REINVENTING TRADITIONAL TECHNOLOGIES FOR SUSTAINABILITY: Contemporary Earth Architecture of Sri Lanka

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INTRODUCTION

In the search for sustainability, Sri Lanka like most countries has been looking at modern and new materials and technologies as much as at the indigenous practices. Despite having possessed a resourceful repository of traditional technologies and practices, their reinventions, however, have remained somewhat unrecognized. This stems partly from the absence of focused research as well as sponsored or recognized programs to promote and experiment with the new possibilities of their applications in modern building.

Sri Lanka's traditional architecture has been extensively studied, and there exists much literature on the art and construction of the buildings. However, a greater focus has been on recording the variety of their spatial patterns together with the architectural compositions and appearances of buildings and their architectural details (De Vos 1988; De Silva 1990; Lewcock et al. 2002). While De Vos and De Silva have constructed a set of patterns of traditional Sri Lankan houses in settlements, Lewcock et al. have traversed the entire range of traditional settlements and buildings and particularly their architectural splendor. Karunaratne has often highlighted the marvel of timber architecture (1984), while many archeologists have discussed the structures and constructions of buildings in the context of the history and archeology of Sri Lanka's ancient civilizations. In contrast, Dayaratne (1999, 2000, 2003, 2007) shows how its indigenous architecture has been inherently sustainable and how some of the modern architects have employed their principles in creating architecture that is appropriate to culture and kinder to the environment. This paper provides a general introduction to the traditional materials of Sri Lanka and examines in detail how earth architecture has been revitalized as a sustainable approach to building.

KEYWORDS

sustainability, earth buildings, reinventions

INDIGENOUS ARCHITECTURE OF SRI LANKA

Sri Lanka as a tropical island in the Indian ocean with a 2500 year old documented civilization has had buildings constructed of numerous natural materials available aplenty in its geographical terrain. Its traditional architecture has been fashioned by principles of sustainability, although it had not been so claimed. Derived from the natural availability of materials and cyclical possibilities of their regeneration, they contributed to a prudent utilization of the earth's resources in constructing its 25,000 or so villages and hamlets, the cities and urban centers as well as the forest temples, monasteries, and enormous religious edifices. In fact, site selection, use and re-use of sites and materials therein have all been fashioned by the culture of simplicity and thrift, reverence to nature, and the understanding that the earth must be treated with care and gentility because it is both fragile and exhaustible (Dayaratne 2000).

Unsurprisingly, earth or mud has been one of its primary and foremost building materials combined with timber as a framework and coconut thatch and paddy thatch as roofing; all materials available aplenty in the settlements themselves. Timber that was renewable through cultivation and reuse complemented and sometimes also became the primary

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material and was abundantly cultivated in home gardens as well as grown naturally in the forests. Stone was used when it was available and appropriate to build, particularly the public and religious buildings that required materials that would endure. On the whole, Sri Lanka's traditional architecture ensured that its consumption of the resources neither dwindled their availability, nor damaged the fine balance of the ecology upon which it depended as an agricultural community.

TRADITIONAL TECHNOLOGIES

Three distinct materials have dominated the building practices of indigenous Sri Lanka; stone, timber, and earth, which have been separately and collectively used and technologies developed. In fact, in the history of architecture of the island, there are different regions in which specific materials have been extensively used because of their availability and the progress of artisans' skills. It is noteworthy that whatever the materials used, their technologies have been refined and mastered with unimaginable dexterity and prowess, evidenced by the ruins of ancient cities and other archeological sources. Some structures have survived thousands of years of human occupation, but present neglect and abandonment clearly demonstrate that, had they been properly utilized and maintained, they would have lasted a few more thousand years; a sustainable building practice indeed.

