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SAHEL SHELTER

PHASE III: EVALUATION OF TESTED PROTOTYPES AND FINAL DESIGN

1. Introduction

The first basic Tuareg Shelters was developed by IFRC-SRU and distributed by Luxemburg Red Cross (LuxRC) and Burkinabe Red Cross (BRC) in summer 2012.

Since then on-going monitoring, evaluation and specific technical testing were conducted to assess best suitable structural system (stability, rigidity, wind-resistance), thermal performance of different cladding layers and durability of used materials. The issues identified during the consultations with beneficiaries, other implementing actors and local authorities during the Phase I, were addressed in different ways through the testing of 3 different prototypes. Such methodology was adopted in order to identify the best solution for: protection against termites as well as occasional flash-floods, etc.

Three different prototypes were set up to test technical performance as well as practicalities of construction, usability and beneficiary satisfaction. The aim was to optimise the first model and develop a set of separate kits that answer to different needs and can be combined according to the situation and necessities.

Special attention was dedicated to improve thermal comfort, as thermal comfort is one of the principal factors for beneficiary satisfaction which has effect on beneficiary health. For this reason all prototypes were set up with a shade net.

This report presents the evaluation of the different technical test, the users-satisfaction as well as a cost analysis for the composition of the "Sahel Shelter" model.

The proposed "***Sahel Shelter***" is a feasible and fast emergency shelter, adapted to the Sahel context. Its durability corresponds to traditional semi-nomad typologies used in the region, making it suitable also for longer term transitional sheltering.

2. Test methodology

Three different prototypes were designed to test different features and address different issues identified in the previous evaluation (see report on "Conception and testing of Tuareg Shelter model"). Three models of each prototype were installed in Sag Nioniogo's (SNG) refugee camp with the participation of the beneficiaries and the Burkinabe Red Cross volunteers in order to assess practicalities of being set up.

During the three months testing period, quantitative data was collected by keeping daily climatic records using a weather station installed on the site to record the wind speed, rainfall, humidity and temperature. Temperatures inside and outside the prototypes were recorded on an hourly base using log tag[1] thermometers. The stability of the structure was monitored by the Burkina Faso Red Cross Team during the testing time and reported to IFRC-SRU research officer through established formats.

Input and feedback from the beneficiaries were collected through a questionnaire submitted at the beginning and at the end of the testing period as well as through regular consultation by the Burkinabe Red Cross technical focal point.

Final evaluation of the prototypes was conducted by IFRC-SRU Research Officer during October-November 2013. The design of a "final optimized Sahel Shelter model" was completed upon these results.

Table 1: *Table Quantitative data and Qualitative data (interview and observation)*

1.- Quantitative Data			
Topic	**Parameter/Indicator**	**Tools**	**Objective**
1.1-Thermal Comfort	Inner temperature	- Thermometer (LOGTAG) placed at the upper part and at the bottom of each new Prototype.	Comparison of temperature inside the shelter with outside temperature. Comparison of temperature inside the new prototype and the old shelter type
	Outside temperature	- Weather station, continued monitoring.	
2.-Qualitative data (interview and observation)			
2.1-Ease of setup	Time measured Observed difficulty	- Observation during the implementation process.	Comparison of ease of set-up for the different prototypes.
2.2-Stability and Rigidity	Stability and deformation during and after the test time	- Continued documentation during the testing time.	Comparison of stability and rigidity of the different Prototypes
2.3- Usability	Beneficiaries' comprehension of opening systems Perception of cladding material & Shade net.	- Regularly documented observations by local team of BF-RC.	Comparison of the usability of openings in the different Prototypes.

3. Basic Analysis of quantitative data

3.1. General weather data for the test site

[1] Log tag are data recorders: http://www.logtagrecorders.com/

A weather station was installed on the test site to record windspeeds, rainfall and temperature. The data was recorded every day by the local team of BRC. To have more exact data on the temperature one log tag was attached to the weather station to automatically record hourly the outside temperature.

Table 3: *Average weather data recorded during testing period*

Weather station data			
Weather station	Registered data		Average
	MAX 24 km/h MIN 1 km/h	Main wind direction: N/NE	5,3km/h NE direction
	Different precipitations during testing period	Max. 10,2 mm^3 07.08.2013	2,9 mm^3
	MAX 47,5°C MIN 20,5°C		34°C

3.2. Detailed temperature data for the tested shelter prototypes

The three prototypes to be tested have all been designed with a shade net protection for better thermal comfort. To capture exact temperature data, 18 Log tag SRIC-4 were installed in all the 9 shelter prototypes, two log tags in each prototype: one under the roof and one close to the floor.

