



URBED-SCAD
Eco-home Analysis Report

INTRODUCTION

INTRODUCTION TO THE SCAD URBED TRUST PILOT ECO-HOME

The award of the prized Platinum Certificate by India's Green Building Council recognises the contribution that the SCAD URBED Ecohome makes to reducing carbon emissions. In introducing a report from architect Dinesh Jeyachandran that show the model eco house will also cost less than a conventional home built from concrete. I want to explain why I have funded the initiative, the benefits it could bring to people living in rapidly growing urban areas, and how the project will be scaled up.

WHY INDIA NEEDS BETTER HOMES

My first contact with India came from a special project at Stanford Business School in California on increasing food output in India. I was invited as a guest of the British Council to speak at a conference on future cities in Goa which also took me to Mumbai and Delhi. But it was only through a chance visit to stay with SCAD (Social Change and Development), seeing their work to help the disempowered in Tamil Nadu, and meeting their inspirational founder Dr. Cletus Babu that I really recognised the need for a different model for urban growth. On my second visit discussions with staff there came up with a set of principles for building better homes, and a discussion with SCAD's founder Dr. Cletus Babu encouraged me to fund an experimental project, which is explained on the project's web site (www.smarterurbanisation.org).

To check urban sprawl, which is adding to congestion and pollution, and provide the mass of people with the tools to improve their lives, something radically different is needed. Currently vast concrete apartment blocks in city centres are eating up concrete and energy, while detached houses on the periphery are taking over land needed for farming or flood control. Two conferences in London on the theme of Indian Urban Futures with a range of experts reinforced our idea of focussing on mid-sized cities, where the scope for change is greatest. Having won the prestigious 2014 Wolfson Economic Prize for showing how to build garden cities that are visionary, popular and viable without subsidy, I wanted to see whether similar

principles might apply to parts of India (<http://urbed.coop/projects/wolfson-economic-prize>). Conferences in Tirunelveli and Chennai in 2019 confirmed that there was indeed a market for a different approach to development that was more organic and environmentally conscious.

WHAT THE ECO-HOME OFFERS

The URBED Trust recognises the valuable inputs from Dr. Richard Simmons, who coordinated the project for the Trust, and Brian Love of Connected Cities, who both visited SCAD with me. We worked with Mr Charles Christy and the Nirman Trust, as well as members of the team at SCAD to produce the model that won the IGBC Green Homes Certification Level: Platinum. Initial designs were developed by members of SCAD's engineering faculty. Having met up with the founder of the Urban Design Collective in Chennai, who had asked for an article on garden cities, we decided collectively to appoint Vidhya Mohankumar to produce a family of designs and assess possible sites. She and her colleagues went on to oversee the construction of the first pilot project on a carefully selected site at the campus at Cheranmahadevi near the city of Tirunelveli. One of her former colleagues Dinesh Jeyachandran in Chennai was later commissioned to produce an evaluation of the project to assess the viability of applying 'green' principles compared with conventional methods.

There are five basic principles:

- A spacious layout for a small family that can readily be extended as needs change and resources allow.
- Construction out of locally sourced materials to reduce transportation.
- Utilising and training the local workforce to provide better job opportunities.
- Climate responsive design by implementing passive cooling techniques to avoid dependance on mechanical air-conditioning.
- Effective grey water treatment by directing it towards the house garden.

HOW THE PROJECT WILL PROGRESS

The performance of the house is being monitored and there is strong interest from people who work at SCAD in occupying a second phase. Local architects have come up with initial designs for a site that SCAD owns near the centre of Tirunelveli. This would create a Sustainable Urban Neighbourhood of some 25 houses along with communal facilities. The plan could be scaled up for different needs and locations. Potential funding sources are being identified, so that detailed design can be worked. Approvals will be secured for construction in 2022, when the housing market revives, along with a business plan that can be replicated elsewhere.

