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Chapter 10
A Case Study on Technical and Social Aspects of Earth Houses in Rural India

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10.1 Introduction

The World Bank has estimated the need for 300 million new housing units for the urban and rural population of the world by 2030 (World Bank 2016). While urban housing projects, especially for upgrading slums, have been given significant attention by international organisations and media, rural housing projects are comparatively neglected and given low importance. However, significantly, 46% of the world population dwells in rural houses. This population is significantly higher in a developing country like India, where the rural population is 67% (World Bank 2016).

The government of India has identified a need for 10 million houses for low-income rural households by 2019 (Ministry of Rural Development India 2016). There is a need for an affordable solution to cater for this shortage of housing. Construction with industrial materials such as concrete or bricks is often considered as a plausible solution, but traditional materials and processes may offer interesting

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alternatives. Traditional buildings are commonly built by households and/or local communities themselves (Schroeder 2016; Bredenoord 2017), thus saving on labour costs. Therefore, material costs become the major contribution to the expense. Traditional building materials are typically cheap and readily available. The houses made with these materials are built in greater variety as each household builds according to their choice, thereby possibly creating a better social, cultural and psychological environment than that provided by most low-cost mass housing schemes (Agarwal 1982).

Earth (soil) is one of the most abundant resources available on the planet that has been used as construction material for over 9000 years (Minke 2006). Even today, one-third of world population still lives in houses made of earth (UNESCO 2018). In developing countries, this number is much higher. Earth houses are considered environmental friendly and affordable as compared to houses built with concrete or fired clay bricks (Houben and Guillaud 1994). Moreover, it preserves the vernacular social and cultural identity of the community. With rapid industrialisation and the increase in popularity of concrete and brick constructions, a decline in earth houses has been observed especially in the rural areas of India. In 1971, 72.2% of buildings in India were made of earth construction (Houben and Guillaud 1994). According to 2011 census, 21.8% of the houses in India have mud as the predominant material for the walls and 45.5% of houses have mud as the predominant floor material (Census of India 2011).

This rapid decline is caused due to various technical and social factors. In order to understand construction with earth and to investigate whether earth constructions can make a valuable contribution to contemporary dwelling construction, it is important to understand the factors that affect the choice of the earth as a building material. A survey was carried out in five regions of India (Himachal, Orissa–Jharkhand, Gujarat, Tamil Nadu and Sikkim) to understand the technical and social factors favouring or limiting the construction and everyday use of earth houses.

10.2 Research Methodology

A unique non-time-intensive approach was adopted for the survey. A total of 32 unstructured interviews were conducted during a time period of one year. The total duration spent with each individual interviewee ranged from a day to two weeks. These unstructured interviews were based on the development of dialogues between interviewer and interviewee; thus, they were predominantly informal discussions. The motivation was to keep the scope of information provided by the interviewee as broad as possible, in an attempt to encapsulate the underlying philosophy and emotions of each interviewee connected with the everyday use of an earth house. One of the disadvantages of this method is that a lot of details, especially technical details, are missed in the discussion.

The selected locations in 6 different states of India (Himachal, Orissa, Jharkhand, Sikkim, Tamil Nadu and Gujarat) are shown in Fig. 10.1. The locations were selected

Fig. 10.1 Map of India marked with interview locations

based on their geographic location and climatic diversity. Recommendations on locations from experts were also taken into account. Forty per cent of the interviews were conducted in the rural areas of south India.

The interviews were conducted to understand the factors favouring or limiting the construction and everyday use of earth houses. These factors include construction technique, performance of already existing structures, maintenance requirements, affordability, image, personal philosophy, influence of government and policies, and education and training. This article is limited to technical aspects (such as construction techniques), performance and social aspects regarding the image of an earth house. Together with traditional earth houses, modern earth houses constructed in recent times were also considered in this research. The interviewee group consisted of people involved directly in earth construction. This included earth house dwellers with different socio-economic background, earth construction experts, architects, engineers, masons, contractors, consultants, educationalists and volunteers. Interviews were held in English and Hindi, wherever possible, and at other times in

regional language. A translator was used in the regions where the interviewer could not speak or understand the regional language.