Stone Technology

The simplest form of the use of rocks for habitation had begun with the occupation of the naturally occurring caves around which walls and roofs in mud, brick, and timber were constructed transforming them to habitable places. As a principle, when natural rock caves, rocks, or boulders were transformed as habitations, minimal changes were made to the rock itself but other constructions completed the enclosure or the enclosing possibility that existed. Moreover, the landscapes were developed using the same attitudes to rocks and boulders or stone that were organized and orchestrated to create the splendor of the natural landscape. Obviously, it was the availability of such opportunities in the geographical terrains that have been exploited, while retaining the ecology of the places to enhance their habitability. The practice has become so popular that often many temples have emerged in difficult terrain, in close proximity to rocks and boulders also exploiting the inherent characteristics of such lands to define spirituality, reverence, and seclusion.

Indeed, Sri Lanka's constructed rock architecture is historically unparalleled, except perhaps by those of Cambodia's Angkor (Higham 2001). Rock builders of Sri Lanka have mastered the art of stone building with specific knowledge of the types of rocks, their materialistic compositions, processing involving retrieval from the earth, and cutting and shaping them to assemble into structurally stable forms. The achievement of this technology is in evidence in a seven storey building known as the *Lowamahapaya* of which unfortunately only the ruins now exist.

Sri Lankan indigenous builders developed a tradition of conscious integration of rocks into landscape that still continues. Boulders dominate monasteries (*Ritigala*, *Wessagiriya*), and add spiritual and serene quality to places. Often, large boulders were cut into in order to create caves or natural boulders were used to define places (Seneviratne et al. 1992). Further, retaining walls have been built across the boulders, creating new terraces. In fact, in all ancient landscape works, retaining walls have played a central role in creating magnificent architectural landscapes.

FIGURE 1. Finely crafted stonework at temples.

FIGURE 2. Natural boulders to define sacred lands.

Carefully laid out stone slabs

Usually, public constructions were qualified to be built in stone. The *ambalams* or the resting places for the travelers and stone bridges, or the *galpalamas* and steps in monasteries often were constructed in large sawn pieces of stone.

Indeed, the development of stone has been so extensive that there exists a whole period of civilization based on stone constructions—rocks, boulders, and refined and crafted stone. In *Anuradhapura* and *Polonnnaruwa*, the ancient capitals of Sri Lanka, a countless number of ruins of buildings that have been constructed of stone pillars on stone foundations as well as mud brick foundations exist that stand as a testimony to the dexterity and deftness of the Sri Lankan builders who had employed stones and rocks as natural resources of the earth sensitively, meaningfully, and with ingenuity.

Timber Architecture

Indigenous communities took to timber as a building material in a similar manner selecting the most apt materials for the most appropriate use. Unlike stone, which cannot be regenerated, timber was a cultivated material. Although large, age-old timber came from the forests that surrounded many villages, the villagers themselves cultivated much of the timber for the domestic use as trees meant purely for producing timber or as fruit trees in their home gardens.

Although extensive stone ruins remain suggesting a predominant stone use, timber with mud or masonry walls and sophisticated wooden buildings

FIGURE 3. Exposed timber ceilings.

have existed from the third century. *Sigiriya* for example has had an elaborate gatehouse made of timber and brick masonry with multiple tiled roofs in its access to the rock palace.

Three types of trees were extensively cultivated and extensively used for buildings. Jak, coconut, and areca-nut trees provided for varying needs and were consumable without any waste. If Jak fruits provided fruit and vegetable for the villagers and feed for the buffaloes, its timber provided for the durable quality required for making doors and windows as well as roofing rafters. The same could be said about the coconut trees of which no waste came about because its fruits provided for cooking, weaved leaves for thatching, and husks and other parts as raw material for kitchen fires. Coconut with a straight and strong stem could be easily husked and transformed into rough timber rafters that were used in ordinary peasants' huts.

FIGURE 4. Celebrating the exposed timber ceilings.

FIGURE 5. Earth walled unplastered peasant house.

Earth Architecture

Although stone architecture of the ancient times has left ruins to display the ingenuity and dexterity of the Sri Lankan buildings, very little of the earthen architecture has survived, except some of the temples and those of the noblemen. However, the continuing traditions of villagers suggest that earth has indeed been one of the most popular and abundantly available materials that contributed to sustain the rural hamlet as a composite of a habitat that plugged into the cyclic and fragile eco-system sensitively and carefully while consuming its resources and inhabiting the spaces so sensitively created.

