Emergency Shelter for Humanitarian Relief in Cold Climates:
P o l i c y a n d P r a x i s

UNHCR Winterised Tent failing in Djakova, W. Kosovo, December 1999/Source: Schellenberg

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Policy and Praxis

Summary

This dissertation looks at the provision of shelter for displaced people in cold-climates. The particular focus is on a design project, the brief of which was to produce an appropriate shelter system that would be available to humanitarian agencies, government departments and supra-national organisations involved in the relief of human suffering resulting from conflict.

The problem I address in this study is the following:

There is currently no explicit, coherent or comprehensive policies that address emergency shelter assistance in cold-climate humanitarian emergencies. Furthermore, there is little evidence that current available shelter systems and methods of implementation provide adequate environments for displaced people in such conditions.

Therefore, my hypothesis is as follows:

Under specific circumstances, cold-climate emergency shelter systems can become an effective and appropriate response to the temporary shelter needs of forced migrants in cold-climates.

The aims of this dissertation are threefold;

1. To take forward the design of a prototype cold-climate shelter system for forced migrants.
2. To increase the understanding of the use and performance of shelter in cold-climates through the development of a generic research and testing methodology for cold-climate shelter for forced migrants.
3. To define specification criteria to assist specialists and procurement departments in NGOs in the deployment of appropriate tents and supporting equipment.

In order to support my hypothesis, descriptions are given of the following:

- *The context* of contemporary thinking on physical planning for, and the provision of shelter in temporary settlements for forced migrants in all climates.
- The definition of an appropriate *design brief* for a cold-climate emergency shelter system.
- A *methodology* for prototype development, which focuses on the materials used, the construction and 'buildability' of shelter prototypes.
- A *testing procedure* for a prototype shelter system.
- A critical analysis of the results from the prototype tests. The success of the design project is reviewed with particular reference to the environmental conditions within the shelter and the performance of the insulation materials used.
- The dissertation concludes with a comparison of the performance of the prototype shelter with that of the current standard aid tent. Finally, future areas for research are identified.

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Glossary of Terms and Definitions

UNHCR – The United Nations High Commissioner for Refugees.

RedR - Registered Engineers for Disaster Relief.

Host Nation – Nations that host displaced people.

Aid Community - Those organisations involved in humanitarian assistance

Physical planning - The process of providing suitable living environments for displaced persons.

Cold Climate - 'Climates where cold weather with rain and snow prevails over extended periods (3 to 5 months)'[1].

Displaced Population (DP). Throughout this dissertation, this term is used to refer to both international refugees and to internally displaced persons. Reference to the terms 'Refugee' or 'IDP' will only be made where there is need for increased specificity. In the context of this dissertation, it is considered that the problems of both groups, if not the responses to them, are essentially the same[2].

IDP. People who, as a result of armed conflict, internal strife, systematic violations of human rights, natural or human-made disasters, or development projects have been forced to flee their homes but remain within the territory of their own country are considered internally displaced persons. Increasingly, international institutions and organisations are called upon to protect and assist internally displaced persons; however, much less institutionalised support is available[3].

Convention Refugee. Within the meaning of the *1951 UN Convention relating to the Status of Refugees*, are people whom governments have determined that "owing to a well-founded fear of being persecuted for reasons of race, religion, nationality, membership of a particular social group or political opinion, are outside the country of [their] nationality and [are] unable or, owing to such fear, [are] unwilling to avail [themselves] of the protection of that country, or who, not having a nationality and being outside the country of their former habitual residence, [are] unwilling to return to it"[4].

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[1] UNHCR Handbook for Emergencies (1999). pp 145.
[2] Chalinder, A. (1998) pp 13.
[3] First International Emergency Settlement Conference. (1996). pp 2
[4] First International Emergency Settlement Conference. (1996). pp 2

List of Illustrations

Chapter 2

Figure 1 Sources of Relief – The Major Players in the Aid Community
Figure 2 Sectors of Operation within the Aid Community for Emergencies resulting from Conflict
Figure 3 Temporary Settlement Options For Forced Migrants
Figure 4 The Remains of Liboi Transit Camp, Eastern Kenya
Figure 5 The Phases of Operation for STSs

Chapter 3

Figure 6 'Warm Room' Project in Prilep, Western Kosovo
Figure 7 The Standard Winterised UNHCR Centre Pole Tent
Figure 8 Family outside their tent in Prilep, W. Kosovo
Figure 9 Centre pole tents in Chegrane Camp, fYRO Macedonia
Figure 10 UNHCR Tent failure in Djakova district, Western Kosovo, December 1999
Figure 11 UNHCR Winterised Tent with Capped Flue Pipe
Figures 12&13 The UNHCR Standard Heater
Figure 14 Military tents used in Elbasen Refugee Camps, Albania
Figure 15 Blace Camp in Eastern Slavonia, Croatia 1994

Chapter 4

Figures 16&17 The OXFAM Hot Climate Shelter System
Figure 18 Nominal Insulation Component Selection Criteria
Figure 19 Testing Procedure for an Emergency Shelter System
Figure 20 Indoor Climate Measurement Apparatus
Figure 21 Sensor types and numbers
Figure 22 Condensation Testing Apparatus

Chapter 5

Figure 23 Criteria Affecting Shelter Provision
Figure 24 Average daily air temperature and average monthly wind speeds for Highland Kosovo
Figures 25 Inside the UNHCR Tent during Winter in Kosovo
Figure 26 Shelter in Kibeho Camp, Rwanda 1994.
Figure 27 Quantifiable Design Criteria

Chapter 6

Figure 28 Summary diagram of the Advantages and Disadvantages of Five Insulation Materials for Shelter Insulation

Figure 29 Cost, Weight and Volume Comparison of Insulation Materials assuming Equal Thermal Performance

Figure 30 Description and Specification of the Tested Shelter Prototype

Figure 31 Axonometric of Construction Sequence of the Tested Shelter Prototype

Chapter 7

Figure 32 Internal Temperature Gradients with and without wind

Figure 33 Global Conductance/Wind speed graph

Figure 34 Component parts of shelter heat loss with no wind

Figure 35 The Dependence of Infiltration Rate upon Wind Speed

Figure 36 Thermographic Imaging of the Shelter Prototype in the Test Chamber

Figure 37 Sectional Elevations Showing the build-up of Condensation and Ice on the Door and the Back Panel of the Prototype Shelter

Figure 38 Axonometric showing the build-up of Condensation and Ice on the in the Prototype Shelter

Figure 39 Tas Ambiens Model illustrating Factors Affecting Thermal Comfort inside the Shelter Prototype

Contents

Summary

Acknowledgements
Glossary of Terms and Definitions
List of illustrations
Contents

CHAPTER 1	**Introduction**	**10**
1.1	**Project Rationale**	**10**
1.2	**Aims and Objectives**	**11**
1.3	**Scope**	**12**
1.4	**Outline of Dissertation**	**13**
CHAPTER 2	**Relief Operations**	**14**
2.1	**Introduction**	**14**
2.2	**The New International Humanism**	**14**
2.3	**Description of a Relief Operation**	**15**
2.4	**Contemporary Views and Policy on Physical Planning**	**17**
2.5	**Planning Supported Temporary Settlements**	**21**
2.6	**Chapter Conclusions**	**22**
CHAPTER 3	**Shelter**	**23**
3.1	**Introduction**	**23**
3.2	**Contemporary Views and Policy on Shelter**	**23**
3.3	**Shelter in Cold Climates**	**26**
3.3.1	**Contemporary Views and Policy on Cold Climate Shelter**	**26**
3.3.2	**Winterised Tents**	**27**
3.3.3	**Non-Tent Response**	**33**
3.4	**Chapter Conclusions - The Need for Shelter Standards**	**34**

CHAPTER 4	**Methodology**	**37**
4.1	**Introduction**	**37**
4.2	**Defining a Brief**	**37**
4.2.1	**Project Background**	**37**
4.2.2	**Consultation and Review**	**38**
4.3	**Developing a Prototype**	**39**
4.3.1	**Insulation Material Selection**	**40**
4.3.2	**Prototype Construction**	**40**
4.4	**Forming a Testing Procedure for a Prototype Shelter**	**41**
4.4.1	**Physical Environment Tests**	**42**
4.4.2	**Thermal Performance Tests**	**43**
4.4.3	**Condensation Tests**	**44**
4.4.4	**Shelter Prototype Modelling**	**45**
4.4.5	**Field Tests**	**46**
Chapter 5	**Defining a brief**	**47**
5.1	**Introduction**	**47**
5.2	**Consultation and Review**	**47**
5.3	**Criteria Affecting Shelter Provision**	**48**
5.3.1	**Logistic Criteria**	**49**
	Shelter Cost	
	Shelter Weight	
	Shelter Volume	
	Supply Lead Time	
5.3.2	**Environmental Criteria**	**50**
	External Environmental Parameters - Air Temperature and Wind Speed	
	Internal Environmental Targets	
	Structural Stability	
5.3.3	**Social Criteria**	**56**
	Patterns of use	
	Shelter ‘Buildability’	
	Living Density	
5.4	**Limitations and Assumptions**	**59**
5.5	**Final Design Brief**	**60**
Chapter 6	**Developing the Prototype**	**61**
6.1	**Introduction**	**61**
6.2	**Insulation Material Selection**	**61**
6.3	**Shelter Prototype Construction**	**64**
6.4	**The Tested Shelter Prototype**	**72**

Chapter 7 Test Results and Analysis 75

7.1 Introduction 75
7.2 Thermal Performance Tests 75
7.3 Condensation Tests 78
7.4 Shelter Prototype Modelling 80
7.4.1 TAS Ambiens Mode 80
7.4.2 Shelter Fuel Consumption Modelling 82

Chapter 8 Conclusions 83

8.1 The Development of a Brief 83
8.2 Prototype Development 84
8.3 Prototype Testing 84
8.4 Future work 85
8.4.1 Research for the Prototype Shelter 85
8.4.2 Research for Existing Shelter Systems 86
8.4.3 Research into Cold-Climate Shelter Policy 87

Bibliography *88*

Appendices 92

Appendix 1 Specifications and Assembly Instructions for the Oxfam Hot Climate Shelter System 92

Appendix 2 Current Research - UNHCR Insulated Tent Liner 94

Chapter 1 Introduction

Shelter is vital part of humanitarian relief and plays a fundamental role in the physical and psychological health of affected populations and is a human right[5,6]. Shelter, and shelter maintenance, continues to play a significant part in the environmental degradation of temporary settlements, whether inside or outside relief programmes. The cost of such shelter exceeds by far the costs of other sector assistance programmes (for example, water supply) per capita of beneficiary population in the majority of emergencies[7,8]. This chapter explains the reasons for undertaking the design project and an outline of the dissertation.

1.1 Project Rationale

This project has explored several concerns that seem to have been overlooked by the aid community. Emergency shelter provision has proved inadequate in recent humanitarian disasters occurring in cold-climates, regarding (1) the logistics of supply, (2) the living environment and (3) for medium to long-term use.

These factors were evident during the recent humanitarian crisis in Macedonia regarding the winterisation of shelter in refugee camps for Kosovar Albanians. When a decision to provide winterised tents was taken in May 1999 by the United Nations High Commissioner for Refugees (UNHCR) for all camps, the tents then took months to be fabricated in Pakistan and delivered to site. By that time, the majority of refugees had returned home, following the agreement made in June with the Yugoslav government in Belgrade. The supply and delivery of 20,000 tents, costing some USD 11.2 million, was made redundant. The tents have since been transferred to Kosovo, but they are not designed, or insulated, to cope with the extremes of cold during winter on the Kosovan plateau, or in the highlands on the borders with Albania and Macedonia[9].

The implications for heating a sizeable number of un-insulated tents in cold-climates are enormous fuel costs and logistical difficulties concerning the transportation of fuel[10]. It is also noteworthy that tailored canvas tents are of limited use to returned refugees in the long-term, as there is no potential for reuse of shelter materials within later reconstruction phases of humanitarian assistance. Given that international funding for disasters decreases substantially following an emergency phase, emergency shelter that is climatically responsive in the short term, and useful over the long-term, should appeal to both the receivers and the givers of aid.

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[5] UNHCR (1999). pp 134.
[6] UNHCR, (1993b). pp 6 (section 2).
[7] UNCHS, Nairobi, (1984).
[8] Cuny, F., (1977).
[9] Manfield, P. (2000a).
[10] Crawford, C. (2000). pp 17.

It is acknowledged by leading aid agencies, including UNHCR and Oxfam, that the use of shelter systems in humanitarian relief is a last resort and that alternative shelter inside hard building construction is preferable in nearly all circumstances[11,12]. It is argued in this dissertation, however, that a greater understanding of the complex problem of providing temporary accommodation in such environments is needed because shelter systems continue to be employed in contemporary humanitarian assistance programmes, and in assistance phases well beyond the emergency. Thus, the following hypothesis has been formulated.

Under specific circumstances, cold-climate emergency shelter systems can become an effective and appropriate response to the temporary shelter needs of forced migrants in cold-climates.

A greater understanding in this field is particularly important because there is little reference material and formal literature in the field of physical planning and shelter[13]. Other sectors, such as medicine, water supply and sanitation, human rights and protection, have well established Non-Governmental Organisations (NGOs) that specialise in the provision of a specific service, for example as OXFAM and water supply, Medicins Sans Frontieres (MSF) and medicine, and each can refer to large bodies of research and field practice manuals. The shelter sector, however, is only now being recognised as an independent sector of humanitarian assistance and further, there is only one organisation whose mandate includes shelter provision (UNHCR), despite the involvement of hundreds of organisations in the implementation of shelter assistance programmes. This has resulted in an 'ad hoc' attitude to shelter provision and has forced it down the list of humanitarian priorities[14].

1.2 Aims and Objectives

The aims of this dissertation are threefold;

1. To take forward the design of a prototype cold-climate shelter system for forced migrants.

2. To increase the understanding of the use and performance of shelter in cold-climates through the development of a generic research and testing methodology for cold-climate shelter for forced migrants.

3. To define specification criteria to assist specialists and procurement departments in NGOs in the deployment of appropriate tents and supporting equipment.

[11] 'hard construction' in this instance refers accommodation constructed with thermal-massive materials.
[12] UNHCR (1999). pp 145.
[13] Zetter, R. (1994).
[14] UNCHS, Nairobi, (1984).

The specific objectives for the design project are:

- To design a stand-alone shelter system for use in the Balkan winter environment by Oxfam.
- To develop these designs through the construction of several prototypes.
- To test the best of these prototypes in order to predict performance in the field, given a series of specified climatic conditions.
- To provide a series of material specifications, costs, lead times and details of supplying agents for all component parts for a successful shelter system.

The design brief prototype development and testing for a cold-climate shelter system has been defined and developed through consultation with senior aid staff of various organisations, including UNHCR and Oxfam, and also through the review of relevant, but limited, literature.

The recent crises in the Balkans are used to illustrate the context of emergencies occurring in such climates because the author worked for humanitarian agencies in Kosovo and Macedonia from December 1998 to June 1999 undertaking emergency shelter assistance programmes. This experience has further enabled the gathering of first hand data from displaced persons and senior agency field staff. Whilst selected information about other relevant crises in cold-climates has been obtained, including those in Afghanistan in 1982/3, Northern Iraq in 1991/2 and Croatia in 1994, it has proved extremely hard to gain comprehensive data relating to humanitarian shelter programmes in cold-climates. Nevertheless, the most recent crisis in the Balkans saw humanitarian agencies implement the complete range of shelter assistance options available to the aid community at various times between May 1998 to the present day, the details of which are discussed at length in Chapter two.

1.3 Scope

This dissertation is only concerned with shelter assistance for persons displaced by conflict in cold-climates but does not address the shelter needs of victims of natural disasters, for whom shelter needs are different[15].

[15] Davis, I. (1979).

1.4 Outline of Dissertation

The structure of the dissertation is detailed below. Chapter two, ‘Relief Operations’, introduces the world of humanitarian relief and the major players within it. It discusses the effects of international involvement in humanitarian assistance and the corresponding effect this has had on the way the aid community operates and delivers aid in the field. In particular, the discussion focuses on the effects of the demand that agencies and donors alike should be made accountable for their actions and perform to recognised international standards of assistance. The role of shelter and physical planning is introduced within this wider framework through reference to the limited available texts, guidelines, standards and handbooks. Reference to other sources, such as interviews with agency staff and displaced persons as well as the author’s first hand experiences, attempt to fill in the knowledge gaps. Thus, Chapter two is not a formal literature review, but instead provides an illustrated context to shelter in humanitarian relief work.

Chapter three, ‘Shelter’, concentrates in detail on the specific problem of providing temporary shelter in emergencies. A selection of contemporary humanitarian emergency shelter systems are then analysed from both technical and social viewpoints and with particular reference to their use in the field.

Chapter four, ‘Methodology’, identifies a process for arriving at a design brief for a cold-climate emergency shelter system and further lays down a framework for developing, and testing a shelter prototype.

Chapter five, ‘Defining a Brief’, defines a specific design brief for cold-climate shelter in close consultation with aid agency staff from Oxfam.

Chapter six, ‘Developing the Prototype’, describes the design and development of several cold-climate shelter prototypes.

Chapter seven, ‘Results and Analysis’, describes the results and analysis of prototype tests performed in environmental chambers and modelling tests.

Chapter eight, ‘Conclusions’, presents the conclusions to the design project and includes a discussion of the limitations of the work. It further sets out method for the selection of cold-climate emergency shelter systems and identifies areas for future research.

CHAPTER 2 Relief Operations

2.1 Introduction

This chapter introduces the world of humanitarian relief. It examines the major players and their roles and the current state of play with regard to physical planning through a review of relevant literature. The chapter concludes with a brief discussion of the role of shelter within these wider concerns.

2.2 The New International Humanism

The number of refugees and internally displaced persons (IDPs) resulting from conflict have steadily increased over the past twenty years. In 1997, a total of 22.72 million forced migrants, including refugees and internally displaced persons (IDPs), in 82 countries world-wide were listed as 'of concern' to the United Nations High Commissioner for Refugees[16]. Fuelled by increasing mass media interest in disasters, foreign participation in the relief of human suffering resulting from conflict has also risen and a new trend of international humanism has emerged[17]. The 1990's witnessed humanitarian interventions of unprecedented scale, first in Kuwait and Northern Iraq in 1991/2, in Somalia in 1993, in Bosnia and Croatia, Rwanda and the Democratic Republic of Congo in 1994/5 and most recently, in Kosovo. Organisations such as the Red Cross Movement and the United Nations High Commissioner for Refugees have evolved from just a handful of lawyers and relief workers in the 1970's to enormous bureaucracies whose funding currently runs to billions of dollars[18].

Over the past decade, concerted efforts have been made to define better how the international community should intervene in humanitarian disasters. At the centre of this debate are the human rights of displaced persons. The creation of new entities such as the War Crimes Tribunal in The Hague in the Netherlands and the Office for Security and Co-operation in Europe (OSCE) have done much to encourage governments to assume collective responsibility for those who suffer as a result of conflict outside their national boundaries. This has profoundly affected the way in which humanitarian organisations operate and whilst increased Western involvement in conflict resolution must be regarded as a positive step forward, financial and political support has been sporadic and the role of humanitarian organisations in relief has subsequently been poorly and inconsistently defined[19].

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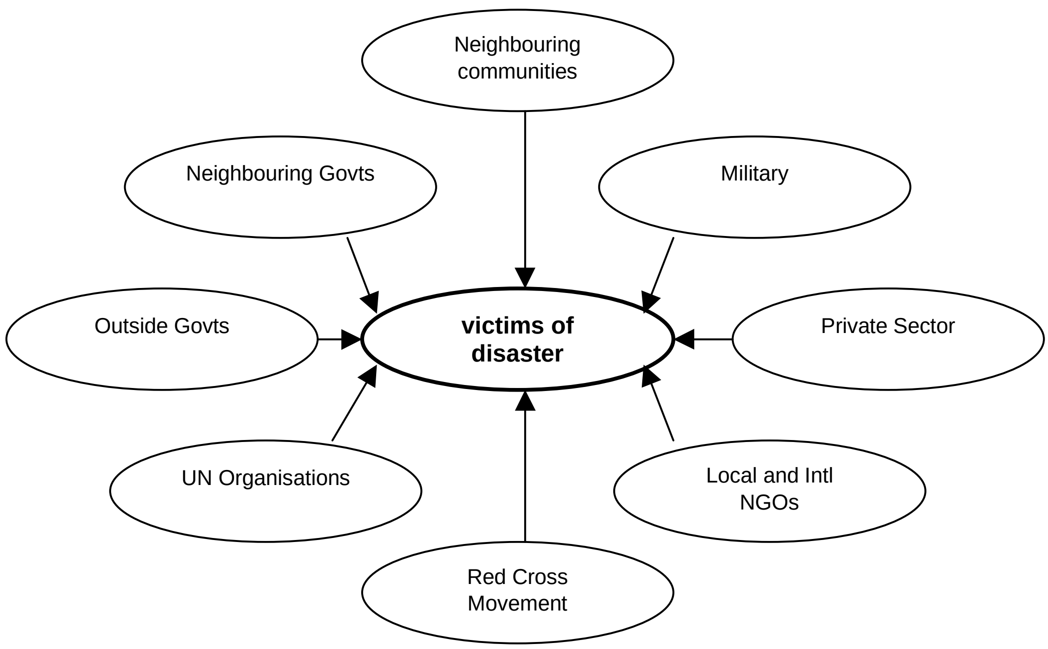
[16] UNHCR (1997).
[17] Ignatieff, M. (1998). pp 9.
[18] Ibid. pp 79.
[19] Hancock, G., (1992).

