Original Article

Economic benefits of contemporary earth construction in low-cost urban housing – State-of-the-art review

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ABSTRACT Most cities and towns in developing countries are experiencing a massive influx of population from rural areas. The majority of the rural population migrates to urban areas hoping to find a job and a higher income for their survival. This large influx creates a high demand for urban housing and infrastructure, which the majority of the migrants cannot afford. Moreover, the insufficient use of low-cost traditional building materials and construction techniques in residential construction has resulted in expensive housing stock for the majority of the poor. There is therefore an urgent need to assess alternative building materials and techniques that are both affordable and sustainable. Stabilised earth is an alternative building material that is significantly cheaper than using conventional brick and concrete, and is also environmentally sustainable. Earth has been used as a construction material on every continent and in every age. This article reviews and argues the economic benefits of using earth as a building material, and describes the associated construction techniques for urban housing provision in developing countries. A critical literature review method was adopted in this article to investigate the economic benefit of contemporary earth construction in low-cost urban housing compared to conventional brick and concrete construction.
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INTRODUCTION

Soil has been, and continues to be, the most widely used building material throughout most developing countries: it is cheap, available in abundance and simple to form into building elements (Morris and Booysen, 2000; Adam and Agib, 2001). Experience has shown that earth remains a viable material, given costly increases in energy consumption caused by the production of modern building materials (Agarwal (1981) and Montgomery (2002) cited in Hadjri *et al* (2007)). Agarwal (1981) and Doat *et al* (1991) stated that the appropriate use of earth construction produces cost-effective and comfortable buildings. Compressed stabilised earth blocks (CSEBs) were successfully used for low-income housing in Sudan (Adam and Agib, 2001 cited in Hadjri *et al*, 2007). Thus, contemporary earth construction is economically beneficial in the construction of low-cost urban housing. This article aims to identify and examine the economic benefits of contemporary earth construction. It reviews the literature and analyses empirical evidence of economic benefits of contemporary earth construction. It also assesses and recognises the local conditions instrumental to making contemporary earth construction economically viable for low-cost urban housing. The critical analysis in this article concludes by highlighting the importance of recognising the economic benefits of contemporary earth construction in providing low-cost urban housing across the globe.

A REVIEW OF THE LITERATURE THAT LACKS EVIDENCE OF THE ECONOMIC BENEFITS OF EARTH CONSTRUCTION

Fathy (1973), a pioneer architect in earth architecture, publicised earth as a potential building material in the construction of rural housing through his book *Architecture for the Poor*. The book explains Architect Fathy's use of earth in the New Gourna settlement in Egypt, and his views of earth as an appropriate material with social and economic advantages for the South (Sanya, 2007). According to Sanya (2007, p. 25), the essence of Fathy's discourse on sustainable architecture comprised recommendations through examples of good practice. Fathy did not consider earth material for urban housing, and his book did not state the financial benefits of earth construction in urban low-cost housing compared to conventional brick and concrete construction. Since 1930, although earth construction has been researched and implemented (Reddy, 2007) in several developed countries such as France, Australia and Germany, and in developing countries such as India, Peru, Brazil and Columbia, there has been little published in general on its economic benefits compared to conventional brick and concrete construction.

CRATerre is one of the leading centres of earth architecture in the world. CRATerre also published a comprehensive guide to earth construction. This guide, written by Houben and Guillaud (1989), covered various aspects of earth construction that included soil type, properties, identification, suitability, stabilisation, test, construction method, production methods, design guidelines and disaster resistant construction. Surprisingly, however, the guide does not analyse the reasons for using earth material in contemporary architecture, the economic benefits of which are notable.

CRATerre also published many articles (CRATerre, 1991, 1998, 2003) on stabilised earth construction, discussing quality and process management of earth construction over the entire project life cycle, from raw-material sourcing to material manufacture, design, construction, use/maintenance, demolition and disposal. One of CRATerre's authors, Minke (2000), published the *Earth Construction Handbook*. Minke presents an overview of the properties of earth as building material based on experiments at the University of Kassel, Germany, as well as experiences and examples from real building projects. He also gives recommendations for achieving good-quality earth architecture, but analysis of financial benefits of earth material in the construction of urban housing is not cited in his research.

