01	25 0.9D+EX
8057 Timber Member1_8	OK	WOOD_5cm	STONE-PINE-	27.64	27.64	0.22	23 0.9D+WX
8058 Timber Member1_8	OK	WOOD_5cm	STONE-PINE-	27.64	27.64	0.03	24 0.9D+WY
8059 Timber Member1_8	OK	WOOD_5cm	STONE-PINE-	22.57	22.57	0.08	20 1.4D
8060 Timber Member1_8	OK	WOOD_5cm	STONE-PINE-	27.64	27.64	0.25	23 0.9D+WX
8061 Timber Member1_8	OK	WOOD_5cm	STONE-PINE-	22.57	22.57	0.07	23 0.9D+WX
8062 Timber Member1_8	OK	WOOD_5cm	STONE-PINE-	22.57	22.57	0.06	23 0.9D+WX
8063 Timber Member1_8	OK	WOOD_5cm	STONE-PINE-	22.57	22.57	0.23	24 0.9D+WY
8064 Timber Member1_8	OK	WOOD_5cm	STONE-PINE-	22.57	22.57	0.09	24 0.9D+WY
8065 Timber Member1_8	OK	WOOD_5cm	STONE-PINE-	22.57	22.57	0.04	23 0.9D+WX
8066 Timber Member1_8	OK	WOOD_5cm	STONE-PINE-	22.57	22.57	0.07	24 0.9D+WY
8067 Timber Member1_8	OK	WOOD_5cm	STONE-PINE-	22.57	22.57	0.27	24 0.9D+WY
8068 Timber Member1_8	OK	WOOD_5cm	STONE-PINE-	22.57	22.57	0.01	25 0.9D+EX
8069 Timber Member1_8	OK	WOOD_5cm	STONE-PINE-	22.57	22.57	0.01	23 0.9D+WX
8070 Timber Member1_8	OK	WOOD_5cm	STONE-PINE-	27.64	27.64	0.23	24 0.9D+WY
8071 Timber Member1_8	OK	WOOD_5cm	STONE-PINE-	27.64	27.64	0.01	24 0.9D+WY
8072 Timber Member1_8	OK	WOOD_5cm	STONE-PINE-	22.57	22.57	0.08	23 0.9D+WX
8073 Timber Member1_8	OK	WOOD_5cm	STONE-PINE-	27.64	27.64	0.17	24 0.9D+WY
8074 Timber Member1_8	OK	WOOD_5cm	STONE-PINE-	27.64	27.64	0.10	23 0.9D+WX
8075 Timber Member1_8	OK	WOOD_5cm	STONE-PINE-	27.64	27.64	0.22	24 0.9D+WY
8076 Timber Member1_8	OK	WOOD_5cm	STONE-PINE-	27.64	27.64	0.01	20 1.4D
8077 Timber Member1_8	OK	WOOD_5cm	STONE-PINE-	22.57	22.57	0.07	20 1.4D
8078 Timber Member1_8	OK	WOOD_5cm	STONE-PINE-	27.64	27.64	0.17	24 0.9D+WY
8079 Timber Member1_8	OK	WOOD_5cm	STONE-PINE-	27.64	27.64	0.10	23 0.9D+WX
8080 Timber Member1_8	OK	WOOD_5cm	STONE-PINE-	27.64	27.64	0.23	24 0.9D+WY
8081 Timber Member1_8	OK	WOOD_5cm	STONE-PINE-	27.64	27.64	0.01	23 0.9D+WX
8082	OK	WOOD_5cm	STONE-PINE-	22.57	22.57	0.07	20 1.4D
9000 Timber Member1_9	OK	WOOD_5cm	STONE-PINE-	67.70	67.70	0.02	20 1.4D
9001 Timber Member1_9	OK	WOOD_5cm	STONE-PINE-	67.70	67.70	0.03	23 0.9D+WX
9002 Timber Member1_9	OK	WOOD_5cm	STONE-PINE-	67.70	67.70	0.02	20 1.4D
9003 Timber Member1_9	OK	WOOD_5cm	STONE-PINE-	67.70	67.70	0.03	23 0.9D+WX
9004 Timber Member1_9	OK	WOOD_5cm	STONE-PINE-	67.70	67.70	0.05	23 0.9D+WX
9005 Timber Member1_9	OK	WOOD_5cm	STONE-PINE-	67.70	67.70	0.07	23 0.9D+WX

Figure 6-15 Optimized Design Results for the Truss Members

6.4.2. Bracing

The previous results show that the columns have too large dimensions. That is mainly due to the lateral forces acting upon the system, for which the stresses are taken by the columns, resulting in their large dimensions. However, this problem can be further optimized by providing bracing to each column system. The bracing provided will thus increase the columns rigidity, and counteract the lateral forces more effectively, and therefore decreasing significantly the members dimensions.

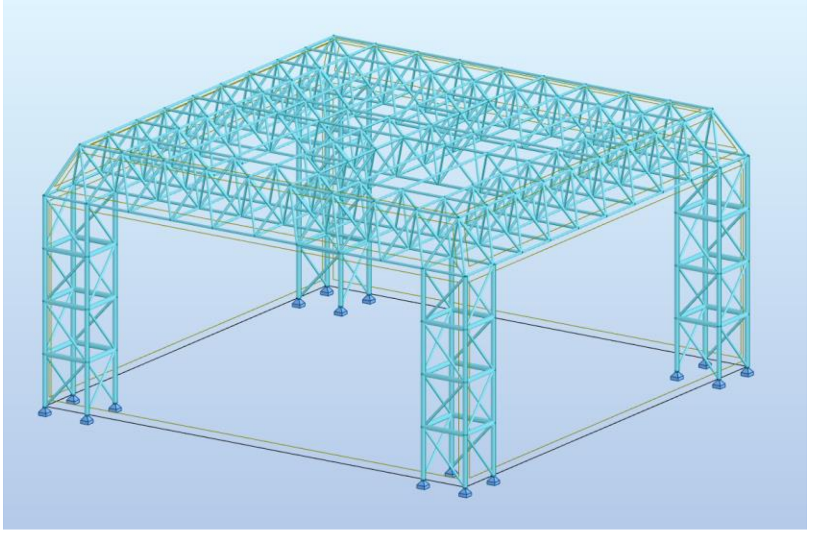


Figure 6-16 Robot Model with Column Bracing System

The following results show the decrease of the column members dimensions to 10 cm, with 5 cm bracing members. This system is shown to be more economic and increases the overall stability of the structure.

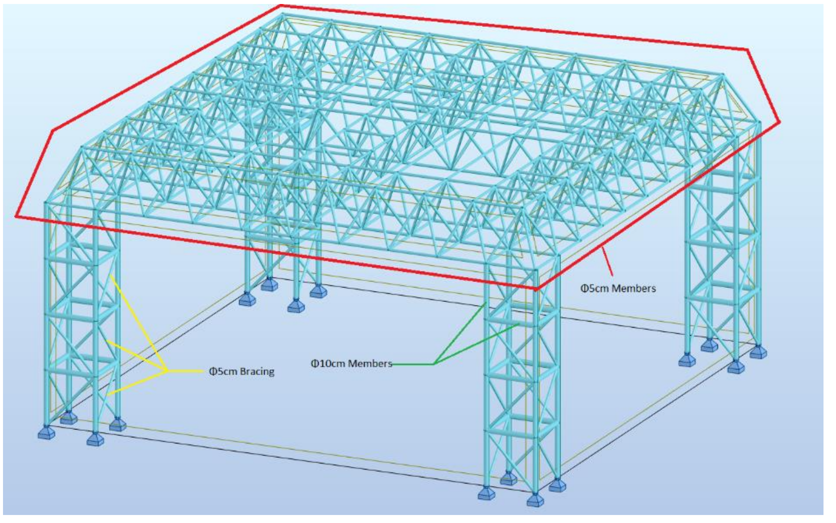


Figure 6-17 Structure Model with 5 cm diameter Bracing, 10 cm Diameter Members for Columns and 5 cm for Truss Members

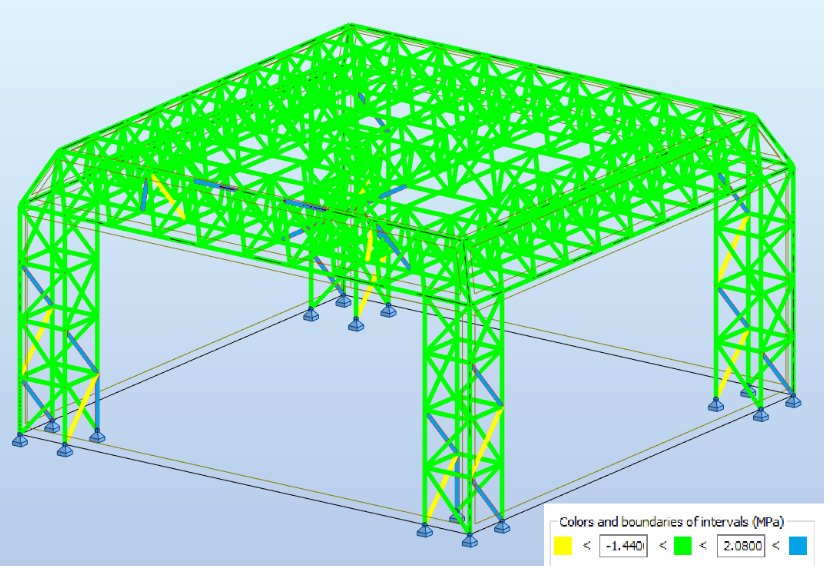


Figure 6-18 Model Analysis Map of Optimized Braced Members Subjected to Ultimate Limit State

The analysis shows that the column sections can now pass the design test at 10 cm diameter, noting that the bracing members are now carrying the stresses due to the lateral forces instead of the vertical elements.