Traditional earth technologies of Sri Lanka have ranged form the use of raw-earth: soil, to processed earth brick as well as those hardened earth materials such as *kabook* (clay ironstone) quarried from where it was available. Although many of the aristocratic houses and buildings built of such materials have stood the test of time and have provided suitable shelter, there also exist many cottages of the poor whose earth constructions have been structurally weak, environmentally unsound, and did not provide stable shelter.

Most of these employed *wattle-and-daub* as the earth technology; a technique in which a hollow timber frame is made first and then filled with adobe balls to create a wall. Often bamboo sticks were used for the verticals (which gives thickness and reinforcements) on the sides of which the splits of the areca nut trees are knotted horizontally to create the frame. Once the wall dries up, a thick mud plaster (*meti*) and a cow-dung mixed mud plaster (*goma meti*) was applied by hand to smooth the surface. Often, instead of cow dung, a lime sand plaster applied with a leveler would finish the wall providing a strong and neat wall. The technology had been employed in constructing even the granary storage houses in the front of the dwellings. The materials having been obtained from the surroundings, and the labour having been provided from the village itself, this was indeed an extremely sustainable practice that consumed little energy and did not produce any toxic waste.

FIGURE 6. Granary Storage houses.

Once plastered and well-sheltered with overhanging roofs, however, the raw earth buildings were structurally stable, environmentally sound, and

also lasted generations provided that the day-to-day maintenance was attended to. The Sri Lankan social and cultural practices had built-in ceremonies and events that ensured their renewal and maintenance thus guaranteeing the continuity of those sustainable building practices.

REINVENTING TRADITIONAL TECHNOLOGIES

In understanding how traditional building materials have been re-invented in contemporary architectural practices, two distinct spheres need to be examined. On the one hand, there are those indigenous communities continuing to engage in the age-old building practices coupled with the modern technologies that have reached the rural settlement. Here, the practice has been rejuvenated largely because of the economic benefits the technologies offer. On the other, there exists a whole new sector of architects and clients collectively and individually advancing and re-using them in often innovative ways driven either by ideology or by individual fascination. This has not only renewed interest and development of innovative practices but also influenced the urban middle class, and the rural poor in the trickle down process of culture. Both spheres however offer ample indications that the ideas of sustainability have inherently been present there if not clearly articulated.

The First Context: The Community

The arrival of modern technologies such as concrete blocks and concrete slabs in the past, however, had pushed traditional technology to the background and it became the aspiration of those in *wattle-and-daub* houses to rebuild them with the concrete blocks, despite the fact that they did not offer the same kind of thermal comforts. The peasants thus exchanged their comfortable, affordable, and sustainable houses for the modern opposite, which were trendy and fashionable and expressed progress, modernity, and a distinct place in the social hierarchy. It is in this context that earth has received an increased attention as a modern building material that can be less costly yet provide for the very same modern needs.

There is not much change in the community building practices in the use of mud or earth except that stabilized earth blocks have been introduced and some artisans trained. The material is moving slowly in to the community that replaces the burnt brick with the stabilized earth blocks. In particular, no design interventions or changes can be seen that could absorb all the benefits of earth building. Nevertheless, urban earth buildings are becoming a common where shops and particularly eating houses are being constructed in earth.

FIGURE 7. An urban shop and a street house built in earth.

The Second Context: The Formal Architectural Practice

The first reinvention of traditional technologies within formal architectural practices emerged in the early 1970s when Sri Lanka was subject to a restricted economy and a program was launched for self-sufficiency through local production. The 1970s was a politically critical period of time in Sri Lanka

when it became a socialist republic and Marxist-nationalist policies were implemented. Importation of modern materials was impossible, and many architects were forced to explore all the options available to be creative. Naturally, many turned to local materials and technologies and Geoffery Bawa, in particular, reinvented a number of traditional technologies to cater to the modern needs.

