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The Emergency Housing Project

Product development of shelters for displaced people, based on field studies in Haiti and Kenya

Master of Science Thesis in the Master Degree Programme,
Industrial Design Engineering

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Department of Product and Production Development
Division of Design and Human Factors
CHALMERS UNIVERSITY OF TECHNOLOGY
Gothenburg, Sweden, 2012

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Abstract

This master thesis was carried out by Fredrik Axelsson, master student in Industrial Design Engineering, at the department of Product and Production Development at Chalmers University of Technology. The project was performed in collaboration with Formens Hus Foundation, who acts in partnership with the Ikea Foundation and United Nations High Commissioner for Refugees (UNHCR).

The aim was to develop an emergency shelter, based on a metal frame made by Formens Hus, that copes with the everyday needs of displaced people. At the same time the product must be inexpensive, of low weight and volume and quickly manufactured to be realistic for UNHCR to produce.

The needs and demands from displaced people and aid organisations were carefully investigated. During the spring of 2011 extensive literature studies were concluded to understand previous work, standards and different approaches of the well-known problem. To secure, complement and unravel the gathered information, several interviews with experts within the field were made. However, to truly understand the identified needs in detail the author managed to perform field studies in Haiti and Kenya. Numerous interviews and observations were carried out in camps, which gave a pragmatic understanding of the situation, very hard to find by only reading reports. After analysing the identified issues, ten main problem areas were concluded: Hindering water to enter, cooking area, storage, privacy, light, ventilation & temperature, security, fire safety, diseases and appearance.

Several concepts were developed for each problem area. All of them were evaluated by an analytical method and through discussions with Formens Hus, examiner and supervisor. In the end, seven part solutions were presented: A durable package functioning as flooring, sandbags, a divided door that improves the cooking conditions, hooks, ventilation opening, folded walls and natural appearance. Hopefully these solutions will, with initiative from Formens Hus, improve and facilitate the dreadful everyday life for displaced people in camps.

Keywords: emergency housing, shelter, field studies, Haiti, Kenya, product development, displaced people, user demands.

Preface

This mater thesis report is the final examination for a Master of Science in Industrial Design Engineering at Chalmers University of Technology in Gothenburg, Sweden. I would like to thank all people that in someway were involved and contributed to the outcome of in this project.

First of all, special thanks to Dennis Kanter and Johan Karlsson at Formens Hus Foundation for providing this master thesis and for valuable knowledge and input during the whole project. Also, I would like to express my gratefulness towards examiner Ulrike Rahe and supervisor Ralf Rosenberg at Chalmers for their guidance, assistance and intelligent opinions. Moreover, thanks a lot to Jim Kennedy, an expert in camp management, who has been functioning as an external supervisor and provided me with exceptional knowledge.

I am very fortunate and pleased to have carried out field studies in Haiti and Kenya, and I have many people to thank for that opportunity. SIDA and Friends of Chalmers provided me with scholarships. Without their assistance the trips would not had been possible. Also, thanks to Yvonne Young, coordinator of the Minor Field Study scholarship of SIDA at Chalmers, for her interest and support.

Martin Sjöholm from MSB and Peter Kussmaul and Stephan Mack from THW enabled the visit in Haiti. At site, I owe my sincere gratitude to interpreter/ driver Ernst Ignace and Dimitrov and Anna Delille who hosted me and made the trip unforgettable.

Maria Nyström from Chalmers, Dan Lewis, Ansa Masoud and Rose Alabaster from UN-HABITAT enabled the trip to Kenya. At site Johanne Hjort and Lorraine Ombech from UNHCR brought us into camps. Thank you. Most of all, I would like to thank all residents in camps I managed to talk to.

It has been enjoyable to get to know the other four students working with similar topics. Hope to see you soon again Marcus Chiu, Carl Johansson, Petrina Salema and Agustin Vargas.

Finally, I would like to thank my family and friends for supporting and encouraging me throughout this project.

Fredrik Axelsson, Gothenburg, 2012
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1. Introduction

In this chapter, an introduction of the project is presented. This includes background information of how the project started, what the ambitions are and how far it already has reached. Moreover, specific effect and object goals are presented as well as delimitations, which constitute the frames for this project.

1.1 Background

Every year millions of people need temporary shelter due to natural disasters or conflicts. These shelters are needed for people immediately after a tragedy occurs. In order for UN and other aid organisations to be able to help in the best way, the shelters must be inexpensive, of low weight and volume and quickly produced. Unfortunately refugee camps, emerged from conflicts, last in average 17 years. As a consequent the shelters/houses must meet the needs that arises from the users during time. Otherwise the homes are likely abandon or poorly maintained. These needs have to be investigated further on in order to understand what demands the product requires. However, it is known today that the shelter preferably should be durable, moveable, easy to assemble and disassemble, upgradable and adaptable to different cultures, social and practical behaviour and habits, climates and environments.

Today there is not really an emergency shelter that suits all the unusual demands for a disaster. A lot of work has been done in this field, but still no one has really managed the task.

Formens Hus Foundation in Hällefors, Sweden, in partnership with Ikea Foundation, has been working with The Emergency Housing Project since 2010. Together with UNHCR a prototype of a lightweight steel frame has been developed and the next step would be to design a suitable cover for it.

Formens Hus is a centre for design in Hällefors, Sweden, and functions as a link between industry and designers. It has a permanent exhibition towards companies, researchers, educations, children and the general public. In the Emergency housing project Formens Hus has received four fundamental parameters from UNHCR that will direct the project:

- Price
- Weight
- Volume
- Simplicity and time to assemble

The shelter frame is modular based and self-supported. It mainly consists of steal pipes of 180 centimetres (cm), joints, ground anchors and wires, see Figure 1. The joints connect the pipes in fixed angles (the roof angle becomes 30°) and provide a safe fastening. The ground

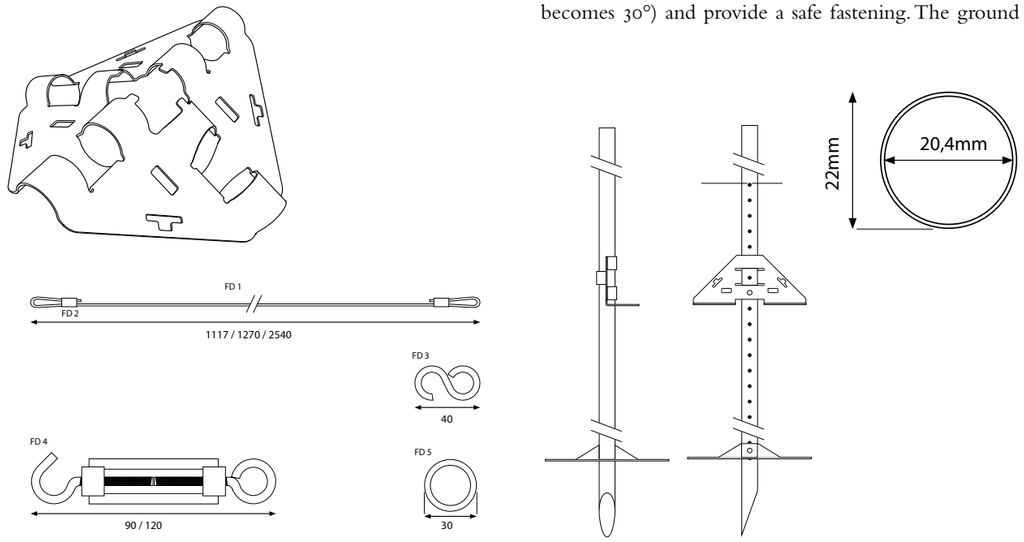


Figure 1. The components for the shelter from left to right; joint, wires with hooks, anchors and diameter of the pipes.

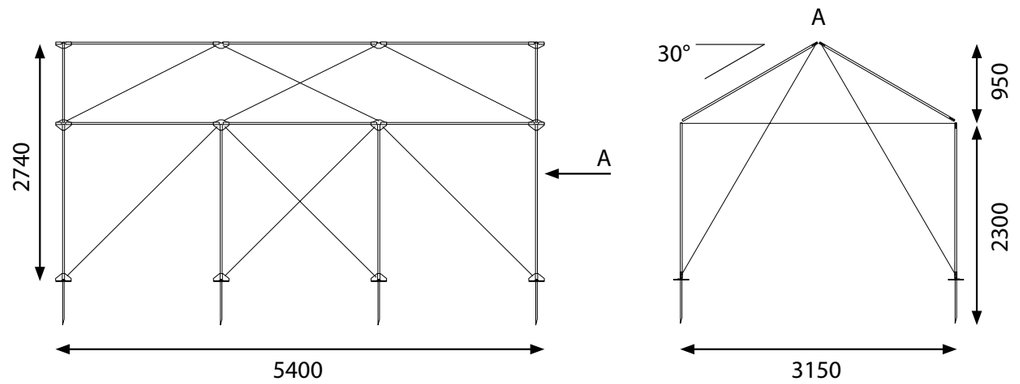


Figure 2. A side view over the entire shelter.

anchor can be assembled in varied ways and positioned at different heights to provide suitable lift or down force in different ground conditions. See Figure 2.

A suitable size for a family of five persons would be three sections, covering 17,5 square metres (m^2). The emergency shelter frame is not intended to be a permanent solution, but a movable foundation that could be upgraded over time by residents.

Formens Hus aims to produce 500 000 shelters per year. Due to the limited size of warehouses the shelters must be rapidly produced when needed. Each batch would include 5000-10000 shelters.

1.2 Effect goals

The goal of the project is to develop a product that reaches as many refugees as possible. Once the product has arrived to the user the next goal will be to make it sustainable. With a long lasting product less maintenance is needed from aid organisations and saved money could be spent on more people.

Another goal will be about flexibility. The product should be able to vary in size in order to fit different needs (home, hospital, rendezvous, bathroom).

Finally, the product should not affect the environment more than today.

1.3 Object goals

In order to achieve the effect goals several object goals need to be fulfilled. The object goals of the project are to develop a product that:

- is inexpensive compared to current models. The price should be about 500 USD for the whole product. Approximately 100-150 USD would be used for a metal frame and another 350-400 USD for a cover.
- is hard-wearing. The cover should last about three years and the frame at least ten years.
- is lightweigthed and have low volume. The steel frame weights 25 kilograms (kg) and the total amount cannot exceed 65 kg.
- is simple and wieldy to distribute and manufacture. It has to fit the workflow of humanitarian aid in emergencies.
- is durable and suitable for heavy whether and tough climates during several years.
- is sustainable in a social perspective. The product should not interfere with local culture and habits. Instead it needs to be adaptable (and perhaps upgradable) to different desires in order to become a home. Additional elements would likely be added to establish a feeling of homeliness.
- do not perceive as inappropriate by the society. The emergency houses are temporary homes, at least officially. The local governments might argue that it should stay that way, to not make them permanent. In that case a careful consideration has to be done concerning "what is a home" and "when does it become permanent". Because, at the same time the product should establish a feeling of homeliness.
- could be modular based in order to fit different sizes of families or be used for other purposes. Therefore it has to be easily adjustable, assemble, dissemble and moveable. However, other scope of uses might require further needs than just a different size.
- contributes to the environment in a better or similar way. The situation in refugee camps is at the moment inadequate concerning environment. A lot of work could certainly be done. Nevertheless, that will not be the major focus.

Following elements should be delivered to Formens Hus, examiner and tutor once the project runs towards its end.

- A report covering the whole project.
- A presentation of the result.
- Visualisation of the product.

1.4 Delimitations

- The project will only include the cover of the shelter, not the frame. Formens Hus has already developed the frame. However, an engineer student will, parallel to this project, do his master thesis about the metal frame. His task will be to improve and refine the frame in order to make it truly durable. Two architect students will investigate in their master thesis how the frame can function as a foundation for local upgrading in a long-term perspective. Finally a fifth student (also studying architecture) will work within camp planning and base his approach on the size of the shelter design from Formens Hus. During the projects the students will meet continuously to help each other and possibly make sure that different approaches fit together. However, the other students' work will not be presented in this report.
- The job will not be an open source project. The results that emerge cannot be shared with potential competing companies.
- The workflow of humanitarian aid in emergencies will be hard to change, regardless of how brilliant a product might be. However, the author will investigate the rules and conditions anyway and perhaps there are circumstances that could be modified.
- The product should be a standard solution and fit different cultures, climates and environments. It will naturally be impossible to go through all concerned cultures to fit local desires. Instead, a few different areas could be analysed to find mutual needs.
- Since most refugee camps occur along the equator this will be the context of the shelter. Still, the climate and environment could vary a lot.

2. Methods and tools

The different methods used in this master thesis are describes in this chapter. The design process often consists of five phases: upstarting, data collection and analyse, idea generation and sketching, revision and follow-up. The effort for each phase can differ from case to case and run parallel.

2.1 Planning

2.1.1 Gantt-chart

In the project planning it could be necessary to illustrate the start, finish and the length of including phases. A Gantt-chart is therefore used. It consists of a horizontal bar chart running along a time axis. The different phases are occasionally overlapping each other or run parallel. This method is called Concurrent Engineering. (Österlin 2007)

2.2 Data collection

2.2.1 Literature study

Literature studies are perhaps the most common way to gain information for a project. The published information can be found in articles, books and in Internet databases. Literature studies are however usually not enough to understand a problem area, but should be complemented.

2.2.2 Observations

To study the handling and behaviour of the usage of products, observations can be applied. The method is quite suitable to apply to identify information that users cannot verbalise or are not aware of. Several observation methods exist, for instance self-observation where the user writes diary, participating observation where the observer interact with users or direct observation where users are watched with cameras or memo pads.

Observations are furthermore opened or concealed. A concealed observation means that the user is not aware of being observed. (Karlsson 2007)

2.2.3 Interviews

To understand users' needs, desires, feelings and attitudes interviews are beneficial. Interviews are categorised into structured, semi structured and unstructured and is either made in a group or individually. The structured interviews include a regulated order and time, whilst the unstructured are made more freely where the subject is more directed by the user. To facilitate users to speak freely about a subject individual interviews are preferred. On the other hand, group interviews are suitable to gain an overlook and save time. (Karlsson 2007)

2.2.4 Field studies

Working as a foreign researcher and designer in developing countries requires preparations and knowledge of how to act in field. The context might be complex and outlandish in several aspects. Here follows a few tips written by the Consulting Firm IDEO who has been working in several project with innovation to the base of the pyramid.

The ability to speak freely

Individual interviews should be accompanied without an audience. The presence of friends or neighbours can influence or limit the user to express freely. However, privacy is not necessarily easy to achieve in field. Being more than one researcher could be useful since one researcher can pull aside the audience in a parallel conversation, away from the primary user.

Women and men might have different point of views, but the ones from women are not necessarily heard. Two separate meetings might therefore be appropriate.

Opinions from people can be influenced by the presence of political heavyweights such as local administrators or chiefs. (IDEO 2009)

The role as a foreigner

The purpose of the interviews and observations, and the fact that nothing will be given away, should be clear for users. If people view the researcher as a source of funds and charity, their behaviour and answers could be influenced by perceived potential benefits.

Unintentionally, NGOs can occasionally express separateness to the local people, perhaps by wearing branded clothing or having a too spatial distance between themselves and the participants. These barriers should be minimised, as well as the perceptions of difference in hierarchical between the groups. Here are a few suggestions to achieve that:

- The researcher should sit at the same height level as the users.
- When more than one researcher is involved, they should not sit together but rather scatter themselves throughout the group.
- Clothes that are organization-branded should be avoided. (IDEO 2009)

Receiving trustworthy information

The information people are saying and thinking is not always the same as what people actually are doing. Participants often have strong beliefs about their routines and daily activities that differ from reality. This misguidance is usually not an intention to mislead the researcher, but simply an overstatement. To receive proper information, a few nights in people's homes could be beneficial. After some time, people will act more natural and become comfortable. The longer the researchers stay in the context the more understanding and empathy they will gain. (IDEO 2009)

2.3 Analysis

2.3.1 Ishikawa diagram

An Ishikawa diagram is a technique, presented graphically, to structure the correlation between reason and effect. After defining problems that should be analysed, possible reasons are identified. The most relevant reasons are then marked and investigated. (Karlsson 2007)

2.3.2 Function analysis

To determine the main purpose of a product and analyse its functions, a function analysis can be made. The result can often be presented in a list of functions. It can be vital to identify all functions in order to make a product that truly fulfils the users' needs and desires. The list of functions will then become a foundation for the specification of requirements. (Österlin 2007)

2.3.3 Specification of requirements

The specification of requirements is based on the function analysis. After weighing the functions, for instance in a scale from 1-5, the most important ones can be categorised into demands and the remaining ones into wishes or added value. The specification of requirements is not only a starting point and a frame for the product development, but also a tool to evaluate concepts. The visual representation is rather similar to a list of function and can therefore be combined. (Wikström 2005)

2.4 Creativity

2.4.1 Brainstorming

Brainstorming is a technique to obtain a range of ideas. The method is carried out in a group, preferably consisting of three to six persons of different background. The ideas are noticed on a flipchart or white board, or drawn together at the table. Critique is not allowed during the session and extreme ideas, far from realistic solutions, are encouraged. Once the ideas are settled they can be combined and complemented to bring new solutions and ideas.

2.4.2 Moodboard

A moodboard is a collection of images that should represent and mediate the same feeling that the future product is intended to express. The moodboard can be discussed with the customer to make sure the project is heading the right way. (Wikström 2005)

2.5 Visualisation

2.5.1 Sketching

To explore, visualise and communicate ideas in product development, sketching is an adequate tool. Sketching is commonly simple and quick and results in two-dimensional images. There are however a few levels of refinement, appropriate for different purposes. Idea sketches are made rapidly to illustrate principle solutions, while realistic sketches are far more time consuming and used to promote products. Technical drawings show hidden parts and are made in details to show important information to facilitate manufacturing. (Österlin 2007)

2.5.2 Physical models

To obtain even more describing visual representations than sketches, three-dimensional physical models are appropriate. The models are used to evaluate functions, solutions and shape, but also as a tool to promote the final result. Using a full-scale model, even though if it is roughly made, could be quite applicable to evaluate size and ergonomic elements. (Österlin 2007)

2.5.3 CAD-models

Computer aided design, CAD, is a tool to build three-dimensional objects by using computer software. Several CAD-software exists, enabling ideas to be visually explored and tested. Shapes, dimensions, colours, construction and strength can be explored. Furthermore, the CAD-software can provide technical drawings and thereby a foundation for production. (Johannesson, Persson & Pettersson 2004)

2.6 Evaluation

2.6.1 PUGH matrix

A PUGH matrix is made to eliminate different concepts by comparing them to a reference object, commonly a competitive or original solution. The different concepts will be assigned a score (for example from -3 to +3) depending on how well they fulfil the requirements and wishes compared to the reference object. Each demand and wish can have an own score, found at the specification of requirements, which means that the most important ones play a more essential role in the PUGH matrix. To maximise the function of the matrix there should not be too many demands and wishes, but the most significant ones. (Johannesson, Persson & Pettersson 2004)

3. Implementation

The working procedure of the project is described in this chapter. The process and content of applied methods are presented, but also a proper background and the implementation of the field studies are pictured. At the end the actual product development, with its several phases, is described.

3.1 Time schedule

The project was carried out during the spring and fall of 2011 and presented in January of 2012. The initial idea was to perform user studies in Haiti and later on, with a developed prototype, evaluate the result through usability tests in Kenya. As illustrated in the Gantt-schedule, see Figure 3, the final result was intended to be presented in October.

Due to the extremely complex context, more time was needed in the first phase understanding the problems, which delayed the whole project. In the end, both the field studies in Haiti and Kenya were carried out during the spring to evaluate the identified problem areas found from literature studies, interviews and observations in Sweden.

3.2 Data collection in Sweden

The first phase in the project was to identify possible needs and problem areas, but also to obtain a background of the current camp situations. Data was gathered in numerous ways to achieve a wide perspective of the context.

3.2.1 Literature studies

A lot of literature has been published the last decades about housing after natural disasters and conflicts. A vast amount of standards, suggestions, recommendations, rules, previous examples and so forth are described, sometimes incoherent to each other. Plenty of publications were read by the author, among others the rather famous Sphere project, UN-HABITAT Shelter projects 2009, Shelter after disaster guidelines 2010 and UNHCR Handbook for Emergencies. Besides all reports, articles and booklets of emergency housing, a few books about smart design for narrow spaces were investigated. In the end these books turned out to have solutions that still required a lot material and durability, which made them a bit irrelevant for most emergency shelters. Furthermore, Internet enabled a great amount of additional essential information, among others through videos showing the everyday life of residents and their views.

3.2.2 Observations

At least two observations were carried out in Sweden before heading to Haiti and Kenya. The first took place at Chalmers University of Technology right in the beginning of the project. Together with the other four students, working within the same context, the prototype from Formens Hus was assembled without instructions. The handling was carried out to

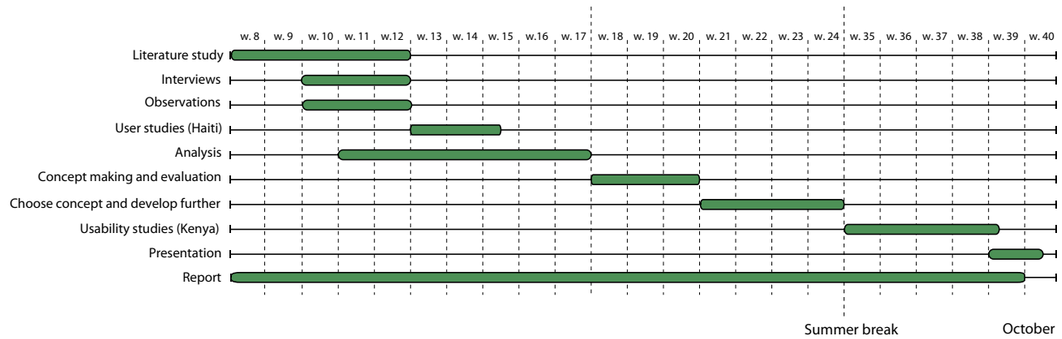


Figure 3. The original Gantt-schedule.

understand the product and to realise what residents will face after receiving it. At this phase several details where not concluded or optimised yet, causing a few issues in the assembling.

In the beginning of May, the author went to Kristinehamn in Sweden where The Swedish Civil Contingencies Agency (MSB) held a training course of a few days for the German aid organisation Technisches Hilfswerk (THW). At the site several emergency shelters were put up, including the prototype from Formens Hus. Besides observing the staff investigating the prototype, the author explored the other models and found several issues identified from the previous data collection.

The visit in Kristinehamn was also made to discuss with THW the possibilities of visiting Haiti with the help from them. Before this meeting, repeated conversations had been held between the author and the THW staff in Haiti. However, nothing had yet been settled. The unit manager in the training course Stephan Mack explained their role in Haiti and how a visit might could be arranged. Thanks to him and his colleagues at site in Haiti, a visit was shortly established and booked.

3.2.3 Interviews

To complement the information from literature and observations about standards, rules, current designs, previous projects, relief help, camp management, camps, behaviour science etcetera, interviews were performed. Most of the interviews were semi structured and carried out orally or by phone calls. Some interviews were however completed by e-mail and thereby rather structured.

Here follows a few names that the author had the pleasure to interview or discuss the subject with.

- Ian Davis, professor in disaster management and among others the editor of the first UN guidelines on 'Shelter after Disaster' published 1982.
- Jim Kennedy, CARE shelter expert and coordinator.
- Martin Sjöholm, project manager at MSB.
- Dan Lewis, chief at the Disaster and Post-Conflict Section, UN-HABITAT.
- Nina Gren, PhD in social anthropology at University of Gothenburg.
- Jaap van Kemenade, former master student in industrial design engineering at Delft University of Technology, who wrote his master thesis about emergency shelter.
- Stephan Mack, unit manager at THW.
- Rose Alabaster, Human Settlements Officer at UN-HABITAT.
- Inger Lise Syversen, researcher and senior lecturer/ associate professor at Chalmers University of Technology.
- Maria Nyström, professor in design in urban development at Chalmers University of Technology.
- Malena Gyllenhak, former master student in architecture at Chalmers University of Technology, who wrote her master thesis about housing after disaster.

3.2.3 Modified scope

At this phase the author was a bit uncertain which path to choose. The initial idea was to make a universal tent solution for camps, but most information gathered claimed it is the worst solution. Building permanent houses with local resources are far more sustainable. At the same time, there are numerous situations when there are no alternatives but tents. As a result the author decided to focus on improving the living conditions in camps through a more user-friendly shelter design.

Due to the number of unsolved problem areas of shelters, related to the everyday lives for residents, the author became more curious to solve these parts than the technical issues of a cover. After a dialog with Formens Hus it was concluded that they should focus on exploring durable and affordable constructions and materials, while the author should continue investigate and solve the user demands.

3.2.4 Meeting users and Ishikawa diagram

To truly understand users they should be interviewed and if possibly observed when interacting with the product. Otherwise, there is a severe risk that the product does not fit the users' needs. Emergency shelter is not different from other products. Actually, this product and its relation with users are very complex, due to issues such as ownership of land, poverty, culture and infrastructure. It is often essential, when designing for another culture, to interact and interview users and gain insight into their situation. Therefore, the author was very keen to meet displaced people in their homes to understand and further investigate the already identified problem areas. An Ishikawa diagram (see Appendix 1) was made about two problem areas, privacy and security, to seek additional possible explanations of the lacking quality. These explanations or reasons became a foundation for additional questions within the two problem areas.

Figure 4. The results of the earthquake.

Figure 5. The riots in Kenya.

3.3 Field studies

3.3.1 Introduction

The aim of the field studies was to verify the identified needs and complement them with additional information to understand the everyday life in emergency shelters. It was essential to separate the general needs from the culture ones. By visiting two locations it became easier to distinguish the general needs and it helped the author modify the conclusions and assumptions from the previous research.

Haiti was hit, on the 12th of January 2010, by an earthquake measuring 7.3 on the Richter scale (Figure 4). The epicenter was located 17 kilometres (km) southwest of the capital Port-au-Prince. More than 200,000 people were killed and 1.3 million displaced. Port-au-Prince was drastically affected and approximately 190 000 buildings were destroyed or truly damaged, causing a great number of urban camps. (UN, DFID, Shelter Centre, 2010)

Kenya witnessed riots and violence after the elections in 2007/2008 (Figure 5). Conflicts emerged between tribes, causing about 1500 deceases, several burned homes and about 300 000 being displaced. Most camps have been positioned on the countryside. In general the IDP camps in Kenya (caused by the political violence) are less structured than refugee camps (with Somali, Sudanese and Ethiopian refugees). Refugees get often more international publication and more support.

The field studies in Haiti and Kenya was funded by SIDA, through the Minor Field Study (MFS) scholarship, and by Friends of Chalmers (see Figure 6).

Figure 6. Funding organisations.

The studies were carried out in two phases between May and July in 2011. A two-day preparation course in Uppsala, Sweden, held by Internationella Programkontoret, was also included in the MFS scholarship. The course helped students to prepare for the field study through lectures, seminars and meetings with experts within concerned countries.

3.3.2 Preparations

In order to perform user tests, interviews and appropriate observations in an unfamiliar culture, researchers must be open-minded and preferably spend a long period of time in the foreign region. Otherwise it becomes hard to truly understand the context. In this project the aim was not to identify local problem areas, but generally ones for camps. Consequently, less pre-studies of current countries was needed compared to local implementation projects. Additionally, the author had already visit Kenya for seven weeks of field study in another project the year before. Those seven weeks were extremely instructive and provided knowledge that is impossible to pre-study. Luckily, the Haitian culture is fairly similar to the Kenyan, enabling the previous knowledge to be applied. Most insights concern methods, behaviour, social interaction etcetera, and could be crucial to master in order to gain worthy response from local people.

Figure 7. Logos of supporting aid organisations.

To further enhance the information gathering at site a report from IDEO, called Human Centered Design Toolkit, was studied. The report aims to facilitate innovation to reach the base of the pyramid and provides methods and tips how needs of constituents can be understood and detected better. To learn more about these methods, see chapter *2.2.4 Field studies*.

3.3.3 Observations, interviews and user tests in Haiti

Thanks to the German aid organization "Technisches Hilfswerk" (THW, Figure 7) the author was able to carry out observations, interviews and user tests in Haiti.

THW provided extensive knowledge about the local situation and former examples of disasters. They also offered help, such as providing an interpreter and driver, renting a car and introduced the author to camp managers, in order to facilitate the author to freely visit

Figure 8. The field studies were carried out with the interpreter Ernst in Haiti and staff from UNHCR in Kenya.

the IDP camps in and close by Port au Prince (Figure 8). Finally THW enabled the author to be hosted by a Haitian family in central Port au Prince, which was extremely helpful for practical matters as well as to understand the situation and culture.

Entering camps were rather straightforward. After talking to the man in charge for a camp, often entitled "the president", and explained the purpose of the visit, visitors were allowed to enter. Once inside the author was permitted to walk around and interview families and observe the everyday life, either by himself or with the help from social workers or camp managers. Most IDPs were curious about the visit. However, being unable to speak the same language was, even though an interpreter was present, limiting the interaction and might have influenced the information that was received. Having spoken Creole would have given a more personal relation to the people and even more important information would probably had been received.

The observations in camps were documented by photographing and by taking notes. Often when shelters were observed semi-structured interviews were held with residents at the same time, which gave qualitative data. The topics discussed were mostly related to the insights that had been drawn before the trip. In total, 15 semi structured interviews were held with IDPs and an additional numbers were unstructured. The quality and length of time varied due to the residents' interest and relation to the subjects and ability to describe it in detail. Most of the interviewees were women between 20-60 years old, but in between men were also interviewed.

Semi structured interviews were also carried out with staff from THW, UN representative at Shelter Cluster, camp managers and social workers. The most successful unstructured interviews were made with the interpreter/driver, the hosted family members and with "presidents" of the camps.

After some time in camps the author realised the difficulty for IDP to express their views about the appearance and aesthetics. Due to lack of alternatives today many did not have any specific opinions. Therefore a user test was put together with identical shelter solutions, but with differentiation in colours and with and without logos (see Figure 9). Suddenly, when alternatives were provided, it became easier for IDPs to express and choose their favourable solution. However, due to the short numbers of alternatives, the test gives only a hint what should be aesthetically appreciated and avoided.

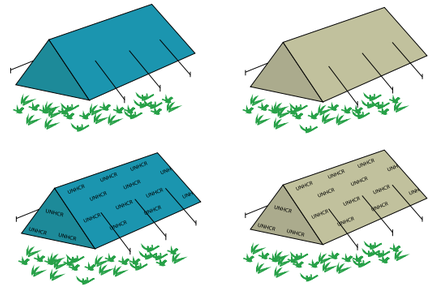


Figure 9. A simple test with different appearance variations.

3.3.4 Observations, interviews and user tests in Kenya

Two weeks after the homecoming from Haiti the author continued the field studies in Kenya, this time with three more students with similar master thesis topics within architecture and engineering. Two of the camps visits were organised by UN-HABITAT and UNHCR. The camps, called Pipeline (699 households in 2010) and Camp 86 (86 families who broke free of the Nakuru camp in November 2008), were located close to Nakuru, about two hours north of Nairobi. Most of the IDPs in Pipeline were English speaking, but in Camp 86 no one were. Consequently UNHCR employers assisted with interpretation. The project group arranged a third visit by themselves. About 1,5 hours north of Nairobi, close to Naivasha, Vumilia camp (225 families) is situated. In common for these camps are that they were self-established in rural areas by displaced people who fled from locations around Rift Valley, commonly from Eldoret.

Observations and interviews were carried out similar as in Haiti. However, the author only had interviews with IDPs in three camps. In total, 5 semi-structured interviews were held with IDPs, three with men and two with women. In order for the IDPs to feel comfortable and being able to point out possible shelter issues, the interviews were held at their homes. Several unstructured interviews were also held since neighbours became curious about the visit and were eager to tell their own story.

Additional semi structured interviews were carried out with an employee at UNHCR and a staff member at UN-HABITAT, both in Nairobi.

The user test about the appearance and aesthetics of shelters was carried out in Kenya as well. Besides the IDPs at the semi structured interviews a number of neighbours and curious IDPs were asked. The test was slightly expanded with a few more alternatives to choose from. Thereby the result became a bit more reliable compared to the one performed in Haiti.

3.4 Product development

3.4.1 Function analysis and Specification of requirements

With a great amount of facts, problem areas, needs and desires, a function analysis had to made. By reformulate the inputs into functions the information was more reviewable and became a clear foundation for approaching concept development. The functions were also weighed, scoring one to three, in order to determine if they were demands, wishes or added values. The function analysis and specification of requirements resulted in a list of functions. The number of functions is vast, but in the end only a limit amount of them were chosen to continue with.

3.4.2 Brainstorming, sketching and concept generation

To obtain a collection of ideas one proper brainstorming was held, see Figure 10. The participants were students within industrial design engineering and the brainstorming was nailed down to a few problem areas. Each participant started by themselves for a few minutes with sketching. The results were discussed and then explored and developed together.

Figure 10. The brainstorming session.

Most of the ideas and concepts were however generated by the author alone. Each problem area received about one day of effort in the first idea generation round. The best ideas and sketches were put together and later presented to Formens Hus, who also contributed with some additional ideas, sketches and thoughts.

3.4.3 Evaluation and decisions

In order to evaluate the different concepts a PUGH matrix was made, see Appendix 3. For each problem area, suitable weighted needs (from the list of functions) were fitted into the matrix, enabling different scores for different concepts. How well each concept could be combined with solutions for other functions was an additional parameter. The concepts were compared to current ideas from Formens Hus: a plain cover and a tarpaulin as a floor. Since they had not involved solutions for the additional problem areas, some concepts in the PUGH matrix had considerably higher scores than the current model.

The concepts were presented and discussed separately with Formens Hus, examiner and supervisor. Based on their views and the PUGH matrix, several decisions were taken and a lot of new information discussed.

3.4.4 Additional information gathering

Once the first idea generation round was completed and evaluated, it was clear that some additional facts were needed.

To gain more knowledge about indoor cooking Maria Nyström (professor in design in urban development at Chalmers University of Technology), who is truly experienced in the field, was contacted. After reading her PhD report about stove design for indoor cooking and discussing the subject with her in person, the author realised how to approach the problem area from a new angle.

Another teacher at Chalmers University of Technology, Carl-Eric Hagentoft (professor in Building Physics), was met in order to understand the alternatives and possibilities for ventilation and temperature.

Acoustics is quite complex. Besides carrying out literature studies, Margareta Zetterblom (senior lecturer at School of Textiles in Sweden) was contacted. After two telephone interviews with her the author realized the limitations and frames for designing a sound absorbing shelter.

Jim Kennedy (working as an shelter expert and coordinator for CARE) has been a continuous (unofficial) mentor during this project. Due to his great experiences in camp management he was once again contacted to give answers about upgrading, flooring, drainage and sandbags. After a few sets of e-mails the author had received clear and extensive answers.

Finally a study visit at a prototype producer was carried out. During the fall of 2011, Formens Hus let two material producers (who were considered having suitable materials) build a full-scale cover prototype out of their own supplies, as can be seen in Figure 11. The companies were Nordifa (producing needle punch) and NMC Cellfoam AB (manufacturing extruded polypropylene). The study visit gave the author plenty of answers about possible technical solutions.

Figure 11. The building of a full-scale prototype.

3.4.5 Further development

Besides a new round of frequent idea generation (this time more in detail), several material and manufacture retailers were phoned, physical models (mock-ups) were built to evaluate ideas and CAD-models were developed through the software Rhinoceros (and rendered through the software Keyshot).

To facilitate the development of the appearance, a moodboard was concluded. Images were carefully chosen to correspond and harmonise with desired expressions.

4. Background

In this chapter a background is given about the current camp situation. A vast literature study was made to gain knowledge about shelter design, camp management, relief aid and behavioural science. To clarify and complement certain areas many experts (among others Ian Davis and Jim Kennedy) were contacted.

4.1 Statistics

335 natural disasters were reported in 2009, which affected more than 119 million people and killed over 10,000 persons. The same year there were also several new conflicts occurred in countries such as Pakistan, Sri Lanka and Somalia, causing millions of people to displacement. In the end 43,3 million people had been forcibly displaced in 2009. The number includes 27,1 million people that fled within their own country (named internally displaced persons or just IDPs) and additional part that had been displaced into other countries (named refugees). Natural disasters were causing most damage in Asian countries, whilst conflicts mostly were affecting countries in Africa. (UN-HABITAT 2010)

In many places around the world, such as Pakistan, Cyprus and Tanzania, camps have been in existence for more than a decade. Some camps in Palestine have existed for half a century without any sign of closing. No one can surely predict how long a camp will exist, but often it is much longer than most will believe. (Kennedy 2004) The average duration for major refugee situations increased in 2003 to 17 years (Architects for Humanity 2006) and the reconstruction after natural disasters usually becomes between two and five years. (Kanter & Karlsson 2010)

Natural disasters and conflicts result in donations worth approximately 3 billion USD each year. A large proportion if this humanitarian aid intends to cover basic shelter requirements to ensure protection and safety. The relief should not just reach the vulnerable people and locations, but also be very adequate and effective. Unfortunately, very commonly the response is limited to tarpaulins and tents. (United Nations 2004) Due to a limited budget and short notices relief aid tends to follow an approach of covering only the basic needs, and usually in an inexpensive way. Water, shelter, nutritional, sanitation, fuel and health care are listed as the basic needs by International Federation of Red Cross and Red Crescent Societies (IFRC) in 2000. (Ashmore et al. 2003)

4.2 Definitions

A refugee is, according to the 1951 Convention relating to the Status of Refugees, someone *"…owing to well-founded fear of being persecuted for reasons of race, religion, nationality, membership of a particular social group or political opinion, is outside the country of his nationality and is unable or, owing to such fear, is unwilling to avail himself of the protection of that country; or who, not having a nationality and being outside the country of his former habitual residence as a result of such events, is unable or, owing to such fear, is unwilling to return to it."* (Geneva Academy of International Humanitarian Law and Human Rights 2012)

Internally displaced person, often just called IDP, is another category, often wrongly called refugee. IDPs have, compared to refugees, not crossed an international border to find sanctuary. Instead they remain within their home countries. Regardless if the reason for the evacuation is the same as for many refugees (often armed conflicts) the IDPs remain under the protection of their government, even though it might be the very same government causing their situation. In contrast to refugees, IDPs are still citizens and retain their protection and rights under human rights and international humanitarian law. (United Nations High Commissioner for Refugees (UNHCR) 2009)

4.3 Aid organisations

4.3.1 Governments

The range of different disaster management operations is huge, and can go from fire relief to water and food delivery. The local governments play a crucial role in disaster management since they are the ones responsible for the welfare of their people. However, when larger hazards occur and governments are unable to control the situation, or have not the knowledge, they call upon the assistance of the international aid.

Humanitarian organisations are, including the UN, financially dependent on their donors. The donations come from private persons and investments originated from (often Western) governments and companies. (Gyllenhak, Report, 2011)

Within the international aid community there is a degree of competition between organisations, often leading to lack of cooperation and coordination. Adding the chaos that disaster situations carry the coordination with local non-governmental organisations (NGOs), local authorities and the national government are commonly deficient. (Gyllenhak, Report, 2011)

The organisations described hereinafter are involved in shelter response after disasters. What is important to underline is that the organisations should behave as guests, not as headmen. The difference is not always clear, easily causing too much influence and decision-making from the international organisations and possibly disrupting the local context. (Davis, 2011)

4.3.2 UN

The United Nations (UN) is a large and widespread organization, founded right after World War II to promote international cooperation. With a support of 192 countries the UN plays an essential role in many, political, military, economical, humanitarian and law issues. (Kemenade, Report, 2007)

4.3.3 UNHCR

UNHCR (United Nations High Commissioner for Refugees) is the United Nations refugee agency. The UN General Assembly created it in 1950 due to the devastation and amount of displaced people from the Second World War. The idea was to make sure that UN has a strong and effective organisation to protect refugees in the countries where they had sought asylum. Besides that, UNHCR also deals with helping governments to find permanent solutions for refugees. (UNHCR 2009) UNHCR is responsible for the coordination of shelter at conflict situations, and thereby often works with refugees. One main task is to provide shelter for vulnerable people in the first phase of disaster management rather than create a structure that lasts. (Gyllenhak, Report, 2011) Unfortunately, UN constantly displays a budget that is under-balanced to meet the humanitarian needs. Moreover, trends show that funding is not rising as fast as the need of humanitarian assistance. (Kanter & Karlsson 2010)

4.3.4 IFRC

International Federation of Red Cross and Red Crescent Societies, (IFRC) is an international NGO that coordinates the international aid community in shelter response after natural disasters. (Gyllenhak, Report, 2011)

4.3.5 IOM

IOM stands for International Organization for Migration and focuses on understanding the migration issues, encouraging social and economic development related to migration and upholds the human dignity and the well being of migrants. (IOM 2012)

4.3.6 UN-HABITAT

UN-HABITAT helps governments and local authorities to rebuild and recover from conflicts and natural disasters. They are not usually involved in the first phase of disaster management. Instead they are engaged a while after, implying strategies of long-term perspective. (Gyllenhak, Report, 2011)

4.3.7 UNESCO

Similar to UN-HABITAT, UNESCO works in the longer-term development and reconstruction phase. UNESCO deals with cultural heritage and their role is to restore and protect historical monuments before and after disasters. They are not a humanitarian agency, but can be critical at disasters due to their knowledge about valuable inherited materials. (Gyllenhak, Report, 2011)

4.3.8 NGOs

A non-government organisation is an organisation independent of the government. The primary mission is not commercial, but focuses among others on social, cultural, environmental and educational issues. NGOs often involve a lot more concrete integration with employees and organizations of local origin compared to UN.

The amount of NGOs is enormous, but most of them are small. A few of the larger ones within disaster relief are Oxfam International, Care International and MSF. Gyllenhak, Report, 2011)

Oxfam International is a collaboration of 13 independent NGOs. Together they cooperate with more than 3000 local organisations in 100 countries to fight poverty and related injustice. Water and Sanitation is their strongest expertise, but they also publicise a lot of research, education and general relief work.

