Innovative Shelter for Disasters

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Abstract

Disasters cause tremendous material and immaterial damage to people and their habitat. During the first days after the disaster the victims have to be provided with food, shelter, security, health care and registration. For sheltering, depending on the local circumstances, tents are often used for a short period of time but often we often see them used for a longer time. However tents are not always the best solution. Although industries have developed new materials and building systems, not all of them are suitable to provide for an appropriate response as desirable for application in shelters. In order to improve this situation, various aspects were presented and discussed during an International Symposium held at the Eindhoven University of Technology (TU/e) in November 2007 under the auspices of Red Cross organizations, universities, NGO's and private companies. As a result the TU/e has embarked on a research project on various approaches for sheltering in close cooperation with the Netherlands Red Cross 1.Development of a collective center. The center has been worked out in detail and a test model of 3 bays will be erected shortly.2.Development of card board housing i.s.o. tents. After detailed studies of other shelters and the material of cardboard, a model of a cardboard housing was produced. The model has undergone physical tests, which has led to changes in the concept.3.Development of a steel frame transitional shelter. The frame has to be optimized in the light of the varying weather conditions. A full scale model of the frame is built and needs optimization from the point of view of providing solutions in state of guidelines. 4.Development of a manual for the design of shelters.Apart from carrying out model tests, a full scale test in a local situation will ultimately prove the validity of the developed concepts. These tests are under development.

Keywords: innovation, collective center, research, disasters

1. Introduction

The number of natural disasters is about 400 per annum. Recent ones are for example, the tsunami in South East Asia (2004), the earthquakes in Pakistan (2005, 2008), hurricane Katrina in New Orleans (2005), the inundations in Bolivia (2007) and recently the typhoon in Myanmar (2008) and earthquakes in Padang, Haiti and Chile (2009). Apart from natural disasters, also man-made induced disasters heavily affect living conditions of people.

After such devastating events, NGO's and aid organizations do their utmost to provide the victims with a form of shelter, either temporary or semi-permanent. Shelters not only provide safety, security and privacy but these also protect against the natural elements.

In practice the quality of these shelters is too often different and inappropriate, the delivery on location is complicated, time consuming and costly and furthermore, the shelters are not sustainable. Tents made of textile or plastic sheets are the most simple and frequently supplied form of shelter provision in post-disaster areas. On the short notice tents are globally accepted by the survivors, but serious problems remain unsolved:

- Shortage of adequate sheltering;
- Time span between disaster and shelter provision is too long;
- Storage of emergency shelters is problematic because of costs and durability;
- The short lifespan of tents;
- Transport of shelters is costly and time consuming;
- Tents are not comfortable (problems with cold/heat/ventilation) and limited height for standing.

When these provisional shelters are used for a longer period than foreseen, the devastating and inhuman situation increases. Sheltering not only concerns the provision of a physical structure; it also has to satisfy a number of other requirements such as:

1. Availability;
2. Simple assembling;
3. Low cost;
4. Durability;
5. Reliability.

The last criterion is crucial because, one of the basic requirements is that victims shall not be subject to another failure of shelter construction. A different approach for shelter aid during the first days after, can be thought of as well:

1. Immediate provision of emergency shelter or;

2. Provision of an emergency shelter, which can be transformed into a transitional shelter or;

3. First provision of a form of communal shelter in a big hall, which facilitates families to recover and to start constructing their own (emergency family) shelter.

Depending on the local situation we can also think of construction:

- purely on self-help basis with local materials;
- with local labor and local materials;
- with flown in components and partly foreign labor.

The types of emergency shelter haven't changed very much over time. Although modern technologies are available these were not put to use, consequently innovations have not taken place. This is mainly because humanitarian organizations' primary target is to provide emergency relief and not to innovate in materials and technology. In our view, a win-win situation can be created if the new technological options would be used for solving both humanitarian problems and for emergency sheltering, for all stakeholders concerned, provided that they can be organized in a proper way.

The International Federation of the Red Cross took the initiative to take the lead in the field of innovation and knowledge sharing related to international shelter programs for post-disaster areas. This initiative is supported wholeheartedly by the United Nations, since they have indicated the need for increased knowledge and understanding (of the impact) of the dynamics of shelter programs and consequently renewed forms of emergency aid.

In order to generate this initiative and to bring all stakeholders together in one place at one time, an International Symposium "Innovative Sheltering' was organized at the Eindhoven University of Technology 21-23 November 2007. The presentations and discussions resulted in the formulation of research and development objectives, research topics and the creation of project groups. The following objective could be formulated.

