

Relationship of economic and environmental factors with the acceptance of earthen architecture technology: A case study of young educated couples in Yazd, Iran

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Abstract

Since time immemorial, earthen architecture has been prevalent in Yazd; however, in spite of its merits and benefits, tendency for it has decreased over recent decades. The main objective of this research is to clarify the relationship of economic and environmental factors with the acceptance of newly built earthen houses. The research is a cross-sectional study conducted through a survey method. The sample population consisted of 145 young educated couples in Yazd selected based on the Cochran formula and through a multi-stage cluster sampling procedure. The results showed that the acceptance of newly built earthen houses among the respondents was higher than average. The perceived usefulness of this architecture in terms of both economic and environmental factors had a positive and significant correlation with the acceptance of that, while none of the demographic variables associated with acceptance. Using the regression model, environmental and then economic factors were found to account for 39 percent of the variance for the acceptance of the earthen architecture. According to these results, it seems that taking environmental and economic factors into consideration can affect people's interest and their acceptance of newly built earthen houses. In this regard, certain architectural solutions are presented in the paper. This research findings provide motivation for further and broader studies in this field.

Keywords: Earthen houses; Economy; Environment; Technology acceptance; Yazd

1 Introduction

Nowadays, building construction is often done without taking the features of traditional architecture into account. That is, modern buildings constructed of steel, concrete and glass bear little relation to human needs. Whereas there is harmony between human nature and traditional architecture, contemporary buildings are too detrimental to human health and the future of mankind. Instead of using harmful construction materials, it is advisable to return to earth as a material which is economical and compatible with the environment and human nature. Building with earth has a long history, and a bright future is envisioned for it. Recent excavations have revealed that earthen architecture in Iran dates back to 6000 BCE. For example, the Chogha Zanbil remnants provide some evidence for building with earth in ancient times. Contrary to popular belief that earthen buildings are not efficient, they have been useful enough to serve as the residence for almost one-third of the world's population [1].

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Currently, almost 40% of the annual energy consumption occurs in the construction sector [2]. In Iran, due to the low cost of energy, the specific design of buildings and the lack of concern about sustainability, a large portion of precious energy is wasted in buildings [3]. Furthermore, the adverse impact on the environment and human health is one of the hidden effects of the choice of construction materials. Due to the growing global concerns about energy consumption, the forms of housing have come into sharp focus [4]. In recent years, environmental problems, such as global warming, ozone depletion, acid rain, low rainfall, resource depletion, use of non-renewable materials and, in contrast, recyclability of earth after building demolition, have led to re-look at the earthen architecture.

Earth, as one of the natural materials tested over hundreds of years, can be used in modern ecological buildings through new methods [5]. Most other materials cannot replace earth, especially in hot and arid areas where wood or natural stone is not available or is difficult to find [6]. Energy-saving features, good thermal characteristics, low carbon emissions and fire resistance are the merits of earthen material. As compared to most materials, production of less waste during the manufacturing process, absorption of moisture and providing a healthier environment for occupants are some other benefits of earth [7, 8].

Approximately 74% of the earth's crust is made of clay and materials suitable for architecture [9]. In fact, there is no other material of this nature on the planet. It is found on most building sites and is extremely cheap and workable. Furthermore, low-income people can often afford this material. Other features including fast and easy construction with semi-skilled workers, production of high-quality houses for a large population, low-cost material preparation, and economical operation, repair and maintenance work are the benefits associated with the use of earth. Due to the possibility of using indigenous and existing materials on the building sites, earthen material reduces transport costs and boosts local economy rather than foreign imports. Despite all the aforementioned good points about earth, it seems the material has lost its credibility primarily because most houses whose walls are made of earth are not capable of withstanding earthquakes. In addition, it is perceived as a construction material used in the houses of the poor [10]. Its vulnerability to moisture and water penetration into it, faster installation of some new materials and the need for a large workforce are the factors that have made earth undesirable for construction.