Often, the innovation was not so much in the material itself, but the ways in which the material and its products were used for generating architectural grandeur in the buildings. Indeed, these reinventions are significant in that together there evolved an approach to architecture that was based on the vernacular and traditions, which is now known as "Bawa style"; an embryo of what later became internationally known as critical regionalism. The architects who followed this approach have developed the attitudes and skills to employ materials and technologies of the past and reinvent them for the contemporary world in a sustainable manner.

Stabilised Earth Blocks (SEB): The Re-invention of the Earth Technologies

More recently, the introduction of SEB has intrigued many architects looking for sustainable building technologies, who have put their hands to the task of building with earth as a modern material. A number of interesting projects have come into being from urban houses to tourist hotels; while a now popular jungle hotel known as the "Ella resort" has used the traditional earth technology of *wattle and-daub* construction. However, the technology that has become popular in the new practice of innovative buildings is the production of Stabilized Earth Blocks—unbaked earth blocks of size $8'' \times 6'' \times 10''$.

Stabilized Earth Blocks

Stabilized earth blocks are an innovative reinvention of the adobe brick promoted by the Auroville Building Center (ABC) in India among many others (Maini 1999). Unlike the ordinary adobe block, which is a mixture of soil and water formed in a timber mould, the stabilized compressed earth block has an additional cement component in its mixture but a smaller quantity of water. The mixture is not kneaded to reach a plastic state, but simply mixed until the cement and soil are thoroughly integrated. Thereafter, the mixture is placed within a mould and compressed with a high level of pressure applied through a hand-operated machine. The formation of the brick is a resultant of the compression of soil and cement together in a wet condition. Dried in the shaded sun, the SEB acquires a high compressive strength suitable generally for two storey constructions but higher strengths can also be achieved for three- or four-storey constructions (Maini 1999).

The combination of other modern technologies has made possible earth buildings that do not require domes, vaults, and other forms of this nature, which used to be associated with earth constructed buildings (Fathy 1969). Earth blocks are sometimes left unplastered and sometimes covered with plaster or are painted with watered earth, added with natural colouring. For earth plaster, a suitable coloured earth is specifically chosen, the hue of which could be later enhanced by means of colour additives. Unlike the lime plastered modern urban dwellings, earth plastered buildings express a feeling of cool interiors. In fact, the interior temperature of an earth building is almost always less than that of a similar ordinary brick building.

FIGURE 8. Traditional technologies at Ella and other resorts.

AN EXPERIMENTAL URBAN HOUSE

In 2000, encouraged by the renewed interest in earth architecture in Sri Lanka, an urban house was constructed experimentally in the suburbs of Sri Jayawardanepura, the new capital. Construction was completed in 2001 and the building has been occupied by a small family for the past eight years.

Two new technologies were kept in mind at the inception of the design of the house, namely Stabilized Earth Blocks and 2″ concrete slabs with precast, pre-stressed beams. Both technologies were becoming popular as alternatives to the conventional brick and concrete constructions, although the skilled craftsmen familiar with the technologies were hard to come by. In this case, a trained craftsman for the making of the compressed earth blocks was found and employed to make the bricks while an experienced ordinary mason was employed for the construction of the entire building. He was trained in the methods of construction for both technologies while being on the job. A large part of the earth blocks were made at site using the soil available at the site, while the shortfall was met from soil brought from nearby hilly sites where conventional land preparations for house building makes such soil available. Standard sized compressed blocks (8″ × 6″ × 10″) were used for the construction of the walls, using an earth, water and cement mix mortar as a filling.

Since the house was designed from inception with the experimental technology in mind, larger spans were avoided and the room sizes were taken as multiples of two feet; the distances recommended for the laying of the pre-cast beams with the 2″ piecemeal concrete slab system. This system has been developed by the Center for National Engineering Research and Development (NERD) of Sri Lanka to eliminate the excessive use of concrete and steel, which entirely eliminates the need for a standard formwork. (NERD Technical Leaflets 1999).