Morton (2002), cited in Sanya (2007), described earth buildings in Scotland without much analysis of cost benefit. Furthermore, Forlani (2002), cited in Sanya (2007), presented the state-of-the-art and prospects of earth building in Italy (Sanya, 2007). Watson and Harries (1995), promoters of unstabilised earth, describe potentialities of cob buildings in Britain. Moor and Heathcote (2002) researched the development of earth building in Australia and published articles on the durability of earth-walled buildings, without research on the cost-benefit analysis of stabilised/unstabilised earth construction compared to conventional (brick, concrete) construction.

There is a significant amount of research output available on Indoor Environmental Quality (IEQ) of earth structures with no emphasis on cost-benefit analysis. Baron Von der Ropp (2002) experimented with the use of earth plaster indoors, which can reduce harmful pollutants. Allinson and Hall (2007) researched the passive air conditioning of rammed earth building. Lindberg and Akander (2002) experimented in a room with earth walls and found that the high heat and moisture-buffering capacity of earth can reduce the need for energy-driven ventilation (Sanya, 2007). Mendonca (2007) also experimented on the IEQ of earth building and contributed knowledge to the field.

There is also literature on standardisation of earth (particularly CEB) as building material without cost-benefit analysis. Keable (2007) wrote the Standard Association of Zimbabwe's code of practice for rammed earth structures, and this has been in place for the past 8 years now. This code is the first of its kind in the region. Walker and Morris (2002) presented the development of performance-based standards for earth buildings in New Zealand, covering the techniques of adobe, rammed earth and CEB. Rauch (2007) researched the earth house with European standards. Houben and Boubekeur (1998) have written a standards guide for CEB. Walker *et al* (2005) wrote a book on rammed earth design and construction guidelines. This book is one of the latest publications on the contemporary earth architecture, and covers a wide range of rammed earth design and technical aspects, but does not analyse any financial benefits of contemporary rammed earth construction.

In an African context, Ngowi (1997) researched and published a significant amount of literature on the potential of earth construction to address the urban housing crisis without emphasising the cost-benefit analysis. Morris *et al* (2002) examined the technical aspects of CEB as a building material in Southern Africa. Sanya (2007) researched the sustainability of earth Architecture in Uganda. His research proved that CSEB is not economically beneficial in the Ugandan context because of the unavailability of cement. Longfoot's (2006) research aimed at developing a low-cost CEB block using locally available sand in Botswana. Stulz and Mukerji (1993) proved that earth is one of the most appropriate building materials for urban dwellings. A Nigerian author, Ogunsusi (Ogunsusi *et al* (1994–1996), cited in Sanya (2007)), has written five books with recommendations for best practices in CEB construction that have shown that earth construction is economically beneficial to urban housing.

A REVIEW OF LITERATURE THAT INCLUDES THE ECONOMIC BENEFITS OF EARTH CONSTRUCTION

Literature on the financial benefits of contemporary earth construction is scanty, and very little structured research is available. According to Adam and Agib (2001), the cost of producing CSEBs will vary a great deal from country to country, and even from one area to another within the same country. Unit production costs will differ in relation to local conditions. Adam and Agib (2001) also pointed out the causes of cost variations, including the following:

1. Availability of soil, whether it is available on-site or has to be transported to the site.
2. Suitability of the soil for stabilisation, and thus the type, quality and quantity of stabiliser needed (it may also be necessary to buy sand if the soil has an excessively high linear shrinkage).
3. Current prices of materials, especially stabilisers.
4. Whether the blocks are to be made in rural or urban areas, the size and type of equipment used, and quality required.
5. Current labour costs and productivity of the labour force.

Adam and Agib (2001) also noted that block-making can be carried out on a 'self-help' basis, whereby labour costs are eliminated and soil is often available at no cost. The Al Haj Yousif experimental prototype school (Figures 1 (a) and 1(b)) constructed CSEBs that were found to be very cost effective by Sudanese standards. The total savings made, in cost per square metre, was approximately 40 per cent compared to conventional brick and block construction. Reduction of the cost of blocks was approximately 70 per cent and of the roofing sheets was 48 per cent. Similar findings were also reported in Kenya, where the average unit cost of CSEBs is approximately 20–70 per cent that of concrete blocks, depending on the method of production followed (Adam and Agib, 2001).