Furthermore, the transition of now major humanitarian organisations from small charities into large supra-national establishments has not been smooth and their involvement in many crises have attracted widespread criticism concerning both the way in which aid is delivered and the standard of assistance offered[20,21]. In 1996, the SPHERE Project was created in order that aid organisations might collaborate to produce guidelines for minimum standards for all sectors of humanitarian assistance[22]. These standards were published in 1998, and whilst most aid organisations have accepted the standards, they have not always been implemented in the field.

2.3 Description of a Relief Operation

When a disaster occurs, the immediate victims must respond and cope as best they can alone[23]. For major disasters, however, outside groups provide assistance. The diagram below indicates where help usually comes from.

Figure 1 Sources of Relief – The Major Players in the Aid Community[24]



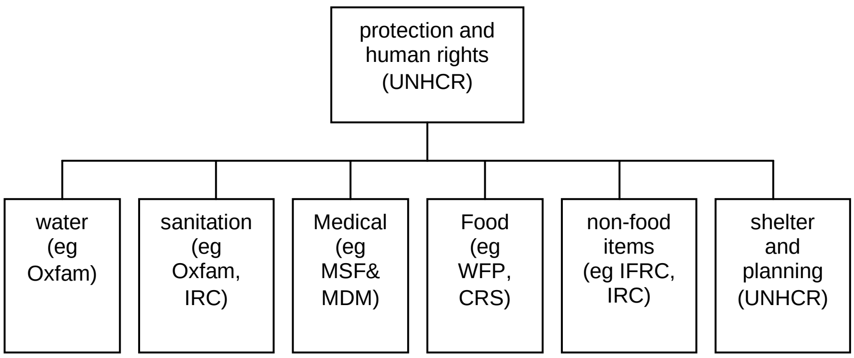
After many disasters, assistance comes from communities from within the affected country and from neighbouring countries. This assistance often arrives in the immediate aftermath of a disaster and before international response has been mobilised, such as Malawian communities who gave refuge to Mozambican refugees in the late 1980's[25].

[20] Ibid.
[21] Karadawi, A. (1983), Harrell-Bond, B. E. et al., (1992).
[22] Refer to Chapter 3.4 for a discussion of SPHERE Standards.
[23] Davis, J. and Lambert, R. (1995). pp 12.
[24] Diagram after Davis, J. and Lambert, R. (1995). pp 12.
[25] Davis, J. and Lambert, R. (1995). pp 12.

The governments of neighbouring countries, as well as outside governments, may also become independently involved with relief operations, particularly if the effects of population displacement are likely to adversely affect them. In an increasing number of cases over the past decade, the military have also been involved in relief operations, most notably in Balkan countries, such as Bosnia in 1994 and in Macedonia in 1999, where entire refugee camps were constructed by military personnel[26]. These groups can be regarded as occasional players whose main function(s) do not usually include humanitarian assistance. The remaining players, including the UN, the Red Cross movement, Government donor organisations and the expanding number of national and international Non-Governmental Organisations (NGOs) form what is commonly referred to as the aid community.

The organisation and inter-relation of players within the aid community is complex. Whilst it is not relevant to this dissertation to describe in detail the way in which the aid community functions, it is worth distinguishing at this point between the humanitarian response to natural disasters and that for emergencies resulting from conflict. Response to natural disasters does not usually involve the potential for large numbers of displaced persons to remain permanently displaced in a country other than their own[27]. This is not the case for emergencies resulting from conflict and the political and legal status of those involved becomes critical in the determination of what can, and cannot, be done to assist. With this in mind, humanitarian assistance can be divided into several sectors and the figure below illustrates a simple model of the categories.

Figure 2 *Sectors of Operation within the Aid Community for Emergencies resulting from Conflict*[28]



key:

IRC – International Rescue Committee	WFP – World Food Programme
MSF – Medicins Sans Frontieres	MDM – Medicins du Monde
CRS – Catholic Relief Services	IFRC – International Federation of the Red Cross
UNHCR – United Nations High Commissioner for Refugees	

[26] German and British military forces were responsible for construction and maintenance of five camps in northern and western Macedonia during April and May 1999.
[27] Davis, I. (1979).

In such emergencies, it is UNHCR that normally assumes responsibility for the legal protection of those affected by the conflict and further takes the co-ordinating role for relief operations. National societies of the International Federation of the Red Cross (IFRC) will usually be present in some capacity as well as any number of local and international NGOs. It is noteworthy that some NGOs have developed sector specialisation, such as OXFAM's involvement in water supply and sanitation. Shelter and physical planning, however, remains the sole responsibility of UNHCR, although Oxfam, IRC, MSF, IFRC, and many other NGOs are currently running shelter assistance under the auspices of UNHCR.

2.4 Contemporary Views and Policy on Physical Planning

Physical planning refers to the process of providing suitable living environments for displaced persons. Planning temporary settlements has direct implications for the use of emergency shelter systems. Shelter systems can be a part of number of settlement options for forced migrants and so it is useful, therefore, to briefly consider contemporary views on physical planning, as shelter is only one part of a much broader picture of the infrastructure required.

Reference literature in this field is limited as the aid community suffers from lack of policy guidelines and an acute lack of institutional memory of best practice[29]. Emergency shelter following natural disasters can refer to a substantial body of literature, whilst there are only very few papers exist that attempt to evaluate site planning for displaced populations resulting from conflict in a holistic manner[30]. The technical appraisals that do include Harris and Hulse (1977), as well as UNHCR's Handbook for Emergencies (1982, and revised in 1999), but the lack of continuity and development in this sector has resulted in 'ad hoc' and 'reactive' planning for temporary settlements[31].

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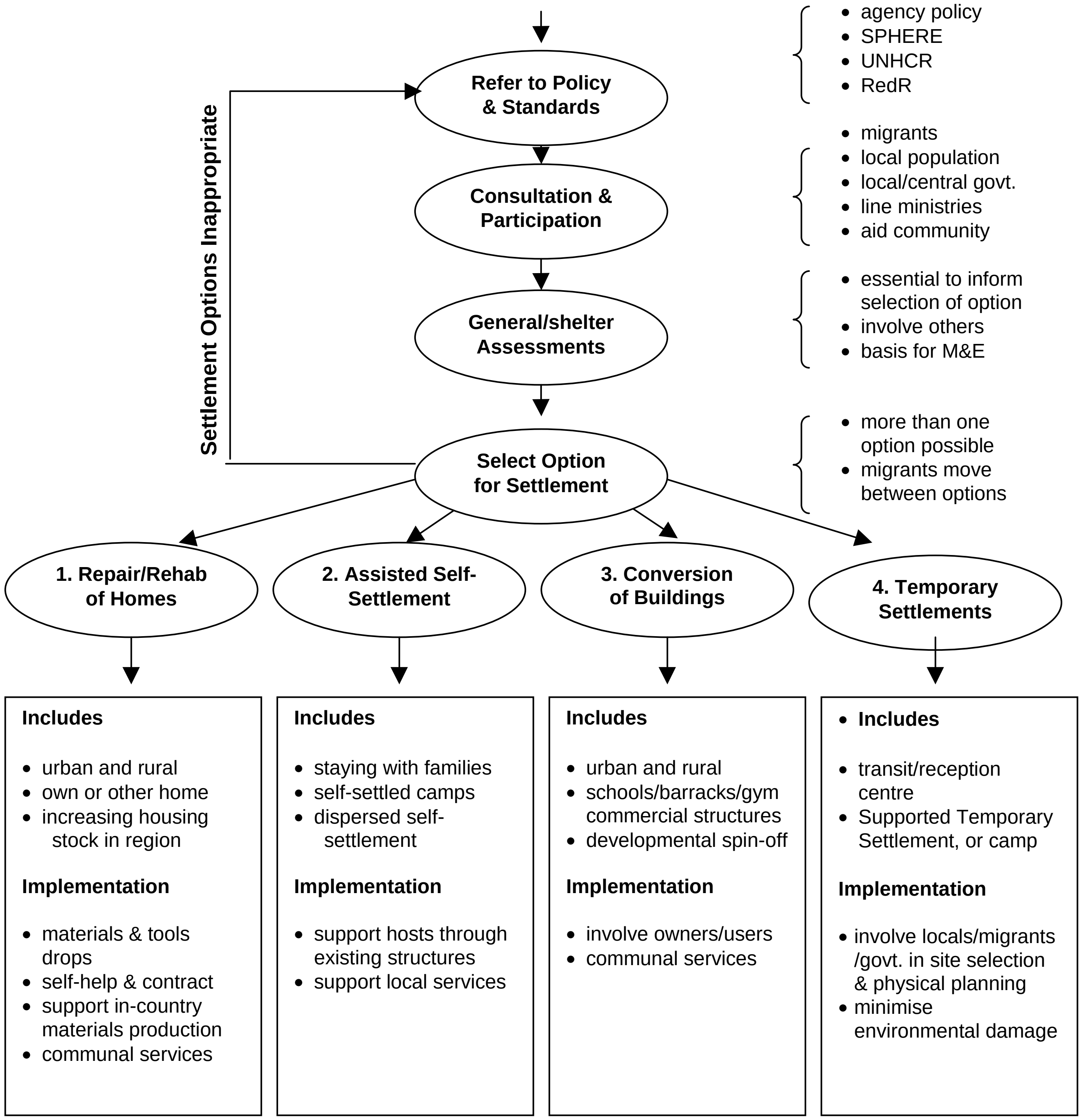
[28] Author's own.
[29] Zetter, R. (1994). pp 31.
[30] Cuny (1977, 80, 83).
[31] UNCHS (1984).

Before looking at these problems in more depth it is useful to gain an overview of the range of temporary settlement options available for implementation in complex emergencies. The following diagram illustrates a decision-making flow chart for the selection of the appropriate option(s).

Figure 3 Temporary Settlement Options For Forced Migrants[32]



[32] Adapted from Corsellis, T. (2001).

The options (1 through to 4) can be regarded in order of general preference, both for forced migrants and the aid community[33]. Repairing and rebuilding homes following conflict is usually the first choice of (previously) displaced people. Humanitarian agencies, in this case, can support temporary repairs to existing property in lieu of more permanent reconstruction and this permits families to return home at the earliest opportunity, regain employment and re-establish social support networks. Shelter systems have been employed in circumstances where migrants are able to return home but there is no accommodation suitable for immediate renovation. This process is currently ongoing in Kosovo and enables individual families to remain on their property whilst waiting for suitable conditions and resources for reconstruction.

When migrants are unable to return home, they may try to find alternative accommodation with friends and family away from conflict. Where this is not possible, various self-settlement options may be taken. Migrants may appeal to the charity of nearby communities and opt to stay with host families. In such circumstances, agencies can support migrants by supporting the local community through upgrading facilities and physical resources in order to minimise the impact of migrants. This occurred on a large scale in Western Macedonia during 1999. This is not always possible, however, as not every local community is willing, or able, to support large numbers of migrants. In such circumstances and where the environment permits, migrants may choose to build homes and livelihoods from scratch. This occurred in Liberia during 1998, when some 10,000 Sierra-Leonian refugees, representing some 15% of the total refugee population, decided to self-settle along the border region[34].

When local communities are not willing to accept self-settled migrants, or environments cannot support them, temporary settlement options 3 and 4 must be employed. The conversion of public and private buildings for temporary accommodation usually involves the creation of partitioned rooms for family units within large internal spaces and the upgrading of infrastructure and services to provide for basic needs, such as water, sanitation, heating and lighting[35]. This can be difficult to achieve as suitable buildings are hard to find and it is further likely to be capital intensive and require significant agency staff resources to ensure success.

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[33] UNHCR (1999) pp 136.
[34] *pers comm* Corsellis, T. (October 2000).
[35] Authors experience.

Thus, we come to the final settlement option for forced migrants; the refugee camp, which has been the default response of the aid community over the past 20 years. There is now considerable internal resistance within the aid community to even consider a camp as a viable temporary settlement option for a displaced population, and a relatively substantial body of literature now exists which indicates that alternatives to camps are clearly preferable in the majority of socio-political, economic and environmental circumstances[36].

One has only to consider the disastrous effects on local physical environments of recent large high-density camps, and the problem of creating durable refugee settlements in areas with scarce resources, to realise that camps are far from ideal. The photograph below illustrates the damage done to the environment to area of bushland by a transit camp on the Somali/Kenyan border during 1994.

Figure 4 The Remains of Liboi Transit Camp, Eastern Kenya

Jacobson argues that by establishing a higher numbers of smaller dispersed settlements, instead of large camps, there is greater opportunity for matching the population size of a DP to the carrying capacity of the local environment[37]. When large population movement do occur, however, it is better to provide well-planned temporary settlements if no other options are possible. Camps can be justified if they are the only way of maintaining agency access to forced migrants and providing a consistent supply of basic human needs, such as those described in figure 2[38]. Cuny argues that camps can be managed effectively to provide suitable conditions as well as be sustainable entities if they are planned at an early stage[39].

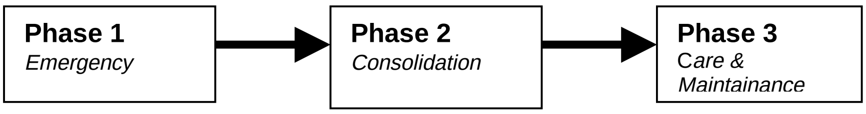
[36] Voutira & Harrell-Bond, B., (1995).
[37] Jacobson (1994).
[38] Chalinder, A. (1998) pp 10.
[39] Cuny, F. (1977). pp 120.

Where there is severe competition for local resources, restricting environmental damage to one location only has significant advantages too. He goes on to say that the total costs of designing and installing a 'liveable' refugee camp are less than the continuing operational costs of a sub-standard camp, which all too often is the result when camps are disregarded as inappropriate[40]. It is difficult to imagine an alternative to the camp solution in the case of the Rwandan crisis in 1994, where the population movement was so large that planning for options 1 to 3 would have been taken too long and endangered human life in the process. Shelter systems have often been distributed in camps, especially where the environment cannot support the use of local materials for such purposes.

2.5 Planning Supported Temporary Settlements

Cuny states that Supported Temporary Settlements (STSs), or camps, can be seen to go through a series of phases and the diagram below illustrates how social and physical factors change with time.

Figure 5 The Phases of Operation for STSs[41]



Phase 1 – Emergency. The moment at which a migrating population decides to stop moving usually heralds the beginning of the emergency phase for a temporary settlement. Displaced people have often travelled a long way on foot by this stage and are often physically exhausted and traumatised by recent conflict. Families and tribal groupings may be dispersed and all will be disorientated in largely unfamiliar surroundings. The STS in this case are usually large camps for which the primary functions include registration, distribution of aid, basic accommodation and other services. Camps such as these are usually located near a road, railroad, or sometimes an airstrip.

The displaced population at this stage is usually capable of very little beyond receiving primary health care and food. It is here that a relief programme needs to respond quickly to provide what refugees cannot do for themselves. The planning decisions made at this point are crucial, as any major mistakes in planning and the provision of shelter and infrastructure will prove extremely difficult and costly to correct. Sometimes, a decision is taken to form a transit camp, such as those established in Cibitoke Province, Burundi for Congolese refugees during 1998[42].

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[40] Cuny, F. (1977). pp 125.
[41] Ibid. pp 126.
[42] *pers comm* Corsellis, T. (October 2000).

Transit camps occur where it is imperative that basic aid is provided for survival although political and environmental factors make it dangerous for a population to remain in the area for any great length of time. The refugees in this particular case were away from the border in a planned relocation at a later stage.

Phase 2 – Consolidation. The consolidation phase represents the end of the imminent threat to the displaced population from disease and famine. There is also an increasing level of social organisation among the refugee population as families begin to regroup and more displaced people arrive. Major infrastructures, such as water and sanitation, become established and there is some evidence of planning and design for semi-permanence (ie, no immediate closing can be foreseen). Family shelters will be adapted in size and material composition as this re-organisation occurs.

Phase 3 - Care & Maintenance. The STS has reached a state of equilibrium at this stage. Its size and population levels have stabilised and although there is the possibility of further refugee influxes, new and old communities become established. The physical planning has either been adapted from earlier phases, or has been designed from the outset to provide for permanent settlement. In other words, the STS is designed to maximise control and administration, reduce costs and facilitate the delivery of relief services. The inevitable development of an informal refugee economy provides work, and with it, a higher degree of independence. There may also be limited integration with the local economy and community.

2.6 Chapter Conclusions

This chapter indicates that physical planning for temporary settlements often decides the scope of shelter assistance. Shelter systems are typically used in parallel to repair and reconstruction assistance programmes and also in supported temporary settlements, such as camps. Figure 5 indicates that the use of shelter is also affected by the phases of operation within an STS and determines the type and specification of any shelter system employed.

CHAPTER 3 Shelter

3.1 Introduction

This chapter examines emergency shelter in detail. It starts with a study of the recent developments in humanitarian shelter policy for all climates and then concentrates on provision of shelter in cold-climates. The chapter concludes with a discussion of the need for standards and the implications for emergency shelter systems.

3.2 Contemporary Views and Policy on Shelter

In recent years, UNHCR has advocated the provision of sustainable solutions for displaced persons. Critically, this term is neither temporary, which may imply that shelter provision is sub-standard over the long-term, nor permanent, which may implies migrants will never return home. This sentiment is very hard to translate into built reality and there is divided opinion among practitioners and academics concerning the nature of sustainable shelter. Browne advocates that emergency shelter should sustain life and not provide permanent homes[43]. This view can be supported if there are adequate resources to upgrade shelter conditions as a settlement moves from emergency to consolidation phases. The danger, however, in this strategy is that funding for emergency programmes steadily reduces over time and shelter provision is often the first to suffer as a consequence. Figures from 1993 indicate that 50% of refugee settlements last longer than 5 years with under 25% lasting under 2 years and this reinforces the view that shelter needs to respond to these life span projections[44].

The UNHCR guidelines state that the shelter has three key aims: (1) to provide protection from the elements, (2) security against violence and (3) privacy for personal and group needs[45]. These aims are echoed by the Registered Engineers for Disaster Relief[46]. It is further recommended that shelter assistance should be phased in a similar manner to those described for camp development. The emergency phase should address immediate needs following a disaster and may involve complementary distributions of construction materials or personal items necessary for survival. The stabilisation phase that follows should provide for minimum shelter standards in accordance with the SPHERE standards[47] and the recovery phase should support construction, reconstruction, or provision of permanent dwellings.

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[43] Browne, G., (1995).
[44] UNHCR, (1993b). pp 1 (section 2).
[45] UNHCR (1999). pp 145.
[46] Davis, J. and Lambert, R. (1995). pp 576.
[47] Refer to Chapter 3.4

Medicins Sans Frontieres (MSF) highlights the importance of environmental health for shelter provision in its guidelines in addition to those described by RedR and UNHCR above[48]. The importance of providing minimum space requirements and ensuring adequate ventilation to reduce the risk of respiratory health problems are mentioned specifically, but in no more detail. Phased shelter assistance is advocated again, with an emphasis placed on supporting self-build programmes during the emergency phase and the supply of tents and/or renovation of public property as secondary options. In post-emergency phases, MSF notes that shelters must be made more permanent, but the discussion is limited to political and programmatic issues. Winter tents and heaters are recommended for shelter provision in cold-climates, but it is also noted that this is an unresolved area of assistance.

Many refugee crises in recent years have occurred in hot climates and agencies have typically supported self-build shelter programmes with distributions of tools and construction materials. This has been the policy for self-settled migrants as well as for those in camps. Material distributions typically include reinforced plastic sheeting for temporary roofing and a structural system from locally available materials such as timber or bush poles[49]. Distributed materials can then be combined with other locally available materials to improve shelter. In urban areas, for example, this may include the reuse of material collected from damaged buildings, whilst in rural areas, materials such as brushwood and leaves can to be used as thatching or internal partitions. Whilst the use of local materials is nearly always preferable to imported materials, Goovearts points out that they are not the miracle solution to shelter needs[50]. The use of bamboo for shelter assistance in Bangladesh during the mid-eighties meant that demand caused prices to rise to the point where the local population could not afford it. Furthermore, bamboo also needed maintenance and replacement which the refugees could also no longer afford. In developed countries, such as the former Yugoslavia, the supply of construction and building materials proved so unreliable that the international community turned to prefabricated systems to provide a short-term solution to the problem.

In such circumstances, and where there is adequate funding available, canvas tents have typically been provided instead. Oxfam notes that tents are stockpiled in small quantities by donor countries and governments in vulnerable regions as well as by the military and agencies such as national Red Cross Societies[51]. It is acknowledged that their usefulness is generally limited to the initial phases of an emergency, due to their small size and the limited potential for adaptation or expansion during later phases of assistance. Tents are relatively quick and simple to erect, they are more acceptable to host nations than more permanent forms of shelter, and remain flexible for later changes to planning or for relocation.

[48] Medicins Sans Frontieres. (1996). pp 114-123.
[49] Plastic Sheeting has been developed especially for aid purposes. See Manfield (1998) for more details.
[50] Zetter, R. (1994). pp 41.
[51] OXFAM Emergencies Handbook (1997).

Good suggests that tents made from local materials might even be procured for emergency shelter, although it is worth noting that if there is adequate lead time to produce tailored tents, it is also likely that there is time and money to find more durable, if not more permanent shelter options[52].

The durability of canvas, however, is insubstantial beyond the short term. Canvas degrades quickly when exposed to damp conditions over prolonged periods and from exposure to high levels of ultra-violet (UV) radiation. Rotting was noted as a particular problem in Afghanistan in 1983 where canvas tents were disintegrating at the base where in contact with the ground after six months use. Tents used in Benin last year were sub-standard within a year due to UV degradation[53].