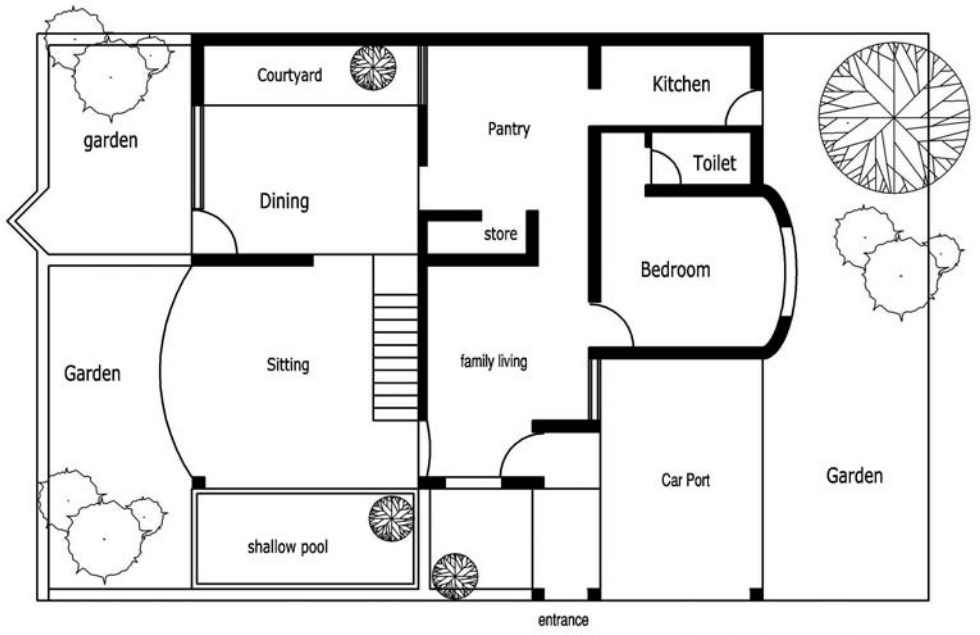
The low-cost slab system involved the making of pre-stressed beams of pre-designed lengths, which could be ordered from NERD approved sites across the island. The slab construction involves the laying of these beams on the walls at 600 mm intervals on which a 50 mm slab is constructed with a square iron grille replacing the conventional steel frame. Standard sized small pieces of formwork made from plywood sheets were used in between the beams, and the concrete slab was laid in smaller portions from beam to beam. Formwork was removed a day after and re-fixed within the adjoining beams to continue the laying of the concrete. This concrete slab construction eliminated cumbersome steel frameworks, formwork, and also extensive labour. Moreover, since plywood formworks were used, no plastering was required.

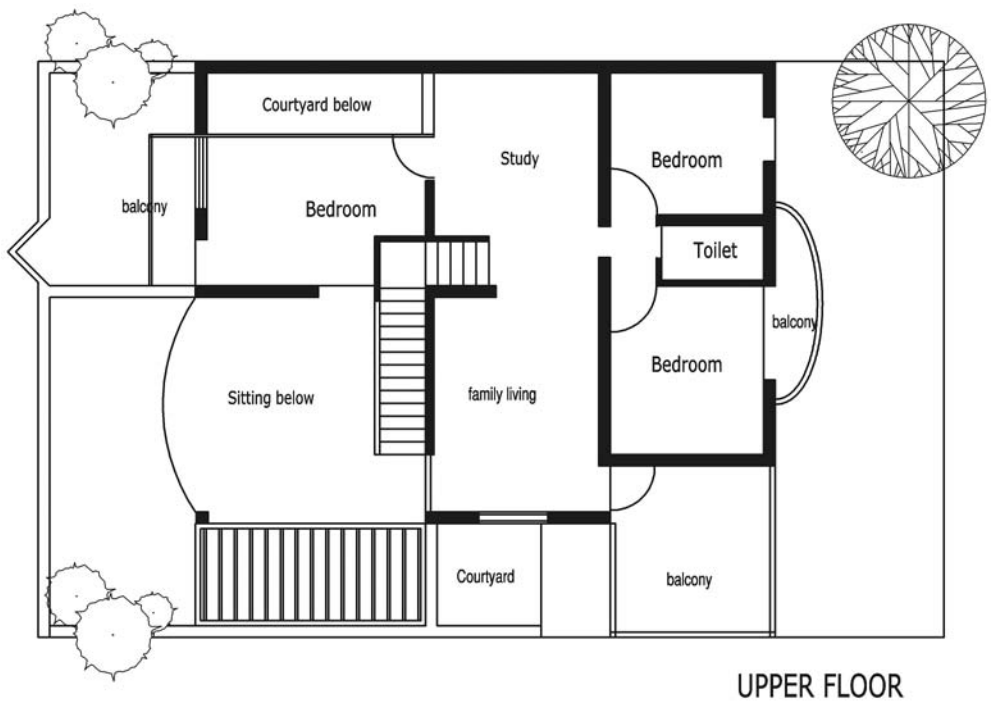
The combination of these two technologies ensured that the use of earth did not result in domes, vaults, and other forms of this nature, which usually differentiate earth constructed buildings from conventional house forms. At the same time, it enabled conception and design of an architecturally flexible dwelling, which if only earth were to be used would have resulted in forms having to be generated, restricted by the potential uses of earth itself for spans. This freedom is found to be necessary in the introduction of earth as a building material in urban settings where built-forms have to be generated within very restricted site conditions and shapes while also creating architecturally interesting and contemporarily valued spaces.