ANSI/AWC NDS-2012 LRFD - Member Verification (ULS) 1001to1015 2000to2095 3000to3003 4000to4127 50...

Results | Messages

Calc. Note | Close | Help

Ratio: Analysis | Map

Calculation points
Division: n = 3
Extremes: none
Additional: none

Member		Section	Material	Lay	Laz	Ratio	Case
1001 Timber Mem	OK	WOOD_10cm	STONE-PINE-	12.27	12.27	0.38	23 0.9D+WX
1002 Timber Mem	OK	WOOD_10cm	STONE-PINE-	12.27	12.27	0.21	24 0.9D+WY
1003 Timber Mem	OK	WOOD_10cm	STONE-PINE-	12.27	12.27	0.10	23 0.9D+WX
1004 Timber Mem	OK	WOOD_10cm	STONE-PINE-	12.27	12.27	0.82	24 0.9D+WY
1005 Timber Mem	OK	WOOD_10cm	STONE-PINE-	12.27	12.27	0.67	24 0.9D+WY
1006 Timber Mem	OK	WOOD_10cm	STONE-PINE-	12.27	12.27	0.42	24 0.9D+WY
1007 Timber Mem	OK	WOOD_10cm	STONE-PINE-	12.27	12.27	0.18	24 0.9D+WY
1008 Timber Mem	OK	WOOD_10cm	STONE-PINE-	12.27	12.27	0.06	24 0.9D+WY
1009 Timber Mem	OK	WOOD_10cm	STONE-PINE-	12.27	12.27	0.05	23 0.9D+WX
1010 Timber Mem	OK	WOOD_10cm	STONE-PINE-	12.27	12.27	0.02	24 0.9D+WY
1011 Timber Mem	OK	WOOD_10cm	STONE-PINE-	12.27	12.27	0.03	24 0.9D+WY
1012 Timber Mem	OK	WOOD_10cm	STONE-PINE-	12.27	12.27	0.84	23 0.9D+WX
1013 Timber Mem	OK	WOOD_10cm	STONE-PINE-	12.27	12.27	0.68	23 0.9D+WX
1014 Timber Mem	OK	WOOD_10cm	STONE-PINE-	12.27	12.27	0.39	23 0.9D+WX
1015 Timber Mem	OK	WOOD_10cm	STONE-PINE-	12.27	12.27	0.21	23 0.9D+WX
2000 Timber Mem	OK	WOOD_10cm	STONE-PINE-	11.28	11.28	0.15	24 0.9D+WY
2001 Timber Mem	OK	WOOD_10cm	STONE-PINE-	11.28	11.28	0.07	24 0.9D+WY
2002 Timber Mem	OK	WOOD_10cm	STONE-PINE-	11.28	11.28	0.08	23 0.9D+WX
2003 Timber Mem	OK	WOOD_10cm	STONE-PINE-	11.28	11.28	0.08	24 0.9D+WY
2004 Timber Mem	OK	WOOD_10cm	STONE-PINE-	11.28	11.28	0.08	24 0.9D+WY
2005 Timber Mem	OK	WOOD_10cm	STONE-PINE-	11.28	11.28	0.07	24 0.9D+WY
2006 Timber Mem	OK	WOOD_10cm	STONE-PINE-	11.28	11.28	0.07	23 0.9D+WX
2007 Timber Mem	OK	WOOD_10cm	STONE-PINE-	11.28	11.28	0.14	23 0.9D+WX
2008 Timber Mem	OK	WOOD_10cm	STONE-PINE-	11.28	11.28	0.12	24 0.9D+WY
2009 Timber Mem	OK	WOOD_10cm	STONE-PINE-	11.28	11.28	0.05	23 0.9D+WX
2010 Timber Mem	OK	WOOD_10cm	STONE-PINE-	11.28	11.28	0.04	24 0.9D+WY
2011 Timber Mem	OK	WOOD_10cm	STONE-PINE-	11.28	11.28	0.07	23 0.9D+WX
2012 Timber Mem	OK	WOOD_10cm	STONE-PINE-	12.27	12.27	0.82	24 0.9D+WY
2013 Timber Mem	OK	WOOD_10cm	STONE-PINE-	12.27	12.27	0.67	24 0.9D+WY
2014 Timber Mem	OK	WOOD_10cm	STONE-PINE-	12.27	12.27	0.42	24 0.9D+WY
2015 Timber Mem	OK	WOOD_10cm	STONE-PINE-	12.27	12.27	0.18	24 0.9D+WY
2016 Timber Mem	OK	WOOD_10cm	STONE-PINE-	12.27	12.27	0.56	24 0.9D+WY
2017 Timber Mem	OK	WOOD_10cm	STONE-PINE-	12.27	12.27	0.20	24 0.9D+WY
2018 Timber Mem	OK	WOOD_10cm	STONE-PINE-	12.27	12.27	0.21	24 0.9D+WY
2019 Timber Mem	OK	WOOD_10cm	STONE-PINE-	12.27	12.27	0.07	24 0.9D+WY
2020 Timber Mem	OK	WOOD_10cm	STONE-PINE-	12.27	12.27	0.03	23 0.9D+WX
2021 Timber Mem	OK	WOOD_10cm	STONE-PINE-	12.27	12.27	0.04	24 0.9D+WY
2022 Timber Mem	OK	WOOD_10cm	STONE-PINE-	12.27	12.27	0.04	23 0.9D+WX
2023 Timber Mem	OK	WOOD_10cm	STONE-PINE-	12.27	12.27	0.07	23 0.9D+WX
2024 Timber Mem	OK	WOOD_10cm	STONE-PINE-	12.27	12.27	0.37	23 0.9D+WX
2025 Timber Mem	OK	WOOD_10cm	STONE-PINE-	12.27	12.27	0.38	23 0.9D+WX
2026 Timber Mem	OK	WOOD_10cm	STONE-PINE-	12.27	12.27	0.09	23 0.9D+WX
2027 Timber Mem	OK	WOOD_10cm	STONE-PINE-	12.27	12.27	0.08	23 0.9D+WX
2028 Timber Mem	OK	WOOD_10cm	STONE-PINE-	11.28	11.28	0.15	24 0.9D+WY
2029 Timber Mem	OK	WOOD_10cm	STONE-PINE-	11.28	11.28	0.08	24 0.9D+WY
2030 Timber Mem	OK	WOOD_10cm	STONE-PINE-	11.28	11.28	0.06	23 0.9D+WX
2031 Timber Mem	OK	WOOD_10cm	STONE-PINE-	11.28	11.28	0.07	24 0.9D+WY
2032 Timber Mem	OK	WOOD_10cm	STONE-PINE-	11.28	11.28	0.08	24 0.9D+WY
2033 Timber Mem	OK	WOOD_10cm	STONE-PINE-	11.28	11.28	0.09	24 0.9D+WY
2034 Timber Mem	OK	WOOD_10cm	STONE-PINE-	11.28	11.28	0.07	23 0.9D+WX
2035 Timber Mem	OK	WOOD_10cm	STONE-PINE-	11.28	11.28	0.07	24 0.9D+WY
2036 Timber Mem	OK	WOOD_10cm	STONE-PINE-	11.28	11.28	0.12	24 0.9D+WY
2037 Timber Mem	OK	WOOD_10cm	STONE-PINE-	11.28	11.28	0.06	24 0.9D+WY

3

Figure 6-19 Optimized Design Results for the Column Members with Bracing System

ANSI/AWC NDS-2012 LRFD - Member Verification (ULS) 1001to1015 2000to2095 3000to3003 4000to4127 5000to5027...