2. Objective and methodological approach

The objective of the project of the Eindhoven University of Technology (TU/e) is to research and develop innovative solutions for sheltering in order to offer a decent habitat both at short notice and in the long run after a disaster. Therefore the TU/e is focusing at research on different approaches for sheltering, in close cooperation with the Netherlands Red Cross:

1. A collective center. This center has been worked out in detail and a test model of 3 bays will be erected shortly;

2. Cardboard housing instead of tents. After detailed studies of other shelters and the material of cardboard, a model of a cardboard housing has been made. The model has undergone physical tests, which led to changes in the concept and to further development;

3. A steel framed transitional shelter. The frame has to be optimized in the light of the varying weather conditions. A full scale model is under construction and to be made suitable for winter conditions;

4. A shelter design manual as part of a mapping database.

The applied research methods are:

- detailed survey of needs;
- establishment of work groups for the research;
- definition of the problem, formulation of research questions, development of directions for solutions/approaches;
- literature survey/interviews/measurements in lab/set up of prototypes/testing;
- field tests, full scale.

3. Development of a collective center

After a disaster, shelters are put up at random since aid organizations have no time to arrange these camps. Consequently there is no oversight and a great disorder. A solution can be to erect a collective shelter for housing within the first 24 hours. This can serve during the first days for sheltering families and from this point the construction of family shelters can be organized. After some weeks the collective center can be used for community purposes, for administration, hospital, church, storage, etc.

Such an arch type of the collective center has already been built, but for livestock purposes (a dairy cattle stable in Dieteren, the Netherlands). This structure has proved that the principle functions properly for its purpose. The question is how can it be made appropriate for housing community facilities and/or families. Other issues are: the volume and weight during transport, ease of erection, the need of skilled labor, and possibilities for re-use, costs, possibilities for anchoring the foundations.

Therefore many questions need to be answered such as, what type of skin, envelope shall be used, what is the heating/ cooling need, what are the options for a heat recovery unit in order to save energy?

The construction under investigation consists of metal truss elements, which can be assembled to curved trusses of 20 meters free span and placed at distances of 4 metres. The skin consists of three layers. The top one (layer 1) is a constructive layer, which breaks the wind forces and can carry loads of snow. Layer 2 acts as a rainwater barrier. Layer 3 is for insulation and is optional, dependent on local conditions.

The aim of this development is a collective center, which can be built up within a short time (24 hours) without skilled people and without heavy equipment and under severe but safe conditions.

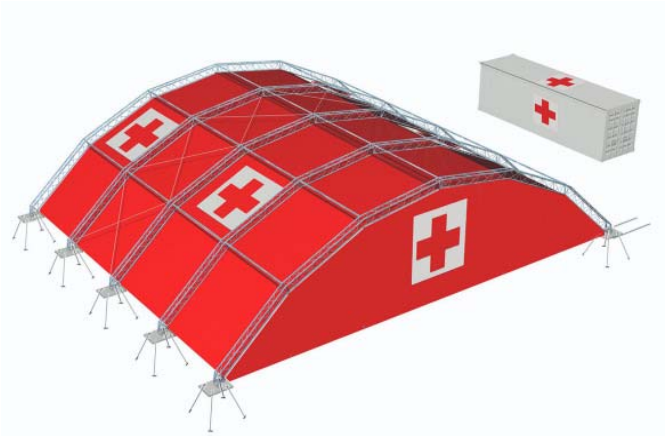

Figure 1: Model of a collective center (Cox e.a.2008b)

4. . Development of hard panel sheltering

Although the ridge type tent is replaced by the special developed Light Weight Emergency Tent (LWET), a number of great disadvantages remain, in case of an emergency. These tents do not give enough protection against weather influences from outside and they have a low comfort level. The material itself is not permanently resistant against humidity, fungi and fire. Safety, logistics, storage and ventilation are other problems. It does not satisfy the minimum requirements for shelter as have been formulated recently by the Shelter Center Geneva. So there are enough reasons to look for other materials.

Cardboard could be a suitable material. The costs of raw materials and production costs are low compared to other materials. Cardboard is available worldwide and can be produced locally, which saves transport costs. Production can be organized on short notice in the vicinity of a disaster area. If properly designed it can be recycled. The raw materials originate from used paper and timber chips and are light in weight (Kinderen et al, 2009).