Military tents have proved to be a fast response to shelter needs of certain large and sudden movements of refugees in warm and temperate climates. The use of the Swiss 'horse tent' was used effectively to respond to the Macedonia influx at Blace in spring 1999[54]. It should be noted, however, that high capital and transportation costs are likely to exclude their use in many emergencies[55,56].

In a small number of assistance programmes, alternative shelter such as commercial 'emergency housing' has been employed, although the success of such housing has been limited as it has rarely met the needs of displaced persons[57]. Such commercial systems are invariably costly and difficult to transport to site. Van Huyk warns about the nature of appropriate design and technology for shelter relief with such commercial or Western systems in mind[58]. He argues that the housing problem for low income people, including displaced people, will 'not be solved on the drawing board' as the gap between standard housing and what low income people can afford is simply too great. This is relevant for emergency shelter assistance because whilst the international community may be in a position to foot the bill for initial capital expenditure on emergency shelter, the bulk of the cost for maintenance and adaptation of such structures rests with the beneficiary population. Hence, any imported materials used for emergency shelter must not be reliant on external construction techniques and equipment.

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[52] First International Emergency Settlement Conference. (1996). Topic 13 pp 1.
[53] *pers comm* Neumann, W. (April 2000).
[54] *pers comm* Schellenberg, W. (April 2000).
[55] UNHCR (1999) pp 145.
[56] *pers comm* Neumann, W. (April 2000).
[57] OXFAM Emergencies Handbook (1997).
[58] Van Huyk (1971). pp 9-10. *Op. cit.* First International Emergency Settlement Conference. (1996). pp 2.

3.3 Shelter in Cold-climates

This section looks at cold climate shelter in three parts; (1) contemporary views and policy, (2) the provision of winterised tents and (3) other shelter responses. In cold-climates, shelter has much more direct and explicit links with refugee health[59]. The only formal reference material for this section is the guidelines mentioned in the UNHCR Handbook for Emergencies. All other data has been collated from interviews with agency staff, unpublished academic papers and from the author's personal experience.

3.3.1 Contemporary Views and Policy on Cold-climate Shelter

In addition to the basic aims of shelter assistance described at the start of this chapter, the guidelines stipulate that in cold-climates, shelter should provide 'enclosed and heated spaces'[60]. In such conditions, the guidelines underscore the importance of a holistic and consistent cross-sectoral approach. In other words, 'seasonally-appropriate'[61] shelter should at all times be combined with suitable non-food items for personal insulation, such as additional clothing, blankets and bedding, suitable food rations with a high calorific rating and adequate heating equipment and fuel[62].

Where only limited resources are available during an emergency phase, agencies should promote 'individual survival' and give priority to personal insulation rather than trying to provide a consistently warm internal environment[63]. In Kosovo during 1998 and 1999, bedding and clothing were distributed to a dispersed population during the first emergency phase when shelter materials were unavailable[64].

In best practice, appropriate shelter provision within cold-climate environments is housing of hard construction[65]. This might be repaired or renovated private property or communal facilities based on the UNHCR 'Warm Room' concept developed for shelter assistance programmes in Bosnia[66]. This was a self-build assistance programme whereby agency staff conducted technical and social assessments relating to building damage in villages and the health and needs of individual communities. Material packages were then distributed based upon the findings of the assessments and usually consisted of building repair kits, such as plastic sheeting, a selection of timber sections, bedding, heating equipment, tools, and insulation[67].

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[59] *pers comm* O'Connor, R., (August 1999).
[60] UNHCR (1999) pp 145.
[61] Ibid. pp 146.
[62] Ibid. pp 144.
[63] Ibid. pp 145.
[64] Author's experience.
[65] UNHCR (1999) pp 147.
[66] International Management Group (IMG) Damage Assessment Guidelines. (No further details)
[67] Author's experience.

This programme was also repeated in Kosovo and the photograph below illustrates a damaged home repaired with basic materials to provide a 'warm room'.

Figure 6 'Warm Room' Project in Prilep, Western Kosovo[68]

emergency roof repairs to a lightly damaged property in Prelip

convective heat losses at the doorway are minimised through the creation of plastic porches

a lean-to roof created at first floor level of a damaged two storey building with no roof

If new construction is needed, agencies should promote self-build programmes with additional shelter materials sourced locally[69]. In all cases, imported materials or shelter systems should be avoided. This stands to reason as using local building materials, as well as local building designs and construction techniques, increases the likelihood that shelter for displaced people will be best suited to the local climate and therefore seasonally-appropriate. Thus, it follows that the use of imported materials runs a higher risk of being both climatically, and culturally, inappropriate.

3.3.2 Winterised Tents

There are, however, certain circumstances where there is no choice for the aid community but to rely on imported emergency shelter systems. These circumstances include; (1) large population movements where the local environment cannot provide appropriate housing or accommodation built using hard construction; (2) where the removal of locally available construction materials is politically or economically unsustainable; (3) where use of locally available materials will cause long-term environmental damage; (4) where the time between the supply of locally-procured shelter and the meeting of beneficiary shelter needs is deemed too long.

In the majority of emergencies occurring under such circumstances, UNHCR has advocated the use of a standard canvas tent. The photograph below shows the tent in use in rural Kosovo during 1999 and an axonometric drawing of the tent construction.

[68] Source: Author's own.
[69] UNHCR (1999) pp 145.

Figure 7 The Standard Winterised UNHCR Centre Pole Tent[70]

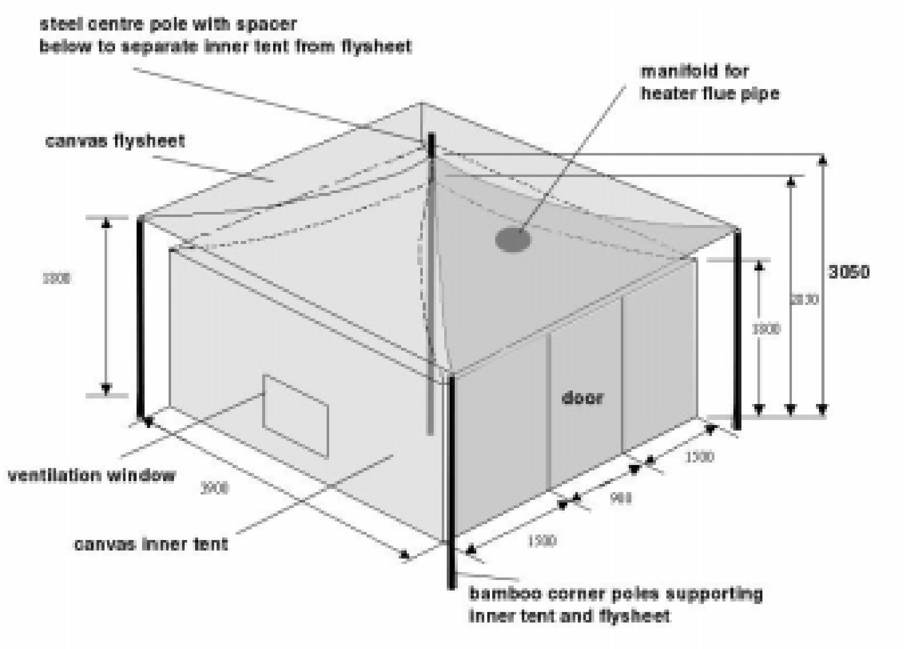

Figure 8

Family outside their tent in Prelip, W. Kosovo[71]

Figure 9

Centre pole tents in Chegrane Camp, fYRO Macedonia[72]

The tents have a double canvas roof with a light cotton inner liner. A standard stove unit can also be distributed with the tent to provide heating and the roof has a steel manifold plate sown into the fabric in order to take a flue pipe to exhaust fumes and gases from the heater. The tent is a severely problematic shelter solution in cold-climates as adequate protection from the elements becomes extremely hard to achieve. Research undertaken by the author last year, and interviews with senior UNHCR staff confirm that this is the case. Schellenberg notes that the refugees returning to Kosovo last year were extremely lucky to survive through this winter without being forced to use UNHCR's seasonal tents extensively[73].

[70] Source: Authors own. This tent is also known as the Pakistani Tent.
[71] Source: Lalah Meredith-Vula
[72] Source: Authors own.
[73] *pers comm* Schellenberg, W. (April 2000).

He goes further to suggest that UNHCR tents are most appropriate for use in interim climates, such as spring and autumn, but certainly not for the Kosovan winter with heavy snow and degrees below minus 20 Celsius. The reasons that the current UNHCR tent is inappropriate for cold-climate shelter response are many and varied, and the discussion to follow explores why.

Canvas sheeting has an inherently low insulation value and so heat loss through conduction to outside air is high[74]. Even if all presently possible additional measures are employed to increase the insulation value of the standard UNHCR tent, such as using heavier gauge canvas, adding a cotton liner and a double fly-sheet, the global conductance of the tent remains very high indeed even compared to very basic hard shelter construction such as accommodation inside un-insulated, single leaf concrete block[75]. Furthermore, tents have negligible thermal mass, which means there is no potential for useful heat gain from either solar gains during the day, or from internal heating, to be stored in any form that allows for useful retention or absorption of heat. This means that these tents heat up and cool down very quickly.

Thus, tents can only store heat energy as hot air. Most tents, however, are inherently 'leaky' structures as the tent construction is often full of gaps at junctions between material sections. Furthermore, the air permeability of canvas is high. All tents experience substantial fabric movement in wind, including those that use more stable armature structures such as frame tents, and all these factors encourages a high air change rate, which means that hot air is likely escape quickly and regularly from the internal living space. The high rate of heat loss means that a large heat source is required to maintain thermally comfortable conditions in cold-climates and that the heater must be running continuously during a heating season[76]. The implications for both fuel costs and for the logistics of supply are likely to be severe and certainly unsustainable beyond a short-term emergency for the majority of shelter programmes[77].

Structural problems with the tent become clear when loaded with snow and exposed to heavy wind, especially in cases where inexperienced and vulnerable people are forced to erect a tent without agency supervision[78]. Goovearts noted widespread failures in the El Hol Camps in Syria where most tents blew over within an hour[79]. The picture below shows the tent failing in high wind and snow loading in Western Kosovo last year. The family stayed throughout the entire winter period and suffered severe frost injuries.

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[74] Canvas has a U-value of approximately 18. For further details see Manfield, P., (2000c).
[75] The global U-value of the UNHCR tent is 2.4. For further details see Manfield, P., (2000c).
[76] The recommended heater rating is set at 5-7 kWatts. UNHCR (1999) pp 144.
[77] Manfield, P. (2000a).
[78] *pers comm* Schellenberg, W. (April 2000).
[79] UNHCR, (1993b). pp 6 (section 2).

Figure 10 UNHCR Tent failure in Djakova district, Western Kosovo, December 1999[80]

Heated tents also present a significant fire risk. Displaced people rarely have experience with the combination of tents and fuel wood burning stoves. The photograph below shows a family in Kosovo that that have capped the heater flue pipe with a piece of timber to reduce the heat lost through the stove. This means that fumes from the heater are not adequately ventilated and increases the risk of carbon monoxide poisoning.

Figure 11 UNHCR Winterised Tent with Capped Flue Pipe[81]

[80] Source: Schellenberg, W.
[81] Source: Schellenberg, W.

In addition, despite the fact that the standard UNHCR heater is relatively stable, the canvas fabric can easily catch fire from the hot heater flue pipe[82,83]. This problem is worsened through differential tent movement in wind, which causes the hot stove flue to displace easily. Furthermore, the high temperatures inside the stove increases the lifting of unburned particles which can also ignite the tent roof. The risk of fire is particularly life threatening in camp situations, where small winds can quickly carry a fire throughout entire blocks of tents. Figures 12 and 13 illustrates the heater inside the tent.

Figures 12 & 13 *The UNHCR Standard Heater*[84]

UNHCR guidelines acknowledge that tents are only suitable for sustaining life in survival conditions and not as a long-term shelter solution. Whilst the intentions of the guidelines at this point are quite clear, it remains unclear what alternative 'seasonally-appropriate' shelter might be employed under these circumstances[85]. In any case, contrary to the guidelines, heated, un-insulated tents continue to be used as cold-climate shelter response for displaced persons by UNHCR and other agencies in shelter programmes that last well beyond the emergency phase of assistance[86].

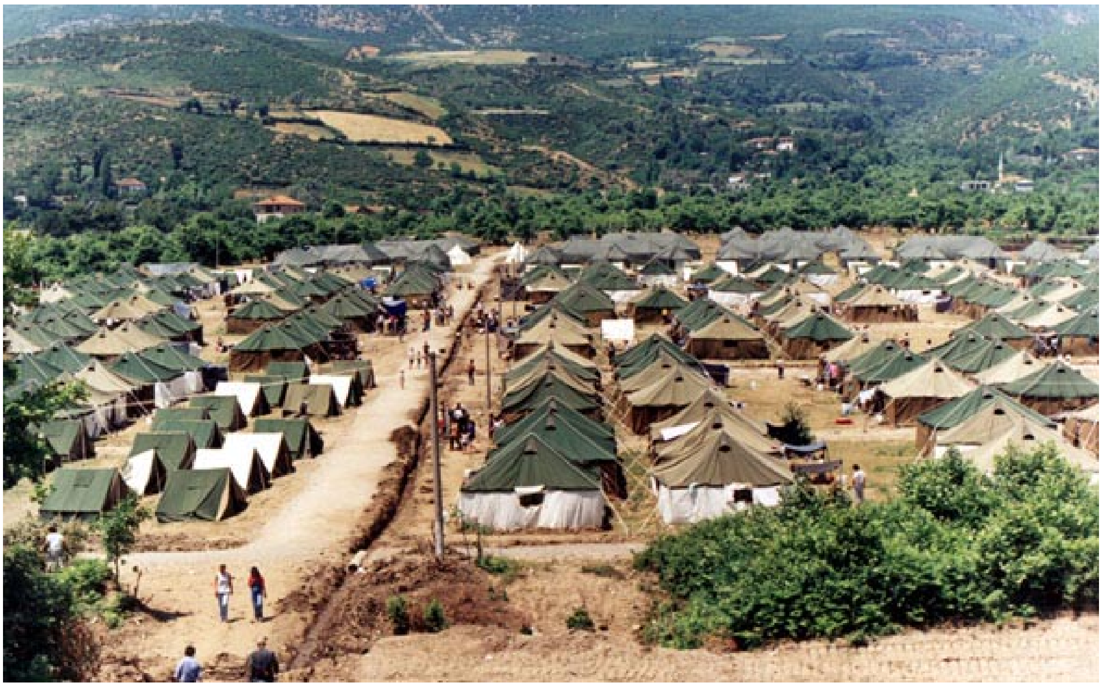
Schellenberg concludes, however, that the use of such tents as emergency shelter response cannot be avoided. The tents are relatively light, easy to transport, easy to erect and reasonable cheap and these are all typical advantages for contingency planning and preparedness. Unfortunately, tents used as an emergency response has often turned into long-term response, even if both seasonal temperature, and migrant need, changes significantly.

[82] *pers comm* Neumann, W. (April 2000). The stove unit was designed in the mid-90's in response to the Bosnian crisis.
[83] *pers comm* Schellenberg, W. (April 2000).
[84] Source: Schellenberg, W.
[85] UNHCR (1999) pp 145.
[86] *pers comm* Neumann W. (April 2000).

In locations such as Macedonia, the annual climate includes period of intense heat as well as cold and in these conditions the use of tents increases the potential for uncomfortably hot conditions in summer months as well as perishing conditions in winter months. This suggests that there are clear limits to the 'seasonal-appropriateness' of tents used as emergency shelter in such climates.

It has been possible to provide military winterised tents for refugee shelter in some emergency assistance programmes. In Albania and Macedonia during 1999, tents belonging to the NATO forces (in this case, KFOR) were used by UNHCR in camps for Kosovar refugees. These tents are comparatively sophisticated 'air-cushioned' tents with a better insulation value than the standard UNHCR winterised tent. These military tents can further be used with space heaters run on diesel generators, which are certainly safer heating devices than the family heaters burning wood fuel designed for use with the UNHCR tent. Big military tents are structurally more stable and allow inhabitants greater freedom to walk and move around. Such tents and their heating devices, however, are extremely expensive and delivery times for large quantities are very long[87].

Figure 14 Military tents used in Elbasen Refugee Camps, Albania[88].



[87] Air-cushioned military tents used in Kosovo cost approximately USD 24,000. *pers comm* Schellenberg, W. (April 2000).
[88] Source: Conlay, T. (DFID).

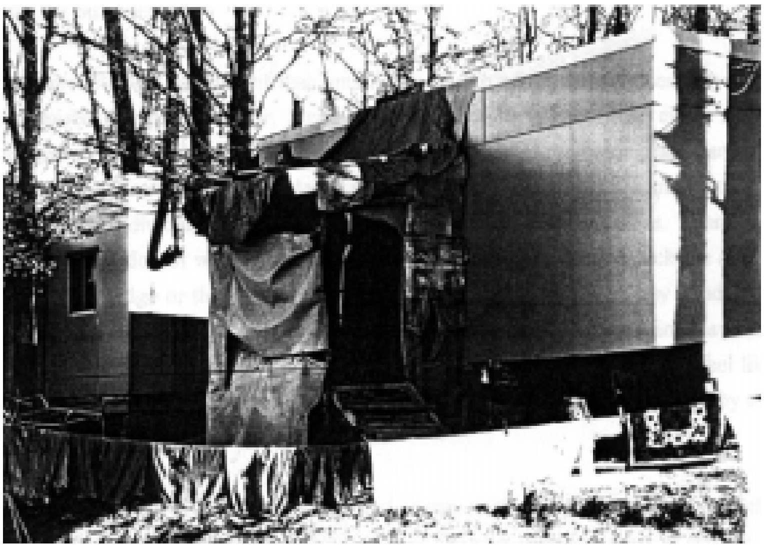
Furthermore, large tents are only suitable for short-term or transitional shelter and are hardly to be used to meet the shelter needs of individual families in remote mountain areas, for example, for isolated families in need of shelter in Kosovo's mountains, where families refused to leave their farm and cattle stock despite the conditions.

3.3.3 Non-Tent Response

Alternative pre-fabricated emergency shelter systems are restricted to the commercial and military sectors. UNHCR guidelines state, however, that neither pre-fabricated building systems, nor especially developed emergency shelter units, have proved effective in large-scale emergencies[89]. This is, however, only a partial truth. In a small number of shelter programmes in cold-climates, specialist pre-fabricated shelters have been provided successfully for displaced persons, some of which were large in scale.

In Kosovo during 1998/9, UNHCR invented the 'ridged shelter' approach. This was an insulated container shelter, manufactured locally from roof and floor timbers, plastic sheeting and insulation material. This was a reasonable cheap compromise and bridged the gap between the supply of more permanent winterised shelter[90]. Pre-fabricated timber frame shelters and 'Port-a-cabins' were used in many Serb and Bosnian refugee camps in Croatia during 1994, an example being Blace Camp, Eastern Slavonia which is illustrated below[91].

Figure 15 Blace Camp in Eastern Slavonia, Croatia 1994[92].



[89] UNHCR (1999) pp 145.
[90] *pers comm* Schellenberg, W. (April 2000).
[91] Camps were built through the German NGO GTZ. Ellis, S. (1996). pp 184.
[92] Source: Ellis, S.

In Northern Iraq during 1992/3, prefabricated units were constructed for Kurdish camps by UNHCR[93]. They opted for using prefabricated timber frame family shelters with double-skin cement-fibre panels sandwiching 40mm styrofoam boards. Heaters were distributed immediately after construction and the shelters were designed with fire-protected manifolds to take a flue pipe. These systems were relatively simple to construct and were joined with wedge shaped steel fixings that held the structure in place with friction rather than bolts. The floors consisted of compacted soil, which were later upgraded with insulated, suspended timber floors. The shelters proved reasonably airtight and it was possible to achieve a comfortable internal thermal environment with only a small heater unit[94]. The cross- section of the shelter was tent-shaped and so whilst providing for permanent inhabitation appeared temporary and this ensured that the shelter programme was accepted by the Iraqi government.

Three temporary villages of 6000 units each were built and they have proved to be a durable solution as they are still in use to this day. These pre-fabricated units, however, were unpopular with UNHCR bureaux and donor organisations as the cost for such shelters was USD 2000 per unit, which is equivalent to USD 100 per square metre. Furthermore, they weighed 2 tons were very costly to transport[95]. A similar response was implemented following the earthquake in Turkey for permanently displaced people and costs fell to USD 60 per square metre of sheltered space. This compares to a cost of USD 25 per square metre for the standard UNHCR tent.

3.4 Chapter Conclusions - The Need for Shelter Standards

The previous two sections have outlined the huge variety in agency response to the shelter needs of displaced persons. These shelter responses, however, have not always been informed by migrant requirements or the demands of the climate in which assistance is needed. It is unfair to blame agencies entirely for this failing, as the availability of funds for shelter assistance has played a key role in determining the choice and the use of shelter systems, and funding is rarely decided by agencies alone. It is worth stating again that donors for humanitarian aid are extremely cautious about involvement in shelter projects as the likely cost, and length of involvement, is so much greater than for all other sectoral assistance programmes. The huge disparity in the levels of funding between assistance programmes has also hampered appropriate response. For example, the funding for UNHCR shelter programme in the Kurdish crisis was between USD 500 to 5000 per capita, whilst the standard cost per family for the average African crisis is between USD 10 to 20[96].

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[93] *pers comm* Neumann, W., (April 2000).
[94] The heater size was 3kWatts, which is half that of the standard UNHCR heater.
[95] *pers comm* Neumann, W., (April 2000).
[96] Ibid. (April 2000).