Results | Messages

Member		Section	Material	Lay	Laz	Ratio	Case
8036 Timber Member1_8	OK	WOOD_5cm	STONE-PINE-	22.57	22.57	0.07	20 1.4D
8037 Timber Member1_8	OK	WOOD_5cm	STONE-PINE-	27.64	27.64	0.01	24 0.9D+WY
8038 Timber Member1_8	OK	WOOD_5cm	STONE-PINE-	22.57	22.57	0.05	25 0.9D+EX
8039 Timber Member1_8	OK	WOOD_5cm	STONE-PINE-	22.57	22.57	0.04	25 0.9D+EX
8040 Timber Member1_8	OK	WOOD_5cm	STONE-PINE-	22.57	22.57	0.17	23 0.9D+WX
8041 Timber Member1_8	OK	WOOD_5cm	STONE-PINE-	22.57	22.57	0.07	23 0.9D+WX
8042 Timber Member1_8	OK	WOOD_5cm	STONE-PINE-	22.57	22.57	0.03	25 0.9D+EX
8043 Timber Member1_8	OK	WOOD_5cm	STONE-PINE-	22.57	22.57	0.03	23 0.9D+WX
8044 Timber Member1_8	OK	WOOD_5cm	STONE-PINE-	22.57	22.57	0.25	23 0.9D+WX
8045 Timber Member1_8	OK	WOOD_5cm	STONE-PINE-	22.57	22.57	0.45	24 0.9D+WY
8046 Timber Member1_8	OK	WOOD_5cm	STONE-PINE-	22.57	22.57	0.05	25 0.9D+EX
8047 Timber Member1_8	OK	WOOD_5cm	STONE-PINE-	27.64	27.64	0.22	23 0.9D+WX
8048 Timber Member1_8	OK	WOOD_5cm	STONE-PINE-	27.64	27.64	0.02	24 0.9D+WY
8049 Timber Member1_8	OK	WOOD_5cm	STONE-PINE-	22.57	22.57	0.05	20 1.4D
8050 Timber Member1_8	OK	WOOD_5cm	STONE-PINE-	27.64	27.64	0.17	23 0.9D+WX
8051 Timber Member1_8	OK	WOOD_5cm	STONE-PINE-	27.64	27.64	0.02	20 1.4D
8052 Timber Member1_8	OK	WOOD_5cm	STONE-PINE-	27.64	27.64	0.22	23 0.9D+WX
8053 Timber Member1_8	OK	WOOD_5cm	STONE-PINE-	27.64	27.64	0.03	24 0.9D+WY
8054 Timber Member1_8	OK	WOOD_5cm	STONE-PINE-	22.57	22.57	0.07	20 1.4D
8055 Timber Member1_8	OK	WOOD_5cm	STONE-PINE-	27.64	27.64	0.16	23 0.9D+WX
8056 Timber Member1_8	OK	WOOD_5cm	STONE-PINE-	27.64	27.64	0.01	25 0.9D+EX
8057 Timber Member1_8	OK	WOOD_5cm	STONE-PINE-	27.64	27.64	0.22	23 0.9D+WX
8058 Timber Member1_8	OK	WOOD_5cm	STONE-PINE-	27.64	27.64	0.03	24 0.9D+WY
8059 Timber Member1_8	OK	WOOD_5cm	STONE-PINE-	22.57	22.57	0.08	20 1.4D
8060 Timber Member1_8	OK	WOOD_5cm	STONE-PINE-	27.64	27.64	0.25	23 0.9D+WX
8061 Timber Member1_8	OK	WOOD_5cm	STONE-PINE-	22.57	22.57	0.07	23 0.9D+WX
8062 Timber Member1_8	OK	WOOD_5cm	STONE-PINE-	22.57	22.57	0.06	23 0.9D+WX
8063 Timber Member1_8	OK	WOOD_5cm	STONE-PINE-	22.57	22.57	0.23	24 0.9D+WY
8064 Timber Member1_8	OK	WOOD_5cm	STONE-PINE-	22.57	22.57	0.09	24 0.9D+WY
8065 Timber Member1_8	OK	WOOD_5cm	STONE-PINE-	22.57	22.57	0.04	23 0.9D+WX
8066 Timber Member1_8	OK	WOOD_5cm	STONE-PINE-	22.57	22.57	0.07	24 0.9D+WY
8067 Timber Member1_8	OK	WOOD_5cm	STONE-PINE-	22.57	22.57	0.27	24 0.9D+WY
8068 Timber Member1_8	OK	WOOD_5cm	STONE-PINE-	22.57	22.57	0.01	25 0.9D+EX
8069 Timber Member1_8	OK	WOOD_5cm	STONE-PINE-	22.57	22.57	0.01	23 0.9D+WX
8070 Timber Member1_8	OK	WOOD_5cm	STONE-PINE-	27.64	27.64	0.23	24 0.9D+WY
8071 Timber Member1_8	OK	WOOD_5cm	STONE-PINE-	27.64	27.64	0.01	24 0.9D+WY
8072 Timber Member1_8	OK	WOOD_5cm	STONE-PINE-	22.57	22.57	0.08	23 0.9D+WX
8073 Timber Member1_8	OK	WOOD_5cm	STONE-PINE-	27.64	27.64	0.17	24 0.9D+WY
8074 Timber Member1_8	OK	WOOD_5cm	STONE-PINE-	27.64	27.64	0.10	23 0.9D+WX
8075 Timber Member1_8	OK	WOOD_5cm	STONE-PINE-	27.64	27.64	0.22	24 0.9D+WY
8076 Timber Member1_8	OK	WOOD_5cm	STONE-PINE-	27.64	27.64	0.01	20 1.4D
8077 Timber Member1_8	OK	WOOD_5cm	STONE-PINE-	22.57	22.57	0.07	20 1.4D
8078 Timber Member1_8	OK	WOOD_5cm	STONE-PINE-	27.64	27.64	0.17	24 0.9D+WY
8079 Timber Member1_8	OK	WOOD_5cm	STONE-PINE-	27.64	27.64	0.10	23 0.9D+WX
8080 Timber Member1_8	OK	WOOD_5cm	STONE-PINE-	27.64	27.64	0.23	24 0.9D+WY
8081 Timber Member1_8	OK	WOOD_5cm	STONE-PINE-	27.64	27.64	0.01	23 0.9D+WX
8082	OK	WOOD_5cm	STONE-PINE-	22.57	22.57	0.07	20 1.4D
9000 Timber Member1_9	OK	WOOD_5cm	STONE-PINE-	67.70	67.70	0.02	20 1.4D
9001 Timber Member1_9	OK	WOOD_5cm	STONE-PINE-	67.70	67.70	0.03	23 0.9D+WX
9002 Timber Member1_9	OK	WOOD_5cm	STONE-PINE-	67.70	67.70	0.02	20 1.4D
9003 Timber Member1_9	OK	WOOD_5cm	STONE-PINE-	67.70	67.70	0.03	23 0.9D+WX
9004 Timber Member1_9	OK	WOOD_5cm	STONE-PINE-	67.70	67.70	0.05	23 0.9D+WX
9005 Timber Member1_9	OK	WOOD_5cm	STONE-PINE-	67.70	67.70	0.07	23 0.9D+WX

Calc. Note | Close | Help

Ratio: Analysis | Map

Calculation points
Division: n = 3
Extremes: none
Additional: none

Figure 6-20 Optimized Design Results for the Bracing Members

Additionally, the bracing system further limited the structure displacement due to lateral forces than the previous model by 24%.

	UX (cm)	UY (cm)	UZ (cm)	RX (Rad)	RY (Rad)	RZ (Rad)
MAX	4.2	4.1	0.5	0.010	0.020	0.010
Node	[illegible]	[illegible]	424	96	61	227
Case	13	14	14	14	13	ULS/3
Mode						
MIN	-1.1	-0.8	-1.0	-0.020	-0.010	-0.010
Node	439	116	94	21	411	106
Case	ULS/7	ULS/8	ULS/4	14	13	ULS/3
Mode						

Figure 6-21 Maximum Lateral Displacement prior to Bracing

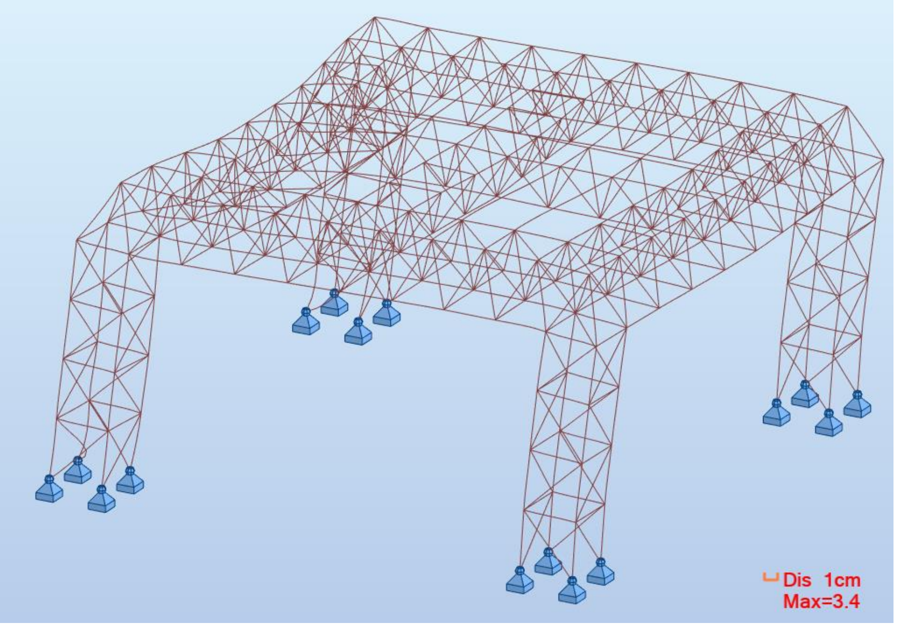
	UX (cm)	UY (cm)	UZ (cm)	RX (Rad)	RY (Rad)	RZ (Rad)
MAX	3.2	3.2	0.5	0.011	0.016	0.058
Node	[illegible]	[illegible]	424	96	61	1
Case	13	14	14	14	13	ULS/4
Mode						
MIN	-0.9	-0.4	-1.1	-0.016	-0.010	-0.058
Node	439	116	94	21	411	26
Case	ULS/7	ULS/8	ULS/4	14	13	ULS/4
Mode						