Vroomen (2007) researched the suitability of cast gypsum-stabilised earth for the construction of low-cost urban housing in developing countries. According to Vroomen

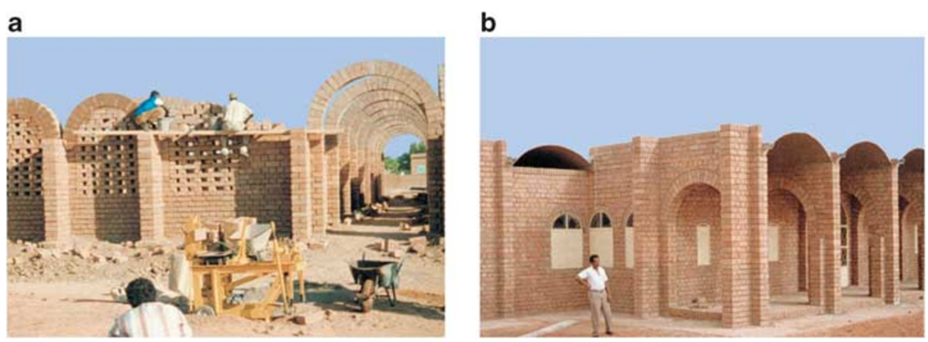

Figure 1: (**a**) El Haj Yousif School under construction with CSEB. *Source*: Adam and Agib (2001); (**b**) El Haj Yousif experimental School. *Source*: Adam and Agib (2001, p. 8).

Figure 2: The first Cast House, Prescott, Arizona, USA, 1996.
Source: Cast Earth Website.

(2007), the product method ‘Cast Earth’, developed by Lowenhaupt, can be characterised as a large-scale casting method and gypsum is used to increase the plasticity of the earth–gypsum mix without negative results. A gypsum–earth mix can thus be applied with a casting method such as those used in normal concrete casting, and the quality of the product (see Figure 2) made out this gypsum-stabilised earth is high. Vroomen (2007) compared concrete construction and adobe construction with the gypsum-stabilised earth in his research and found a large number of advantages. Table 1 presents a qualitative comparison of the performances of the three methods.

According to Vroomen (2007), the principal advantages of gypsum-stabilised earth over concrete blocks are that costs are expected to be far lower, as no expensive cement is used; costs for transport are minimal as gypsum can be produced *in situ*; energy requirements are far lower because gypsum requires calcination at 125°C only, instead of sintering at 1100°C; and the carbon dioxide release is very low compared to that of cement. Vroomen (2007, p. 58) also compared the input requirements between hollow concrete blocks and gypsum-stabilised earth to investigate the economic benefit of this contemporary earth construction in urban low-cost housing. Owing to the lower mix rate and the smaller wall volume of hollow concrete blocks, more than two times more gypsum is needed for gypsum-stabilised earth than concrete for hollow concrete blocks (see Table 2).

According to Vroomen (2007, pp. 58–59), the internationally paid price of industrially produced gypsum is approximately 2.5–3 times lower than that of cement, and based on the assumption that this international price relation is a strong indicator of the local price relation, one could conclude that the costs for the total amount of gypsum needed for a gypsum-stabilised earth wall is only 1.1–1.3 times lower than the price for the total amount of cement required for a hollow concrete block wall. However, the costs of the additional required measures, such as an extended roof and an improved moisture barrier, have not been taken into account. This means that a gypsum-stabilised earth wall would probably be more expensive than a wall constructed out of hollow concrete blocks, if all the other costs for the erection of a gypsum-stabilised earth wall are equal to those of a hollow concrete block wall. As the performance (actual and perceived) of

Table 1: A qualitative comparison of adobe, gypsum-stabilised earth and concrete

Qualities	*Adobe blocks*	*Gypsum-stabilised earth*	*Concrete construction*
Material cost	Very low	Low	High
Labour involved	High	Medium	Medium
Image of product	Very low	High	Very high
Durability	Low	Medium	High
Energy required	Very low	Low	Very high
CO_2 production	None	Very low	Very high

Source: Vroomen, 2007.

Table 2: A comparison of input requirements between hollow concrete blocks and gypsum-stabilised earth

	Hollow concrete blocks	*Gypsum-stabilised earth*
Stabiliser	Cement	Gypsum
Mix rate	15% cement	24% gypsum
Wall, width	Hollow, 10 cm	Massive, 14 cm
Ratio of required amount stabiliser	1	2.25
Ratio of price of stabiliser	2, 5–3	1
Ratio of total costs	1, 1–1, 3	1

Source: Vroomen (2007, p. 58).

gypsum-stabilised earth is probably lower than that of hollow concrete blocks, no successful implementation can be expected. If, however, the costs of construction or of gypsum can be reduced, for example by producing it locally, some opportunities may arise for gypsum-stabilised earth as a construction material for low-cost housing in developing countries (Vroomen, 2007, p. 59).