Goovearts also notes that the exceptionally high shelter standards in some Bosnian and Croatian programmes, as compared with those standards of assistance in African emergencies, has also obstructed the formation of equitable shelter standards.[97]

It is fair to say, however, that few agencies have any permanent staff with substantial shelter implementation experience and this has led to confusion concerning the level of appropriate shelter provision in emergency programmes. For example, there was little consensus among agencies implementing emergency shelter assistance in Kosovo between November 1998 and March 1999 concerning how, and to what level, damaged housing should be repaired for immediate inhabitation[98]. There were vast differences in the level of agency competence and awareness in the field and the best that UNHCR could do was to recommend adherence to their own shelter policies developed for Kosovo from Bosnian models. The UNHCR shelter recommendations in this case, however, were not adhered to by all NGOs largely because programme funding obtained by many NGOs from donor organisations had been based upon grant applications whose detailed shelter aims differed substantially to those of UNHCR. Once programme funding was confirmed, agencies were often bound to implement the policies in their respective grant applications, even if they were found to be inappropriate at a later date.

In 1993, UNHCR organised the first international workshop on improved shelter response. This was the first time an international forum had been assembled to evaluate the state of policy and praxis in this sector. Goovearts' paper presented at the workshop is one of the most important papers to be written on the subject and identifies the main bottlenecks in the sector. His most salient criticism is the lack of global shelter and planning policies, which have hampered the provision of liveable environments for displaced persons. He highlights the need for social and climatic conditions to inform shelter standards as well as a detailed framework of how to assess for shelter needs. Environments containing severe winter climates and as well as those with high rainfall pose 'serious problems for current [emergency] shelter'. He notes that the current UNHCR tent is 'inadequate' for use as an emergency shelter solution and that other shelter assistance options, including repair and reconstruction, placement of migrants with host families and the conversion of communal facilities, need to subjected to similar re-evaluation for the formation of standards.

[97] UNHCR, (1993b).
[98] Author's experience.

The shelter policies of UNHCR came under close scrutiny in 1994 following external evaluation of assistance programmes within the former Yugoslavia and Northern Iraq. The report mentions specifically (1) the inadequacy of preparedness, (2) the lack of climatically appropriate and durable emergency shelter and (3) the lack of consideration for standards of provision for displaced persons[99]. The SPHERE guidelines, published in 1998, set out to combat such problems with donor and agency involvement, by obtaining consensus for a coherent set of aims for all programmes in all sectors, including that of shelter.

Most NGOs and donors have accepted the SPHERE standards in principle and they are proving to be useful as benchmarks with which to design and implement shelter programmes, even if the standards are not met in all cases[100]. The standards are, however, of limited use. They consist of lists of indicators and generalised guidance notes and do not go into substantial detail or refer explicitly to best field practice. For example, the guidelines concerning cold-climate shelter specifically are just a few hundred words in length. The guidelines mention that key factors for cold-climate provision should include external temperature, wind, insulation of the shelter, heating arrangements, available clothing and blankets and calorific intake. There is, however, no discussion of how much additional food or clothing should be distributed if there is no heating in a shelter. There is no discussion of the relation of shelter insulation to external temperature, or an analysis of the health implications for dense living in temporary accommodation in cold-climates. In addition to these technical considerations, there is no discussion of the social effects of living in temporary shelter in cold-climates, such as how the priorities of displaced people may change over time or as the season changes.

Furthermore, the SPHERE standards do not provide systematic product performance for emergency shelter systems or shelter programme assessment methods, which were both central recommendations from the UNHCR international shelter workshop in 1993. This dissertation now seeks to develop standards for emergency shelter in cold-climates through the design of a prototype shelter system for Oxfam. The next chapter discusses the methodology of the shelter design process.

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[99] Zetter, R. (1994).

[100] *pers comm* Corsellis T. (October 2000). It is of interest, however, that although UNHCR participated in the development of the SPHERE project, it did not to sign up to the completed standards, choosing instead to unilaterally identify and maintain its own policies. MSF took the same decision.

Chapter 4 Methodology

4.1 Introduction

This dissertation now focuses upon a design project for a cold-climate emergency shelter system in order to advance an understanding of cold-climate shelter assistance. This chapter explains the methodology for (1) the definition of the brief for the design project; (2) the development of prototype shelters and (3) the testing procedure for the best performing shelter prototype. The chapter concludes with a discussion of the limitations and assumptions necessary to validate the design project.

4.2 Defining a Brief

4.2.1 Project Background - The Development of a Hot Climate Shelter for OXFAM

In May 1999, the author completed the development of a new shelter system for displaced people in hot climate environments in collaboration with Oxfam[101]. This shelter system has been developed as a viable alternative to the expensive and often inappropriate shelter systems currently available on the commercial market. In summary, the hot climate shelter offers two significant advances on existing systems: it is assembled, rather than being fabricated, from material readily available in the construction industry. This serves several key purposes including; (1) reducing shelter lead-time to that needed only to purchase the material, (2) procuring only materials from competitive regional markets and (3) employing materials that are useful in later reconstruction phases. (*This shelter has just been deployed by OXFAM to El Savaldor following the earthquake last week – 16/01/01).

Despite the fact that shelter clearly has very different objectives in hot and cold-climates, many of the construction issues, and criteria for material selection during an emergency phase, are similar. These criteria include low packed shelter volume and weight and simple construction. For this reason, the cold-climate shelter prototypes uses the OXFAM hot climate shelter design, and structure, as a point of departure for the design of a cold-climate emergency shelter system. It is also noteworthy that using a single structural system allows for the development of a 'family' of compatible shelter systems that can be adapted for use in any given environment. The figure below shows the Oxfam hot climate shelter at the Inter-Agency Technical Co-ordination meeting (ITC) at Bordeaux in 1998 and in use in a Sudanese refugee camp in Kenya. Refer to Appendix 1 for further details of the shelter system.

[101] The hot climate shelter system was developed by Howard, J., Corsellis, T., Manfield, P., and Martin, J., from 1997/99 and has since become the new shelter standard for OXFAM. Refer to Martin (1999) for specifications.

Figures 16 & 17 The OXFAM Hot Climate Shelter System[102]

Oxfam shelters are in the centre of the picture (Neumann's cardboard tube shelter is far right)

Dinka refugees inside an Oxfam shelter on the Sudanese border

4.2.2 Consultation and Review

It is sensible to return once again to the UNHCR guidelines and other reference literature to formulate a brief for a cold-climate emergency shelter system. Five primary concerns are raised concerning their use: [103]

- High unit cost
- Long shipping time
- Long production time
- Transport problems including cost of transport
- Inflexibility

It is interesting that the first four concerns of UNHCR, as written in the guidelines, are logistical problems, which are largely issues for agencies rather than for refugees. It is only the last concern that refers to the standard and appropriateness of shelter provision. The guidelines are no more explicit about this last point, but one may speculate that 'inflexibility', in this case, refers to the inability of shelter systems to respond to both emergency phase shelter needs as well as medium to long-term shelter needs. These needs include response to changing local environmental conditions and the changing social needs of occupants.

[102] Refer to the OXFAM Emergency Guidelines on Water, Sanitation and Shelter Packs for further details.
[103] UNHCR (1999) pp 145.

Goovearts also notes that [emergency] shelter systems should provide the following[104]:

- dry floors
- the fabric construction should allow control of ventilation and humidity
- the insulation value of the fabric should be the demands of the climate to reduce heater-fuelling requirements.

A near comprehensive set of design criteria are now identified, building upon the issues identified above. Discussions with technical advisors within Oxfam's Emergencies Department and UNHCR staff have further informed the brief. The brief is broken into three sections (1) logistics criteria (2) environmental criteria and (3) social criteria. The brief is defined and developed in detail in Chapter five.

4.3 Developing a Prototype

Prototype development is separated in two parts, the results of which are discussed in chapter 6. The first part is to identify suitable materials. The structural system uses the same design and materials as for the hot climate shelter system developed for Oxfam described in the previous section. Therefore, the remaining materials to be selected are those to insulate the roof the floor and the doors of the prototype. The table below illustrates the criteria used to select appropriate materials.

[104] UNHCR (1993b). pp 4.

4.3.1 Insulation Material Selection

Figure 18 Nominal Insulation Component Selection Criteria

	(Insulation value)
1	'U' value
	(Cost)
2	Unit cost
3	Bulk purchase price
	(Production)
4	Weight
5	Packed volume
6	Extent to which production is standardised
7	Number of manufacturers world-wide
8	Lead time (for supply of material for 1000 kits)
9	Compatibility of production dimensions
	(Degradation)
10	Chemical
11	Fire
12	Water moisture/vapour
13	Human use
14	UV light
	(Environmental Health)
15	Toxicity when burnt
	(Structural Performance)
16	Tensile strength
17	Compressive strength

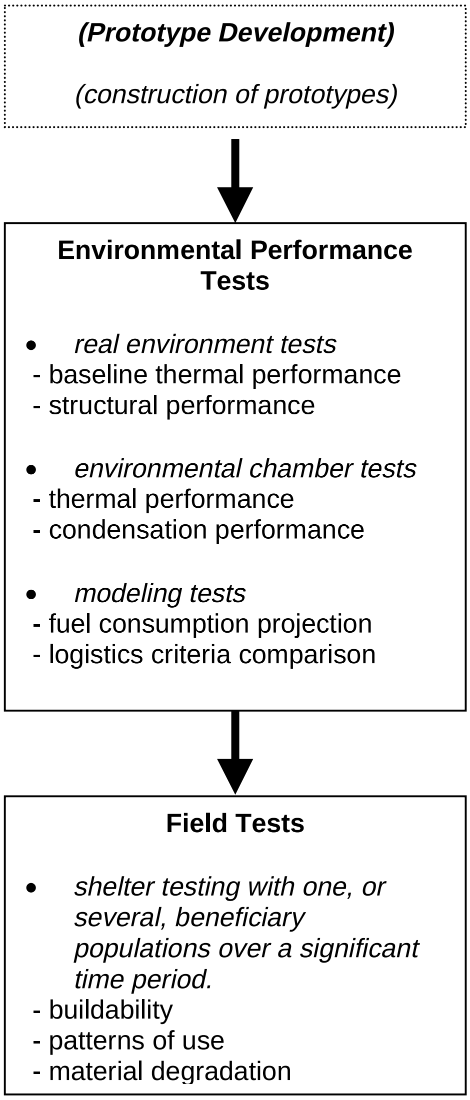
4.3.2 Prototype Construction

As a first step to ascertain what is possible to build, it is necessary to physically construct several shelter prototypes. The aim of this part of the testing procedure is to ascertain that a shelter prototype remains within 'buildable' limits using materials that conform to the environmental, social and logistical criteria described earlier in this chapter. In this way, inappropriate designs and materials can be eliminated before more involved testing is undertaken.

4.4 Forming a Testing Procedure for a Prototype Shelter

A series of tests can be then undertaken having selected the best performing shelter prototype from the previous development phase. The diagram below indicates the testing procedure.

Figure 19 Testing Procedure for an Emergency Shelter System



4.4.1 Physical Environment Tests

Empiric environmental testing of a prototype shelter in a real environment, but outside of an aid programme, allows the design team to quickly assess performance in use without the expense of environmental chamber testing or the risk of field deployment. This phase should include subjective social tests, such as living and sleeping inside the shelter, erecting and disassembling the shelter kit with and without instructions, and baseline environmental tests, such as the evaluation of the air temperature differential between inside and outside air with, and without, the use of a heater. A series of structural tests should also be undertaken for wind and snow loading in a real environment. The design project did not allow adequate time for these tests to be performed.

4.4.2 Thermal Performance Tests

The next stage of testing involves placing a shelter inside an environmental chamber to allow the thermal and structural performance to be measured with a greater degree of accuracy against key environmental parameters such as wind, temperature. This section describes an experiment that was designed to determine whether the shelter and a small heater were capable of providing a habitable environment under extreme winter conditions[105]. There were two principal objectives for the thermal performance experiments;

1. Determine the thermal properties of the shelter and generalise the findings to predict performance 'in the field'.

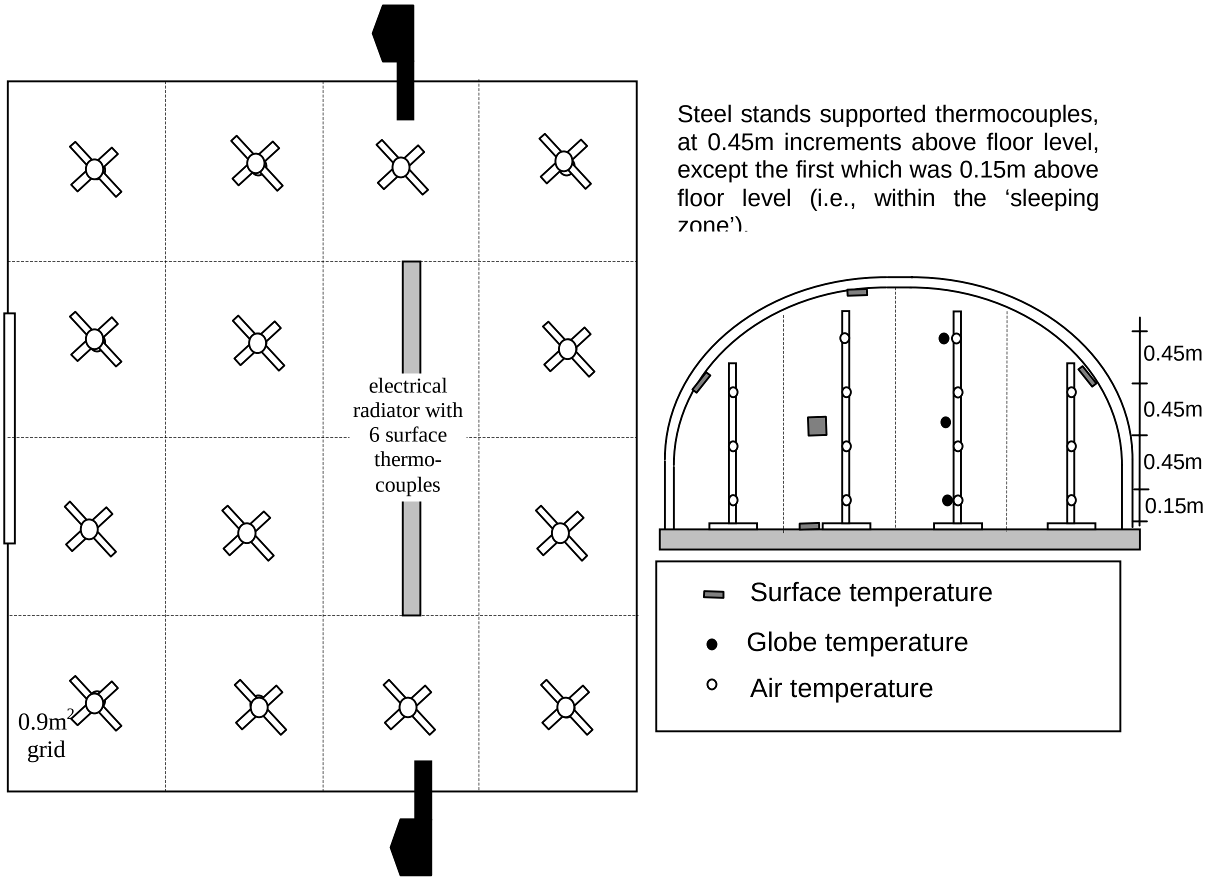
2. Determine the variability of the indoor environment and the likelihood that thermal comfort can be achieved.

The indoor climate monitoring was designed to address the extent of thermal stratification and the occurrence of draughts within the comfort zone due to air leakage. Radiant temperature is also important for human comfort. To address this issues, the following instrumentation was fitted (Figure 20). Using the results from this monitoring, in conjunction with a known power input to an electrical heat source, it is possible to derive heat loss coefficients under a range of test conditions. A car manufacturer agreed to allow the use of their environmental chamber for the first experiment[106], inside which it was possible to manipulate both temperature and wind. The aim of the experiment was to gauge the thermal performance of the shelter with a small heat source whilst in an environment at minus twenty degrees Celsius and whilst experiencing various wind speeds up to a maximum of 12.5 metres per second (Gale Force 6).

[105] The thermal performance experiments were designed with Dr. D. Robinson, formerly at the Martin Centre, Cambridge University.
[106] This test was undertaken at the Ford Driveability Test Chamber (DTC) at Dunton, Essex, UK.

The shelter prototype was placed inside the test chamber and an array of 56 thermocouples, 3 globe thermometers, and 8 surface thermocouples were added: (1) inside the shelter on metal stands, to form a three dimensional grid; (2) on the shelter surfaces, both inside and outside; and (3) on the heater[107]. In addition, a thermal imaging camera was used to produce graphical data to substantiate findings from the thermocouple readings.

Figure 20 Indoor Climate Measurement Apparatus



Surface temperature sensors were placed on each main plane. For essentially vertical surface, these were at the mid-height. Globe temperature sensors were positioned on one central stand (near to the door). All air and surface temperature measurements were recorded at 15-second intervals. The numbers of sensors that were required is tabulated below.

[107] Globe thermometers measure both air temperature and the radiant environment to give an overall reading of thermal comfort.

Figure 21 Sensor types and numbers

Sensor type	Number
K-type thermocouples for air / surface temperature	48 / 12
Globe thermocouples	3
Electrical power consumption recorded	1
Infrared thermograph camera	1

The following six experiments were designed:

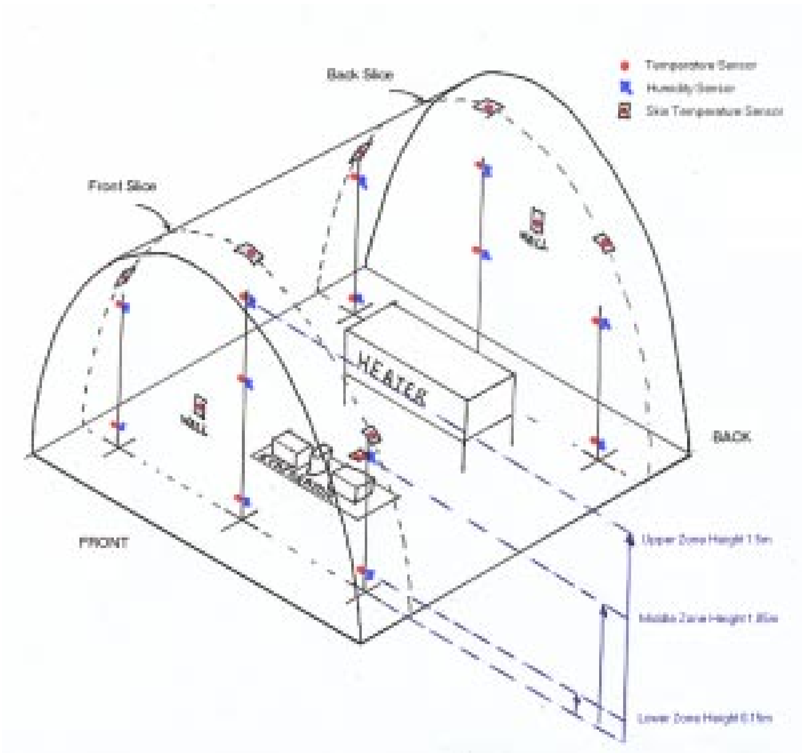
1. Warm-up without wind to evaluate shelter thermal time constant.
2. Normal orientation (rear of shelter facing wind), preconditioned (structure already heated) and light wind ($2.5ms^{-1}$).
3. Normal orientation, preconditioned and medium wind ($7.5ms^{-1}$).
4. Normal orientation, preconditioned and heavy wind ($12.5ms^{-1}$).
5. Preconditioned and no wind.
6. 45^{o} orientation, preconditioned and medium wind.

4.4.3 Condensation Tests

An experiment was also undertaken by Crawford at Cambridge University Department of Engineering in December 1999 to evaluate the effects of moisture production upon internal living conditions. For this experiment, the prototype shelter was erected inside a cold chamber at minus 20 degrees Celsius and a water evaporator placed inside the shelter to mimic the production of water vapour from habitation by 6 occupants (including respiration, cooking and washing). A small heat source was also placed inside the shelter. A range of temperature and humidity sensors were placed inside the shelter in two vertical sections to measure the effects of moisture production upon surfaces and the relative humidity of the internal air. The figure below illustrates the testing apparatus used for the experiment[108].

[108] The experiment is described in detail in Crawford, C. (2000).

Figure 22 Condensation Testing Apparatus[109]



4.4.4 Shelter Prototype Modelling

Test results from the environmental chamber allow for the calibration of several thermodynamic models. The Environmental Systems Performance programme (ESP), developed at the University of Strathclyde, was used to predict the performance of a shelter over a prolonged time period within real environments. This can be used, for example, to calculate the fuelling requirements of a shelter over a winter period in a specific location. The author and Kate Crawford at the Engineering Department, University of Cambridge, undertook this experiment[110].

A second computer model, called TAS Ambiens, was used to create two-dimensional thermal pictures of the shelter to obtain greater resolution of the internal thermal environment of the shelter, and is useful for monitoring the effects of design changes to the original calibrated prototype model. In addition, several simple spreadsheet models were built in MSExcel to predict changes in logistical values relative to design changes made to the original prototype. These experiments were undertaken by the author in a later paper[111].

[109] Source: Crawford, C. (2000).
[110] Ibid.
[111] The experiment is described in detail in Manfield, P. (2000a).