10.3 Result and Discussion

10.3.1 Construction Technique

The earth construction technique has a strong relationship with the climate of the region. In Himachal, which is a region with a cold climate and regular seismic activities, unstabilised adobe was the most commonly adopted construction technique. Adobe is a technique where rectangular blocks of earth are cast in moulds and joined together with mud mortar. Pine needles and risk husk were added to soil for the production of the adobe. These are known to improve the insulation of earth building materials. The foundations were mostly made up of stone with mud mortar and were raised around 30–50 cm in order to prevent contact of water with the unstabilised adobe blocks. The house walls were usually plastered with cow-dung plaster. A traditional earth house of a low-income household in Bir can be seen in Fig. 10.2a. The house has suffered from significant deterioration over a period of 20+ years and requires significant maintenance. In some modern earth houses, of high-income households, near Dharamshala, significant attention was paid to design and engineering details resulting in durable and aesthetically appealing houses. These houses were constructed with unstabilised adobe and later covered with a stabilised plaster. These modern earth houses consist of lintel and plinth bands (ring beams) that were made with concrete in order to improve their seismic performance. Toilets and bathrooms were constructed with concrete or fired clay bricks which perform well when in contact with water.

The northeast state of Sikkim is cold, cloudy and seismically active. The vernacular construction technique known as "Ikara" is prevalent in this region. Ikara is a type of construction that is a similar technique to wattle and daub. In Ikara houses, timber frames with bamboo weaves act as the structural wall members that are daubed with unstabilised mud. A traditional Ikara house located in Namchi can be seen in Fig. 10.2b. Ikara houses are framed structures that perform structurally well in an earthquake. The lightweight construction also helps to prevent fatal accidents in the case of extreme earthquakes. A modern earth house constructed with compressed earth stabilised blocks (CESB) located in Namchi can be seen in Fig. 10.2c. The construction blocks were stabilised with cement. A stabiliser is added to soil to provide superior mechanical strength and durability to the building. Lintel and plinth bands made of concrete were also used in this building.

The states of Jharkhand and Orissa, located in the central east of India, have a composite to hot and dry climate. Khunti and Sundargarh are both home to tribal communities where living in an earth house has cultural significance. The houses in these locations were constructed with a cob technique. In this technique, a thick

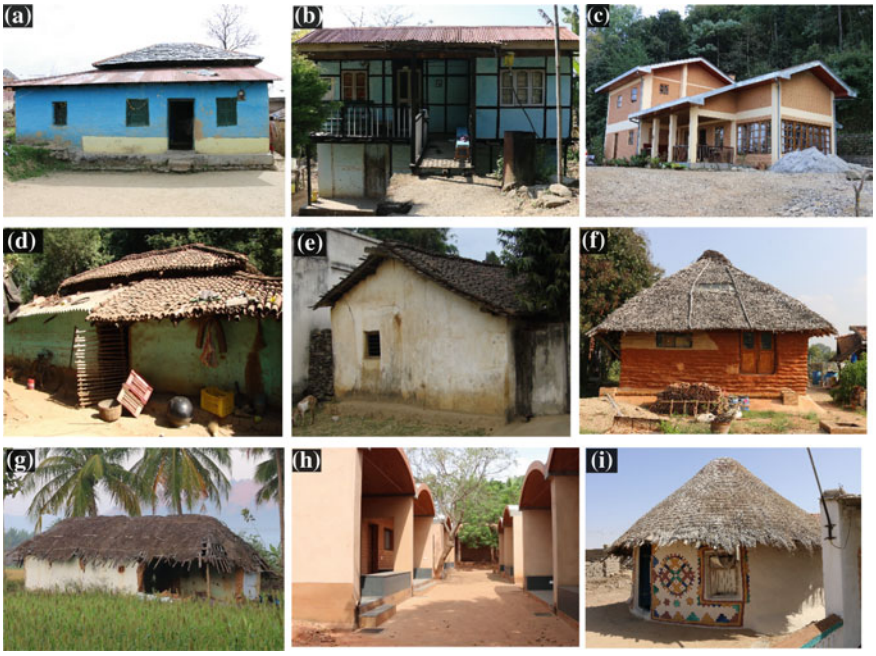

Fig. 10.2 Earth house in **a** Bir (North) **b** Namchi (North east), **c** Namchi (North east), **d** Khunti (East), **e** Sundargarh (East), **f** Tiruvannamalai (South), **g** Sittlingi (South), **h** Pondicherry (South), **i** Khavda (West)

monolithic wall is raised from the foundation. Figure 10.2d, e shows traditional earth houses in Khunti and Sundargarh, respectively. Cow dung has been used for the plastering of cob wall. Local tiles, known as "Khapra", have been used as roofing material. A significant deterioration of the walls was seen in these houses.