Steps should undoubtedly be taken to optimize materials for a durable and sustainable architecture in friendly relationship to the environment. However, not only is the problem technical, but also it is connected with the involvement and perceptions of the community [11]. In fact, the use of earthen material requires the effective management of physical and human resources. So far, just a few studies have been carried out on the acceptance of earthen architecture as a behavior among target groups. The fundamental question of this research is "what is the relationship of economic and environmental factors with the acceptance of newly built earthen houses in the city of Yazd?"

2 Literature Review

In a study on the economic feasibility of compressed stabilized earth blocks (CSEB), Kumar et al. [12] showed building a mortarless CSEB wall cost less than other traditional wall systems, such as concrete block walls or fired clay brick walls. By way of example, due to the need for a large number of workers, the construction cost of clay brick walls was higher. However, the cost of mortarless CSEB walls would be as much as that of light-frame wooden walls, which was the most commonly used system in the study area. Hardin et al. [13] investigated the cost-effective ways of building affordable houses in the United States and showed rammed earth had the potential benefits, especially with a view to reducing the costs of utilities and maintenance. Minke [14] stated that earthen materials were more affordable than other conventional building

materials. Hadjri et al. [15], Walker et al. [16], etc. also achieved the same results for the economic benefits of these materials.

A group of researchers took account of environmental issues as well as economic aspects. Adegun and Adedeji [17] pointed out that housing solutions should address the issue of construction materials particularly to support the development of less costly and more eco-friendly ones. They reviewed 136 research outputs from 17 African countries. Their search through the literature showed that earthen materials were cheap, clean and efficient in terms of thermal comfort. However, despite these benefits, there was a low acceptance for them. Sameh [18] sought to examine the obstacles in the way of returning to earthen architecture in Egypt. The high demand for sustainability in the construction sector and the increased need for affordable housing in Egypt provided a good opportunity to return to traditional materials, including earth. She regarded building regulations as a key factor in impairing the quality of construction, which presented a negative image of earthen architecture in the construction market. Further, she suggested the documentation of previously used techniques of construction in Egypt, such as Hassan Fathy's works and passive methods for designing a building with earth. Those passive techniques included shading on walls and roofs by using plants or sun breakers and providing ventilation by courts and wind catchers.

Assefa and Frostell [19] evaluated the social acceptance of ecological methods and the internal effects of building characteristics in Sweden. Methods of material flow, power supply and heat production were assessed. Furthermore, they focused on carbon emissions, waste, over-exploitation of renewable sources and the use of toxic materials in manufacturing. Internal effects were studied by the assessment of the dangers threatening physical health, safety and well-being due to the indoor environment of building and locality. Those dangers were identified by questionnaires and social science methods. Life-cycle costs were also considered for the economic dimension. The researchers also recommended social studies to develop eco-friendly and economical technologies. Correia et al. [20] classified the parameters of assessing vernacular heritage into the three main scopes of society, environment, and economy so as to provide solutions for enhancing the sustainability of contemporary architecture.

In addition, some researchers investigated the prevailing view about using earthen materials. Kebaili and Youcef [21] analyzed various attitudes towards earthen architecture in Auroville, India. They did it with respect to economic and environmental issues. They found that using compressed stabilized earth blocks (CSEB) was a suitable alternative for conventional materials. In general, the results showed that people had a positive attitude towards buildings constructed with CSEB, which was really interesting in comparison with the view of the inhabitants of New Gourna who had no desire to use them. In spite of the positive attitudes of Indians, the limited use of CSEB was problematic, and they concluded that providing better motivation for using such buildings would require more serious efforts. Bosman [22], working in the field of the acceptance of earthen houses, found that people considered these materials inferior. Generally, his findings indicated the low acceptance of earthen buildings in South Africa. In his research, the factors related to the acceptance of earthen architecture were surveyed in order to improve the housing conditions. Furthermore, he stated that previous studies had not pointed out enough to the factors associated with the acceptability of this kind of building. He showed that there was a relationship between the acceptability of earth houses and housing features, such as sewerage system, running water and electricity. However, by personal and household characteristics such as household size, income and ownership type, the acceptance of these houses could not be predicted. Danso [23] studied the benefits and problems of the earthen houses constructed in Ghana and indicated that cool indoor temperature and affordability were the merits of these houses. In the year 2004, SANPAD[†] examined the