CARE International is another major NGO with projects in 70 different countries and 90% of their employees employed locally. CARE is active in relief projects as well as in development projects, and is sometimes responsible for education in camps. MSF (Médécins sans Frontières) or Doctors without Borders is a French organisation that provides medical aid and raises awareness of the complications for the vulnerable people. They also have a few publications on temporary housing. (Kemenade, Report, 2007)

4.4 Camps

4.4.1 Situation

Camp management is extremely complicated and the number of refugees and related housing needs are enormous. Usually aid organisations are engaged in more issues than shelter provision, meaning that refugees and IDPs are often on their own for the construction of shelters. (Kemenade, Appendix, 2007) The location delegated by a government is commonly carried out without certain considerations of appropriateness. There are not necessarily many locations to choose from, especially in urban areas where parks could be the only alternative. (Sjöholm 2011) See Figure 12.

Occasionally, governments apply "push factors" to decrease the length of camps. By making the camps unattractive less displaced people become eager to populate it and more become keen to leave and return to

Figure 12. An urban camp in Port-au-Prince, Haiti.

Figure 13. Overcrowded camps are very common.

their domicile. However, the idea of push factors is partly based on the thought that displaced people are living in camps voluntarily. In most cases, people do not have an alternative location to escape to. By worsen the camps and making them unattractive, the already poor living conditions can decrease significantly. (Alabaster 2011)

Camps can differ significantly in several perspectives, even within the same country. The result is dependent upon preparations, who lives there and who runs and control it and is quite related to politics, economic wealth and geographic location. Certain camps are planned and organised, while others are chaotic and dysfunctional. In Haiti for instance, a year after the earthquake of 2010, there were very few planned camps with carefully prepared sustainable solutions. Even though camps differ a lot they are in general quite unplanned. Tarpaulins and perhaps tents are distributed, and due to the amount of vulnerable people it becomes hard to control and ensure that camp management guidelines are fulfilled. People put up shelters as they like, without any information, knowledge and experience of what is functional in the long-term. In several situations the displaced people are, at this stage, often not aware or would never assume that they will stay in camps for more than a few weeks, definitely not years. The perception of planning and long-term thinking is very much related to culture. (Sjöholm 2011)

To build a camp that outgrows itself is the worst possible result. It causes overcrowding, implies costs of rebuilding or relocation to avoid the overcrowding. (Kennedy 2004) Within a year or two camps often become overcrowded, denying residents both dignity and space to pursue livelihoods. (Forced Migration Review 2009) See Figure 13.

More and more host states respond to extended refugee situations by containing the residents in isolation. The refugee camps are frequently insecure, especially close to borders and far from the governing regime. These host governments require the majority to live in designated camps, minimising the amount of refugees who desire to leave the camp for employment or education. The trend, called '*warehousing of refugees*', means severe implications of human rights and economic growth (Kemenade, Appendix, 2007) Furthermore, sexual and physical violence remain a huge concern, caused by despair and the extreme conditions. Women and children are usually the majority of refugee communities (47% of the world's refugees are under the age of 18 (Architects for Humanity 2006)) and often the ones most haunted and affected. (Kemenade, Appendix, 2007)

In common for most camps is that no one wants to live in it. When camps are established people of different tribes or background are possibly forced together. For instance in former Jougoslavia this became a huge issue during the conflict at the 90s. Having Christians and Muslims in the same camp was critical.

The security risk varies significantly between camps, but are generally more common in those camps emerged from conflicts. Thievery, robbery and mistreatment are examples of issues arisen, not only due to difference of people but also from injustice. Equitable treatment for all residents is not always achieved and could sometimes cause violations and riots (even though it regards only a slight difference). (Sjöholm 2011)

Host communities are not often very found off the displaced people. Sympathy and an understanding for the vulnerable people rarely exist. Displaced people, especially refugees, are not popular since they occasionally take over hosting cities (including jobs), litter the site with waste, steal, increase the food prices and commonly do not share the international relief aid with the host community. Many of the hosting people feel unfairly treated. However, displaced people from natural disasters are more accepted. Hosting communities are in this case often from the same country and culture and feel sorry for the affected people. (Sjöholm 2011) (Davis, 2011)

4.4.2 Population

The number of people living in camps varies of course and depends on the crisis. Aid organisations try to set up smaller camps of maximum 20 000 people rather than one huge camp if the total sum concerns hundreds of thousands displaced people. Smaller camps are easier to manage and overlook, which is crucial regarding fire risks, security problems and the spreading of diseases among others. (CBC News 2007)

4.4.3 Location

The site of camps is usually, but not always, located on the edges of towns or on open fields, away from border and war zones. Preferably the site should have a sloped terrain that provides natural drainage. The areas chosen should moreover be far from breeding sites of insects that can carry disease. (CBC News 2007)

Refugee camps could easily get isolated and become artificial towns that are highly dependent on external aid. The living conditions and sense of dignity are very much influenced by the state of homes and should therefore be enhanced more than today. (Kemenade, Appendix, 2007)

Tents, which usually are used in camps, should not be pitched in long rows. Placing them in clusters like in many traditional village, or letting the residents themselves choose the layout, are preferred. It would make residents more comfortable. (UN 2004)

4.4.4 Length of stay

Camps are supposed to be temporary solutions, until displaced people can safely return to their home. However, based on previous experiences, organisations have learned that residents often end up living in camps longer than expected. Refugees from Kosovo lived in camps in Albania for three months, while refugees from Somalia have been living in camps in northern Kenya since 1991. (CBC News 2007) Most of the Somali refugees are located in Dadaab in Kenya, the largest refugee camp in the world. Currently 400 000 people are living in three camps originally designed for 90,000. (Care 2012)

4.4.5 Space

The recommended minimum space is 3,5 square metres per person in warm climates and 4,5 square metres in cold climates. However, due to the emergency situation, large groups of people are often crammed into much smaller spaces. The minimum distance between shelters should be two metres (m). (CBC News 2007)

4.4.6 Reception Centre

Registration is prioritised to keep track of who is in the camp and the centre is often placed at the entrance of the camp. The displaced people are given a registration document to prove they are a resident of the camp and serves as their entitlement to get food rations, blankets, clothing, and cooking utensils. Rules, who is in charge and what is expected of the new residents are presented. (CBC News 2007)

4.4.7 Water Point

For every 200 to 250 resident there should be at least be one place to get water and that location should be within 100 metres. One gallon (3,785 litre) of water per person per day is the minimum amount of water required in an emergency situation. The amount should be increased to about five gallons as son as possible in order to cook, wash dishes and clothes and assure personal hygiene. (CBC News 2007)

4.4.8 Food storage warehouse

Food is commonly stored on a warehouse, which often is a large tent. The warehouses should be positioned near the reception office for security and to facilitate the unloading from trucks (which is easier at the entrance than in the middle of the camp). Residents do not pick up food every day, but given rations to last for a week or a month. To avoid long line-ups and chaos food is handed out to different people on different days. (CBC News 2007)

4.4.9 Hospital/Clinic

If residents have access to a clinic or a hospital in the host country, the aid organisations will not establish its own. The level of hospitals in camps varies significantly. In some camps the hospitals are large with highly developed clinics where doctors can perform complex procedures. One hospital or clinic usually serves 200,000 people. (CBC News 2007) Figure 14

Asphyxiation from indoor cooking and water and sanitation related diseases are very common and severe issues. These are not unique for camps, but widespread in poor communities. Each year more than 2,2 million people die from preventable water and sanitation sickness (Architects for Humanity 2006), and according

Figure 14. From top: A clinic, market, latrines and school.

to The World Health Organisation 2 million people die yearly from pollutants in cooking smoke. (Good 2012)

4.4.10 Latrines

One latrine per family is ideal. Very often public latrines are however used and then there should be at least one for every 20 people, see Figure 14. The appropriate position is downstream and away from water sources. Furthermore, the latrines should be no more than 50 metres from shelters, otherwise it will be too far for people and the latrines will not be used. Space to build new latrines should also be provided when the old ones become full. (CBC News 2007)

Experience shows that displaced people often do not use latrines since they are generally shared and since people are not culturally used to them. When latrines are shared few families feel any ownership of them. Consequently, the maintenance is poor and residents avoid using them. (Ashmore 2002)

4.4.11 Market

Dependent of the relationship with host community the size and activities of markets in camps differs. Merchants mostly sell food such as fruit, vegetables, clothing, soap and so on. Displaced people can, even though they not are working, have money to buy food and products. Some brought it with them when they fled and some have relatives abroad who send them money. Generally speaking, there is one market per 20,000 people. Displaced people can also sell goods, such as grown vegetables or crafts they have made (Figure 14) (CBC News 2007)

4.4.12 School

A sense of normalcy can be central for children living under extreme circumstances. A basic sort of schooling could be enough to help children to keep a sense of normalcy in their lives, which is favourable for their recovery. (Figure 14) There should be about one school per 5,000 students. (CBC News 2007)

4.4.13 Non-family shelter

People missing families are placed together by gender in large tents. Usually the solution works fairly well, the group develops into a large family where the residents assist each other with babysitting etcetera. (Sjöholm 2011)

4.5 The cluster approach

In the past there has been a great shortage of collaboration and communication between aid organisations, which has been truly problematic in disaster situations. As a result, a cluster approach was established in 2005 to facilitate the coordination. (Sjöholm 2011)

A cluster involves a group of stakeholders with in common focus on service or sector provided during crisis. Each cluster has its own cluster lead agency that are responsible for the coordination. With a cluster approach expertise can be shared between organisations, adequate needs are easier prioritised, efficient resource allocation are facilitated and small individual organisations are able to provide more effective support. (UN, DFID, Shelter Centre, 2010)

The cluster lead agencies, found in Figure 15, have the overall responsibility to prepare for new crisis and perform capacity assessment. Regarding shelters, UNHCR is the cluster lead for conflicts and IFRC is convener (rather than leader) for natural disasters.

Area of Activity		Global Cluster Lead Agency
Agriculture		FAO
Camp Coordination/ Management:	*IDPs (from conflicts)*	*UNHCR*
	Disaster situations	*IOM*
Early Recovery		UNDP
Education		UNICEF/Save The Children
Emergency Shelter:	*IDPs (from conflict)*	*UNHCR*
	Disaster situations	*IFRC (convener)*
Emergency Telecommunications		OCHA/WFP
Health		WHO
Logistics		WFP
Nutrition		UNICEF
Protection:	*IDPs (from conflict)*	*UNHCR*
	Disasters/civilians affected by conflicts (other than IDPs)	*UNHCR/OHCHR/UNICEF*
Water, Sanitation and Hygiene		UNICEF

Figure 15. The cluster areas and leading agencies.

4.6 The response

In case of a natural disaster the first response deals with saving lives. The specific circumstances settle the type and amount of humanitarian efforts, but usually search and rescue teams, food and water are prioritised. After that, shelters are needed, which in reality often implies tarpaulins rather than tents. The Swedish Civil Contingencies Agency, MSB, always provides tents when they operate. Tarpaulins are often not lasting more than two or three months and MSB consider these to be insufficient. MSB is however only providing help for about 500 displaced persons in disasters, while UNHCR or IFCR are responsible for perhaps 500000 people. In other words, the supply volumes and costs are too vast at the moment to provide every family with a tent. (Sjöholm 2011) Regardless if tarpaulins or a durable long lasting shelter is provided the possibility that residents sell the product to gain money for the next few days exists. (Sjöholm 2011)

Besides the cost of tents, the production time and storage are problematic. More than 90% of the tents are sewed in China or Pakistan, partly due to their supply of cotton. The tents are distributed to warehouses in countries that are eager to have their own emergency supply. However, most of the tents are distributed to larger organisations, such as UNHCR who has five hubs around the world (Malaysia, Panama, Italy, Ghana and Dubai) containing large warehouses. Even though the warehouses are fairly large the supplies are rarely enough for large disasters. Therefore new tents need to be sewed, which in some cases have taken three months before they are ready to export. (Sjöholm 2011)

4.7 Logistic

The bottleneck in the supply chain is the actual transportation of shelters from one site to another. Air transportation is common, but there are not necessarily enough airplanes available. Many organisations are eager to get hold of them at the same time, but the majority of the organisations have to wait. Moreover, the local airport is not always designed to receive so many air planes as a disaster situation might require. Consequently, queues quickly emerge and the cargos get delayed. Additionally, the coordination of the shelters reaching the right receiver is another challenge. The situation is usually chaotic, but still aid organisations must have local organised recipients to make sure the shelters end up with the intended recipients. (Sjöholm 2011)

Standard relief tents are fairly heavy (70 kg - 100 kg) and of large volume compared to other relief items. The transports are therefore expensive, especially by flight. (UN 2004) To minimise the cost shelters can be transported by truck or boat. Over long distances shipping is the cheapest way. However, shipping is more suitable for replacing or pre-position tents rather than emergency response due to the slow process. (UN 2004) Standard sea containers of 20 feet (ft) are applied, and tents are either parcelled with or without Euro pallets into the containers. Arrived at site the tents are unloaded by hand or by forklifts. (Sjöholm 2011) The cost for a long shipping is about 20 USD. (Kanter 2011)

In an emergency, airfreight is naturally the quickest mean of transporting tents. Tents are flown in from the nearest hub and additional warehouses. Once the load arrives forklifts and cranes commonly unload the tents, but occasionally by hand as well. (Sjöholm 2011) Worth mentioning is that numerous trucks will often still be needed to transport the tents from the storage location to the distribution site. (UN 2004) The airfreight can cost more than the actual tent. A long flight can reach as much as 1000 USD for a 50 kg tent. (Kanter 2011)

After the cargo is unloaded the shelters are taken to a distribution central. The location of it could vary significantly, being either in a camp, in a village or close to the airport or harbour. From here displaced people are picking up the shelters by any means. Commonly it means carrying it by themselves, but can also be by car, horse or donkey. (Sjöholm 2011) See Figure 16.

4.8 Tents

A shelter that is portable, with a cover and structure, is usually called a tent, see Figure 17. Several different tent designs exist today, yet there are three main classifications: single-fly (one layer of fabric), double fly (one layer of fabric and a fly-sheet) and winterized (one layer of fabric, an inside layer, a fly-sheet and a hole for a stove-pipe). (UN 2004)

The lifespan of emergency tents is at the time of writing short in relation to the cost of purchase, warehousing and logistics. Once they reach the displaced people they are generally not lasting more than six to twelve

Figure 16. A distribution central.

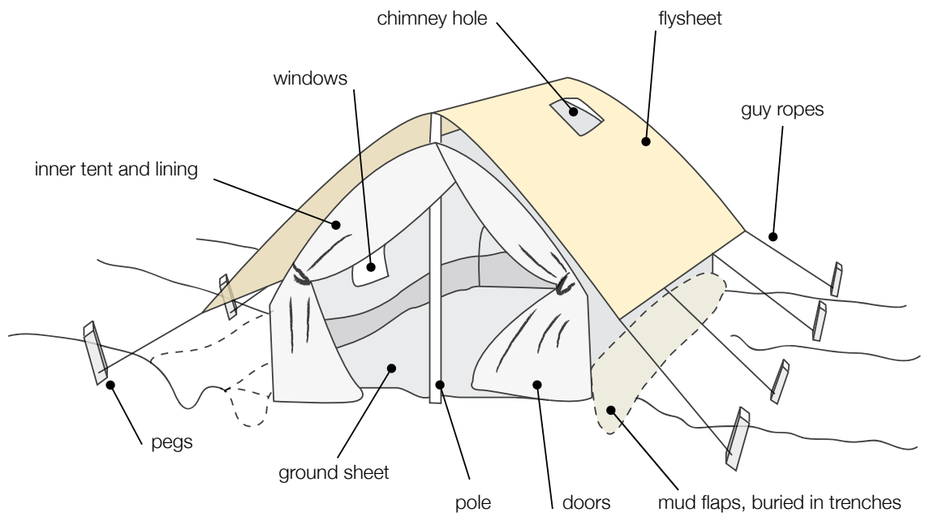


Figure 17. Common tent components.

months and do not create any significant long-term value. Furthermore the tent solutions are not made locally, but from abroad and in a universal design. The tents are thereby not adapted, other than to the climate, to different living situations and cultures. (Kanter & Karlsson 2010) (Sjöholm 2011)

4.8.1 Material

Today, most tents consist of cotton canvas, made from pure cotton or a mixture of cotton and polyester. The quality of the raw material is, as much as the quality of the weaving, determine the durability of the canvas. (UN 2004) Generally speaking tent canvases are lasting longer than tarpaulins, but can partly be a result of different construction designs. (Sjöholm 2011) An increasing number of tents expect to be made from synthetic materials such as polyester and polyvinyl chloride (PVC) in the future. (UN 2004)

4.8.2 Different tent designs

Numerous tent and shelter designs have been conceptualised and redesigned for decades, a few of them can be seen in Figure 18. Definitely, there has been a great deal of creativity in the ideas and several solutions have got some publicity. Prefabricated structures, shipping containers and polyurethane yurts have been suggested and explored. (Architects for Humanity 2006) However, few of the designs have actually been built and tested, and not many solutions reach (or cope with) the actual camp field to be evaluated for real. Even though the ambitions are high there are few of the designs that match the complex and difficult needs and circumstances that are required for shelters. Movable, inexpensive, light weighted, have low volume, easy to replicate, culturally excepted and easy to assemble are only a few of the needs. For instance, aluminium pipes were included in one shelter solution. Instead of using the durable aluminium pipes for shelter construction several residents sold, due to the material value, the components to gain income. As replacement residents cut down the nearby forest and used wooden sticks. (Kennedy 2007-2008) Shigeru Ban, who is known

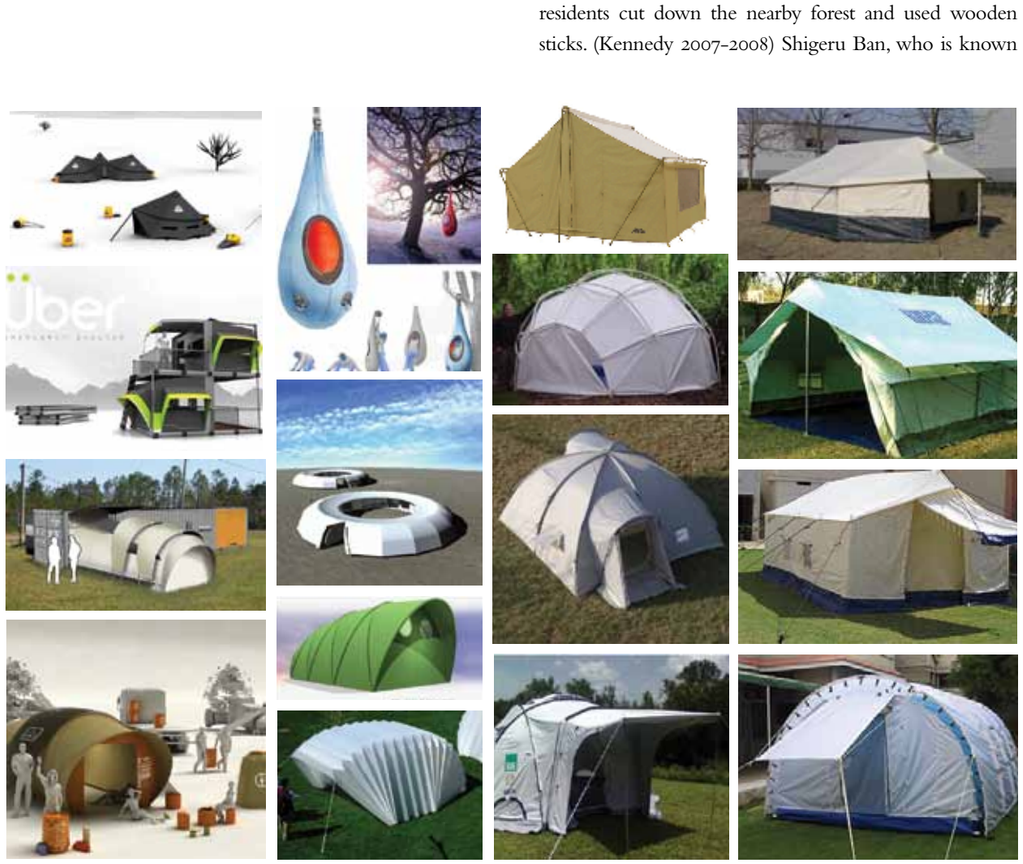


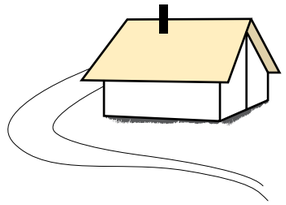
Figure 18. Several shelter designs. The tent at the top right corner is one of the current standard tents used by UNHCR and IFRC. It is made to fit a family of five in order to fulfil minimum standards.

for his cardboard and paper tube architecture, provided another shelter design in Rwanda (Figure 19). To minimise the cost and utilize local paper resources he developed a frame of paper tubes and connections of plastic. A mobile paper tube production line was also included in order to produce it on site. Unlike aluminium, paper tubes have no local monetary value. After evaluation UNHCR found the solution to be too costly and difficult to replicate for mass production. (Kemenade, Report, 2007) (Architects for Humanity 2006)

Figure 19. Paper tube frame in Rwanda.

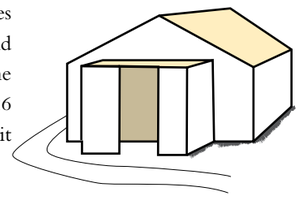
4.8.2 Canvas ridge tents

Canvas ridge tents are one of the most common designs among aid agencies such as, IFRC, UNHCR, IOM, UNICEF, and MSF. The models are often possible for warm and cold climates, include steel pipes (occasionally bamboo), weights between 75-120 kg and vary between 12-16 square metres.



4.8.3 Frame tents – the canvas rests on a solid frame

Frame tents are for family use, but are not often seen in camps since they are bulky and costly compared to ridge tents. The internal space is larger than in a ridge tent, but it requires more metal poles and other materials. The size is between 12-16 square metres and it weights 115 kg.

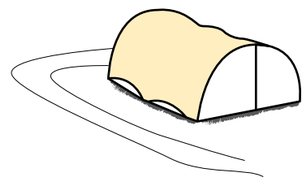


4.8.4 Centre pole tents

Centre pole tents were developed by UNHCR and exist with high and low walls for warm (single fly) and cold (double fly materials) climates. The tent weights up to approximately 120 kg and varies between 12-16 square metres. There is also a double-poled design of 24 square metres. Among others, the Iranian and Turkish Red Crescent Societies have used the centre pole tent.

4.8.5 Hooped tents

Hooped shaped tents have a relatively large internal space, no external guy ropes, suitable for windy locations and possible to extend by placing several structures in a row. At the same time they require more poles than a ridge tent and more technical materials. A model for warm climates was developed by OXFAM and another for cold climates has been made by IOM (which has been deployed in vast numbers in Afghanistan). The weight varies between 40-115 kg and the size is 16 square metres.



4.9 Alternatives to tents in camps

4.9.1 Tarpaulins

One of the most common solutions in emergency provision is tarpaulins. Providing poles, ropes, nails and tarpaulins is relatively inexpensive and can reduce the local environmental damage due to fewer trees being cut down. The standard size of a sheet is 4 m x 5 m. (UN 2004) The durability is usually however not as good as tents and definitely not comparable to more solid materials such as metal sheets. Strong winds and frequent sun make the plastic sheet very vulnerable and after three months they are commonly not functioning anymore. (Sjöholm 2011)

Shelter kit

Shelter kits are not particularly common at the time of writing, but the approach is gaining popularity and has proven to work relatively well in many situations. The kit is a fast way of delivering shelter possibilities of low cost. Each kit includes tools and a tarpaulin, making it possible for displaced people to build their own shelter construction. (Kanter & Karlsson 2010)

4.9.2 Cash for work

The use of cash grants and material vouchers has been showed to work well in several emergencies. The approach has encouraged agencies to think in new ways and move away from standard emergency relief solutions, like tents and tarpaulins. (UN-HABITAT 2010) The cash grants are commonly paid after residents performed contraction work (such as digging drainage and building latrines) or cleaning up the camps. Problems can emerge though in refugee camps if the displaced people are gaining more money than the hosting community. The local prices could thereby increase, making the hosting residents unable to afford. This has happened in Darfur.

The approach has given varied results in different cultures. In some areas for instance people have picked up and spread out the very same trash they just cleaned up, only to gain more money. (Sjöholm 2011)

4.9.3 Local shelter construction

Shelters that are built locally and constructed with well-known technology, materials and building traditions are very favourable. The durability varies of course. Simple erected structures of sticks and leaves are not lasting very long, while solid shelters by earth or cement foundation are the opposite. Locally built housing are often cheaper than supplying tents from abroad. However, due to lack of materials and land restrictions the solutions are not always applicable. (UN 2004)

4.9.4 Transitional shelter

Transitional shelter is a strategy, for non-emergency response, to support communities to reach permanent accommodation, minimising displacement and consider town planning, sanitation, land tenure, neighbouring populations, the local economy, security, human rights and cultural factors.

A transitional shelter is, with a more concrete explanation, a house structure with foundation in which usually a family can live for as long as their permanent accommodation is built or restored (Figure 20). Transitional shelters are implemented for natural disasters, not commonly in conflicts (due to land issues). Preferably these shelters are built from local materials and are adaptable to climate and culture. (Sjöholm 2011)

Transitional shelters are usually emerging one year after a natural disaster, and built with a solid foundation. (Sjöholm 2011) The transitional shelters can be appropriate when local hazards and land tenancy have been solved, but also if the start of reconstruction is severely delayed or if harsh climate conditions are occurring. The shelter solution provides durable houses, can involve beneficiaries in the design, can be of culturally familiar materials and supports local productions. (Shelter Centre 2011) (Oxford Brookes University, Lessons from forty years of disaster shelter, 2011) At the same time transitional shelters can remove the political motivation to provide real permanent reconstructions. There is a severe risk that vulnerability is prolonged, since they suit the NGO timeframes and budgets more than people's long term needs. (Clermont et al. 2011) Moreover, valuable financial resources might be wasted instead of used for permanent reconstruction, slums can arise in the long run if transitional shelters are not demolished and the area taken by the transitional shelters can, in congested urban regions, be at the same site needed for proper reconstruction. (Oxford Brookes University, Lessons from forty years of disaster shelter, 2011)

The use of transitional shelters carries an overall strategy in three steps. The strategy implies the implementation of immediate shelter, to a transitional shelter and finally to a permanent reconstructed dwelling.

Figure 20. Transitional shelters in Haiti.

There is another strategy possible when the climate conditions are not too harsh and safety and health can be secured. The strategy includes two phases, immediate sheltering to a permanent reconstructed dwelling. By excluding the transitional shelters several advantages are drawn. Cash reserves are saved, less vulnerability is rebuilt, social distribution is avoided, the use of host families and existing large buildings are encouraged and rapid reconstruction is triggered. (Oxford Brookes University, Lessons from forty years of disaster shelter, 2011) (UN-HABITAT 2010) However, in order to implement the strategy the immediate shelters (tents) must be durable enough to last until the proper reconstruction is well progressed. That period of time can vary significantly. Sometimes the need for emergency shelter is still kept several years after the natural disaster occurred.

4.10 Standards and guidelines

The aid community has, in the beginning of the new millennium, communally produced several new relief instructions. These handbooks are thick and contain a vast number of guidelines and standards. The aim was to modernize outdated handbooks with new additional knowledge and insights and to explore how improvement of the coordination and implementation of aid can be achieved.

4.10.1 The Sphere handbook

The Sphere project is a communal effort of several humanitarian NGOs and the Red Cross and Red Crescent movement. The Sphere handbook carries tremendously amount of information about meeting

the urgent survival needs after disasters. Water supply and sanitation, nutrition, food aid, shelter and health services are the five sectors of focus. Minimum standards within these areas have been formulated, as well as practical indicators of how the goals can be met. (Kemenade, Appendix, 2007)

The Sphere standards have been criticised by numerous agencies for being irrelevant for dense urban settings. Half of the world's population lives in urban areas and cities are often densely populated. Poorly developed urban areas are very vulnerable to hazards and 40 of the 50 fastest-growing cities are located in earthquake zones.

It has been reported from situations that there is no possible way to control and ensure the space standards since many camps are spontaneous and unplanned. Allowing 45 square metres per person, as well as 3,5 square metres of covered living space, in urban camps is often impossible to achieve. Instead, the standards could be seen as indicators of guidelines for what would be appropriate. (Clermont et al. 2011) (UN, DFID, Shelter Centre, 2010)

4.10.2 UNHCR handbook for emergencies

UNHCR has produced a set of protocols covering emergency management and problem areas in refugee emergencies and guidance on the support of field operations. (Kemenade, Appendix, 2007)

4.10.3 Shelter Centre

"Shelter Centre is a non-governmental organisation registered in Switzerland which supports the sector of humanitarian operations that responds to the transitional settlement and reconstruction needs of populations affected by conflicts and natural disasters, from the emergency phase until durable solutions are reached." (Shelter Centre 2012) Shelter Centre has made several reports and publications, among others Transitional Settlement Displaced Populations. The principle members of the University of Cambridge Shelter project put this book together and it offers an analytical overview on settlement situations of displaced people. The Sphere handbook and UN publications are put in a broader perspective, but also complemented with other studies and experiences. (Kemenade, Appendix, 2007)

4.11 The options of emergency housing

The number of people that become displaced from a natural disaster or weapon conflict is usually vast. Offering tarpaulins or tents in camps is one solution. There are however several options, most of them usually much better and preferred than applying camps. The different shelter alternatives differ a lot since they are suitable for different situations. Shelter Centre has in of their reports categorized the alternatives into six main options: *dispersal in host families, rural self-settlement, urban self-settlement, collective centres, self-settled camps* and *planned camps.* The first three options imply that people become dispersed into different spots and the three last ones that people are grouped together. It is also possible to view the options as four self-settled options and two planned. (Corsellis & Vitale 2005)

Dispersed in host families

The first option involves that local families are willing to offer displaced people households or land. (Corsellis & Vitale 2005) (See Figure 21.) Either they share accommodation or the displaced people can set up temporary shelter nearby. In both cases water, cooking, sanitation and household services are shared. Usually the hosting people are extended family members or with the same ethnic background. (United Nations High Commissioner for Refugees (UNHCR) 1999)

Dispersed in rural self-settlement

The second option means that displaced people can settle in rural contexts that are owned collectively, rather than privately. (See Figure 21.)

Dispersed in urban self-settlement

The third option is to settle in an urban environment, either by occupying unclaimed properties and land or by settling informally. (See Figure 21.)

Grouped in collective centres (mass shelter)

The forth option is based on using larger pre-existing facilities in order to fit a great amount of displaced people. These facilities could for instance be town halls, gymnasiums, hotels, warehouses, community centres and disused factories. (See Figure 21.)

Grouped in self-settled camps

The fifth option means that displaced people settle in a camp without assistance from aid organizations or local government. (See Figure 21.)

Grouped in planned camps

The sixth option is to have a specific site where services are provided from aid organizations and governments. (Corsellis & Vitale 2005) (See Figure 21.)

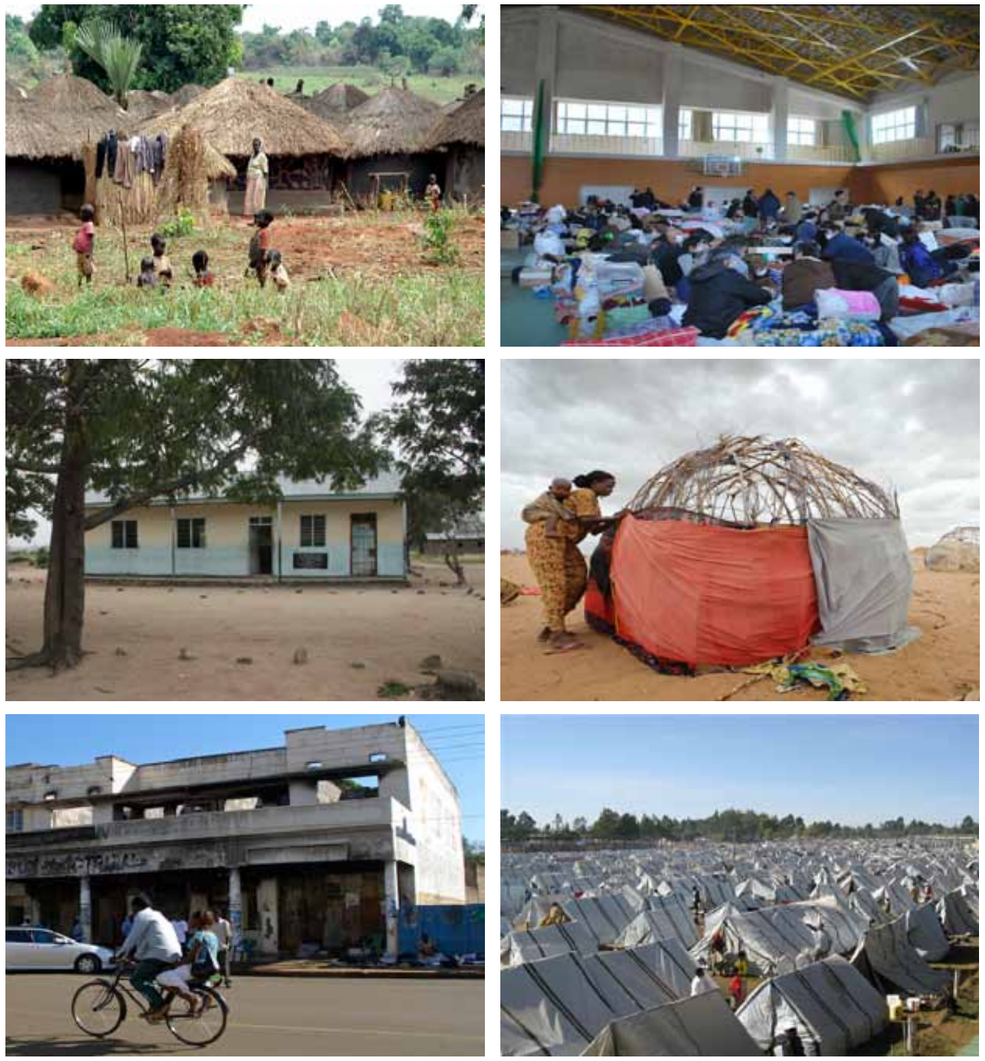
It is significantly important that UN, aid organisations or governments evaluate these options thoughtfully before taking action. One solution could be tremendously inappropriate in a specific situation. (Kanter 2011) However, it is likely that more than one option could be applicable in a disaster and that external aid could be used with different approaches for all options. (Corsellis & Vitale 2005)

4.11.1 Dispersed options

In most cases displaced population prefer to live in dispersed settlement rather than grouped settlement. This attitude reveals the importance of letting displaced people maintain independence as much as possible and sustain themselves. External aid could still be useful or necessary and offer developmental benefits. (Corsellis & Vitale 2005)

The approach of a dispersed settlement includes several more benefits:

- The risk of being an obvious target for attack (during weapon conflicts) decreases. (Corsellis & Vitale 2005)
- By involving displaced population in local communities people can become more self helped, independent and responsive to changing needs during time. (Corsellis & Vitale 2005) (UNHCR 1999)
- Using local contacts or strategies could be useful in order to meet the needs of dispersed people. (Corsellis & Vitale 2005)
- The cost and administrated support from aid organisations could be less since dispersed settlements require smaller initial investments rather than large-scale responses (for instance importing materials and arrange served camps). (Corsellis & Vitale 2005) (UNHCR 1999)d
- The solution is rather quick to implement.
- The impact on the local environment could be less than in camps. (Corsellis & Vitale 2005)



The disadvantages are:

- There is a risk that communities and host families become impoverished and overburdened.
- When registration of affected people is required it is difficult to distinguish the people from host population.
- Identifying protection problems could be harder than if people are grouped together.
- Aid assistance is probably needed for host population as well, making the total amount of people in help much larger. (UNHCR 1999)

Figure 21. Different shelter solutions. The left column implies dispersed alternatives and the right one grouped.

4.11.2 Collective centres (mass shelter)

Collective or mass shelters are normally used in urban areas and considered to be temporary. (UNHCR 1999) Individual family shelters should however be preferred if possible. (Kemenade, Appendix, 2007)

The advantages are:

- The solution can be used immediately without interrupting hosting area.
- Water, sanitation and other services are quickly available.
- Less materials and constructions are needed for supplying the effected people. (UNHCR 1999)

The disadvantages are:

- Privacy is hard to achieve.
- The mass shelters can become overcrowded rather fast.
- Services such as sanitation are easily overburdened. (UNHCR 1999)
- Emotional security is lacking. (Kemenade, Appendix, 2007)
- The solution is not appropriate, like a private shelter, in order to preserve and rebuild a family unit. (Kemenade, Appendix, 2007)

4.11. Planned (and self-settled) camps

Camps that are dense and include large populations are the worst accommodation option for displaced people. (UNHCR 1999) Initially services are provided to help, but in the long run people have to (in some measure) take care of themselves. The options of doing so are very limited which neglects the living conditions. (Kemenade, Report, 2007) Unfortunately, camps are sometimes the only option due to lack of alternatives. This option is common in regions where pre-existing infrastructure is inadequate.

When planned camps are needed:

- The amount of displaced people is greater than the supply of local resources. With 100000 people in urgent need of shelter, there are rarely enough local resources. (UNHCR 1999)
- Local people are hostile or unwilling to host displaced people. (Corsellis & Vitale 2005)
- If displaced people are entering a neighbouring country (becoming refugees) the local government are not always willing to integrate the refugees in the society. (Sjöholm 2011)
- There is no local settlements close by to host displaced people.
- Emergency and long-term support for dispersed solutions could imply too high financial, social and political costs.
- Providing infrastructure for dispersed settlement could be time consuming. When the need of shelter is crucial a camp could sometimes enable a quicker solution.
- Local environment can be fragile. To encumber the area with displaced population could worsen the situation further. In some cases the environmental impact can be less affected in a grouped settlement. (Corsellis & Vitale 2005)
- Land rights often become a great issue after disasters since people often cannot confirm their ownership of land. (Sjöholm 2011) The effect can imply that reconstruction assistance cannot be legally offered and affected people may not receive any assistance except for in camps. In this case there is a great risk that people will remain displaced for many years. (Collins, Corsellis & Vitale 2005)

The advantages are:

- The approach is fast and can, due to high scalability, provide shelters to a large amount of people. (UNHCR 1999) (Kanter & Karlsson 2010)
- Being able to identify and communicate with the effected population could be easier than in dispersed solutions. (UNHCR 1999)
- Arranging repatriation can be facilitated. (UNHCR 1999)

The disadvantages are:

- Health risks increase significantly with high population density.
- The risk of environmental damage is high in the vicinity of the camp.
- Great concentration of population could increase the risk of becoming vulnerable (during weapon conflicts).
- By providing support for displaced population exclusively the host community can become resentment. Tension could be exacerbated further if local resources are limited and host community need to share it with displaced population. (Oxfam 2004)
- Camps are usually not available immediately after disasters since they take time to construct. (Corsellis & Vitale 2005)
- Governments or private landowners are often unwilling to let land in camps become permanent settlements. Due to risk of not regain the area (and creating a new settlement) shelters need to be temporary. This is usually an unwritten rule. However, refugee camps last in average for 17 years and the settlements are obviously not temporary (even though shelters are constructed for that purpose). The shelters are rarely moved from one place to another but need to be moveable in order to be viewed as temporary. (Sjöholm 2011) Draping tent walls in mud could be a strategy to provide thermal comfort (keeping the shelter warmer in winter and cooler in summer), draught proofing and establish a more solid construction. (UN 2004) Yet, mud walls are usually not perceived as permanent structures. Neither is drainage around shelters and across camps.
- Structural shelter solutions are, due to its long duration, rarely reached for the majority of people. Instead the shelters often remain to be of improvised nature and put a heavy strain on the local environment. (Kemenade, Report, 2007)
- Livelihood activities are rarely functioning in camps as good as in self-settled options. (Corsellis & Vitale 2005)
- Planned camps cannot in general expand in size in order to meet new arrivals. The facilities available are therefore rarely enough to meet the needs. (Corsellis & Vitale 2005)
- The activities for displaced population in camps are limited and people can become apathetic. (Sjöholm 2011)
- Temporary shelter solutions, which often are needed (in order to satisfy political requirements), often result in tents. Tents are costly (due to air transportation), not durable (last about six to twelve months), do not gain local people with work opportunities (the development possibilities are minimal) and carry great risks that people accept too low standard of life. (Gyllenhak, e-mail conversations, 2011) Survival can be accomplished on very low levels, and priority of proper shelters can be neglected for the benefit of more tents. (Kemenade, Appendix, 2007) But tents negate human needs beyond survival. For instance cultural and social expression, security, privacy and being environmentally appropriate are vital for a home, but are not fulfilled at all. As a consequence of the opposition towards tents they are poorly maintained and abandoned more frequently than local shelter solutions. Unique tents for each cultural and environmental location are naturally impossible to supply from UN or aid organizations since they usually cannot even afford to distribute tents to all affected persons. In other words the humanitarian needs often exceed the budget. (Kanter & Karlsson 2010)

4.12 The life in camps

The everyday life in camps differs logically, but often includes outdoor activities in front of the shelters such as managing stalls, growing vegetables, keeping an eye on cattle, repairing tools, drying clothes, babysitting, child minding, playing and other simple activities related being with family and friends and observing the surroundings. (Kennedy 2004) Furthermore, the provision and cooking of food are commonly a major part of the day, especially as an IDP. Refugees often obtain more relief supply privileges, such as food and water, as their situation gains more attention. (Alabaster 2011) The water is rarely purified in camps, but shipped in from the outside. However, rainwater is occasionally collected for washing oneself and clothes. (Sjöholm 2011)

After natural disasters displaced people continue to work with their previous job outside camps, as long as these are not damaged. When camps emerge in a nearby country, due to weapon conflicts, there are frequently few refugees who are allowed to work outside the camps. Instead, any goods that refugees can overcome (for instance tarpaulins provided from aid organisations) are sold outside the shelter or in local markets. Some may also assist in camp management activities such as digging drainage or fetching water. (Sjöholm 2011)

To minimise passivity and disorder it is essential that people have some activity to accomplish during the day, not necessarily new and varied ones. (Sjöholm 2011)

Depending on the construction and appropriateness of the shelter the displaced people are either present most of the time for daily activities or only at night for sleeping. (Sjöholm 2011) (See Figure 22 and Figure 23.) Qualitative shelters and calm surroundings, where people feel safe and at home, are essential for people's health. From Palestine is has been reported that people are exhausted travelling and moving through West Bank back to their camps. Having been held at several checkpoints or at gunpoint, people become psychically worn out and fall a sleep for hours once they reach the camp. The same behaviour has been reported about children. They fall a sleep at home as a way of relieving the tension of dangerous or long journeys home from school. (Gren 2009)

Latrines, garbage pits and shower booths are eventually emerging. After some time, the shelters turn their backs onto the communities since few inhabitants would want to have their front doors facing straight into these areas. (Kennedy 2004)

Figure 22. IDPs in Haiti. The indoor temperature and lack of space make people stay outside during the day.