Figure 6-22 Maximum Lateral Displacement with Bracing

6.5. Lateral Displacement

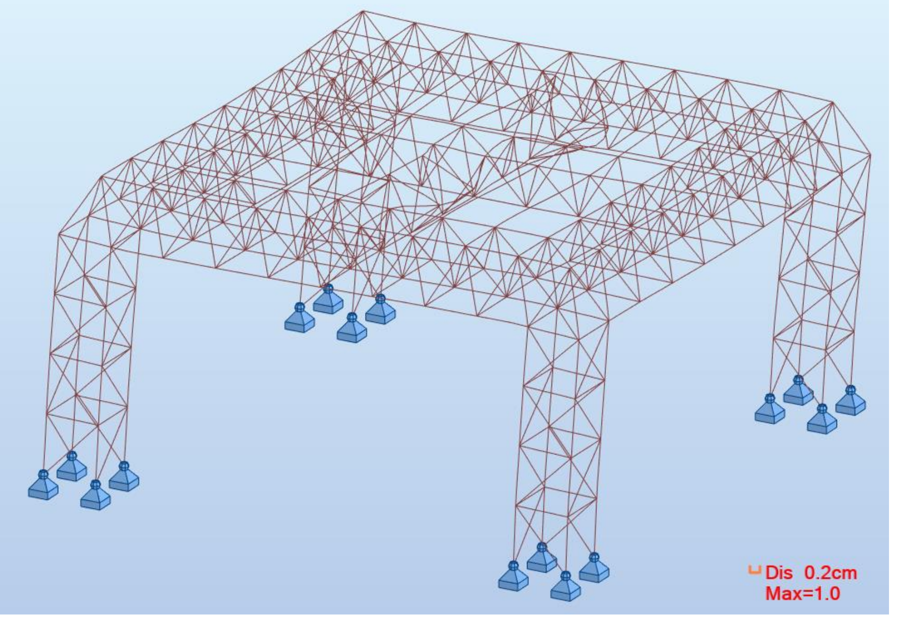
6.5.1. Displacement Due to Wind Load

The following figure below shows a representation of the lateral displacement of the structure due to wind load only, not taking into account any structural weight or load combinations. Note that its maximum is greater than that of the service limit state combination, and that is because the weight of the structure contributes to its stability.



6.5.2. Displacement Due to Earthquake Load

The following figure below shows a representation of the lateral displacement of the structure due to earthquake load only, not taking into account any structural weight or load combinations.



Chapter 7: Foundation

7.1. Foundation Type

Considering the structure to be lightweight, the type of foundation expected is isolated footings. The concept requires cylindrical footings, therefore a cylindrical isolated footing shall be used at each column base, as indicated in the figure.

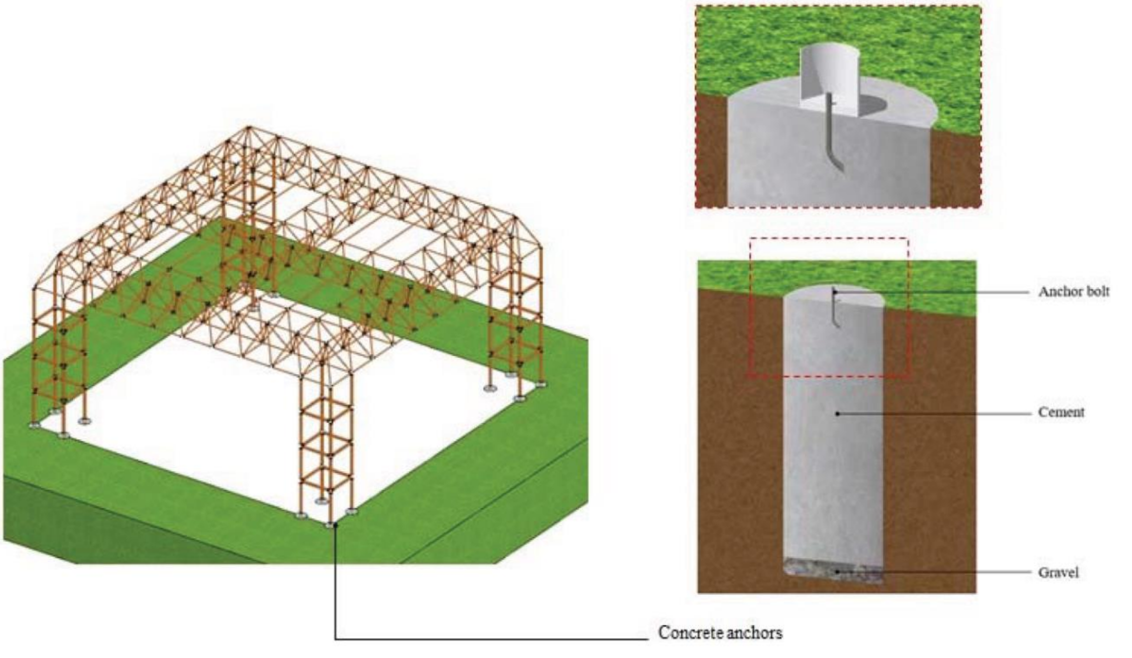


Figure 7-1 Detailed View of the Foundation Type

7.2. Footing Design

The dimensioning of the concrete footings shall be done in accordance with ACI 318 code.

$$\boldsymbol{q = \frac{P_{SLS}}{A}} \qquad (7\text{-}1)$$

Where

q = Allowable soil bearing capacity (T/m^2)

P_{SLS} = Force applied on the footing at service limit state (T)

A = Cross-sectional area of the footing (m^2)

The maximum force applied on a single footing at service limit state was extracted from Robot and the result is displayed in the figure below.

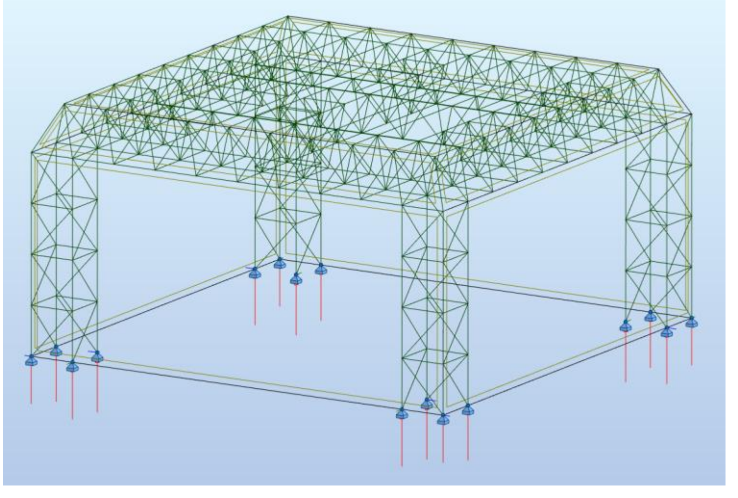


Figure 7-2 Software Results of Base Reactions

	FX (kG)	FY (kG)	FZ (kG)	MX (kGm)	MY (kGm)	MZ (kGm)
MAX	208.26	216.55	5826.18	0.00	0.00	0.00
Node	11	6	11	16	16	11
Case	SLS/3	SLS/2	SLS/2	SLS/3	SLS/2	SLS/3
MIN	-3469.24	-3471.00	-5203.31	-0.00	-0.00	-0.00
Node	61	21	21	36	61	76
Case	SLS/2	SLS/3	SLS/3	SLS/3	SLS/2	SLS/2

Figure 7-3 Maximum Vertical Base Reaction Service Force

Noting that the cross-sectional area of the footing is circular, and knowing the soil bearing capacity is 300 kPa or 30 T/m^2, the diameter of a single footing equates to 50 cm.