[†] South African-Netherlands Research Program on Alternatives in Development

acceptance of adobe and other building materials in several areas. The research findings pointed to the low acceptability of adobe blocks. The problems of these houses were mentioned as washing away, cracking and collapsing under the influence of rain and climate [24]. Kay Stewart et al. [25] found that the adoption of solar and earth-sheltered houses in North Carolina, as two examples of energy-saving and cost-effective buildings, would depend on the acceptance of users, the availability of funds, livability and construction technology. The researchers investigated the reaction of the participants in the study to such design features as size, spatial arrangement, lighting, privacy, access, maintenance costs and energy efficiency. They concluded that the willingness to live in earthen houses depended on three factors including community acceptance, access and lighting. It was suggested that these factors are the ones that any architect should consider while designing these buildings.

Some studies in the literature have focused on the opinions of the construction professionals about earthen buildings. Aghimien and Aghimien [26] showed there was a relationship between the suitability of compressed stabilized interlocking earth blocks for construction and the willingness of architects to use them. Moreover, the low cost of raw materials and the cost reduction in finishes/maintenance were of importance to the respondents. Niroumand et al. [27] studied the acceptance of earthen architecture among architects and researchers from ICOMOS in six countries, including Iran. They surveyed the triggers, incentives, barriers and reasons involved in the progress of earthen architecture, including economic aspects and climatic conditions. According to 58% of the respondents, the main environmental factors were environmental protection, minimizing environmental impacts of buildings and reducing waste. Although British and Malaysian experts considered energy costs to be the primary cause for the introduction of earthen architecture, American, Indian and Australian experts perceived ecological issues as the prime contributors. Most experts thought of the lifetime reduction of costs as the strongest economic motive, and the reduction of operating costs was of lesser importance. Further, Iranian and British experts showed more interest in using these kinds of building due to the historical background to earthen architecture in their countries.

What is apparent from most of these studies is that the majority of researchers have sought building professionals' opinion, while only a small number of them (such as Bosman, Kebaili and Youcef) have rated the acceptance of earthen architecture among people. Of the pieces of research surveyed in the present study, no one has taken into account the age groups that are in urgent need of housing. In this case, the literature suffers from a big gap. Meanwhile, the studies ever conducted have ignored Iran, especially the city of Yazd which is the origin of earthen architecture. Therefore, with such shortcomings in the literature, the present research can be considered as an important and positive step to fill the gap.

In our review of the studies, no one was found to have tested Davis's technology acceptance model in the field of earthen architecture. In this regard, the present research is of novelty.

3 Theoretical Framework

The theoretical framework of this research is based on the technology acceptance model (TAM). The theory of technology acceptance is proposed as a way of promoting a new idea, technology or man-made technique in a community or culture. There has been a lot of debate about how, why and how quickly an idea can spread through a particular culture. The purpose of this theory, which was first introduced by Davis in 1989, is to describe the patterns of accepting a new technology and its mechanism in order to predict its compatibility in the future. This theory seems like a highly reliable method for testing and modeling the modernized traditional architecture, i.e., earthen buildings. Indeed, the theory shows how to spread the modernized forms of traditions.

In the theory of reasoned action, Ajzen and Fishbein [28] stated that "We have examined the potential effects of variables external to our theory, such as demographic characteristics, personality traits and traditional measures of attitudes towards persons, institutions and policies. We argued that such variables have no necessary relation to any particular behavior, since they have no consistent effects on the beliefs underlying these behaviors" (P. 91). However, to test this idea in the present study, some demographic variables such as age, income and level of education were considered as independent variables.

As Davis [29] put it, to accept a technology, there should be two factors, perceived ease of use (PEU) and perceived usefulness (PU) of that technology. These two influence the intention to use (IU) prior to the actual use in the model (Fig.1). In fact, the technology acceptance model (TAM) is the first model in this field outlining the acceptance of a technology.