Once the basic properties of a shelter prototype have been established, for example, identifying and quantifying the main sources of heat loss, modeling can be undertaken to assess the thermal efficiency of the prototype. Simple spreadsheet models can be built to quantify the effects of changes to construction, such as calculating the new temperature differential resulting from an increase in the insulation value for one or several component parts.

4.4.5 Field Tests

The final stage of testing is to deploy the shelter to the field within an agency shelter assistance programme. This is the acid test for a shelter system and will establish whether assumptions made during the design phase hold true in reality. It is important that this final test should be undertaken, when possible, with several beneficiary populations in order that an average response can be gauged, particularly with reference to social criteria, such as ‘buidability’, and the way in which the use of the shelter, and its component parts, changes over time. Field-testing was not undertaken in this project.

Chapter 5 Defining a Brief

5.1 Introduction

This chapter describes the design brief in detail. The brief is derived from a review of the limited available literature and consultation with John Howard, and others, at Oxfam Emergencies department. Criteria are quantified where possible and assumptions are made where data is unavailable.

5.2 Consultation and Review

Before moving on to a detailed analysis of the factors affecting shelter provision, a central dilemma relating to method must be addressed;

> *Should a shelter system be optimised for the average cold-climate condition, or for the worst-case cold-climate condition?*

Calculating the average cold-climate condition would perhaps be the most appropriate for the formation of such a universal piece of equipment. The likelihood is that 'worst case' conditions will only be manifest for a small proportion of the occupation period in the majority of 'cold-climate' environments and any standardised shelter system must further perform in climates on the boundary of the generalised UNHCR definition of 'cold-climate'[112]. Calculating average information would also allow for a more accurate evaluation of key social parameters as well as the technical and environmental criteria. For example, a better understanding of the building skills of recently displaced persons in the Balkans and in the Caucuses would give an indication, although not a failsafe guarantee, of the level of appropriate construction and technology to be used. The data necessary, however, for such a definition is not currently available.

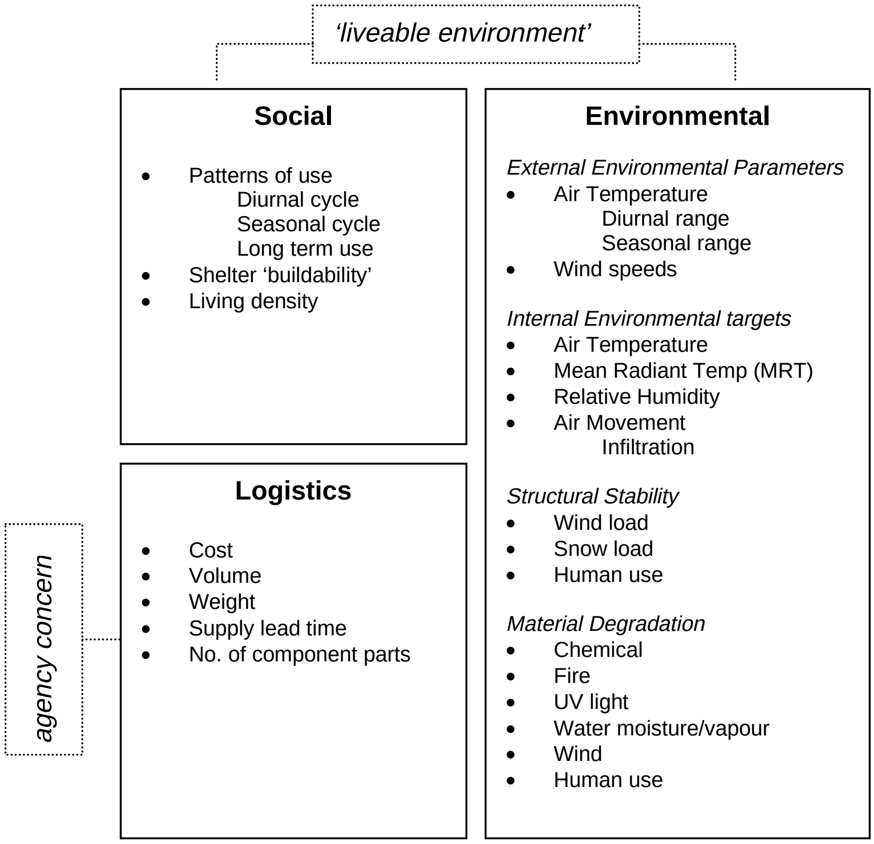
An alternative strategy would be to determine the most severe conditions under which emergency shelter assistance is considered viable. Whilst this is certainly the safe option for the aid community, such as approach might well be wasteful of resources in non-severe cold-climates. Despite the drawbacks, this project uses the latter strategy and refers to the environment in highland Kosovo to inform key environmental and social criteria for the brief. Highland Kosovo has a particularly extreme climate in winter and conversations with various aid staff confirmed that it is one of the most severe environments in which emergency shelter systems have been deployed.

[112] Refer to the glossary for the UNHCR definition of cold-climate.

5.3 Criteria Affecting Shelter Provision

The diagram below splits the design brief into three distinct areas of concern.

Figure 23 Criteria Affecting Shelter Provision



The diagram above is not an exhaustive list of criteria but rather represents the key concerns that agency staff will have to address when selecting and specifying emergency shelter. In theory, it should be possible to quantify the majority of criteria described within the logistics and environmental sectors. The lack of available field data, however, means that some values for criteria in these sectors have to be assumed. It is not possible to assign explicit values for the all the social parameters and their inter-relation with many logistics and environmental criteria further undermines the credibility of designing to definitive values. For example, the simplicity and ease with which a shelter system can be erected, nominally a social criteria, is linked to the number of component parts, a logistics criteria. If the number of component parts is defined too rigidly, simplicity may reduce the potential for flexibility.

Therefore, where the design brief cannot be quantified, it remains discursive rather than prescriptive, and tentative generalisations within substantial tolerances are offered instead[113]. The factors affecting shelter provision are now described in it constituent parts together with the reasons for selecting each criteria.

5.3.1 Logistics Criteria

Logistic criteria are largely informed by the UNHCR winterised tent, which has been the most consistently used cold-climate emergency shelter system in relief programmes in cold-climates.

Shelter Cost. As previously stated, the cost for shelter assistance, per capita of beneficiary population, exceeds by far the costs of other sector assistance programmes in the majority of emergencies. This means that the cost of a shelter design is a primary agency concern. In absence of relevant data, the UNHCR winterised tent has provided the best guide for target pricing, as it represents a degree of consensus between donor organisations and operational agencies concerning an acceptable, and achievable, expenditure per capita for emergency shelter needs in cold-climates.

The UNHCR tent has a floor plan of 16m^2 and costs approximately £125 sterling[114]. This is equivalent to £17.80 sterling per person, assuming the same living density as those for the design brief of this project. A target cost of £200 sterling was eventually decided upon with Oxfam for a complete shelter system, inclusive of any packaging costs[115]. This is equivalent to £33 sterling per person. This higher cost, as compared with the UNHCR winterised tent, is justified by much higher insulation levels and hence lowers running costs.

Shelter Weight. The shelter should be light enough to be carried and constructed by one family group[116]. It was further decided with Oxfam that it should be possible to carry the shelter with a maximum of 3 people, as it cannot be relied upon that the entire family will be fit, healthy or of an age to help carry equipment[117]. A carrying weight of 35kg per person was agreed with OXFAM. Hence, with three people carrying the shelter system, the target for total weight was set at 105kg. This is also the approximate weight of the UNHCR Tent.

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[113] For further discussion concerning the combination of social and technical consideration for shelter and physical planning refer to ACCESS in Corsellis, T. (2001).
[114] Cost excludes works transport. *pers comm* Neumann, W. (August 1999).
[115] *pers comm* John Howard, OXFAM GB.
[116] Refer to a later discussion of living density under Social Criteria in this chapter.
[117] *pers comm* Howard, J. (August 1999).

Shelter Volume. The shelter kit should be compact enough to be carried by two to three persons and be sufficiently compact to minimise transportation costs, either by air or land[118]. A target volume of $0.5m^3$ was decided upon for this project. The un-insulated UNHCR tent has a packed volume of $0.28m^3$. This value is substantially higher than that of the UNHCR tent, but it is hard to envisage how insulation material can be added to the shelter without significant affecting total volume.

Supply Lead-time. Supply lead-time, as discussed in Chapter 5.3.1, proved critical in the provision of emergency shelter in Macedonia during 1999 and is one of the five key concerns listed by UNHCR in their guidelines. For this reason, materials for component parts of the shelter should be chosen from industrial manufacturers that have either the production capacity, or substantial material stockpiles, to cope with large and spontaneous demand. This means that material can be supplied in bulk and at short notice to meet the unpredictable needs of humanitarian emergencies. Using global material standards further increases the likelihood of local production and hence local procurement. Local procurement will significantly reduce transportation time and associated costs. The time period for any one component from order date to delivery for adequate material for 1000 shelter units was fixed at ten to fourteen days[119].

5.3.2 Environmental Criteria

External Environmental Parameters

External air temperature. External air temperature is perhaps the single most important climatic parameter for refugee health in cold environments and gives the clearest indication of the risk of mortality within a DP from the climate. In the primary stages of an emergency, air temperature range should be used to assess the importance of shelter relative to other sectors of assistance. The most useful climatic data to obtain for a specific locality is the diurnal air temperature range in both winter and for all other seasons. It is also necessary to gauge the thermal performance of the shelter under various wind speeds, as heat loss from tents due to infiltration is high.

The obvious problem for defining design targets for air temperature, as discussed in Chapter 5.2, is deciding which climate, or set of climates to choose. Kosovo was chosen and the monthly weather file for the Djakovica/Albania border in Kosovo detailed below has been extrapolated from data from the closest weather station, which is Pristina:

118 *pers comm* Howard, J. (August 1999).
119 *pers comm* Howard, J. (August 1999), Neumann, W. (April 2000), Carlson, J. (February 1999), Saalovara, A. (August 1999).

Figure 24 *Average daily air temperature and average monthly wind speeds for Highland Kosovo*[120]

Location:		Djakovica/Albania border	
Altitude	**+ 900 m**	**lat: 42.4°**	**long: -20.35°**
Winter months	*Avg. daily max. temp*	*Avg. daily min. temp*	*Avg. monthly wind speed*
	°C	***°C***	***m/s***
November	5.90	-0.28	3.1
December	1.85	-4.27	3.1
January	1.00	-5.93	3.6
February	4.67	-4.86	3.5
March	9.44	-0.31	3.6

Kosovo is a plateau surrounded by mountain ranges to the north, south and west of the province. Temperatures on the plateau (Pristina) can reach –15°C at night in the month of December and reaches –20°C or lower temperatures at higher altitude. The average monthly minimum air temperatures detailed above are appreciably higher but can be used to predict heating and fuel requirements for the most extreme environments in Kosovo. It was decided to test the shelter to –20°C as it would be extremely unlikely that any number of heated shelters could be maintained in more severe conditions where the logistics of the provision of aid becomes unrealistic[121].

Wind speed. It was not possible to obtain data for maximum wind roses in Highland Kosovo, but average monthly data was found. The average wind speed data for this location indicates low to average monthly values, but it is likely that exposed localities will have much higher average wind speeds and most locations will experience gusts of higher, but undefined, wind speed. Therefore, the data obtained is not particularly useful for defining wind speeds for structural stability tests, but the data can be used to calculate average thermal performance over a winter period. In the absence of maximum wind speed data, it was decided the shelter should be tested in still, ambient wind conditions and at several intermediate speeds up to a maximum of 12.5 m/s or Gale Force 6.

[120] Data obtained from METEONORM Version 3.0.
[121] *pers comm* Howard, J. (August 1999).

Internal Environmental Targets

Internal environmental targets are split into four criteria (1) internal air temperature (2) mean radiant temperature (MRT) (3) relative humidity and (4) air movement and infiltration. Before each criteria is discussed, it is necessary to first make some difficult decisions concerning both the thermal comfort of occupants and the level of sufficient, and appropriate, humanitarian assistance.

Thermal comfort is defined as "that condition of mind in which satisfaction is expressed with the thermal environment"[122], which implies the inclusion of subjective criteria, as well as directly measurable data. The chief factors affecting thermal comfort include, but are not limited to, the four criteria listed above[123]. Thermal comfort affects refugee health and, ultimately, the mortality rate in cold-climates. It is noteworthy, however, that the conditions for thermal comfort will vary between, and within, beneficiary populations and this presents problems for a specification of a standardised shelter system. The following example illustrates the point;

Afghani refugees from nomadic backgrounds survived several very cold winters during their displacement in the early 1980s without proper heaters inside canvas tents[124]. Such a low standard of shelter assistance was considered an inconceivable option for Kosovar refugees in Macedonian camps during 1999. This has to do, in the main, with the high level of available funding for the Macedonian crisis, but it was also linked to the understanding that many Kosovans refugees had previously lived in urban locations and that their perception of thermal 'comfort'[125], was likely to be more sensitive than that of nomadic refugees from the highlands of Asia. It is admitted that adapting shelter programmes to perceived cultural differences in thermal comfort is a dangerous road to tread, as failure to identify vulnerable groups, such as the sick or the elderly, may expose such people to an unacceptable health risk. Nonetheless, the issues of 'refugee expectation' and previous 'physical conditioning', are certainly factors considered by donor agencies when awarding funds to emergency programmes and, indeed, by operational humanitarian agencies when assigning scarce resources.

Internal Air Temperature. An internal temperature target for temporary shelter that reflects contemporary building standards, such as those in Europe, would be ideal. It is recognised, however, that it is not possible to meet these internal temperature standards if sufficient heating equipment and fuel cannot be sourced locally by a displaced population, or supplied by humanitarian organisations.

[122] ASHRAE (1989). Section 8.16.
[123] Lechner, N. Heating, Cooling, Lighting (1991). p. 28.
[124] *pers comm* Neumann, W. (April 2000).
[125] 'Comfort', in this instance, refers to the conditions necessary for survival.

In these first stages of an emergency, UNHCR advocate the provision of 'survival conditions' and appropriate levels of bedding and clothing are distributed in the absence of available heating equipment and fuel[126]. Internal air temperature in such conditions will track that of the outside air or may be several degrees higher depending on the shelter, tent or building being inhabited, and the risk of mortality is high. UNHCR acknowledges, however, that the provision of clothing and bedding alone is not sufficient, or acceptable, for the needs of a DP over the duration of an entire winter period. Displaced people have a right to a 'liveable' rather than a 'survivable' environment beyond the very short-term phases of assistance and in these later phases, UNHCR guidelines stipulate that the internal ambient temperature inside a shelter should be between 15 and 19 degrees Celsius[127].

The UNHCR air temperature target range is certainly necessary for vulnerable groups such as the elderly and the very young, who are especially susceptible to heat loss from changes in air temperature, as their surface area to body ratio is high when compared to that of adults[128]. O'Connor, however, quotes average European bedroom temperatures at 14 degrees Celsius, which suggests that a lower target temperature range might appropriate for the majority of a population if similar standards in clothing and bedding are also provided[129]. This divergence in needs within a potential DP indicates that adherence to inflexible temperature targets and standards have the potential to be either wasteful of limited resources or place individuals within a DP at a higher health risk. Despite these difficulties, the average mean target temperature for the internal shelter environment was set at 16^{o}C ± 4^{o}Celsius[130].

Mean Radiant Temp (MRT). The radiant temperature inside a shelter will be largely determined by the type, and kilowatt output, of the heating device employed, and represents a key design criteria for the stove rather than the shelter system. It is important, however, to realise that the design of a shelter system also impacts upon the radiant environment. Radiant temperature is affected by the temperature of internal surfaces of the shelter as well as those of the heater itself. The average internal surface temperature of a shelter is also likely to track outside air temperature if there is little or no insulation in the shelter construction, and this leads to heightened asymmetry in the radiant environment. No target value is set is for MRT, although the radiant environment will improve for occupants if the shelter is highly insulated.

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126 UNHCR (1999) pp 144.
127 Ibid. pp 146.
128 Manfield, P., & Corsellis, T., (1999). Appendix 3, pp 2.
129 Ibid.
130 *pers comm* Rory O'Connor. (August 1999).

Relative Humidity. Relative humidity (RH) refers to the amount of moisture carried by a unit volume of air at a specified temperature as a proportion of its saturation level, and it is measured in percent. In general, humidity has a small part to play in people's perception of thermal comfort, although high ambient humidity, ie that above 70%, will contribute to precipitation of vapour in the immediate surroundings creating damp conditions. Prolonged exposure to this RH level will encourage microbial growth on surfaces and increase the incidence of fungal skin infections, ear infections and mild respiratory illness. Relative humidity below 30% causes a significant drying action on the eyes and the skin and there is also impairment of the secretion of mucus in the respiratory passages and impairment of the function of the ciliated epithelium. This predisposes to a dry cough initially and an increased risk of infection[131].

Relative humidity becomes a health risk at significantly high or low values. Fifty percent relative humidity is comfortable for most humans whilst 20-80% RH can be tolerated. This value range will depend, to some degree, on the beneficiary population[132].

Air Movement and Infiltration. Air movement is an important component of thermal comfort. Occupants living in temporary shelter in cold-climates would tend to be more comfortable with no air movement as this minimises convective heat loss from the surface of the skin. Some air movement is required, however, to provide a minimum air change rate which is necessary to guarantee the removal of waste and toxic gases from respiration, cooking and burning fuel. The necessary fresh air supply rate for a shelter containing 6 occupants, assuming there is no smoking, is 12 litres per second per person (l/s/person). The necessary air change rare rises to 18 l/s/person for when occupants smoke and/or the stove is being used for cooking, and this corresponds to an air exchange rate of 1.5 air changes per hour (ac/h) [133].

Structural Stability

The structural stability of a shelter is dependent on (1) wind load (2) snow load and (3) human use. Each of the three criteria are discussed below.

Wind load. A shelter is at greatest risk of structural failure during buffeting wind conditions. These conditions can occur where an average wind speed is relatively low, but where there are also shorter, high speed gusts[134].

[131] Manfield, P., & Corsellis, T., (1999). Appendix 3, pp 3.
[132] *pers comm* Rory O'Connor. (August 1999).
[133] CIBSE Handbook (1997).
[134] *pers comm* Baker, N. (August 2000).

Thus, defining a maximum average wind load for the design brief does not offer any guarantees for structural stability in the field, as failure is possible in low average wind speeds. Testing for such failure is best undertaken empirically in the field within real shelter assistance projects.

Snow load. Photographic evidence from Kosovo confirms that tents are at a high risk of failing due to snow loading[135]. Heavy snowfall during the night presents the highest risk of structural failure, as it is unlikely that anyone is awake and able to remove the build up of snow at regular intervals. No data was available to set a maximum snow load and no testing was undertaken.

Human use. Occupation and use of relief shelters is intense. This intensity is increased in cold-climates because occupation rises to close to 24 hours per day. The wear on elements such as the door, which is in near constant use, and the wall sections, which are loaded and unloaded daily with personal belongings, takes its toll. Any shelter systems will have to use materials that can cope with such usage. Testing structural stability through human use was not undertaken in this project.

Material Selection

All component materials will have to be tested for degradation from the various causes outlined in figure 23 . Fortunately, most standardised construction products have supporting environmental health literature relating to use within the building trade. This may not, however, always be relevant in a relief context. These two examples illustrate the point; (1) flame spread fire tests on products for use in cladding systems may not guarantee fire protection on the inside of a heated tent. (2) All plastics degrade when exposed to light and the high surface to volume ratio of reinforced polyethylene aid sheeting means that this product may be vulnerable to significant degradation over an anticipated life span. Most UV degradation testing to date on such products has been undertaken in laboratory conditions and no empirical field data exists, especially in cold-climates[136].

[135] Refer to Figure 10 showing the UNHCR winterised tent failing under snow load in Kosovo.
[136] Ogier, P. (1997) UNHCR/MSF Sheeting Standards Research.

5.3.3 Social Criteria

The importance of social criteria for shelter design should not be under-estimated. The temptation in a project, such as this one, is to design to what is easily quantifiable. Hence, the majority of shelter systems produced in the commercial sector refer exclusively to criteria described in the logistics and environmental sectors. Therefore, this section seeks to expand upon the UNHCR definition of an appropriate 'liveable environment'.

Patterns of use. It is necessary to understand what is involved in the daily lives of displaced persons living in temporary shelter. The daily ritual of living in emergency shelter in a cold-climate has been informed by an interview with Lalah Meredith-Vula, whose family and friends lived in a UNHCR tent in Northern Albania during the winter of 1999/2000. Further resolution has been added through experience of the author and literature review of non-relief shelter.

Most tents are not designed to be occupied constantly in cold-climates. Even nomadic groups who live in cold-climates, such as the Turkic yurt dwellers of the Steppe, and the Koryak and Chukchi from Upper Siberia, spend a significant portion of their lives outside[137]. Living densities of these peoples inside their homes are also markedly lower than those of UNHCR standards for refugees[138]. It can be concluded, therefore, that prolonged and enforced occupation of tents and tent-like shelters in cold-climates is a particularly unnatural state of inhabitation for most humans, and especially unnatural for the majority of refugees who are not nomadic.