Earth blocks were laid using an earth cement mixed mortar of 1:8 (w/w) proportion and the walls were left un-plastered. Externally, they were painted with watered earth, added with natural colouring. Earth was sieved for this purpose, and a suitable coloured earth was also specifically chosen the hue of which was later enhanced by means of colour additives.

FIGURE 9. Earth walls and bricks at a site.

FIGURE 10. Plans of the urban house showing the brickwalls.





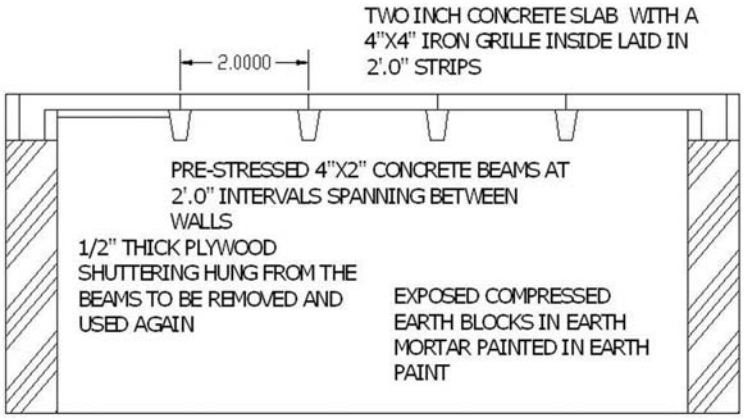


FIGURE 11. Section through the slab.

Its appearance in stark contrast to the modern urban dwellings offers a feeling of a colder interior and in fact, the inside atmosphere is at least 3 degrees lower than outside at any given time. Part of the reason for the lower temperature within the house was the result not only of earth walls but the plaster that did not use cement as an ingredient. Instead, lime, mud, and sand of 1:2:6 (v/v) proportion was used to apply a 1″ thick plaster surfaced with lime in order to obtain a smooth finish in the interior. In the exterior, the lime plaster was avoided, saving both labour and materials while finishing it with a coat of selected earth, dissolved in water and *chemifix*; a glue that is often used as a bonding material in wood. This also added water resistance to the exterior to withstand Sri Lanka's heavy rainfall.

The experimental case study presented here does not totally represent the contemporary earth architecture of Sri Lanka where many earth technologies of various combinations are being experimented by many architects. Indeed, the leisure industry has enabled the pursuit of earth technologies for small scale buildings mainly to enhance the idyllic tropical atmosphere that the resort hotels and jungle retreats seek to promote. In the area of housing and particularly in urban areas, earth architecture has its appeal more because of its thermal qualities and also the potential lowering of costs while enabling the making of unique and exclusive buildings, which the urbanites desire.

FIGURE12. Exterior views of the walls: ivy grown over earth walls.