Figure 23. IDPs in Kenya. The indoor temperature is hard to cope with.

4.13 Sustainable approach

According to many experts the most desired solution after natural disasters is to support permanent housing that is benefitting the local environment and is anchored in the culture and surroundings. With financial help and technical instructions a lot of people could manage by themselves to rebuild their old houses into new ones. (Gyllenhak, e-mail conversations, 2011) This becomes a more holistic and progressive approach to the problem compare to camps. Instead of delivering ready-made shelters (Kemenade, Report, 2007), which could place people in renewed vulnerability (Oxford Brookes University, Lessons from forty years of disaster shelter, 2011), the international aid concentrates on stimulating and reinforcing local development by promoting independence and supporting great relationship with host communities, all in collaboration with the displaced people themselves. By involving the affected people in the development the solutions often becomes more sustainable, cheaper, motivating (Kemenade, Report, 2007) and supports the community according to their own priorities and world-views. Reconstructions that is only conceived and implemented by foreigners are in other words usually not preferred if local alternatives are available, (Oxford Brookes University, Lessons from forty years of disaster shelter, 2011) at least not in the long run. In the initial phase families are sometimes logically welcoming prefabricated temporary housing. It arrives quickly and addresses short-term needs. But shortly complex problems emerge due to long-term use of shelters and then suddenly families start to realize the immediate need for permanent shelters in a familiar environment. (Oxford Brookes University, Literature review, 2011)

People who have had a productive life outside camps, developed practical skills and received education have proven to be much better prepared to contribute to reconstruction of their country compared to people surviving on minimal standards in camps. (Kemenade, Report, 2007)

Western societies could offer political pressure and support peace procedures in tensed or conflict situations. Nevertheless, the role as supply accommodator inquires a lot of responsibility. As soon as items such as food, health care, security, education and equipment are delivered to displaced people a huge business emerges for foreign enterprises. This industry is common today and it has become more and more criticised since the procedures are viewed as paternalistic and stigmatizing and a limited investment is put into the human resources of displaced people. (Kemenade, Report, 2007) Instead foreign manufactures and suppliers are sometimes gaining on this approach, and thereby expanding the priority for aid organisations and governments, beyond just helping affected people. For example they are often eager to provide highly visible shelters to be photographed in promotional advertising, spend distributed money, satisfy donors or electorates expectations, respond to political and commercial interests, secure votes for future elections and sell products. In recent years intermediate shelters have been increasing in popularity among aid agencies and these solutions are prolonging the vulnerability of affected families and the business of the aid industry. In order to achieve a sustainable solution this supply driven approach needs to be transformed according to experts into a more demand driven response. Consequently, aid organisations and affected people should as much as possible resist all pressure from designers, donors, suppliers and manufactures to practice the supply driven response. (Oxford Brookes University, Lessons from forty years of disaster shelter, 2011)

4.14 Cultural and social appropriateness

Besides supporting permanent housing it is also very beneficial and important to maintain the cultural and social expressions and traditions in the shelters. Familiar techniques, shapes, constructions, functions, aesthetics and materials are usually preferred. Even the amount and positions of rooms, number of shelters (one for children, one for husband and wife etcetera), the location of doorways, the existence of windows, sleeping arrangements, the total size, how the house is extended for additional family members etcetera could be quite essential for the acceptance. These layout solutions of houses differ significantly between cultures, possibly even between two locations with a distance of a few hundred km. (Gyllenhak, e-mail conversations, 2011) (Oxfam 2004) (Kennedy 2011) In other words, it is impossible to make one solution that fits all needs. (UN, DFID, Shelter Centre, 2010)

People are usually constructing homes based on previous experiences and community's ambitions, and in order to achieve a functioning locally production of housing people should be able to continue with that. Using well-known solutions is a foundation for reconstruction and these should be improved and embraced, not replaced. (UN-HABITAT 2011) It maximizes the local livelihood opportunities. (Ferrer, Serra & Ashmore 2009) Furthermore traditional practices often offer, regarding climate change, the most feasible solutions and smallest footprints. (Oxford Brookes University, Lessons from forty years of disaster shelter, 2011)

Several experts claim that the single most important lesson from working within this field is to learn from the local people and their building practices. Immediate mobilization towards permanent shelters, with participation from affected people in assessment, design, implementation, monitoring and evaluation is generally the best long-term solution. Shelters most grow with participation of communities and not simply be built by suppliers. (Oxford Brookes University, Lessons from forty years of disaster shelter, 2011) (Ferrer, Serra & Ashmore 2009) Participation and opinions from individuals and groups who spend a great deal of the time within shelters should be prioritized. (Oxfam 2004) The role from aid organisations would rather be to provide tools, materials and knowledge in construction technique. (Davis, 2011)

As an aid worker it is extremely essential to respect (and understand as far as possible) cultures, customs and structures of the communities and countries that you are working in. (Oxfam 2004) Otherwise the outcome of the effort will most likely not function efficiently. For instance, in several disasters new houses were built using technologies so alien or expensive that residents were unable to replicate or maintain them. In the end people abandon these technologies, even though the original idea behind them might have been great. (The cd3wd project 2012)

Another example regards the importance of privacy in some Muslim locations. Many women avoid exposing their appearance and private matters to unknown men and individuals. As a consequence privacy becomes truly essential for shelter design. For instance, the positions of windows and doors have to be placed in a way that they hinder insight. And the thickness of walls should prevent shadows to be projected on them while using indoor light. These kinds of examples should be taken into consideration, especially in Muslim locations where people are quite careful about privacy. (Sjöholm 2011)

4.14.1 Basic needs

Traditionally emergency humanitarian relief focuses on physical needs and survival. These needs could be found at the bottom in Maslow's hierarchy of needs: breathing, food, water, sex, sleep, homeostasis and excretion. (See Figure 24.) This means, besides water and food, that shelter, heat, clothes, sanitation and hygiene are the most obvious features for humanitarian aid organisations initially.

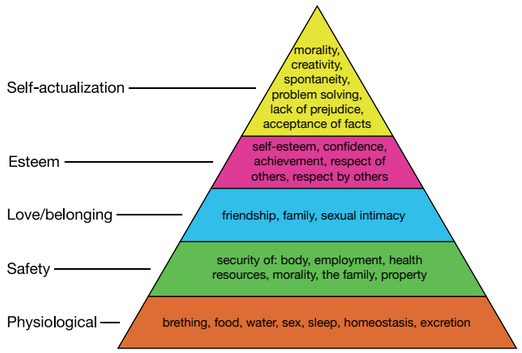


Figure 24. Hierarchy of needs.

According to economist Manfred Max Neef survival factors alone are however not enough. In the design and planning of aid and development a wider set of needs should be taken into consideration. Besides protection from injury and hot an cold weather, it could be for example a living environment, a place for privacy and intimacy, an accommodation to relax in and belong to, a social spot and a place to create and personalise. Max Neef classifies the fundamental human needs as subsistence, protection, affection, understanding, participation, leisure, creation, identity and freedom. The needs are constant across time periods and through all human cultures, but the strategies of how to achieve them differ significantly. Compared to Maslow, Max Neef claims there is not really a hierarchy of needs (apart from subsistence) and that human needs rather are a dynamic system where they overlap each other. (Kanter & Karlsson 2010)

Regardless if Maslow's or Max Neef's approach is right or not, cultural and social appropriateness is subordinated to survival. In emergency situations it is most important to have a shelter at all. (Kemenade, Appendix, 2007) Besides, there are no alternatives for affected families even though they most likely have doubts about temporary shelter (and would prefer to live in a more familiar way). Tents and tarpaulins are better than nothing and therefore accepted. People would not refuse to use them if the alternative is to sleep outside. (Sjöholm 2011) Unfortunately the general life span of camps is many years and shortly people feel the importance of more than just survival. Displaced families hunger for a home. (Kemenade, Appendix, 2007)

But an actual home for long-term use could in most cases only be designed and built by people from similar cultures. And as soon as the real emergency phase is transcending into a long recovery and developing stage families become more careful about their needs beyond survival. (Sjöholm 2011) As a consequence the material supplies sent within the first ten weeks need to be aligned with future relief efforts. (Kanter & Karlsson 2010)

There are numerous stories about long-term shelters with perfectly engineered solutions that have been rejected due to lack of appropriateness to culture. For instance, in Ethiopia affected families ended up using new houses as storage. In Pakistan geodesic domes were provided (see Figure 25), but neglected since the spheroid form turn out to be cultural incompatible. (Kanter & Karlsson 2010) In Somalia it became very hard to convince locals that mud-built family houses had some advantages over the traditional and familiar tukul shelters (see Figure 26). Since they had lived in nomad huts for generations they believed it must offer an optimal solution for life in the desert. (Kemenade, Appendix, 2007) And finally in Sri Lanka after the tsunami 2004, tents turned out to be inappropriate due to the corrosive coastline and the livelihood disadvantages. (Oxford Brookes University, Literature review, 2011)

If displaced people could be responsible for their own shelter it empowers them to adjust the house to private wishes and be better maintained. (Kemenade, Appendix, 2007)

Figure 25. Geodesic dome.

Figure 26. Tukul house.

4.15 The mission of shelter

Several experienced specialists in this field claims that shelter after disasters only function for real when it is perceived and driven by a profound understanding that shelters is not just protection from weather, a place for accommodation or somewhere to store belongings. It works when programmes and organisations are driven by the realisation that shelter is the foundation block for people's recovery. (Oxford Brookes University, Lessons from forty years of disaster shelter, 2011) Programmes most not merely include a roof; it should as well offer a return to normal life. (Oxford Brookes University, Literature review, 2011) As long as people only have a "house" and not a "home" nothing happens. A house is a structure, but a home is much more. A house or

a shelter serves to protect residents, but a home is a segment of the creation of domestic environments that express the deep structures of society. (See Figure 27.) (Oxford Brookes University, Lessons from forty years of disaster shelter, 2011) Or as camp resident claims: *"Everybody wants the same thin, rich or poor… not only a warm, dry room, but a shelter for the soul."* (Architects for Humanity 2006)

Shelter design is consequently a huge and important challenge for designers (regardless if it is professional or indigenous). To create places with meaning, not simply spaces are perhaps the core of the challenge. Places should provide identity, a profound sense of belonging and emotional (not just physical) security. Fulfilling these social, emotional and psychological needs should be prioritized more, particularly in recovery situations where survivals need additional security after the chaotic situation of human and material losses. (Oxford Brookes University, Lessons from forty years of disaster shelter, 2011)

To achieve a shelter that meets these needs designers, architects, planners and engineers must interact sincerely and continuously with social workers, health workers and anthropologists. By doing so the result becomes, most likely, more implementable with additional focus on the residents. The influence and knowledge from field workers could make developers realize that shelters should not be thought as a component in isolation. Instead shelters, livelihoods, environment, psychosocial recovery etcetera should all be considered at the same time when housings are developed. (Oxford Brookes University, Lessons from forty years of disaster shelter, 2011)

What must be said though is that shelters could hardly become a home, or bring a true life with dignity, when all that is being provided is the bare minimum for existence. Shelter programmes are frequently using Minimum Standards, but the use of them discourages a life with dignity (which could be expandable, positive and enhancing). And there are no indicators or directions for what could be comfortably above

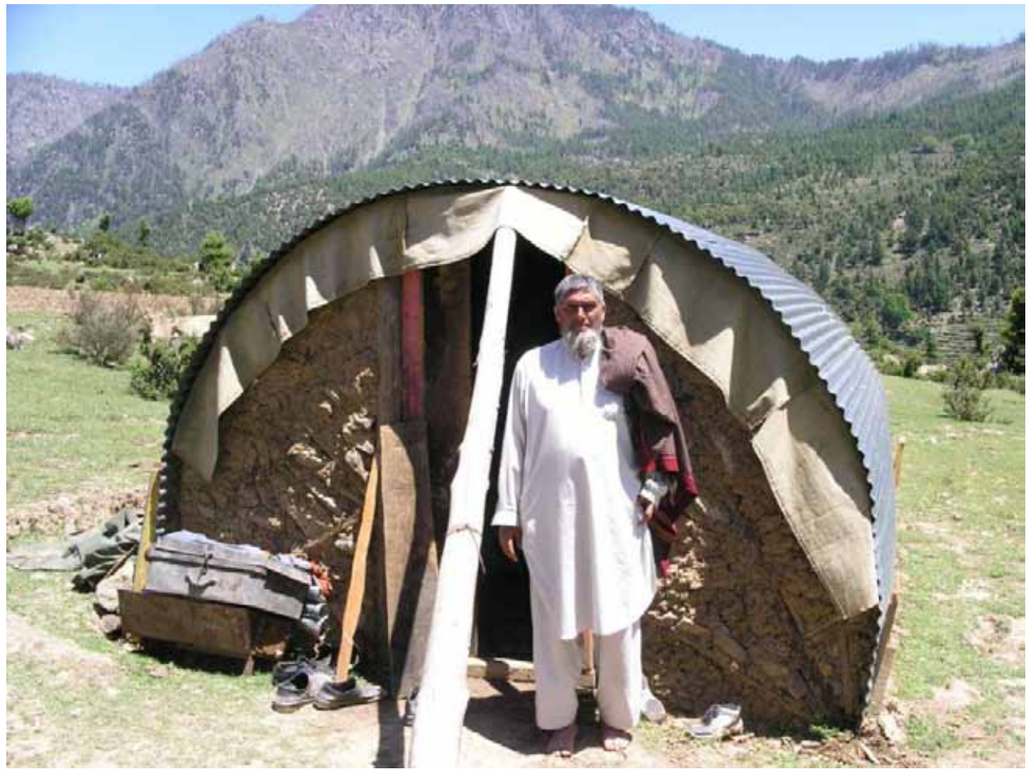


Figure 27. A house, but maybe not a home.

minimum. (Kennedy 2004) In other words shelter programmes often lack the ambition of establish long-term solutions and fulfil more than just the basic needs.

Rumana Kabir, who is an architect/independent shelter and housing consultant in Bracknell UK, describes her view of the complex subject:

"I feel very sad to see that we in the humanitarian relief system do not learn how to do it better, as we fail to capture the lessons learnt and move forward. It feels as if we are going backwards by delivering shelter as a relief product and standardising it, in the name of 'humanitarian intervention'. I wish we had more time to review in advance, before jumping into any new disasters concerning ways to make the shelter interventions that are a more durable solution for future risk reduction and not repeat the mistakes we are likely to make when we are in a hurry." (Oxford Brookes University, Lessons from forty years of disaster shelter, 2011)

4.15.1 Additional needs

Obviously shelters related to disasters and conflicts are a truly complicated issue, but at the same time one of the most important bases of general living conditions. (Kemenade, Appendix, 2007) Many functions and aspects are useful to consider beyond the most obvious ones (such as providing protection from the climate, security and privacy for individual households etcetera). Shelters could function for activities like workshops, worships, community gatherings, clinics, storage rooms and more. (Oxford Brookes University, Lessons from forty years of disaster shelter, 2011) It should be affordable to use, habitable, accessible in its features, provide a life with dignity and be adapted for (further) disasters such as landslides and earthquake aftershocks. (Oxfam 2004) Without attention to these needs and only on housing, the recovery phase will likely be restricted. (Oxford Brookes University, Lessons from forty years of disaster shelter, 2011)

Moreover a shelter has additional functions embedded in itself. It marks territorial claims or rights, serves as a location to receive relief assistance, is worth a great deal financially for a household (Oxfam 2004) and it gives people time to gather fuel and food, look after their children and handling other fundamental activities (UN 2004).

4.16 Behaviour

Regardless of cause to a disaster the population has experienced dramatic scenarios. Family members could have died or been badly injured. The aftermath is however not necessary a peaceful recovery from the situation. In case of a weapon conflict displaced populations are commonly still feeling threatened. Someone is after you and the future is uncertain. The consequence here, as well as in natural disasters, is that people becomes anxious. Their behaviour changes even though the routines and living patterns might continue in similar ways. (Sjöholm 2011) Depression, pain and changed habits (or problems) of sleeping could be a symptom of general exhaustion from disaster effects. In Palestine, where people have been living in permanent camps for about half a century, people talk about having no future, no life and no happiness. (Gren 2009) Furthermore, new norms and attitudes could arise with camps leading to greater extent of thievery, violence and less care for others. (Syversen 2011)

4.16.1 Dependency syndrome

Several ethnographic studies confirm that loss is not necessary followed by powerlessness. On the contrary loss could provide a sense of empowerment for affected people. (Gren 2009) However, when camps are provided as a solution a common problem that develops after a while is passivity from displaced people and less eager to solve situations by themselves. (Kemenade, Report, 2007) The lives are more or less about waiting and being dependent of aid workers. (Kemenade, Appendix, 2007) After long time of idleness people become bored, lazy, not motivated in improving their own situation and tend to hold on strongly to their cultural identity. The behaviour is called "dependency syndrome". (See Figure 28.) (Kemenade, Report, 2007)

People who have survived disasters might have lost all their belongings and family members. To end up in a shelter that is incorrect and outlandish regarding culture, location, materials and quality is humiliating. Shelters should not stigmatise displaced people as victims, but as assets. Having poor shelters with patronising signs and logos on the front showing it is a 'gift' is consequently not appropriate to minimise the apathy and dependency syndrome among people. (Oxford Brookes University, Lessons from forty years of disaster shelter, 2011)

Figure 28. The life of a refugee is often about being dependent on aid and waiting for it.

Providing aid to displaced populations tends to shape people as helpless. In the long run the creative energy of the people suppresses, hindering residents to help themselves. This has been seen for instance for food rations in Palestine. Instead of only preventing people from starving the rations made them into dependent receivers. Furthermore, accepting relief was often regarded shameful for adult men, resulting in women and children being sent to collect rations. (Gren 2009)

4.16.2 Ownership

The sense of ownership of supplies, such as tents, for displaced people differs a lot between cultures and settlement option. For instance, by living in planned camps someone else is making rules and decision over you. Some familiar acts or behaviour are perhaps not permitted. In other words, displaced people become guests rather than residents. (Sjöholm 2011)

Martin Sjöholm, who is employed at MSB (Swedish Civil Contingencies Agency), has been working in several countries after disasters. Haiti and Pakistan are, among others, two countries he visited recently and he describes the sense of ownership to differ significantly between the countries. (Sjöholm 2011)

In Haiti, generally speaking, people are directing their effort on their own family rather than including the community (see Figure 29). There is not really a sense of belongingness to the camps. For instance, stealing from neighbours would not be prohibitive for some if there is a chance of improving your own situation. Since people furthermore are not truly eager to take care of their own equipment most of it placed outside the shelter will disappear shortly. Regarding shelters or tents the perception is similar. People are not willing enough to look after and maintain them and would not save it for later use if they received a better house. The tents

Figure 29. The family is perhaps much more essential than your community in Haiti.

Figure 30. In Pakistan the view of ownership is different from Haiti.

are functioning more as places to accommodate people temporary than homes. Perhaps their view of shelters and tents are based in their previous housing situation. If people have lived in poor shacks before, then the shelters might not be a great difference in terms of feeling of homeliness. And the people that are affected the most in natural disasters are usually poor, with simple houses and cheap building components. As a consequence people might not be afraid losing valuable materials and belonging due to the lack of them.

In Pakistan the sense of ownership seems to be much more noticeable than in Haiti (see Figure 30). The delivered equipments are treated more as belongings. Shortly after receiving tents people have been seen upgrading and improving them. Besides construction work it could regard decoration such as placing carpets on the floor.

A great difference between Haiti and Pakistan, besides the view of individualism and collectivism, is the climate. In Pakistan it could get fairly cold in some locations. Living in cold regions has shown historically to require planning and long-term thinking, which could be quite an advantage in disaster situations due to its long run. In many warm countries, among others Haiti, people tend to take one day at a time. Quite often people have not constructed houses that are prepared for natural disasters. When one actually strikes, the subsequent phase (involving living in poor and difficult conditions) are presumed to be short by many and that view direct their behaviour. However, the subsequent phase is unfortunately often not a few weeks, but several years.

The economy is another element that could affect the perception of ownership. With financial (or other possible) means to upgrade or obtain a proper house the chances of establish a sense of ownership will most likely increase. The house would perhaps need to be seen as an investment or an effort in building. Otherwise people would not signify it to be a substantial possession. (Sjöholm 2011) Even though it is the people themselves that are responsible for the state of their shelters, it must be realised that possibilities are rather limited and that displaced people live lives of waiting, being dependent and often not able to build permanent houses. (Kemenade, Appendix, 2007)

Finally, to actually build or assemble a shelter could be a way to achieve responsibility and belongingness. If you only receive a ready-made shelter, without having any involvement in it, then people are not as careful anymore. The shelter becomes impersonal and perceived as borrowed, without any sense of responsibility. (Sjöholm 2011)

4.17 Insights and conclusions

After receiving the previous information, the author became sceptical about the scope of this project. To make a foreign universal shelter solution for countries along the equator will definitely not match the described needs. Politics, climate, culture, the need for spaces and so on differs significantly. Local and permanent solutions are naturally the best alternative, and therefore the author started rethink if there was any possibility to facilitate local shelter constructions from abroad.

After spoken again to shelter and camp management experts the author realised that a great amount of local resources do not always exist to provide temporary shelters. Especially after sizeable disasters there is often a need for additional supplies. As a result the author started to investigate if it was possible to design a flexible solution from abroad that is adaptable for different locations and cultures. Several sketches were drawn to explore how different shapes and forms could emerge from the same pieces. The idea is comparable to the shelter kit, where displaced people themselves construct their homes. At the same time it could be essential to not give the people too many choices at this time. Being displaced from a natural disaster or a weapon conflict is an extremely dramatic experience. The least you want to do at this stage is to put effort in complicated tasks. Instead, a shelter should be obvious how to assembly.

In the end, the author realised that the amount of different cultures is too vast to satisfy the culture needs and expressions. Instead, the focus of this project became to simply investigate the general needs living in emergency shelters and how these could be fulfilled with a shelter design. Such a design will obviously not be the best housing solution after disasters and conflicts, but at least it can improve the existing living conditions in camps and make the everyday life a little less dreadful.

5. Identified needs and problem areas

This chapter describes the problem areas that experts and reports have shown to be very critical. Without doubts the main problems today, related to the everyday lives in shelters, are the lacking durability and indoor temperature. The following facts constitute a summary of literature studies, interviews, observations and field studies in Haiti and Kenya. However, it cannot cover all exceptions and unique variations. The chapter ends with an analysis of the facts.

5.1 Introduction

5.1.1 Modified scope

The shelter model from Formens Hus already fulfils a lot of the standards and needs described in this chapter. At the same time, it does not really cover more than the absolute basic needs, such as providing walls and roof, being lightweight, of low volume, inexpensive and durable. Due to the long existents of camps the shelter should not only be durable, but also cope with the needs that are essential for long-term living. Designing a safe, homely and comfortable emergency shelter (a place to recover and restore an ordinary life in) would be tremendously desirable. These supplements are not necessarily in conflict with the basic needs, but could be added. It seemed to the author that few current emergency shelters include these aspects.

Half way through the information gathering of problem areas a meeting was held with Formens Hus, at the request from the author, to discuss the specific focus of the scope. A choice of path had to be made between focusing on the technical aspects of a cover for the metal frame or on solving conceptually the identified user demands. In the end it was determined that the author should continue with solving the user demands, while Formens Hus parallelly concentrated on the technical aspects.

5.1.2 Facts of visited countries

Haiti

Haiti was in June 2011 still suffering heavily from the earthquake in January 2010. The capital Port-au-Prince was severely damaged. 1,5 years after the disaster a massive number of people was still displaced and lived without proper housing conditions. Many were squeezed together in parks or in open urban fields, covered by tents or tarpaulins with poor wood constructions (see Figure 31). The camps were often informal and unplanned, generating a chaotic look for outsiders. Additional facilities, such as latrines, warehouses and reception centre, were (if they existed) of varied quality. It is estimated that these conditions concerned about one million people (even though the number is hard to ensure).

Figure 31. One of many urban camps in Port-au-Prince.

After the earthquake a large amount of aid organisations supported, and still does, the country with relief assistance. Unfortunately, it has not been as effective as expected. The lack of social infrastructure (there are few domestic organisations to collaborate with) and the vast corruption are likely contributing. According to several local workers the camps will not function at all once the foreign relief organisations are leaving. People have become too dependent of help, for instance in Corail. Corail is a massive IDP camp outside of Port-au-Prince. It was planned and organised by foreign organisations, transitional shelters were built and it has little relation with the ordinary life in town. Like the IDPs in town the residents have been surprisingly quiet and calm about their situation. Many have accepted the circumstances, even though they still regard their lives to be very painful and problematic.

The atmosphere in Port-au-Prince is hectic and noisy. The traffic is chaotic and dirty, with hours of traffic jams each day. The author and translator/driver were commonly stuck for one or two hours crossing the town in the middle of the day. People are social and in great numbers, often selling any possible goods along the streets. For instance, timber and unused tarpaulins were found. The climate is hot and humid with frequent heavy rainfalls, making the roads and camps muddy. Occasionally, demolished houses emerge caused from the earthquake. As in many African countries there is a certain laidback feeling over the people. The lives are taken day-by-day, not as in northern Europe where planning and organising is very much rooted in people's behaviour.

Kenya

The affects of the political riots from the elections of 2007/2008 were still in 2011 apparent. During the visit in July IDPs were demonstrating against the government and the way they treated IDPs. People were marching towards Nairobi from Naivasha, where many IDP camps are located, to show their disappointment and point of view.

Compared to Haiti the camps in Kenya were located on the countryside (see Figure 32). The ones the project group visited were relatively sparsely populated. Many had an informal garden or courtyard, occasionally marked by fences. People made a living out of farming or selling goods, but many lacked constant income. Animals, such as goats, chickens, cows, were commonly seen, not just outside of shelters but also occasionally inside. In other words, people and cattle were living close together.

The visited camps were self-established. Most of the families had received 10,000 Kenyan shillings (about 105 USD) from the Kenyan government as compensation for losses in their previous homes. IDPs from in common regions had gathered their money to purchase the plot of land that they were living on. A certain part of the land was used for housing and the rest for agriculture.

Figure 32. Rural camps are common in Kenya.

5.2 Durability

5.2.1 Material and construction

Durability is one of the most critical problems with shelters. Short budgets from aid organisations or governments are naturally a great constrain for durable solutions. The transportations, materials and productions become extremely expensive since a massive number of people often are affected during natural disasters or conflicts and they need immediate and long-term help. The issue with governments or private landowners that are unwilling to let land for camps are limiting the means even further. With only non-permanent shelter solutions available long lasting and durable materials are often not applicable. (Sjöholm 2011)

Tents and tarpaulins are a common solution for displaced people, but the durability is rather poor today (see Figure 33). Some tents last only a few weeks, but some could manage a year. That is more or less the maximum length today. Most of the tents are however not functioning at all after six months. Several of them are not even designed for displaced people, but for trekking activities and as overnight dwelling only. The everyday in- and outdoor routines are in other words not taken into consideration.

Regarding tarpaulins the durability is even worse. In many reports and instructions it is claimed that tarpaulins could be used for three months or more. But in reality, depending on location of course, tarpaulins could hardly withstand one or two months. (Sjöholm 2011)

Regardless of tent and tarpaulin model the weather is often tearing the constructions apart really fast (see Figure 34). Sun, rain, wind and occasionally sandstorms and a corrosive coastline (Oxford Brookes University, Literature review, 2011) are extremely demanding and make the materials porous. Quite often the materials shrink after some usage and creates stress. Usually then zippers break rapidly and joints, seams and corners are quite exposed, especially close to doors (due to the constant motions) and where the frame is fitting tight to the cover. The design should prevent that scratches could be enlarged (Sjöholm 2011), because once a tear has begun it can propagate relatively quickly. (Ashmore 2002) If a joint or any other component breaks the rest should not fall apart. (Alabaster 2011)

Furthermore, walls and roofs that are facing south break much faster due to ultra violet light. (Sjöholm 2011) One of the guidelines from standards concern the resistance to ultra violet light. (Maximum five per cent loss on original tarpaulin tensile strength under ISO 1421 after 1500 hours UV under ASTM G53/94 (UVB 313 nm peak), to be tested outside and inside reinforcement bands (ICRC standard 2003).) (UN 2004)

Rotting is another common problem today and it can lead to water leaks and to collapse. In order to prevent rotting from spreading, the broken sections should be replaced, which might require shelters divided into exchangeable sections. (UN 2004) The valance flaps, or mud flaps, are quite often braking due to rotting. The flaps are located at the end of the walls and touch the ground and endure the water constantly. (Ashmore 2002) The material choice of the flaps becomes essential in the design since the function is vital for the overall durability.

The residents' behaviours and habits could affect the durability as well. Ropes are used for hanging laundry, doors are frequently opened and closed and items are leaned towards walls (making the water soak through the canvas). (UN 2004) Sometimes people fix ropes around the outside of shelters to stop them from flapping, but this reduces head height and puts strain on the canvas. (Ashmore 2002) In many occasions the cover loses its connection with the frame and starts to hang down, decreasing the height of the ceiling. As a result people frequently put sticks to elevate and support the cover. The material should therefore be durable enough to hinder the sticks from poking through the canvas. (Sjöholm 2011) In other words shelters need to tolerate the everyday use from people.

One of the standards indicates that the lifespan of a shelter structure and cover should be capable of 18 months of usage. Formens Hus is however aiming for a structure that could last at least ten years and a cover that is durable three years. (Kanter 2011)

Figure 33. Several layers of tarpaulins are not enough.

Figure 34. A common look of shelters after some time.

5.2.2 Water

As soon as shelters obtain cuts or holes then water usually becomes a problem. Heavy rains cause terrible soggy indoors environment and among others personal belongings could be damaged. It is extremely common that canvas fails and allows water to leak. Walls, roofs and floor should therefore not just be waterproof, but also robust towards wind and sun. (Sjöholm 2011)

There are a few ways to avoid water from leaking inside. First of all it is beneficial to avoid rain from lying in puddles on the roof. Therefore the roof should have a reasonable slope for rainwater drainage with large overhangs (they provide shading to walls as well). Above 30° is preferable for normal tiles and thatch and above 20° for well-lapped corrugated iron sheeting. (Corsellis & Vitale 2005)

Secondly, water is commonly entering from sides and underneath. The mud flaps should be dug properly, be at least 40 cm wide and cope with moisture, rot, sunlight and heavy objects placed on top. If possible, support should also be given to people to dig drainage ditches to prevent the shelters from flooding. (UN 2004) The position of ditches should be at least 50 cm from the tent pegs. (Few residents are though applying drainage.) (Kennedy 2011) If mud flaps and drainage are not enough, elevated floors are another solution to separate residents from the wet ground.

Thirdly doors, windows and openings should be possible to close properly. (UN 2004)

Condensation could also emerge, but could be solved by an external area for wet clothes to dry, ventilation, raised floors, less water splashing back onto the walls and a roof with a reasonable slope. (Shelter Centre 2011)

5.2.3 Wind

As mentioned before wind loads are vital to take into consideration in a shelter design. Shelters should manage wind speeds peaking at 75 km/h (21 m/s), or force 8 on the Beaufort Scale (Gale Force). The shelter shall afterwards return to its original shape and position without damage. (UN 2004) However, what needs to be mentioned is that several locations, often along the equator were many camps are located, are even worse exposed during rain seasons. In southern part of Haiti for instance the wind speed can reach 245 km/h (68 m/s). Naturally it might be too hard to cope with such forces for a non-permanent solution, but it gives a hint of the importance of durable constructions. (Carnegie 2011)

As a consequence a long thin shelter design, angled away from the prevailing wind, with low walls could be advantageous. (Sjöholm 2011) (Ashmore & Corsellis 2002) However, in dense camps the position will possibly not make any difference. Moreover the canvas should be strongly tightened in the frame to avoid it from flapping in the wind. (Sjöholm 2011) This includes the roof as well. If it is tied down properly on the walls then the risk of uplift is minimised. Instead the loads are transmitted all the way through to anchorages in the foundation. Hipped roofs, which are braced in all four directions, are less vulnerable than gable roofs. Proper connections between the roof and walls can though overcome the weaknesses in gable roofs. Furthermore, the angel is essential for the durability. Steep roofs increase the lateral loads, but low roofs increase the risk of uplift. As a rule of thump the slope should often be between 20° to 30°. (Corsellis & Vitale 2005) Finally, anchoring the structure into the ground is necessary. Screw anchors or driven earth anchors function well and connect easily to a frame. Shallower, broader anchors are more likely to be removed and re-installed than deep-driven anchors, which require more excavation to remove. (Carnegie 2011)

Besides durability it could be beneficial to minimise heating from hot winds and dust or sand to enter. To achieve that, doors, windows and openings should be closed properly and possibly be positioned away from the direction of the prevailing wind. (UN 2004) (CBC News 2007)

5.2.4 Additional information found from field studies

People tend to place heavy objects like timber on roofs in order to minimise movements of the textiles. Since many tents and tarpaulins are seriously damaged after just two weeks supplementary construction components, preferably iron sheets, are added. Still, rainwater penetrates the sheets along the ground and at the connections.

The "mud flaps" at the bottom of the wall did not seem to work properly. Their function is to hinder water from the sides and avoid wind lifts. In Haiti, where winds and rain are a huge challenge, the mud flaps were rarely dug into the ground (like they are designed for). Instead stones or cement blocks were placed on top (which increased the risk of damaging the flaps), see Figure 35. The cement blocks become covetable and people could steal from neighbors. In the rural areas of Kenya the author did not find several concrete blocks or stones on the mud flaps. The tents were instead rather worn-out and the flaps did not seem to function anymore. Maybe the function of the flaps should be better expressed in the design, making people understand that it should be dug deep into the ground?

In Haiti, where heavy rains are fairly common, homemade thresholds where often seen at the entrance. They were usually made out of a piece of wood. However, according to the residents, the thresholds did not work properly, but let the water inside. See Figure 36. Obviously, there is a need for a durable and watertight solution that still enables people to pass by it effortlessly.

Figure 35. The mud flaps covered in cement blocks.

5.3 Construction components

5.3.1 Roof

One of the keys to a well functioning shelter is the provision of roofing material suitable for the climatic conditions and living habits. The supply of proper roofing material is in priority to wall materials. Walls can often be made out of earth or locally available materials and do not need to withstand the same loads as roofs. Roofing materials are furthermore often expensive and replacements are not improvised as easily. (Kemenade, Report, 2007)

Roofs should have a sufficient gradient for rainwater drainage and wind resistance. As mentioned before the angel should, as a rule of thumb, be above 30° for normal tiles and thatch and above 20° for well-lapped corrugated iron sheeting.

The local climate is also contributing a great matter for the appropriate choice for roofs. There are mainly three types of roof structure: flat, pitched, and vaulted.

Figure 36. Threshold to hinder water.

Flat roofs, with a slight gradient (three cm per metre), are the simplest roof structure to allow water to be drained off. This solution is common in hot dry regions but is less suitable for areas of tropical cyclones/hurricanes since there is an increased risk of pressure differential that may tear the roof away.

Pitched roofs are common in temperate climates due to its ability to drain water from rain. It is also preferable (with a minimum gradient of 30°) in tropical cyclone regions since they are less vulnerable to wind forces than flat roofs are. Pitched roofs are, after flat roofs, the easiest type of construction.

Vaulted roofs are a bit more complicated in the construction, at least for permanent structures. Regarding emergency shelters the solution is easier to apply. One of the most common emergency shelters used by UNHCR posses this solution. However, it might neglects the possibilities for residents to replace the roof with local materials. At the short sides of the shelter another part needs to be connected to the roof. Usually it implicates either gables or hip roofs.

Gable roofs require two rectangular walls to support the beams at the ends, and two A-shaped walls above, which meet the ridgeline.

Hip roofs offer better protection against high winds (such as uplifts), since four slopes offer bracing in each direction. Hip roofs rest on four rectangular walls, which often means that less material is used. At the same time hip roofs imply additional complexities in framing the roof). (Corsellis & Vitale 2005)

It could be quite favourable to include overhangs in the roof since they provide the walls with shade and protection from heavy rains. It should be ensured though that roof overhangs is not too large to increase the hazard from strong winds. (Shelter Centre 2011)

In order for roofs to function satisfactory the connections to the battens need to be tied down properly. The battens should in its turn be securely fastened to the walls. Thereby the wind loads can be transported down to the anchors. (Ferrer, Serra & Ashmore 2009)

5.3.2 Flooring

Floors are a very simple but yet essential approach in keeping people comfortable, dry and healthy. In most shelters floors do not exist, making it troublesome for residents during rainy nights. In some countries earth floors are used traditionally, and therefore displaced people in this regions might not be actuated in receiving floors. However, after some time living in poor temporary shelters many residents realise, like in most camps around the world, the importance of floors. As soon as the rain starts the living environment get soaked, cold and unpleasant without a barrier. (Sjöholm 2011) Still, floors are frequently neglected as supply from aid organisations, as they are expensive and bulky to transport. Instead tarpaulins, or no floors at all, are distributed together with tents. (UN 2004) If tarpaulins are used they, depending on its thickness and the ground surface, get damaged quite fast. If you can afford, or somehow have it obtainable, carpets, plywood, blankets, sacks, cardboards etcetera are used as temporary additional solutions. These make the living environment a bit more tolerable than thin damaged tarpaulins, but are yet not a long-term solution. (Sjöholm 2011)

If floors somehow could be delivered to displaced people it carries several advantageous. But in order for it to function well there are some requirement to fulfil.

A floor needs to include an air gap between the surface and the ground to enable ventilation to prevent dry rot (Sjöholm 2011) and insulation from coldness. The air gap only needs to be one or two cm to provide considerable insulation and ventilation. (UN 2004) However, vermin are attracted to these spaces (since it provides an ideal area for them) and should be sealed off without obstruct the airflow. (Corsellis & Vitale 2005) If the average temperature in certain camps fall below 0 °C overnight then, according to standards, rugs, mattresses or insulating flooring should be made available. (UN 2004)

The material needs to be stable and durable enough to carry excessive deflection and resist sharp objects. (Corsellis & Vitale 2005) It also needs to be water resistant (UN 2004) and easily cleaned. (Kanter 2011)

Floors could be categorised into solid and suspended. Typical materials used for the structures are earth, reinforced concrete, timber beams or joists (covered with decking or sheet materials) and concrete beams and infill blocks with a floor screed. (Corsellis & Vitale 2005) The structures are then often covered with wood boards, plywood or matting. (UN 2004)

Regardless if floors and tarpaulins are delivered or not, the lack of drainage is often partly the issue. To ensure a camp life free from flooding indoors channels should be dug closely to the shelters. However, many residents are not aware of it, causing extensive flooding. (Sjöholm 2011)

Additional information found from field studies

The tarpaulins included in the shelter design had broken due to sharp heavy objects or added shelter frames that penetrated the floors (see Figure 37).

People often sleep on the floor (due to lack of space or money), but once the rain starts it becomes too wet to stay asleep. Doorsteps, sandbags and concrete blocks are sometimes used to protect or elevate beds, equipment and the entire shelter from floods. However, these attempts are not good enough. In order to hinder people from becoming wet during night- and daytime, there is a great need for a durable waterproof (or elevated) floor and a more durable UV-resistant roof.

Figure 37. Wood frame penetrating the canvas.

5.3.3 Walls

Proper walls are easier exchanged after some time than proper roofs. Nevertheless, walls have to carry heavy wind forced and hold burglars away. Furthermore, if storms approach, among others tropical cyclones, all openings need to be sealed. (Corsellis & Vitale 2005)

Internal walls that divide interior spaces often serve to provide complementary support to load-bearing walls. (Shelter Centre, Transitional shelter guidelines 2009)

5.3.4 Door

Doors are one of the most fragile components of shelters. Often this appears due to zippers failing, eyelets breaking or Velcro tape getting clogged. Ropes used in wet freezing conditions can implicate that doors freeze shut. Lacing or toggles with overlapping canvas is the best way of closing doors, at least regarding tents. (UN 2004) In one field study in Eritrea it was found that the lacings generally worked well without failure. However, the toggles were more easily broken. (Ashmore 2002)

When a door is designed into a shelter it is essential to leave an overlap at the door. Then you decrease the risk that the fastenings are under tension. (UN 2004) Moreover, if bearing walls are used doors should be positioned at least 600 millimetres (mm) from building corners. (Shelter Centre, Transitional shelter guidelines 2009)

5.3.5 Windows

If the walls are load bearing the windows should, similar to the doors, be positioned with a 600 mm distance to the corners to avoid compromising the ability of walls to transfer the loads and stresses. (Shelter Centre, Transitional shelter guidelines 2009)

Most commonly windows are covered by mosquito nets. They also have canvas flaps that could be lowered to close the windows during storms or to improve privacy. (UN 2004)

5.4 Living environment

5.4.1 Space and volume

The living space should meet the UNHCR and Sphere standards: enable at least 3,5 m² per person. This means 21 m² for a shelter classed for a family of six, 17,5 m² for a family of five and 14 m² for a family of four. (UN 2004) In this project the shelter is aimed for five persons.

The volume should also be efficiently used. More than 60% of the total floor area should have a minimum standing height of 1,8 m. (Shelter Centre, Transitional shelter standards, 2009) At the time of writing many shelters, especially tents, have insufficient head height. The actual living space is thereby reduced significantly. Even though a few shelter designs meet the standards (many do not) the living space is still too small according to the displaced people. (Ashmore 2002) At the same time a shelter that is big enough to fit several families should be avoided. This mistake has been made over and over again since the 70s. People have possessions, perhaps cattle or land and need privacy. These needs are hard to achieve by squeezing families together in large military tents. (Davis, 2011)

There are several important functions that are hard to accomplish without a reasonable volume. These should be taken into consideration while the shelter design is developed. Here follows a few essential functions.