SCAD, with further support from the URBED Trust, leading engineers Buro Happold, and the Welsh Centre for Alternative Technology (CAT) are establishing a centre for sustainability called Gardens of Delight, using the pilot house as a source of inspiration along with other SCAD innovations such as the adjoining bio digester that turns food waste into energy, and work with womens' groups in the villages. The idea is to promote the concept of sustainable design, and train both existing students, and also others in how to apply the principles in practical projects. Support will be sought from foundations in both India and the UK, and applications will be made to appropriate government programmes.

Dr. Nicholas Falk

www.urbedtrust.com

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GLOSSARY

Adobe	- Sun-dried mud blocks.
Brickwork/Brick wall	- Masonry wall built with bricks and mortar laid in courses.
Carpet area	- Net occupiable internal floor space.
Cement	- A binder, binder, a substance used for construction that sets, hardens, and adheres to other materials to bind them together.
Concrete	- Composite material composed of fine and coarse aggregate bonded together with a binder. Most interchangeably used for cement concrete.
Conventional	- Prevalent building systems in the market.
Jali	- Geometric patterned openings made from arranging building block units of brickwork with gaps in between.
Joinery	- Wooden doors and windows.
Labour	- Workforce involved in construction of buildings.
Laterite	- Rock type rich in iron and aluminium.
Lime	- Calcium containing inorganic binder material that is naturally occurring and used in construction
M.Sand	- Manufacture sand, used as fine aggregate in Cement concrete. It is made from powdered rocks.
Material	- Building materials used in construction.
Mild Steel	- Low carbon steel
Mortar	- Plastic mixture of binder and fine aggregate used to lay masonry units
Plinth	- The platform, generally elevated from ground level, over which the structure is built.
Plinth area	- Total built area of the building foot print
Prefab	- Prefabrication.
RCC	- Reinforced cement concrete
River sand	- Fine aggregate quarried from sand beds of water bodies.
Surkhi	- Powdered broken brick.
Terracotta	- Clay based type of earthenware, glazed or unglazed.
Vernacular	- Pertaining to a particular social and geographical region.

INDIAN TO INTERNATIONAL NUMERICAL SYSTEM CONVERSION

No. of Digits	Indian system		International system	
5	10,000	Ten Thousand	100,000	Hundred Thousand
6	1,00,000	One Lakh	100,000	Hundred Thousand
7	10,00,000	Ten Lakhs	1,000,000	Million
8	1,00,00,000	One Crore	10,000,000	Ten Million
9	10,00,00,000	Ten Crores	100,000,000	Hundred Million
10	1,00,00,00,000	Hundred Crores	1,000,000,000	One Billion

1

UNDERSTANDING SUSTAINABILITY IN INDIAN CONTEXT

- Sustainability and sustainable development.
- The pitfalls of urbanisation.
- Region specific parameters for sustainable development.
- Traditional building techniques.

1.1. INTRODUCTION

The conventional understanding of sustainability can be paraphrased to be a concept that protects the rights of the present without compromising the ability of the future to meet its needs. Dating to the 1970s, the idea of sustainability first cropped up as a response to collapsing natural ecosystems and a realisation that unchecked development will have disastrous consequences. Post the Bruntland Report of 1987, the idea of sustainability got traction and permeated into various cultural and scientific spaces.

Independent of context, however, sustainability is difficult to define. Architecture lends itself as one of the sciences best suited to operationalize sustainable development. Arguably, architecture and urban design are high impact sciences. The built environment is a significant contributor to waste. Sustainable design, therefore, is vital to minimising waste and optimising energy, water and resource consumption. It is the art of creating environmentally efficient and responsive buildings.

Sustainability is a fast-evolving science. It is imperative to adapt it specifically to various countries and region specific environments. Asia is the most populous continent in the world. India in particular is projected to overtake China as the most populous nation by 2027. Architecture in India is consumed by dichotomies.

Conflicts which shape everyday life in countries like India are also reflected in urban planning and architecture. Cities are characterised by rapid growth and high density of population. They are also marked by rampant migration, some of which is seasonal in nature. Typically, the moving populace in India would practice seasonal migration, moving to large cities between agriculture seasons.