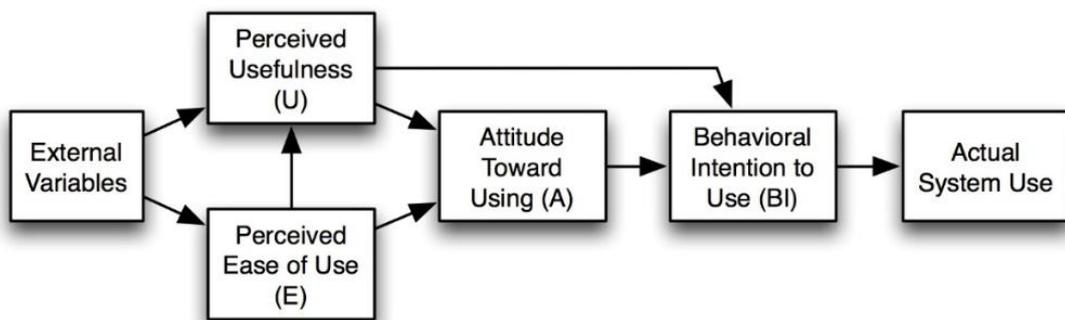


Figure 1. Technology acceptance model, Davis, 1986 [29]

Contrary to the increasing number of technology acceptance theories, they are rarely used in architecture and building industry research, although some studies have recently been conducted in this regard [30, 31, 32]. The TAM is presented in Fig. 2 to define the acceptance of earthen architecture technology and perceived usefulness.

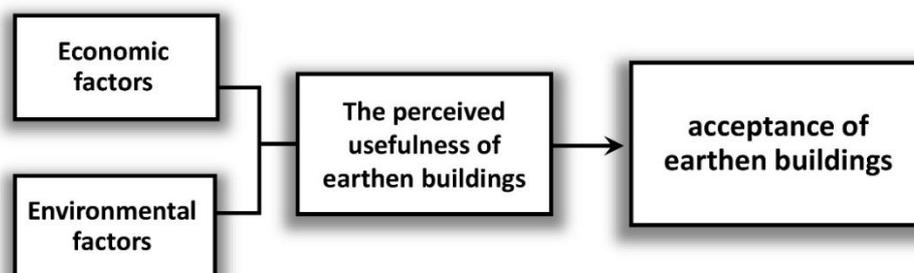


Figure 2. A model for the acceptance of earthen architecture technology and perceived usefulness

In fact, various factors such as the previous experience of habitation, the perceived ease of use, the perceived usage compatibility and perceived usefulness can be linked to the acceptance of earthen architecture [33]; however, in this paper, only the two economic and environmental factors, as the subsets of the perceived usefulness of earthen buildings, are examined.

4 Methodology

In terms of the time criterion, this research is cross-sectional. In terms of purpose, it is an applied study conducted through a survey method. Moreover, the study is based on a descriptive-

analytic approach. The data collection tool was a researcher-made questionnaire whose validity and reliability were assessed through Cronbach's alpha.

The statistical population of the study consisted of young educated couples aged 19-39 in Yazd. As the marriage statistics of Yazd province indicated, the people in this age group had 8500 marriages in 2015. The selection of these people was in light of the fact that they tended to be in need of housing and, therefore, potential applicants for a dwelling. Their opinions could help us plan the intended type of architecture. Since the city of Yazd accounts for 60% of the province population, it was concluded that there were 5100 marriages taking place in the city per year. This meant 10200 people (male and female) were involved. In the meantime, 55% of the people were found to have university education in Yazd. That would mean 5610 married educated people who constituted the statistical population of this study.

After the population size (N) was determined, the Cochran formula was used to determine the sample size as follows:

$$n = \frac{\frac{t^2 pq}{d^2}}{1 + \frac{1}{N} \left(\frac{t^2 pq}{d^2} - 1 \right)} \quad \text{eqn. (1)}$$

In this formula, n is the sample size, t equals 95% (the error rate equals 1.96), N is the population size, p represents the presence of trait and equals 50%, q is the lack of trait and equals 50%, and d stands for the probability of error and equals 0.08. After the values were put in the Cochran formula, the sample size was estimated to be 145 individuals.