Table 4: *Average of the minimum and maximum temperature measured inside the Shelter during the testing period, in comparison to the average outside temperatures*

Temperature recorded data for shelter					
Sahel Shelter	**Name**	**Average of interior Max. temperature**	**Average of interior Min. temperature**	**Average of interior temperature**	**Average of exterior temperature**
Prototype 1 Wood structure	A	35,6°C	22,2°C	**29,3°C**	**34°C**
	B	35,7°C	21,3°C		
	C	40,5°C	21,5°C		
Porototype 2 Metalic structure	A	36,6°C	21,2°C		
	B	35,8°C	21,1°C		
	C	37,3°C	21,2°C		
Prototype 3 Rattan Structure	A	37,8°C	21,5°C		
	B	38,5 °C	21°C		
	C	38°C	21,5°C		

The log tags automatically register the temperature every hour during the whole testing period in total registering 1.346 measures for each log tag (in total 12.114 lectures). The log-tag data was recuperated by the IFRC-SRU Research Officer at the end of the testing period and processed for analysis.

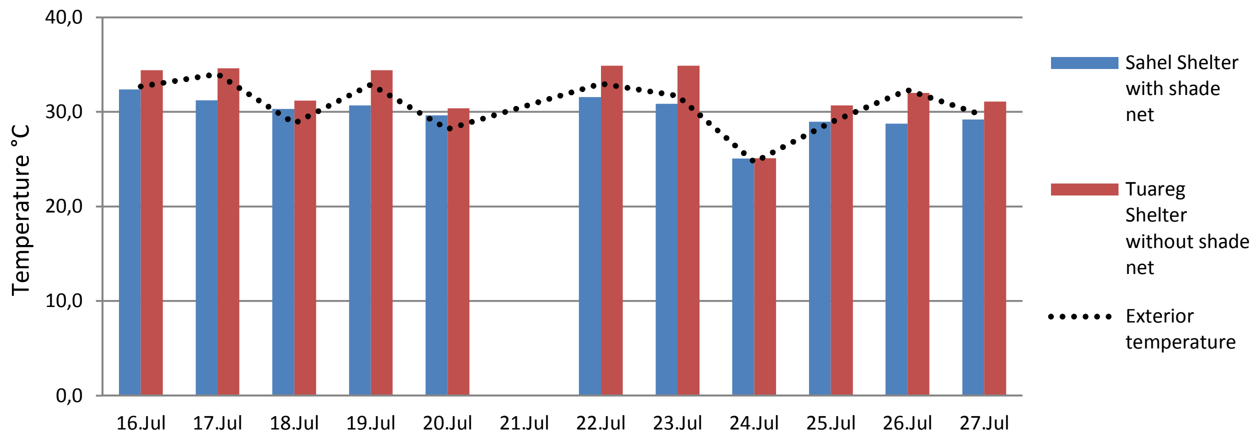
***Table 5**: Basic description of the shelter models designed and tested by IFRC-SRU*

Shelter type	Description
Tuareg Shelter 	First model designed for immediate emergency Rectangular plan with dome roof Structure: eucalyptus wood Side cladding: Secco (vegetal) mats Dome cladding: two standard 4x6m UNHCR tarpaulins
Based on the analysis of the first “Tuareg Shelter” model the following prototypes were designed to address technical weaknesses and concerns expressed by different stakeholders.	
Sahel Shelter prototype 1 	Improvement of first model to achieve longer lifespan and better thermal comfort. Rectangular plan with dome roof, optimized structure **A** Structure: eucalyptus wood with termite’s protection system. Cladding: Secco (vegetal) and plastic mats A Dome cladding: One piece of 4x10m tarpaulin from UNHCR roll Shade net structure **A** flood protection **A**
Sahel Shelter prototype 2 	Rectangular plan with dome roof Structure: metal poles and wooden dome structure optimized structure **B** Cladding: Secco (vegetal)and plastic mats **B** Dome cladding: One piece of 4x10m tarpaulin from UNHCR roll Shade net structure **B** flood protection **B**
Sahel Shelter prototype 3 	Rectangular plan with dome roof Structure: reed frames Cladding: Secco (vegetal) and plastic mats **B** Dome cladding: One piece of 4x10m tarpaulin from UNHCR roll Shade net **A+B** flood protection **B**

All prototypes for the Sahel Shelter were designed with shade net, in order to collect scientific data on the influence of this element on the thermal comfort. Different structures to support the shade net were tested for their structural stability.

All Shelters were installed in basically the same exposure situation (SNG camp), the reason for these differences clearly lie in the Shelter features not in outside conditions like a shaded or particularly breezy site.