7.3. Footing Depth

The footing depth shall be evaluated according to two criteria, to resist the shear force applied by the structure, specifically the two-way or punching shear, and to resist the uplift generated by the lateral forces.

7.3.1. Punching Shear

The critical section of the punching shear, where the two-way shear forces are at a maximum, occurs in an area which offsets each side of a column with half the effective depth of the slab. This section yields a perimeter around the column denoted by b_0.

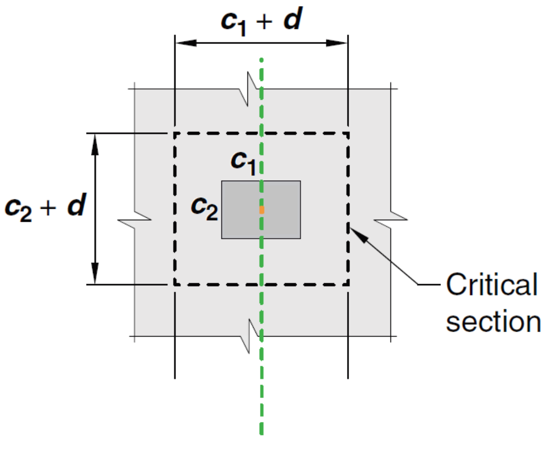


Figure 7-4 Critical Section b_0 for Interior Columns

The punching shear design shall be in accordance with the following formula

$$V_u\ (T) \leq \phi\ V_n \qquad (7\text{-}2)$$

Where V_n is the nominal shear force and it is equal to

$$V_n\ (T) = V_c + V_s \qquad (7\text{-}3)$$

However, no reinforcement will be required, therefore

$$V_u\ (T) \leq \phi\ V_c \qquad (7\text{-}4)$$

The shear strength provided by concrete subjected to punching shear and flexure only is

$$V_c\ (T) = min \begin{cases} 0.17 \left(1 + \dfrac{2}{\beta}\right) \lambda \sqrt{f_c^{'}}\ b_0\ d \\ 0.083 \left(\dfrac{\alpha_s d}{d_0} + 2\right) \lambda \sqrt{f_c^{'}}\ b_0\ d \\ 0.33\ \lambda \sqrt{f_c^{'}}\ b_0\ d \end{cases} \qquad (7\text{-}5)$$

Where

$f_c^{'}$ = Specified compressive strength of concrete (MPa)

λ = Shear reduction factor

b_0 = Critical section of the column (m)

d = Effective depth of concrete (m)

$$\beta = \frac{column\ greater\ dimention}{column\ lesser\ dimension} \qquad (7\text{-}6)$$

$$\alpha_s = \begin{cases} 40 & for\ interior\ columns \\ 30 & for\ edge\ columns \\ 20 & for\ corner\ columns \end{cases}$$

Using the structural analysis software, the critical force applied at ultimate limit state is given in the figure below.

	FX (kG)	FY (kG)	FZ (kG)	MX (kGm)	MY (kGm)	MZ (kGm)
MAX	213.77	219.78	5843.90	0.00	0.00	0.00
Node	61	6	11	16	16	11
Case	ULS/5	ULS/3	ULS/3	ULS/11	ULS/10	ULS/4
MIN	0.66	0.65	675.18	0.00	0.00	0.00
Node	31	11	1	71	66	51
Case	ULS/13	ULS/12	ULS/6	ULS/6	ULS/5	ULS/12

Figure 7-5 Maximum Vertical Base Reaction Ultimate Force

Vu	d	b_0	α_s	β	φVc (1)	φVc (2)	φVc (3)
T	cm	cm			T	T	T
5.8	10	62.8	40	2.00	8.77	17.92	8.51

Thus $$\frac{V_u}{\varphi V_c} = 0.68 < 1$$ (ACI 318-19 Clause 22.5.10.1)

Therefore, a minimum depth of 10 cm is required to resist the punching shear forces without reinforcement.

7.3.2. Soil Bearing Capacity

Using SAFE software, having input the soil subgrade reaction of 3,600 T/m^3 under the 10 cm thick footing, the soil reactions under service load combinations exceeded the soil bearing capacity of 30 T/m^2.

The soil pressure was at its maximum in the center of the footing, therefore increasing the footing's depth was favorable.

After optimization using SAFE, a depth of 40 cm was achieved so that the soil pressure didn't exceed its bearing capacity.

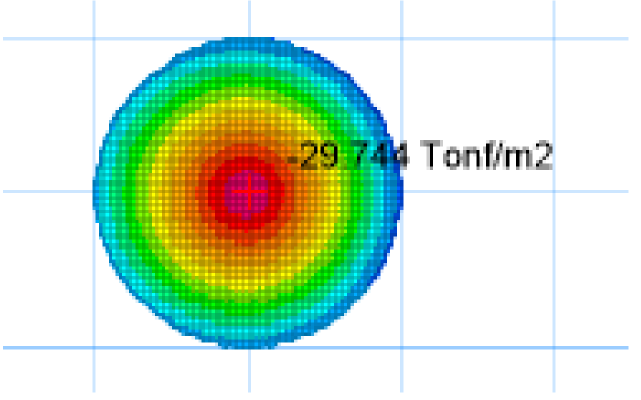


Figure 7-6 Soil Pressure After Depth Modification

$$\frac{q_u}{q_{allowable}} = 0.97 < 1 \qquad \text{(ACI 318-19 Chapter 13)}$$

7.3.3. Settlement

The maximum permissible settlement of a single footing is 25 mm. Analyzing the results from SAFE we can conclude the following.

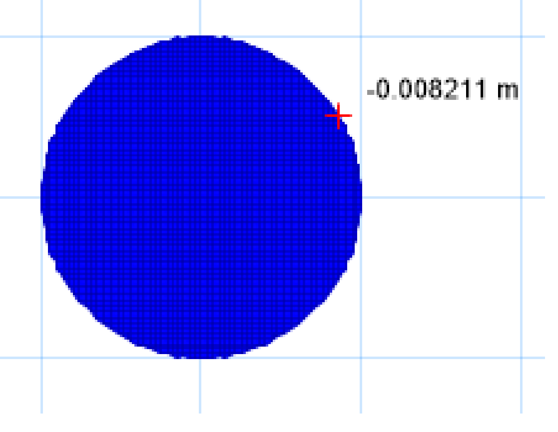


Figure 7-7 Maximum Settlement of the Footing

The maximum settlement from the data shown reaches as high as 8 mm, laying far lower than the limit of 25 mm.

Chapter 8: Base Plate

8.1. Overview

A column base is made with a plate and an anchor rod. The base plate is attached to the bottom of the column, and the anchor rod is embedded into the concrete foundation. The type of column base used in this project is a cylindrical base plate and one anchor rod for each column.

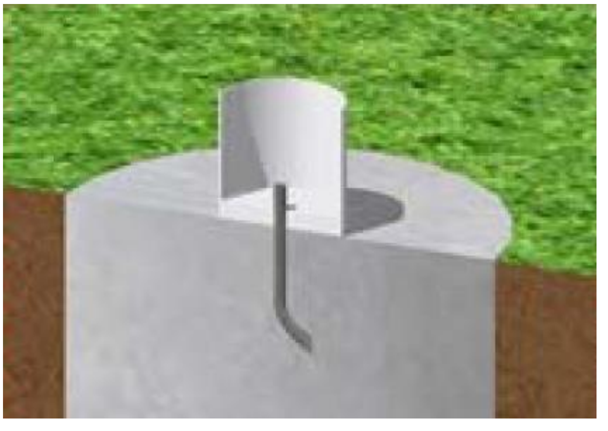


Figure 8-1 Column Base Detailed View

8.2. Base Plate Design

The base plate is subjected to two main forces: axial and shear forces. Since the anchor rod is placed at the plate's centroid, rotation of the column is not restricted thus creating a pinned connection at the base, therefore moment forces are not applicable

The plate and anchor rod design will be based on the critical axial forces, compression or tension, combined with lateral shear forces. The figure below shows the critical case where these forces are at a maximum.

	FX (kG)	FY (kG)	FZ (kG)	MX (kGm)	MY (kGm)	MZ (kGm)
MAX	213.77	219.78	5843.90	0.00	0.00	0.00
Node	61	6	11	16	16	11
Case	ULS/5	ULS/3	ULS/3	14	13	ULS/4
Mode						
MIN	-3485.43	-3487.16	-5288.87	-0.00	-0.00	-0.00
Node	61	21	21	36	61	76
Case	13	14	14	14	13	13
Mode						

Figure 8-2 Maximum Base Plate Forces at Ultimate Limit State

Since the system is one-way symmetrical, two cases will be taken, one where the axial force of 5.2 T is compressive and the other is tensile.

8.2.1. Software Input

The design of the column base will be done using RAM Connection software, based on the AISC 360 provisions.

The two critical load combinations are defined as follows.

