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Re-design, re-use and recycle of temporary houses

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Abstract

Disasters are recurring to global problems, which results in homelessness. The affected region had economical, environmental and social problems as well. In relief and reconstruction phases, the need for integrated management appeared in order to use the national sources actively and productively. Especially housing implementations had an important role for future development of the affected region. For accelerating the reconstruction of the region and forming a sustainable community, which maintains itself socially, environmentally and economically over time; energy usage for construction should be kept to a minimum. Past research in Turkey shows that the cost of temporary houses (to be used as the short term shelter) had a ratio of 10–15% of the total expenses of whole construction activity. For saving money and protecting the environment and conserving scarce resources, the affected region must consider the option of temporary houses to meet their short and long-term need during the reconstruction process. After the end of usage, temporary houses should be able to be re-used for the same or new function. This study is a test of re-design and re-use of a temporary housing site; by using recycled materials, minimum energy and voluntary participation so that this site can finally become a permanent housing site.

Keywords: Temporary housing; Re-design; Re-use; Recycling

1. Introduction

The link between energy production, use and local and global environment is causing increasing concern worldwide. In the developed countries there is a growing demand for an environmental impact assessment of all building projects, which will include considerations of embodied energy for their sustainability [1]. Sustainable building strives to minimize the consumption of energy and resources for all phases of the life-cycle of buildings—from their planning and construction through their use, renovation and to their eventual demolition. It also aims to minimize any possible damage to the natural environment [2].

This can be achieved by applying the following principles during the entire building process:

- lowering the energy demand and the consumption of operating materials,
- utilization of re-useable or recyclable building products and materials,
- extension of the lifetime of products and buildings,
- risk-free return of materials to the natural cycle,
- comprehensive protection of natural areas and use of all possibilities for space-saving construction [2].

On the other hand, waste control and management is one of the great challenges to modern society. Due to the lack of disposal sites and limitation of natural resources, recycling of construction and demolition (C&D) waste has attracted considerable attention and a lot of research and development work has been allocated to this subject. Today, in most European countries, it is economically feasible to recycle up to 80–90% of the total amount of C&D waste, and most demolition and recycling technologies are, in general, easy to be implemented and controlled [3]. When re-used materials were adopted in a one-family house, the embodied energy decreased about 45% [4]. Recycling is widely assumed to be environmentally beneficial, although the disassembly, collection sorting and processing of materials into new products also entail significant environment impacts [5]. This paper presents the importance of design and waste management for reusing

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and recycling building materials and constructing new housing sites after a disaster.

2. Aim of the study

The aim of the study is to optimize the design of the building in terms of ecology, economy, functionality and configuration. Effort has been made to transform the temporary buildings into permanent buildings. There is a need for multiple use and conversion. Permanent houses will extend the life-span of the buildings and reduce maintenance and renovation costs. At the same time, consideration given to waste management and control of the temporary housing site for minimizing demolition and dismantling waste and cost.

3. Studied object

After the devastating earthquakes of 17 August 1999 and 12 September 1999 very large losses occurred. Approximately 300 000 housing units were demolished or damaged. Emergency shelters were needed for 600 000 people [2]. To meet the shelter needs in the initial phase three alternatives were proposed: (i) shelters of friends and relatives; (ii) moving to a second undamaged house or renting a house; (iii) organized camps (generally for whom their houses collapsed) or tent shelters which were beside the damaged buildings. The second alternative also includes using empty public buildings [6]. In addition to the above-mentioned emergency sheltering, a plan was made to build temporary houses. A total of 63 500 units temporary house were built, 30 604 units by the Ministry of Public Works and 32 896 units by private persons and establishments (national and international aid) [7]. One of the temporary sites constructed after the earthquake in Duzce was the Beci Temporary Earthquake Housing site, which was located close to University of Abant Izzet Baysal. The land belonged to the university. The site was used by victims until the end of 2003. There were 32 temporary houses in the site and 64 housing units (see Fig. 1). The houses consisted of two family houses divided vertically by a separating wall (see Fig. 2).