According to Hadjri *et al* (2007), in Zambia, housing construction using conventional materials (brick, concrete) is too expensive for the majority in urban areas, where transport amounts to approximately 40 per cent of the total material cost. In research carried out by Hadjri *et al* (2007), 10 residents living in Zambian rural earth-constructed houses were interviewed on five key issues: durability, affordability, living conditions, aesthetics and their general preference with regard to living in an earth dwelling rather than a 'modern' house. All interviewees agreed that earth dwellings were very affordable in comparison with houses built with conventional materials (brick, concrete). In the same study, out of the 60 questionnaires circulated to Zambian design practices and contracting companies, only 22 were completed, representing a response rate of 37 per cent. It was noted that 73 per cent of respondents never used earth in their projects. Respondents were asked to rate a range of criteria for potential specification and selection of earth as a building material in their projects on a 5-point Likert scale. The results, shown in Figure 3, indicate that 'material cost' was accorded the highest mean importance rating (4.58), followed closely by availability (4.37) and easy workability (4.11).

Gooding and Thomas (1995) researched and examined the level of technical achievement in production and the level of social acceptance of cement-stabilised building blocks in several developing countries surveyed early in 1995. The survey established that these blocks are currently in common use and are likely to be more widely used in the future. They carried out an economic analysis of building materials competing for the urban and peri-urban markets that shows that cement-stabilised earth block is cheaper compared to conventional building material**.** Their research findings are briefly explained below in Table 3.

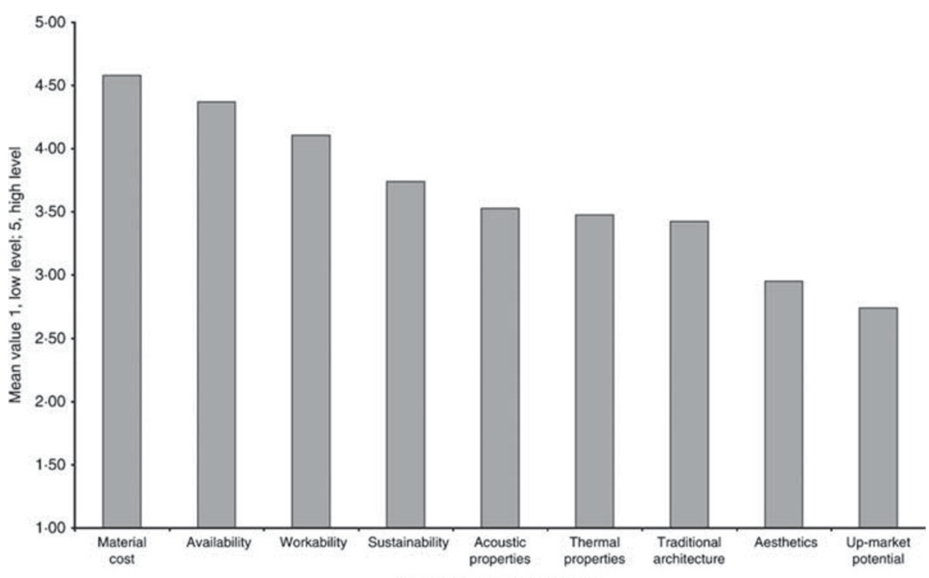

Figure 3: Factors influencing the specification of earth in the Zambian construction industry.
Source: Hadjri *et al* (2007).

Table 3: Costs for labour, construction materials and built-up walling in the principal countries of focus

