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STRAW BALE HOUSES: A QUICK SOLUTION TO ACCOMMODATION PROBLEM

Mehmet Fatih Altan[1*], Ahmet Emre Tekeli[2] and Omer Faruk Capar[3]

[1]*Department of Civil Engineering, İstanbul Aydin U., İstanbul, Turkey*
[2]*Department of Civil Engineering, Nisantasi U., Istanbul, Turkey*
[3]*Department of Civil Engineering, Bulent Ecevit U., Zonguldak, Turkey*
[*]*altanmf26@hotmail.com, atekeli1976@yahoo.com, ocapar@yahoo.com*

ABSTRACT

In this study we compared the construction costs of two houses that are built either with commonly used construction materials or using straw bale. For this, a prototype unit is chosen and total construction costs are computed based on this prototype. Straw bale option has been found to be more economical and provided better insulation. Straw bale houses being much more environmental friendly than other options, seems to be a good solution to housing problem in Central Anatolia, where the raw material, straw, is abundant and easily accessible.

Keywords. Alternative Solution, Straw Bale House, Environmental Friendly, Insulation, Cost Analysis.

1 INTRODUCTION

Although straw has been used in masonry for long time, its popularity is increased by being used as straw bale starting with 1990s. With the elasticity, durability and easy access to the raw material, it is mainly used in roofs and floors of the constructions, especially in the countries that are based on agriculture (Magwood 2000). Use of straw in straw bale format where the straws are bundled together by some machinery, began in 1890s in US. This arose due to hardly provision of the wooden equipment in 1800s in Nebraska province (Bainbridge, 1988, Inkpen, 1998). The initial use of straw bale without the wooden supports, where the bales are compressed and covered with plaster, has been called as Nebraska Technique and the first recorded structure constructed using this technique was a school with one classroom in US (Steen et al. 1994, Minke et al. 2005). Besides the advantages that straw bale provided, the use of straw bale as an insulation material was observed in 1921 at France's Montagris Part where a total of 2200 units straw bale had been used on the wall, floors and roof systems (Minke et al.2005). With the wooden reinforcement, two storied straw bale structures came in to existence in 1938 in US (Minke et al.2005). Nowadays Nebraska Technique, using straw bales in wooden and steel carcass system has been used in many countries such as US, Germany, Austria, Chile, China, Iraq (Capar 2008). High insulation, production simplicity and being more environmental friendly properties of straw bale have encouraged use of it in construction. Moreover, since straw bale walls are thick and light construction materials, they increase stability of load-bearing properties of the

constructions. These walls result in more flexible behavior against earthquake loading when compared with stone and brick walls (Capar 2008).

In this study we compared the construction costs of prototype village houses designed using conventional construction materials and straw bale. The insulation characteristics of the materials and the insulation costs are also investigated. It is seen that prototype designed using straw bale is found to be more economical especially in Central Anatolia where straw bale is abundant.

2 THE FEATURES OF RESEARCHED PROTOTYPE UNIT

2.1 Prototype Plan

Prototype is designed as a village house having 40 m^2 in plan with dimensions of 8m by 5m (Figure 1). It is designed considering the local climate and aesthetics point of view.

Figure 1. Prototype plan

2.2 Characteristics of the Alternative Construction Materials Used in Prototype

Bearing reinforced concrete system was designed using C20/C25 with Ø14/ Ø28 reinforcement. Design bearing reinforced concrete system was masonry design performed using bricks with dimensions of 19x19x13,5 cm. The load carrying structure of the straw bale house was same as that of the Straw bales had bearing reinforced concrete system of 45x35x40 cm. The design that included use of ytong had dimensions of 60x25x20 cm (Table 1).

Table 1. Equipment features

Structure type	Construction material	Dimensions (cm)	Reinforcement	Concrete type
Straw-bale house	straw bale	45x35x40		
Concrete house	brick	19x19x13.5	Ø14/Ø28	C20/C25
Concrete house	ytong	60x25x20	Ø14/Ø28	C20/C25
Masonry house	brick	19x19x13.5	Ø14/Ø28	C20/C25

2.3 Cost Analysis of Prototype

Unit prices used in construction costs computations are obtained from the manual of Directorate General for Construction Affairs issued annually by Ministry of Environment and Urban Planning expenses and the insulation costs are added on top of the final results. Design in which straw bale used is found to be most economical choice (Table2).

Table 2. Cost comparison

Structure type	Cost (TL)
Reinforced Concrete with brick	11 277
Reinforced Concrete with ytong	10 981
Reinforced Concrete with straw bale	6 048
Masonry with brick	12 338
Masonry with straw bale	6 266

2.4 Insulation Characteristics of Prototype

Cellulose present in the straw bale provides good insulation. Insulation characteristics of the prototype is computed by the numeric value indicating the thermo conductivity λ. Smaller λ values provide better insulation. Since the straw bale releases the heat gradually, it is a better selection among the other construction materials (brick and concrete) and provides good energy saving. Thermal conductivity values, λ given in Table 3, are obtained from TS825.