The buildings were constructed in August 2000, in Duzce, Turkey. The infrastructure of the site was constructed by Disaster Work General Directorship of Turkey. Temporary houses were donated by Zonguldak Governorship. Houses were used by coal mine workers before the donation. Construction materials were recycled materials.

Fig. 1. Beci temporary housing site (general view).

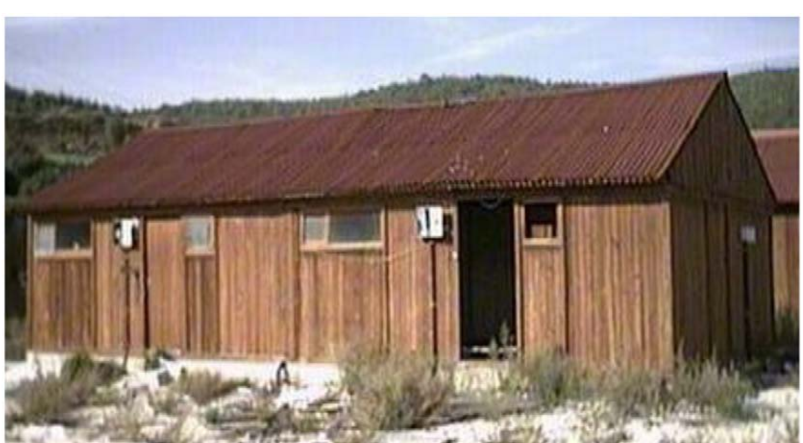

Fig. 2. Beci temporary houses view (two family houses).

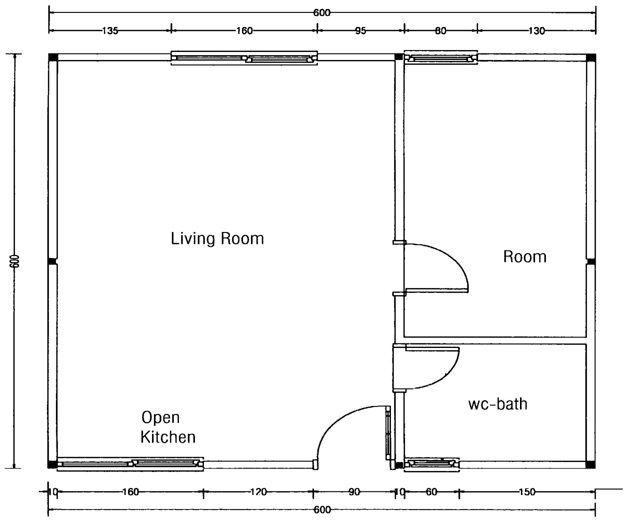

Fig. 3. Beci temporary house plan.

Table 1
List of construction material for the temporary housing unit

Material size (cm)	Unit	Material type
90 × 194	1	Door
80 × 194	1	Door
75 × 194	1	Door
155 × 110	1	Window
155 × 55	1	Window
80 × 110	1	Window
50 × 50	1	Window
2300	1	Sheet metal
9500	1	Chip wood
75/75	1	Shower fixture
40/55	1	Lavatory
	1	European style toilet
	2	Siphon
200	1	Crackling tube

Each housing unit has a net residential floor area of 36 m^2 (see Fig. 1) and consisted of a room, a dining room, an open kitchen, a common bath and toilet. Houses were made of timber and had no prefabric characteristic (Fig. 3).

Construction materials and electrical materials used in temporary houses are summarized in Tables 1–3. As the junctions were made by nail the loss occured to materials during dismantling increases. Demontable construction should be preferred in design phase for future uses.

There is also 5 m^3 concrete and 5 m^3 penning used per temporary house to form the foundation. But forming foundation by concrete reduces the recycle potential of the land.

4. Assumed methods for re-use and recycling building materials

The re-use and recycle process of temporary houses is shown in Fig. 4. The decomposition of main building materials represents flow for product recycle. The decomposition of lower building materials represents the flow for material and feedstock's recycle.