Indoor activities should be enabled more freely than today. Activates, such as sleeping, eating, cooking, washing, dressing, gatherings and care of children, elderly and infirm, need to be carried out. (Shelter Centre, Transitional shelter standards, 2009) Moreover, the life of the most vulnerable people, such as old and wounded, should be considered. (UN 2004)

Space for a workshop should be enabled. Many families use their homes for daily occupations. Providing a workspace would therefore be appropriate and appreciated. (Oxford Brookes University, Lessons from forty years of disaster shelter, 2011) This need is essential for long-term shelter usage, since a sustainable solution requires that residents become self-sufficient. However, adding an extra space for a workshop after a while might be tricky. Once a camp has been established the shelters are quite often packed together, leaving few extra square metres for expansion. Moreover, aid organisations have repeatedly not enough financial or logistic means to provide residents with enough additional materials. As a consequence it is better to include, if possible, the workspace initially in the shelter or let residents expand the shelters with local materials if space and financial means are available. (Sjöholm 2011)

Space for a store is desirable by many inhabitants since it is a common way in many countries to make a living. The same area could perhaps be used as cooking place or workspace as well. Having a store, workshop, enterprise, kitchen garden or space for cattle could be a quite considerable difference since it provides an additional opportunity for breadwinning. (Gren 2011)

Space for storage of personal belongings, tools, cooking equipment and food should be addressed, see Figure 39. (Oxfam 2004) UNHCR's manual recommends the promotion of economic enterprises for camp residents. However, the manual does not assign space for granaries or tool storage, which the enterprises require. (FMR 2009)

Finally it is beneficial and desirable for residents if the shelter design includes the external spaces. By doing so the everyday habits and activities could be met better, than just proving four walls and a roof. (Shelter Centre, Transitional shelter standards, 2009) The location of openings, the design of the structure and the opportunities for alternative internal subdivisions should enable the internal and external space to accommodate livelihood support activities where required. (Oxfam 2004)

5.4.2 Storage

Although more and more shelter designs include an internal division, which creates a sleeping and living room, the overall size does still not permit the inclusion of significant amounts of tools etcetera. (Kennedy 2004) Besides the lacking space the means to store belongings efficiently are also missing.

Usually food, water, household possessions (possibly from the previous home), clothes and job-related tools and materials need storage since they occupy a great share of the internal living space (see Figure 38). (Shelter Centre, Transitional shelter standards, 2009) (Oxford Brookes University, Literature review, 2011)

Today there are guidelines saying that tents should have useful storage pockets, which are integrated into the inner liner. (Shelter Centre, Transitional shelter standards, 2009) These are handy for mosquito nets and lightweight items. (Oxford Brookes University, Lessons from forty years of disaster shelter, 2011) Nevertheless, the pockets are not the optimal solution (regarding durability and enough space), but it is a step in right direction. Marie Rose, a displaced woman from the earthquake in Haiti in 2010 comment: *"The problem is that we have nowhere to store the things we rescue from the ruins."* She has been keeping watch over her property since the first day, in case of robbers. (ICRC 2012)

At the moment in shelters the walls are barely utilised at all for storage. Bags are now and then hanged from the frame, foremost to protect food from ants or other insects. As long as the items are not heavy and only fasten in the frame the shelter is usually baring the load. But hanging objects in the cover will definitely damage it. (Sjöholm 2011)

Figure 38. Lack of storage is limiting the living space.

Figure 39. Lack of living space is limiting the storage.

Displaced people do not pick up food every day from aid organisation. Instead, they are given rations, in the initial phase, to last for a week or even as long as a month. (CBC News 2007) Consequently the food supplies are of large volume and might need elevated storage to hinder insects from reaching it.

Additional information found from field studies

No solution for storage was included in the observed shelters. Instead great piles of clothes, tools, buckets, construction materials, cooking equipment, food and water cans were covering the floor. The actual living area is thereby too small for daily activates (such as washing yourself, manufacturing products or cooking food) and for general wellbeing. Furthermore the ceiling is very low, creating a feeling of stuffiness. People wish for bigger space, more rooms, to be able to use the walls and a chance to separate items into certain spots. In Haiti the author found a normal family to be about six persons living in a shelter, usually on less than 17,5 square metres. The amount of people was similar in Kenya as well.

There is definitely a great need for residents to be able to move around more freely inside, especially after natural disasters when a number of IDPs end up being handicapped.

5.4.3 Cooking

Cooking is perhaps one of the most common housing activity per day, regardless of culture or region. Shelters should enable space for cooking and be functional even during heat and heavy rain. Quite often today women, who usually are the ones to cook, strive after a roof extension, which provides the cooking space with ventilation and shade. If women had been asked, they would clearly express that they do not want to cook in the open during monsoon rains or inside in the heat. (CARE 2012)

The cooking spot usually differs depending on the type of fuel. Using firewood (without ventilation) the smoke often becomes too toxic for indoor cooking and residents are compelled to cook outside. Paraffin or charcoal is less harmful (but still hazardous) and people are then cooking indoor or at the entrance. Generally speaking families cook individually and store equipment close the entrance. (Sjöholm 2011)

Most often in camps cooking is carried out outdoors over open fire. Besides the toxic smoke from firewood, the narrow indoor space and the heat are usual explanations for being outside. (Sjöholm 2011) Even though most women might lack a roof extension for shade and rain cover, the outdoors cooking is very much advantageous compared to indoor cooking. As long as people cook outside efficient ventilation is enabled. Indoor cooking though brings severe health issues and is still common in many countries, not just in camps. Asphyxiation from indoor cooking is the single most common cause for death of children under five years, not water pollution, diarrhoea, malnutrition etcetera. (Ted 2012) According to The World Health Organization (WHO) more than 2 million people die every year from cooking smoke. (Good 2012) This is more than twice the number that dies from malaria. (Wikipedia, Malaria, 2012) Preparing food indoor in sub-Saharan Africa is commonly a dirty slow process that fills the house with smoke comparable to inhaling two packs of cigarettes a day. (Good 2012)

Additional information found from field studies

The location of the cooking space is interesting for the shelter design. It varies within both Kenya and Haiti. In rural parts of Kenya, where firewood is common, people cook outside. The kitchen could be an additional homemade small shelter with roof. In urban areas of Kenya however, were charcoal is used, families chose to cook inside the shelter even though the space is narrow, dark and the stove still generates very unhealthy smoke (see Figure 41). Many are aware of the risks from the smoke, but the habit is a cultural behaviour and would be hard to change. Cooking in Kenya is often regarded as a private matter and not the business of your neighbours. Therefore many stay inside to cook, but close to the door due to better light and ventilation. In Haiti the cultural is quite comparable and the author found people in urban camps behaving similar to Kenyans (see Figure 40). IDPs tried to achieve insight protection when cooking, but were at the same time rather eager to ventilate the smoke. Furthermore the lacking of space outside the tents, due to extremely dense camps, "forced" many to stay inside. Therefore, some chose to create a separate cooking space by making a small opening in the back of the tent. The separate space generates advantages such as safer storage of tools and more space at the entrance.

Cooking outside is, according to the author, preferable since it decreases the danger of asphyxiation, the risks of damaging the floor and the hazard of burn injuries from boiling water and food.

Furthermore, some tents had an additional roof outside the entrance, at times with cement blocks on the ground. That creates an extra square metre room for your family, giving the impression that is it one's own veranda, and becomes appropriate for cooking.

The shelters in camps today are lacking a suitable space for cooking. An expert in shelter and camp design has confirmed that. The studies from Haiti and Kenya brought the author to the conclusion that a cooking space, included in the shelter, with insight protection, rain protection and sufficient ventilation would be beneficial and salubrious.

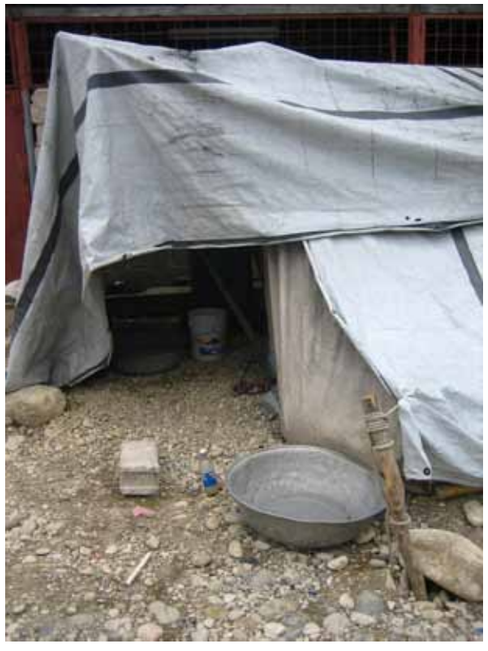


Figure 40. The location for cooking is often close to the entrance in urban camps.

5.4.4 Light

Indoor light for reading and other daily activities should be an ambition. Electricity is fairly rare and therefore alternatives should be regarded. Outdoor lighting that penetrates the thin canvas is probably the most common "solution" today. A few attempts of using solar panels have been done, but at the time of writing it is fairly expensive and inefficient. The light should either way have enough illuminance and not too coloured hue. (Sjöholm 2011)

When camps are positioned in urban areas there are usually streetlights around and it gives some additional sense of security. The lights make it possible to hinder unauthorized people to enter the camp. In some locations, among other Haiti, residents utilise the close by electricity by "borrowing" it and leading it into their own shelter. (Sjöholm 2011)

Additional information found from field studies

Even though electricity is rather uncommon in camps (both for Haitians and Kenyans) people want to obtain it to be able to read, hear news, charge cell phones and so forth. At the moment, candles or kerosene lamps are common instead.

Figure 41. Ventilation and light are desirable when cooking, still people often cook inside.

5.5 Safety and health

5.5.1 Physical and emotional security

In the Sphere standards it is stated that shelters should, beyond survival, provide security and personal safety to protect displaced people from the climate and enhance resistance to diseases and ill health. Furthermore, family and community life should be sustained as far as possible to attain human dignity. (Corsellis & Vitale 2005)

To be forced to leave your home and move into an emergency shelter is frightening and creates insecurities. The situation itself is horrifying. What people want and need after a shocking severe happening is a safe and comfortable environment. The shelter should be a secure place for recovery. Unfortunately, the living environment in tents or shelters excludes more or less all personal security (see Figure 42). (Kanter 2011) Living in tents or under tarpaulins increase, due to the thin fragile material, the risk of burglaries. There are several examples from past situations where families are reluctant to move into these kinds of shelters. Displaced people do not feel secure against intruders living under these conditions. (Carnegie 2011) One older woman from Haiti tells in a report that she and many others have been robbed since no doors exist. *"People come at night. Just the other day robbers took H$45 ($5)"*. A friend of the woman adds that she cannot sleep at night because she is worried that this might happen again. (Clermont et al. 2011)

To hinder burglars of entering, locks can be put up (if doors exist). By doing so you demonstrate that the shelter is someone's property, but also indicates that something valuable might be inside. As a consequence walls might be cut and opened by burglars, causing damage to the shelter as well. (Sjöholm 2011)

The frequency of break-ins varies from place to place. In some locations it might not be common at all. Instead, it is then the equipment placed right outside the shelter that disappears (stoves, fuel, building materials etcetera). (Sjöholm 2011)

Even though most displaced persons living in camps are not wealthy people and have few belongings of valuable to lose, the lack of security is still an important issue to handle. A break-in means than someone has been entering your most private zone and poking around and investigating your belongings. Regardless if something is stolen or not it could mean a huge violation and humiliation. (Karlsson 2011)

In order to obstruct the possibilities for brake-ins durable walls and doors, proper locks and closable ventilation openings should be included in the shelter design. See Figure 43.

Figure 42. Many shelters are lacking security.

Figure 43. The lacking quality of the construction is a common security issue.

Locks for doors or windows might be necessary to provide. The design should at least make sure that locks could be added further on. (Shelter Centre 2011) A lockable door is one feature that most displaced people want. If the shelter is fragile and a lock would not contribute to security, then some residents have a lockable case inside where valuables are stored. (Sjöholm 2011)

Another way of avoiding burglars from breaking in is to hinder them from certainly judging if someone inhabits the shelter at the moment. Burglars will not break in if residents are present (except during nights possibly) and as long as they are not sure they will most likely not risk getting caught. (Shelter Centre 2011) Therefore shadows projected on walls should be avoided, indoor light and sound should not penetrate walls and locks should preferably not reveal if these are actually locked. (Sjöholm 2011)

Additional information found from field studies

Burglaries are more common in bigger camps where people do not know each other. The shelter materials and doors are not durable enough to hinder robbery or rapists. Several people told the author that you cannot leave your shelter and feel secure about it unless your neighbours are guarding it for you. Plywood and metal sheets are both thicker than tents and common modifications made by IDPs. With proper connections the materials aggravate burglaries to enter.

The instability of the shelter also contributes to an experience of insecurity. The shelter is shaking quite a lot in heavy winds and rains, causing fear for the residents.

5.5.2 Ventilation and temperature

Efficient ventilation must be included in shelters to enable a reasonable and tolerable life. Along the equator the temperature is fairly high, often causing exhausting indoor heat. The climate is additionally very dry or humid, which means that a shelter design preferably should have high ceilings and withstands +5-+50 degrees Celsius. (Kanter 2011)

One of the most simple but yet effective solutions to ventilate heat and moisture is to have a large opening in each gable close to the roof (warm air rises). It enables cross ventilation, since the indoor temperature is warmer than the outside. (Sjöholm 2011) If the air gaps are placed between the wall cladding and the roof it is advisable to let them be 15 cm high. The size of the openings should however not undermine the stability of the walls. (Shelter Centre, Transitional shelter standards, 2009)

To improve the ventilation the outlet opening would be positioned higher than the inlet opening and on the leeward side (to enhance the draught effect). (Shelter Centre 2011)

The minimum accepted ventilation should be achieved through an unobstructed opening of 0.01 m². The result should be that the air changes per hour vary between 7 and 14 times. (Shelter Centre, Transitional shelter standards, 2009) The ventilation openings also need to be adjusted to regulate temperate and hinder water and intruders to enter. (UN 2004)

Indoor cooking generates unhealthy smoke and should be ventilated adequate. If flue pipes are used, the dimensions of them should be 8-10 cm. (UN 2004) Most shelters in warm countries do not though contain pipes, due to the additional cost.

Condensation is a common issue and could be avoided in more ways than just ventilation:

- A covered external area could be provided for wet clothes and shoes to dry.
- Raised floors protect the indoor environment better from rising of moisture and direct contact with damp grounds.
- Using roof overhangs or similar solutions could prevent water from splashing back onto the walls of the building.
- Use pitched roofs to allow water to run off and drainage. (Shelter Centre 2011)

To minimise temperature, double roofs could be applied. By doing so an air gap emerges and the heated air in between can be ventilated. This minimises heat radiation. (Corsellis & Vitale 2005) The distance between them should be at least 100 mm. (Shelter Centre, Transitional shelter standards, 2009) The same procedure is sometimes used by residents later on, by shading the whole shelter with sheets or similar. It creates a gap that, recommendable, is about 50 cm to ventilate appropriate. (Ferrer, Serra & Ashmore 2009)

Figure 44. The original ventilation solution is commonly not functioning after some time in field.

Thick walls and insulating roofs should be endeavoured to make the shelter cool in the day and not too cold at night. (Corsellis & Vitale 2005) A rather bright colour of the cover is also beneficial, to reflect heat radiation rather than absorbing it. (Sjöholm 2011)

At the time of writing several shelter solutions include many of the standards and guidelines previously mentioned. But after some usages in camps the constructions are damaged and so become the ventilation solutions. The functions stop working and residents are subsequently getting sick (see Figure 44). (Kanter 2011)

Additional information found from field studies

The indoor climate is extremely hot during the day, especially close to the ceiling. Fever, headaches and breathing problems are the consequences. Furthermore, many claimed to suffer from stress or high blood pressure due to the exhausting and restless situation. A shelter should be the place for recovery after a disaster, but people are forced to leave their house due to the hot indoor climate. They return in the late afternoon. Some people put an additional layer of tarpaulin or braid palm trees as a roof or wall, creating an air gap. Others make small openings in the canvas (see Figure 45). But

Figure 45. Home-made ventilation openings.

the temperature is still fairly hot inside. Ventilation, preferably at the roof, is necessary and important as well for ventilating smoke from indoor cooking.

A notable difference between the findings from Kenya and Haiti was the night temperature. In Haiti the climate was still rather warm and humid during the night. But in Kenya, at least in the highland during June/July, the temperature is surprisingly cold. Due to lack of beds a lot of people have to sleep on the cold ground. Therefore an elevated floor, even of just one or two cm, could help people maintain a better body temperature during the night. The ventilation apertures/gaps might as well be important to close temporary in order to maintain a comfortable indoor temperature.

5.5.3 Fire safety

Tent or tarpaulin fabric is seldom made fireproof, as treatments are expensive and can be toxic. Instead fabric can be made fire retardant more cheaply, meaning that the fabric burns slowly and more time is given to evacuate. (UN 2004)

Standards promote an evacuation to last not more than 30 seconds. Therefore doors should be easily opened from the inside when locked. If a sub-division is included it should not hinder the access to doors in case of an emergency. (Shelter Centre, Transitional shelter standards, 2009) Standards continue claiming that two opposite doors should be possessed and that the fabric should withstand a flame from cigarettes and matches without spreading. (UN 2004)

Like several other important shelter functions fire safety is often embraced initially in the design, but damaged after some usage. Many shelters are fireproofed but rain, wind and sun deteriorate them. In the end they are not working anymore. As a consequence it is more suitable to put an effort in preventing fires from happening. Informing residents to not light fires indoor or "invite" the activity to be carried out in a safe spot are two ways of approaching the problem. (Sjöholm 2011) Working with communities to improve solid waste disposal and to install firebreaks in camps have also proved more cost-effective and practical than trying to build fireproof shelters. Perhaps therefore, there are fairly few fires reported from camps. (UN-HABITAT 2010)

5.5.4 Diseases

Residents should be protected from mosquitoes, flies and other disease vectors. This function is above all important during nighttime. Beside mosquito nets (covering windows and beds) a ten cm vertical edge is currently used under the entrance to hinder crawling insects. All openings greater than six mm in diameter close to the ground should also be filled. (Shelter Centre 2011)

According to some shelter experts it is mainly the malaria mosquitos that are the real challenge regarding vermin. (Sjöholm 2011) The mosquito nets are thin, but have to be durable and not brittle to ultraviolet light. (UN 2004) Fixing points should be included in the shelter in order to hang additional mosquito nets. (Shelter Centre, Transitional shelter standards, 2009)

Besides vermin, water can be a common source for severe diseases (see Figure 46). Cholera and dysentery are typical infections, spread by contaminated water from an infected person with diarrhoea. Symptoms are diarrhoea, vomiting, fever or abdominal pain and can lead to death. (Wikipedia, Dysentery 2012) (Wikipedia, Cholera, 2012) Cholera was for instance quite noticed and problematic in camps in Haiti after the earthquake in 2010, especially during rainy seasons. (Sjöholm 2011)

Figure 46. Water and vermin (attracted to food) spread diseases.

Additional information found from field studies

In order to protect food from mice, rats and insects, people store food (usually perishables) on the bed or in bags hanged in the ceiling. Due to lack of money and refrigerators people buy small portions every day. Obviously there is today not a great need for storage of large quantities of fresh food. However, staples such as rice, sugar, corns and beans are bought less often and are instead stored in bigger bags. These provisions are common in the emergency phase as well as afterwards. Water is usually stored in large buckets or cans.

The stored staples are attracting mice, rats, chickens and occasionally insects. In one shelter in Kenya for instance the author noted corns disseminated on the floor. According to residents rats had bitten through the sack. In other shelters chickens walked around inside looking for food. Obviously there is need for sealed storage of food to hinder animals of living close to people.

Animals like rats and flies are a great problem since they spread diseases. Cholera, typhoid, trachoma, salmonellas, strep infection, diarrhoea, meningitis and staph infection are examples. Camps are furthermore often dense with people with lack of soap, making diseases easily transferred between neighbours, especially on the occasion of rain.

The smell of cooked food is furthermore attracting a lot of flies and insects. However, the author find it difficult to solve that problem by a shelter design. Today people could cover the dish with a lid or similar object while not eating. But flies will always be around and impossible to avoid completely. However, the lack of clean water is perhaps the most common cause for spreading diseases. Either it is not clean for drinking or enough of it to wash hands. Water supply and quality is nevertheless beyond the scope of this project.

Stagnant water should be avoided to minimise breeding sites of insects. Elevated floor can also be problematic since it enables a dry comfortable space underneath for vermin, such as snakes.

5.5.5 Other health issues

Materials or coatings that could be toxic to fabricators, inhabitants or the environment must be avoided. This still applies even later on when parts are modified for re-use, burnt or buried. (Shelter Centre, Transitional shelter standards, 2009) Furthermore the disposal should not pollute the ground water table or enter the food chain. (UN 2004)

Paints are often solvent-based and contain toxic chemical components. Even for months after the first use, the components slowly vanish into the indoor environment. This occurs especially with high temperature and humidity, causing harmful effects on human health such as nausea. (Shelter Centre 2011)

5.6 Privacy

As stated in chapter *5.4.1 Space and volume* individual family shelter should be proffered to communal accommodation. Individual family shelters provide psychological comfort, emotional safety, territorial claim for future security and necessary privacy. It also becomes a foundation to rebuild or preserve family unity. (UNHCR 1999) Nevertheless, a family shelter needs to be big enough for daily activities of five persons, and 17,5 m^2 is not a sustainable solution to enable that. (Sjöholm 2011)

The perception of privacy varies from culture to culture, but still there seems to be many similarities. Palestinian refugees for instance are quite careful about their privacy, partly due the Arabic and Islamic culture. Women carry veils in public, but not among their closest friends and families. Consequently it becomes important to divide the home into at least two sections, one to welcome guests and one to live and dress privately. Furthermore, many consider the poor soundproofing walls to be troublesome. The lack of isolation, but also the proximity to each other, force people to unintentionally listen to quarrels and private matters from neighbours. (Gren 2011)

To divide the home into sections and establish fairly soundproof rooms are not unique needs for Palestinian refugees, but for most people. Therefore shelters should enable sub-division for the indoor space (UN 2004), but at the same time maintain cross-ventilation and access to doors in case of an emergency. (Shelter Cluster Haiti 2010) The division are commonly made by residents themselves to create a living room and a bedroom or, if individuals from different families live together, to separate men and women. Usually a fabric sheet is then used, but in some shelters an adjustable division wall is already included in the design. Regardless, the division is rather fragile and not soundproof. (Sjöholm 2011) It is however shown that a flexible space is important to provide. (Shelter Centre, Transitional shelter standards, 2009) Internal walls can also serve to provide complementary lateral support to load-bearing walls and help to sustain ceiling joists. (Corsellis & Vitale 2005)

To enable additional privacy, walls and roof should be much more soundproof than today. Even though that the perceptions of how much sound that is tolerable differs significantly between cultures and people, there is a universal need or desire to live without being exposed to noise and to emit sound unopposed. (Sjöholm 2011) A girl from Haiti mentions in a video clip how a group of men behave in her camp. *"They don't care about the time. If it's sleeping time, they make a lot of noise and don't let us sleep"*. (Trust 2012)

Besides a fairly soundproof material it is important to hinder attrition and to enable doors and openings to be properly closed, as openings let the sound pass through.

Hindering neighbours from viewing indoor activities could also be an important approach to attain privacy and maintain the dignity of people who might have recently lost everything. (UN 2004) When indoor light is used shadows could be projected on walls (see Figure 47). It could be a sensitive matter, especially for Muslim women. It is however solved easily initially with thick or solid canvas, dark colours or two cover layers. (Sjöholm 2011)

Figure 47. Projections on tent canvas.

Additional information found from field studies

The indoor division that are put up by IDPs are at the moments often fragile and not soundproof.

A museum named The Bomas of Kenya was visited in Nairobi. The museum has a permanent exhibition of full-scale traditional huts from all Kenyan tribes. In most of these huts the living space is divided into two rooms with an insight protection at the entrance. Clearly these two arrangements for privacy have always been important and should be fulfilled in emergency shelters as well.

In order to provide insight protection for the shelters, people put up curtains or create a barrier at the entrance. This hinders outsiders (including vendors) to see inside the house. Many residents want to carry out indoor activities, especially cooking, in privacy from neighbours, but at the same time obtain outdoor light and ventilation. See Figure 48.

Figure 48. An insight protection.

Surprisingly, few residents expressed a desire of having windows. If they did, it was rather for the purpose of ventilation than lookout. However, the author still suspects that lookouts, not necessarily as windows, can be quite beneficial to minimise anxiousness for residents. In bigger camps, when residents are not too familiar with everyone, you might want to keep an eye on who is right outside your house.

The lack of soundproof walls is also problematic for privacy. Tents or tarpaulins are thin and not enough to hinder the sound of crying babies, fighting couples or sexual actions from neighbours. Many, including the ones who emit the noises, regard this to be annoying and really exhausting. It interrupts and disturbs the human behaviour with its privacy. Obviously there is a great need for soundproof material, possibly achieved by a thick or folded fabric.

Finally, the density of shelters in a camp interferes with privacy as well (see Figure 49 and Figure 50). This is more common in Haiti where IDPs are pressed together in city parks. But even on the countryside of Kenya people have a limited amount of space to organise the camps. Consequently, people find themselves being overcrowded and claiming "there is not enough space to breath". The task of solving over-population is, however, not within the scope of this project.

Figure 49. Shelters are often packed together with narrow paths in between.

Figure 50. A camp in Port-au-Prince located in a park. The density minimise the privacy.

5.7 Handling

5.7.1 Buildability

In order to ensure that shelters are understood and assembled right, aid organisations are preferably educating a few displaced people about them. These people are in turn educating others and so on. Generally speaking it is men that are assembling shelters, while women are more active in the interior. (Sjöholm 2011)

The amount of displaced people after natural disasters or conflicts are commonly massive. Most people cannot wait for instructions of the included functions and how shelters are assembled. The answers have to be easy to grasp for first time users. Instructions for assembling (illustrations and descriptions in English, French, Spanish or appropriate language) should thereby, according to standards, be included, either laminated on a sheet or printed on shelter or shelter bag. Two untrained adults should manage to assemble the shelter without expert supervision. However, most likely there will be more people involved in the assembly.

It should also be highlighted that the displaced people have just gone through dramatic experiences. Many might be vulnerable. The people's abilities to build shelters at that moment must be considered. (UN 2004) But also the previous experiences of building homes is important to reflect upon. Displaced people might never have built their own house before, or only used clay, wood or iron sheet. Tents or similar constructions can be unfamiliar to many and challenge the perceptions of assembling. Generally the people that are affected the most after natural disasters are the poorest ones with low education level. These people might not know how to read or to think strategically. Subsequently the shelters must be truly logical and obvious how to use. (Sjöholm 2011)

The need for a simple assembling became obvious for instance after a filed study done 2002 in Gash Barka, Eritrea, close to the border of Ethiopia. United Nations Development Programme, UNDP, reported that only 10% of the original 1200 shelters that were distributed were used. People found them heavy and difficult to erect. (Ashmore 2002)

It could be quite important to only reveal one way of assembling a shelter design. Usually there is only one way, but not necessary. To be appropriate for different cultures or locations the same components could possibly be designed to create different shelter solutions. Still, too many options are not suitable for these circumstances. It is better that experienced aid organisations choose one way and only enlighten that one. (Sjöholm 2011) (Syversen 2011)

Finally, a shelter should be quick to assemble. The time should not surpass several hours (Kanter 2011) and preferably be assembled without attached tools (Sjöholm 2011).

Additional information found from field studies

The speed of assembling the shelter is not severely critical according to staff at THW. As long as the time is not exceeding many hours it is fine. The usability and understanding of the assembling should instead be enhanced rather than time efficiency.

5.7.2 Adaptability

A shelter solution should allow residents a reasonable degree of adaptation to better suit their needs. (UNHCR 2007) Common patterns of behaviour, that should be taken into consideration, are for example mud brick for sidewalls (UN 2004), additional plastic sheet for roof, suspension device and sub-division of rooms. (Sjöholm 2011)

As the family grows and additional space and rooms are needed it will be essential that the size is adjustable. Therefore a shelter would preferably be modular based in order to vary in size. The connecting points should be adapted to different types of expansions (either shelter materials or locally available materials) and an adjustment should not interfere with the floor. (Oxford Brookes University, CENDEP Shelter Conference 2010 Report, 2011)

Shelters, especially tents, should be adapted to old persons and minority ethnic groups. Most people are not used to live in tents. (UN 2004) In order to fit old or disabled people the floor should not be filled with items but easily accessible, the ceiling should not be in the way for daily activates and the construction should be durable enough to grab or lean against.

The choice of materials and the design of components can be worth rethinking a few times. Most likely the shelter components will be reused later on for several different purposes. It is beneficial if the parts are adaptable, usable and brings additional value to people further on. (Oxford Brookes University, CENDEP Shelter Conference 2010 Report, 2011)

Additional information found from field studies

The shelter should be adapted to different soils and to slopes. It should also allow people to furnish and decorate freely to suit their needs and taste.

5.7.3 Reparability

Residents are often repairing their shelters, as water often leaks into them. After about six to twelve months using tents, these are worn out. Then residents transcend to use tarpaulins, as both aid organisations and residents hardly can afford anything more durable. (Sjöholm 2011)

The repairs and improvements should be possible with local materials and with non-specialist skills and equipment. The design should furthermore maximise the number of components and materials that are easy to repair and maintain. Spare components would preferably be included with the shelter. (Shelter Centre, Transitional shelter standards, 2009)

To facilitate reparability further it is appropriate to strive for few components and few different sorts of components. (UN 2004) If the parts are common (or even standards) globally (with fabrication of low-cost techniques) it would increase the odds for easily accessible reparability. (Shelter Centre, Transitional shelter standards, 2009)

5.7.4 Upgradability

The most common type of upgradability is reparability. But besides that a shelter should, according to standards, include modularity. By being modular based (having connection points in the covering and structure that attach shelters of the same type) it can be connected to each other easily and create large structures. The connection points should preferably also be adapted to shelters of other types and for expansion with locally available materials. (UN 2004)

It is a rather common sight today that people connect their own tent with neighbours' tents to make larger structures. Usually people use single skinned tarpaulins to create the extension. Unfortunately their tents will not gain the benefits of a ventilated air gap between the tarpaulin and the inner tent. In hot locations a sunshade at the entrance are occasionally built. The area can be provided as a veranda to socialize or perhaps to store animal feed for the dry season. (UN 2004)

Usually people are not expanding their homes, but stick to the 17,5 m² or given size. Camps are generally dense with shelters, causing few empty spaces left. If someone is interested in expanding it might evolve a fight with neighbours. In order to expand in compressed camps it needs to be planned or executed from the beginning, unless vertical expansion is made. However, organising that an extra space next to your shelter is available in the future is rather hopeless and naïve to think. It is usually impossible to control and direct these types of commands for a massive amount of people, especially regarding this question as available land is regularly lacking for displaced people.

There are few shelters at the moments that are modular based. It is therefore hard to verify if UNHCR or other suppliers would distribute more modules later on if needed. (Sjöholm 2011)

Another important aspect is the land security. Residents in camps do usually not own the land they possess. Families will therefore not invest in anything more permanent than what is portable. (Carnegie 2011)

5.8 Appearance, semantics and cultural appropriateness

Putting an effort in the visual appearance of shelters is perhaps easily forgotten. Nevertheless, it could be a quite essential and effective way to satisfy diverse involved people and become the convincingly piece towards competing designs. Identification, communication, expression and aesthetics are four basic aspects to consider.

5.8.1 Identification

Displaced people should identify a shelter as a home. (Oxford Brookes University, Lessons from forty years of disaster shelter, 2011) At the same time it needs to be recognized as a product from certain organizations. (Shelter Centre, Transitional shelter standards, 2009)

5.8.2 Communication

Shelters commonly need to be movable to be accepted by landlords. To enhance the acceptance it could also communicate movability and not be perceived as permanent. (Sjöholm 2011)

To facilitate the understanding of functions the purpose of spaces, as well as the contact surfaces, can be communicated. One of the functions that are important to understand is the mud flaps. The mud flaps are supposed to be dug into the ground. By doing so up to ½ ton of soil could be placed on top, holding the tent down. Besides great additional stability it also reduces water leakage into the shelter.

Drainage ditches are as well preferable to dig and the function should therefore be communicated. Ditches around shelters prevent them from flooding during rain. (UN 2004)

Important functions that are hard to understand or perceive shall be accompanied by instructions with illustrative drawings, suitable for multi-lingual and multi-cultural use in varied climatic contexts. Beyond ensuring that the assembling is well understood by an untrained adult (which might be the most important function to communicate), instructions for safe disposal are desirably included. (Shelter Centre, Transitional shelter standards, 2009)

5.8.3 Expression

Shelters should if possible mediate family, community, social and cultural expression. This is however more or less impossible to achieve with a universal shelter since the amount of different expressions are vast. Perhaps, it might be possible to enable a foundation that is, in some sense, adaptable to a few different desirable expressions. Despite that a shelter design generally will not meet the desirable local expressions, it should still not interfere with them. (Gyllenhak, e-mail conversations, 2011) In order to do so shelters should express simplicity and timelessness.

Displaced people have experienced dramatic happenings right before they reach camps. What all want is a safe and comfortable place. Therefore shelters should preferably not just be safe, but also express safety and confidence.

Shelters should avoid being associated with being a gift. That could minimise the risk of dependency syndrome and the perception from the tenants of being a victim. Colours and logos are examples of visual appearance that should be well considered for this matter.

5.8.4 Aesthetics

To gain publicity, and in the end more sponsors, shelters need to attract donors to invest. It is favourable if the shelter design could attract donors without upsetting the residents. (Kemenade, Report, 2007) As soon as a shelter gets an expensive look jealousy from neighbours, perhaps even violence, could emerge. If not a whole camp can be provided with attractive shelters the appearance should not look too expensive. As a consequence the appearance should be harmonic, discrete and salience at the same time. (Sjöholm 2011) (Kemenade, Report, 2007)

According to standards military, camouflage and dark colours should be avoided. Instead, the colour should be rather discreet and reassuring, both inside and outside. (UN 2004) Some colours, such as orange, emits a bit odd indoor light once the sunlight is penetrating the canvas, making it harder to read etcetera. Discreet colours, that do not affect the indoor light hue too much and not absorbing heat, are preferred. (Sjöholm 2011)

Additional information found from field studies

In Haiti it was noticed that USAID had donated many tarpaulins for the people (see Figure 51). Each of these tarpaulins was completely covered with the USAID logo. The extreme artificial appearance might enhance the impression of being victims and contributes to the "dependency syndrome". In Dadaab, the huge long lasting camp in northern Kenya, many people are born into dependency and have never worked.

As mentioned in chapter *3.3.3 Observations, interviews and user tests in Haiti* a simple test was made to investigate what IDPs thought about these logos on their shelter. The alternative that got the most votes was the most discreet one, a grey tent without logos. Consequently, more cautiousness and awareness should be given to the appearance and what it might communicate.

Being able to decide the appearance of your own shelter seems to be relevant. Perhaps it connects with being able to take control over your situation and influence your life. That would probably give you confidence and driving force.

Plywood, iron sheets and robust materials seem to be better accepted culturally than tarpaulins and tent canvas. Several people gave, according to the author, the impression that they wanted a shelter material that felt costly with high quality. Consequently, a new shelter design should not only have more qualities; it should look and feel better as well.

Figure 51. Camps in Haiti were filled with tarpaulins from USAID and each one was covered with their logo.

5.9 Production and logistic

The economy is crucial for shelter design. In order to generate a realistic product the logistic and production need to be efficient and inexpensive.

5.9.1 Manufacturing

Rapid scalability and short production time must be possible. According to Formens Hus 10000 shelters should be able to produce per month. This necessitates a simple construction and materials that are commonly available in large quantities. Besides financial benefits it is favourable since different local manufacturers might produce the product.

According to standards it is moreover appropriate to minimise the amount of components, minimise the amount of different components (UNHCR 2007), use components that are available globally, use appropriate materials, tools and skills for local manufacturing and repair (Shelter Centre, Transitional shelter standards, 2009) and minimise the spillage of material (Flink et al. 2009).

5.9.2 Transport

According to standards emergency shelters should:

- Be of low volume, meaning 0,3-0,5 m^3.
- Be lightweight. 40-60 kg is preferred, but according to Formens Hus 65 kg will still be all right.
- Be of sensible size for transport. The shelter should fit a Euro pallet of 120 x 80 cm. The height should be less than 2 m. These measurements also fit sea containers of 20 ft (6,1 x 2,44 x 2,6 m) and 40 ft (12,2 x 2,44 x 2,6 m).
- Enable transportation by residents. At least two healthy adults should be able to carry the shelter bag a short distances. (UN 2004)
- Keep a stock of spare parts. (Shelter Centre, Transitional shelter standards, 2009)

Additionally, it should be possible to fit at least three packed shelters onto a Euro pallet. (Kanter 2011) Once they reach the displaced people they might be loaded and unloaded by hand. (Sjöholm 2011)

5.9.3 Storage

According to standards emergency shelters should:

- Be protected from sun, rain and vermin during storage.
- Be stored dry and ventilated off the ground.
- Be kept in easily countable piles at least half a metre from walls.
- Be checked regularly to avoid moisture and rotting. (UN 2004)
- Be stockpiled for five years without degradation. (Shelter Centre, Transitional shelter standards, 2009)

5.9.4 Packing and labelling

Many actors will handle the shelters. Therefore it is important for logistics and programme staff to understand the type and performance of the shelters. (Shelter Centre, Transitional shelter standards, 2009)

According to standards emergency shelters should:

- Be in one package. There is a great risk that pieces become separated in transport if several packages are used for the same shelter. (Flink et al. 2009)
- Communicate content, assembly, use, maintenance and safe disposal of the shelter for an untrained adult in different cultures with different languages. Illustrations/pictograms/pictures and instructions in English, Spanish, French or appropriate language are necessary solutions.
- Allow the agency name to be exposed on the bag or/and shelter.
- Allow the manufacturer's name/trademark and location to be displayed on the shelter. (UN 2004)
- Allow batch and delivery number to be displayed on the bag or/and shelter. (Shelter Centre, Transitional shelter standards, 2009)
- Communicate particular design, size, thermal performance, amount of people it can accommodate and if it is mosquito proofed or not. (Shelter Centre, Transitional shelter standards, 2009)
- Communicate the date of manufacture, the length of time in storage, conditions of storage and means of transport on the shelter. (Shelter Centre, Transitional shelter standards, 2009)
- Communicate if the shelter already has been deployed. (Shelter Centre, Transitional shelter standards, 2009)

5.10 Climate

In many regions along the equator there might be large changes of climate between day and night and seasons. During extreme hotness and coldness people are the most vulnerable. (UN 2004) For this project it is primarily hot dry climates and hot humid climates that are concerned.

5.10.1 Hot dry climates

Shade and ventilation are primary shelter functions for hot dry climates. Flysheets are therefore common since they establish an air gap over a tent, which is ventilated. (UN 2004) Adequate distance between the layers is at least 100 mm. (Shelter Centre, Transitional shelter standards, 2009) If a structure is only covered in tarpaulins the indoor temperature increases significantly, behaving like a green house. (Ferrer, Serra & Ashmore 2009)

Dust could also be problematic in dry areas. Shelters should therefore be possible to close properly during sand storms. (Corsellis & Vitale 2005) The openings should moreover, if possible, be positioned away from the direction of the main wind to minimise dust and hot winds to enter. (Oxfam 2004) At the same time it can get surprisingly cold at night at high altitude and in deserts, meaning that winter shelters might be required. (UN 2004)

5.10.2 Hot humid climates

As in warm hot climates the main functions of shelters in hot humid climates are to provide shade and efficient ventilation. Moreover, it becomes very beneficial with drainage, large roof overhangs and rotting proof materials. At the moment cotton canvas, which is common for tents, is particularly prone to rotting. (UN 2004) (Corsellis & Vitale 2005)

5.11 Environment

The impacts in local environment should be minimised, both during and after camp existence. The shelter components should neither be toxic to fabricators and residents (even later on when parts are disposed or modified for re-use). (UN 2004) Therefore materials

that are toxic by burning or burying, and possesses a threat to pollute the ground water table or enter the food chain, should be avoided. (Shelter Centre, Transitional shelter standards, 2009)

5.12 Analysis and Conclusions

A great amount of information and knowledge have been gathered about emergency housing. The insights have given the author a wide perspective of the context. In the end the most vital and applicable areas had to be chosen to continue with.

To clarify, summarize, and weight the identified needs from literature, interviews and field studies, a list of functions was made. The base function was to enable a shelter that protects displaced people from weather. Each function was rated from one to three (with three points as highest score). The entire list of functions can be found in Appendix 2. The result was shown to Formens Hus and it was decided that ten problem areas should be investigated further. These areas were possible to reform. Still, knowing the standards and background of logistic, handling etcetera were rather beneficial, since the problem areas overlap each other. Even though the future work implied several focuses, numerous other needs were excluded and left for Formens Hus to consider in their own work. The ten areas can be found in Figure 52. The scores are the mean values of the ratings for each area's underlying functions (see Appendix 2).

Main function: Protect people from weather			
Durablity	Living environment	Safety & health	Other
Hindering water to enter (3 p)	Cooking area (2 p) Storage (2 p) Privacy (2 p) Light (1 p)	Ventilation & temperature (3 p) Security (2 p) Fire safety (2p) Diseases (2 p)	Appearance (2 p)

Figure 52. A categorization of the most essential problem areas for this project.

6. Product development

In this chapter a description of the product development is made. The process included idea generation, evaluation, additional information gathering and concept descriptions. All identified problem areas were processed parallelly, but to facilitate the understanding each area is described separately in this chapter.

6.1 Introduction

Formen Hus has during this project worked parallel with the construction and possible materials. During the author's product development phase Formens Hus was investigating needle punch and extruded polypropylene as suitable materials for the cover. The needle punch is soft but can be pressed to increase the stiffness. It is used as canvas for miniature golf and tennis course and costs 4-5 USD per square metre. Extruded polypropylene is less flexible and fluffy and costs 3 USD per square metre.

The author continued working with the condition of three packages per pallet. Without any changes or extra features, the shelter design from Formens Hus is just exceeding to fit four packages (see Appendix 4). In this project partial solutions will be added and therefore four packages for a pallet will be hard to achieve. A hammer and a screwdriver will also probably be included for each package.