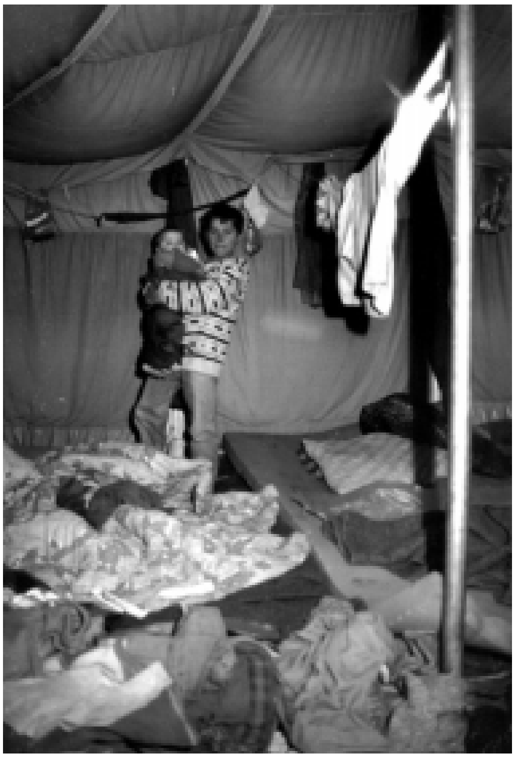
Kosovo Case Study

Emergency Phase. UNHCR winterised tents were distributed to returning refugee families in Kosovo during November and December 1999, where there was no suitable buildings for temporary repair, as most had been destroyed by heavy artillery and tanks or had been burnt down[139]. The families concerned were largely self-sufficient farmers from Djakova, Prizren and Malesevo districts who had been repatriated from refugee camps in Kukes, Albania and were known to the interviewee. These families received clothes, blankets and cooking implements in addition to a winterised tent, but no food, heater fuel or additional shelter materials was distributed in these initial phases of assistance. Their daily routine included the collection of water and salvaging building materials from damaged buildings.

[137] Oliver, P. (1997). p. 832.
[138] Manfield, P., (2000c).
[139] *pers comm* Lalah Meredith-Vula (April 2000).

No sanitation infrastructure remained, and so personal washing and clothes washing occurred outside and people defecated in nearby bushes. Inside the tent, space for men and women's were separated and the old and the very young were placed together around the heater in the centre of the tent. Bedding was placed on planks to reduce heat loss to the ground and belongings were piled against the sidewalls of the tent. Everyone wore lots of clothing layers all of the time and there was a perpetual smell of mould and body odour.

Figures 25 Inside the UNHCR Tent during Winter in Kosovo



Post-Emergency. The tent continued to be used as somewhere to sleep, but reoccupation of damaged buildings increased as agencies provided shelter materials for temporary building repair to more and more families. The children were sent to school, where possible, or put to work on salvaging building material. Some men in better health slept in the remains of damaged housing as the weather improved to relieve the pressure inside the tents. Seed planting occurred later in spring, but the crops were only half grown, so families were largely fed on the remaining livestock.

Long-term Reconstruction. When the winter months were over, widespread reconstruction began in Kosovo. By April, the snow had disappeared and the average daily air temperature rose quickly allowing for concrete to mixed and timber roof repairs.

The data above points to the need for emergency shelter to be assembled from indeterminate materials rather than fabricated and tailored tents, allows for a range of potential uses and adaptations following the emergency phases. This allows for simple disassembly to permit use of individual component parts. For example, materials that can be used to provide temporary rehabilitation of damaged buildings, such as plastic sheeting and rolls of roof insulation, can also be used for temporary roof repairs and so reduce the need for subsequent material distributions by agencies. Furthermore, indeterminate materials allow greater potential for a beneficiary population to participate in solving its own shelter problems with greater autonomy and make more appropriate climatic shelter responses as the physical and political environment changes with time.

Shelter 'Buildability'. 'Buildable' in this instance refers to the extent to which the construction process needed to erect the shelter is achievable according to a consensus understanding of the average building skill levels possessed by forced migrants. In the absence of any reference literature, the field experiences of aid staff are used to inform shelter prototype construction.

Living Density. Shelter living density standards are also often disregarded by UNHCR in order to maintain access for the maximum possible number of displaced persons[140]. Living density is essential for occupant wellbeing, personal privacy and for health. In addition to the interview data for Kosovo, independent anthropological studies in Rwanda in 1995 indicate that there are long-term problems associated with high-density living, including aggressive and violent behaviour[141]. The photograph below illustrates a shelter in Kibeho camp in 1994.

Figure 26 Shelter in Kibeho Camp, Rwanda 1994.

[140] Cuny, F., (1977).

Dense living makes personal hygiene harder to maintain and in cold-climates and increases the moisture production inside a shelter (from respiration, cooking and washing), which increases relative humidity, the effects of which are discussed earlier.

The UNHCR shelter standards for cold-climates recommend $4.5m^2$ of sheltered floor area per person. This would mean less than 3 beneficiaries could fit comfortably into a shelter using the hot climate shelter structure with its floor area of $13m^2$. While this standard is fully supported, in reality, the cost implications make this figure unlikely for the majority of emergency shelter assistance programmes. Following conversations with agency staff, it was decided that testing should proceed on the assumption of a maximum capacity of 6 people. This was based on the fact that the UNHCR tent with a floor area of 16m2 has regularly housed 8 people giving a living density of 2 metres squared per person[142]. The OXFAM Shelter floor area is 13m2 and an equivalent living density allows space for 6.5 persons, which was rounded down to 6 persons.

5.4 Limitations and Assumptions

Shelter Construction. Any construction that needs to be built in a minimum time period by non-skilled labour from within a beneficiary population needs to be both simple and straightforward. This is not to say that certain individuals and ethic groups are not capable of advanced construction, rather that these skills cannot be relied upon within every family group. For the purposes of this project, it was necessary to rely upon the field experience of several aid personnel in order to anticipate what construction methods and techniques are possible with a beneficiary population in Kosovo within an emergency shelter assistance programme. This is particularly important not only in terms of the viability of the initial construction process, but also in the way in which a shelter system might be maintained, or degraded, over time. As a result of many discussions, several assumptions were made about maintenance, including maintaining high tension in the cross bracing of the structure and the plastic sheets, and the extent to which a shelter would be sealed in high winds in the extremes of cold weather. Prototype development and environmental tests were altered accordingly.

Social Behaviour. Similarly, in the absence of detailed studies, a number of assumptions were made about the extent to which a beneficiary population might impact on their emergency shelter environment in social terms. This includes the amount of cooking within a shelter, cigarette smoking, and the movement in and out of the shelter, daily routines and anticipated activities within and around an emergency shelter.

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[141] Chalinder, A. (1998). pp 33.
[142] *pers comm* Neumann, W. (April 2000).

5.6 Final Design Brief

The table below summarises that brief for those criteria that can be quantified in explicit terms. The rest of the criteria described in this chapter remain in discursive form only.

Figure 27 Quantifiable Design Criteria

Criteria	*value*	*unit*
Social		
Living density	2.16	pp/m^2
Environmental		
External environmental parameters		
air temperature	-20	deg.C
Wind speed	12.5	m/s
Internal environmental targets		
air temperature	16±4	deg.C
Relative humidity	50%	-
Air Infiltration	1.5	ac/h
Structural stability		
wind load	12.5	m/s
Logistics		
cost	200	GBP
volume	0.5	m^3
weight	105	kg
supply lead time	10	days

Chapter 6 Developing the Prototype

6.1 Introduction

This chapter discusses the results of insulation material section process and the results of the physical construction of shelter prototypes.

6.2 Insulation Material Selection

Following investigation, five insulation materials were identified for prototype development: (1) mineral fibre, (2) low and (3) medium density glass fibre, (4) closed cell foam and (5) composite spun polymer fabric. Mineral fibre is made from melted igneous rock that is then spun into a 'woollen' fibre of varying densities. The mineral fibre material selected for further development in this project was a 'duct wrap' product which was bonded to a reinforced plastic film, which improves both tensile strength and the ease with which it can be handled. Glass fibre is made in a similar fashion to mineral fibre except employing silicon instead of stone. A medium density glass fibre duct wrap product and a highly compressible low-density glass fibre loft insulation product were selected for further testing. Closed-cell foam is made by foaming and setting plastics. The foam product selected in this case is foamed polyethylene and is very similar to the 'carry mats' used for recreational camping. The composite spun polymer fabric is a highly compressible polyester wadding insulation enclosed between several spun polymer fabric sheets made from polypropylene. This last product was made especially for this project by a manufacturer in Britain. The diagram below records the advantages and disadvantages for the five insulation materials selected.

Figure 28 Summary diagram of the Advantages and Disadvantages of Five Insulation Materials for Shelter Insulation

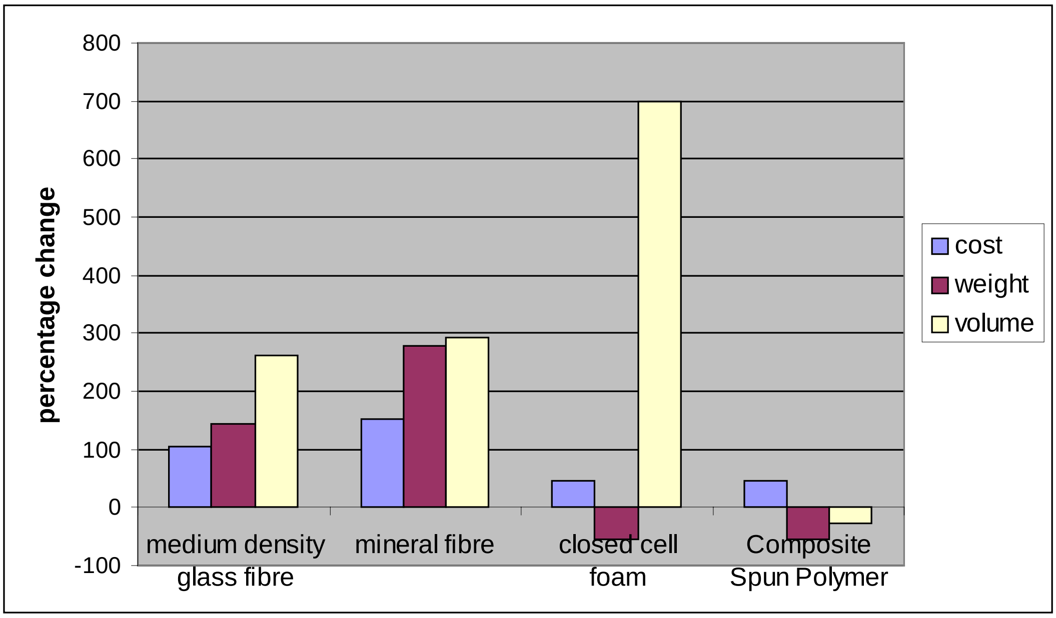
Mineral fibre	**Medium Density Glass Fibre**	**Low Density Glass Fibre**	**Closed Cell Foam**	**Composite Spun Polymer Fabric**
Advantages: Resistant to water, UV, fire and chemicals. Cheap. Short supply lead-time.	*Advantages:* Resistant to water, UV, fire and chemicals. Cheap. Short supply lead-time. Low volume.	*Advantages:* Resistant to water, UV, fire and chemicals. Very low packed volume. Cheap. Short supply lead-time.	*Advantages:* Resistant to water, UV, and chemicals. Very low density High insulation value Short supply lead time Good tensile strength	*Advantages:* Low packed volume Low density High insulation value Highly compressible
Disadvantages: High volume High density Low tensile strength Low resistance to human handling	*Disadvantages:* Low tensile strength. Low resistance to human handling.	*Disadvantages:* low tensile strength. Very Low resistance to human handling.	*Disadvantages:* Unknown resistance to fire, UV and chemicals High cost High packed volume	*Disadvantages:* High cost Unknown lead time Not resistant to fire Good tensile strength

Without first obtaining data concerning heat loss for a shelter system within a real environment, or in an environmental chamber, it is impossible to predict the insulation value of material needed to maintain comfort conditions for occupants. It was decided that the insulation value should be maximised, providing all other material selection and logistical criteria described above have been addressed.

The insulation material selection procedure was not exhaustive as there was only limited time assigned to this project phase. Furthermore, information could not be found for all criteria listed in figure 18. The graph below, however, compares the performance of the five materials in relation to four key selection criteria, namely, insulation value, cost, weight and packed volume.

In order to compare effectively the material characteristics, the thermal conductivity of each material was used to calculate how much material was needed to provide an equivalent insulation value (a U-Value of 0.28). The cost, weight and volume of each material were then calculated for comparison. For clarity, parameters for low-density glass fibre have been set to a base of 100 and values for all other materials are expressed as a percentage of this base case.

Figure 29 Cost, Weight and Volume Comparison of Insulation Materials assuming Equal Thermal Performance (low density glass fibre = base - 100)[143]



The substitution of both medium density glass fibre and mineral fibre products for low density glass fibre shows at least 100% premiums for cost, weight and volume to achieve the same thermal performance. Closed cell foam has a lower total weight compared to low density glass fibre, but accounts for nearly eight times the packed volume, which makes the cost of transportation relatively expensive. Low-density glass fibre remains the cheapest method of achieving a U-value of 0.28, but the composite spun polymer fabric has both lower weight and volume for the same thermal performance.

This analysis indicates that the best scoring materials are low-density glass fibre and the polymer fabric. However, it is difficult to say which of all the fabrics is the most appropriate for a cold-climate shelter system as the relative importance, or weighting, of each criteria selected for comparison could not be decided with Oxfam. Therefore, all five materials taken through to the nest stage for prototype construction.

[143] Manfield, P. (2000a). pp 12.

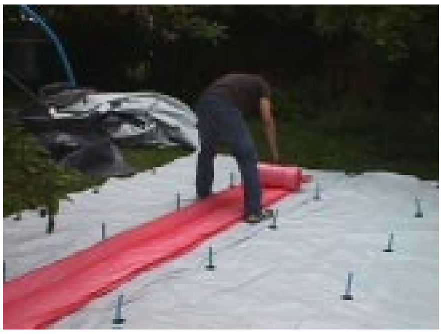
6.3 Shelter Prototype Construction

Having decided on appropriate insulation materials for testing, several prototype designs, based upon the OXFAM hot climate shelter, were then identified for construction tests.

Prototype 1 - *Ventilated Monarflex 'Universal' Sheeting Sandwich*

Monarflex universal sheeting with poly toggles/ snap-fitted to eyelets

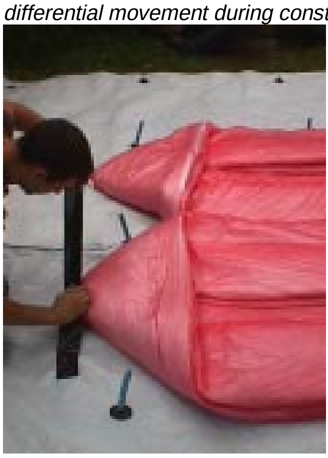
20mm pipe spacers push fit over the poly toggles



resin free glass fibre is rolled between the spacers

insulation is taped to sheet to minimise differential movement during construction/

top sheet toggles are snap fitted to the pipe spacers




the erected shelter showing insulation sagging into the living space

Design Aim

The aim of this design was to examine whether it was possible to create an insulated roof cavity in the shelter that was ventilated in order to remove moisture from the internal environment. This prototype uses a double layer of Monarflex Universal reinforced plastic sheeting for the roof with 150mm expanding low-density glass fibre sandwiched between the sheets. The two sheets were kept apart to provide a cavity using sections of 20mm diameter Medium Density Polyethylene (MDPE) water piping. These plastic pipes attached to the sheets by push fitting over Monarflex plastic toggles that snap-fitted into eyelet patches that were already welded to the sheet during its manufacture. Polyurethane closed cell foam was used to insulate the floor, which comes in rolls 1.2 metres wide and is 5mm thick. Lengths were cut and taped together before being placed on the shelter floor and covered with a UNHCR tarpaulin to protect it from wear and tear.

Conclusions for Prototype 1

The low-density glass fibre used in this prototype is resin-free and expands to some ten times its packed volume, thus achieving the highest insulation value to packed volume ratio of any material used during prototype development. It was not possible, however, to construct doors using this material due to its weight and volume. This is because resin-free low-density glass fibre has very low tensile strength and falls apart over time under the effects of gravity, wind and human use. Nonetheless, resin free expandable glass fibre proved a useful material for roof insulation and closed cell foam proved effective as a floor insulation material.

The way in which the roof was constructed was also problematic. The spacers do not maintain a sufficient or consistent cavity across the roof and so it unlikely that this design would provide effective ventilation for the insulation material in the roof. In addition, the spacers tended to displace the toggles from the eyelets where there was sufficient compression caused by the tension in the two sheets creating an unstable system. As soon as the toggles are displaced from the eyelets, the roof sheet is no longer watertight.

Using the spacers was also problematic in the sequence of construction. The entire roof with integral 'spacers' had to be made on the ground and then hauled over the structure. This was difficult to achieve and impossible to then sufficiently tension the sheeting to maintain effective internal volume.

Prototype 2 Mineral Fibre Rockwool 'Duct Wrap' Sandwich


mineral fibre duct wrap is easy to cut but difficult to join


insulation comes in 1x4 metre rolls


shelter construction is straight forward


four lengths of mineral fibre cover the roof with overlap joints to prevent cold bridging


constructing doors with mineral fibre duct wrap and UNHCR sheeting

deformation of the shelter under the Self-weight of the mineral fibre roof

mineral fibre is too heavy to be used as door insulation as it pulls itself from the structure

experiments with mineral fibre products for flooring insulation

high density mineral fibre batts between two reinforced UNHCR tarpaulins

Design Aim

The aim of this prototype was to investigate how mineral fibre products could be used to provide insulation in the roof, for door and for the floor. This roof sandwiches 40mm thick, reinforced foil-backed mineral fibre wool between two layers of UNHCR specification sheeting. Each roll is four metres long and allowed six metre lengths to be cut and taped together. The door and end design for this shelter again uses mineral fibre duct wrap enclosed between two sheets of UNHCR plastic sheeting. The mineral fibre and plastic sheets are then laced together using polypropylene rope and laced over the end hoops of the shelter structure and buried in the ground. High-density mineral fibre batts were placed between two UNHCR tarpaulins for the floor.

Conclusions for Prototype 2

As part of the roof construction, mineral fibre duct wrap retains its nominal thickness, and hence the maximum insulation value, between the plastic sheets in all parts of the roof except for when it passes over the structure. This is made possible because the inner plastic sheet bearing the load of the insulating material sags more than 50mm below the position of the supporting hoops whilst the top sheet is at high tension with no dead loading and does not sag to the same degree.

The construction process, however, is not straightforward. The insulation rolls must be taped together to make efficient use of production sizes and these taped joints may pull apart after construction[144]. The mineral fibre also fell away from the plastic foil backed reinforcement if not handled with care and there is a risk that this material may disintegrate through mishandling in the field.

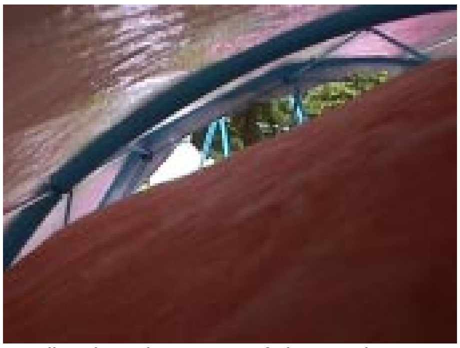
Furthermore, the weight of the mineral fibre duct wrap necessary to cover the entire roof is potentially too heavy to be manageable by a family unit. The self-weight of the mineral fibre duct wrap further caused significant deformation of the plastic water pipe structure after a period of several weeks. This structural deformation highlights the inherent weakness of the structure employed, but also implies that the mass per unit area of this product is close to the maximum load bearing capabilities of the structure. Shelter using mineral fibre products was rejected.

Prototype 3 Inverted Monarflex 'Universal' Sheeting, with Suspended Insulation

glass fibre duct wrap forming roof and floor insulation in one section

experiments with resin free glass fibre and closed cell foam

polypropylene rope is attached to the roof sheet using poly-toggles



ventilated gap between roof sheet and insulation

[144] Rockwool later confirmed that there is a European product made in Germany called *Klimarock* in 6 metre lengths of a comparable insulation value to the material used in this prototype. They also confirmed that this material would be available in bulk with a short lead-time.

Design Aim

The aim of this prototype was to investigate the feasibility of suspending insulation from the inside of a shelter using a single reinforced tarpaulin, rather than sandwiching it between tensioned sheets of roof plastic. This would enable ventilation of the insulation and reduce the risk of interstitial condensation within the insulating layer. This method of construction uses only one Monarflex Universal sheet with proprietary 'poly-toggles', snap fitted to the eyelets facing inside the shelter. A network of plastic rope is then fed through the toggles to form attachment points for rolls of insulation. The insulation could then be ventilated between the living area and the plastic roof sheet and would enable one roll to form a complete loop, covering roof wall and floor.

Conclusions for Prototype 3

The construction method for this prototype is easy and straightforward but the foiled-backed glass and mineral fibre products tested are not sufficiently durable to be inside a living space and cannot cope with damage from live loads on the floor and live loading compresses the roll to negligible insulation value. Both products also readily absorb moisture, which pose further hazards in region such as the floor, which are especially susceptible to moisture ingression. It is also not clear whether glass and mineral fibre products pose a risk to inhabitants if they are exposed within a living area and ingested through breathing[145]. For these reasons this design was rejected.

[145] Manufacturers of both glass and mineral fibre insulation assured us that their products posed no health risk, but acknowledged that they could be an irritant to some people. There was not sufficient time to confirm these assurances with an independent expert.

Prototype 4 Owens-Corning 'Miraflex' Glass Fibre Ducting Insulation Sandwich


glass fibre duct wrap is thrown over the first roof sheet. The packed roll is shown at the fore front


25mm duct wrap is light enough to construct doors


but it lets little light into the tent

Design Aim

This prototype investigates the use of glass fibre duct wrap insulation as a material for the doors and roof and was constructed in an identical manner to prototype No. 2 where mineral fibre ducting insulation is sandwiched between two layers of UNHCR sheeting.