Table 2
List of construction material for the temporary housing unit

Material size (cm)	Length (cm)	Unit	Material type
10 × 10	600	9	Timber
10 × 10	194	13	Timber
10 × 10	135	3	Timber
10 × 7	600	5	Timber
10 × 7	330	6	Timber
5 × 7	300	16	Timber
2 × 5	300	6	Timber
5 × 10	194	9	Timber
2 × 10	194	170	Timber
2 × 10	140	20	Timber
2 × 10	85	24	Timber
2 × 10	150	56	Timber
2 × 11	370	115	Rafter
5 × 5	120	21	Interior furnishing (timber)
2 × 5	80	3	Interior furnishing (timber)
2 × 5	100	6	Interior furnishing (timber)
2 × 10	120	250	Interior furnishing (timber)
2 × 10	80	35	Interior furnishing (timber)
2 × 10	100	20	Interior furnishing (timber)

Table 3
List of electrical material for the temporary housing unit

Unit	Material type
1	Transformer 2 × 16A
1	Transformer 1 × 25A
3	Square junction box
2	Commentator electric switch
1	Ordinary electric switch
5	Turnout
5	Luxury globe
3	Cock
1	3 fuse box
1	Counter
1	Electricity meter
1	Electric shuttering
1	32 A leak flow relay
1	Doorbell trans. (4,8,12 V)
2 × 1.5	750 cm cable
3 × 2.5	1000 cm cable
3 × 1.5	500 cm cable
2 × 1.5	400 cm cable

4.1. Forms of processing

The production procedures to manufacture a new building product from the material can be divided into primary and secondary processing. The process of constructing a new building material from raw materials is called primary processing and constructingthe building from the building materials is secondary processing [5].

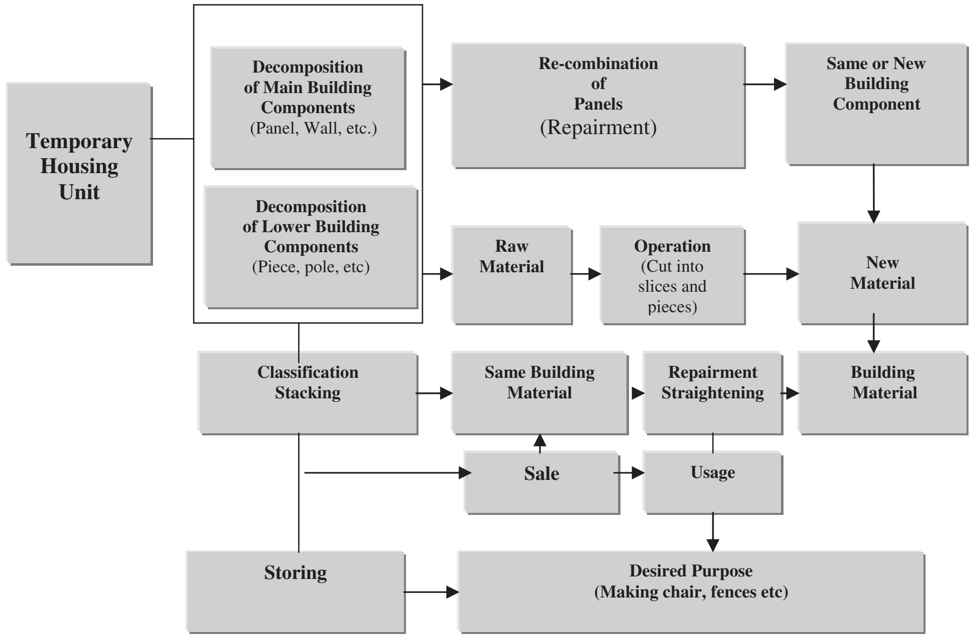

Fig. 4. Recycle and re-use process of temporary houses.