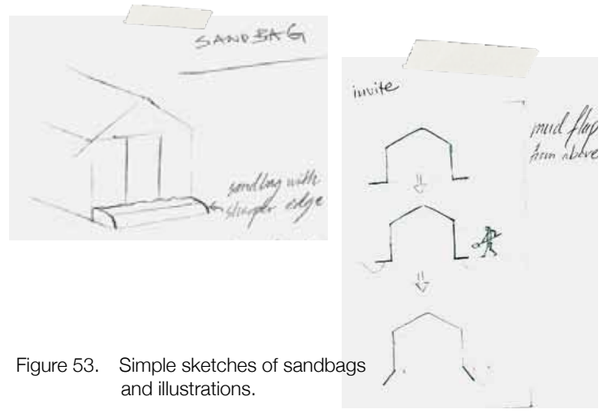


Figure 53. Simple sketches of sandbags and illustrations.

6.2 Hindering water to enter

6.2.1 Sketching

Hindering from sides

Blocking water with sandbags is a traditional technique. Consequently, the first concept implicated sandbags, but in the same piece as the wall. Thereby the bags would be impossible to steal. See Figure 53.

The second idea was to use symbols and illustrations on the mud flaps. These images should describe that the flaps are dug into the ground and that a ditch is created. Today people are often not familiar with these solutions, unless aid organisations inform about it.

The third concept was to force residents to dig down the mud flap. If the flap is pointing upwards or if it has a fixed constant angle downwards, the residents have to dig a hole along the wall to cover the flap. Otherwise, water will enter.

The forth idea was an elevated floor covering the whole living space. The water is going to pass underneath it and thus not reach inside.

Hindering from underneath

The next area of idea generation is avoiding water from underneath, in other words flooring. Three main ideas were developed.

The first idea was based on adding pipes, with smaller diameter than the ones for the steel frame, so they could fit the package. The pipes are placed widthwise in the shelter, with supports underneath. Several ideas of supports were explored, among others stackable plates and sandbags (see Figure 54). Once the pipes are positioned, thin boards are put on top to act as flooring.

Using the boards from the package was the next idea (see Figure 55). Possibly, supports that elevate the floor could be fastened in the boards right from the beginning. Another alternative is to use the short sides as supports. Regardless of solution, some support is needed to elevate the boards.

Finally carpets were considered as flooring. Using carpets means that they will be placed directly on the ground, without supports. Thereby the thickness is essential for how well it will function. At the same time it cannot be too thick in order to fit into the package.

Irrespective of solution, a floor can only cover a certain part of the living area. It would be too expensive and heavy to supply 17,5 m^2 according to Formens Hus.

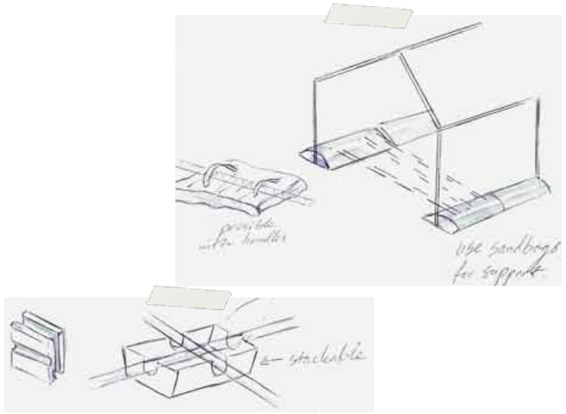


Figure 54. Supports for a floor.

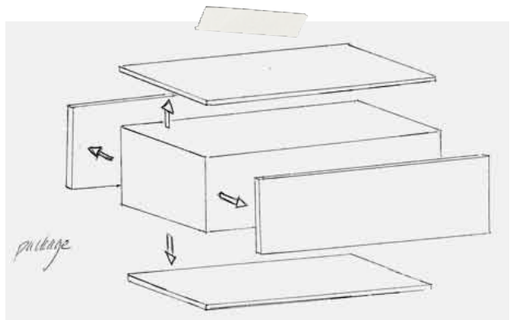


Figure 55. The package could be used for flooring as well.

6.2.2 Decisions for further development

Floor is, once again, not a solution that UNHCR is prioritising, even though they are well aware of the problem. However, if floor is provided for just one section of the shelter, and only costs about 20 USD it might be a possibility for UNHCR, and other organisations, to support floors. UNHCR is interested in including solar panels, costing 10-20 USD, to the shelter. The solar panels are, assumed by the author, to be a way to attract donors rather than actually function in field. The author strongly believes that flooring is a much more urgent need and more functional than solar panels. Therefore, if floors are presented at the same price, preferably as the package, it might be a way to convince UNHCR.

Formens Hus has also been sceptical about including a floor, due to the limited cost and weight. Instead they suggest that flooring could be shipped in later on as an upgrade. However, the author regards this approach to be unrealistic in numerous locations. First of all the budgets from aid organisations are rarely enough for displaced people. Tarpaulins are more common than shelters, due to lack of financial means. Consequently another round for upgrading the shelters seems too optimistic. Further on, the logistic of supplying floors to the same families that received the shelter will be hard. Camps are often chaotic and supplies are sold on the street.

In the end, it was decided that the author should develop the flooring concept further. It was also determined (based on the result from the PUGH matrix and discussions with Formens Hus, examiner and supervisor) that sandbags with illustrations and drainages were interesting areas to continue with.

One of the prototype producers was visited and the following insights were drawn:

- The package must be durable enough to tolerate the tough handling in transportation.
- A pallet will consist of a few shelters, all together wrapped in clingfilm.
- All shelter components will be parcelled at one site.
- Printing illustrations on the mud flaps will be very inexpensive.
- Sandbags can be a separate item (not included in the walls) in order to become cheaper.

6.2.3 Additional information gathering

Upgrading and flooring

To investigate how realistic an upgrade for temporary shelters is, Jim Kennedy, an expert on camp management, was contacted. He states that upgrading shelters from abroad in a second phase is difficult to achieve. There is usually neither the will nor the funds available to provide such supplies to families. Those organisations that still implement shelter and reconstruction programs are focusing their money and energies more and more on permanent reconstruction and repair.

After the earthquake in Haiti the distribution of shelters was so chaotic that it will be extremely difficult to match the upgrades with the original shelter recipients. Half a year after the earthquake, only 27% of the camps had support of a NGO or a management/governance structure overseen by partners of the shelter cluster. Distributing more materials from abroad to a certain target group, several months later, will be hard to achieve. (However, it would be wrong to say that other camps in Haiti were completely lacking in organisation. Each camp had its own local community governance and leadership structures. The people in charge had not always the greatest awareness of health issues, but nevertheless they held control and organised the camps according to local priorities.)

Generally speaking, camps that emerge from conflicts are more planned than the camps established after natural disasters. Most of the camps for refugees have a multiple-NGO presence, usually with UNHCR at the top. Whilst, as in Haiti, it is much more common for "spontaneous" camps with less control and support from NGO:s. Local governments often do not wish to admit the existence of the non-supported spontaneous camps. (Kennedy 2011)

Sandbags

With a large amount of sandbags (about 50-100 pieces) that should be filled, very few of the beneficiaries will be willing to do the work, without being prodded by NGO staff. The reason is not necessarily the dependency syndrome, but the lacking of a small spade for each family. One layer of sandbags (about ten pieces), which is the case in this project, will however most likely be possible for a family to fill. These bags will hold back surface water up to about 7-10 cm of height. Unfortunately, there are several sites, such as southern Sri Lanka and northern Kenya, where floods are much higher. It should be underlined though that for almost everyone in the world, sandbags are not a normal "civilian" construction material. Instead the technique can be seen as artificial for people.

In sub-Saharan Africa residents sometimes use mud as a thin surface on shelter walls. The amount of mud that is needed is less than for sandbags, the process is quicker, and it still has a significant benefit in terms of thermal control of the interior of the shelter.

Regardless if sandbags or a mud surface is utilised, there is a common problem today about the holes that are being dug. Aid staff tries to convince residents to dig the mud from some larger ditch-digging project, perhaps hundreds of metres away from their shelters. However, most people dig up a large hole close to their shelter plot. This can create a minor hazard, as the hole inevitable becomes a rubbish dump and possibly, after the rain, a breeding-ground for mosquitoes. (Kennedy 2011)

Drainage

Drainage is appropriate to dig around the shelter and then connect it to a few mutual ditches, which crosses the entire camp, into a site drainage solution. (UN 2004) (Sjöholm 2011) The suitable drainage depth depends on the amount of rain, the slope of the site, and type of soil. Sometimes it needs to be 50 cm deep, which often makes it unstable. Therefore they must be filled with stones or similar to prevent injury, collapse, and stagnant water and rubbish. (UN 2004) There have been cases where families are unwilling to dig 50 cm deep ditches due to child safety. (Kennedy 2011)

The width of a ditch should be around 50 cm, in most cases. The same distance is fairly adequate for the space between the ditch and tent flap. (Kennedy 2011)

Usually camps are located in the outskirts of towns or on secure sites away from war zones and borders. When there is time to prepare and choose a campsite before inhabiting it, a sloped terrain that provides natural drainage is an appropriate choice. (CBC News 2007) A slope of 1-6 % is suggested by Sphere guidelines. (UN 2004)

6.2.4 Further development of flooring and package

A floor only covering a few square metres can make a crucial difference for a family. It would provide them with a water protection that enables people to sleep properly. The following paragraphs describe the further concepts of flooring and package.

Generally speaking, people do not receive any floors from aid organisations due to heavy weight, large volume and high price. However, if only a part of the living area is covered with floor these parameters decrease significantly. During the field studies it was found that people often sleep on the floor and in a divided part of the shelter. It is during the night, when people need sleep and cannot run away, that the floor really makes a difference. In other words, the most important function for flooring is to enable displaced people to sleep properly. Therefore only a few square metres are critically needed.

The shelters will be packed on a Euro pallet and fit three packages. A package could be of several measurements, but 40x80x182 cm will be the most practical one. Each side of the package could function as a part of the floor. Using the measurements above (but excluding the short sides), a total floor area of 4,32 m^2 is achieved. According to Formens Hus a floor cannot cost more than 10-20 USD, due to the limited budget from UNHCR. This means 4,6 USD per m^2.

Depending on the volume of the cover and frame, the thickness of the floor differs. The total shelter volume without changes or extra features is estimated to 0,5036 m^3. If three packages are delivered on one pallet then each one can occupy 0,5824 m^3 ((1,2x0,8x1,82)/3). As a consequence 0,0724 m^3 is available on the pallet for further additional components (which are floor, sandbags and storage solution). See Appendix 4 for calculations.

Material and construction

In order to determine suitable materials and constructions for flooring, several experts were contacted. Antal Boldizar, who research and educate within polymeric materials and composites at Chalmers University of Technology, instructed about the advantages of using plywood rather than plastic materials. Before contacting Antal, the author had an idea of using recycled plastic. This material is cheaper than new plastic and could be a key point in the marketing of the product. However, durable recycled plastic is insufficient in the production phase (50% of the total cost emerges from the manufacturing) and therefore hard to cope with large quantities of materials. Common plastic materials are, according to Antal, tricky to use as well, due its lack of stability. Instead, Antal recommended plywood or possibly laminated sheets. Plywood is common in many different fields, found in many countries and has appropriate standard measurements (1220 x 1840 mm). The measurements are quite perfect to fit the four longer pieces of a package.

Different plywood materials were then investigated, but most of them turned out to be too expensive or too heavy. Furthermore, many are not water resistant or durable enough to be placed directly on the ground. Consequently, water resistant supports are needed to elevate the floor. If two layers of supports are used (see Figure 56), with a short distance like 40 cm in between, then a thin plywood sheet (about three mm) would work. However, that requires anyhow a lot of materials.

After some research, a waterproof plywood sheet in birch, seven mm thick, was found at a retailer. The price and weight were slightly above the UNCHR budget, 7 USD and 4,4 kg per m^2. However, according to the retailers no extra supports would be needed.

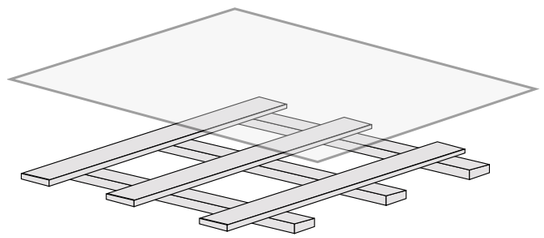


Figure 56. Plywood and supports.

Robert Kliger, professor in steal- and wood construction at Chalmers University of Technology, recommended a sandwich contraction of wood veneers and foam. Unfortunately, neither he nor the author could found any retailers producing the construction for a reasonable price.

Even though Antal Boldizar suggested plywood, different polymeric solutions were investigated. The material needed to have a durable construction and required an "alternative" polymeric solution. Twin-wall was in the end found and chosen since it fitted the requirements well. Twin-wall is made out of polypropylene and consists out channels in one direction, a little bit comparable to cardboard (see Figure 57). Cardboard is moreover used in many camps during night-time to isolate from coldness, but it does not resist water.

Retailers of twin-wall were contacted and one of them, Eqpack, had realistic prices. One square metre of 3,5 mm and 0,45 kg would cost roughly 2 USD. The sheet would not need any additional support towards the ground.

Form and functions

The shape of the floor and package are very much connected to the material choice and the thickness. At first, before settling the material, several ideas of how the pieces could be connected to create an impenetrable floor were explored.

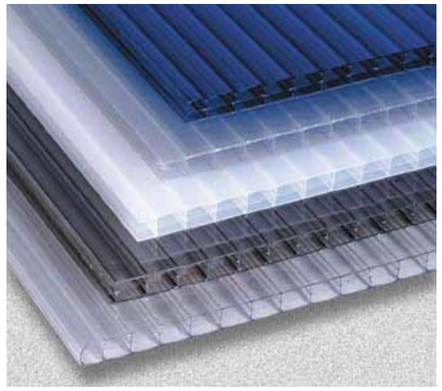


Figure 57. Some samples of twin-wall.

Using slots are common in floors today and the same principle could be applied in this case as well. Making a cut at the short edges would in addition possibly enable a functional connection for a package. See image C, Figure 58.

If the structure of the pieces is I-profiles these will overlap each other. Once they are placed together they will strengthen the whole structure. With careful tolerances, no extra connection in between is needed.

Having a puzzle solution is another double functional expedient. Just as using slots, it could be a connection for a package. On each side of a piece, a square, that is equal in height and depth, are either added or removed. Consequently a puzzle is created. See image A, Figure 58.

Finally the floor could be in one piece. As long as the material is soft and possible to fold, no additional connections are needed. See image B, Figure 58.

After evaluating these ideas with twin-wall as material and estimated how they would function in camps, the solution in image B was chosen. The most important purpose of flooring is to separate people from the ground during night-time. The floor will mainly be

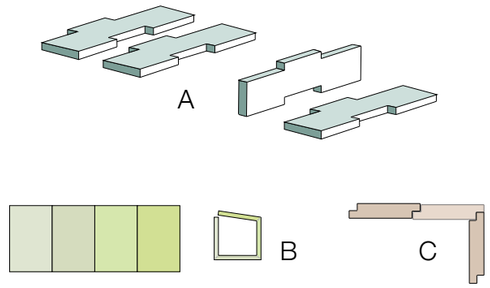


Figure 58. Connection solutions between the floor pieces.

used for sleeping area and only cover a small part of the ground. The ground itself is usually not flat, but irregular. Consequently it is not really any major advantages with connected floors. It needs to be flexible in its use and cheap to manufacture. Therefore the form should be as simple as possible, meaning no connections included in the structure of the floor. However, as a package some connections have to be made in order to seal it.

After frequent contact with the retailer it became clear that it was possible for their subcontractor to deliver larger pieces. 240 x 180 cm was needed for the package, which is exactly the widest possible measurement since their trucks are not any wider inside than 240 cm.

To emphasise to residents that the package also is appropriate as flooring, illustrations could be printed on the inside. Most likely, people know best themselves what leftover materials are most suitable for. And raised floors could sometimes be created using mud and earth alone. However, these solutions are not always possible and suitable and therefore an additional floor is added. There have been situations though when local people have rejected to build floors even though aid organisations have been promoting them. The residents were not used to floors in their previous homes. When the rain season began suddenly everyone understood the advantages. (Kennedy 2011) In other words, it might be important to give obvious alternatives for the later usage of the package.

Connections for package

Twin-wall is, due to the lengthways channels, only bendable in one direction. Therefore a package of six sides cannot be folded as cardboard or be in one piece. The short sides have to be separated from the larger piece, meaning three parts as a whole.

First of all the largest piece needs to be sealed at the long side. Several ideas were developed and investigated. Angle irons are a common solution and would technically work here as well. However, the irons should preferably be screwed from the inside, in order to avoid screws penetrating the cargo. Placing the irons on the inside make them hard to reach. See image A, Figure 59.

Another idea was to use boards along the side. It brings a thickness for the screw to grab hold to, and can be done from the outside. The only disadvantages are some additional material and loss of volume inside. See image B, Figure 59.

After experimenting and processing the material the author realised that an additional piece for the connection was not necessarily needed. Twin-wall is tough and has several channels that the screws can attach to. By folding the edge, creating a flap of two cm, the connection could be screwed from two directions and the construction becomes very stabile. See image C, Figure 59.

After evaluating the different ideas the last one was chosen. It is most cost efficient and does not require additional components (except screws), which is very desirable for the product. Regardless of solution cable ties could be added afterwards to secure stability.

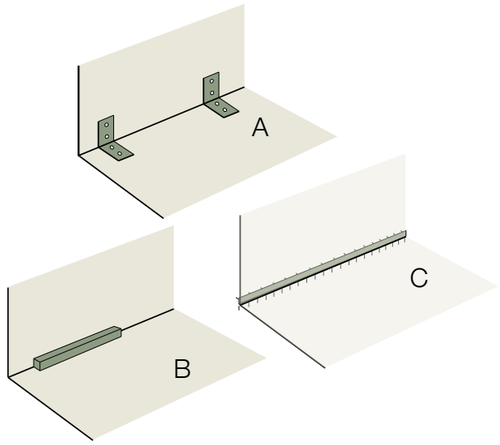


Figure 59. Ideas of how the package can be sealed.

The short sides do also need to be sealed (see Figure 60). In addition to the connecting principles mentioned before a tube solution was studied. However, to enable a tube with five sides requires several parts or another material. To facilitate the manufacturing and logistic, few materials are appropriate. Therefore the short sides will be in the same material with similar connection as the long side.

Worth underlining is that the actual packaging of the partial solutions into the package is not within the scope of this project.

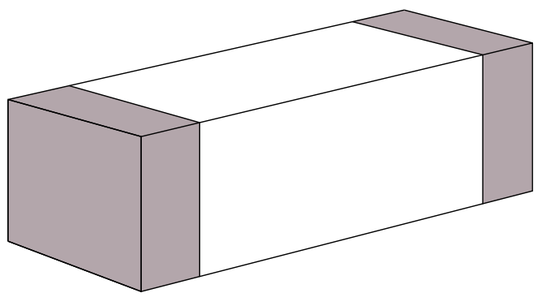


Figure 60. The short sides need to be sealed as well.

6.2.5 Further development of sandbags

To further minimise the risk of water leaking in from the side, sandbags could be utilised. Sandbags are a commonly used at flooding, creating a barrier. This method is well-tried and has been used for long time.

After the meetings with Formens Hus, and later on with the examiner and tutor, several ideas of sandbags, included in the mud flap, were developed and prototyped. The most successful one turned out to be a solution that does not add any extra parts. The "sand pocket" is instead created in the same piece as the wall and folded and stitched twice on each side (see Figure 61). The opening, where sand or earth is put, could be placed more or less anywhere. However, to avoid water to enter between the wall and the sandbag the opening was placed ten cm "behind" the wall with an opening of five cm (assuming the total length of the bag would be the recommended measurements of 40 cm for mud flaps). In that way the wall hinder water to enter into the pocket.

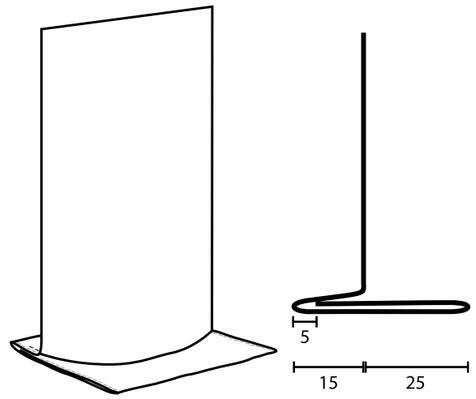


Figure 61. A sandbag included in the wall.

The concept was discussed with Formens Hus. The conclusion became to continue with the idea, but in another material and as an external component. The material of the shelter would, according to Formens Hus, not be flexible and soft enough to function as sandbags. The shelter material is as well rather expensive and therefore cheaper textiles would be preferable. But most importantly, the production time of the wall will increase significantly if stitches and folding are needed. The external sandbag can afterwards be attached to the shelter, either through welding or by just attaching it manually in field.

Form and functions

The development of the new sandbag is based on the idea that mud flaps still exist. The sandbags become a complement rather than a replacement. However, the length of the mud flaps does not necessary need to be 40 cm anymore when sandbags are added. In this master thesis proposal, the length will be assumed to be 30 cm, since that was the last suggestion by Formens Hus.

At the field trip in Haiti it was found that stones or cement blocks, which are placed on top of the mud flaps, became valuable items. People stole them from neighbours. As a consequence the sandbags needs to be tightened properly to the shelter. To minimise the production cost the sandbag will not be welded, but manually attached.

The new sandbag developed into a pocket with a flap, which is connected to the vertical shelter pipes with galvanised eyelets (see Figure 62). The sandbag flap is about 70 cm long and placed under the mud flap. Then, the sandbag flap is folded over the mud flap, placing the sandbag along the wall. Once it is filled with sand, a load is established that will minimise the risk of uplift.

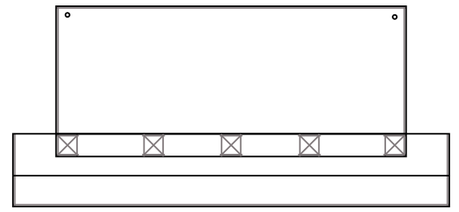


Figure 62. A sandbag with a flap that connects to the metal frame.

The solution requires that the user understand that the flap should be folded up side down. The pursuance is perhaps not obvious to a first time user, which is necessary in this case. Therefore a redesign was made of the previous solution. By replacing the sandbag flap with two straps, less material is needed and the understanding of how to handle it enhances. See Figure 63.

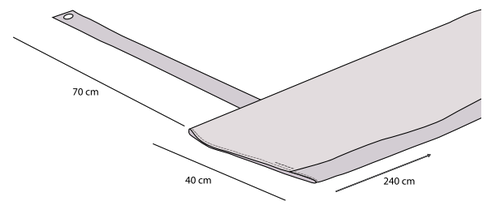


Figure 63. A sandbag with straps attached to the metal frame.

The sandbag could be placed in- or outside. The most obvious benefit of having them inside is that mud flaps might not be needed and material is thereby saved. The risk that rain will run inside is slightly less when the bags are placed indoor. Furthermore, it is easier to control and protect the sandbags from damage and theft if they are located inside.

Placing them outside brings more benefits. They put load on the mud flaps, which creates additional stability. It also becomes easier outside to fill them with sand, more indoor surface is accessible, the lower part of the wall is protected from damaged from water, the expression of stability is enhanced and the distance to close by footpaths is enlarged. Regardless if they are placed in- or outside they form a barrier. The barrier hinders people to enter from underneath and enhance the emotional security.

In order to avoid the sand from falling out, or that rain is entering, the opening is placed on the upper side with overlapping edges. Ropes, firmly sewn to the sandbag, can then be tightened around to secure the function. Without these there is a risk that the edges will bulge.

The sandbag straps include two eyelets. Consequently the sandbag could be hanged from any of the shelter pipes to enable storage. There have been cases where refugees have preferred to use the sandbags to hold and carry their belongings, or sold them in local markets. In dry regions and seasons, water barriers are perhaps not necessary. If the sandbag then has an added value and double function it is very valuable.

Material

Sandbags are usually made out of plastic threads or hessian. Usually plastic materials are more resistant to repeated soakings and freezing, making them more durable in the long run. However, the durability is not necessarily about the choice of material, but a question of how many children and animals that tries to pick at, or chew on, the bags. (Kennedy 2011)

A Swedish retailer, called Säckgrossisten, was contacted that sell sandbags out of polypropylene. According to the sales official the bags are not noticeably affected by water. The material and manufacturing cost are also low. Each sandbag would be about 0,5-1 USD.

Measurements

In order to hinder water to enter the shelter, the sandbags must overlap each other. In other words the length needs to be more than 180 cm. The width should cover the underlying mud flap and consequently needs to be more than 30 cm. Once the bag is filled both the length and width will shrink due to an expanding height. Therefore it is favourable to add some extra volume to the bag.

The thickness of the polypropylene canvas, at the Swedish retailer, is less than 0,5 mm. A sandbag is folded once, meaning that the total thickness, including the straps, will be about 1-1,5 mm. To cover the whole shelter ten bags are needed.

Illustrations

To clarify the function of the sandbag illustrations will be printed on top of it (see Figure 64). To further improve the water barrier drainages can be used. It is an efficient method that has proven to work well. However, few displaced people are aware of this solution, or they are missing tools or they are apathetic and reluctant to take action. Therefore there should be illustrations of drainage. Regardless of the state of people it is better to inform them about possible solutions than not. At least a certain part of the residents will follow the advice. It is very essential that drainages are dug immediately. Camps are rarely planned before they emerge and shortly the shelters will be packed next to each other. Then it is too late for proper drainages. As a consequence a shovel, not necessary a big one, would be very suitable to include in the shelter package. A shovel would furthermore clarify the functions of sandbags and drainages.

It is appropriate to dig ditches around the shelter and then have a few mutual ditches, which crosses the camp, and connects to each shelter. Even though the efficiency of drainage is very much in relation to slopes, ditches are nevertheless functioning to some degree and a significantly better solution than nothing. (Sjöholm 2011)

Worth mentioning is that camps are not necessarily placed in open fields, suitable for drainage. Sometimes, people are barricading urban areas, like parks or sports grounds due to lack of alternatives. These locations are most likely inappropriate for drainage, since it will damage the ground. However, after a few months with IDP:s or refugees the grass plot or foundation will be destroyed anyhow.

To minimise thefts it is beneficial if the straps are attached to the frame. The eyelets will, by its shape, indicate that it should be connected to a pipe. It is yet beneficial with redundancy, meaning that illustrations showing how they are attached will increase understanding. However, the author was uncertain if such an illustration should be included in the same image that illustrates the sandbag being filled with sand and drainage being dug. Since the straps are folded, placing the sandbag right next to the frame, it might be hard to visualise the attachment underneath. The easiest solution would be to visualise a separate illustration of the straps connected to the pipes.

People from different cultures, countries and level of education will interpret the illustrations. Therefore it is essential to have obvious figures rather than descriptions. The reading direction differs as well, meaning that each illustration should not be too dependent of which illustration that was previously read. A proposal was made, but after showing it to a graphic designer the author realised that it needed to be more simple with less details.

A sandbag is not necessarily an item that people are familiar with. They are not used traditionally in many cultures and therefore people might be sceptical or unaware of the function. Therefore it might be important to include in the illustrations how rainwater is hindered by the sandbags and then transported with the drainage.

If a camp however is settled in a desert or a dry region people will perhaps not understand the purpose of the bags anyhow. But, as mentioned before, the sandbags have additional functions than hinder water. These functions will though be hard to illustrate. Nevertheless, the solution is meant to use mainly along the equator, where rain occurs on a periodic basis.

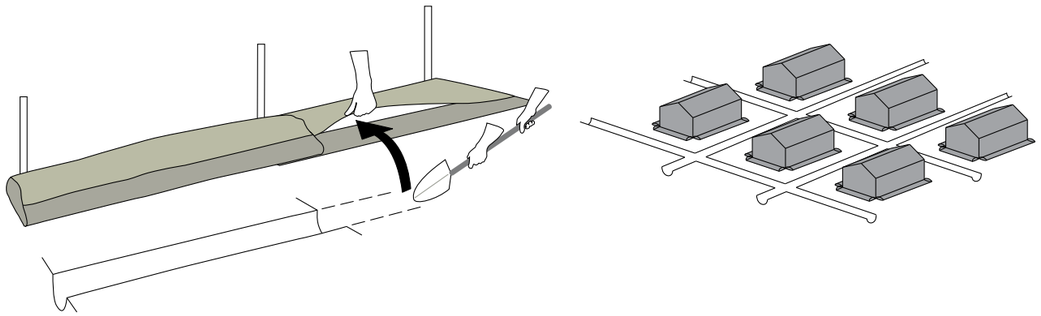


Figure 64. Illustrations placed on the sandbags, showing its function. Drainages are also visualised.

6.3 Cooking area

After the field studies in Haiti and Kenya it became obvious that an external space for a store and for cooking was beneficial. The space should be semi-outdoor, meaning that it is easily accessible for passing people and ventilates the cooking smoke efficiently. At the same time, insight and rain protection should be promoted.

6.3.1 Sketching

After frequent sketching work, three major areas of solutions were identified, all of the same basic idea. By "inviting" people to cook outside (by adding a few roofs or walls) residents would be protected from rain and indoor heat, but it would still enable privacy, space for a store and most importantly sufficient ventilation.

The first solution implied an extension of the current shelter design with 90 cm (see Figure 65). The shape and components would be the same as before, except that the additional pipes are half of the length. With half a section extra there was suddenly several ways to create a semi-outdoor room. As long as the original gable side was untouched and included a door, the additional room only needed a few parts. Several sketches were therefore made with variations of including parts. In some sketches the whole gable was missing and in some the sidewall and roof was left out. A few ideas of using the door as a partition wall and insight protection were also considered. Thereby a cooking spot could emerge. From a user point of view, the best solution would though be to add an entire half section with a large door and small openings in the middle of the roof (see Figure 66). That would invite people to cook and sell goods outdoors, whilst at the same project the feeling of being indoors.

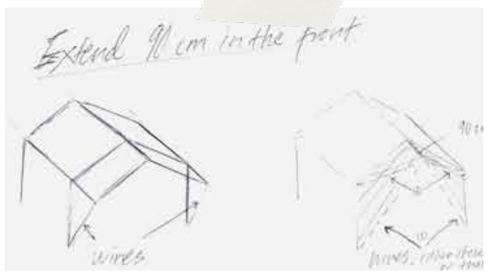


Figure 65. Several sketches of how the shelter can be extended with 90 cm were done.

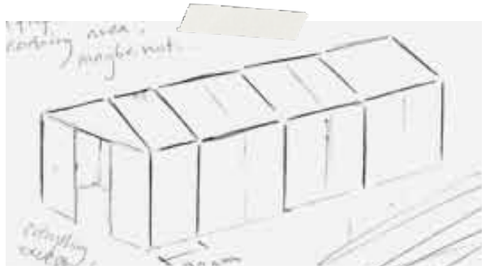


Figure 66. Adding a half section can increase the conditions for a proper cooking space.

The second concept was quite similar to the previous. The idea was to add a whole section of 180 cm and exclude a few components. This meant that no additional type of part is needed. The same idea could be applied with the current three sections, meaning that one of them would be used as cooking area and store. However, that would decrease the remaining living area significantly and should therefore be avoided.

The final category was about creating an outdoor room with existing components. By turning the wall into a roof, a veranda emerges (see Figure 67). The roof provides shade, rain protection and ventilation, but not any insight protection. Another idea was to create a room out of wires. These could be attached in the roof-ridge and connected to the ground. Then tarpaulins or local materials could be fastened to the wires and thus secure rain and insight protection.

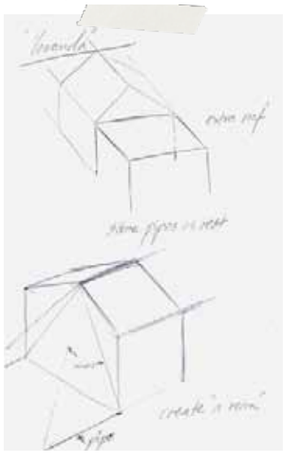


Figure 67. A few ideas of verandas.

Most of the ideas are based on adding a few parts to the current model. Worth mentioning is the potential problem with wind. As soon as additional pieces are not tightly connected and large openings are left, there is a severe risk that the pieces will get damaged.

6.3.2. Decisions for further development

After discussing the topic with Formens Hus it became clear that it was not an option to add an additional whole or half section to the shelter. The concepts of adding 90 or 180 cm pipes were therefore excluded. Instead, the cooking area must be included in the original measurements.

Based on this insight, the author was eager to investigate alternatives for designing a cooking area. The door (and its surrounding area) plays an essential role for the cooking in many locations. During the study visit at the prototype producer it was found that Formens Hus, at that stage, did not have a clear solution for the door.

6.3.3 Further development

The cooking area had to be reconsidered in order to fit the project scope of Formens Hus. An expert in stove development for developing countries, Maria Nyström at Chalmers University of Technology, was therefore contacted. She has been working in the field for 15 years and among others studied the risks of asphyxiation from stoves in Vietnam. One of her conclusions became that stoves placed indoor should not be exposed to frequent ventilation during cooking. It is important with a calm spot that is protected from the wind and other substantial air circulations. A small amount of vorticity implies more efficient burning and that decreases the flow of smoke. Placing the stove close to a wall is furthermore adequate. The smoke will then follow the wall rather than swirl around indoor. About a metre above the stove, a ventilation opening is needed. The distance to the opening must however be tested and evaluated to secure efficiency.

An alternative solution to ventilate smoke would be to have large ventilation openings at the gables and place the shelter in the wind direction. With decent flow of wind that penetrates the shelter in one direction the smoke can be ventilated. However, it is most likely hard to direct displaced people, by the shelter design, which direction the short ends should point at. It might not even be possible to determine the wind direction due to the microclimate.

Form and functions

Shortly the author understood that the door was the key to enable a calm cooking area. When people cook indoor they are usually close to the door due to better daylight and ventilation. In other words, this is usually the natural location for cooking. At the same time it is, according to Maria Nyström's studies, inappropriate to expose the stove for additional flow of air (which is the case when residents cook next to an open door).

Two concepts were developed to protect the cooking area from wind and frequent ventilation. The first one has a divided door, which enable people to open or close both the upper and lower part (see Figure 68). Thereby the lower part could enable wind and insight protection and the upper part ventilates the smoke. An added value with this idea is how it solves the ordinary ventilation to minimise indoor temperature. To create an indoor breeze, which could cool people slightly, sometimes necessitates an opening at the bottom. And this is available here. (See later on Figure 91)

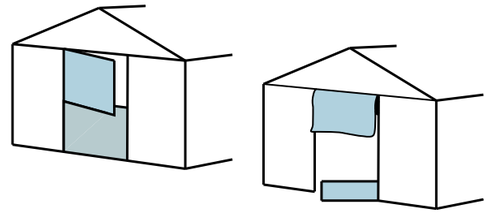


Figure 68. A divided door, here showing two examples.

The second concept implicates air holes in the middle of the door (see Figure 69). Either these are placed in the centre of the door or at the sides. By having small holes, and a larger opening at the other gable, a draw effect could emerge and the smoke disappears. However, less daylight is entering with this solution.

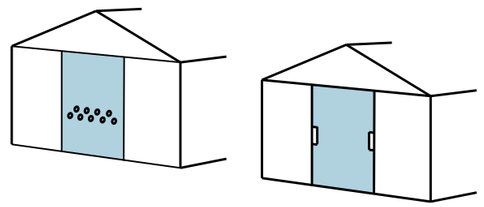


Figure 69. Air holes in the door.

The draw effect is possible to enable with the first concept as well. By setting the door ajar the same function emerges. Consequently more advantages were found in the first concept and thereby chosen.

Since Formens Hus did not have a proper solution of a door and how to connect it to the walls, the author took the freedom of designing all relevant components. It was necessary to establish a foundation before specifying the actual design of the cooking ventilation.

Shortly a doorcase was developed since it implies several advantages in this case. Locks, hinges and eyelets (to attach the upper part of the gable) could be screwed into the doorcase, instead of damaging the walls. Also mud flaps could be included in the doorcase if it goes along the ground. (A mud flap would never last if it was directly connected to the door and frequently in movement.) The doorcase has to be either folded or divided into parts since the width would be at least 135 cm and not fit a pallet.

Two concepts were mainly developed (see Figure 70). To minimise the amount of different parts concept B was chosen. Concept A could, as illustrated, be of two identical parts as well. However, the flap at the top (which is the same length as the mud flap) would then cover the knobs from the upper part gable. The knobs would still be reached, but in a more complicated and irritated matter. Furthermore, more material is used for concept A. The actual door is then attached to the doorcase with hinges. The door contains of two pieces that are overlapping and attached to each other with eyelets and knobs.

Material

The material the author suggests for both the doorcase and door is vacuum pressed extruded polypropylene. It is far stiffer than the ordinary extruded polypropylene. The doorcase flaps however should, in order to enable folding, not be vacuum pressed. Certainly, there are plenty of alternatives when it comes to materials for the cover and door. However, that decision has been a task for Formens Hus and vacuum pressed and ordinary extruded polypropylene are two of their current options.

Measurements

Vacuum pressed extruded polypropylene should at least have a thickness of three mm. The doorcase needs to be 180 cm high and 68 cm wide, excluding the mud and connecting flaps. The flap at the top will hang from the crossing wire and would preferably be ten cm high, since that would match the upper part gable. To read more about the gable, see section *6.7 Ventilation and temperature.* Regarding the actual door pieces, they should overlap each other so they can fasten.

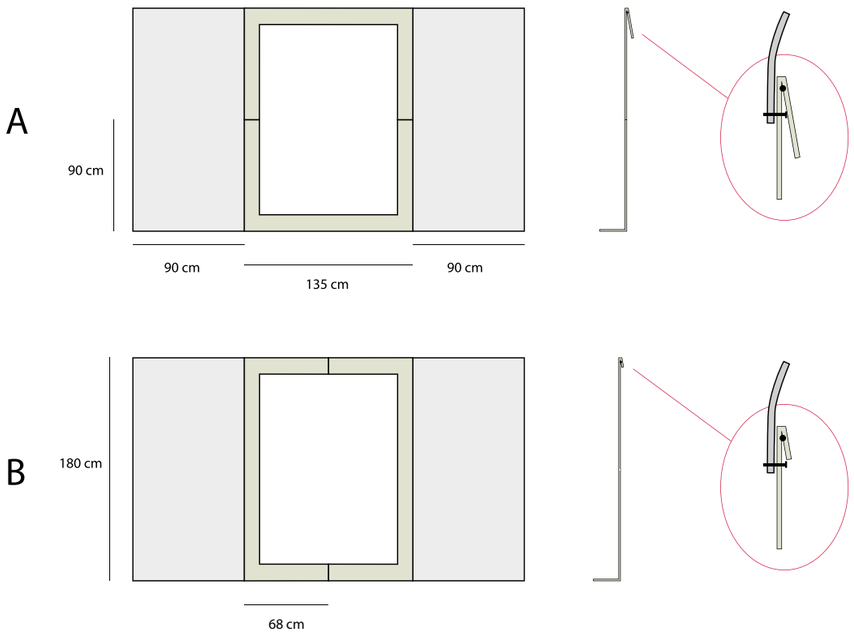


Figure 70. Two concepts of a doorcase, in between the wall pieces.

6.4 Storage

Clothes, buckets and cooking equipment were identified in the field studies as items taking up a lot of space. These are occupying a large amount of the living space, making the daily activities inside a bit complicated.

6.4.1 Sketching

The shelter from Formens Hus has a fairly high ceiling and therefore several ideas about using this space were generated. Either they included hanging boards (from the package) in the ceiling or wires fasten in between the frame. Many different variations of using these parts were done. In the end, wires attached to hanging board pieces were considered to be the simplest, yet most efficient, solution (see Figure 71).

Figure 71. Storage in the ceiling, using wires.

The second idea became to have storage standing on the ground. Again boards, possibly from the package, were used. Either these became shelves, fixed to the frame, or a foundation to attach poles into. The poles could be shaped as hooks or as chairs, resting on each other. Another solution was a hanging storage space (for clothing) with adjustable legs. The item is made out of textiles and therefore possible to compress (see Figure 72).

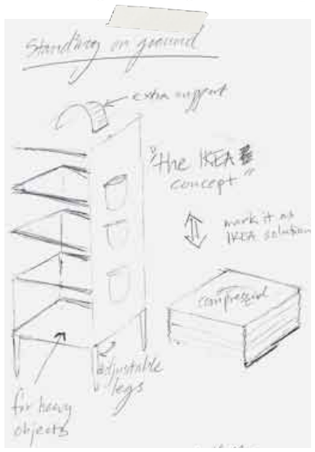


Figure 72. Hanging and standing storage.

The last main solution was to enable hanging storage directly into the frame. Elastic shelves, hooks, pockets, two twisted elastic ropes, nets, and shaping the walls to enable storage were a few ideas. Due to the great stability of the frame, there are many different and simple solutions that could be added. See Figure 73.

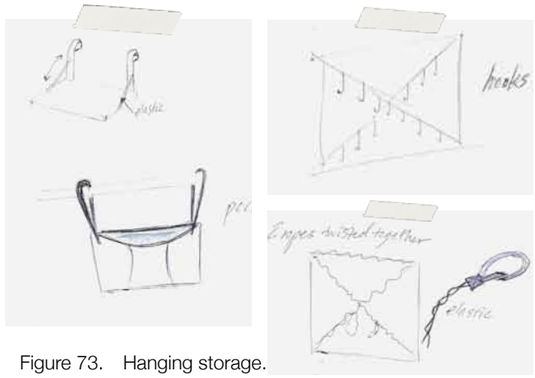


Figure 73. Hanging storage.

If the solution should be based on a hanger attached to the steel frame, it should be known that the loads are best managed close to the joints and at the verticals and horizontal pipes, not the ones running at an angle. According to Formens Hus, the loads should not be more than 30-40 kg per pipe.

6.4.2 Decisions for further development

Storage is not a priority from UNHCR and therefore it will be hard, according to Formens Hus, to add such a solution to the shelter. However, if storage can be included in other already existing items for a low cost, it could be possible to incorporate it. After discussions with Formens Hus it was decided to include hooks into the cover attachments. At the study visit at the prototype producer the author could inspect the attachment between the frame and cover. At this phase it consisted of a thin bent metal sheet, about two cm wide and one mm thick. See Figure 74.

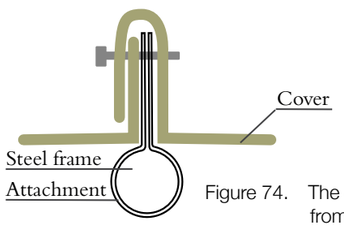


Figure 74. The cover attachment from above.