Home to some of the largest urban populations in the world, India has numerous megacities where millions are packed together. These megacities are marked by poverty and rapid urbanisation. While urbanisation itself is to be expected, and even welcomed, a distinction must be made between controlled and uncontrolled urbanisation. When controlled, urbanisation can be a boon and can lead to an increase in opportunities and all round improvement in social and environmental parameters.

A country such as India does not have the advantage of homogeneity, not in its population, nor culture, landscape or environment. As such, contradictions thrive in India. Therefore, conventional sustainable practices are often not practical in India. Sustainable design is often Euro-centric. It is made to western sensibilities and made to suit western urban and peri-urban population makeups. Applications of these norms in a country such as India would be met with failure. In addition to huge populations already residing in these cities,

India also faces a lot of internal migration. This form of migration is seasonal; more often than not in line with agricultural seasons. Therefore, there is a need in cities for inclusive and affordable short term housing. This kind of development is usually uncontrolled and not suitable to any form of sustainability.

Therefore, there remains an urgent need for city and urban planning catering to low-income households which also take into account sustainability and long term environmental impacts. Considering that the need of the hour is access to housing for all, there is a concerted effort from the Government of India, and other non-profit organisations, to build affordable housing which is also sustainable. This form of housing, to be handed over to low income families, are situated not only within urban spaces but also in rural areas. Some organisations that work towards this are -

1. HUDCO - Housing and Urban Development Corporation Limited

Was created to address concerns of housing deficit in India. HUDCO sought to fill gaps in housing finance and urban infrastructure development. Being a Public Sector Undertaking(PSU) under the aegis of the Government of India, HUDCO works extensively on fulfilling housing needs of Economically Weaker Sections and Low Income Groups in India.

2. UNDP - United Nations Development Programme

In partnership with the Ministry of Rural Development (MoRD), UNDP, through the Governance & Accelerated Livelihoods (GOALS) project, helps promote affordable housing for the rural poor.

3. Tata Trusts

Under one of the in-house programmes, the Tata Trusts have partnered with key stakeholders to promote sustainable habitats that provide a conducive living environment and sustainable housing to people from economically weak urban communities, to improve their quality of life and address challenges around basic services like water, sanitation and waste management, land tenure and affordable housing for the urban poor and urban governance and capacity-building.

Additionally, the Government of India also has schemes in place to address housing shortages. These schemes are with the aim of promoting home ownership, even for low income families, as opposed to being social housing that is owned by the Government and rented by low income families, or homeless families. Social housing or Public housing can refer to any rental housing owned and managed by the State or non-profit organisations for the purpose of providing affordable housing. In India, the term social housing is replaced by 'affordable housing', 'low-income', or 'cost-efficient' housing. The difference in terminology stems from the fact that unlike in the USA or European countries, such housing in India isn't composed of

rental housing units. Instead, there exists in India a multiplicity of schemes with the aim of execution and delivery of low income housing units to the economically weaker sections of society. In India, these schemes include the National Housing Policy, 1994; Jawaharlal Nehru National Urban Renewal Mission, 2005; Rajiv Awas Yojana 2013), the Pradhan Mantri Awas Yojana (PMAY) launched in 2015 provides a fresh impetus – the PMAY-Urban (PMAY-U) subsumes all the previous urban housing schemes and aims at ‘Housing for All’ to be achieved by the year 2022. The total housing shortage envisaged to be addressed through the PMAY-U is 20 million. The mission has four components: In Situ Slum Redevelopment, Credit Linked Subsidy Scheme, Affordable Housing in Partnership, Beneficiary-led construction or enhancement. The Indian Government has also provided for numerous initiatives like the Green Rating for Integrated Habitat Assessment (GRIHA) to promote green buildings.

In addition to welfare initiatives of the Central Government, State Governments in India are also encouraging affordable housing by providing rebates on stamp duty rates levied on housing for the EWS, low and middle income groups.

Affordable housing is difficult to define. One of the most commonly accepted and used definitions posits housing affordability as a measure of expenditure on housing to income of the household. The Indian Government also adopted a similar

definition through the Report of the High Level Task Force on Affordable Housing on All in December 2008, “Affordable Housing refers to any housing that meets some form of affordability criterion, which could be income level of the family, size of the dwelling unit or affordability in terms of EMI size or ratio of house price to annual income.”