***Table 6**: Temperature data recorded from 16.07 to 27.07.2013in Sahel Shelter Prototypes with shade net and old Tuareg Shelter model without shade net*

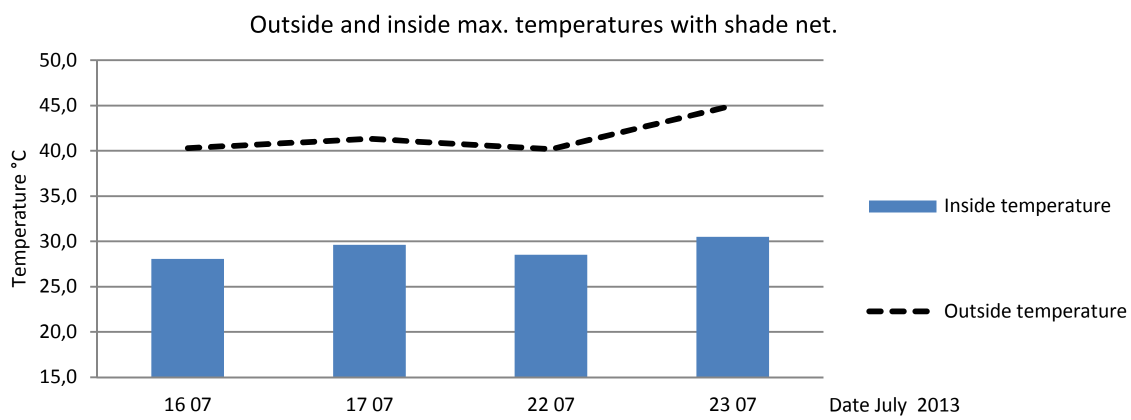


The recorded data in table 6 clearly shows that the inside temperature "Tuareg Shelter" (without shade net) regularly exceed the external temperature by between app. 5 to 8°C! On average the temperature recorded during daytime in the Tuareg Shelter is 6 °C higher than the average outside temperature.

In the 10 days presented in the table the temperature average inside the "Sahel Shelter" (with shade net) stays up to 7°C lower than the outside temperature average. In overall average the maximum temperatures inside Sahel Shelter during the testing period is some 5°C lower than the average of the outside temperatures.

The following graph shows the interior temperature "Sahel shelter" with shade net in relation to the outside temperature on the four hottest days on September 2013. Inside the shelter with shade net the temperature is 10 to 12°C lower than outside!

***Table 7**: Outside and inside temperatures during the four hottest days in July 2013*



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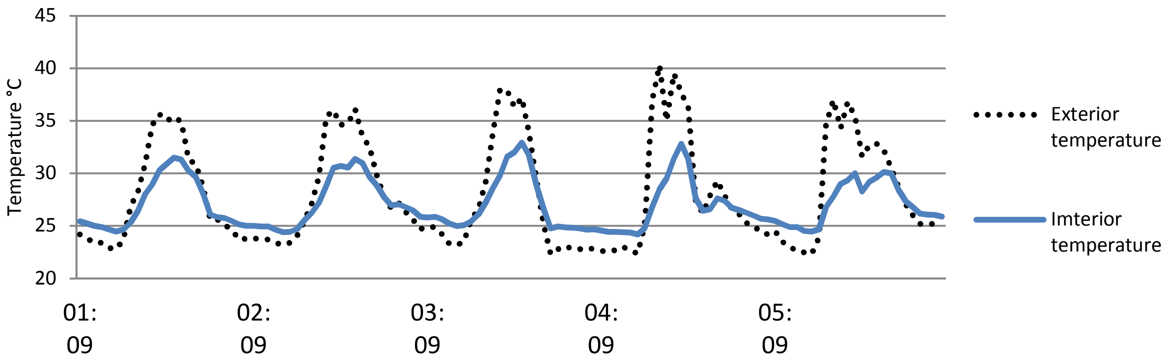

Table 8: *Average temperature data recorded in the prototypes from 01.09 to 05.09*

The graph in table 8 confirms the positive effect of the shade net on the inner temperature, with a reduction of temperature between 5°C to 10 °C.

4. Basic Analysis of observations and beneficiaries' feedback (qualitative data)

4.1. Setup

The first three prototypes were built under direct supervision of the IFRC-SRU Research officer. Two additional models of each prototype were built by the beneficiaries with support from the BRC team.

Table 9: *Setup time and observed difficulties from the BRC team*

Setup time			
Sahel shelter	**Prototype 1**	**Prototype 2**	**Prototype 3**
Average of set up time	**5 hours**	**4 hours**	**3 hours**

*All the prototypes were built by a team of 5 persons (3 volunteers of BRC and 2 Tuareg).

Observed difficulties

Although there is an hour's difference in the average set-up time of the prototypes 1 and 2, the reasons cannot be clearly attributed to technical features of the shelters.

The main difficulty - for all types - was the excavation of the holes to anchor the poles because of the very hard lateritic soil. The stitching of the secco mats for the inner roof cover takes up to 2 hours, but can be performed in parallel to the setting up of the structure. Installing the termite protection (for prototype 1 and 3) took another hour.