Id	Load	Column					
	Description	Axial [T]	V2 [T]	V3 [T]	M2 [T*m]	M3 [T*m]	Load type
1	ULS_Compression	-5.3	3.5	3.5	0	0	Design
2	ULS_Tension	5.3	3.5	3.5	0	0	Design

Figure 8-3 Load Combination Input

8.2.2. Results

The software was set to optimize the set of data given and yield the optimized and economic plate and anchor rod dimensions.

The following dimensions were resulted by the software.

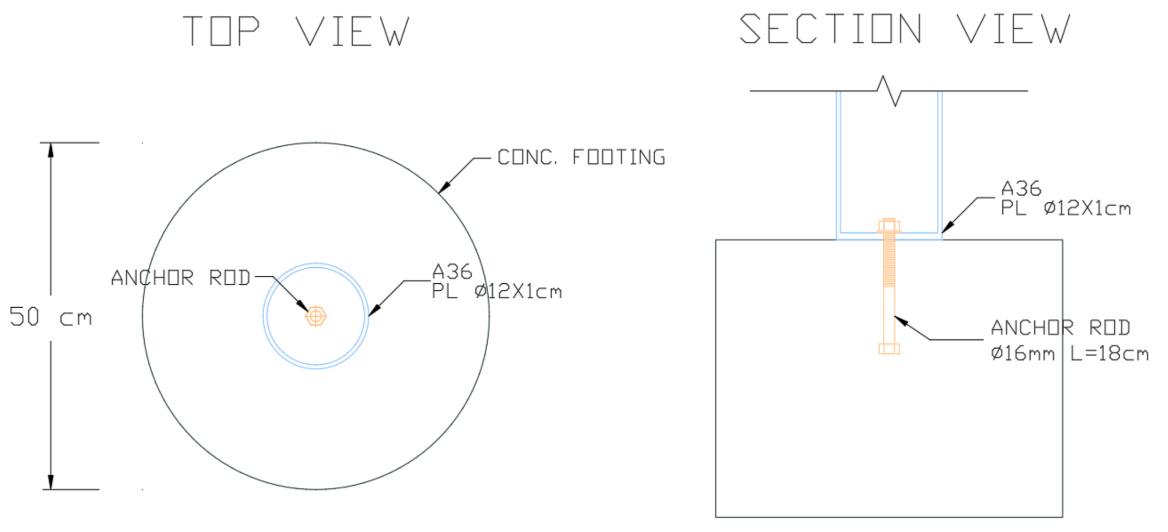


Figure 8-4 Final Dimensions of the Base Plate and Anchor Rod Components

And the detailed design of these following elements resulted in the following data in the figure below. Note that demand/capacity ratio is just below 1, and the critical case was due to tensile stresses combination.

DESIGN CHECK

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Anchor tension	[Ton]	7.63	5.30	ULS_Ten...	0.69	Eq. D-2
Breakout of anchor in tension	[Ton]	8.23	5.30	ULS_Ten...	0.64	Eq. D-3, Sec. D.3.3.4.4
Pullout of anchor in tension	[Ton]	5.86	5.30	ULS_Ten...	0.91	Sec. D.3.3.4.4
Anchor shear	[Ton]	2.32	1.75	ULS_Ten...	0.75	Eq. D-29
Breakout of anchor in shear	[Ton]	4.16	1.75	ULS_Ten...	0.42	Table D.4.1.1, Sec. D.4.3
Breakout of group of anchors in shear	[Ton]	4.16	3.50	ULS_Ten...	0.84	Table D.4.1.1, Sec. D.4.3
Pryout of anchor in shear	[Ton]	16.46	1.75	ULS_Ten...	0.11	Eq. D-3, Table D.4.1.1, Sec. D.4.3
Ratio	**0.91**					

Figure 8-5 Analysis Results for the Dimensioned Column Base

$$\frac{Demand}{Capacity} = 0.91 < 1 \quad \text{(AISC 360-16 Chapter D)}$$

Chapter 9: Connections

9.1. Connection Type

The wooden members of the truss and column systems are connected one to another by a wooden joint. This joint connecting the members forms a connection. This connection, alongside the wooden members, is made of the wooden joint, a small wooden cylinder and glue.

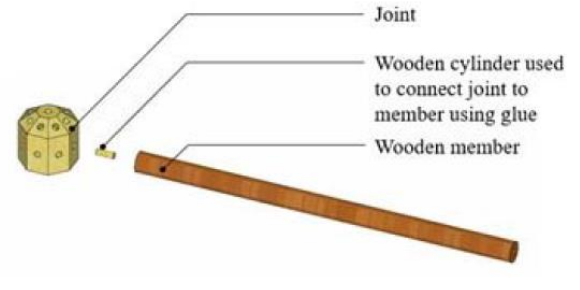


Figure 9-1 Typical Wooden Connection Assembly

This connection does not restrict the wooden member from rotation, thus it is a pinned connection, and no moments shall be present at their position.

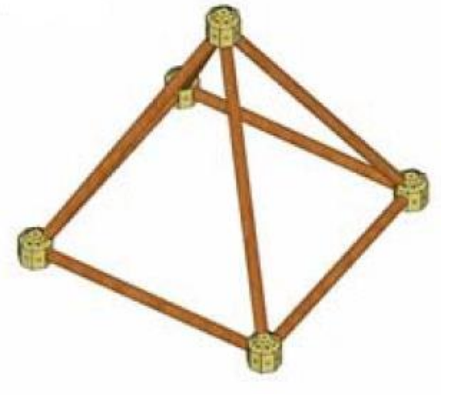


Figure 9-2 Assembled Wooden Frame

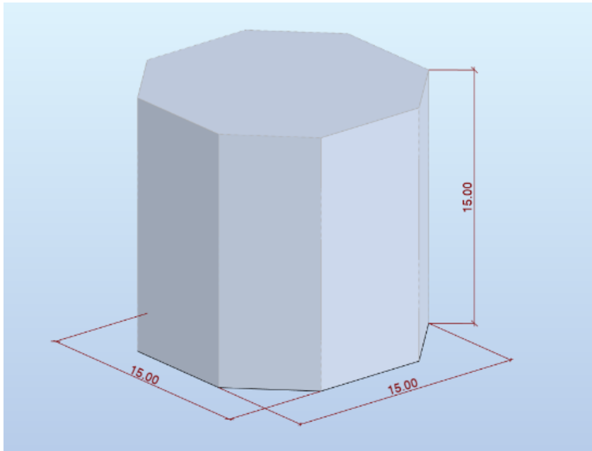


Figure 9-3 Typical Column Connection Dimensions

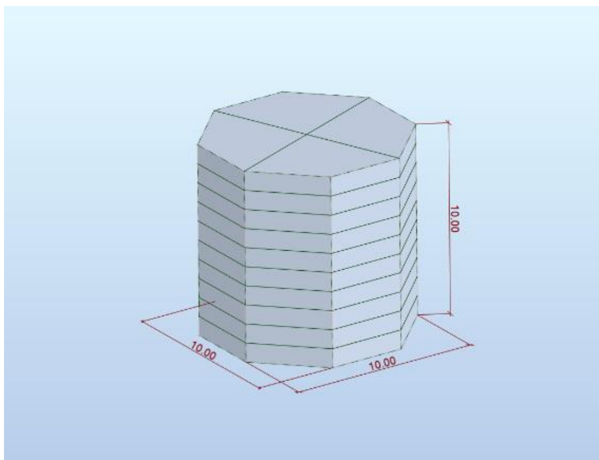


Figure 9-4 Typical Truss Connection Dinemsions

9.2. Connection Design

The design of the wooden connections was divided into two categories: column connections and truss connections. Each category experiences different member dimensions and forces, thus the dimensions of the connections vary between these categories.

The analysis and design of the connections was done using 3D volumetric design in Robot Structural Analysis software.

9.2.1. Column Connection

The connection design for columns was selected according to the critical combination of forces. The critical joint where the forces are maximum is joint 2 as indicated in the figure below.

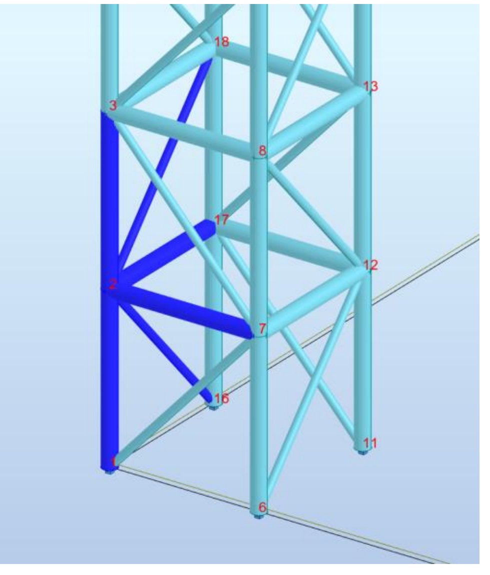


Figure 9-5 Column Joint

Then, evaluating the forces in each joining member yields the values below.