Another source of conflict in Indian sustainable design is between imported building technologies and traditional building knowledge. Given India’s predominantly tropical climatic conditions, using glass facades, for example, is highly unsuitable. However, it is widely used in multi-storey office buildings across the country, almost as the norm. It is a highly inefficient and wasteful form of design unsuited to India’s climate.

On the other hand, traditional building technologies have holistically developed over centuries and use locally sourced materials. While not without faults, they are largely more suited to local macro climatic conditions. Here, it is important to notice a shift in how sustainable architecture is viewed. Design, which was previously focused on what is important for the building, must now shift to be environmentally and ecologically centered. Sustainability becomes an integral part of architectural design. It is also not fair to blindly apply contemporary sustainability standards like LEED, Cradle to Cradle and Zero-carbon buildings to structures



Fig. 1.1. In-situ slum rehabilitation project at Karimadom Colony, Thiruvananthapuram, Kerala. Each building unit accommodates 20 households. 28 such building units are being to slowly replace the shanty homes that occupy the neighborhood.

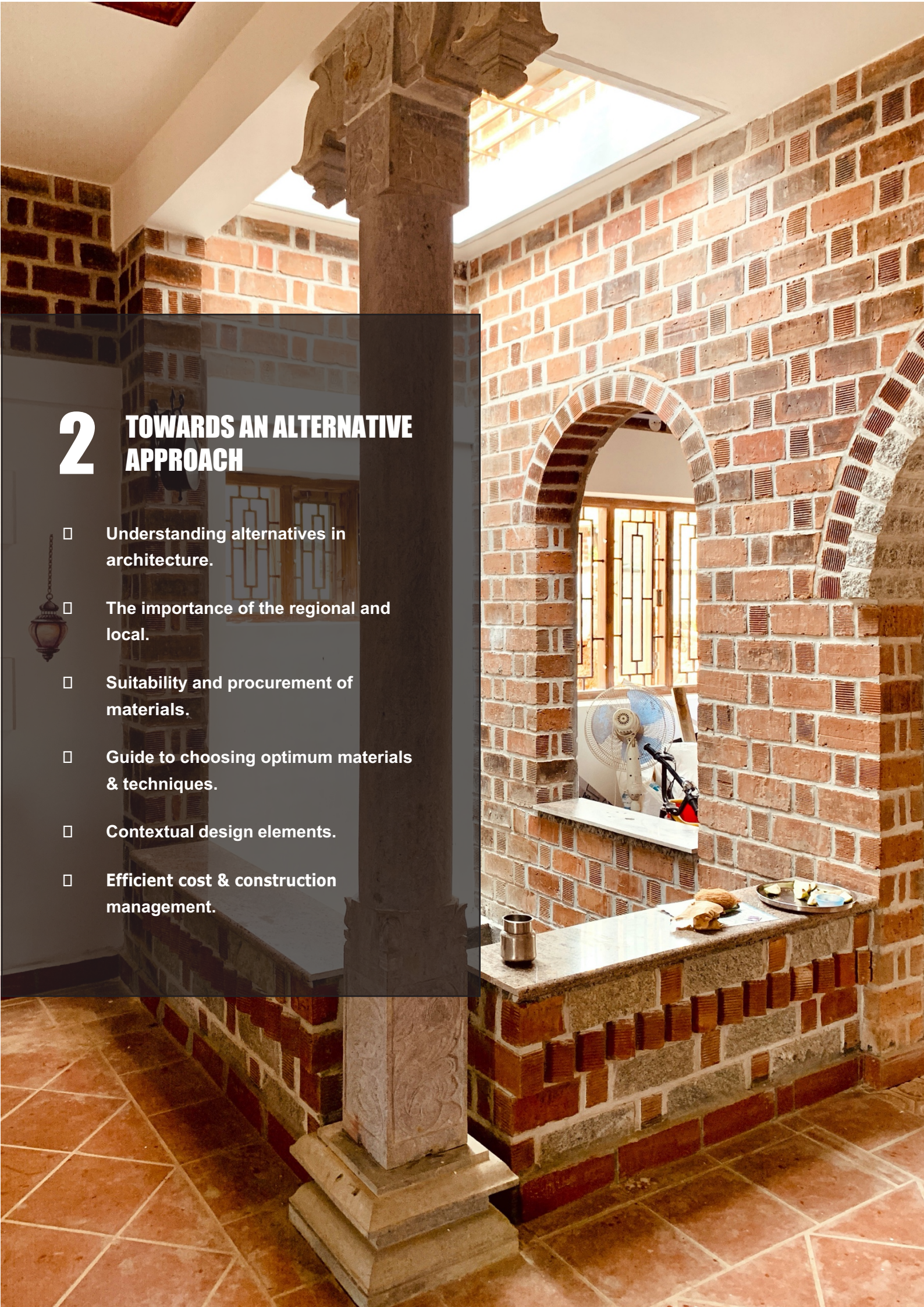
in developing nations. While it must be acknowledged that LEED parameters are evolving and becoming more inclusive, its parameters must also be designed to be region specific. Sustainable architecture in these places must work within broader historical and social context.