The Prototype 3 proved difficulties to assemble mainly due to lack of experience of the set up teams with this new structural system of reed frames instead of wooden poles. Furthermore some of the frames were skewed and deformed, which made assembly more difficult. Nevertheless the set up time was shortest, because of the reduction of work-time for the connections.

4.2. Stability and Rigidity

All the Sahel Shelter prototypes are self supporting structures independent of cladding or guy-ropes and pegs for stabilty. Pegs are only used to fix the final cladding layer, the tarpaulin to the ground. In terms of maintenance as well as for space consumption this is a high added value.

The prototypes were tested for stability of the structural system in itself (whether the structure resists the different forces applied during the testing, without collapsing) and the rigidity of the structure (whether the structural system remains in shape or the forces cause temporary deformation). Table 10 summarizes the observations recorded for the different prototypes.

***Table 10**: Observations on rigidity and stability of the structure*

Stability of the structures		
Sahel shelter	**Rigidity/stability at the setup day**	**Deformation after testing period**
Prototype 1 Wooden poles and dome structure	Good stability and rigidity of the self-supporting shelter structure.	The shelter structure doesn't show deformations.
Prototype 2 Metal poles, wooden dome structure	Good stability and high rigidity of the self-supporting structure.	The shelter structure doesn't show deformations.
Prototype 3 Structure made of braced reed-frames	Good stability as self-supporting structure. Low rigidity due to flexibility of materials.	Some deformation of the shape on the roof panels.
Shade net Wooden poles stabilized with diagonal bracing (model A) or guy ropes and pegs (model B)	The rigidity and stability of the structural system depends on the tension of the ropes supported by the pegs or the rigidity of the bracing.	Displacement of pegs and loss of tension in the guy-ropes. Some shade net structures of both models (bracing, ropes & pegs or combinations) collapsed during testing period.

The structural systems of both prototype 1 and 2 did not show deformation or displacement of elements. Both structural systems allow for easy replacement of elements in case of damage. Interestingly the structure of the Prototype 2 with metal poles and wooden dome structure was more appreciated by the set-up team and the beneficiaries, than the wood poles or the reed-frames.

The reed-frame structure was less appreciated because it is less rigid and therefore gives a less durable impression.

The Shade net structure is the only structure of the tested ones, that depends fully on the guy-rope, pegs and bracings for stabilty. In consequence the rigidity was also compromised. This structure needs continuous mantainance and control to assure stability. The use of guy ropes requires more space, which is a compromising factor in environments with spatial limitation.

4.3. Usability

During the testing period the field team regularly recorded observations regarding the use of the shelters and the different features. Furthermore the beneficiaries' feedback was collected in several sessions during the testing period. The below table presents a summary of the collected qualitative data.

***Table 11**: Observations on usability*

Usability			
Shelter	**Opening system**	**Cladding material**	**Shade net/exterior space**
Tested prototypes (P1;P2,P3)	Beneficiaries show good comprehension and utilization of the various opening possibilities for cross ventilation, which the concept of flexible cladding layers allows for.	- High acceptance of the used cladding materials which correspond closely to the beneficiaries traditions. - Particular appreciation of the colorful plastic mats for the inner cladding. - The different possibilities of adjusting the outer tarpaulin layer are not well understood or used.	-the large shaded space outside the shelter is barely used. -The beneficiaries did not maintain the shade net structure (like re-tensioning the guy ropes or stabilizing the bracing) during the testing period.

5. Evaluation of the prototypes

5.1. Analysis

The issues presented in the following table were identified during the first phase of the development process for an upgraded Sahel Shelter model. Consultation were held with local authorities, the key shelter actors and the beneficiaries (for more detailed information see first report on "Conception and testing of Tuareg Shelter model").

***Table 12**: Evaluation of how the solutions tested in the different Prototypes answer to the key issues to be addressed that were identified in the evaluation of the first Tuareg Shelter model*