Table 4
Definition of recycling methods

Number	Recycled method	Definition	Example
1	Product recycle	Method of reusing without processing	Reuse a glass bottle after washing
2	Material recycle	Method of recycling materials after processing	Recycling a glass bottle as glass
3	Feedstock recycle	Method of recycling feedstock after processing	Recycling a glass bottle for aggregate of concrete

4.2. Forms of recycling

The recycled material of a building is defined as a material which can be remade and re-used as a building material after the building is disassembled. It is called ‘‘recycled’’ when the building product partly or totally manufactured from the disassembled materials. The method of processing recycled material can be classified into three types: PRODUCT recycle, MATERIAL recycle, and FEED-STOCK recycle. ‘‘Production recycle’’ refers to a process where the product can be used again, without changing the form/nature of the material. ‘‘MATERIAL recycle’’ is a process that, after it is separated/collected, the disassembled material is processed into a building material. ‘‘FEEDSTOCK recycle’’ refers to a process where the disassembled material is processed into feedstock to make a building material. The definitions are summarized in Table 4 [5].

5. Case study of Beci temporary housing site

5.1. Method

Initially the project of existing site was sketched and future use of the site was determined. Three design alternatives were created by architect Hakan Arslan as well for permanent housing. Comparisons were made by considering economic, social and environmental effects. The best-fit solution was selected (see Fig. 5) after weighing the following factors: minimization of existing resources, feasibility; social (neighborhood, culture, etc.) and physical sustainability; distances between housing units and existing location plan. Procurement of new material were considered to be taken from demolition and dismantling of other temporary housing units which were close to the existing one. As productions of timber houses are not prefabricated, there is no change for dismantling and re-use potentials of temporary house in another site. Materials need of new permanent houses were met from nonused temporary houses of the site. Attention is paid to minimize demolition waste. Demolition and dismantling of temporary houses and construction of new permanent houses were carried out by volunteers who were students from Universit of Abant Izzet Baysal Construction Department. Generally, secondary processing was used while constructing the new permanent house. But in some implementations such as plaster, coating, etc. primary processing used as well. The buildings were dismantled/ disassembled by hand. It is difficult to estimate an accurate value for the manual