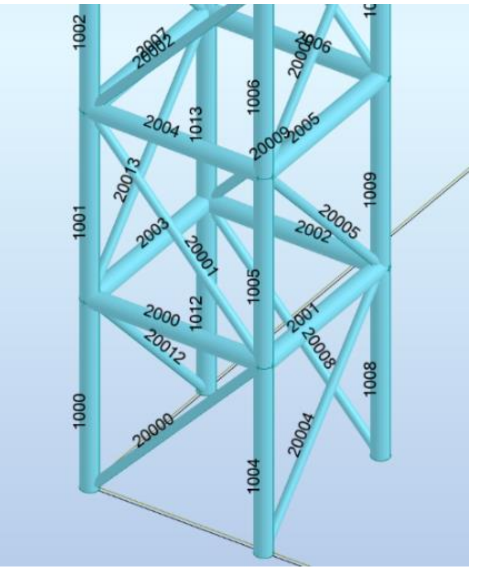


Figure 9-6 Column Members ID

Bar/Node/Case	FX (kG)	FY (kG)	FZ (kG)
1000/ 1/ ULS-	-4616.59	-24.22	-5.92
1000/ 2/ ULS-	-4620.51	-8.69	-16.20
1001/ 2/ ULS-	-2976.33	-71.76	-5.13
1001/ 3/ ULS-	-2980.23	-20.90	-5.13
2000/ 2/ ULS-	-6.63	-133.74	-60.52
2000/ 7/ ULS-	-6.63	-76.29	-64.49
2003/ 17/ ULS-	-77.08	-32.40	-5.07
2003/ 2/ ULS-	-77.08	-0.79	-9.37
20012/ 16/ ULS	-219.86	-66.00	0.32
20012/ 2/ ULS	-221.23	-0.02	-0.79
20013/ 2/ ULS	-1842.35	-0.14	0.10
20013/ 18/ ULS	-1843.37	-66.74	-0.99

Figure 9-7 Column Members Critical Forces

Isolating this joint, then modeling the connection with the forces separately, the stresses in the connection can be determined. The connection dimensions were selected as 15x15x15 cm. Note that the connection model was approximated for simplification reasons.

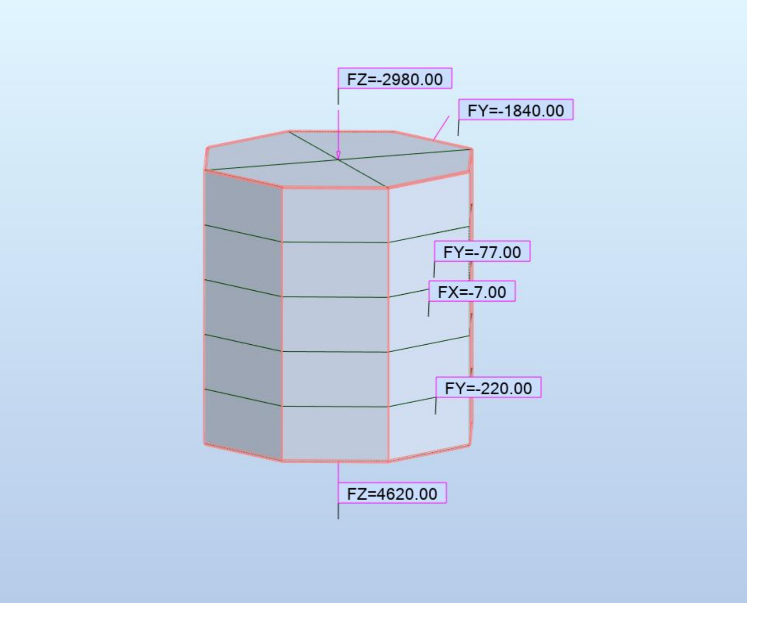


Figure 9-8 Robot Model of the Column Connection with Applied Forces

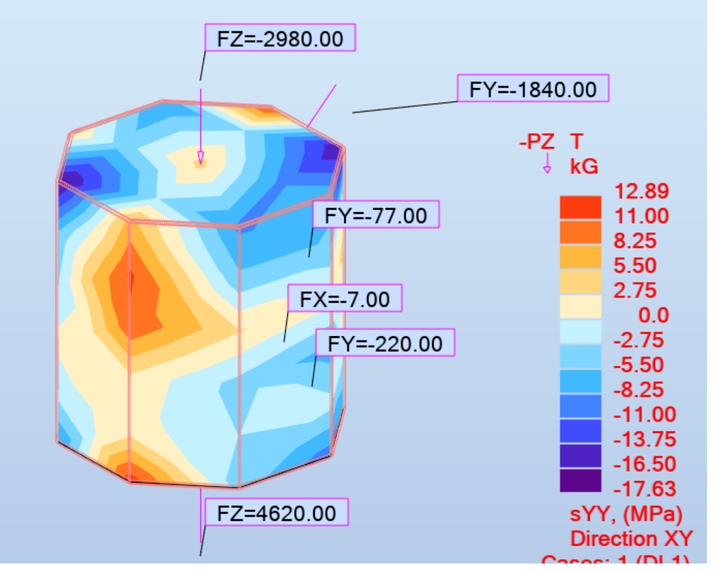


Figure 9-9 Results of the Internal Stresses of the Column Connection

$\sigma_{max} < F_c, F_b$ (In accordance with AWC NDS-2012)

The internal stresses in the connection do not exceed the crushing strength or the modulus of rupture of the wood material. Therefore, the connection is verified.

9.2.2. Truss Connection

As the previous part, the connection design for truss was selected according to the critical combination of forces. The critical joint where the forces are maximum is joint 86 as indicated in the figure below.

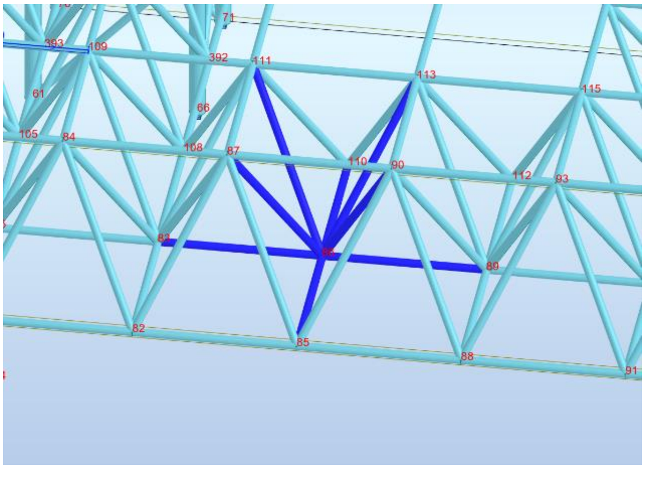


Figure 9-10 Truss Joint

Then, evaluating the forces in each joining member yields the following results.

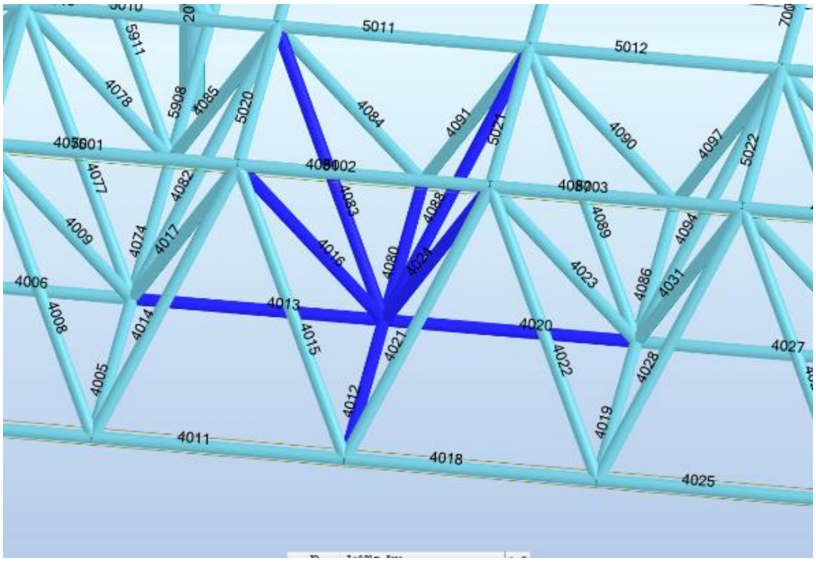


Figure 9-11 Truss Members ID

Bar/Node/Case	FX (kG)	FY (kG)	FZ (kG)
4012/ 85/ ULS+	677.69	16.29	0.55
4012/ 86/ ULS+	677.69	16.29	-0.51
4013/ 86/ ULS+	79.56	0.80	0.92
4013/ 83/ ULS+	79.56	0.80	-0.10
4016/ 86/ ULS+	71.96	2.19	0.99
4016/ 87/ ULS+	71.08	2.19	0.28
4020/ 89/ ULS+	19.19	0.46	1.10
4020/ 86/ ULS+	19.19	0.46	0.08
4024/ 86/ ULS+	684.88	0.02	0.48
4024/ 90/ ULS+	683.71	0.02	-0.23
4080/ 86/ ULS+	14.12	11.08	2.21
4080/ 110/ ULS+	14.12	11.08	1.10
4083/ 86/ ULS+	1325.02	0.15	0.37
4083/ 111/ ULS+	1324.13	0.15	-0.32
4088/ 86/ ULS+	92.56	0.58	1.01
4088/ 113/ ULS+	91.39	0.58	0.34

Figure 9-12 Truss Members Critical Forces

Isolating this joint, then modeling the connection with the forces separately, the stresses in the connection can be determined. The connection dimensions were selected as 10x10x10 cm, as opposed to the column connection. The connection model was also approximated for simplification reasons.