<table>
<tr><th colspan="4">Evaluation of Prototypes regarding key issues to be addressed</th></tr>
<tr><th>Identified issues</th><th>Prototype 1</th><th>Prototype 2</th><th>Prototype 3</th></tr>
<tr><td>Foundation System
(too weak)</td><td colspan="3">For all types the proposed foundation system performed well:
- No observed displacements or deformations
> Suitable number of supports
> Adequate depth of the excavations</td></tr>
<tr><td>Wooden Structure
(concerns about Environmental Impact through large scale cutting of wood for the shelter structures)</td><td>- No signs of overload (cracks, deformation) observed in the structure.
> The reduction in the number and diameter of the structural elements (55% less wood than for the Tuareg Shelter) does not affect the stability of the structure.</td><td>- No signs of overload (cracks, deformation) observed in the dome structure.
> The reduction in the number and diameter of the pieces for the dome structure (66% less wood than for the Tuareg Shelter), does not affect the stability of the dome.</td><td>The structure of this prototype does not use any wood but is completely made of reed which is assembled to frames with diagonal bracing for stability.</td></tr>
<tr><td>Termites</td><td>- No termite attacks on the wood structure.
- Other flying insects have attacked the upper part of some wooden poles and secco mats.</td><td>- No termite attacks on the wooden dome structure.
- Other flying insects have attacked the secco mats.</td><td>- No termite attacks on the reed frames.
- Other flying insects have attacked the secco mats.</td></tr>
<tr><td>Structure Stability Fixing Systems</td><td colspan="2">-The connection-knots with nylon ropes are more rigid than with the cloth-straps used in traditional structures.
- The knots remain strong after the testing time with no deformations or degradation of the nylon ropes.
> The structures remain stable.</td><td>- Difficult to join the reed frames due to deformation of some frames.
- More rope needed to join the frames than expected.</td></tr>
<tr><td>Cladding
Better protection from wind and dust, privacy, waterproofness.
Avoid piercing of the tarpaulin by the wood structure</td><td colspan="3">The concept of cladding was the same for all prototypes only varying in dimensions and way of fixing.
-The two layers, plastic mats and the secco mats provide better protection of wind and dust as well as more privacy and comfort, than the single layer of secco used in the Tuareg Shelter model.
- The full covering of the dome with secco provides a protection layer between the wooden structure and the tarpaulin and prevents piercing or fraying of the tarpaulin outer covering.
- The outer layer of a 4x10m tarpaulin has moved on some shelters (between 15 and 20 cm to either side) due to displacement of the anchoring pegs and resulting loss of tension in the fixing system. In those cases there was penetration of rain through the “ridge” sides of the shelters</td></tr>
<tr><td>Thermal comfort</td><td colspan="3">- All protoypes with shade net clearly provided better thermal comfort than</td></tr>
</table>

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of the shelter and UV Protection of the tarpaulin	without. - The tarpaulins on the prototypes with shade net show less deterioration than those directly exposed to sunlight. - The tested shade net structures are not satisfactory. The excavations for the poles are not deep enough (because of the hard soil) to provide sufficient anchorage and displacements of pegs and poles resulted in collapse of some structures.		
Drainage As site preparation is impossible due to hard soil	The flood proofing with an inner line of "sandbags" performed well during the raining season.	The flood proofing with an outer line of "sandbags" performed well during the raining season. Deterioration of outside bags due to the UV exposition.	The flood proofing with an inner line of "sandbags" performed well during the raining season.

5.2. Evaluation summary

- The structural systems of prototypes 1 and 2 provide better performance according to the evaluated criteria.
- The fixing methods with nylon ropes for the prototypes 1 and 2 provided a good solution without problems.
- The structure of the Prototype 2 with the metal poles and the wooden dome structure was most appreciated by the team and the beneficiaries.
  → Although the metal structure is more costly, the cost balances out as the termite protection is not needed for the metal poles and the guaranteed durability is higher. Therefore this structural system is selected for the final model.

- The prototype 3 with reed structure, mainly has disadvantages during the setup process because of the unfamiliar structural system. Furthermore production of larger quantities in reliable quality poses problems on the suppliers side (women cooperatives of basekt weavers produced the reed frames for the prototypes).
- The fixing method for the prototype 3 required an experienced team and closer control for obtaining a good result. Several panels were deformed or displaced.
  →This solution althoug interesting will not be further explored for this context.

- No termite attacks were registered on the wooden structures.
  →However, a more durable shelter solution will need to explore protection of the wood and secco mats from flying insects infestation.

- The cladding layer system provided excellent results on all the prototypes for the two inner layers. The tarpaulin layer has shifted due to insufficient anchoring and did not provide full waterproofing during heavy rains.
  → It will be necessary improve the fixing system for the tarpaulin layer.

- The shade net has proved it's value as UV- protection for the tarpaulin and for reduction of the temperatures inside the shelter.

- The two different alternatives of anchoring systems for the shade net structure, have not performed well. The excavations for the poles could not be made deep enough in the hard soil. Also the performance of the pegs was reduced due to the soil conditions.
  →It will be necessary to design an improved structural system for the shade net of the final Sahel shelter.

- The flood protection system with sand bags has performed well and will be used for the final Sahel Shelter.

6. Sahel shelter, final conception

The aim of design is to provide a specific shelter solution for the Sahel context while maintaining the basic characteristics of rectangular shape with pillars and dome which is widely appreciated by the beneficiaries.

The solution needs to be easy to implement even with only basic skills. The Tuareg know well the context and traditional techniques but their knowledge of more sophisticated techniques is very limited and would require delivery of complementary training.

The solutions should be based on the obtained information after the testing period and use as much as possible local materials in order to support the local economy and keep the cost low.

6.1. Structure

The proposed dimension for the Sahel Shelter is 6m x 3.35m with a total surface area of 20,10m^2 (Sphere Standard foresees 17.5 m2 for 5 people).