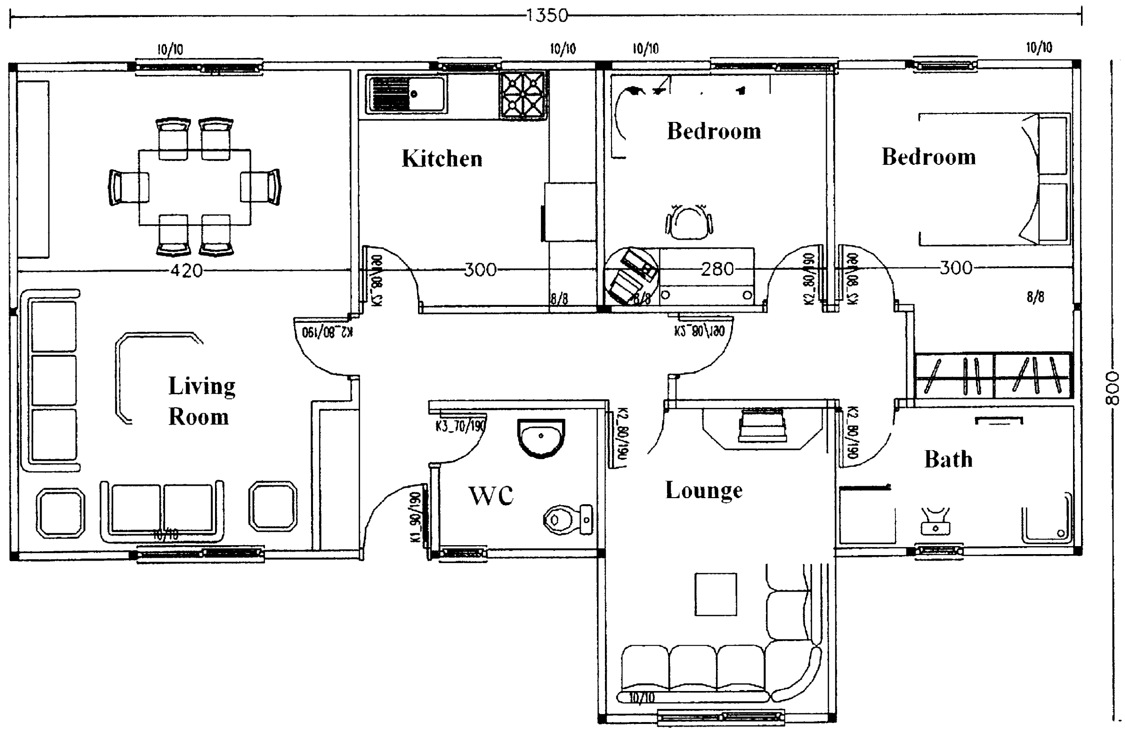

Fig. 5. New permanent house formed from two temporary houses and some additional parts.

disassembly. But energy consumed by volunteers (university students) participation were nearly in minimum level. Therefore, cost for neither dismantling nor constructing occurred.

Firstly, dismantling and demolition of temporary housing units were made with respect to roof, wall panel and base panels (see Fig. 6). Then, for 1 m size enlargement of living room, ground was digged under the spot height of pumping head. Templates were penetrated. Shuttering filled up with penning under 5 cm from the height of pumping head. Cab heater harness wire's outlet line was in the middle of the living room. So its outlet is closed. The new outlet of cab heater is formed by a transition to the corner of the living room. The centers of two temporary houses were opened up by cut off with saw. The Hall is in this section. A new partition wall system was heaped up on 10/10 cm size posts. Posts were resized according to new plan. Posts were produced from waste materials acquired from dismantled/demolished temporary houses. New detailed solutions were found due to places of posts used in the building. After that, wall and roof structures formed and were sheathed.

5.2. Discussion

The study was limited to re-use, recycle and re-design of temporary houses which was done after the disaster. Post-disaster housing is a complex issue with regard to economic, social and physical environment. It has long-term impacts to the affected region as well. Re-use and re-design of temporary house give chance, for using the sources to accelerate the reconstruction of the affected region and not to tap national treasuries for grants and loans of housing. Because the sooner people turn their daily life the sooner the affected region will be reconstructed. The possibility and feasibility of using the temporary houses and housing sites with the same (house) or different functions (mukhtar office, workmen dormitory, youth camp, etc.) must be considered before the disaster. İt is important to give a sustainable function to the houses and site. Especially, attention must paid to extend the utilization period of the houses. In this way, temporary houses cost should be minimized. Consequently, for quick decision; planning and design must be made before the disaster by considering sustainability, minimum energy consumption, flexible design, and long-term effects. The recycle potential of houses, land and infrastructure should be increased. The important role of re-use of temporary house, debris and waste management following a natural disaster are usually neglected or underestimated. More attention must be paid to these issues.

6. Conclusion

Sources transferred for temporary house construction should be kept to a minimum by considering post-usage phase of disaster-affected areas. The first method is to pass permanent housing in short term and construct low cost temporary shelters with recycled, demontable materials and which should be aimed at only for short-term usage [8]. There must be also possibility for usage of these shelters