Prototype 4 Conclusions

The relatively low density of glass fibre duct wrap is easy to handle during construction for both the roof and the doors and only a small structural deformation was recorded in roof after several weeks. As with the Prototype 2, glass fibre duct wrap retains its nominal thickness in all parts of the roof between the plastic sheets, except for when it passes over the structure, hence, retaining the greater part of its maximum insulation value.

As with Prototype 2, it is not possible to effectively tape pieces of glass fibre ducting insulation together in the field, and similar concerns were raised about the material joints disintegrating in the field.

Overall, this prototype scores well although glass fibre duct wrap has a much lower insulation value to packed volume ratio compared to that of the resin-free low-density glass fibre insulation used in Prototype 1.

Prototype 5 Web Dynamics Composite Spun-Polymer/Polyester Quilt

doors and roof are made of the same composite material

the material is lightweight and easy to construct

seam stitching could prove to be a weak point

material translucency gives better internal lighting conditions

Design Aims

This prototype tested the suitability of composite polymer fabrics for use as shelter insulation. The top layer of the material consists of a spun polymer, which is vapour permeable but water-resistant. Polyester wadding is woven into the underside of the fabric, which provides the insulation and a second polymer breather layer is sown to the inside face.

Prototype 5 Conclusions

The material is extremely light and easy to handle and construction remains simple as one material is used for both roof and doors. Furthermore, the material is translucent, which provides good daytime lighting within the shelter.

Unfortunately, only a few manufacturers can produce composite, quilted products using spun polymers at present, and this is likely to hamper competitive pricing. Composite products such as these involve several manufacturing processes and not necessarily all within a single company, which is further likely to contribute to longer supply lead-times as compared to those of industry standard materials. Therefore, this material is rejected for this design project as it does not answer the fundamental logistical criteria. Development of shelter materials with the manufacturer, however, was continued as part of another shelter project with OXFAM.

6.4 The Tested Shelter Prototype

A final shelter was constructed for testing using the best performing elements from the previous prototypes and this design was then tested. Figures 30 and 31 describe the tested shelter.

Figure 30 Description and Specification of the Tested Shelter Prototype

PROTOTYPE No.:	**5**	
PROTOTYPE Name:	**Tested Shelter**	
Materials Cost per unit*	**£ 145**	****ex-transport, ex-heater***
Materials Cost per unit*	**USD 232**	
Mass per unit*	**94.5kgs**	

PART FUNCTION	MATERIAL ITEM	SPECIFICATION	QUANTITY	WEIGHT	COST
Skin	UNHCR Reinforced Sheeting	4 metre wide roll	18 metres	14.4kgs	£ 25.92
Ends	Monarflex T-Plus Scaffold Sheeting	4 metre wide roll	16 metres	12.8kgs	£ 23.04
Structure	MDPE Tubing	63 mm OD	18 metres	18.4kgs	£ 16.02
Pegs	Steel Re-bar	10mm OD	3.0 metres	1.8kgs	£ 1.50
Purlins	Alu Tubing	15.9mm	10.8 metres	4.2kgs	£ 6.16
Tensioners/ Cross bracing	PP Rope	8mm dia	52 metres	14.0kgs	£ 1.56
Insulated Flooring	Polyurethane Closed Cell Foam	5mm thick x 1.2m wide roll	10.8 metres	1.9kgs	£ 10.80
Insulated Door/Ends	Polyurethane Closed Cell Foam (translucent)	2mm thick x 1.2m wide roll	48.0 metres	3.8kgs	£ 24.00
Insulated Skin	Miraflex resin-free glass fibre roll	150mm thick x 570mm wide x 10.7m	3.0 rolls	23.1kgs	£ 36.00

Space Heater	Canadian Heater	Kerosene/diesel fuel	1	40.0kgs	£ 200.00
OR					
Locally-made stove	Kosovan Bread Stove	Solid fuel	1	20.0kgs	£ 25.00

Prototype Component Description

The structure consists of 3 lengths of polyethylene (MDPE) water piping which form 3 hoops that sit on steel reinforcement pegs in the ground on a square plan of side length 3.6 metres. The hoops are joined horizontally by 3 hollow-section aluminium tent poles and cross-braced internally with two lengths of polypropylene rope. The rope acts in tension against the tent poles, which are in compression. The roof consists of expanded resin-free glass fibre sandwiched between two layers of UNHCR specification reinforced polyethylene sheeting, which are laced with polypropylene rope and tensioned over the hoops and buried in the ground at the sides. The door and back end of the shelter consists of translucent closed cell foam, sandwiched between transparent reinforced polyethylene scaffold sheeting which is also buried into the ground at the bottom. The floor consists of low density closed cell polyurethane foam under a reinforced plastic tarpaulin.

The shelter is heated by either a folded sheet steel bread oven, which burns solid fuel and is produced the Balkan region, or a higher specification heater burning either diesel or kerosene fuel, adapted from the US army model specifically for relief purposes[146].

[146] For details of heater suppliers and specifications, refer to Manfield, P. & Corsellis, T., (1999). Appendix 2.

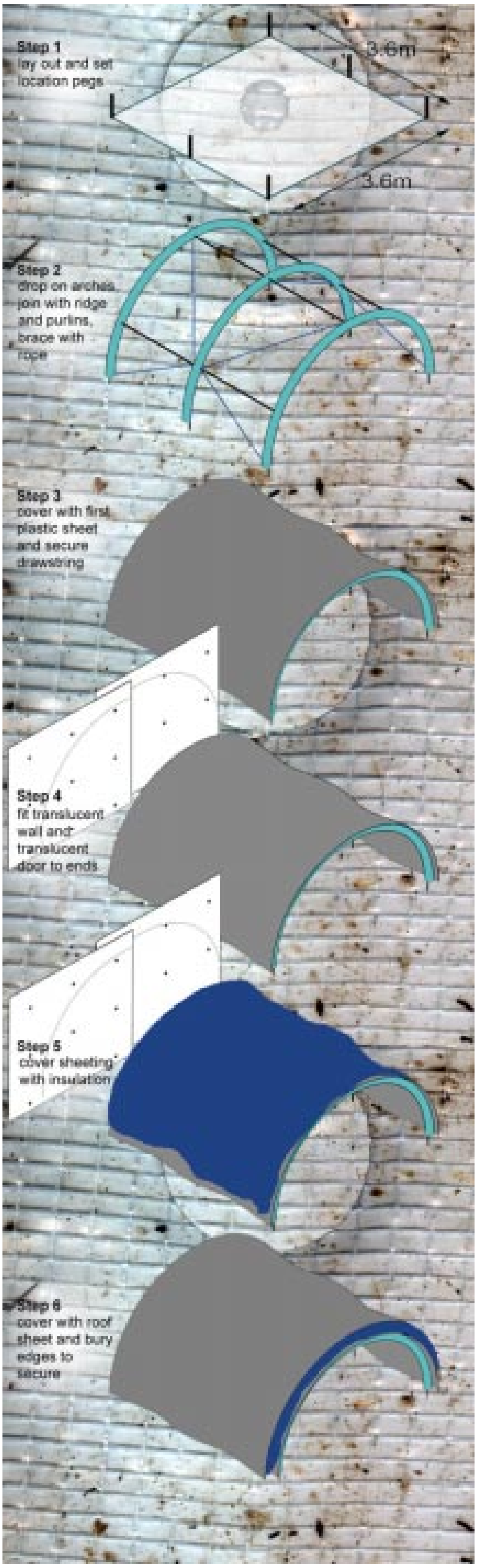


Figure 31 *Axonometric of Construction sequence of the Tested Shelter Prototype*[147]

[147] Drawing by Trinder, M. and Ashmore, J.

Chapter 7 Test Results and Analysis

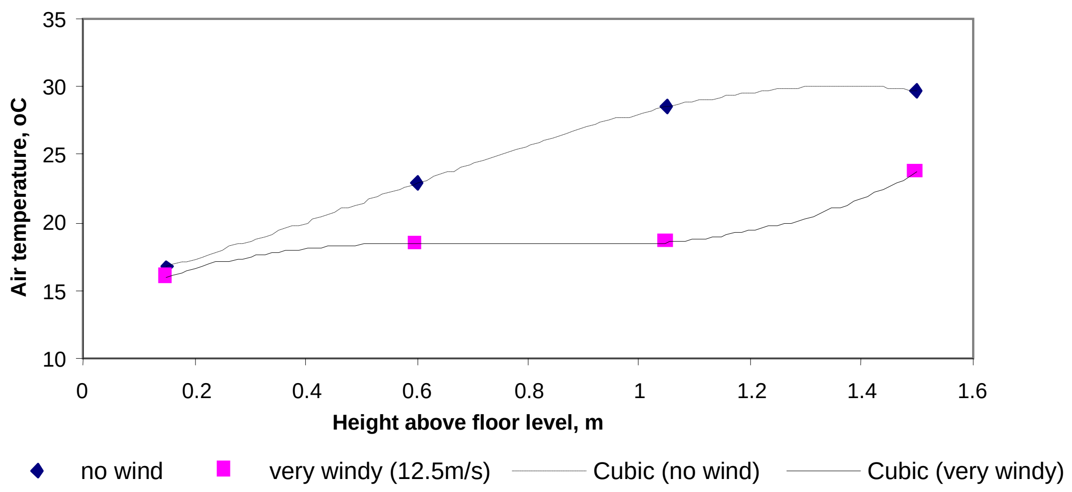
7.1 Introduction

The best performing shelter prototype from the construction tests was selected for environmental and field tests. The limited time period for this project has only allowed for part of the necessary environmental and field tests to be completed and testing in a real environment was not undertaken. This chapter describes the results and analysis of several experiments undertaken in environmental test chambers to evaluate the relationship of heat lost from the shelter relative to air temperature and wind speed. The results of other tests performed, that are outlined in the methodology but not described in detail, are also discussed including Computational Fluid Dynamics (CFD) modelling and condensation tests.

7.2 Thermal Performance of the Shelter Prototype in Cold and Windy Conditions

The prototype shelter was placed inside the environmental chamber and thermal tests, described in Chapter four, were undertaken. The results of these tests are described below[148].

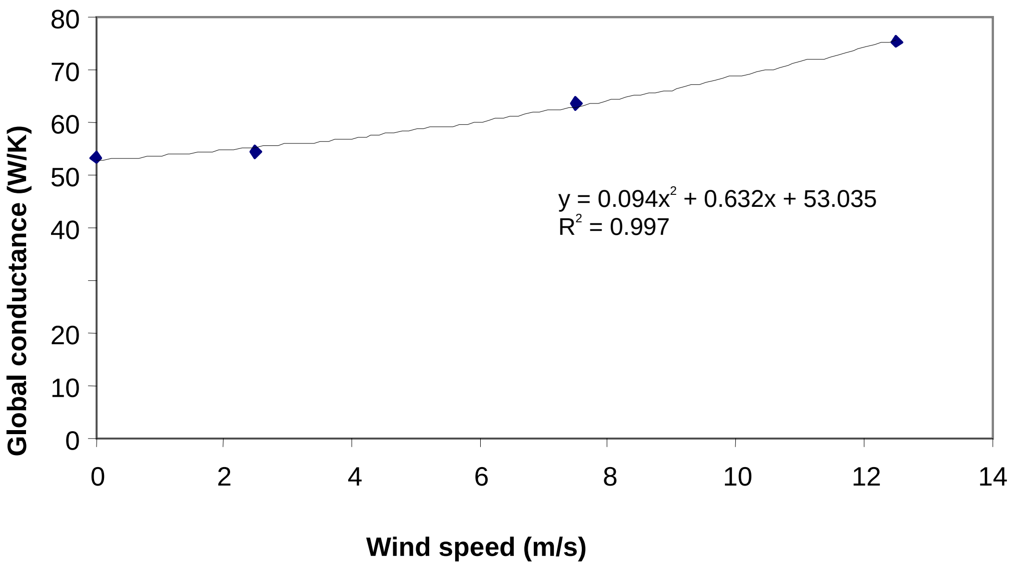
Figure 32 Internal Temperature Gradients with and without wind



[148] The results for the thermal performance experiments were prepared with Dr. D. Robinson, formerly at the Martin Centre, Cambridge University.

The graph above shows how heat is dispersed within the shelter environment using a 2.4 kW heat source, with no wind, and when the wind is at Gale Force 6. The first point on the x-axis (0.2 metres) represents the level from the ground at which occupants would sleep. This is critical as it likely to be the coldest part of the tent and also the zone in which occupants are at the greatest risk of perishing. The graph shows that in both still and gale force conditions, the lowest part of the tent maintains a minimum of 15.6 ^oC (±0.7 ^oC) which is comfortably inside the survival temperature for the majority of humans, and adequate for vulnerable groups including the young and the elderly[149]. In the absence of wind, there is a 15 ^oC temperature difference from head to foot which represents uncomfortable thermal stratification. Buoyancy and wind-driven infiltration increases the mixing of hot and cold air. Occupation of the tent will further increase air mixing, although not at night when occupants are likely to be sedentary.

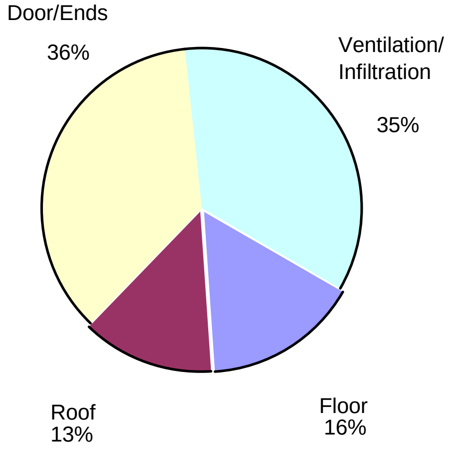
Figure 33 Global Conductance/Wind speed graph



The shallow gradient indicating that heat loss is not greatly affected by wind speed, even at gale force speed. This would indicate that the shelter is effectively sealed against drafts[150]. This can be attributed to the sturdy frame structure, although the extent to which the shelter is sealed in the chamber also affects performance in wind.

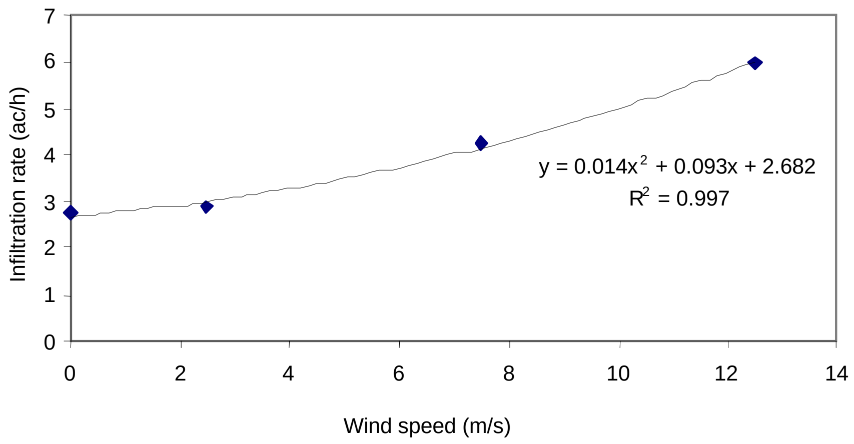
[149] *Pers comm* R. O'Connor, Cold-climate Physician, British Antarctic Survey.
[150] Several assumptions were made concerning the extent to which low-level shelter sealing would be performed in the field and the test rig was altered accordingly.

Figure 34 Component parts of shelter heat loss with no wind[151]



After adjustments were made for the heat losses to the test chamber floor, it was possible to disaggregate the overall thermal performance of the shelter into its constituent parts. The pie chart indicates where in the shelter heat losses are occurring for still air and ambient conditions at –20 °C. The fabric floor and roof combine to represent just under a third of heat losses whilst the ends of the shelter account for another third. The remaining third is lost through air infiltration occurring in still, ambient conditions due to the thermal convection currents inside the tent. These results highlight the need to increase insulation at the doors and to form better seals at material joints in the shelter in order to reduce heat losses through infiltration.

Figure 35 The Dependence of Infiltration Rate upon Wind Speed



The graph above indicates that the shelter provides a minimum air change rate of 2.8 air changes per hour (ac/h) without wind (refer to y-axis intercept). If the occupants smoke, the minimum supply rate should be 1.47 ac/h and the air change rate is still satisfactory.

[151] Data relating to the floor condition have been normalised to model average Kosovan winter ground temperature rather than the steel decking of the test chamber. Refer to Manfield, P., & Corsellis, T., (1999). for the original data.

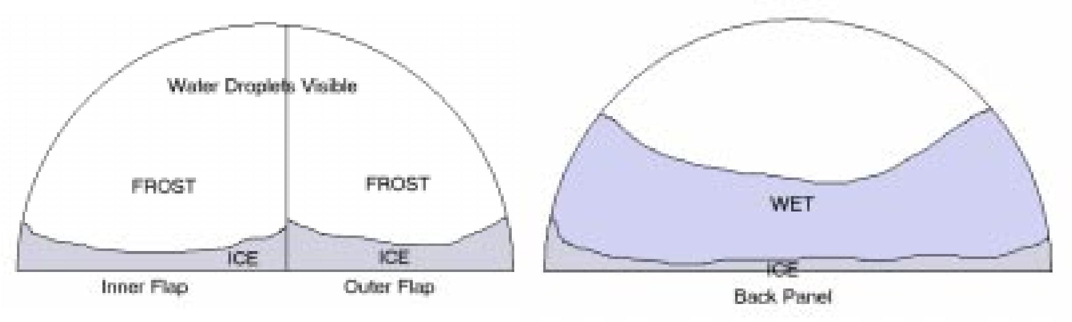
Figure 36 Thermographic Imaging of the Shelter Prototype in the Test Chamber

Figure 36 shows a photograph taken with a thermal-imaging camera, and it confirms that heat loss through the roof is very low and that there is little cold-bridging occurring between the rolls of insulation. This means that a loose method of construction, such as that described in Chapter 6.3, can ensure good thermal performance. This is aided by the fact that low density resin-free glass wool continues to expand for some 30 minutes after unrolling from the packaging and so fills any unintentional gaps left during the construction process.

7.3 Condensation Tests

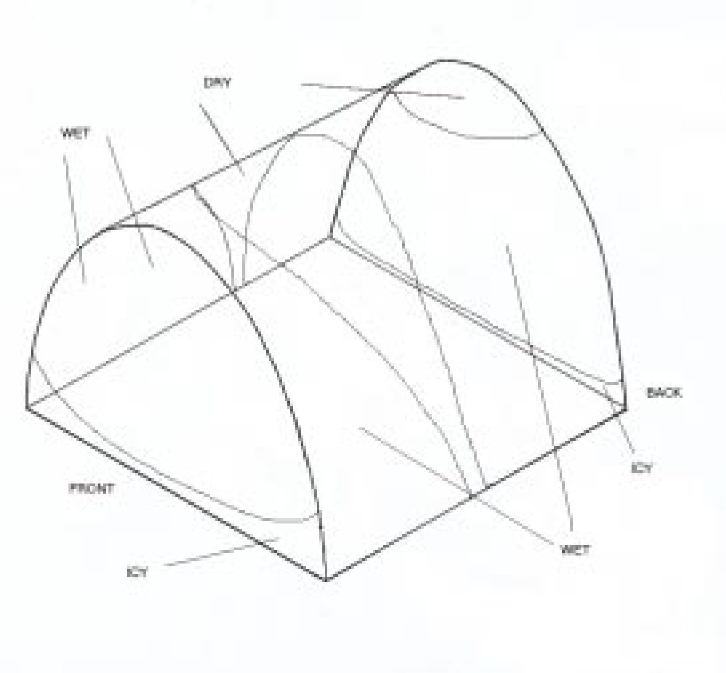
The following diagrams illustrate the performance of the prototype shelter when subjected to 'worst case' moisture production inside the living environment. The two elevations below illustrate the effects of moisture production inside the shelter in an environment at –20 degree Celsius.

Figure 37 Sectional Elevations showing the build-up of Condensation and Ice on the Door and the Back Panel of the Prototype Shelter



Results indicate that the surface temperatures of the door and the back panel are low enough to cause damp conditions. This occurs because the doors have the lowest insulation value of anywhere in the tent and also because the air infiltration rate in still conditions is not high enough to stop condensation forming. The surface temperatures are below freezing on the lowest parts of the door sections and this causes ice to form.

Figure 38 Axonometric showing the build-up of Condensation and Ice on the in the Prototype Shelter



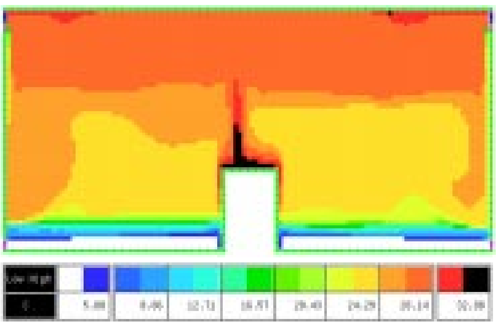
The axonometric shows less dampness on the roof sections as the insulation in this part of the shelter is much higher, but conditions are still likely to be uncomfortable. These results show that more insulation is required at the door and back panel sections of the shelter and that a higher air infiltration rate is required in cold and still conditions.

7.4 Shelter Prototype Modelling

Subsequent computer modelling work undertaken by the author questions further whether internal conditions in the shelter provide for thermal comfort[152]. The model has been calibrated using results from the environmental chamber tests. The six images illustrated below are two-dimensional cross-sections of the internal environment of the prototype shelter each describing a key determinant of thermal comfort. The model shows the shelter with a 3 kiloWatt heater at the centre and in an environment with a temperature of–20 degree Celsius with no wind.