1	*Country*	*Kenya*	*Tanzania*	*Botswana*	*Ghana*
2	Exchange rate	68.5 (£1)	865 (£1)	4.22 (£1)	1780 (£1)
3	Unskilled daily labour wage	70 (£1.02)	1000 (£1.16)	5 (£1.18)	1500 (£0.84)
4	Foreman wage per day	250 (£3.65)	2000 (£2.31)	35 (£8.29)	3500 (£1.97)
5	Skilled construction labour/day	200 (£2.92)	2500 (£2.89)	35 (£8.29)	3500 (£1.97)
6	Cement cost/50 kg	370 (£5.40)	4000 (£4.62)	10.95 (£2.59)	6000 (£3.37)
7	Sand cost/tonne	1000 (£14.60)	4286 (£4.95)	22.6 (£5.35)	7600 (£4.27)
8	Soil cost/tonne	429 (£6.26)	1714 (£1.98)	1.7 (£0.40)	517 (£0.29)
9	Machine cost (Cinva Ram type)	22000 (£321)	80000 (£92)	670 (£159)	111625 (£63)
10	Cost/sq.m. for internally rendered wall built with std size soil-cement block	327 (£4.78)	2970 (£3.43)	16.45 (£3.90)	4360 (£2.45)
11	Cost/sq.m. for internally rendered wall built with large-size soil-cement block produced by impact	213 (£3.11)	1866 (£2.16)	11.36 (£2.69)	2551 (£1.43)
12	Cost/sq.m. for internally rendered wall built with sandcrete blocks	457 (£6.67)	3341 (£3.86)	25.21 (£5.97)	4880 (£2.74)
13	Cost/sq.m. for internally rendered wall built with burnt bricks	NA	3454 (£3.99)	19.79 (£4.69)	4796 (£2.69)
14	Cost/sq.m. for internally rendered wall built with quarry stone	418 (£6.10)	NA	NA	NA
15	Ratio of labour wage to cement cost	5.29	4.00	2.19	4.00
16	Ratio of soil-cement to sandcrete cost std size	0.72	0.89	0.65	0.89
17	Ratio of soil-cement to sandcrete cost large size	0.56	0.56	0.45	0.52

Figures given are in local currency
NA means particular type of building material was not used/found for constructing the wall in particular country.

Source: Gooding and Thomas (1995).

Table 3 shows the raw data, labour rates, cement costs and so on that were gathered in the field and subsequently used to perform the economic analysis contained in the relevant country appendix by the researchers (Gooding and Thomas, 1995). This table also shows the best case for the costs of built-up walling using, respectively, standard-size blocks made by conventional quasi-static compaction of soil-cement to low pressure, large-size blocks made by impact compaction of soil-cement to high pressure, sandcrete blocks, burnt bricks and quarry stone. The ratio of labour wage to cement cost (row 15 in Table 3) was thought to provide a good indicator of the economic viability of soil-stabilisation; however, this has proved to be incorrect. Although this labour–cement ratio varies widely from country to country, the cost ratios of standard block soil-cement walling to sandcrete walling (row 16) and of large block impact-formed soil-cement walling to sandcrete walling (row 17) vary very little. The results of the economic analyses show that using current low-pressure production, switching from sandcrete to soil-cement will reduce walling costs by between 11 per cent and 35 per cent. This is significantly less than the figure of 50 per cent that has been quoted in the past (Gooding and Thomas, 1995). In previous studies, only the costs of the individual walling elements have been compared, whereas in this study the cost of a built-up wall has been used for comparison. Consequently, small blocks are disadvantaged. A larger number must be used per square metre of walling (usually considered in earlier analysis), more mortar is required (not normally considered) and they take more time to lay (not normally considered). Although this type of production method is less expensive than sandcrete, a cost advantage of 30 per cent or less is unlikely to encourage the uptake of the technology in areas where social stigma is a factor (Gooding and Thomas, 1995).

The Auroville Earth Institute in India is a research and training centre in earth architecture. Training courses have been conducted from the very onset, and many technologies have been researched, developed and promoted under the supervision of the director, Satprem Maini. According to Maini (2005, p. 5), costs are too often limited only to the monetary value. In Auroville, a cubic metre of CSEB is approximately 23.6 per cent cheaper than a cubic metre of country-fired bricks. But the energy approach should be integrated: some studies have shown that, in the Indian context, building a square metre of masonry with CSEB consumes five times less energy than a square metre of wire-cut brick masonry and 15 times less than country-fired bricks. CSEB are generally cheaper than fired bricks and this varies from place to place and specially according to the cement cost (Maini, 2005, p. 6). The cost breakdown of a 5 per cent stabilised block will depend on the local context, and in India, with manual equipment (AURAM press 3000), it is usually within the following figures:

- Labour: 20–25 per cent, Soil and sand: 20–25 per cent, Cement: 40–60 per cent, Equipment: 3–5 per cent.

Maini (2005, p. 6) further stated that, in Auroville, a finished cubic metre of CSEB wall is generally 48.4 per cent cheaper than wire-cut bricks and 23.6 per cent cheaper than country-fired bricks. The strength of a block is related to the press quality and the compression force, and to the quantity of stabiliser, and this implies that to reduce the cost of a block one should try to reduce the quantity of cement but not the cost of the labour by unskilled people. One should also not cut down the cost of the press with low-quality machines, which would not last long and would not produce strong blocks (Maini, 2005, p. 6).