In the recent past, various experimental prototypes were developed. Unfortunately, tests with these prototypes were not successful so far. For example the shelter developed by TU Delft tested in Chad camps showed leakages. A new design developed from scratch is the “Hexayurt” from Vinay Gupta:

it is stable by itself (without a metal frame). Inspired by the method of Gupta, Msc students of the TU/e have made an improved hard panel shelter. The design is based on the cavity principle, both for walls and roof, and it consists of 2 layers of cardboard, which provides space for ventilation of the produced damp/humidity inside and gives structural stiffness. (See fig. 2). A series of tests were carried out on stiffness and bending and also on damp transport. The latter showed that transport of damp was different from what was expected. A revision of the design is under development now.

Figure 2: Cardboard shelter prototypical design

5. Development of a steel framed winterized transitional shelter

Internal displaced persons (IDP's) in Pakistan, in particular in the SWAT valley are housed in a type of emergency shelters, which are not suitable for winter conditions. These structures consist of corrugated galvanized iron (CGI) sheets that are joined on a make shift timber framework. This does not resist heavy wind loads and barely provides any heat insulation. The Red Cross is making significant efforts to develop a transitional shelter to offer a medium and even long-term (winter/shelter) solution since the IDP's cannot return to their homesteads.

In close cooperation with the Red Cross the TU/e has embarked, together with the local Pakistan relieve agencies on the development of a more adequate system. The basic idea is the construction of steel frames (both columns and trusses), which can easily be erected under supervision of one coordinator.

Figure 3: Pakistan steel frame for winterized shelter

Because of the limited time available some prototypical structures were developed simultaneously in Pakistan and at the TU/e. This so-called 'parallel prototyping' approach had both advantages and disadvantages.

The Pakistan prototype is mainly based on experience than on calculations. One of the leading issues is that the components have to be transported by donkeys, so the weight has to be limited. This is one of the reasons why the field workers in Pakistan differ in opinion with the TU/e on the sizes and

weight of the frames. This situation is even more complex because decisions of local authorities on dimensioning of the frames are difficult to 'be revised' for reasons of loosing face.

The TU/e prototype is evidence design based. The TU/e performed structural calculations, and did tests on building physical aspects such as damp transfer, ventilation, heat insulation.

The roofing issue has not been solved until now: what could be the proper roofing material? Of course CGI could be used, but there are problems with finding proper connectors, not causing leakages, (a type of clipping system).

During the summer period the walls can do with a single layer of textile material. However a winterized version needs materials that induce better insulating, ventilating, etc. properties. The research focuses also at developing cheap and simple materials. One of these may be KICI materials. This is made out of used textile from clothes and has promising qualities. Usually clothes, nearby the camps are abundantly available due to donations. So, one of the R&D challenges is to find out in what way a simple production process for KICI can be set up. Since textile can consist of different fibres such as linen, polythene, etc., variations can be made when composing the KICI material, addressing different requirements and purposes, exists.

6. Development of mapping and shelter design

The preceding sections dealt with ex-post shelter approaches for disasters. This section will go about ex-ante approaches. After a disaster humanitarian aid agencies are in (desperate) need of reliable information of the area, which they need for developing and executing their emergency aid program such as sheltering. These agencies do not exactly know the conditions they will have to work in and what they can expect. At this moment, no comprehensive overview of the specific conditions of a certain area in terms of: climatologic, geological, infrastructural, socio-economic or technological conditions.

Further, many post-disaster reconstruction projects all over the world were completed, where builders have used various building systems for the provision of both emergency shelters as well as semi-permanent buildings. However, a number of these projects are not as successful as desired, because all the agencies in the field apply their own methods and techniques.

On location coordinators of emergency relief, need support of a group of professionals for their operations. However, there is hardly any communication possible and the coordinators have to operate on their own judgment. They have to rely on sources like well-documented manuals in order to be able to judge and take decisions about appropriate means of proposed local shelter solutions and other provisions. Furthermore, local craftsmen, in charge of making those shelters and other provisions, do not always have the knowledge how to optimize constructions. In many cases shelters are built and improved by trial and error. This is an unwanted situation because: when these structures turn out to be badly functioning, the displaced persons are faced with a collapsing structure, consequently Governmental bodies and NGO's loose their confidence. For these reasons:

“Any Emergency Shelter solution shall be ‘perfect”

The overall solution can be the availability of a comprehensive mapping of all aspects which may be needed to take proper decisions with regards to aspects of emergency aid. The mapping has to provide also insight in the socio economic and physical environment characteristics of these areas.