This research benefited from a multi-stage cluster sampling procedure. In the first stage, after the neighborhoods, i.e. clusters, were identified in the city, 20 were selected randomly. In the second stage, the residential houses were selected through systematic sampling inside the neighborhoods. In the third stage, inside homes and among every several college-educated couples aged 19-39, one individual was selected randomly. At times, there was only one person to select at this stage.

The content validity of the study was evaluated with giving pre-implementation questionnaire to several professors. To evaluate the reliability of the questionnaire, Cronbach's alpha technique was used. As presented in Table 1, the results indicated that the reliability was sufficient and acceptable.

Table 1. Reliability coefficient of the variables

Variable	Dimension	Attributes	Number of indices	Cronbach's alpha in total	Cronbach's alpha for each index
Perceived usefulness	Economic factors	Operating costs	6	.824	.721
		Utilization and maintenance costs	4		.706
	Environmental factors	Possibility of using natural resources	4		.879
		How to deal with climatic condition	7		.755
		How to deal with harmful factors for nature and human	3		.695
Acceptance of earthen houses			12	.753	

Cronbach's alpha coefficients of higher than 0.6 suggest the reliability of the tool.

5 Results

The sample consisted more of women (58.2%) than men, and the average age of the respondents was 30 years. In fact, 31.4% of them were in the 30-34 year-old category and constituted the majority of the sample. In terms of income, 16.7% of them received less than 10 million IRR³ per month. The salary range of 10 to 15 million IRR was common for 29.4% of the sample. Further, 23.8% of them had between 15 million and 20 million IRR earnings, and 30.2% had an income of over 20 million IRR a month. The participants were divided into three groups, 29.7% of them had associate degrees, 42% a bachelor's degree and 28.3% a master's or doctorate degree. Meanwhile, 89.9% of the sample had a household size of 2-4, the family members of 7.8% ranged from 4 to 6, and 2.3% had between 6 and 8 persons. In other words, the average family size was 3.2 people. A high percentage of 70.2 was the native of Yazd, and 29.8% was non-native. The majority of them (90.8%) were born in cities; 43.5% had a villa, 56.5% had an apartment, and the percentage for homeowners was 54.6.

Table 2. Mean difference of acceptance in terms of gender, birthplace, nativity status, housing and ownership type

Variable	Dimension	Mean	T	P-value
Gender	Male	44.2	1.8	.065
	Female	40.8		
Birthplace	City	42.4	.23	.8
	Village	41.7		
Nativity status	Native	42.2	.4	.8
	Non-native	43		
Housing type	Villa	41.9	.6	.5
	Apartment	43.1		
Ownership type	Owned	42.47	.009	.9
	Rented	42.46		

According to the t-test results in Table 2, there is no significant difference between the two genders in terms of acceptance ($P \geq 0.05$). That is, the difference of the average level of acceptance in terms of gender is not significant. The mean of acceptance is 44.2 among the men and 40.8 among the women, which implies the men had a slightly higher acceptance rate. The difference between mean scores also shows that the average acceptance is not different in terms of place of birth and nativity status ($P \geq 0.05$). However, by comparing the means, one can see that the city-born and the non-native people have higher acceptance rates. In addition, acceptance is not different in terms of housing type and ownership status ($P \geq 0.05$). With a closer look, the respondents having an apartment had slightly greater acceptance.

Table 3. Mean difference of acceptance in terms of income and level of education

Variable	Dimension	Mean	f	P-value
Income	Less than 10 million	41.1	.54	.6
	Between 10 and 15 million	41.03		
	Between 15 and 25 million	43.6		
	more than 25 million	43.2		
Level of education	Associate degree	39.58	2.721	.07
	Bachelor's degree	43.13		
	master's or doctorate degree	44.88		

³ 1 US Dollar (\$) = 42,000 Iranian Rials (IRR)

As the results of Fisher's exact test in Table 3 show, there is no significant association between the acceptance of earthen houses and the income of people ($P \geq 0.05$). Regardless of the significance level, the respondents with a salary of 15-25 million IRR had greater acceptance than the other income groups. The test results also show only a minor difference in acceptance between the distinct levels of education. In other words, the association between the level of education and the acceptance of earthen houses is not significant ($P \geq 0.05$).