According to Kotak (2007), there was a huge demand for houses to rehabilitate the earthquake-affected families in Gujarat state (India) after the 2001 Kutch earthquake. Hunnarshaala Foundation for Building Technology and Innovations, Bhuj, India is a registered not-for-profit corporation that built several stabilised rammed earth houses for the earthquake-affected families. The genesis of Hunnarshala lies in the collaborations and associations that were formed after the 2001 earthquake in Kutch, with an objective of capacitating people for reconstruction of their habitat. Hunnarshala offers its knowledge and skills for building designs, settlement planning, social housing, disaster reconstruction, waste-water treatment systems, infrastructure development and so on (HUNNARSHALA, 2009). There were two types of houses built in this rehabilitation exercise: circular (Figure 4) and rectangular (Figure 5).

According to Kotak (2007, pp. 70–71), the total cost of the rectangular house was Rs 52 400.00 (approximately £650.00, cost/sq.ft. = Rs. 148.00) and of the circular house was Rs. 23 000.00 (approximately £300.00, cost/sq.ft. = Rs. 107.62). Tables 4 and 5 show the breakdowns of the construction cost of the rectangular and circular houses.

The above cost/sq.ft. includes walls, foundation, plinth, roof, Indian Patent Stone flooring, wooden doors and windows. It does not include electrification and plumbing (Kotak, 2007, p. 71).

Sanya (2007) researched the sustainability of earth architecture in Uganda. He evaluated earth building techniques of adobe, wattle-and-daub and CSEBs. A fourth technique of conventional fired brick was chosen as a benchmark for comparison. Using a multi-criteria analysis approach and ideas from systems theory, the four techniques were evaluated on social, economic and environmental sustainability criteria. Sanya's research comparison revealed that, for the same architectural quality, the wattle-and-daub and adobe techniques are more sustainable *vis-à-vis* brick because they contribute to alleviation of poverty and improved socio-economic conditions while also remaining ecologically benign. However, compared to the brick alternative, the CEB technique perpetuates conditions of socio-economic indigence and engenders more

Figure 4: Circular house under construction in 2001 Kutch earthquake rehabilitation exercise.
Source: Kotak (2007, p. 71).

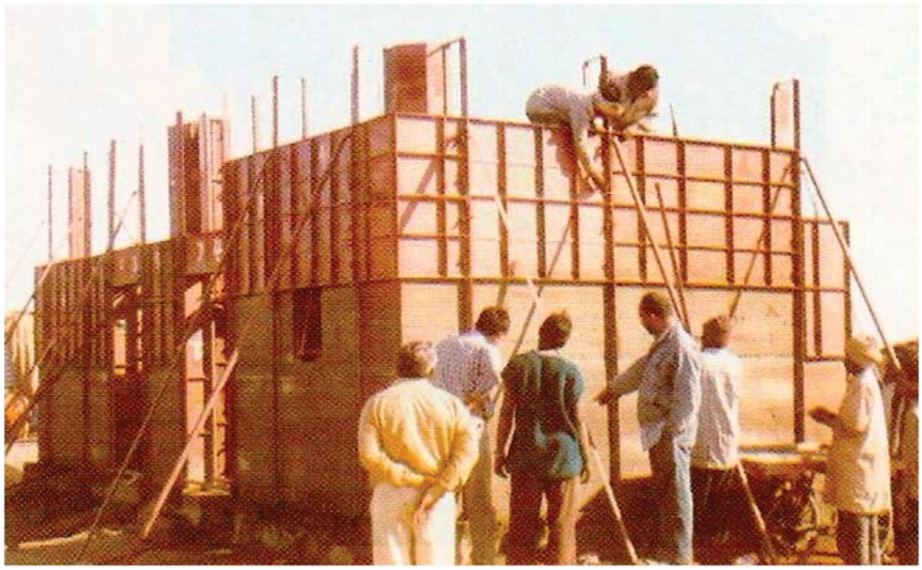

Figure 5: Rectangular house under construction in 2001 Kutch earthquake rehabilitation exercise.
Source: Kotak (2007, p. 70).