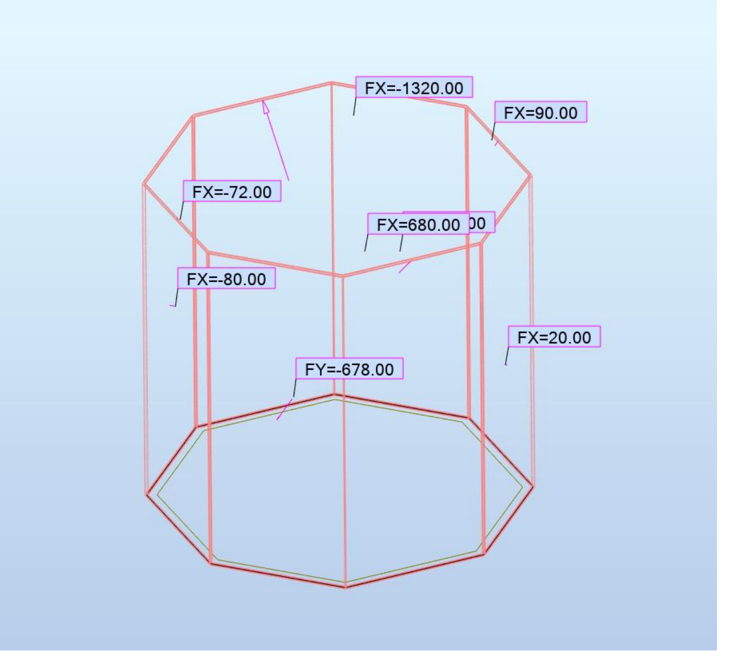


Figure 9-13 Robot Model of the Truss Connection with Applied Forces

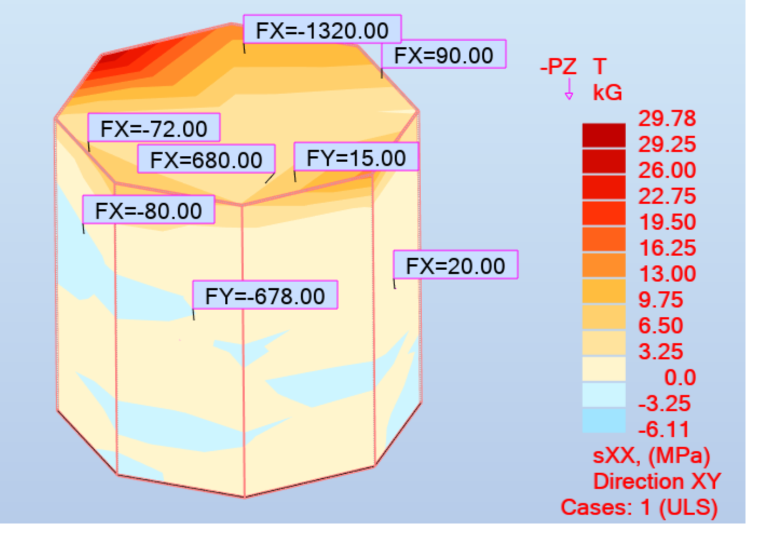


Figure 9-14 Results of the Internal Stresses of the Truss Connection

$$\sigma_{max} < F_c, F_b \quad \text{(In accordance with AWC NDS-2012)}$$

The internal stresses in the connection do not exceed the crushing strength or the modulus of rupture of the wood material. Therefore, the connection is verified.

BIBLIOGRAPHY:

1. Ban Shigeru, Zuckerman Jacobson Heidi, Kimmelman Michael, Pollock Naomi, Weizman Eyal, ***Shigeru Ban: Humanitarian Architecture***, Aspen Art Museum, 2014.
2. Çayli Eray, Aykac Pinar, Ercan Sevcan, ***Architectures of Emergency in Turkey: Heritage, Displacement and Catastrophe***, Bloomsbury Academic, 2021
3. Charlesworth Esther, ***Humanitarian Architecture***, Routledge, 2014.
4. Davis Ian, ***Shelter after disaster***, Paperback, 1978
5. Elsayed Doaa Salaheldin Ismail, ***Emergency Architecture and Resilient City Transformation: A Proposed Matrix for Post-earthquake Reconstruction***, Maggioli editore, 2017.
6. Hammet Jerilou, Wrigley Maggie, ***The Architecture of Change: Building a Better World, University of New Mexico Press***, 2016.
7. Jaber Nader, ***Emergency Architecture Guidebook,*** Obrapropria, 2020.
8. Nussaume Yann, **Tadao Ando**, Walter de Gruyter GmbH, 2009.
9. Pelsmakers Sofie, ***Design Studio Vol. 1: Everything Needs to Change: Architecture and the Climate Emergency***, RIBA Publishing, 2021.
10. Serrazanetti Francesca**,** ***TAMassociati : taking care, architecture with Emergency,*** Milano : Mondadori Electa, 2017**.**

SITOGRAPHY:

1. https://www.dezeen.com/ retrieved on March 2020.
2. https://www.history.com retrieved on March 2020.
3. https://en.wikipedia.org retrieved on March 2020.
4. https://www.unrwa.org retrieved on March 2020.
5. https://www.fmreview.org retrieved on March 2020.
6. http://da2ottomanempire.weebly.com retrieved on March 2020.
7. https://www.chinadaily.com.cn retrieved on March 2020.
8. http://twofriedeggs.blogspot.com retrieved on March 2020.
9. http://www.dailystar.com.lb retrieved on March 2020.
10. https://www.aa.com.tr retrieved on March 2020.
11. https://data2.unhcr.org retrieved on March 2020.
12. https://www.thoughtco.com retrieved on March 2020.
13. https://managementhelp.org retrieved on March 2020.
14. https://www.esomar.org retrieved on March 2020.
15. https://www.medair.org retrieved on April 2020.
16. https://torino.repubblica.it retrieved on April 2020.
17. https://www.agi.it retrieved on April 2020.
18. http://www.ansa.it retrieved on April 2020.
19. https://www.theguardian.com retrieved on April 2020.
20. https://syrianobserver.com retrieved on April 2020.
21. https://www.dargroup.com retrieved on April 2020.
22. http://www.maffeis.it retrieved on April 2020.
23. https://iass-structures.org retrieved on April 2020.
24. https://www.arch2o.com retrieved on April 2020.
25. https://co.pinterest.com retrieved on April 2020.
26. https://en.wikiarquitectura.com retrieved on April 2020.
27. https://www.researchgate.net retrieved on April 2020.
28. https://www.academia.edu retrieved on April 2020.
29. https://www.sciencedirect.com retrieved on April 2020.
30. http://histoire-cerf-volant.com retrieved on April 2020.
31. https://www.arquine.com retrieved on April 2020.
32. https://www.flickr.com retrieved on April 2020.
33. http://www.gsmt.noao.edu retrieved on April 2020.
34. https://www.arthurbest.uk.com retrieved on April 2020.
35. http://ultraatechsteelbuildings.com retrieved on April 2020.
36. https://www.constrofacilitator.com retrieved on April 2020.
37. https://issuu.com retrieved on April 2020.
38. https://www.woodworks.org retrieved on April 2020.
39. https://circus-collection.blogspot.com retrieved on April 2020.
40. https://www.architecturelab.net retrieved on April 2020.
41. https://www.archdaily.com retrieved on April 2020.

42. https://www.e-flux.com retrieved on April 2020.
43. https://www.archiexpo.es retrieved on April 2020.
44. https://www.tensinet.com retrieved on April 2020.
45. https://www.shelterinventory.org retrieved on April 2020.
46. http://www.wooddryingequipment.com retrieved on April 2020.
47. https://theconstructor.org retrieved on April 2020.
48. https://www.ifrc.org retrieved on April 2020.
49. https://plasticinehouse.com retrieved on April 2020.
50. https://www.wikihow.com retrieved on April 2020.
51. https://tinyhousetalk.com retrieved on April 2020.