Tiruvannamalai and Sittlingi, in Tamil Nadu, in the south of India are located in a hot and humid climate. Cob construction is also commonly seen in this area. Several innovative techniques have been implemented in this area, and a significant rise in modern earth construction has been observed. Figure 10.2f shows an Earthbag building located near Tiruvannamalai. In the Earthbag technique, soil is filled in a jute or plastic bag and these bags are stacked mostly with the help of barb wires. The red soil used in this construction was stabilised with lime. The construction of this building was completed in 4 months. Sittlingi has a mix of modern CSEB (Compressed Stabilised Earthen Blocks) houses and traditional cob houses. Significant abandoned and highly damaged traditional houses were observed in Sittlingi (Fig. 10.2g). The use of local quarry ash was prominent in the modern earth construction houses.

Auroville and Pondicherry, also located in Tamil Nadu, are located in a warm and humid environment. Auroville and the surrounding areas of Pondicherry have many modern earth structures. CSEB blocks stabilised with 5–8% of cement have been commonly used. Figure 10.2h shows a CSEB construction in Pondicherry. One of

the architects explained that the soil was dug out from the lowest contour of the site so that the dugout part can be used to collect rainwater. Another architect explained that the most important aspects of modern earth construction are supervisory skills and craftsmanship.

In the western state of Gujarat, a hot and dry climate is prevalent. This zone also has a history of high seismic activities. "Bhungas" are traditional earth houses of this region, and some Bhungas constructed post-earthquake can be seen in the village Gandhi nu Gam located in Khavda (Fig. 10.2i). Many of the houses collapsed during the 2001 earthquake; however, it was stated that many Bhungas survived. The cylindrical shape is considered good for earthquake resistance by locals. The Bhunga shown in Fig. 10.2i was constructed with adobe. The mortar was prepared by mixing cow dung with soil, and there was no foundation. A lintel band was made of locally sourced wood, and the roof was made of bamboo covered with grass.

The climate of a region has a strong influence on the construction technique and the materials used for construction. The type of construction and the recipe of the earth material depended on the availability of raw materials, which are location-dependent. Most of the modern earth houses utilise cement which has standardised properties and quality, and is available almost everywhere. The cost of construction of modern earth houses is comparable to concrete or fired brick houses. Traditional earth houses are constructed with a minimal monetary investment from the dwellers.

It was often mentioned by the interviewee in the regions of high seismic activity that traditional earth houses are inherently earthquake-resistant. These houses and techniques have been developed over a long period of time. Modern earth houses are seismically protected by plinth and lintel bands that are usually constructed of reinforced cement-based concrete. According to this survey, a stabilised earth structure is both labour- and time-intensive. Traditional houses are generally built by the dwellers but modern earth houses require skilled labourers and good supervision. There is not widely available skilled labour for modern earth construction.

10.3.2 Performance

The benefit of earth structures over conventional structure made up of fired bricks and concrete was acknowledged widely. The earth houses were considered environmentally friendly for the following reasons: (1) they utilised locally available resources, thus saving significant embodied energy that is spent on transportation; (2) the material is unfired and therefore reduces energy consumption; and (3) demolition waste can usually be re-used and usually does not end up in landfill disposal.

Almost all interviewees mentioned that the indoor temperature was controlled well in all seasons. This was considered by far the most beneficial aspect of earth houses. An earth house dweller in Tiruvannamalai emphasised "Mud housing is appropriate to the indoor climate, holistic way of leaving. These are live spaces, air is passing through". A mason in North of India mentioned that several local people were interested in earth houses as they were considered good for health. In another

example, an architect, practising in the south of India, mentioned that a doctor was willing to make his house out of mud due to his belief of the healing power of earth.

Earth houses, especially those which are unstabilised, disintegrate in nature and can be re-used numerous times. The dweller of an earth house in Bir mentioned that they constructed their present house from the material of their ancestral house. They believed that earth houses have an infinite life as they can be re-used multiple times. A young architect appreciated the fact that vegetation is possible to be grown on demolished earth material.