6.4.3 Further development of hooks

The simplest and cheapest solution to include into a cover attachment was hooks. The production and material cost would be small as well as the volume. The cover attachment made by Formens Hus is connected to each pipe. Its flap is poisoned in between two cover pieces and then these are fastened with a screw bolt. On each pipe three cover connections are placed, meaning that 75 hooks are included in the shelter.

Form and functions

Several ideas was sketched and developed. At first hooks were placed vertically. Unfortunately, that implies several different angles, meaning that either four different versions are needed or that only one hook will be vertical (see Figure 75).

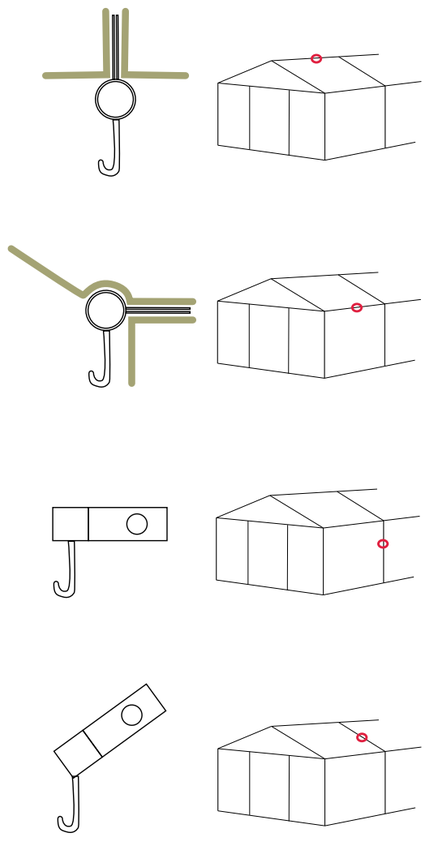


Figure 75. Placing the hooks vertically would imply four different attachments.

Soon the author realised the advantage of placing the hook piece as close as possible to the pipe and 90 degrees towards the attachment flap (see Figure 76). This enables the user to hang items safely regardless where it is positioned. To further minimise uneven load to the construction, but also carry more items, two hooks can be located towards each other. With this geometry extrusion is suitable and it is an efficient method for mass production.

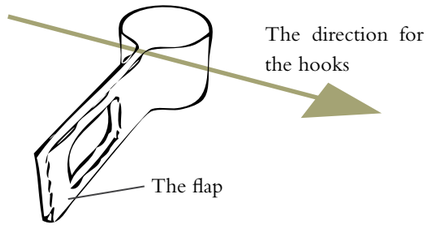


Figure 76. It is beneficial to place the hook along the arrow.

Additional sketching was then carried out to determine the shape. Right away, each hook got two lobes that, regardless of location, could hold or block items from falling. During the sketching the author realised that the upper lobe could with current length not exceed an angle of 30 degrees, due to risk of penetrating the canvas (see Figure 79). The shape in sketch C in Figure 77 was considered appealing, but it would not function equally well in certain locations as a narrow angle. Therefore the second lobe also got an angle of 30 degrees. Still it was important to include softness in the shape to empathise comfort. Thereby the corners got a rather large radius.

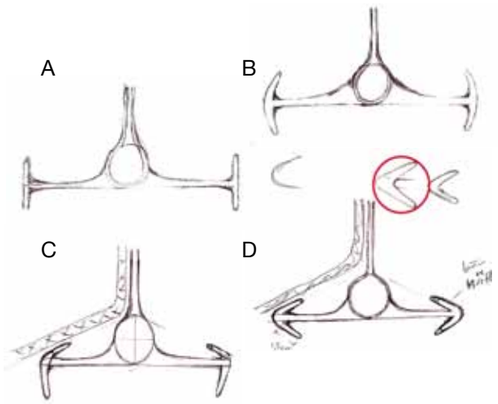


Figure 77. Sketches of hooks with lobes. The marked one was chosen in the end.

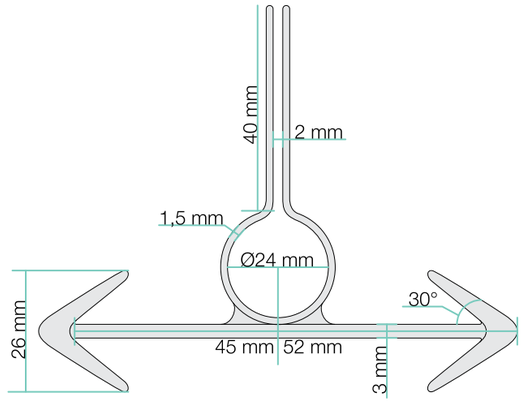


Figure 78. Cross-section of the developed attachment.

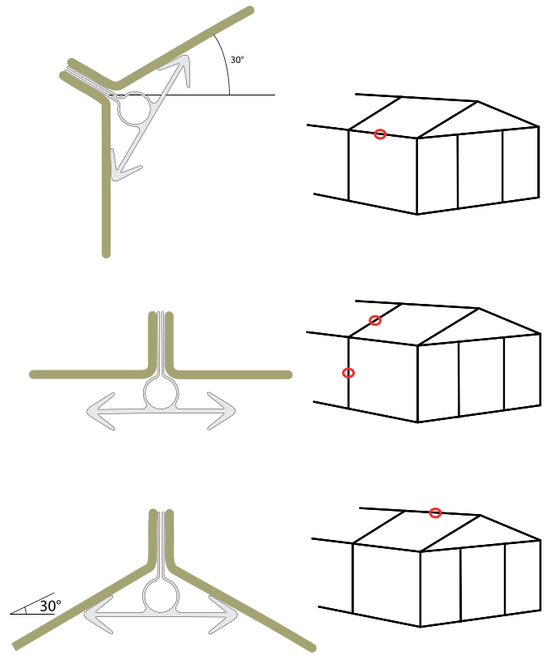


Figure 79. The cover attachment functions as long as the lobes are 30 degrees or less.

The result became two hooks, which reminded a little of arrows (Figure 78). That was not really the purpose. The hooks suddenly communicated something more than just being hooks. It got too much direction, meaning that the arrows indicated a message or a function that did not exist. Furthermore, the expression from the arrows became too hard and strict, especially if metal was used. The indoor comfort, expressed in the moodboard (see Figure 99), needed to be enhanced more. Therefore the hooks got larger radius and softer expression. Besides, having a less pointed and sharp hook decreases the risk of penetrating the canvas or hurting passing children. The upper lobe became smaller to minimise contact with the cover. Still, it remains there to hold or block items from falling. See Figure 80.

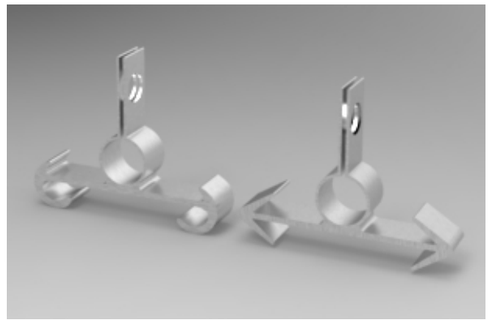


Figure 80. The new solution to the left.

Once the shape was settled and the author was pleased with the solution a potential problem was discovered. The connection between the gable and the long sides should be fixed with the same hook. The angel of 45 degrees might be problem, depending on the canvas material. However, both the materials that Formens Hus is considering would most likely manage the extra curve. But to secure possible fractions and to enable local stiff materials to be used in the long run, the flap was enlarged with 1,5 cm (see Figure 81). That would hopefully be enough to fasten various cover materials with different stiffness.

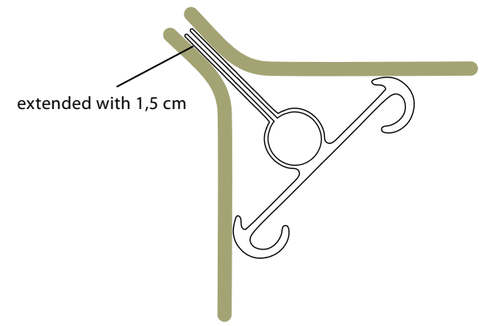


Figure 81. An extension of the attachment.

Material

As mentioned before the geometry makes extrusion to a suitable manufacturing method and it is fitting well for mass production. Either metal or plastic could be extruded. Plastic is in general cheaper but not as durable. Polyoxymethylene (POM) is a stiff sort of plastic, possible to use. According to Antal Boldizar, at Chalmers University of Technology, there is though a risk of fraction due to constant stress, especially in combination with sunlight and increased temperature.

Formens Hus, that is truly advocating inexpensive solutions, informed about general prices of plastic (2 USD/kg) and processed aluminium (5 USD/kg). Gustav Holmqvist, a teacher within manufacturing technique at Chalmers University of Technology, was contacted. He explained that the prices of aluminium could vary from 3-14 USD/kg depending on the geometry and alloys. The thickness of material would furthermore be rather even to minimise skewness. Steal is another alternative. However, steal is usually only extruded with simple geometries, such as H, L and T beams. Bended steal sheet could be another manufacturing technique, but that would change the current shape entirely.

The Swedish company SAPA, who are experts in manufacturing aluminium profiles, were contacted. After viewing the attachment they suggested, due to the small distance between the two flaps, two separated profiles what are fasten to each other afterwards (see Figure 82). The tools would cost about 2800 USD, which is fairly low considering that each year about 37,5 million hooks would be produced. Moreover, the thickness was recommended to be at least two mm, to minimise damage of tools and the width can be decreased to 1,5 cm.

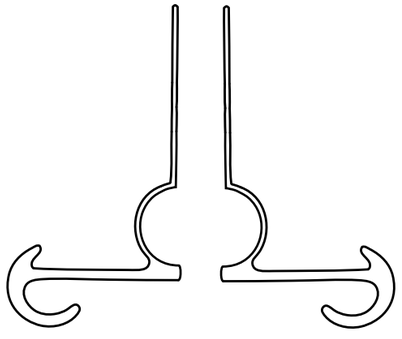


Figure 82. The cover attachment is preferably made out of two separated profiles.

6.5 Privacy

Privacy is lacking a great deal in camps. There seems to be three main areas where privacy could be improved; inside the shelter, at the entrance, and towards neighbours.

6.5.1 Sketching

Inside the shelter people are commonly dividing the room into two with drapery. The drapery is often thin and only hanged from the ceiling. To improve the privacy between the rooms a few sketches was done. The most effective solution was to use the same measurements as the gable parts (see Figure 83). Thereby, no new type of piece is needed. Possibly the piece could have less thickness or cheaper material since it is less susceptible to damage.

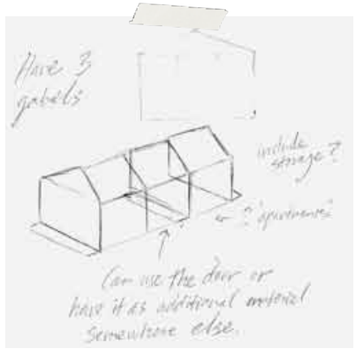


Figure 83. An extra gable, indoors.

Passing people should not be able to look into the shelter. Today the door is often wide open to enable ventilation. Certainly, ventilation could be solved differently. However, if people choose to use the door as ventilation opening the privacy should be supported. This could either be solved with a drapery hanging in the door case or by having two doors that are overlapping sideways.

Finally the cover should separate the residents from neighbours and passing people. In other words, projections (shadows) and sound should not penetrate the cover. A thick material or several thin layers could solve the projections and improve the acoustical absorption. The cover could also be folded, for instance with an origami technique, to enhance the acoustical absorption further.

6.5.2 Decisions for further development

Based on the result from the PUGH matrix and discussions with Formens Hus, examiner and supervisor, it was determined to continue developing a folded outdoor wall and an indoor division wall. The issue of projected shadows is solved with a thick and tough cover material. In other words, that specific task is left to Formens Hus to manage. It was also decided to not include an extra insight protection (commonly a drapery) beyond a door. Residents are most likely having their own textiles to apply.

After visiting the prototype producer several insights were drawn:

- Wall and roof pieces could be of the same single component.
- Each piece is 92 cm wide with additional eight cm flaps on each side. The height is 182 cm with an additional 15 cm flap at the top and a mud flap at the bottom of 30 cm. See Figure 84.
- The wall and roof piece could be extended in order to overlap each other, creating a roof overhang.
- Needle punch has the advantage that it can let moisture through.
- The connection between the wall pieces could be solved, like the roof overhang, with a foldable overlapping.
- Due to the thick wall it will not be a problem if clothes or other items are leaning towards, or touching, the canvas.

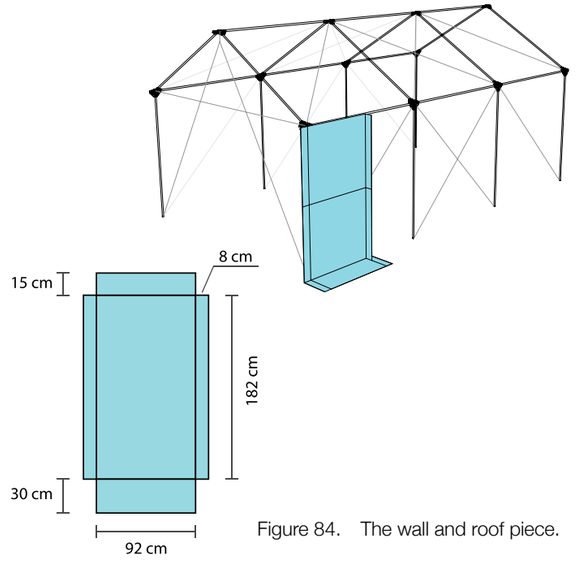


Figure 84. The wall and roof piece.

6.5.3 Additional information gathering about acoustics

A material that hinders the sound from penetrating accomplishes sound isolation (see Figure 85). Instead, the sound is reflected back. Concrete, thick glass, and bricked walls are examples of efficient materials with good sound isolation properties.

Sound absorption lets the sound pass through, but decreases the amount of it (see Figure 85). When an acoustic wave penetrates a material it loses its energy due to friction. The amount of lost energy depends on density, fibre structure and thickness of the material. Possible air slots to a wall or roof behind also have a great impact. (Acqwool 2012)

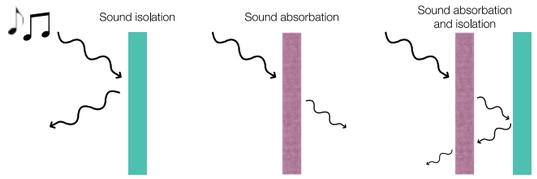


Figure 85. The difference of sound isolation and sound absorption.

6.5.4 Further development of indoor wall

Above all, the problem today is the lack of privacy towards neighbours. The privacy between family members is a second hand issue. In small, yet proper, houses today sheets are (almost regardless of country) often used to divide the living space. The division is partly made to separate the living room (where guests are welcomed) from the bedroom where all private belongings and manners are done.

Margareta Zetterblom, Senior Lecturer at School of Textiles in Sweden, were contacted. She claims that a soundproof division in between rooms are hard to achieve. Just a small gap between rooms will be enough to let the sound go through.

To design a division that is completely tightened might be possible. However, an opening is needed to enable ventilation to pass through. But the opening will at the same time let the sound go through, and the function is out of commission.

Besides the lack of sound isolation, an indoor wall will be more than seven square metres and thus costly. There are obviously several drawbacks. Consequently the author decided to not continue with a division, but leaving it (as well as the drapery at the front door) to the residents.

6.5.5 Further development of sound absorbing wall

Camps are generally very dense with a lot of people living close together. Families are consequently lacking privacy, even though walls and roofs are provided. To minimise the amount of sound and light that penetrate the shelter the material choice is fundamental. Regarding sound absorption the result is, as mentioned previously, very much connected to density, structure and thickness of the material. The more friction the material provides the better the sound absorption gets. Folding the wall is one way to establish a "thicker" material with more friction.

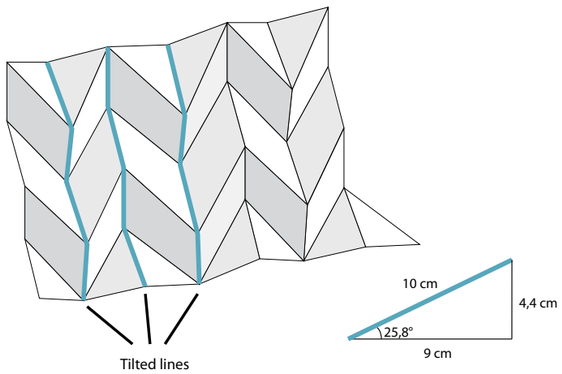


Figure 86. A folded structure, applicable for walls.

Form and functions

As mentioned in at chapter *6.2.2 Privacy*, origami techniques were investigated (see Figure 87). The folding principles are sometimes complicated, but in this case rather superable. The folding cannot be too complex since the piece must be mass-produced. Moulds will therefore be necessary.

Based on that knowledge a folding, illustrated in Figure 86, was made. The angle of the tilted lines could vary of course. The more sloping angle the more sound absorbing. At the same time more material is then needed.

The shape and appearance is not only functional for sound absorbing but also evoke interest, which is essential in order to attract donors. With just a slight angle of the tilted line it does not become too strange and unfamiliar for residents. In fact in some cultures the structure could resemble of the traditional technique of making houses, namely braided leaves (see Figure 88).

Figure 88. Braided leaves have a similar appearance to the folded structure.

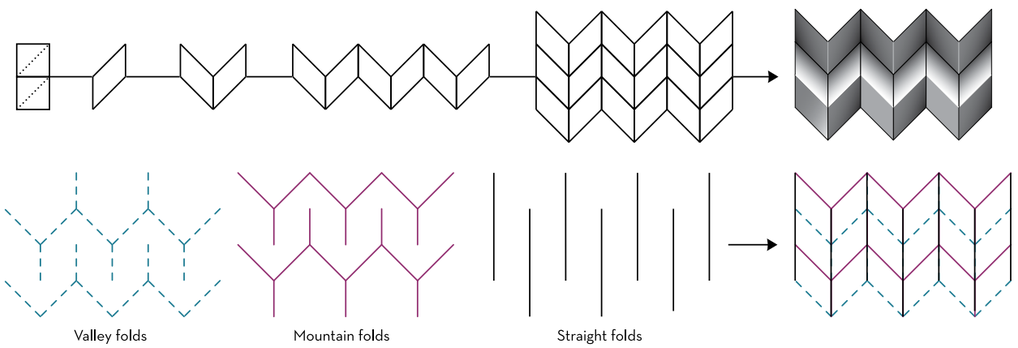


Figure 87. Origami technique.

Material and measurements

The walls, using this folding, need to be made out of needle punch or similar textiles. Due to the origami principle the material must be foldable in several directions. Soft materials are therefore necessary.

Initially, in the previous idea generation phase, the author had many ideas of applying the flexibility that the structure could provide. The folding makes it collapsible, which could be used for doors, windows and other openings. The mould settles the elementary form, which the piece always will strive after. Thereby it becomes possible to use the foldability in an intelligent way. At the study visit at NMC a few of these ideas were discussed with Formens Hus. According to them the folding principle could certainly be applied for needle punch, but it will not be collapsible due to its thickness and stiffness. Therefore, the pieces will only be used as walls and roofs, not with any flexible functions. However, the vast amounts of folding will probably strength the wall structure. The prototype at NMC was significantly stiffer around the joints, between two wall pieces, where they were folded to each other.

The illustration (see Figure 87) shows that an unfolded piece has the same base as height. The angle is 45 degrees. Once it is folded though the projections of these measurements will change a bit. All of them will decrease, creating a shorter but "thicker" piece.

According to Formens Hus the moulding, that is necessary for the folding, would be a too slow production technique. They claim that the price would be about the double, due to the extra time needed. In order to fit this project the production cost cannot be more than 10% of the total price.

There are efficient manufacturing techniques, which do not slow down the production, for creating structures in materials. Rolling technique for instance can press patterns into the material. However, the structure cannot be larger than 1/10 of the material thickness. In other words, the technique cannot be applied in order to improve sound absorbing walls and roofs. (Kanter 2011)

6.6 Light

6.6.1 Sketching

Sufficient light during daytime is favourable to facilitate everyday activities. With thicker and more solid construction materials, less amount of light is penetrating the walls. Consequently openings for light admission, such as ventilation holes, doors, windows or lookouts, could be necessary. Electric lightning is certainly another solution, but it is not common in camps today, and also outside the scope of this project. Another solution is to invent a lamp out of a plastic bottle filled with water and bleach. Placing the bottle at the roof, with half of it outside and half inside, the sunlight reflects through the water into the indoor environment. To learn more about the technique visit www.youtube.com/watch?v=o-Fpsw_yYPg&feature=related

6.6.2 Decisions for further development

Based on discussions with Formens Hus it was decided to not continue working actively with a light solution. Having a bright colour of the roof and using the ventilation and door openings will bring enough daylight into the shelter. Windows are, according to the author, desirable to some extent, but rather as lookouts than light sources. Moreover, windows will increase the price and probably the risk of damage (due to more seams).

6.7 Ventilation and temperature

Ventilation is truly necessary in camps along the equator. The temperature is incredibly troublesome. In Haiti for instance, proper outdoor stores with double roofs could be seen. The lower roof has several large openings at the top. The second roof layer decreases the indoor temperature since the heated air underneath is ventilated immediately. This principle is well known in warm areas.

6.7.1 Sketching

An attempt to design double roofs was made (see Figure 89). In order to make a durable construction, boards (possibly from the package) were used. Two pieces fasten to each other and connected to the frame would be enough to create a double roof. However, that requires the "original roof" to be different from the walls (due to holes at the top), meaning that another component is added. Furthermore, the connection to the pipes requires additional parts and needs to be carefully executed.

Figure 89. A second roof is very beneficial, but harder to construct in this case.

Another solution would be to have large openings at the gables to enable cross ventilation (see Figure 90). The air will enter through the easiest way, meaning the biggest opening. During daytime this could be done by opening the doors, and during nighttime there can be an opening in the upper part of the gable. Included in this concept was also a mechanical solution to adjust the gable opening. The solution functions as a blind; a rope is pulled and a piece is elevated.

Elevated floor could be a solution for ventilation. With gaps in between the floorboards, air will seep in. Naturally, elevated floors can be combined with other ventilation openings.

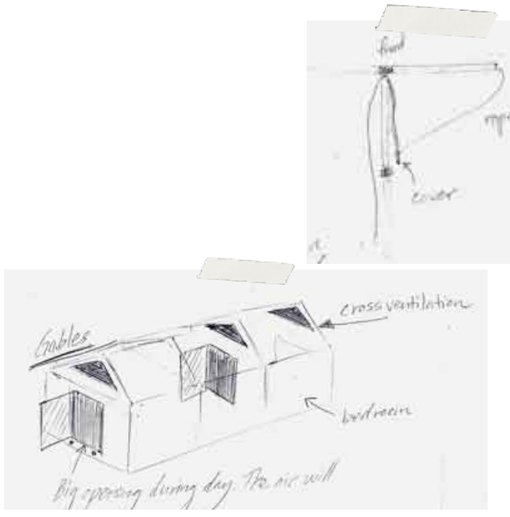


Figure 90. Large gable openings and a blind solution.

Air is, as water, easily seeping in if any gaps are not closed properly. The connection between the wall and roof could therefore be designed in a way so that small openings are provided. The roof could offer overhangs, meaning that rainwater will not enter into the openings underneath.

6.7.2 Decisions for further development

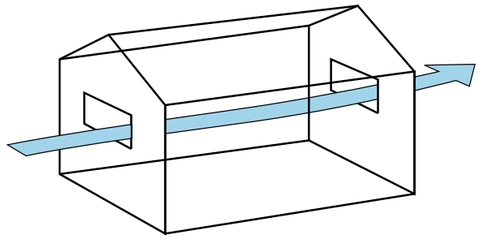
After discussing the topic with Formens Hus it was established that a shelter package cannot be used as a roof solution as well. Due to the risk of damage during transport, the durability cannot be assured. Instead, the idea of ventilation opening at the gables, as well as the blind function, should be investigated further.

At the prototype producer it was concluded that eyelets and knobs could be implemented in the cover. Furthermore, the author was also told that a shade net (instead of having two roofs) could be placed on top of the shelter to reflect sunlight with 50% and create an air gap.

6.7.3 Additional information gathering

There are two main principles for ventilation in emergency shelters (see Figure 91). The first one implicates two large openings facing each other. The technique works fine when the inside temperature is warmer than the outside. Cross-ventilation is generated and the difference in temperature evens out. However, once that is completed, wind is necessary for further ventilation.

The second ventilation solution includes one opening at the bottom of one side and another opening at the top of the opposite side. The lower opening should preferably be the air intake and therefore larger. Air streams commonly take the easiest route. The incoming air from underneath will rise due to heating and exiting through the higher opening. The stream gives, like a fan, a cooling effect for the residents, without contribution from the wind. (Hagentoft 2011)



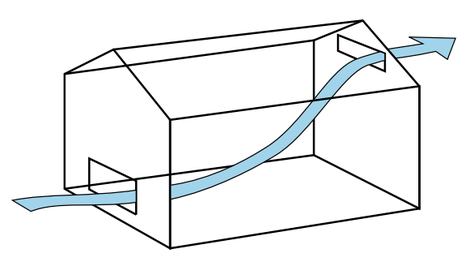


Figure 91. Two principles for ventilation, the second one is most preferred.

To minimise temperature, regardless of ventilation solution, an emitting layer on the inside of the roof is suitable. That would obstruct heat to pass through. Moreover, bright colours on the outside are suitable since the radiation will, to a larger extent, be reflected from the surface. (Hagentoft 2011)

6.7.4 Further development of ventilation opening

Form and functions

Initially the author developed several concepts with an openable part in the middle of the gable. The opening could be placed right above the door, making it accessible to open and close without a blind. The hot air that should be ventilated will however still remain along the ceiling. Therefore it is important to have an opening all the way up.

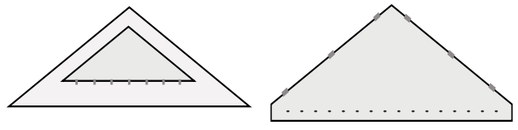


Figure 92. Openable upper gables.

Based on this knowledge, the next concept became to open the whole upper gable (see Figure 92). With fixed attachments along the roof the bottom could have knobs that are attached to the walls and doorcase. Thereby it could be open form underneath and be reachable. Shortly, the author realised that it would not though be possible to elevate the piece unless extra material is added. The length of the horizontal distance should, more or less, be equal to the sum of the two diagonal distances. A few ideas were investigated in order to find a simple expansion. Lacings and flexures were two of them (see Figure 93). The flexures would perhaps though poke out a bit when they are fastened, which increase the risk of damage from wind. The lacings might work theoretically, but would probably be too time consuming and long-winded for the user.

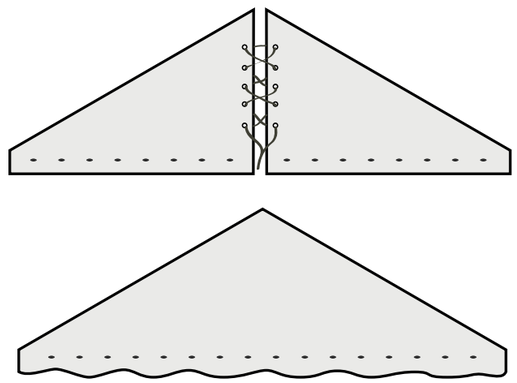


Figure 93. Openable upper gable, expandable.

After folding and cutting a lot of paper models a new solution emerged. One concept had the expanded material folded in the middle and on the inside. When the opening is closed and folded the wind would hopefully not grab the folding. If that turns out to be an issue a seam could be added in the middle, tightening the left and right side together.

The solution could easily be combined with a blind principle. A wire is attached through the eyelets in the middle and then led through one diagonal pipe all the way to a reachable position. Pulling the wire will naturally elevate the piece. See Figure 94.

The ventilation opening is attached with knobs at the bottom. In order to fasten the knobs eyelets are needed along the walls. Consequently four out of 16 pieces of wall, as well as the doorcase, needs to be punched.

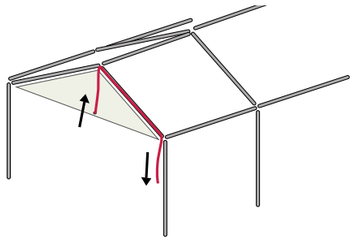


Figure 94. A blind principle is rather easy to implement.

Material and measurements

Needle punch or similar textiles will be necessary for the ventilation opening. In order for the piece to be elevated the material needs to flexible and foldable. Certainly, stiffer materials could be applied as well. However then the piece will not be elevate, but only provide an air gap at the bottom. Furthermore the piece needs to be folded along four lines in the middle. The folds facilitate the gable to open and the smoother the turn-up goes the better. Therefore textiles are preferable.

The folds result in three centre parts (see Figure 95). The middle of these should be as wide as the sum of the other two. Thereby the centre parts are, when the gable is closed, "behind" the actual gable piece and well protected from wind and rain.

At the bottom a flap is added to fasten the piece to the walls and doorcase. The flap is overlapping only a few cm since it should be attached in the doorcase, not the door. Besides, letting it overlap even more would decrease the door high, which should be avoided.

Finally, at the diagonal lines, flaps of eight cm, just like the walls, are added for connections.

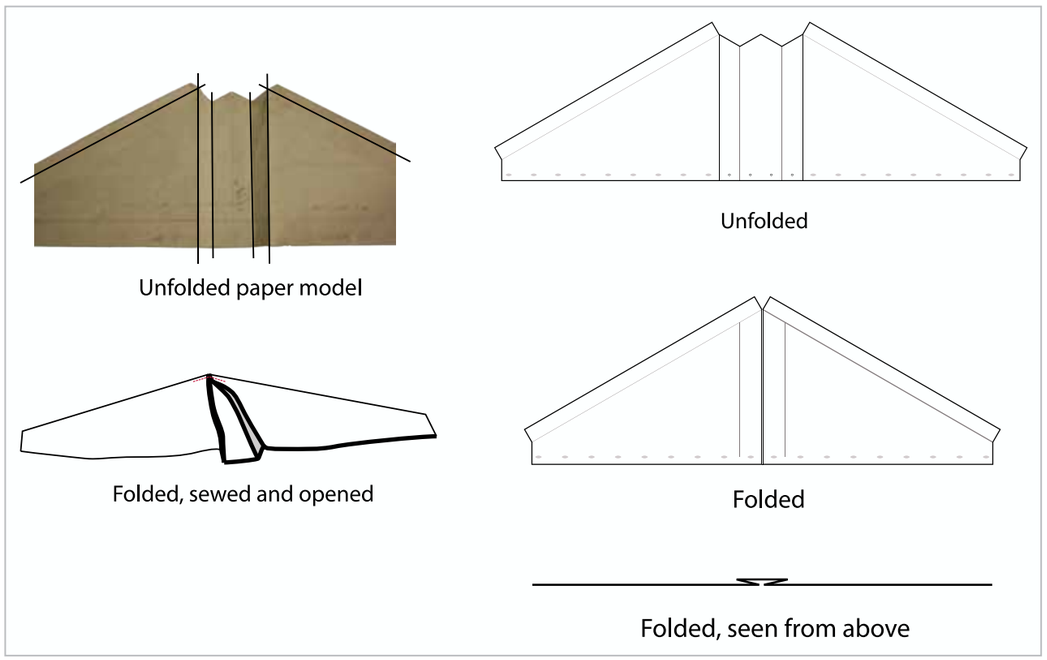


Figure 95. The result of folding models and making mock-ups.

6.8 Security (emotional and physical)

With dense camps, poor shelter durability and many unknown people around, security is important. Six areas were found to increase security, either emotional or physical.

6.8.1 Sketching

The first concept, regarding emotional security, was about having a difference in front and backside appearance of the wall (see Figure 96). The outside of the wall could have a robust appearance and the inside could be softer, fluffy and reassuring. At the moment there is not really any difference between the sides. Due to the fragile material it could be beneficial to make a clear difference between in- and outside. Entering the shelter should imply a feeling of security, homeliness and warmth. The atmosphere and experience should differ significantly from the one outside.

Figure 96. Different indoor and outdoor appearance of the wall.

The second concept about emotional security is to use sandbags and drainage. By doing so, the gap to close footpaths is increased and less people are then passing right outside the walls.

Following ideas were explored to increase physical security. As a consequence it improves the emotional aspects as well.

Thick and tough materials would be truly advantageous to hinder brake-ins. At the time of writing, the materials are easily cut. Another advantage is that it becomes harder for passing people to judge whether someone inhabits the shelter at the moment. Thicker material leads to decreased risk of projections on the walls and less sound leaking through. Without knowing for sure, people might not take the risk of possibly breaking into a populated shelter.

All openings, such as windows, doors and ventilation holes, are possible areas for break-ins or insight. Therefore, the ventilation opening was placed as high as possible, to obstruct people from reaching in.

Lookouts do not need to be large (see Figure 97). In fact it is better with small ones so that the indoor privacy is not lost. Knowing what is happening outside could calm down the residents, since it provides them with information about the surrounding activities in the camp. Depending on the budget, this idea could either be implemented in the walls or in the ventilation opening.

Figure 97. Small lookouts, included in the wall and roof piece.

Just like thick material is hindering passing people to judge whether someone inhabits the shelter, a similar protection is needed for the locks. With a cover or a space to hide the lock, or by using a proper lock with keys and handles, it can obstruct outsiders to quickly judge the inhabitancy of the shelter.

6.8.2 Decisions for further development

Based on the result from the PUGH matrix and discussions with Formens Hus it was concluded to only focus on the emotional security. The solutions are presented in chapter *6.11 Appearance, semantics and cultural appropriateness.* The concepts for physical security are very much related to proper locks, materials and construction. It is therefore a task for Formens Hus.

6.9 Fire safety

6.9.1 Sketching

Camps are usually dense, which has very few advantages. For example, once a fire has broken out it spreads fast. It is therefore essential to facilitate the evacuation of the shelter. The locks used in the shelter should therefore be of a simple kind, so that they can be opened from the inside without using keys. Hooks and deadbolt locks are some examples of appropriate locking mechanisms.

Fire resistant materials could be another solution. Unfortunately, it is expensive. However, fire retardant material is cheaper. It decreases the burning time and facilitates residents to evacuate.

6.9.2 Decisions for further development

After discussions with Formens Hus, examiner and supervisor it was decided to not continue working on fire safety. Once again, the solutions are more or less based on proper materials and practical locks, meaning it is a task for Formens Hus.

6.10 Diseases

6.10.1 Sketching

To minimise the risk of diseases vermin and water should be hindered to enter the shelter. Mosquitoes and flies are difficult to avoid, even with mosquito nets in windows. Instead nets covering the bed during nighttime are more reliable. Other vermin, such as mice and insects, should, as well as water, be stopped from entering. Two different areas were developed (and have been mentioned before).

According to existing standards, a ten cm threshold is sufficient to hinder crawling animals. Sandbags, which are a well-known way to hinder water, could function as the threshold. As long as the edges of a sandbag are sharp or steep, small vermin should not be able to climb them. Moreover, it is extremely important to avoid stagnant water between the sandbags and shelter walls. Stagnant water is a perfect condition for mosquito breeding, but it might also tear the wall piece apart in the long run. Several ideas of how rainwater could be led to the ground were developed. However, which path the water will flow is hard to predict and it is therefore necessary to perform field tests before establishing modifications.

The second idea is to dig drainages around the shelter. As long as this is done collectively and widespread in a camp, the risk of creating breeding sites is not as high.

6.10.2 Decisions for further development

Based on the result from the PUGH matrix and discussions with Formens Hus, examiner and supervisor, it was concluded that both sandbags and drainages were suitable to continue developing. Further work is described in chapter *6.2 Hindering water to enter.*

6.11 Appearance, semantics and cultural appropriateness

6.11.1 Ideas

Identification

The shelter should be identified as a home, even though the perception of a home differs between cultures. However, one common denominator could be a place protected from weather. A home is usually an area indoors, in other words, a separation from the outdoor environment. Therefore the separation should be fairly stable and effective to hinder water, wind, sun etcetera to enter. Flooring would therefore contribute to a feeling of homeliness in many cultures.

Besides being a home, the shelter should be identified as a product from certain organisations. Logos are therefore printed on the canvas. The logos facilitates that refugees, IDP:s, local people, and other involved understand who is operating or sponsoring parts of the camp. The logos are also important for attracting donors. Often photos are taken at site shortly after the shelters have been assembled, with logos clearly exposed in order to show the world how well the organisation is operating.

There is however a risk that residents feel as victims rather than citizens, with numerous and too conspicuous logos on their homes. Therefore several ideas about discreet, yet existing, logos were generated. Placing them at the gable or on a second roof would probably be best, from a production point of view. Although, there might be a risk that the piece is placed inside out, with the logos pointing inwards. The walls, which constitute most of the shelter and most of the production time, are then intact.

Communication

The shelter should communicate movability. As long as it is not cast into the ground, landlords would commonly allow the shelter as they are. To enhance the expression of movability, sandbags could be placed on the mud flaps to hinder uplift and water. Sandbags are considered to be temporary and moveable items, and would therefore fit perfectly.

By providing daylight, ventilation and protection for insight and rain, a cooking area can be communicated. Nevertheless, due to cultural and social habits, the considered cooking area will not necessarily be utilized as intended.

Contact surfaces should be communicated. So far storage, sandbags, mud flaps and drainage are the pieces where the surfaces or functions must be clear.

Regarding the sandbags a few simple ideas for illustrations were generated. The illustrations should be printed on top of the sandbag and describe that it is actually a bag, and not just a surface, that should be filled. Similar illustrations were made to communicate that the mud flaps should be dug into the ground and that a drainage system should be made.

Expression

In order to not interfere with family, community, social and cultural expression, a foreign imported shelter should be simple and familiar. The expression cannot be too daring and innovative. Due to the current metal frame, the shape (which is rather traditional) is fixed. The surfaces, colour, and materials are however left to consider.

Based on interviews with experts, and the field tests in Haiti and Kenya, suitable colours are concluded to be “soft“, natural, discreet and bright. This concerns the indoor environment even more, in order to establish a reassuring atmosphere.

To express confidence and safety all components should have a ”perfect fit”, without gaps, leftover material or straps hanging out. All pieces should have a clear purpose. It is also important that the shelter is not flapping or shaking due to winds. With a solid construction, residents will certainly feel more safe and calm inside.

Besides being stable, it would be beneficial to express stability as well, since it carries confidence. An object with a wider baseline then the top, for instance a triangle, expresses stability (see Figure 98). Adding sandbags or other items at the bottom would thereby enhance the expression of stability. The items could furthermore have a different colour, preferably darker, to look even more heavy.

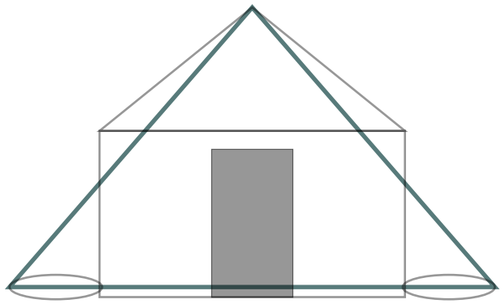


Figure 98. A wider baseline expresses stability.

The expressions of quality and costliness in material, design and construction should be considered. However, there are both advantages and disadvantages with such expressions. People could become more eager to take care of and maintain the shelter pieces. At the same time, the risk of thievery could increase. After evaluating this information, the author decided to enhance the expression of quality rather than cheapness.

Figure 99. A moodboard expressing movability, stability, quality, safety and discreetness.

6.11.2 Decisions for further development

Appearance, semantics and cultural appropriateness were not discussed with Formens Hus as thoroughly as the other problem areas. The ideas within this topic do not really imply any costs. Therefore Formens Hus were open-minded about all ideas and gave the author the freedom to continue working without frames.

6.11.3 Further development

Moodboard

The expression that the author wanted to mediate with the product was visualised in a moodbord (see Figure 99). For a larger image, see Appendix 5. The underlying values for it were mostly picked from the function list.

Movability and *stability* could perhaps been seen as contradictory, but not necessarily. The image at the middle and bottom illustrates the stability and temporary parking. The vehicle is possible to move when it is requested, but in the meantime it stays where it is parked. The stone blocks (made with preciseness) in the picture beside enhance the feeling of stability and heaviness. The expression the images carry is very desirable for a moveable emergency shelter.

Besides stability the stone blocks stand for *natural* and *qualitative materials*. Together with the images of wood boards and metal beam they represent an honest, traditional and strong shelter. Generally speaking people seem to regard natural materials as more qualitative and costly than plastic materials. Stones, metal and wood are known to last long and be applicable for constructions.

Safety and *caring* are the next desired expression. The pictures of stone blocks and the lifting jack carry a tough and robust feeling. In order to amplify a more homely and soft expression the image of a child was added. Just like the security a child experiences in the arms of her mother, the shelter should emit a caring expression.

Finally a *discreet* shelter, *in harmony with nature*, is desirable. Emergency shelters from abroad will always look artificial in the local context. Materials, construction techniques and layout will often be different than local solutions. To minimise that gap soft natural colours can be utilized. Brown, yellow and grey are therefore presented, since these ones would fit many environments well.

Communication

The ideas and descriptions about identification, communication and expression were still intact in this phase and should be added to the final result.

During the later development an idea about redundancy, concerning the floor, emerged (which is mentioned in *6.2.4 Further development of flooring and package*). The package material could certainly be used for several purposes; often the residents know how it is best utilized. In this case, the affected people are not necessarily familiar with the material before. Nor have they all experience in flooring. In many countries people use stamped earth floors, which works fine with solid walls. But emergency shelters are not possible to mould into the ground and therefore water will enter. The attached floor will therefore, even though many are not aware of or can predict it, be an important item to separate people from penetrating water. To emphasize that the package could be utilized as flooring, illustrations will be added to the final result.

7. Final result

A description of the final solutions is given in this chapter. Each solution is declared in detail, but without motivations. To minimise the content and keep the result accessible the motivations for each detail are found in previous chapter. At the end an evaluation and an overview is given to validate and summarise the result.

7.1 Flooring and package

The floor/package consists of three components, one large part and two identical smaller pieces (see Figure 101). The large one, measuring 240 x 182 cm, is folded at four locations to create a box. The box is sealed at the long side by a two cm wide flap that is screwed from the outside.

At the top and the bottom of the box a smaller piece, 42 x 78 cm, is added. The piece is placed within the box and folded twice to enable two flaps, of two cm each, to be screwed into the larger part (see Figure 100).