Natural resources in the region have already been stretched thin; having been subjected to stress and depletion due to demographic development and changes, uncontrolled urbanisation, and resource intensive consumption. These issues are exacerbated greatly by the climate change crises.

Presently, development policies in India are not aligned to environmental protection or towards proper utilisation of natural resources. In order for cities in India to be able to sustain themselves, new urban developments must be future proof and cater to a variety of consumers.

2 TOWARDS AN ALTERNATIVE APPROACH

- Understanding alternatives in architecture.
- The importance of the regional and local.
- Suitability and procurement of materials.
- Guide to choosing optimum materials & techniques.
- Contextual design elements.
- Efficient cost & construction management.



INTRODUCTION

An alternative approach to the conventional western-inspired, unaffordable, exclusive building practices is not a prescribed set of materials, techniques or design elements. It is the idea of recognising that one size fits all solutions across the planet doesn't work. It is basically a way of thinking/designing which will result in regional, affordable & inclusive design solutions rooted to context.

But what do we mean by 'going regional'?

Firstly, it comes from procuring materials locally. Utilising resources available in your closest proximity helps to save a lot of energy which would otherwise be spent on transportation and sourcing of distant materials, which is not environmentally sound nor economically feasible. Secondly, it is about designing structures to suit the local climatic and geographical needs.

Design needs to pay heed to micro and macro climates. It is erroneous to say that aesthetics and safety guidelines will be compromised upon doing so.

Vernacular buildings are developed over years of research & development into local building practices and knowledge to do just that, using the materials available locally. This makes for buildings which are better optimised in making use of natural lighting & ventilation, which helps by saving energy and eliminating recurring costs. As they are constructed taking into account localised