Despite the advantages, technical limitations of earth houses led people towards choosing industrialised construction materials. The durability of traditional earth houses was a major concern of all the interviewees. Most of the traditional earth houses faced significant deterioration due to rain and required frequent re-plastering. Sometimes, the rain also resulted in structural weakening of the earth houses. In this specific case, raising the foundation was considered an important precautionary step. The rule of a good hat (roof) and good boots (foundation) was suggested by architects for enhanced durability.

One of the most commonly identified limitations of traditional earth houses was termite infestation. An expert commented that the problem could be solved if the construction is properly detailed and the foundation is treated with pesticides and insecticides. A rise of plinth level was also suggested as a method to prevent termite infestation. The problem of termite infestation was prevalent in the houses, which were not continuously functional for many years. An experienced earth architect living in an unstabilised earth house for over 10 years elucidated the problem "There are so many traditional unstabilised houses that are standing for years. Termite infestation was not a big problem in past. Previously 'Chulas' (wood/coal fired stoves) were used for cooking and the smoke from Chulas functioned as a termite repellent. Now these Chulas are replaced by a gas stove or electric cooking equipment. This has resulted in an increase in case of termite infestation in unstabilised earth building. The building and material techniques are not upgraded to accommodate such changes".

Earth houses are known to regulate indoor temperature and humidity. In a unique case of an Ikara house (North East), the thermal behaviour of an earth house was stated to be poor as compared to a concrete house. This was due to the use of Galvanised Iron (GI) sheet as the roofing material that has a high thermal conductivity and low thermal inertia; thus, the house was hot in the summer and cool in the winter. The GI sheets were also the most widely adopted roofing for fired brick houses in the region. In many cases, traditional earth houses were modified over the time without full consideration and they lost the essential characteristics such as thermal behaviour and aesthetics of an earth building. Other issues such as cleanliness and problems with rodents were also acknowledged. For example, an interviewee mentioned that even though mud flooring kept the house cool but it also result in unhygienic conditions during rainy season, i.e. when a person entered the house with wet feet, the whole house would get dirty.

In the modern earth structures, good design and engineering usually results in a durable structure. One of the contractors mentioned that the CSEB blocks have

a longer life than fired brick and they are much stronger. It is thought this stated was considering low-quality "country-fired" bricks where strength could be typically 3 MPa. Termite infestation, deterioration due to rain and frequent maintenance (re-plastering) are not a problem in modern earth construction, due to the presence of cement-based stabilisers. However, in colder regions, the problem of cracking on the exterior surface was observed in few CSEB houses. This was hypothesised to be due to improper curing of cement-stabilised blocks. In a colder climate, the cement takes an extended amount of time to cure and thus results in poor quality of blocks.

In one of the building project which was developed as a community centre for villagers, the architect emphasised on the issue of the weathering of CSEB brick and the rise of water from the foundation due to the absence of an impervious lining under the foundation resulting in the flaking on the wall. This problem was solved by re-plastering the wall, which may have to be undertaken periodically.

Most of the limitations of earth houses has been seen to be able to be overcome by addition of stabilisers and high-quality construction. This, however, results in the increase in construction costs making the structures unaffordable for low- to medium-income households. For the dwellers of traditional earth houses, the issues of termite infestation and frequent re-plastering have resulted in a choice of fired brick over the earth as construction material.

10.3.3 Image

Image of any materials plays an important role in its choice of use. Earth construction in developing countries suffers from a lower societal image.

A Pondicherry-based architect said, "*village people don't want a house which looks like a village house. They want something which urban people aspire for. It may be eco-friendly, or good for the climate or may be good for your health, but status and associations that people have with a concrete house is something which you can't change easily*". An architect from Gangtok (North East India) mentioned, "*Natural building is considered poor man's dwelling. It was once upon a time mass housing for people in Sikkim but then came people from different countries who were influential and powerful. They made houses with foreign material like RCC. Many people were influenced by them to build with this new material. New materials were maintenance free and were much more durable. This changed the perception right away. RCC gave the opportunity to build taller. In a big family, the parents could make a 5-floor house and give an individual floor to their children. Hence, it was definitely an interesting material choice in urban areas. Moreover, the land prices were getting high. RCC became a status symbol in Sikkim. RCC house and a car is the progress in life. People aspire for it. Despite marring the landscape, it is popular because people want to show that they have progressed*" (transcribed from recording).