With regard to sheltering there is need of mapping of the technological characteristics of innovative sheltering solutions -products and construction materials - (to be) applied in disaster areas as well as what technology or techniques are to be used. In addition the socio-economic impact of measures shall be indicated as well.

The Shelter Centre in Geneva is working on manuals for transitional shelters: standards, prototypes and guidelines. In general, these booklets are showing the “what” but not enough the “how” and “why”. From our own Pakistani shelter design experience we learned that such documents are not adequate and aid workers in the field report that such documents are hardly being used.

So there is need for an alternative way of offering the required information. Professionals have learned how to handle specific information, but the coordinator and his helpers (who are usually laymen in certain fields) need a different approach for receiving and using the information. As they have to learn how to handle with it under changed circumstances, since no disaster is a copy of a preceding one. Compare it with a cooking book, which shows what ingredients are needed but it neither tells why you choose for those ingredients in order to obtain a certain taste nor does it tell you why you choose for cooking, frying, etc. You have to learn how to prepare the same food under other conditions with other ingredients.

In light of the above, it is required to investigate in what way this information has to be offered: in writing / drawings / pictures/ CD / demo’s / websites /schemes. Anyway the backbone shall be a database, which shall be kept up to date.

The structure of the mapping and the filling of the database are built up of ‘layers’:

1. Universal information of the locations, local, regional and national;

2. A method as how to retrieve local data and for sheltering a more specific section;

3. A shelter layer (similar layers can also be developed for other provisions).

With the following modules:

3a. The general/ universal shelter design method (independent of local conditions);

3b. Methods: as how to convert local data into data for calculations (e.g. technical such as wind loads: what wind load needs to be taken into account and how do you define that, with what reference period. What about human comfort such as ventilation? Application of results from 3a. will result into design suggestions;

3c. Methods how to carry out model tests;

3d. Methods how to build the developed shelters.

For mapping the following baseline information has to be given (see fig. 4): what are the national setting, geographical physical system, social system (Egmond 1999). These aspects influence the setting of the sector. Within this sector the technology needs and the technology capabilities determine (in this case) for sheltering the inputs for the production of shelter. The requirements for shelter come from the national setting etc.

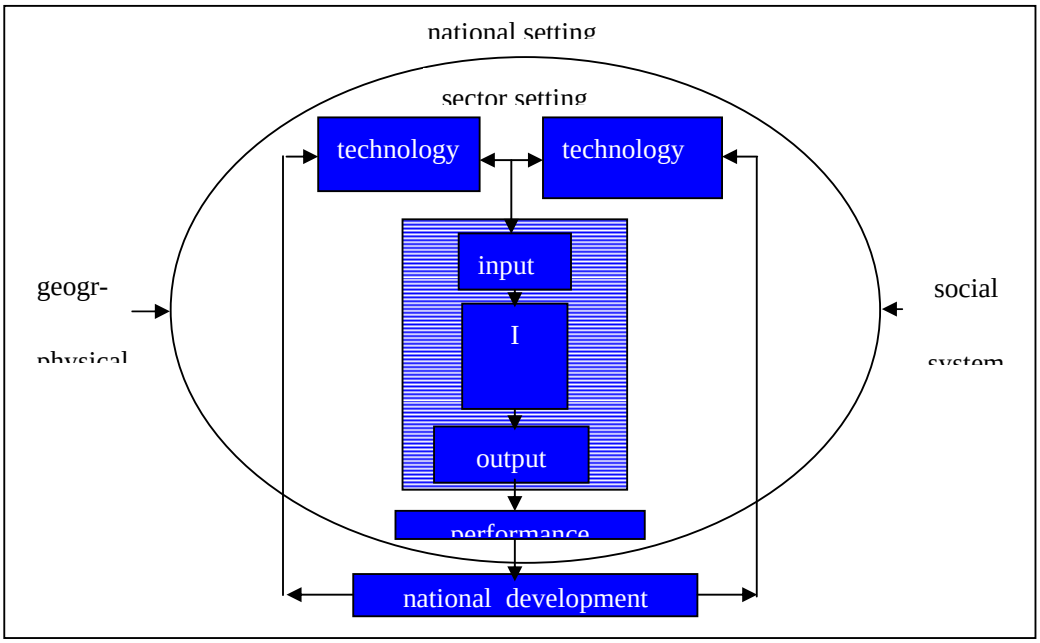

Figure 4: Frame for mapping (van Egmond 1999)