Table 4. *The results of correlation between age, household size and acceptance*

Variable	Acceptance of earthen houses	
	R	P-value
Age	.180	.051
Household size	.028	.7

The correlation test indicates a positive relationship between age, household size and acceptance of earthen houses, but this relationship is not statistically significant ($P \geq 0.05$) (see Table 4).

Table 5. *The results of normality test and one sample t-test for the main research variables*

Variable	Shapiro-Wilk	Asymp. P-value	Minimum	Maximum	Mean	Std. deviation	theoretical average	T	P-value
Economic factor	.976	.205	12	55	38.5	8.2	33.5	7.2	.000
Environmental factor	.981	.377	25	70	49.3	9.2	42.5	8.6	.000
Acceptance of earthen houses	.96	.14	14	60	42.3	9.8	37	7.1	.000

As shown in Table 5, the mean of acceptance is 42.3 which is higher than the theoretical average (37), and this difference is statistically significant ($P \leq 0.001$). Furthermore, the importance of environmental and economic factors is higher than average, which is also significant ($P \leq 0.001$).

Table 6. *Pearson correlations between the research variables*

	Economic factors	Saving utilization and maintenance costs	Saving operating costs	Environmental factors	Dealing with harmful factors for nature and human	Dealing with climatic conditions	Using natural resources
Acceptance of earthen houses	.550	.604	.514	.596	.508	.568	.361
	.000	.000	.000	.000	.000	.000	.000
Using natural resources	.592	.626	.509	.664	.392	.341	1
	.000	.000	.000	.000	.000	.000	
Dealing with climatic conditions	.585	.584	.504	.891	.571	1	
	.000	.000	.000	.000	.000		
Dealing with harmful factors for nature and human	.489	.462	.528	.737	1		
	.000	.000	.000	.000			
Environmental factors	.712	.683	.627	1			
	.000	.000	.000				

Saving operating costs	.956	.671	1
	.000	.000	
Saving utilization and maintenance costs	.818	1	
	.000		

As presented in Table 6, there is a positive and significant correlation between economic and environmental factors and the acceptance of earthen architecture ($P \leq 0.001$). In other words, as economic and environmental factors become more important in construction, the acceptance of earthen houses increases. There is a positive and significant correlation between the acceptance of earthen houses and economic attributes, namely "saving operating costs" and "utilization and maintenance costs". This means that, if more attention is paid to these factors, the architecture will gain greater acceptance among the public. There is also a positive and significant relationship between the acceptance of earthen houses and environmental attributes, namely "possibility of using natural resources", "how to deal with harmful factors for nature and human" and "how to deal with climatic conditions". That is, with the improvement of these features, the acceptance of earthen houses becomes greater. Similarly, there is a positive and significant correlation between "saving operating costs", as well as "saving utilization and maintenance costs" and all the environmental attributes, specifically "how to deal with harmful factors for nature and human", "possibility of using natural resources", and "how to deal with climatic conditions". This implies that all of these three environmental attributes can be conducive to saving costs, and the other way around.

Table 7. The result of multivariate regression analysis to estimate the determinants of accepting newly built earthen houses

Independent variables	B	Std. Error	Standardized	T	P-value	Collinearity	
			coefficients			Tolerance	VIF
			Beta				
Constant	-.958	3.676		.261	.795		
Environmental factors	.384	.069	.532	5.588	.000	.478	2.092
Economic factors	.950	.268	.337	3.543	.001	.478	2.092
	R	R Square	Adjusted R Square	f	P-value	Durbin-Watson	
	.635	.404	.390	30.468	.000	1.919	

The contribution of each independent variable to the dependent variable was determined through regression analysis (Table 7). Among the variables entered into the regression equation, the two variables "economic factors" with the beta value of 0.337 and "environmental factors" with the beta value of 0.532 remained in the model. According to Table 7, the coefficient of correlation between these variables and acceptance is 0.635. The adjusted R Square equals 0.390, indicating that 39 percent of the variations in the dependent variable are explained by these variables. Furthermore, this regression model is linear and significant. The value of f-test for explaining the significant effect of the independent variables on acceptance is almost 30.47, and the significance level is 0.000.