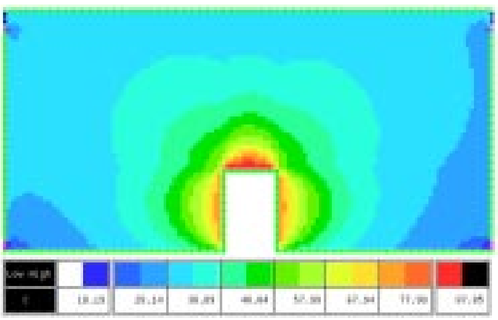
7.4.1 TAS Ambiens Model illustrating Factors Affecting Thermal Comfort inside the Shelter Prototype

Air Temperature



The image above indicates there is an undesirable and excessive internal stratification of air temperature. It is anticipated that occupancy and wind-driven infiltration will reduce the thermal asymmetry between top and bottom through greater air mixing, although the environment is still likely to be uncomfortable for occupants.

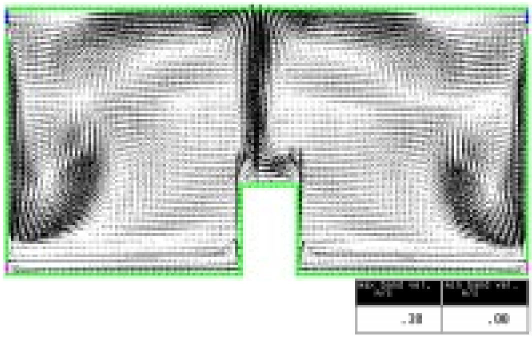
Mean Radiant Temperature (MRT)



The image above confirms that radiant environment is also asymmetrical, and that the MRT is very low at the doors of the shelter. The analysis does confirm, however, that thermal efficiency is maximised when the heater is placed in the centre of the shelter.

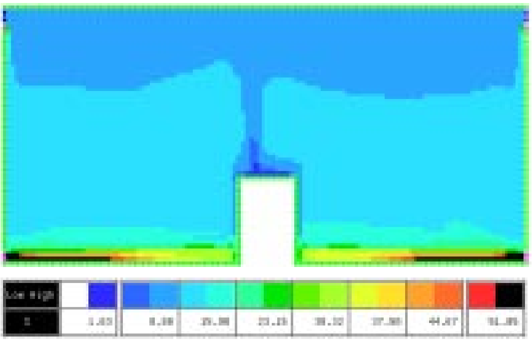
[152] Manfield, P. (2000a).

Air Flow



The thermal buoyancy of hot air alone causes the airflow through the shelter in this model. The image above indicates that air movement is highest above the heater, where a plume of rising hot air is visible, and at the door, where cold air falls from leaks at the top of the door and the rear of the shelter. The areas adjacent to the door and the rear show the highest air movement within the living space and this will adversely affect thermal comfort. This image reinforced the view that there is a trade off between providing a healthy air change rate and a thermally comfortable environment.

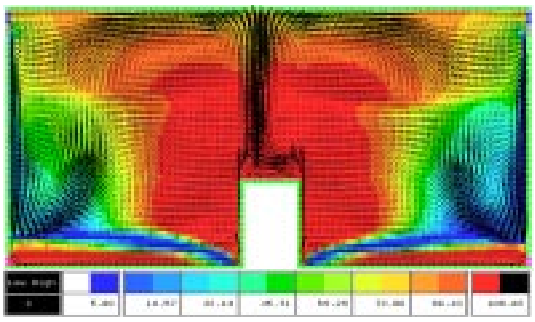
Relative Humidity



The image above indicates that relative humidity increases with height as air temperature increases. The air is likely to have a much higher humidity when occupied for any length of time due to moisture production from respiration, cooking and washing, and this image does not account for these factors. When this is combined with the low rate of air exchange, the relative humidity will increase to 100%, becoming super-saturated and causing internal condensation to form[153].

[153] Crowther, K. (2000).

Percentage of People Dissatisfied (PPD)



The Percentage of People Dissatisfied (PPD) is the number of people that are dissatisfied with thermal conditions in a particular environment according to recognised building comfort standards. The image above shows where in the shelter conditions necessary for thermal comfort are achieved. Results indicate that most of the environment is extremely uncomfortable either because the environment is too warm (next to the heater and when standing up), too cold (when lying down) or too much air movement (by the doors).

7.4.2 Shelter Fuel Consumption Modelling

Further modelling tests indicate that the prototype shelter needs only a quarter of the heat input required by the UNHCR winterised tent in order to maintain a ‘comfortable’ air temperature in an environment with an external air temperature of minus twenty degrees Celsius[154]. The implications for fuel consumption and cost are profound, particularly for areas of severe cold. However, the extra cost and volume of the prototype shelter system needed to achieve this thermal performance may well be over the narrow tolerances allowed by UNHCR for an emergency shelter. It is difficult to know, in practice, which parameter will be critical in selecting a shelter system for humanitarian assistance. Indeed, many criteria have not been included in this technical study which may preclude a shelter system regardless of thermal performance, weight, volume and even cost. However, the prototype is the first attempt to challenge the existing UNHCR standard and it is hoped that the future research will produce more competitive results.

[154] Manfield, P. (2000a).

Chapter 8 Conclusions

This dissertation began with the following hypothesis:

Under specific circumstances, cold-climate emergency shelter systems can become an effective and appropriate response to the temporary shelter needs of forced migrants in cold-climates.

A review of several aid programmes in chapter three demonstrated that cold-climate emergency shelter systems can become an effective and appropriate response to the needs of forced migrants in such climates, but only where certain conditions have been satisfied. These conditions include cultural acceptance, climatic suitability and supply-side logistics factors.

The specific aims of the project have been to (1) develop a design brief and specification criteria for cold-climate emergency shelter, (2) develop a prototype through construction tests and (3) perform a series of environmental tests for the developed prototype. The conclusions to achieving these three aims are presented below in the order of the dissertation structure. The wider implications of the results achieved are discussed for each aim and the dissertation then concludes with a discussion of areas for future research.

8.1 The Development of a Brief

Chapter five laid down the framework for the development of the brief for a cold climate emergency shelter system and concludes that it can be separated into three sectors (i) social (ii) environmental and (iii) logistics.

It must be noted, however, that the shelter prototype has been designed to a standardised brief informed by the various requirements of a number of case study shelter assistance programmes. Developing a standard winterised shelter has therefore resulted in an inherently compromised solution, which is likely to be controversial within the aid community as priorities differ between agencies. Achieving consensus for the implementation of a single new emergency shelter system is likely to be difficult. The design project in this dissertation, however, has been carried out in close consultation with Oxfam and is tailored to their needs and experience in the field. Greater information-sharing between NGOs will allow agencies both to use each others' standard shelters in specific circumstances, and to achieve consensus where it is appropriate to do so. Agencies involved in the supply of water and sanitation meet regularly to share ideas and standardise equipment, such as pipe connectors. Similar meetings are required for the temporary shelter sector to develop within the aid community, which lacks an NGO mandated primarily to undertake shelter programmes.

8.2 Prototype Development

The prototype proposed substituted the assembly of readily available construction materials for a pre-fabricated tent, such as the UNHCR tent. Construction tests confirmed that it is possible to build the prototype using a minimum of cheap materials and tools, and answered the logistics criteria described in the brief. Prototype cost and weight are both comparable to those for the UNHCR tent and delivery lead-time for a 1000 units is ten days rather than 2 months.

Beyond the scope of this dissertation, however, remain the questions whether assembled shelters can answer key social criteria, especially buildability. The extent to which the prototype is 'buildable' by displaced people relies on assumptions based on the experience of aid staff at Oxfam, and that of the author, and these assumptions have yet to be substantiated through field tests. Lessons learnt during prototype construction indicate that the assembled shelter prototype is likely to stretch to the limit what is possible in self-build assistance programmes.

8.3 Prototype Testing

The results and analysis of the thermal performance tests points to a qualified success for the prototype shelter, especially when compared to the existing standard UNHCR tent. A comfortable air temperature can be achieved in extremely cold and windy conditions with only a small heater, whereas the UNHCR tent may require up to four times the power rating of that used inside the prototype shelter in order to achieve the same air temperature[155].

Despite the successes of the thermal performance tests, subsequent modelling and environmental tests indicate that there are clear limits to the performance and use of the prototype shelter. Whilst a comfortable internal air temperature can be sustained with adequate air mixing, other conditions necessary for thermal comfort, including humidity, air movement and radiant temperature, are not achieved. Crawford's condensation tests indicate that it difficult to maintain a dry internal environment in extremely cold conditions and it is unclear to what extent, and by what method, such a shelter should be ventilated. Furthermore, the design of an effective manifold to pass a hot flue pipe through plastic sheeting remains unresolved and the fire risk unquantified. The testing methodology however, does succeed in moving closer to a common regime for testing for existing and future shelter systems.

[155] Manfield, P. (2000a).

8.4 Future work

Future work is identified in three areas (1) research for the prototype shelter developed in this dissertation, (2) research for existing shelter systems and (3) research into cold-climate shelter policy.

8.4.1 Research for the Prototype Shelter

The common testing regime explored within this dissertation needs to be developed to a state where it can be disseminated to the numerous manufacturers of emergency tents and prefabricated shelter systems. The result of this should be a comparable and consistent specification list to assist agency procurement officers in the purchase of appropriate temporary shelter and supporting equipment.

Shelter systems that are assembled from cheap components, rather than being tailored or prefabricated, represent a significant departure from the status quo. In order for new developments in shelter to achieve success in the field, a higher level of participation from humanitarian organisations, and a greater awareness of shelter programmes among aid personnel will be required. It will also require well-designed, and well-supported, field and social testing. This not only requires adequate funding, but also sufficient time to allow the long-term tests to produce valid results and conclusions.

The field testing of current and prototype shelter systems needs to be undertaken to determine buildability and social acceptance. In terms of technical considerations, this project could further benefit from a detailed discussion of clothing, bedding and food requirements for displaced people in cold-climates. Cold climate shelter systems should be deployed as part of winterisation 'packages' These packages must include, in addition to the shelter system, heaters and fuel, insulated flooring, clothing, bedding and adjusted food distributions.

Unfortunately, whilst other sectors have reasonable private sector involvement in product development, shelter does not. The fragmented nature of the construction industry hampers research and development and the lack of available resources for such work means progress is slow. Consequentially, future research work must be undertaken jointly between the aid community and the private sector. This was achieved successfully with the development of the new plastic sheeting standards in 1997 with MSF, UNHCR and numerous manufacturers. It is acknowledged, however, that developing more complex products, such as specialised shelter systems and materials, may involve larger capital investments. Currently, aid organisations are unwilling to make such investments.

8.4.2 Research for Existing Shelter Systems

The analysis provided in chapter three concerning the performance in use of the UNHCR winterised tent demonstrates that it has been unable to meet a number of the conditions necessary for successful deployment in severely cold environments, such as Kosovo. Senior aid staff state, however, that the use of the tent in such climates cannot be avoided as there are currently no other feasible shelter systems available. It is necessary, therefore, to improve the design of the tent.

In an email to the author, Schellenberg calls for the development of an extended standard tent 'kit', the component parts of which might be altered to suit the specific demands of a local environment. For example, he mentions specifically the addition of insulated floors and liners for increased thermal performance and tent ring-beams and external wind breaks for further structural stability. A previous study by the author comparing vernacular and humanitarian cold climate shelters indicate that this flexible approach bears similarities to vernacular shelter response, such as the Yurt. The yurt can, for example, increase or decrease its insulation value by adding or removing layers of felt according to the climate, and this approach is perhaps better suited to the shelter requirements of displaced people[156].

Neumann notes that tents are an extremely unpopular item with UNHCR bureaux and desk officers due to the high unit cost and the cost of stockpiling, particularly when compared with other items of assistance[157]. This indicates that any alternative shelter system must compete with the cost of the UNHCR standard tent. Higher costs can only be mitigated if short-term running costs of such shelter are substantially lower than the shelter itself. Furthermore, implementing changes to shelter policy within UNHCR is difficult, not least because donor organisations have such a strong influence. Neumann notes that it took ten years to improve the design of the standard UNHCR tent, because of its marginally higher cost. Research into new shelter systems is likely to be met with similar resistance if there are similar marginal cost implications.

Existing cold-climate shelter systems might also look to use rolls of cheap specialised 'breathable' fabrics, such as spun polymers, in much the same way that rolls of plastic sheeting are used for hot-climate shelter. Such material could be stockpiled by industry, as well as in small quantities by agencies, in order to achieve realistic delivery lead-times. The development of an insulation package for integration with the existing standard UNHCR tent design is currently being undertaken by a fourth year student at the Department of Engineering at Cambridge University[158].

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[156] Manfield, P. (2000c).
[157] *pers comm* Neumann, W., (April 2000).
[158] This research is being undertaken by Rachel Battilana in collaboration with the author and Tom Corsellis at the Martin Centre, Department of Architecture, Cambridge University. Refer to Appendix 2 for details of the UNHCR tent insulating liner.

8.4.3 Research into Cold-Climate Shelter Policy

The design brief developed in this dissertation might be expanded into a decision-making tool to specify standards of other shelter assistance options, as well as for the design of emergency shelter systems. These options might include placing displaced persons with host families, the rehabilitation of damaged buildings, including private and communal property, and shelter in camps. In order for this work to gain full validity, however, the shelter sector as a whole requires a comprehensive review in order to reach consensus for detailed standards for assistance[159].

UNHCR currently only considers one climatic classification of cold-climate shelter. There is need to create a range of climate definitions within this classification in order to inform the specification of emergency shelter. For example, an annual climate with a minimum temperature of –5 degrees Celsius is likely to require a different shelter response to a climate with periods when the air temperature is –20 degrees Celsius. Similarly, annual climates that contain periods of intense heat as well as cold should inform shelter selection.

There is also need for greater resolution concerning the type of living environment that emergency shelter systems provide in cold-climates. This is certainly needed if winter tents continue to be used in assistance programmes beyond emergency phases, when emergency shelter should provide not merely survival conditions, but a living environment for prolonged occupation. Referring again to the study of vernacular cold-climate shelters, it is interesting that the insulation value of the UNHCR tent is well below that of the yurt. This would appear inappropriate when one considers that even such 'professional' nomadic tent dwellers choose to forgo the savings in shelter weight and volume in favour of adequate insulation for their living environment during the winter months[160].

In order for the shelter sector to progress, therefore, it must present its role in a way that appeals to politicians and donor governments[161]. Whilst it is well known among experienced practitioners that good physical living environments contribute substantially to the basic health profile and psychological wellbeing of a displaced population, there is little recognition outside the sector of the direct 'cause and effect' of poor shelter and poor refugee health[162]. Goovearts' advocates that 'political norms' for shelter provision must first be established in order to ensure donors and host governments allow adequate funding for shelter programmes, regardless of the location, and regardless of the ethnicity of a beneficiary population.

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[159] Corsellis, T. has made a funding application to the British Department for International Development (DFID) for a 2 year research programme to review shelter and physical planning for forced migrants.
[160] Manfield, P. (2000c).
[161] UNHCR, (1993b). pp 4 (section 2).
[162] UNHCR, (1993b). pp 10 (section 2).

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Appendix 1

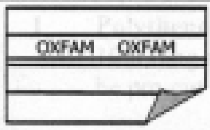
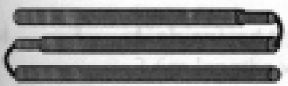
(Adapted from OXFAM Emergency Guidelines on Water, Sanitation and Shelter Packs)

Oxfam International

EMERGENCY FAMILY SHELTER SYSTEM

Assembly Instructions

LARGE VERSION (SES2/L)

Kit List (All packed in large bag)		Quantity
	7 metre x 4 metre Reinforced white plastic sheeting	1
	2.5 metre x 4 metre Reinforced white plastic sheeting	2
	1.5 metre tubing MDPE 63mm diameter	12
	0.2 metre sleeves MDPE 50mm diameter	9
	3.60 metre poles kits 15.9mm, 1.2mm wall thickness galvanised steel tube, in three sections connected by springs. Packed in polyethylene bag	3
	0.5 metre stakes 12mm mild steel reinforcement bar Packed in polyethylene bag	6
	6.50 metre tensioning rope 10mm polypropylene	2
	3.00 metre tensioning rope 10mm diameter polypropylene	1
Weight: 40.5 kg		

Material Requirements *per shelter*:

Plastic Sheeting 4m	12.0m
MDPE tube 63mm	18.0m
MDPE tube 50mm	1.8m
Steel Rebar 12mm	3.0m
Steel Tube 15.9mm	10.8m
PP Rope 10mm	16.0m

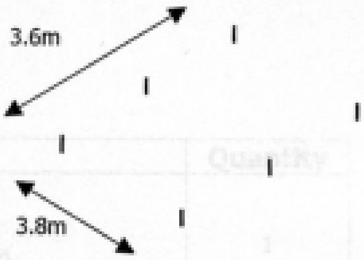
Appendix 1 (continued)

ASSEMBLY INSTRUCTIONS - Large Kit Version

Plan and orient shelter layout according to physical planning considerations, such as optimal use of external space, prevailing winds, and surface water drainage, based on social and technical assessments. A single person can assemble this shelter, although it is easier with two persons.

1. Pegs into Ground

Drive in 6 x pegs (12mm mild steel reinforcement bar, item 6.) 3.8m x 3.6m perimeter, 5.2m across diagonal from extreme corners, 1.8m between pegs along sides.



2. Construct Plastic Poles

Construct 3 poles from 4 identical 63mm tube sections each, by inserting the 9 identical sleeves:

3. Construct Steel Poles

Unfold and assemble the three poles.

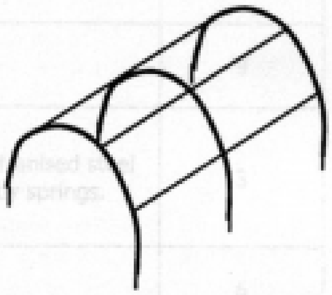
4. Construct Frame

Drop one arch onto the central pair of pegs, keeping holes in the inserts visible.

Slide each metal pole through the ***through*** holes in the centre inserts until the metal pole is half way through.

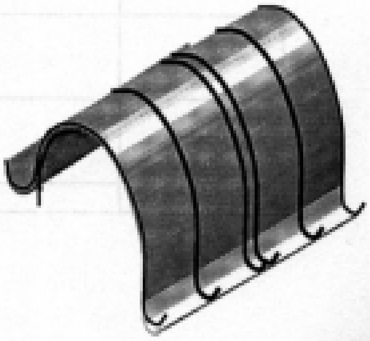
Drop the other two arches onto the remaining pairs of pegs. Keep holes in the inserts visible, ensuring the ***blind*** hole faces towards each metal pole end.

Slot each metal pole end into the ***blind*** hole.



5. Covering

Lay 7m x 4m plastic sheet over arches so that the central blue parallel reinforcement bands run either slide of central arch.



6. Rope Tensioners

Perforate sheeting along each end reinforcing bands and lace with 2 x 6.5m polypropylene rope.

Tie one end of each rope to corner peg, and draw rope tight, creating approximately 0.2m overhang at each end. Tie off free end of rope around other corner peg.

7. End Covers

Closed End: Using a 2.5m x 4m plastic sheet, hang with blue reinforcement strips vertically, tuck corners between plastic frame and plastic sheeting. Bury end into ground or weigh down.

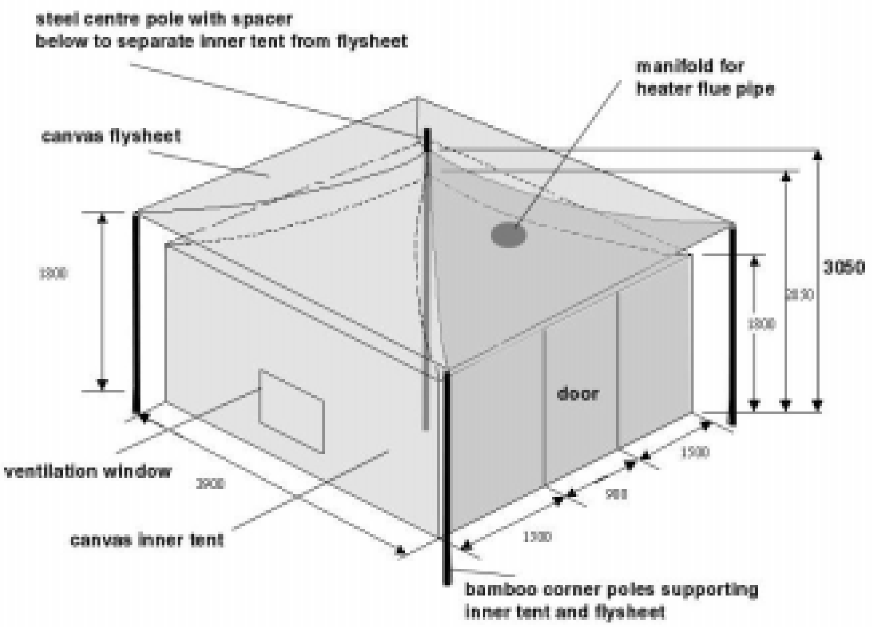
Entrance: An entrance can be used on one or both ends, depending on ventilation and access requirements. Same as for closed end except use two 2.5m x 2m plastic sheet. Allow for overlap. Cut slits at 0.2m intervals along edge of reinforcing strips where each door section meets in centre, and lace 3m length of rope. Bury ends of one or both sides of doors in trenches in heavy rains.

Appendix 2

(Current Research at Cambridge University)

UNHCR Tent Liner

Winter Tent Axonometric Drawing



Winter Tent Liner