The final solution takes up the structural system of prototype 2 with an important reduction of structural elements to only 12 main poles. For these poles metal tubes were used instead of wooden poles, whereas the dome structure was kept unchanged with wooden elements. The main idea behind using metal poles was to avoid the possibility of termite infestation, improve the resistance of the structure and reduce the building time.

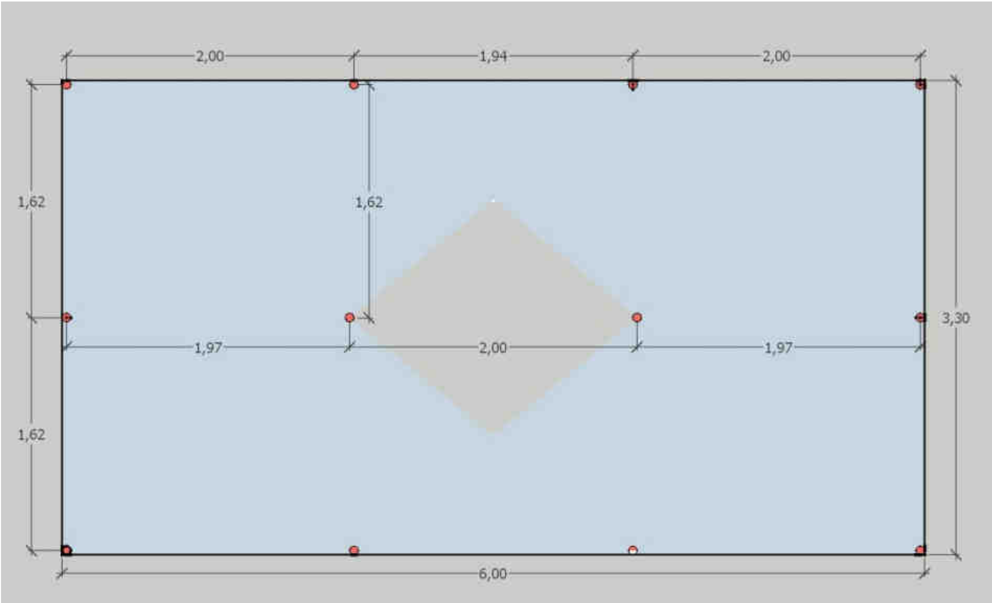
The height of the central pillars is set to 2m and the height of the perimeter to 1.10m. These measures decreases the exposed surfaces of the structure, increases stability, namely wind resistance, and further reduces wood quantity while still offering 66% of the inside shelter space over 1,80m of height.

All of these structural modifications do not affect the shape of the actual shelter prototypes and the general proportions of the original model remain similar. However the new dimensions allow for standardisation and simplification of the construction process through reduction of materials for structure as well as for cladding material.

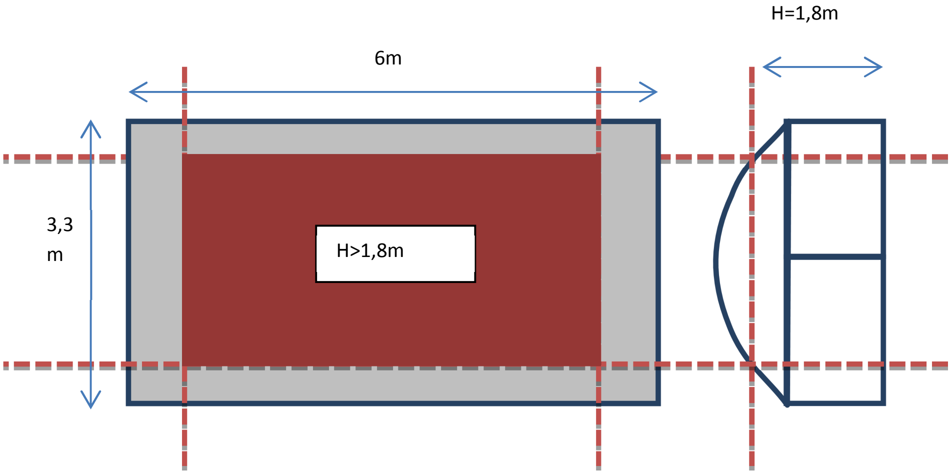
Foundation Plan and Stakeout

The rationalisation and standardisation of the dimensions of the Sahel *Shelter* also facilitates the stakeout process. The reduction of pillars consequently also means a reduced number of excavations. Furthermore, with the measures undertaken to stabilise the structure and make it more self-supporting, the depth of the new excavation can be reduced from 30cm to 25cm for each pillar.