CONCLUSIONS

This experimental earth house among many others amply demonstrates that earth can easily be employed as an urban modern material to construct at least two-storey buildings, particularly dwellings. It also shows that earth as a material produces cooler interiors, provided no cement is used in the plaster work. Since the house was constructed using a wall-on-wall structural system, without many concrete columns, except three where two larger openings were required for the sitting room and the garage, the structural capacity of Stabilized Earth Blocks to take the loads of an upper floor has been reconfirmed.

It shows that unlike the many attempts by Hasan Fathy to reintroduce earth, new buildings have to avoid the negative consequences of earth constructions. This means, vaults have to be avoided and larger spans have to be obtained by using other materials for the construction of roofs and floor slabs. In this case, a thin slab laid on pre-stressed beams were used. Moreover, while earth as a material may be employed, the modern ideas of space, such as open planning and spatial fluidity, incorporation of visual courtyards through large openings, and indoor bathrooms and pantries, etc., should be included intrinsic to the design because contemporary clients view houses as elegant, spacious, and modern settings.

As for construction, it is noteworthy that the use of earth does equate with burnt bricks or popular cement blocks. It consumed less energy to produce and consumed less cement for both the brick and the mortar. However, it should not exclude concrete or any other materials. The task in fact is to employ a well integrated multiplicity of technologies, both traditional and modern. The two-inch thick slab on pre-stressed beams was a useful system that reduced the load of the first floor, while providing a sufficient stable and strong floor.

The experiment also shows that it is easy to transfer the technology to artisans and make them become innovative in its use. We also found that with respect to costs, the wages for artisans have to remain competitive for earth construction to attract them to build with earth instead of cement blocks or burnt bricks. This is crucial because it is mostly the artisans who determine the materials to build with, and they alone can either promote or discourage the prospective builders from accepting earth.

Resulting from these experiments in Sri Lanka, earth as a material has now been accepted in general, and most important its derogative image is being shed as a material for the poor. The construction technologies employed produce savings in both the material and labour since no plastering is necessary. Moreover, the houses being built are seen as semi-luxurious and thus contribute to the transformation of the perception of earth from an inferior material to one of superiority. Indeed, the design and construction of these dwellings have demonstrated that it will be possible to change the public perception of earth as a material while architecturally exuberant buildings can be designed using a combination of low-cost technologies.

FIGURE 13. Earth cottages in a way-side resort: Ambalama.

This paper has discussed the ways in which the traditional architecture of Sri Lanka has employed a number of natural building materials in appropriate technologies to build buildings that are inherently sustainable, sensitive to Nature, and promote local skills. It showed that architecture has evolved culturally well-suited to the attitudes and aspirations of the people (Oliver 1985) and continues to do so. Development and progress had relegated these practices in preference to machine intensive, unsustainable building practices (Khalil 1999a), which are now being slowly reexamined.

However, it was increasing problems of poverty, lack of resources, and controlled economies that had first pushed the architects to return to the traditional materials and technologies and produce innovative and creative ways of authentic building. Today, awareness of sustainability and rising costs as well as climate change in the urban areas have recalled many of these as potential technologies for modern buildings. A number of traditional technologies have been reinvented, and among them earth has become one of the most experimented technologies of building.

One of the obstacles in promoting earth buildings is in their valuing as economic commodities. Although the clients may be persuaded to build in earth, there is a possibility that these houses may be appraised low by the real estate valuers given the difficulties in marketing. This cannot be ascertained conclusively because none of the modern houses have still entered the housing markets.

This paper examines the possibility of reinventing technologies such as earth that have been sensitive to the environment. Earth as a material has had a long history and despite its popularity in the past (Agrawal 1981;Damulji 1993; Denyer 1978; Gardy 1973; Jain 1992) attempts to repopularize (Fathy 1969; Graeme 2002; Houbent and Guillaud 1985) remains unknown as a potential modern material, although sustainability has given it a new impetus and new life with communities having begun to reinvent the practice for the modern world. Given these new directions and reinventions, it is fair to conclude that the future of the earth industry will produce more innovative ways of building (Norton 1986; Khalil 1999b) that will be sustainable and lighter in demands on the earth's limited resources.

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