The material is twin-wall polypropylene with a thickness of eight mm. Due to its consisting layers (see Figure 57) the screws can be fasten properly. However, at the short sides of the smaller pieces the screws must be screwed diagonal to not enter the channels of the large part.

The colour of the floor/package is grey. Grey, black and white are the standard colours for twin-wall and thereby cheapest. Moreover, grey harmonises with the moodboard and does not show dirt and mud as obvious as a white piece would do (see Figure 102).

After several conversations with Eqpack they finally gave a price for the components. Each package would cost about 24 USD (excluding sales tax) for the three components. The price includes UV-resistance of the twin-wall and transportation from the subcontractor in Belgium to Stockholm, Sweden (a distance of about 1500 km). The price also assumes that three full loaded trucks are applied, leading to 4750 sets of packages. The total weight for each package is 7,5 kg, since the area is five square metres and the weight is 1,5 kg/m^2. The volume is in total 0,0402 m^3, which means that three packages fit into a Euro pallet (Figure 103). See Appendix 4 for calculations.

At the inside of the small pieces a sticker is placed with an illustration showing that the package could function as floor as well (see Figure 104). Stickers are inexpensive, costing about ten cents.

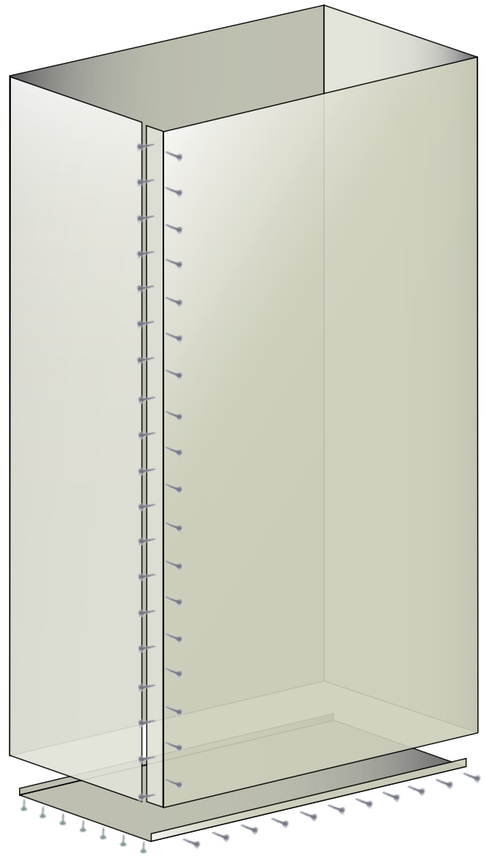


Figure 100. The package is folded to facilitate the connection between the pieces.

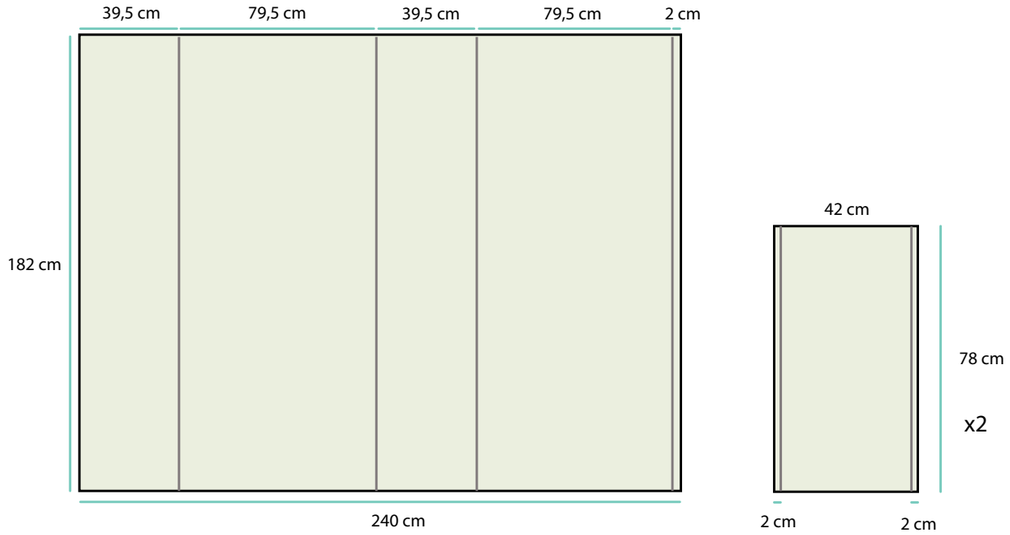


Figure 101. The package consists of three pieces, one large and two small.

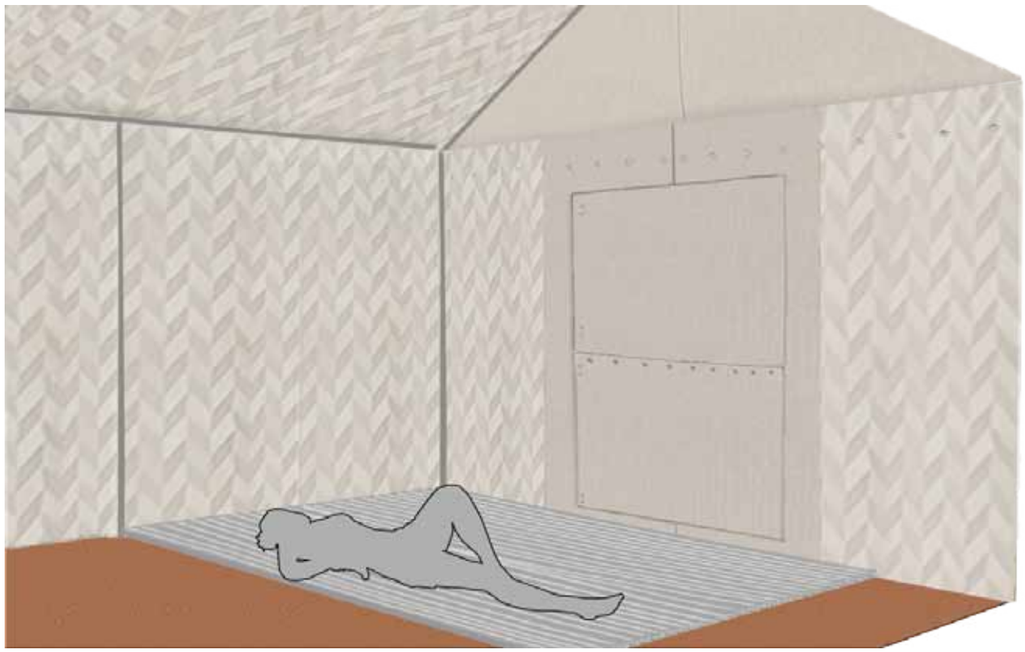


Figure 102. An eight mm thick twin-wall piece is enough to separate residents from a wet ground.

Figure 103. A Euro pallet can contain three packages.

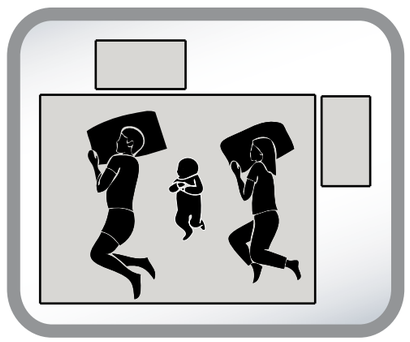


Figure 104. A sticker should be placed on the package to enhance the floor function.

7.2 Sandbags

The actual sandbag consists of a piece measuring 95 x 240 cm. The piece is folded to create a bag and seamed at the short sides. The opening is positioned at the upper side with overlap of 15 cm to hinder sand from falling out (see Figure 106). The overlap could certainly be longer if tests show that sand is still leaking out. To minimise the risk, ropes are firmly sewn to the sandbag and tightened around it.

Two straps, of 83 cm in total, are seamed at the sides. The straps include two eyelets. See Figure 105.

Appropriate material for the sandbag is polypropylene and the thickness is 0,5 mm. The sandbag and straps are folded, meaning that the total thickness is mainly one mm. Altogether ten sandbags are needed for hindering the water (see Figure 108). The author suggests that two extra bag is added, as a spare part or storage (see Figure 109). Each sandbag costs about 0,5–1 USD and the total volume of twelve bags is 0,014 m^3 (see Appendix 4).

Placing the sandbags on top of the mud flaps could imply that rain water get caught in-between the bag and wall. Field tests must reveal if the water seeps out or not. However, in several camps today people drape the walls in mud to strengthen them. By doing so over the sandbags the possible areas for stagnant water vanish.

Illustrations are printed on the upper side of the sandbags. To secure the understanding and minimise complexity the images are made two-dimensional. See Figure 107. Besides encouraging the use of drainage, suitable distance between shelters is also presented.

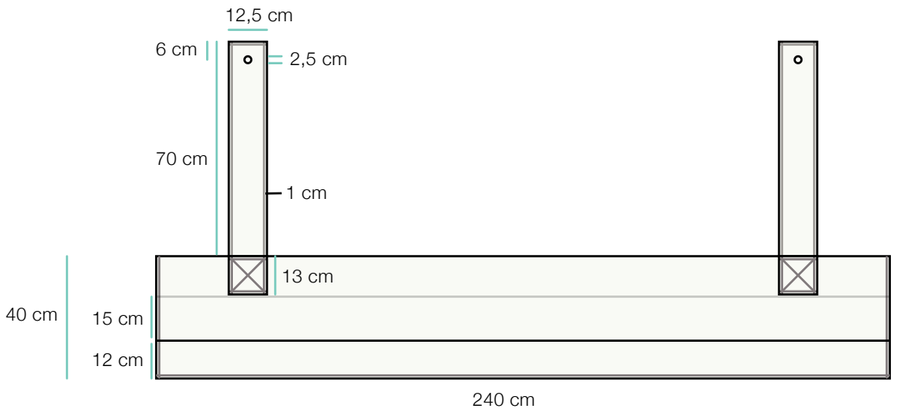


Figure 105. Blueprint of the sandbag.

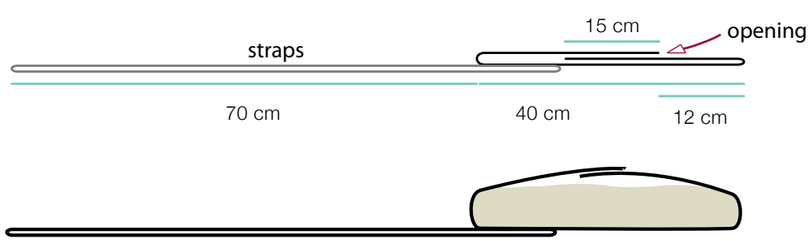


Figure 106. The sandbag viewed from the side.

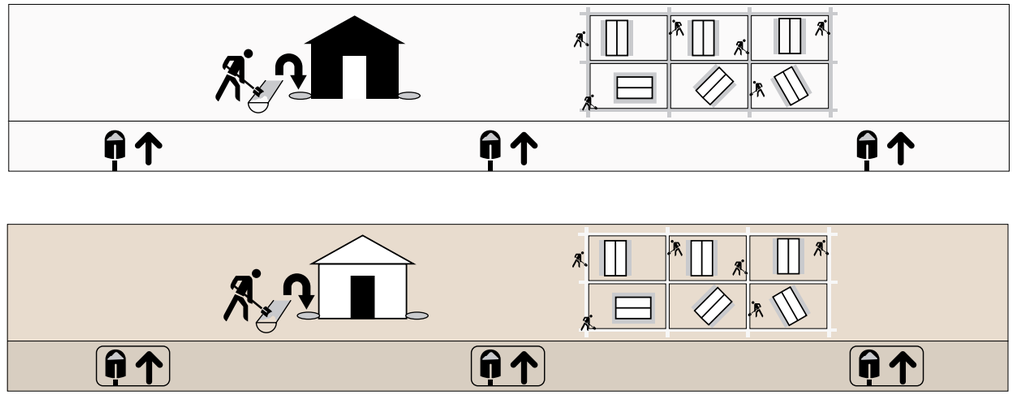


Figure 107. Illustrations printed on the sandbag.

Figure 108. Ten sandbags will be necessary to cover the whole shelter.

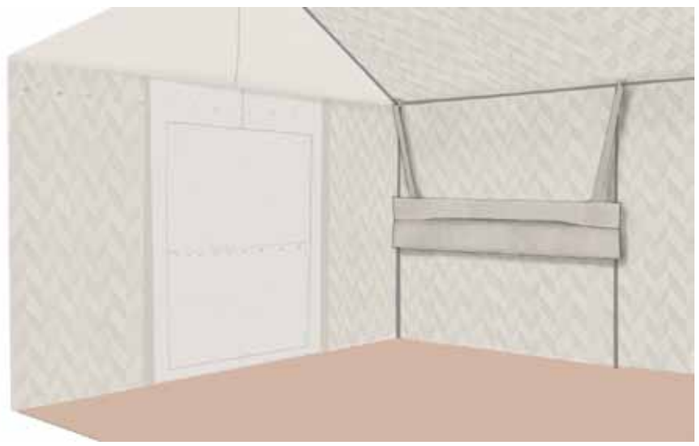


Figure 109. The sandbags can also be used for storage by hanging them to the frame.

7.3 Divided door

A door and doorcase constitute the third solution. The doorcase consists of two identical pieces that are folded in several locations to enable mud flaps and connections to adjacent walls. The measurements are 180 cm high and 68 cm wide, excluded the mud and connecting flaps (see Figure 111). The flap at the top will hang from the crossing wire and would preferably be ten cm high, since that would match the upper part gable. To fasten the upper part gable to the doorcase eyelets are placed along the top.

The actual door is attached to the doorcase with hinges. The door contains of two identical pieces that are overlapping and attached to each other with eyelets and knobs. See Figure 110.

Both the doorcase and door are (except the flaps) made out of vacuum pressed extruded polypropylene. The thickness of them is three mm and the parts have the same colours on both sides.

Having thick walls in the shelter, that do not let through the outdoor light, could be beneficial in a health perspective. With only sufficient light at the door, this area will be the natural cooking spot, where also ventilation is provided. The divided door enables a wind protection, which minimises the flow of smoke. See Figure 112.

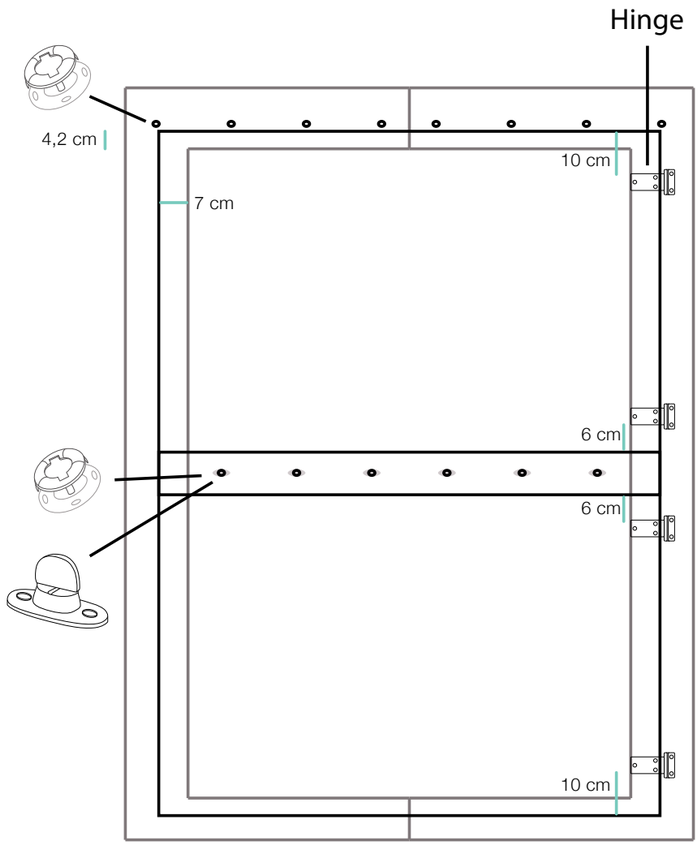


Figure 110. The solution consists of a doorcase, two overlapping doors, eyelets, knobs and hinges.

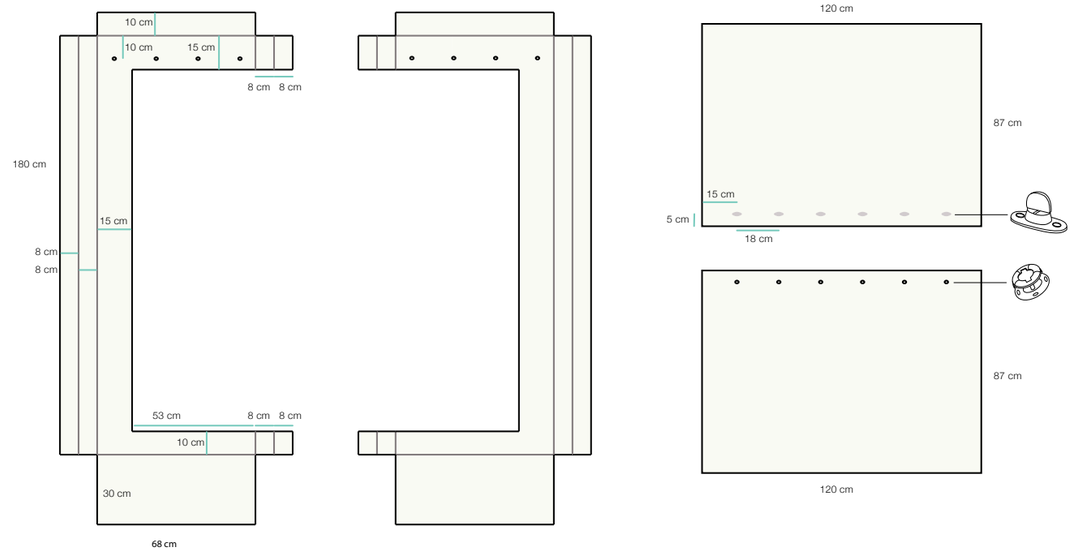


Figure 111. Blueprint of the pieces.

Figure 112. Indoor cooking is commonly made close to the door. The divided door enables ventilation, but also wind protection which minimises the flow of smoke.

7.4 Hooks

A hook out of aluminium, which also functions as a attachment between walls, is the next partial solution (see Figure 113). The attachment is fastened by a screw bolt at the pipes. For each pipe three hooks are placed, meaning 75 hooks per shelter (see Figure 114). The width is 1,5 cm and the thickness varies between two and three mm (see Figure 115).

The geometry makes extrusion to a suitable manufacturing method. Two separated, but identical, profiles are extruded and then attached to each other (see Figure 116). Due to large quantity of hooks (75 x 500000 per year) the tool and assembly cost of the two parts are negligible in the log run. Each hook weight 0,036 kg, has a volume of 0,128 cm^3 (see Appendix 4) and costs less than 0,2 USD (1,175 SEK). For each shelter the hooks weights 2,7 kg, cover 9,6 cm^3 and costs about 13 USD (88 SEK).

Figure 113. The cover attachment functions as a hook.

Figure 114. Three hooks are needed for each pipe. A lot of storage is thereby enabled.

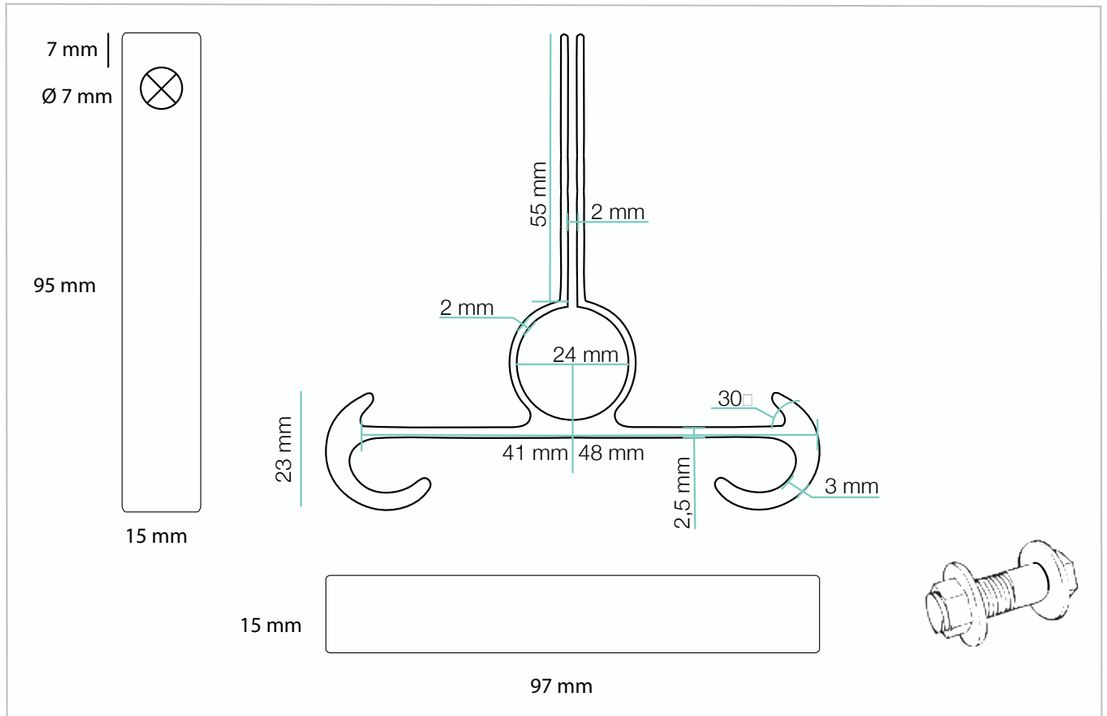


Figure 115. Blueprint of the components.

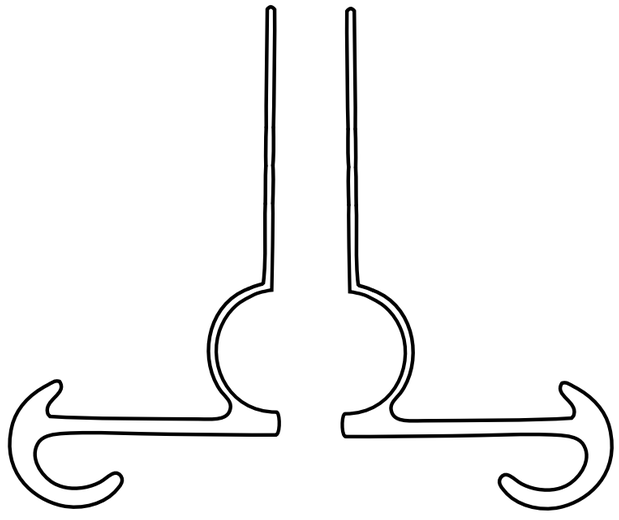


Figure 116. The hook is manufactured by extruding two identical profiles, which are later attached to each other.

The author realised one potential problem with the solution. A roof overhang cannot be applied using the hook (see Figure 117 and Figure 118). At the time of writing Formens Hus has not yet decided if it will be included or not. However, roof overhangs are often recommended. If Formens Hus chooses to proceed with an overhang the hook will most likely be in the way. Therefore a redesign was made. The new hook does not function equally well for storage, but will yet provide some help. To improve the storage use in the roof two holes are included in the hook. Moreover, the flaps are shorter in this design since the hook is not blocking the connections to the walls at all. See Figure 119 and Figure 120.

Each hook weights 0,030 kg, has a volume of 0,112 cm^3 (see Appendix 4) and costs about 0,15 USD (1,028 SEK). For a whole shelter the hooks weights 2,25 kg, covers 8,4 cm^3 and costs about 11 USD (77 SEK). See Figure 121.

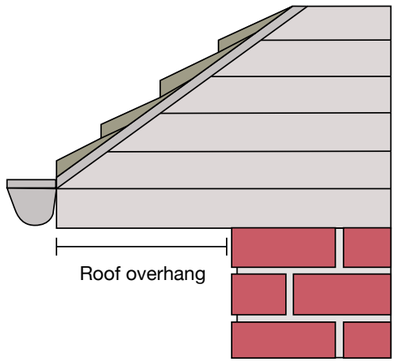


Figure 117. Roof overhangs are common for houses.

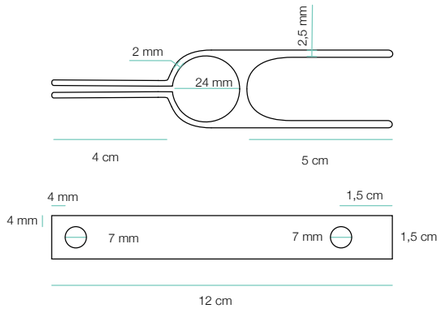


Figure 119. Blueprint of the pieces.

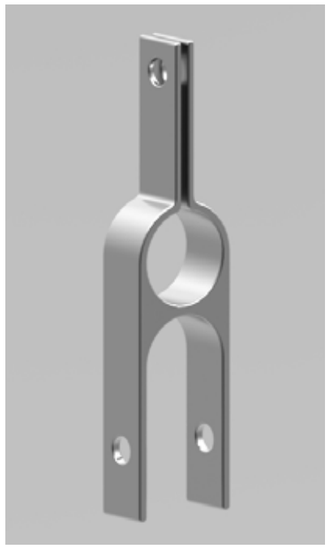


Figure 120. A redesign of the hook.

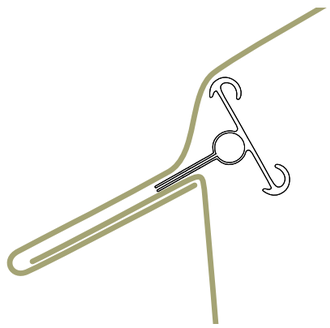


Figure 118. The design of the cover attachment might be in the way to enable a roof overhang.

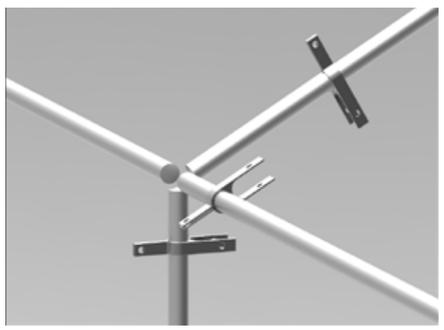


Figure 121. Less material is used in the redesign, making it slightly cheaper.

7.5 Sound absorbing walls

The next partial solution is a folded wall (see Figure 122). Each column is ten cm wide when unfolded and has folding lines of a 45° angle, creating parallelograms. Once it is folded with an angle of 26° the measurements change a bit (see Figure 124). Instead of ten cm, the width of one column becomes nine cm, making the "thickness" of the wall 4,4 cm. The wall thereby "shrinks" and additional material is needed to enable a piece of 92 cm width and 182 cm height. To facilitate the connection between walls the outline regions are plain, making the flaps longer than 8 cm and 15 cm. In total nine columns are folded, which brings the side flaps to be 13,5 cm (5,5+8 cm) and the overall unfolded width (excluding the already existing eight cm flap) to be 99 cm. 18 rows are folded, meaning that the upper flap is 25 cm (10+15 cm) and the total length of the material unfolded (excluding the mud flap and the already existing 15 cm flap) is 200 cm (see Figure 123).

The folded piece would require about 18,5% more material than a plain one, since the folded piece is 1,98 m^2 compare to the plain that is 1,67 m^2.

The wall should be made out of needle punch of four mm and be moulded. According to Formens Hus the production time would be too slow. If the pattern however is desirable it can yet be pressed into the material without reducing the production speed.

Figure 122. The folded wall increases the sound absorption.

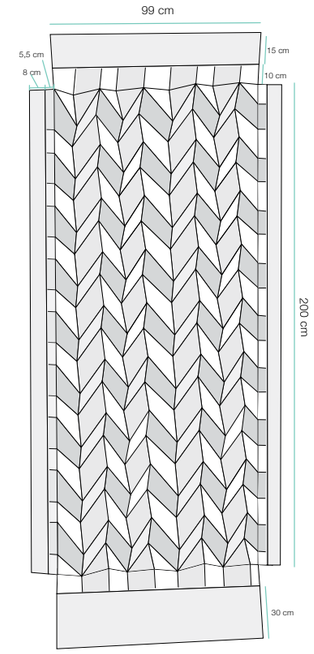


Figure 123. A wall and roof piece.

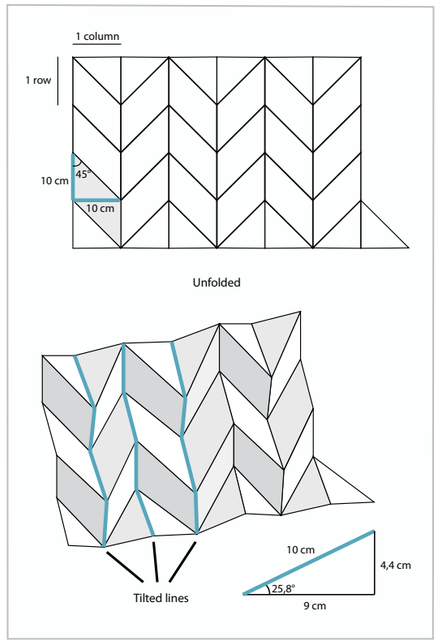


Figure 124. The structure unfolded and folded.

7.6 Ventilation opening

The solution is an expandable gable part (see Figure 126). It is folded along four lines in the middle, placing the centre parts, when the gable is closed, "behind" the actual gable. Needle punch is suggested as the material since it is flexible and foldable. A four-metre wire, costing about 2 USD, is attached to the gable part through the eyelets in the middle. By leading it through a diagonal pipe into the shelter (and fasten it to a hook) a blind function emerges. See Figure 125.

The ventilation opening is attached with knobs at the bottom. In order to fasten the knobs eyelets are needed along the walls. Consequently four out of 16 pieces of wall, as well as the doorcase, needs to be punched. The attachment could establish a small additional roof overhang that hinders water to enter through the slot above the door.

At the top, along the diagonal lines, flaps of eight cm are added for connections. See Figure 127.

Figure 125. A metal wire is attached to the gable piece, led through a pipe and fasten into one of the hooks.

Figure 126. The gable piece is made out of needle punch in order to be foldable.

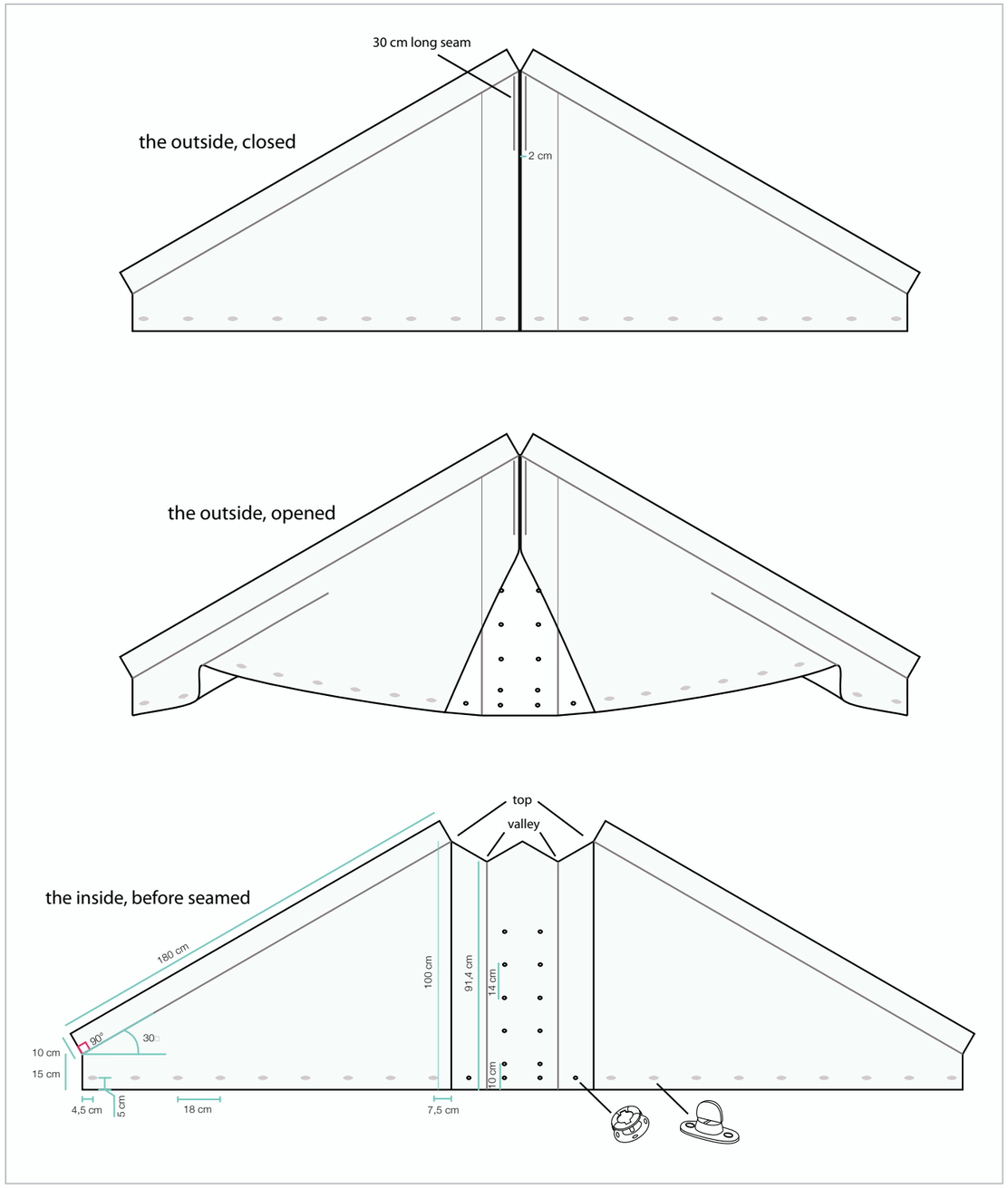


Figure 127. Blueprint of the piece.

7.7 Appearance, semantics and cultural appropriateness

The last partial solution concerns the appearance. The author considered that many shelter designs have a sense of military expression. A camouflaged colour and the replication next to each other, creating structure, does not fit with the desired expression. To minimise the association with military, four colours were chosen, grey, yellow, green and a reddish hue. See Figure 128. The colours bring more identity to each home and match together. Even though if shelter deliveries are mixed up (which is common) the different colour components match well together. Regardless of colour, the interior wall and roof piece is brighter than on the outside.

Moreover, the sandbags are consistently the same dark colour and the logo is only positioned on the gable.

Figure 128. Four discreet and natural colours, fitting well together.

7.8 Evaluation of result

The outcome of this project is more or less based on the demands and wishes from the list of functions. By comparing the list with the actual result it is possible to evaluate how well the solutions fulfilled the needs. It turned out that the solutions meet the identified needs fairly well, with only a few exceptions. However, proper field studies have to be made in order to secure this statement.

Furthermore, there are at least two areas of importance that concern the final result without being included in detail in the list of functions: the cultural appropriateness and the environmental impact.

7.9.1 Fulfillment of demands and wishes

The demand "Tolerate use" is extremely essential for a successful result. However, it is unclear how well the divided door and the ventilation opening achieve the demand. Using hinges, eyelets and knobs might be hazardous solutions since they all are rather fragile for everyday usage and rough weather. Consequently, other solutions for adjustable attachments should preferably be considered as well before prototyping the pieces.

The wish to "Enable storage for belongings" is neither perfectly fulfilled. Among others, bags of food and cooking equipment are common belongings and these items will be hard to store with the help from hooks. Ropes can certainly be fastened into the hooks, creating multiplied solutions for hanging items. But heavy large packages and products will be difficult to elevate from the ground. Thereby, the solution for storage neither manages to meet the desire of "Minimise the risk of attracting animals and insects to staples" or hinder items from penetrating water.

During the project a maximum price target was settled for a floor. According to Formens Hus it could not cost more than 20 USD. The final result enables a floor and a package of 24 USD, without the assembly of the pieces into a package. In other words the budget is surpassed. At the same time, the 24 USD are still an estimate from the retailer and includes the transport from the subcontractor in Belgium to Sweden. Eventually at a closer look, the price can possibly decrease into 20 USD or less.

Finally, the desire to "Enable walls and roof to be much more soundproof than today" is unclear how well it is achieved. The folded wall piece (also applicable for the roof) enables more friction due to more material per square metre. However, without testing the solution it is hard to review if the folding will make a difference or not. As a result the wall should be prototyped with a few variations and evaluated thoroughly before settle its relevance.

7.9.2 Cultural appropriateness

A universal emergency shelter will definitely not correspond with most cultures and local expressions. Yet it is still feasible to minimise the interference with cultural expressions. In common for many permanent houses along the equator are the "natural" colours and building materials (such as earth, wood, stone, concrete etcetera). Consequently, the shelter design ended up being fairly discreet with some variations of colours. The logos are few and can be concealed by elevating the ventilation openings where the logos are placed. As in previous mentioned demands and desires, the wish of designing a cultural appropriate (or neutral) shelter is hard to evaluate. Perhaps the shape or material is more essential for the acceptance than the colours and complexional? Probably the critical elements for acceptance varies from culture to culture, making it hard to generalise how well the shelter appearance in this project minimises the interference with cultural expressions.

7.9.3 Environmental impact

In the list of functions it is stated that the damage of environment should be minimised, for example by avoiding toxic components. But the environmental impact can certainly be minimised in more ways. However, most of the alternatives are related to the material choice and durability, which mainly has been the task for Formens Hus. At the moment the fragile canvas material is commonly braking into small pieces and dispersed into the nature. Hopefully, a four mm thick wall piece of needle punch or extruded polypropylene will last longer and not just vanish into the nature.

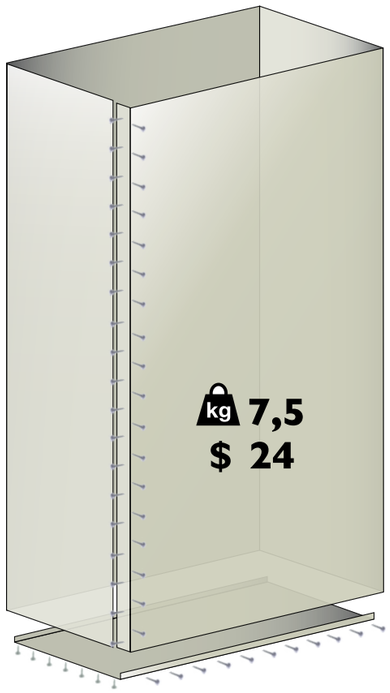
Besides the wall and roof pieces, sandbags are added to the shelter. The thickness of material is thin and the position is exposed to UV radiation, cattle and playing

children. Consequently, there is a great risk that the solution is vulnerable and that material get dispersed into the nature. Therefore additional effort would probably be needed to secure the lifespan of it. Potential improvements could be to enlighten residents to cover the sandbags in mud, placing them indoor or having a thicker material.

7.9 Overview

Here follows an overview of the result with price and weight of a few pieces. The additional pieces (doors, walls and ventilation opening) are fundamental parts to include in a shelter. Consequently, the solutions do not really bring any added costs for Formens Hus.

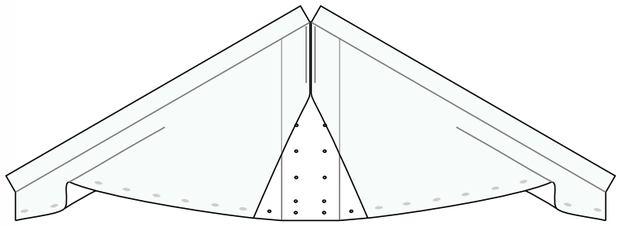
At the time of writing it is unclear how much the cover weighs exactly, due to the unsettled material choice. However, adding the additional pieces will not exceed 65 kg, which is the upper limit. Moreover, the total volume enables three packages to fit into a Euro pallet.

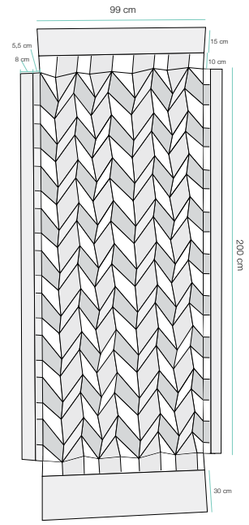


75 pieces

kg 2,7
$ 13

kg 2,25
$ 11





8. Discussion

In this chapter thoughts and insights from the whole project is discussed. For example, the result for each solution includes questions, possible improvements and potential issues. Even though the whole result section implies suggestions for further development, a separate paragraph in the end is presented to give a few concrete recommendations for Formens Hus.

8.1 Mission of the project

The initial scope of this project was to develop a cover for a shelter frame, made by Formens Hus. The major challenge of the task was to make the cover durable and long lasting. Eventually I chose not to focus on a durable cover, but on additional problem areas within the shelter design. The durability is definitely the most critical need for emergency shelters, yet I found several arguments to not work directly with it. The durability of shelters is mostly related to choice of material and construction. As a master student of industrial design engineering I certainly have experience in those fields, but people of other professions, such as mechanical engineers and material experts, are far more suitable for this task. My expertise is rather to identify and understand users and their needs in order to design products that truly fulfil and correspond to users. Since the additional problem areas for emergency shelters had not really, as I found it, been solved or been included in current designs, I considered them to be perfect focus areas for my master thesis. They also enabled far wider perspective of problem solving and creativity than a durable cover design, which is suitable for a thesis project in industrial design engineering.

8.1.1 Effect and object goals

The effect and object goals partly describe the aim of the product as a whole. Durability, lightweight, low volume and efficient production are essential aspects, but still hard to evaluate since the product has not yet been built and tested. Furthermore, the scope of the project was modified, meaning that the overall goals do not perfectly match the new problem areas. Still, a few of the goals, such as low weight, cost and volume, were constantly embraced during the product development and (I believe) achieved as well. Also, designing a universal emergency shelter that is non-permanent and do not interfere with local culture and habits were addressed and perhaps accomplished in the best manners.

8.2 Project plan

A Gantt-schedule was concluded initially to plan for the 20 weeks of work. The second phase of the project (the product development part) was at this time however hard to plan since the outcome and extent of the research phase was completely unknown.

Eventually, it turned out that the research became far more comprehensive than expected and planned. The issue of emergency housing is extremely complex and loads of reports, standards and research should be understood before designing a shelter. As a result, the research phase became prolonged and so did the project as a whole. Besides the complicated background, the fact that I worked by myself, had very high ambitions, applied for scholarships and arranged the field studies, naturally contributed to the extended time frame. Before this master thesis I have never been participating in a product development project only by myself, but in a group of 2-5 students. Consequently, as in most other projects, I let the goal become broad and ambitious, with few limitations. In the end it became hard to cope with, meaning that the project not only became extended, but also had to exclude prototyping, user tests of concepts and a clear focus on the environment.