6 Discussion and Conclusion

Earthen architecture, which involves the use of eco-friendly materials both in production and utilization, minimizes environmental degradation but maximizes the possibility of using natural energies. This kind of architecture not only addresses environmental pollution but also reduces operating costs. In this research, an attempt was made to survey the relationship between the acceptance of newly built earthen houses and the economic and environmental factors. The

study was conducted on the basis of Davis's technology acceptance model and with the participation of young educated couples in the city of Yazd, Iran.

The research findings showed that the acceptance of newly built earthen houses was higher than the average score, which is partially consistent with the results obtained by Kebaili and Youcef [21] who found positive attitudes towards compressed earth blocks. However, according to Adegun and Adedeji [17], Bosman [22] and SANPAD [24], these houses have found poor acceptance among target groups, which is attributed to environmental and physical problems in such structures. In the present study, there was no significant association between demographic variables and the acceptance of newly built earthen houses. For example, acceptance among all the income and age groups was equal, and the rate of acceptance among the people with different types of residence such as owned, rented, villa or apartment did not show a significant difference. This finding is consistent with that of Bosman [22] who showed that personal and household characteristics have no clear association with the acceptance of newly built earthen houses. Moreover, Ajzen and Fishbein [28] claimed that demographic traits bear no relation to any specific behavior (i.e. use of earthen architecture in this case), which has no lasting effect on the central beliefs. The lack of income-acceptance relationship suggests that earthen houses are not just for the poor and that they can be accepted by the affluent and privileged social classes too. Dethier [9] also stated that the use of earthen architecture is never associated with a specific social class, and everybody can make use of earth as a kind of raw material for building; as a result, most urban and rural houses, whether old or modern, are constructed of earth.

There was also a positive and significant relationship between environmental and economic factors and the acceptance of this architecture. The test results showed that the usefulness of this type of architecture in both environmental and economic terms has a strong relationship with its acceptance. Therefore, as the cost savings in operation, maintenance and utilization build up, the acceptance of this architecture among the public rises too. This finding is consistent with the results of the technology acceptance model, stating that, with an increase in usefulness, technology acceptance goes up too. Aghimien and Aghimien [26] showed that "low-cost raw material" and "reduced cost of finishes/maintenance" are among the criteria for the acceptance of a kind of earthen material.

Through a regression analysis, it was shown that economic factors are less correlated with acceptance than environmental ones are. That is, although the costs of land preparation, material manufacture and building construction are lower in earthen architecture, and hence greater acceptance of this architecture, environmental criteria are of higher importance. These criteria with a coefficient of about 0.53 had a major effect on the rate of acceptance.

In addition, according to the majority of respondents, factors such as the use of natural light (sunlight), proper orientation of land and buildings to the sunlight, connection with nature and bringing it into the house, and the use of renewable natural resources (e.g. water, wind, sun, etc.) were well received in this architecture. This is why those respondents expressed their tendency for the earthen architecture. Additionally, as stated by them, acceptance will increase if the building can fight the dry air off, thermal changes and dust are avoided, good insulation is provided for noise, heat and humidity, and adequate ventilation is given. Meanwhile, the people believed that toxic materials are not used in earthen constructions. The safety and non-toxic emissions of the materials were, thus, approved by the majority.