Stakeout plan for Sahel Shelter



66% of the inside shelter space over 1,80m of height



Dome Structure

The conception of the “Sahel Shelter” includes the dome concept as it is an important principle in the Tuareg traditional shelter. The geometry of the dome is improved trough arcs attached in a rectangular perimeter over the poles heads. With this layout, using diagonals and triangulations, the resistance of the entire system is improved and the rationalisation of used material represents another substantial reduction of wood.

Bracing

The reduction of different structural elements required additional measures to ensure stability of the structure. In this sense triangular bracing was introduced in the perimeter - as well as in the dome structure. The used material is ϕ 40mm eucalyptus wood fixed with 3mm rope, in the four vertical corners, as well as in the intermediate part of the dome.

Dome structure and vertical bracing

Stabilisation bars

To allow more flexibility and decrease the number of excavation for anchor-points stabilisation bars were added to the bottom part of the structure. The material used is the same as for the bracing, 40mm eucalyptus wood rods fixed with 3mm rope, along the longer part of the shelter from the door opening to the outer corners. These bars also serve to attach and tension the tarpaulin and the shade net, making them independent of ground anchors.

Stabilisation bars

Structural Joints

Two different materials for the structural joints are proposed: 3mm nylon rope to join the wooden elements and metal wire for the connections of wooden and metal elements.

This fixing system with secure and stable knots needs preparation and monitoring for staff and beneficiaries.

Structural joints

6.2. Cladding System

Vertical Cladding - First Layer

For the walls two layers are used. The first interior layer consists of plastic mats of 1.20m x 2.05m as found in the local market. They are attached directly to the "lintel-beam" with a continuous sewing line. On the short sides of the shelter the mats are also sewn to the vertically to the corner poles. On the longer side the mats are not fixed vertically, so that they can be rolled up to allow ventilation.

First Layer, plastic mats

Vertical Cladding - Second Layer

The second layer of the vertical cladding is fixed with the same logic, flexible on the long side of the shelter and fixed on the short side. For these layer vegetal "secco" mats of 1, 90 x 2,10m from the local market are fixed with the same sewing technique.

Vertical Cladding – Secco mats

Dome Cladding - Inner Layer

The inner layer that covers the wooden dome structure is made of secco mats and has to be pre-confectioned before setup. The mats are sewn together to a full cover of the dome. This cladding element is prepared with 12 (3x4) pieces of vegetal mats of 1, 90mx2,10m. Finally the cover is fixed over the dome as one piece, serving to protect the second layer, the plastic sheet, from the wooden structure, while at the same time providing insulation and a comfortable interior ambience highly appreciated by the beneficiaries.

Dome Cladding - Inner Layer

Dome Cladding - Outer Layer

This layer is reduced to one 4m x 10m tarpaulin from a roll. At the two long sides a 2" PP tube is sewn to the sheet on app. 8m and a 4mm nylon rope passed through the tubes. This rope is used to pull down and tension the plastic layer and fix it directly to the shelter structure at the 4 corners. With this simple solution one intact cover is provided for the shelter, avoiding difficulties of joining two tarpaulins and the anchoring with the pegs in the hard soil. Furthermore the plastic sheet is pulled down over the short ends and anchored to the lower part of the structure at four points. This provides extra protection against lateral rains and winds during the rainy season.

Dome Cladding - Outer Layer

6.3. Lifespan and Protection Systems

Shade Net

Based on the learning from the analysis of the prototype shade net structures, the new shade net structure is attached to the main shelter structure. Four 2m rods are fixed to the shelters poles at the sides of the door openings and four 1m rods at the corner poles. To provide the support for spanning the shade net over the entire shelter the vertical rods are connected horizontally over the shorter span of the shelter with 3.3m rods

The shade net is fixed to the shelter structure on four points.
As confirmed through the previous testing of prototypes, the shade net improves the thermal comfort inside the shelter and protects the plastic sheet layer from UV exposure preventing fast deterioration.

Shade Net and structure

Flood Protection

The proposed solution is a barrier with sand bags positioned around the perimeter of the shelter. The bags are made from 90kg (50x90cm) plastic sacks available on the local market. They are cut in half in and sewn by hand to form tubes of 25cm x90cm and filled with sand from the site. A very simple, and cost effective solution that works well.

Flood Protection

6.4. Logistics and Economics

The objective of the Sahel Shelter design was clearly to upgrade the existing Tuareg shelter solution, providing longer life-span, better stability and comfort of the shelters.

Consequently such modifications have a direct repercussion on the unit cost of the shelters.

The concept of the proposed Sahel Shelter offers the possibility to be distributed in a combination of different kits as complete solution, or in combinations of kits according to the specific needs and situations. The proposed kits provide the flexibility to adapt the composition of each kit separately to the locally available materials. Furthermore, this kit conception facilitates distribution in logical phases of the building process and seasonal requirements (rain proofing, flood-protection, shading).