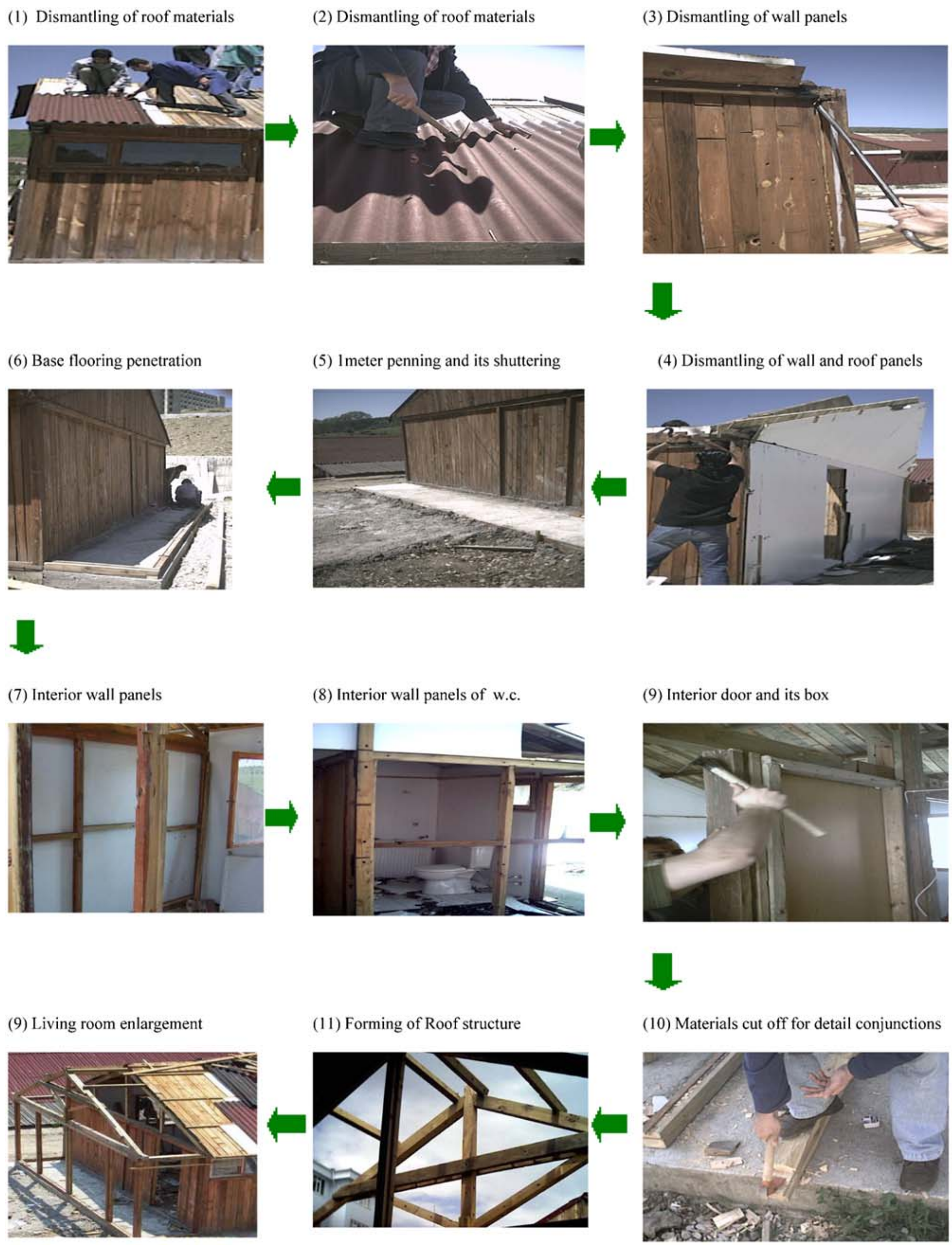

Fig. 6. Process of dismantling temporary house and reconstructing permanent house.

material in permanent houses or for other purposes. Later on temporary shelter units should be transformable into a permanent house, recycled, and their re-use potentials after usage or evacuation must be kept to a maximum level. For appropriate usage of the resources local material stock and labor possibilities should be determined and solutions should be found for using this possibility by re-evaluation after post disaster situations. Local material will minimize transportation expenses. However, using less equipment and construction methods, which have no requirement of qualified labor should be preferred. The design team of temporary houses should consist of various disciplines under the leadership of the planner responsible for future re-design, re-use and recycle of the temporary houses. Users and operators of the building must also be involved in the design phase. Training of operators for dismantling will minimize the losses occured during the demolition. In design of temporary houses few junctions must be used instead of complex junctions for increasing the participation of NGOs and affected community to the construction process. Also for increasing potentials of re-use and recycle of housing land and infrastructure (if the site will not use no longer), construction type of the housing site and infrastructure should be designed in order to make minimum intervention (excavation) to the land and should be easily dismantled after usage. This will either minimize energy used for dismantling or loss of infrastructure materials.

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