When we consider the shelter design in more detail, seven basic indicators have to be known: and documented but all tuned and be appropriate to the local circumstances:

- Functionality (e.g. dimensions, surfaces);
- Architecture (e.g. shapes);
- Materialization (e.g. local materials);
- Technical, physical, chemical and biological requirements (e.g. design rules, standards, subsoil, weather conditions, loads, termites);
- Construction (e.g. site preparation, building methods, craftsmanship, tools, logistics, procurement);
- Costs (e.g. men, materials, logistics, equipment, supervision, procurement);

- Environmental effects (e.g. water, air, deforestation, depletion, repair, replace, recycle).

The TU/e is working on mapping along different lines:

- development of a method for mapping the technological characteristics of innovative sheltering solutions - products and construction materials - (to be) applied in disaster areas as well as the socio economic and physical environment characteristics of these areas;

- application & testing of building methods, in order to judge the appropriateness;

- establishment of a useful tool to determine the specific terms of reference for sheltering in particular disaster areas, which can be used during the development, monitoring and testing of products and construction materials for sheltering in disaster areas.

The integration of the research results will lead to the development & set up of a web based database and information system on socio economic and physical environment characteristics of these areas as well as the locally used technologies and construction practices. This will facilitate the development, monitoring and testing of products and construction materials for sheltering in a particular disaster area.

This database informs every Red Cross organization in case of an emergency with the correct data and local contacts and organizations. Moreover the database can be used for developing location-tied sheltering concepts. Other universities will be invited to join this group. Egmond (2008). Similar to websites (e.g. Wikipedia) also a database master is needed to assure proper use. One of the problems to be solved is the possible misuse. For example well informed persons may claim beforehand certain areas of land where in future emergency shelters are planned to be placed.

7. General conclusions

1. The working combination of NGO's, universities and companies is a unique procedure, which needs to be followed. Each group can give its own specific input and so a big part of the spectrum can be covered.

2. The collective center has been worked out in all details technically, also the local appropriateness has to be tested. Since various local conditions need to be taken into account.

3. Parallel prototyping can be a good approach when not sufficient research capacity is available on location. By good communication, tests can be carried out at universities

meanwhile in the field the prototype can be further developed and adapted to local circumstances.

4. Mapping is a complex and broad theme, which needs further in-depth development. Different countries may require for the users a different way of presentation of information from the mapping.

References

Akkerman MS (2007) “Project proposal E.U. Sheltering”, *Internal report TU/e.*

Akkerman M S, Cox M G D M, Cubert I.E., Haas T C A de , Limpens V (2009) “Pakistan Steel Transitional Shelter for Winter 2009-2010”, *Internal Report TU/e.*

Cox M G D M, Gijsbers R, Hulsbergen H, Kok P (2008a) “Family shelter for emergencies developed for cold outsider temperatures, pilot project for field testing and monitoring.” *Project proposal TU/e.*

Cox M G D M, Gijsbers R, Haas T C A de (2008b) “Applied design of an energy Efficient Multi-layered Membrane sheltering system”, *Proceedings IAHS conference, Kolkata, November, India.*

Doreleijers W (2008) “Appropriate Architecture for Southern Sudan.” *MSc. Thesis TU/e.*

Egmond de Wilde de Ligny E L C van (2008) “Diffusion and implementation of innovative sustainable building technologies for post-disaster reconstruction”, *Proceedings International Technology and Knowledge flows for post disaster reconstruction, symposium, Surabaya.*

Egmond de Wilde de Ligny E L C van (1999) “Technology Mapping for Technology Management”, PhD. Thesis, Delft University Press. Delft.

Erkelens P A (2007) “Low-cost housing, a continuous struggle (overview, research, future)”, *Proceedings of CIB world congress, May, South Africa.*

Erkelens P.A., Egmond E. van (2009) “Towards innovative (Emergency) sheltering”, *Proceedings 3rd CIB International Conference on Smart and Sustainable Built Environments, June, Delft.*

Kinderen D van, Klos F (2009) “Sheltering revisited, new sustainable shelter solutions for disaster relief: hexayurt revisited”. *MSc. Thesis, August, TU/e.*

Shelter Center Geneva (2009), *Draft Shelter standards.*

Silas Johan (2008) “Reconciling technology to disaster mitigation”, *Proceedings International Technology and Knowledge flows for post disaster reconstruction, symposium, Surabaya January 2008.*