An expert on earth construction from Bangalore mentioned that the unstabilised mud houses are more of a social problem than the technical one. He gave a different

view on the image issue. According to him, in rural areas the walls are thick, and if users are aware of their building, they can live peacefully even though there is erosion on the outside. The user knows that the building will work satisfactorily irrespective of erosion. People looking from outside judge the building and form opinions about it. The problem of image is also a result of aesthetics. A significant amount of earth houses in a deteriorated state can be seen throughout the country.

The users of earth houses also shared their views. A low-income family dwelling in traditional earth house in Bir (North India) mentioned, "*When we see our neighbours, we see houses with bricks and it makes us feel that our house should also be made with bricks. Our kids also say that we want these houses, one with lintels and beams*" (translated from Hindi and transcribed from recording). A community from the tribal village of Sundargarh (central east of India) shared their views, "*Nowadays it has become all about the money in the world. Today we are in an independent India. The mud house days are gone. Before we used to use lungi (traditional pants) and now we use jeans pants. Likewise, slowly people are learning and getting educated and therefore they decided to move to a brick house. When we started earning some more money, we wanted to go for a proper concrete roof. Whoever has a cycle, they think that their life will be better with a motorbike. We see changing from a mud house to concrete building as a positive change. We do it mostly to show to others that we are also modernizing. We do not want to be left behind. When people will see this place changing then they will get a good impression of the people who live here. The mud houses stay strong for 30 years but the brick houses will stay strong for more than 90 years. Hence, we have accepted change and have moved on to brick and concrete houses*" (translated from Oriya and transcribed from recording). Two of the mason interviewed in this survey shared similar views and emphasised that people in the village do not want to build with earth anymore. There are also terms like "Pakka house" and "Kaccha house" that are often used by the government to classify people based on the type of house they own. Houses made with natural materials are considered as Kaccha (weak) houses, and the dwellers of these houses have a lower social status.

The people who can afford and chose to have a modern earth house often derive their motivation from a holistic (ecological) way of living life. Their motivation for choosing an earth house comes from the notion that earth houses are sustainable. They consider industrial building materials as polluting the whole ecosystem. One of the farm owner living in modern cob house near Tiruvannamalai (South India) said, "*People are really searching for a different way of life and they are looking for a different style of architecture. People have been very stifled with the consumeristic and materialistic society and the concrete boxes in which they are living. Cement is not locally sourced and coming through big MNC's (Multi-national companies). It is a material that is really not as durable as people imagine. All the cement construction happening now are also going to fall down someday as they are constructed in an improper way. The idea that an earth construction is not durable need not be true. It depends on how scientifically you are constructing it. The mud houses are living spaces, they breathe. Air can pass through it and the feel of living in these spaces is good and natural*". (transcribed from recording).

The image is the most important factor that favours the choice of building material. For low-income households in the rural area, the image of earth construction is low and something that is outdated. They aspire for a house that urban people possess. For the people interested in a holistic lifestyle, the image of cement and other industrialised material is bad as these materials are known to pollute the environment. Their choice of an earth house is based on living in a sustainable and natural habitat.

10.4 Conclusion

Construction techniques, performance and image govern the choice in favour or against earth construction methods. Earth construction, unlike construction with cement and brick, is dependent on the climate and availability of raw materials. Modern earth houses are labour-intensive, and it is also difficult to find skilled labour in most regions.

Although the advantages of earth houses, such as a better indoor climate, environmental friendliness and recyclability, were widely acknowledged, limitations with regard to termite infestation, poor water resistance and weathering were the major technical drawbacks that motivate the aspiration (for concrete/brick house) of low-income households. The environmental friendliness of earth construction was a major motivation for people interested in a holistic lifestyle. The limitation in traditional earth houses has been overcome by using stabilisers in modern earth houses. However, this modern practice is far away from being affordable for low-income households. In cases where a traditional earth house has been upgraded, a synergy between traditional and modern architecture was missing.

As an outcome of the survey, two specific but opposing motivations were identified: (1) Low-income families living in traditional earth houses aspire for a brick or concrete house; and (2) families that have adopted an alternative and sustainable lifestyle and prefer living in a "natural habitat". The families in the latter group usually have a high income. The social aspects such as a low societal image of traditional earth houses in comparison with other households in the same community were the main reasons behind the choice in favour of modern building materials over earth. The identified negative social, technical and financial aspects place a new requirement and demand re-invention of traditional earth house as a necessary step towards their acceptance.

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