8.3 Methods

Compared to previous projects, this one did not include a vast number of methods. The greatest challenge was to understand the context, which was made through literature studies and interviews. I did not find any emergency shelters that coped with the identified problem areas, and thereby evaluations and analysis methods of current designs were not implemented. However, the advices given from the consulting firm IDEO about interview techniques for the base of the pyramid turned out to be quite applicable. I became far more aware of my own role as an interviewer and how differently users, depending on my actions, could perceive me.

8.4 Implementation

8.4.1 The scope of the project

The overall scope of this master thesis was to improve the emergency shelters of today. Gradually, I became sceptical to the whole approach of emergency shelters since they have proven to bring few benefits. But in the end I understood that it sometimes is the only option.

To question my original task was perhaps not adequate since it slightly delayed the process. Formens Hus would most likely known better than me about the options of housing after conflicts and disasters. Yet I found it important to truly understand the alternatives and circumstances for the problem. A holistic approach and overview of the situation facilitated the understanding of my own role and which limitations I had to cope with.

8.4.2 Several focus areas

Having several focus areas contributed to the extra time needed. Generally in similar student projects, one product is developed, fairly in detail. But in this case, each problem area did not require a complicated solution and were rather independent of each other. As a result I was quite eager to present a concept for each problem area, meaning several products (or partial solutions). I consider the concepts to be rather well thought-out and realistic, but most of all I believe the strength of my work has been to emphasise the problems and given concrete examples of solutions. Most likely there are smarter or more inexpensive hooks, ventilation openings and sandbags. I would be very glad if someone chose to make improvement and modifications of the partial solutions, and I believe I provided a clear foundation to proceed from.

8.4.3 Supervision

During the project I received supervision, not only from the examiner and tutor, but also from Formens Hus. The comments and advises from Formens Hus were very valuable and made sure that the concepts did not surpass the budget and the scope of the project.

I believe I provided several interesting ideas and sketches, but Formens Hus made me realise the limit budget and the necessity of extremely simple solutions. For instance, using two roofs with a proper air gap would certainly provide better ventilation than gable openings. Yet, the solution requires additional types of components, meaning it would cost too much to produce.

8.4.4 PUGH matrix

A PUGH matrix was carried out to evaluate different concept ideas. A few of them received very high scores since they were evaluated towards the idea of a plain cover by Formens Hus, which does not incorporate the aspects of the problem areas into the design.

The PUGH matrix definitely became a foundation for the decision taking of further development. What must be mentioned thought is that the matrix is quite subjective and does not necessarily tell "the truth" of which concept that must be the best one. It gives the designer an overview and a totalisation of the concept qualities, but does not necessarily include all essential parameters. In the end, the actual concept decisions were made together with Formens Hus, after discussing the advantages and disadvantages of each concept.

8.5 Field studies

8.5.1 Preparations

The realization that the field studies in Haiti and Kenya were actually going to come true took quite some time. I considered, right from the beginning, that studies abroad would be very essential, but the logistics of the studies and the scholarships were uncertain for a long time.

Once the trips were booked, I felt quite confident of the approaching field studies. Spending two months in Kenya and Uganda the year before, in a developing project mainly in urban slum areas, was extremely instructive. On sight, I was rather curious to explore the new locations and interact with people. At the same time, I was quite well-informed and aware of the security situation and followed the advisements given from my contact persons.

8.5.2 Implementation

Since I already had identified the most critical problem areas of emergency shelters I operated structured and a bit reductive in field. If the project had just started

I would have had to throw myself out into the local society and customs more to understand the needs. That would have required more time and perhaps implied security issues, at least in camps of Port-au-Prince.

8.5.3 Coming from abroad

Being a foreign researcher in Haiti and Kenya brings a few drawbacks, especially visiting people who experience the aftermath of a natural disaster or conflict. To gather reliable information, it is favourable if people are behaving naturally, without too much influence of the presence of a foreigner. This is however hard to ensure, since the whole situation is rather odd and unnatural. I believe researchers have to spend quite some time in field before residents start to forget about them and feel comfortable again. In my case, I felt several times that I could have gained more qualitative information if I had accomplished a closer relation to residents. The focus areas were sometimes rather sensitive, and who wants to talk to a stranger about such subject? Consequently, I would have had to stay inside the camps several days in a row in order to understand residents further, which I (due to the security situation) was not keen on doing,

Being unable to speak the same language as the users made the interviews a bit unnatural and jerky sometimes. The common way of discussing topics together with a user became rather difficult and so did the chance of asking attendant questions. Moreover, having an interpreter obstructed the possibility of catch sight of details that perhaps would have been interesting to investigate more. Instead, the interpreter's own view could have influenced the answers I received, without the possibility for me to control it.

To summarise my insights from the field studies, I believe the outcome would have been better if I presented myself more carefully and spent more time together with people to establish a mutual trust. I also realised the advantaged of discussing topics and having interviews together with sociologists, who could provide background and explanations of people's behaviour.

8.6 Result

8.6.1 Introduction

The result includes several partial solutions and I am quite certain that several improvements can be done for each of them. I would have preferred to work together in a group of designers to reach even further with ideas and smart solutions and spend more effort on each solution. Still, I am proud to present fairly realistic and well thought-out concepts for several different problem areas and for numerous varieties of users. The following chapters include some thoughts that should be considered before proceeding with the ideas.

8.6.2 Flooring and package

Heavy rain can cause flooding that is quite severe. Therefore it is important to investigate how well an eight mm thick floor would help. Would the elevation be enough?

The large piece of the package has four folding lines. One of them is positioned only two cm from the edge in order to create a flap that seals the piece. Since the package has not yet been built I am uncertain if the folding is possible or if the width needs to be longer than just two cm.

The smaller pieces also contain flaps of two cm, but only along two of the four edges. The remaining two sides have be screwed diagonal to not enter into one of its channels and lose the grip. Consequently, it is important that the assembly of package can be carried out carefully, with consideration to details such as this one.

The stick with illustrations has not been evaluated in terms of understanding. I consider that a graphic designer should have a look at it (who has a better understanding of its semantics than I). Moreover, the illustrations would still need to be field tested before any conclusions could be drawn.

8.6.3 Sandbags

There is a clear risk about designing a wide sandbag with the opening on top. Due to the load of the sand, the bag could possibly opens up. As a result it might

be better to divide the bag into smaller sections to strengthen the flap that holds the sand.

As for the illustrations on the package, the illustrations on the sandbags should preferably be evaluated and redesigned by a graphic designer. To protect the sandbags from UV radiation they can be covered in mud. It is inexpensive and common today concerning the walls. Possibly, additional illustrations showing resident that mud could be added on top would be suitable to investigate.

8.6.4 Cooking area

Having a divided door might be an unfamiliar solution for residents. I am not sure how people will react or use it. But the same reasoning concerns the sandbags and ventilation openings as well. The solutions I have supplied are not "natural solutions" and therefore a bit alienated. Unfortunately, that is commonly the consequence of using universal emergency shelters. Furthermore, it might as well be harder to secure that the door can be locked properly.

The purpose of the divided door is to minimise and ventilate the smoke from indoor cooking. To understand how the smoke and the flow of air will behave, field tests should be made. It is far too complex to calculate the fluids and predict the result.

8.6.5 Storage

The thickness of the hooks is based on discussions with the manufacturer. I have not made any calculations of abrasion resistance, but I am fairly confident they will last. However, there might be a risk that the hook loses its grip of the steel pipes when load is added. To minimise that risk the hooks should be screwed properly, but still without damaging the canvases.

I see one essential drawback of using a cover connection with current design. In order to attach them, they must be skewered to the steel pipes during the assembly of the frame. Once the pipes are attached to each other it becomes harder to skewer the cover connection. However, the foundation of the design was out my scope and something to adapt to.

In Rwanda a shelter design was once provided, but people ended up selling the valuable components made out of aluminium. Naturally I was a bit uncertain if aluminium was the best choice of material for the hooks. I believe though that the amount of material in my case is small and probably not considered as valuable in the same way.

8.6.6 Ventilation opening

To fasten the ventilation opening to the wall, knobs and eyelets are provided. The fastening is not really a smooth, simple and fast handling, but it works. In the long run there is a risk that people will not use the ventilation opening as intended if it turns out to be too time-consuming. Furthermore, the eyelets in the ventilation opening are rather exposed for damage with an attached wire that residents are pulling.

The ventilation opening is perhaps the solution that requires most additional work. For instance, I believe facilitation of the elevation should be investigated. It could be vital to add folding or wrinkles in order for the piece to be elevated. This has not yet been explored.

8.6.7 Walls

The folded wall was the partial solution I developed and redesigned the least. After exploring a few origami techniques I chose a simple one and stuck to it. As a result there could be a different folding technique that provides more friction per area and thereby better sound absorption.

The structure could increase the sound absorption, but it also might increase the risk of wind damage. With wrinkles along the shelter walls, the wind might grab the canvas easier and in the end wear out the piece.

8.6.8 Appearance, semantics and cultural appropriateness

The significance of the appearance is hard to evaluate, at least without field tests in several locations. I believe though the variation of colours can add a value to residents and minimise the artificial expression. Nevertheless, the most essential role for the shelter appearance today is probably to attract donors. Due to lack of time I have not really investigated what could be an interesting appearance from this point of view.

Besides various colours on the outside I suggested a bright indoor colour to enhance the feeling of entering indoors. The idea of having different expressions on the inside and outside is not based on any proper knowledge or study, but on assumptions. Consequently I cannot estimate if the idea will contribute to a more secure and cosy home. Like most other partial solutions it must be field-tested. I am quite convinced though that this idea will not be seen as vital as the other solutions, even if it does not bring any large additional cost. Consequently, its potential value is only discovered if the final product reaches the actual camps and residents can experience the difference.

8.7 Recommendations

Building prototypes and testing them in a technical perspective is essential. Also having proper user tests in several locations are vital. Besides these phases I would like to give a few comments to Formens Hus of additional aspects I believe could improve the shelter.

The assembly of the shelter must be exceptionally easy to grasp. How the pipes are connected to the joints is perhaps rather obvious. But the position of wires and when to skewer the hooks are easily misunderstood. In the end, the cover must be really simple to attach in a right manner without assistance. Otherwise the durability will not last very long.

Compared to several other emergency shelters the design from Formens Hus has a high ceiling. The upper space should definitely be used in an efficient manner. If a second phase of supplies would be accomplished somehow, bunk-beds would fit rather well.

9. Conclusion

Thanks to an extensive research of the problem situation the author managed to gain adequate knowledge in order to develop a product that fits the complex needs. The product, consisting of several part solutions, enhances water resistance, safe cooking, storage, privacy, ventilation and cultural appropriateness. The author truly hopes that shelter developers take advantage of this report and that the identified needs will gain more attention in upcoming emergency shelter projects. At the time of writing most designs deal with durability, not the remaining user needs. However, they are not exceptionally hard to solve. As long as the needs gain attention and are prioritised, it is possible to develop an emergency shelter that people can live in and regain their strengths, not just a protection from heavy weather.

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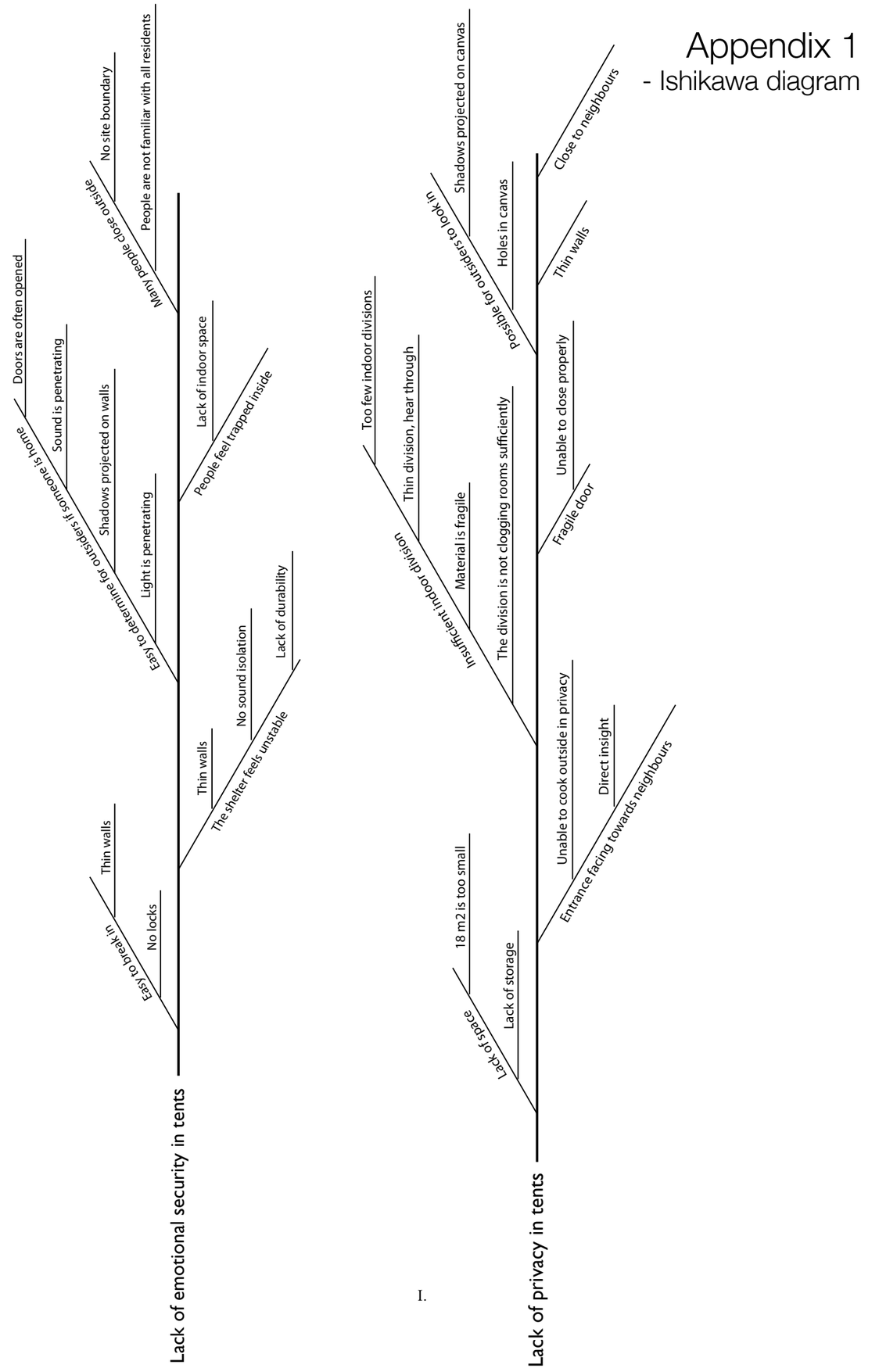
Appendix

Appendix 1
- Ishikawa diagram



Appendix 2
- List of functions & Specification of requirements

Base function: Enable shelter that protects IDPs and refugees from weather.

3 = demand
2 = wish
1 = added value

Durability

Material and construction

3 Last three years.
Notes: The cover should last three years and the frame at least ten years. If one component breaks the rest should not fall apart. Corners, zippers, openings and joints are fragile components at the moment. The material should be durable enough to hinder sticks from poking through the canvas.

3 Protect residents from sun, cold, wind and rain.

3 Be resistant to ultra violet light.
Notes: A wall and a roof facing south break much faster due to ultra violet light. Furthermore, the covering must meet Ultra Violet light resistance standards of plastic sheeting: maximum five per cent loss on original tarpaulin tensile strength under ISO 1421 after 1500 hours UV under ASTM G53/94 (UVB 313 nm peak), to be tested outside and inside reinforcement bands (ICRC standard 2003).

3 Tolerate use.

1 Be durable in a corrosive coastline.

3 Prevent the cover from shrinking if it creates stress.

1 Allow windows and doors (if bearing walls are used) to be positioned at an adequate distance (usually 600 mm) from the building corners.

1 Prevent that scratches could be enlarged.

1 Prevent items from touching the walls.

3 Keep the cover properly fixed to the frame.

Water

3 Allow people to sleep and carry out daily activities without becoming wet.
Notes: The walls, roof and floor should be completely waterproof.

- **3** Avoid rain from lying in puddles on the roof.
  Notes: The roof should have a reasonable slope for rainwater drainage with large overhangs (they provide shading to walls). 30° is preferable for normal tiles and thatch and above 20° for well-lapped corrugated iron sheeting.
- **3** Avoid water to enter from sides and underneath.
  Notes: Mud flaps should be dug properly, be at least 40 cm wide and cope with moisture, rot, sunlight and heavy objects placed on top. Support people to dig drainage ditches to prevent the shelters from flooding. A floor should separate residents from the wet ground.
- **3** Enable doors, windows and openings to be closed properly.

2 Avoid personal belongings to become wet.

1 Minimize condensation.
Notes: An external area for wet clothes to try, ventilation, raised floors, less water splashing back onto the walls and a roof with a reasonable slope are suggestions for solutions today.

3 Be rot proofed.

Wind

1 Minimize heating from hot winds.
Notes: Doors, windows and openings could be positioned away from the direction of the prevailing wind.

1 Minimize dust to enter the shelter.
Notes: Doors, windows and openings should be able to close properly during sand storms.

3 Minimize damage from wind.
Notes: The shelter should manage wind speeds peaking at 75 km/h (21 m/s), or force 8 on the Beaufort Scale (Gale Force). The shelter shall afterwards return to its original shape and position without damage. If possible, avoid the canvas to flap. Moreover, a long thin shelter design, angled away from the prevailing wind, could be advantageous.

2 Minimize uplift.
Notes: The roof should be tied down on the walls.

Construction components

Flooring

3 Enable a floor that separates residents from a wet ground.

2 Enable a floor with ventilation underneath.

2 Enable a floor with insulation from coldness.
Notes: An air gap of just one or two centimetres provides considerable insulation. However, vermin are attracted to these spaces and should be sealed off without obstruct the airflow.

3 Be staple and durable enough to carry excessive deflection and resist sharp objects.

3 Be of a water resistant material.

Living environment

Space and volume

3 Be large enough to suit a family of 5 people.
Notes: The living space should, according to standards, be at least 3.5 m2 per person. More than 60% of the total floor area should have a minimum standing height of 1.8 m.

2 Enable indoor activities more freely than today.
Notes: The living space is too small (for sleeping, eating, washing, dressing and care of children and elderly) and the storage of personal belongings should therefore be addressed.

2 Minimize the feeling of confinement.

1 Facilitate the life of disabled persons.
Notes: The floor space should have an open layout.

2 Enable space for a workshop.

1 Allow space to be used for a store.
Notes: The space could perhaps be used as cooking area as well.

1 Avoid the space to be large enough to fit many families.

Storage

2 Enable storage for belongings.
Notes: Clothes, tools, materials, cooking equipment, food and water are common belongings. It is beneficial to separate these items into different spaces and protect them from water.

Cooking

2 Enable a space for indoor cooking with sufficient ventilation.

- Allow cooking during heat and heavy rain.
- Allow cooking in privacy.
- Minimize the risk of damaging floor.
- Enable storage for kitchen tools.
- Allow cooking with sufficient outdoor light.
- Be placed without hinder any passage and to operate freely.
Notes: The risk of burn injuries from boiling water/food should be taken into consideration.

Light

1 Allow comfortable light for reading.
Notes: Outdoor lighting should penetrate the shelter since a vast amount of residents do not have access to electricity. The light should have enough illuminance and not too coloured hue.

Safety and health

Physical and emotional security

2 Obstruct the possibility for brake-in.
Notes: Fragile walls, few proper locks, ventilation openings

1 Prevent that people outside can judge if someone inhabits the shelter at the moment.
Notes: Shadows can be projected on walls, light and sound penetrates walls, easy to determine if doors are locked, doors are often opened when people are present.

2 Communicate stability and indoor environment.
Notes: Thin and flapping walls, sound penetrates walls, poor quality of roof and walls generate holes.

1 Minimize footpaths close to shelter.
Notes: There are rarely land boundaries that hold back passers.

1 Enable lookouts.

2 Enable to lock shelter.

Ventilation and temperature

2 Allow ventilation openings to be adjusted.

3 Be adapted to hot dry and humid climates.
Notes: Efficient ventilation, high ceilings and withstands +5-+50 degrees Celsius should be included in the shelter design. If 2 layers are used for roof then the distance between them should be at least 100 mm.

3 Enable intense ventilation for hot climate.
Notes: The outlet opening would preferably be positioned higher than the inlet opening and on the leeward side (to enhance the draught effect). Furthermore, to avoid moisture the openings ought to be placed close to the gables. If the air gaps are placed between the wall cladding and the roof it is advisable to let them be 15 cm high.

2 Let the air changes per hour vary between 7 and 14 times.
Notes: The minimum accepted ventilation should be achieved through an unobstructed opening of 0.01 m2.

2 Allow smoke from indoor cooking to be ventilated adequately.

2 Allow temperature to be adjusted.

2 Prevent that people freeze during night.
Notes: A lot of people sleep on the floor due to lack of beds or space. The floor could be vastly cold. Elevating the floor from the ground with just one or two centimetres could be enough to establish a better body temperature.

Fire safety

3 Enable evacuation from shelter within 30 seconds.
Notes: Doors should be easily opened from the inside when locked.

3 Allow to sub-divide the indoor space without hinder the access to doors in case of an emergency.

3 Possess two opposite doors.

3 Withstand a flame from cigarettes and matches without spreading.

Diseases

2 Protect residents from mosquitoes, flies and other disease vectors.
Notes: This function is above all important during nighttime. Besides mosquito net a 10 cm vertical edge is currently used at the entrance to hinder crawling insects.

2 Minimize the risk of attracting animals and insects to staples.
Notes: The food is usually stored in bigger bags. Gaps close to the floor should not be larger than six mm to hinder mice and larger animals.

2 Allow stagnant water to be removed from shelter.
Notes: Today drainages (positioned at least 50 cm from the pegs) are suggested from aid workers, but few residents are applying this solution.

Other

1 Facilitate cleaning of floor.

2 Avoid materials or coatings that could be toxic to humans.
Notes: This function still applies even later on when parts are modified for re-use.

Privacy

2 Enable to sub-divide the indoor space properly.
Notes: The sub-divisions used today are lacking in many ways. They should be durable, better closed, more soundproof, preferably two of them and adaptable in its use. At the same time cross-ventilation should be maintained and the access to doors in case of an emergency should not be hindered.

1 Allow more space for each person.
Notes: 17,5 m2 is too small for a family. Lack of storage also minimises the actual living area.

1 Enable to open the entrance door and other openings without loss of privacy.
Notes: Many residents want to carry out indoor activities, especially cooking, in privacy from neighbours, but at the same time obtain outdoor light and ventilation.

2 Enable walls and roof to be much more soundproof than today.

2 Enable to close doors and other openings properly.
Notes: Openings let the sound pass through.

2 Hinder neighbours from viewing indoor activities through walls and roof.
Notes: Shadows projected on walls should be eliminated. Attrition should be minimized to avoid openings.

Handling and ergonomics

Buildaility

2 Be easy to grasp how to assemble.
Notes: Instructions for assembling (illustrations and descriptions in English, French, Spanish or appropriate language) should be included, either laminated on a sheet or printed on shelter or shelter bag. Two untrained adults should manage to assemble the shelter without expert supervision. (However, most likely there will be more people involved in the assembly.)

1 Be fast to assemble.
Notes: The time should not surpass several hours.

1 Enable assembly without attached tools.

Adaptability

1 Allow residents a reasonable degree of adaptation to better suit their needs.
Notes: Common patterns of behaviour include for example mud brick for sidewalls, an extra threshold at the entrance, additional plastic sheet for roof, suspension device and sub-division of rooms.

1 Allow residents to decorate and furnish feely to suit their needs and taste.

1 Be adapted to old and minority ethnic groups.
Notes: Most people are not used to live in tents. In order to fit old people the floor should not be filled with items, the ceiling should not be in the way for daily activities and the construction should be durable enough to grab or lean against.

2 Allow the size to be adjustable.
Notes: The shelter should preferably be modular based in order to vary in size. The connecting points should be adapted to different types of expansions (either shelter materials or locally available materials). An adjustment should not interfere with the floor.

2 Be adapted to different soils and to slopes.

Reparability

2 Enable the residents to repair, maintain and improve the shelter with local materials.
Notes: Repairs and improvements should be possible with non-specialist skills and equipment. The design should furthermore maximise the number of components and materials that are easy to repair and maintain. Spare components would preferably be included with the shelter.

2 Enable the residents to extend the shelter by using local materials.

Other

3 Be movable.

2 Be easily understood
Notes: The functions should be communicated to facilitate the use.

2 Be efficient to use.
Notes: The functions should be effortless to use.

1 Enable reuse of parts.
Notes: It is beneficial if the parts become like an added value later on, either as a foundation for a permanent home or as construction material in a different context.

Appearance semantics and cultural appropriateness

Identification

2 Be identified as a home.

2 Be identified as a product from certain organizations.

Communication

2 Communicate movability.
Notes: The shelter must not be perceived as permanent.

1 Communicate (if it exists) the purpose of spaces and functions.

2 Communicate contact surfaces.

2 Communicate the function of mud flaps.

1 Communicate the locations for cooking activities.

Expression

1 Mediate family, community, social and cultural expression.
Notes: This is extremely hard to achieve with one shelter since the amount of different expressions are vast. However, it is not impossible to enable a foundation that is, in some sense, adaptable to a few different desirable expressions. Despite that the design mostly will not meet the desirable local expressions it should still not interfere with it.

1 Express confidence and safety.

2 Express quality and costliness in material, design and construction.
Notes: The perception of quality might differ a lot between cultures. However, often natural materials (such as wood, stone, metal and natural fiber) are regarded as more attractive and expensive than polymer materials.

2 Minimize the perception from the tenants of being a victim.
Notes: The colours and logos are examples that could enhance the perception that the shelter is a gift.

1 Express simplicity and timelessness.

Aesthetics

2 Attract donors to invest.
Notes: It is favourable if the shelter design could attract donors without upsetting the residents. As a consequence the appearance should be harmonic and salience at the same time.

3 Avoid military, camouflage and dark colours.
Notes: The colour should be rather discrete, neutral and reassuring, both inside and outside.

3 Avoid colours that absorb heat.

2 Avoid numerous and too conspicuous logos.
Notes: The positions of logos could really influence the living experience.

Production and logistic

Manufacturing

3 Allow rapid scalability and short production time.
Notes: 10000 shelters should be possible to produce per month.

2 Allow a simple construction.
Notes: It is of great value that the construction has as simple design as possible. Besides financial benefits it is favourable since different local manufacturers might produce the product.

3 Minimize the amount of components.

3 Minimize the amount of different components.

1 Enable components to be available globally.

1 Enable appropriate materials, tools and skills for local manufacturing and repair.

2 Minimize the spillage of material.

Transport

3 Be of low volume.
Notes: 0,3-0,5 m3 is suitable.

3 Be lightweight.
Notes: 40-60 kg is preferred.

3 Be of sensible size for transport.
Notes: The shelter should fit a euro pallet of 120 x 80 cm. The height should be less than 2 m.

3 Enable transportation by residents.
Notes: At least two healthy adults should be able to carry the shelter bag a short distances.

3 Fit sea containers.
Notes: 20 ft or 40 ft.

3 Enable loading and unloading by hand.

2 Keep a stock of spare parts.

Storage

3 Be protected from sun, rain and vermin.

3 Be stored dry and ventilated off the ground.

2 Be kept in easily countable piles at least half a meter from walls.

3 Be checked regularly to avoid moisture and rotting.

2 Be stockpiled for five years without degradation.

Packing and labelling

3 Be in one package.

3 Communicate content, assembly, use, maintenance and safe disposal of the shelter for an untrained adult in different cultures with different languages.
Notes: Illustrations/pictograms/pictures and instructions in English, Spanish, French or appropriate language are necessary solutions.

3 Allow the agency name to be exposed on the bag or/and shelter.

3 Allow the manufacturer's name/trademark and location to be displayed on the shelter.

3 Allow batch and delivery number to be displayed on the bag or/and shelter.

3 Communicate particular design, size, thermal performance, amount of people it can accommodate on the shelter and if it is mosquito proofed or not.

3 Communicate the date of manufacture, the length of time in storage, conditions of storage and means of transport on the shelter.

3 Communicate if the shelter already has been deployed.

Recycling

1 Maximize the amount of components and materials that are suitable for later re-use, upgrading, modification or reconstruction on return.

Environment

3 Minimize the damage of surrounding environment (during and after camp).
Notes: The components should neither be toxic to fabricators and residents (even later on when parts are disposed or modified for re-use).

Economy

3 Cost maximum USD 450-500 (the cover).
Notes: The metal frame that Formens Hus has developed costs between USD 100-150.

Appendix 3
- PUGH matrix

Hindering water from underneath

The parameter *Used for the "right" purpose by residents* is not included in the list of functions.

	Scores from the list of functions	**Pipes and boards**	**Boards**	**Carpets**	**Current concept from Formens Hus**
Material price	3	-2	-1	-1	0
Weight	3	-2	-1	0	0
Minimize different components	3	-1	0	0	0
Combined with other functions	3	0	0	0	0
Separate residents from wet ground	3	3	3	1	0
Ventilation underneath	1	2	2	0	0
Isolate from coldness	2	2	2	1	0
Durable	3	2	2	1	0
Water resistant	3	2	2	1	0
Avoid brake-ins	2	0	0	0	0
Used for the "right" purpose by residents	2	1	0	0	0
Possible to repair and upgrade	2	2	1	0	0
Protect from vermin	2	1	1	1	0
Easy to assemble	2	-1	0	0	0
TOTAL SCORE		**18**	**25**	**10**	

Hindering water from sides

The parameter *Minimise that people step on it* is not included in the list of functions.

	Scores from the list of functions	**Sandbags**	**Floor (all over)**	**Invite to dig**	**Force to dig**	**Current concept from Formens Hus**
Material price	3	0	-3	0	-1	0
Weight	3	0	-3	0	-1	0
Minimize different components	3	0	-1	0	-1	0
Combined with other functions	3	1	0	0	0	0
Tolerate use	3	0	2	1	0	0
Separate residents from wet ground	3	2	3	1	1	0
Minimize that people step on it	1	0	2	1	1	0
Communicate the function	2	1	0	1	0	0
Allow cooking space	2	0	0	0	0	0
Minimize stagnant water	2	-1	0	0	0	0
Adapted to different soils and to slopes	2	0	0	0	0	0
Express stability	1	1	0	0	0	0
TOTAL SCORE		**10**	**-4**	**9**	**-5**	

Cooking area

	Scores from the list of functions	**Extend 90 cm**	**Extend 180 cm**	**Combine 90 and 180 cm**	**Extend the side**	**Veranda**	**Current concept from Formens Hus**
Material price	3	-1	-2	-2	-1	-1	0
Weight	3	-1	-2	-2	-1	-1	0
Minimize different components	3	-1	0	-1	-1	0	0
Combined with other functions	3	1	1	1	1	1	0
Privacy outside	2	2	2	3	1	0	0
Socialising with neighbours	1	2	2	1	2	3	0
Minimize exposure to smoke	3	2	2	2	2	2	0
Operate freely around	2	0	0	0	0	1	0
Not damaging floor	2	2	2	2	2	2	0
Enough outdoor light	1	2	2	2	2	2	0
Functions as store	1	2	2	1	2	2	0
Avoid uplift	3	-1	-2	-1	-1	-3	0
Equipment is burglar-proofed	2	-1	-1	-1	-2	-1	0
Enable indoor activities more freely	2	0	0	0	0	0	0
Possible during heat and rain (including wet ground)	2	1	1	1	1	1	0
Minimize fire risk	1	0	1	1	0	1	0
Tolerate use	3	-1	-1	-1	-2	-2	0
TOTAL SCORE		**8**	**3**	**3**	**1**	**2**	

Storage

The parameters *For heavy objects, For light objects, Efficient storage* and *Used for the "right" purpose by residents* are not included in the list of function.

	Scores from the list of functions	**Hanging from ceiling**	**Standing on ground**	**Hanging on side**	**Current concept from Formens Hus**
Material price	3	-1	-2	-1	0
Weight	3	-1	-1	0	0
Minimize different components	3	0	-1	-1	0
Combined with other functions	3	0	1	0	0
For heavy objects	1	0	2	0	0
For light objects	2	2	2	2	0
Used for the "right" purpose by residents	2	0	0	0	0
Tolerate use	3	0	0	0	0
Dry clothes	1	2	0	1	0
Evacuation within 30 seconds	3	0	0	0	0
Avoid objects to become wet	2	2	2	1	0
Be accessible	2	-1	2	1	0
Prevent objects from touching the walls	2	1	2	1	0
Allow intense ventilation	3	2	2	2	0
Allow sub-division	2	0	0	0	0
Easy to assemble	2	0	0	0	0
Efficient storage	3	3	2	1	0
TOTAL SCORE		**19**	**21**	**14**	

Light

	Scores from the list of functions	**Ventilation openings**	**Windows**	**Lookouts**	**Thin material**	**Bottle & bleach**	**Current concept from Formens Hus**
Material price	3	0	0	0	1	-1	0
Weight	3	0	0	0	1	0	0
Minimize different components	3	0	0	0	0	-1	0
Combined with other functions	3	1	1	1	0	0	0
Avoid coloured hue	1	0	0	0	0	0	0
Allow reading	2	2	2	1	1	3	0
Avoid water to enter	3	-1	0	-1	0	-2	0
Minimize damage from wind	3	-1	0	-1	-2	-1	0
Tolerate use	3	0	0	0	0	-1	0
Avoid brake-ins and burglary	2	-1	0	0	-1	0	0
Cover the openings	3	0	0	0	0	0	0
Reach all potential rooms	2	0	0	0	0	0	0
TOTAL SCORE		**-1**	**7**	**-1**	**0**	**-12**	

Ventilation

The parameters *Have a cooling effect for people, Function well without wind, Minimise heating* and *Used for the "right" purpose by residents* are not included in the list of functions.

	Scores from the list of functions	**Gables**	**2nd roof**	**Elevated floor**	**Gap on side**	**Current concept from Formens Hus**
Material price	3	0	-1	-3	0	0
Weight	3	0	-2	-3	0	0
Minimize different components	3	0	-1	-1	0	0
Combined with other functions	3	1	1	1	0	0
Be affective	3	2	2	2	1	0
Ventilate indoor cooking	2	1	2	3	1	0
Prevent people from freezing during night	2	0	-1	2	0	0
Adjust openings	2	0	-1	-1	0	0
Enable lookouts	1	0	0	0	1	0
Minimize damage from wind	3	-1	-2	-1	-1	0
Avoid water to enter	3	-1	-1	2	0	0
Have a cooling effect for people	2	1	1	3	1	0
Function well without wind	2	1	1	3	1	0
Dry clothes	1	2	1	1	0	0
Avoid brake-ins and burglary	2	-1	0	-1	-2	0
Enable subdivision	2	0	0	0	0	0
Keep privacy	1	0	0	0	-2	0
Used for the "right" purpose by residents	3	0	-1	-1	0	0
Minimize heating	3	0	2	0	0	0
TOTAL SCORE		**9**	**-4**	**7**	**1**	

Emotional security

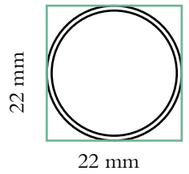
	Scores from the list of functions	**Different sides**	**Minimize footpaths**	**Lookouts**	**Current concept from Formens Hus**
Material price	3	0	-1	0	0
Weight	3	0	0	0	0
Minimize different components	3	0	0	0	0
Combined with other functions	3	0	0	1	0
Hard to judge if residents are inside	1	0	0	-1	0
Communicate stability and indoor environment	2	1	1	0	0
Enable lookouts	1	0	0	2	0
Enable to lock	2	0	0	0	0
Express confidence and safety	1	1	1	0	0
Avoid brake-ins	2	0	0	0	0
TOTAL SCORE		**3**	**0**	**4**	

Appendix 4
- Calculations

Volume of pipes

0,022 x 0,022 = 0,000484 m²
0,000484 x 1,8m x 25 pcs. = **0,02178 m³**

length

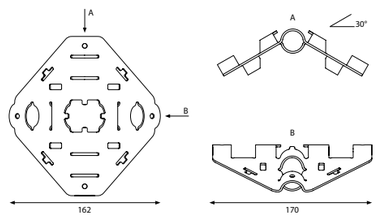


The space around each pipe will be hard to utilize. Therefore, the volume each pipe occupies is more or less 22 x 22 mm.

Volume of joints

0,017 x 0,017 = 0,000289 m²
0,000289 x 0,005m x 20 pcs. = **0,0000289 m³**

thickness

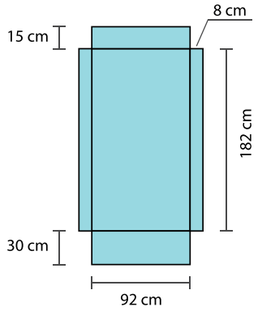


The space around each joint will be hard to utilize properly. Each piece is also bended, which means that additional space will be occupied on top and underneath the nested joints. Therefore it is assumed that each joint occupies more or less 170 x 170 mm.

Volume of cover

Wall and roof pieces

1,08 x 2,29 = 2,4732 m²
2,4732 x 24 pcs. = *59,3568 m²*

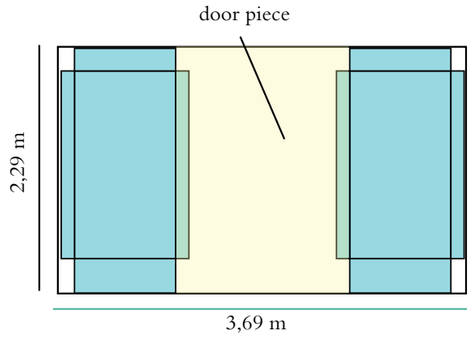


Additional two cm is added to the length in order to compensate for the extra volume needed when folding the piece. In other words, the measurements are 1,08 x 2,29 m².

Gable parts, lower pieces

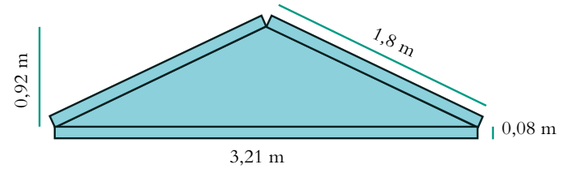
3,21 + 8 + 8 + 8 + 8 + 8 + 8 = 3,69 m
3,69 x 2,29 x 2 sides. = *16,9 m²*

Since each part of the gable (two wall pieces and one door piece) includes two cm extra width, the width is 3,21 m (0,92 + 0,92 + 1,37). Moreover, each part has also two flaps at the sides of eight cm. Therefore, the total width is 3,69 m. To compensate for the extra volume of foldings, the total area is assumed to 3,69 x 2,29 m.



Gable parts, upper pieces

(3,21 x 0,92) / 2 = 1,4766 m²
1,8 x 0,08 x 2 pcs. = 0,288 m²
3,21 x 0,08 = 0,2568 m²
(1,4766 + 0,288 + 0,2568) x 2 sides = *4,0428 m²*



Total cover volume

59,3568 + 16,9 + 4,0428 = 80,3 m²
80,3 x 0,006 = **0,4818 m³**

The material thickness is 4 mm, but the pieces cannot be packed without some additional volume in between. Therefore the thickness is put to 6 mm.

Total volume of shelter (without additional partial solutions)

0,02178 + 0,0000289 + 0,4818 = **0,5036 m³**

Euro pallet

1,2 x 0,8 m = 1,728 m²
For 5 packages => 0,3456 m³/pc.
For 4 packages => 0,432 m³/pc.
For 3 packages => 0,576 m³/pc.

Not more than 3 packages fit a Euro pallet (with current measurements of the pieces).

Available volume for additional partial solutions

0,576 - 0,5036 = **0,0724 m³**

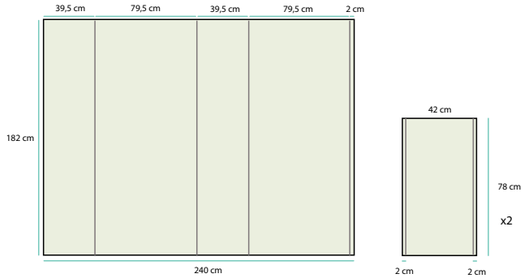
Is it possible to add partial solutions, and still fit three packages per Euro pallet?

Floor, sandbags and storage solutions are the partial solutions that obtain additional volume. Together, these solutions should not occupy more than 0,0724 m^3.

Floor

(2,4 x 1,82) + (2 x (0,42 x 0,78)) = 5,0232 m^2
5,0232 x 0,008 = *0,0402 m^3*

the thickness is 8 mm

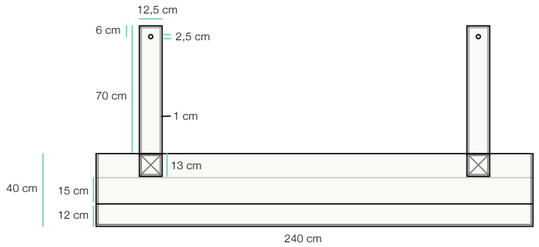


Sandbags

(2,4 x 0,4) + 2 x (0,83 x 0,125) = 1,1675 m^2
1,1675 x 0,001 x 12 pcs. = *0,014 m^3*

12 sandbags

the overall thickness is 1 mm

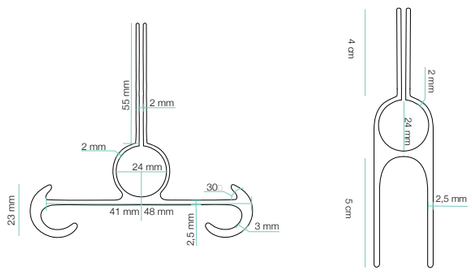


Storage

According to the CAD-software Rhinoceros the two storage solutions have a volume of 0,000128 m^3 and 0,000112 m^3.

0,000128 x 75 pcs. = *0,0096 m^3*

0,000112 x 75 pcs. = *0,0084 m^3*



Total volume of floor, sandbags and storage solutions

0,0402 + 0,014 + 0,0096 = **0,0638 m^3**

The additional three partial solutions still enable three packages per Euro pallet. 0,0086 (0,0724 - 0,0638) m^3 per package is left for additional use.

Appendix 5
- Moodboard