Table 4: Cost of rectangular rammed earth structure at Hastkala Nagar, Kutch, Gujarat, India

	Units	*Quantity*	*Unit rate*	*Total cost*
Labour cost	—	—	—	6500
Soil	Tractor	5	200	1000
Sand	Tractor	4	200	800
Cement	Bags	38	125	4750
Diesel	Litres	3	20	60
Oil	Litres	2	50	100
Water	Tanker	6	150	900
		Total amount in Rs	14110	
		Volume of wall in cubic feet	445	
		Total cost in Rs/cubic feet	31.7	

Source: Kotak (2007, p. 71).

Table 5: Cost of circular rammed earth structure Bhunga at Hodka, Kutch, Gujarat, India

	Units	*Quantity*	*Unit rate*	*Total cost*
Labour cost	—	—	—	2200
Soil	Tractor	3	200	600
Sand	Tractor	2	200	400
Cement	Bags	19	125	2375
Diesel	Litres	2	20	40
Oil	Litres	1	50	50
Water	Tanker	4	150	600
		Total amount in Rs	6265	
		Volume of wall in cubic feet	196	
		Total cost in Rs/cubic feet	32	

Source: Kotak (2007, p. 70).

environmental problems. By contextualising the research findings at an international level, it is argued that the economic and environmental opportunity cost of disregarding sustainable approaches to building construction and to production in general is too high for a country like Uganda, and indeed for global ecology. Contextualisation of the research outcomes at the international level suggests that social, environmental and economic sustainability can best be engendered and safeguarded by decentralised production systems based on use of local resources and simple process cycles. According to Sanya (2007), adobe and wattle-and-daub have reduced costs. This reduction in cost comes from simplicity of process and dependence on local resources. Dependence on local resources reduces distance greatly, thereby eliminating many of the transportation costs. Simplicity of process lowers costs by eliminating the need for expensive equipment and superfluous consumption of other inputs (labour, raw materials and fuel). Complex technologies, on the other hand, increase distance and demand for expensive equipment and superfluous inputs, resulting in higher overall costs. For example, cement, which is a key ingredient in brick and CEB walls, is produced in complex processes that depend on faraway resources – factors that make cement a very expensive building material.

According to CRATerre (2005), Uganda has experienced barriers to earth building such as the need for new legislation, technical training, and public awareness of sustainability and knowledge-sharing. Most importantly, the number of cement factories in Uganda is sparse and the production rate of cement cannot meet demand. According to Kamugisha (2001), in Uganda there are two cement plants, mainly operating below capacity, and these produce for the domestic and export market in the neighbouring countries of Rwanda, Burundi and Eastern Democratic Republic of Congo, which also lack cement plants. This has contributed to the high cost of cement in the region. Much of the cement in Uganda is also imported from Kenya and Tanzania. From 1987 to 1995, the deficit of actual cement consumption stood at approximately 15 000–20 000 tons, and in 1995 the deficit tripled in Uganda (Kamugisha, 2001). In 1995, actual demand was calculated at 269 342 tons per year by UNIDO (1997) and potential demand was estimated at 700 000 tons per year. Only approximately 200 000 tons were produced locally. Between 1996 and 2000, it was estimated that Uganda would spend approximately US$40 000 000 on import of cement from Kenya and Tanzania (Kamugisha, 2001). Therefore, it is evident that the CSEB construction technology is not a cost-effective solution to low-cost urban housing in the Ugandan context, which is an exception to many other developing countries. Sanya's (2007) research did not explore any earth stabilisers other than cement that could be cost effective in the Ugandan context.

CONCLUSIONS

It is evident from the above literature review that the financial benefits of low-cost earth construction in developing countries is greatly dependent on the cost of additives that are used to manufacture the building units, and that of transportation of raw materials or finished products to the construction site. Further, there is an energy cost associated with the production of anything, and this can provide an approximate overall measure of environmental impact. Building with earth is considered as an appropriate and cost- and energy-effective technology. However, one has to understand the material and master its disadvantages, which normally are dependent on the soil quality, and which, negatively, can adversely affect the block quality, cause shrinkage cracks and lower wall strength compared with high-quality fired bricks or concrete. Based on research on gypsum-stabilised earth, it can be concluded that gypsum-stabilised earth may be successful in regions with a dry climate, where gypsum can be produced locally and the costs of cement are extremely high owing to the added transport costs. Produced locally, with natural resources, semi-skilled labour and few transport needs, contemporary earth construction for low-cost urban housing can be very cost effective, according to context and available skills.

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