The following table presents the cost of the separate kits and the complete shelter, using the best value for money prices from local suppliers in Ouagadougou, Burkina Faso (as of Oct. 2013). The termite protection kit although proven successful in the prototypes is not included in this final model as the metal poles of the structure do not need this protection.

The kits included in the Sahel Shelter are the "structure kit" two cladding kits, one for the basic enclosure and an additional for rain-protection furthermore the "shading kit" and the "flood protection kit". Finally, a kit with basic tools necessary for the setting up of the shelter. This tool kit can of course be used for several shelters. One tool kit per 10 shelters has proven sufficient for this setting and the required set-up speed.

***Table 13**: Sahel Shelter Kit prices*

Sahel Shelter Prices					
Kit Structure (Wood + Metal)					
Material	**Dimension**	**Unit/ shelter**	**Unit price (CFA)**	**CFA**	
Eucalyptus (Ø4.0cm, L 4M)	Unit	23	625	14.375	
Rope Nylon (Ø4.0mm)	m	100	30	3.000	
Post with "U"(D= 50 L>1,35m)	Unit	10	3.000	30.000	
Post with "U"(D= 50 L>2,25m)	Unit	2	3.750	7.500	
				54.875	**82,52 €**
Kit Flood prevention					
Material	**Dimension**	**Unit/ shelter**	**Unit price (CFA)**	**CFA**	
Plastic sacks (30x40x90cm)	unit	12	400	4.800	
Thread &sewing needle	kit	2	600	1.200	
Sand (m3)	m3	0,85	0	0	
				6.000	**9,02 €**
Kit Cladding (closure, privacy, protection, comfort)					
Material	**Dimension**	**Unit/ shelter**	**Unit price (CFA)**	**CFA**	
Secco mats (1,90x2,05)	Unit	20	2.250	45.000	
Plastic mats (1,2x2,20)	Unit	10	2.500	25.000	
Rope Nylon (Ø1.0mm)	m	100	30	3.000	
				73.000	**109,77 €**
Kit Cladding rain protection (tarpaulin)					
Material	**Dimension**	**Unit/ shelter**	**Unit price (CFA)**	**CFA**	
Tarpaulin (4x10m)	m2	40	1.659	66.370	
Rope Nylon (Ø4.0mm)	m	30	30	900	
Wood tensors(20x70x10mm)	Unit	8	250	2.000	
PP tube 2"	m	12	333	3.996	
				73.266	**110,17 €**
Kit Shade Net					
Material	**Dimension**	**Unit/ shelter**	**Unit price (CFA)**	**CFA**	
Shade net(4x9=36sqm)	m2	36	551	19.836	
Rope Nylon (Ø4.0mm)	m	45	30	1.350	
Eucalyptus (Ø4.0cm, L 4M)	Unit	8	625	5.000	
				26.186	**39,38 €**
Kit basic Tools					
Material	**Dimension**	**Unit/ shelter**	**Unit price (CFA)**	**CFA**	
Hammer	unit	1	3.000	3.000	
Crow bar	Unit	1	6.500	6.500	
Machete	Unit	1	1.300	1.300	
Shovel	unit	1	1.725	1.725	
				12.525	**18,83 €**
				Total price	**369,70 €**

Note: - The shade net price is calculated included the shipping and taxes!

- *The price of the tarpaulin is calculated as proportion of a full roll of 4x80m (UNHCR standard)*

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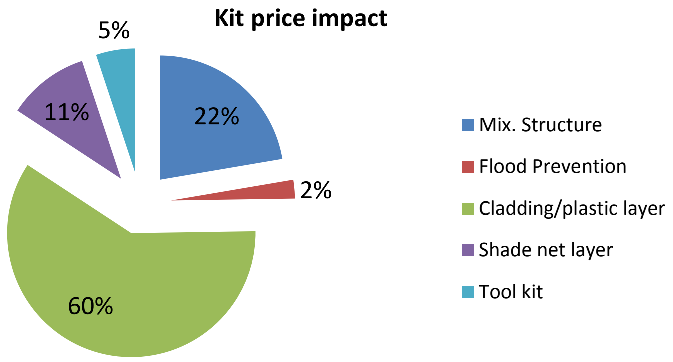
***Table 14**: Price repercussions of the different kits of the Sahel shelter model*

Sahel Shelter (FULL)	
Metal/wood Structure	82,52 €
Flood Prevention	9,02 €
Cladding/plastic layer	219,95 €
Shade net layer	39,38 €
Tool kit	18,83 €
Total price in Euro	370 €
Total price in USD (1€=1,35USD)	499 USD



The total price of the Sahel shelter including a full tool kit is 499 USD

The Cladding system with the plastic layer represents 60% of the total price. For emergency distributions either the plastic mats or the secco layer can be economized without compromising the general features of the shelter. For longer lifespan, better protection against the elements and better thermal comfort, both layers are recommended.

The shade net kit is only the 10% of the total price

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