On the other hand, the respondents had certain problems with this type of architecture, specifically the faint possibility of water insulation. There are problems related to water supply and sewage systems, rain erosion and moisture penetration in sultry conditions. Since Yazd, as the research site, is hot and arid, there are concerns about the design of baths and sanitary facilities and the resulting water penetration in interior walls. These concerns are based on the conception of old adobe houses that had no connection to any water supply or sewage system

inside them. In the case of those houses, outdoor water supplies and sanitary services were prevalent. It seems that the interaction of water is more acceptable with stone and brick than with earth and adobe into which water soaks easily.

In general, believing in environmental benefits can affect the acceptance of the public. This means that reconstruction of traditional earthen buildings while paying attention to environmental and climatic conditions can play a key role in the acceptability of these buildings. Public understanding and awareness of environmental issues such as air pollution, weathering, energy conservation and compatibility of earthen architecture with these issues can help to change attitudes about earthen architecture.

Therefore, it is suggested dealing with thermal changes by increasing the thermal capacity of the floor (through increasing the thickness of the earthen floor [34], using dark colors on the earthen floor, using the earth's high heat capacity to construct heaters [35]), increasing the heat mass of walls (through thickening earthen walls [36], using clay as a kind of heat storage, using wall heaters (element) and earth together [37], using Trombe wall [38]) and so forth.

Such solutions as installing door/window shades to deviate dust, designing simple forms for windows without acute angles, reducing window/opening surfaces outside the house and door/window sealing can partially lessen the ill effects of sand and dust on earthen architecture. It is also possible to prevent the penetration of sand and dirt by producing moisture to absorb dust, locating the house entrance against the wind and in a recessed area, using tall walls and parapets, and creating green space. One of the problems of old adobe houses, which caused troubles in the past, was wall destruction especially in lower parts. To eliminate this defect, it is helpful to use stabilized and compressed blocks, moisture- and erosion-resistant coatings and to protect earth wall corners by using lippings such as wooden profiles or backed bricks [39].

To optimize sound insulation, making use of double walls made of earthen panels [40] and earthen blocks with rounded corners and corbel arrangement [39] can be effective solutions.

In the case of moisture insulation, recommendations may be made for window sills (e.g. proper angle [41], covering with cement-earth tiles using more cement and high compression), flooring (e.g. proper slope [42], using bitumen as moisture insulation, building interior floor higher than the ground level [41], using vapor barriers and drainage rocks for the interior floor [34]), foundations (e.g. insulating the base of buildings against moisture [41]), finishing (e.g. making proper bonds to earthen blocks, regular maintenance, using cement coating with two layers of PVA paint, mixing bitumen and paint, and applying lime slurry or oil-based paints [41]) and strengthening the walls against moisture (e.g. making proper bonds between the earthen blocks and using similar compounds for producing mortar and blocks [41]).

For thermal insulation, it would be better to insulate earthen walls (by building double walls with a 20-30-cm-deep cavity filled with insulating materials such as straw [42], insulating external walls on the interior side and installing clay pots [43]) and roofs (by applying clay and straw plaster, arched roofs, and installing clay pots).

To lower the operating costs, it is beneficial to optimize wall thickness (by constructing buttress [44] and light earthen roofs [40, 45]) and keep down the labor costs (by using high-speed execution materials such as prefabricated earthen panels [39], interlocking earthen blocks, using stabilizers, and recruiting skilled and experienced workforce or labor-saving machines).

To reduce utilization and maintenance costs, such as the costs of energy and consumption, the high heat capacity of earth can be used to keep foods cool and cut down power consumption [46]. Furthermore, to save restoration and repair costs, it is necessary to improve the durability of doors and windows (e.g. by making proper connections between window/door components and the earthen building, waterproofing window sills and using resistant baseboards), stabilize floors (e.g. by using stabilized compressed earth blocks) and reinforce foundations.

Finally, with regard to the findings of this study, the economic and environmental benefits of earthen architecture and its advantages over other building types should be informed in the

society, especially at schools. Moreover, holding exhibitions is a viable way of demonstrating the levels of technology in constructing earthen materials. It is also suggested that this type of research, as reported in this paper, be carried out by qualitative or combined methods, and their results be compared with this quantitative research. The role of education in making this type of architecture acceptable can also be examined with interventional studies.

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