Table 3. Thermal conductivity values

Construction material	Thermal conductivity (λ)
Straw	0.058
Brick (19x19x13.5 cm)	0.33
Ytong (60x25x20 cm)	0.16
Lime mortar, lime concrete mortar	1.00
Plaster mortars which has been produced by inorganic essential light aggregates	0.35
Reinforced concrete structure element with fittings	2.50
Polistiren - particled skimmings	0.035

3 COST COMPARISONS OF THE ALTERNATIVES

The comparisons are made in two sections. In the first part only the cost values are mentioned and then the insulation comparisons are provided.

3.1 Cost Comparisons

The unit cost of straw bale having dimensions 45x35x40 cm is 3.00 TL in Central Anatolia, where the prototype is mainly designed for. The transport and workmanship costs are minimum since the raw material is abundant in Central Anatolia. When compared, all construction materials yielded approximately similar cost values.

However, since the straw bale option cause a reduction in the fuel consumption values, the fuel costs in straw bale becomes less and straw bale becomes the most economical option among the others.

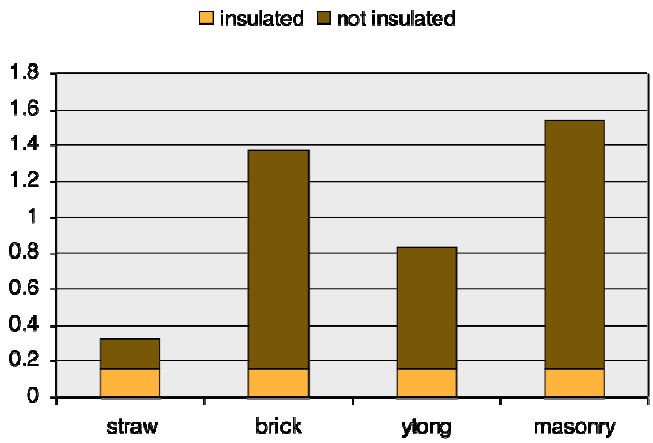
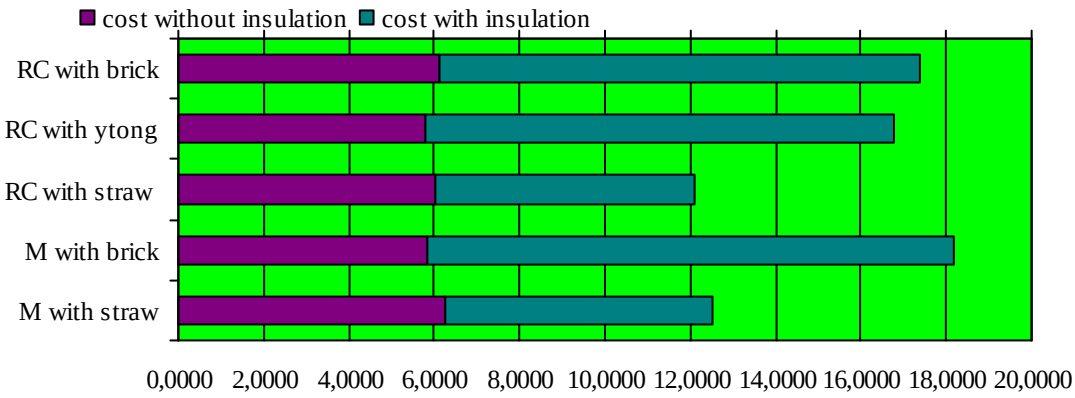


Figure 2. Cost comparisons

3.2 Insulation Comparisons

Thermal conductivity values, λ taken from TS 825 are used in "İZODER" to compute the heat insulation coefficients. It is seen that straw bale provided the best insulation among the others. It is also seen that the other construction materials can provide the insulation properties enabled by straw bale just after the jacketing (Figure 3).

Figure 3. Comparing of insulated and not insulated houses



4 RESULT AND SUGGESTIONS

After the comparisons performed regarding the thermal conductivity, straw bale had the lowest value, providing the best insulation among the other construction materials. Other construction materials could satisfy the insulation provided by straw bale only after jacketing. Even though the construction costs have been found similar among the all construction types, straw bale designed house found to be the cheapest alternative after including the insulation costs, namely the jacketing (Table 4).

Straw bale, a naturally healthy construction material having good insulation performance, has been used in Europe and America since 18th century. Nowadays, in the US, there are more than 100 000 straw bale houses that can provide all the facilities and comfort expected from a house.

Every year after harvesting too much straw bale is obtained. Instead of burning the straw and polluting the weather with CO_2 gas, using the straw bale as a construction material will reduce the environment pollution and provide so much benefit for the economy of the country.

Table 4. Cost comparisons with and without the insulation

Structure type	Thermal conductivity	Jacketing value (cm)	Thermal conductivity coefficient after jacketing (U)	Cost without insulating (TL)	Cost with insulating (TL)
Reinforced concrete with brick	1.215	19	0.16	6104	11277
Reinforced concrete with ytong	0.67	19	0.16	5808	10981
Reinforced concrete with straw bale	0.16	-	0.16	6048	6048
Masonry with brick	1.382	22	0.16	5826	12338
Masonry with straw bale	0.16	-	0.16	6266	6266

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