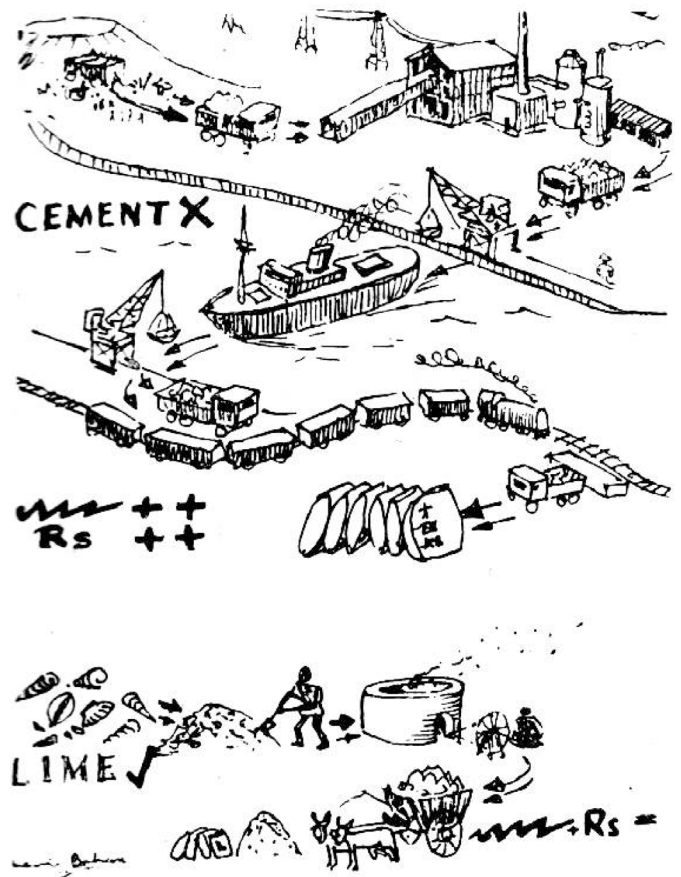


Fig. 2.1. Transportation involved in cement & lime.

factors, they are more suited and sensitive to the environment.

An important aspect that is often overlooked is preserving regional identities and respecting local aesthetics. A cookie cutter, one-size-fits-all approach to architecture does a great disservice to local know-how. All this and more constitutes to going regional.

Goes without saying, when these principles are applied into practice, it becomes pertinent to make them inclusive & affordable in a country like India. While urbanisation is to be expected of any



Fig. 2.2. Centre for Developmental Studies, Thiruvananthapuram, Kerala



Fig. 2.3. Brejith-Ullas Residence, Thiruvananthapuram, Kerala

country, rapid and uncontrolled urbanisation brings with it a host of problems.

Gentrification of communities and localities mean that low income families are being increasingly pushed out of spaces occupied by them for generations. An influx of educated and employed people into cities has led to a visible change in the architectural landscape. Urban spaces and city centres are no longer affordable nor are they welcoming to low income families. These families, who are often essential city workers or provide services, are shifted to settlements on the outskirts of cities from where even the commute into the city is difficult.

Any development of spaces in cities have to be inclusive of all communities and affordable across a range of incomes in order to be sustainable.

Broadly, our alternative approach in its implementation has 3 major components:

1. Materials & Techniques
2. Design
3. Cost & Execution

2.1. MATERIALS & TECHNIQUES

The physical aspect is the most noticed and obvious aspect of all. Nevertheless, it does play an important role in meeting our cost efficient, energy efficient, environment friendly priorities. There are no 'good' and 'bad' materials. There are several factors

that go into consideration before a material or a technique is chosen. This is largely based on the context. An ideal material is the one that is,

- 2.1.1. Cheap,
- 2.1.2. Environment friendly,
- 2.1.3. Locally sourced,
- 2.1.4. Easily available,
- 2.1.5. Easily workable,
- 2.1.6. Familiar among labour force,
- 2.1.7. Recyclable/reusable,
- 2.1.8. Renewable, etc.

Usually, we do not get this 'ideal' material as some of these aspects tend to be contradictory. For instance, Aluminium which is nicknamed as 'frozen electricity' is cheap & readily available. Whereas timber, a material with almost zero embodied energy tends to be costly when it reaches the site.

As previously emphasis was laid on, a pure environmental approach would only set things backward in a country like India. Affordability may take precedence over environment friendliness based on the user/client. Market availability may take precedence over resource proximity when there are tight deadlines. Likewise, many other environment ideal factors may have to be compromised to suit a particular project or a client. Thus, a balanced approach is essential in order to prioritise one over the other when choosing materials.

The charts below might help.



Fig. 2.4. Neerada Suresh Residence, Thiruvananthapuram, Kerala



Fig. 2.3. Laurie Baker Centre for Habitat Studies, Thiruvananthapuram, Kerala

2.1.1. MATERIAL COST

Low  High



Fig. 2.6. Each of these materials, however used in different components of a building, are compared to each other on the basis of affordability in their own categories among other alternatives.

2.1.2. ENVIRONMENTAL IMPACT

Low  High

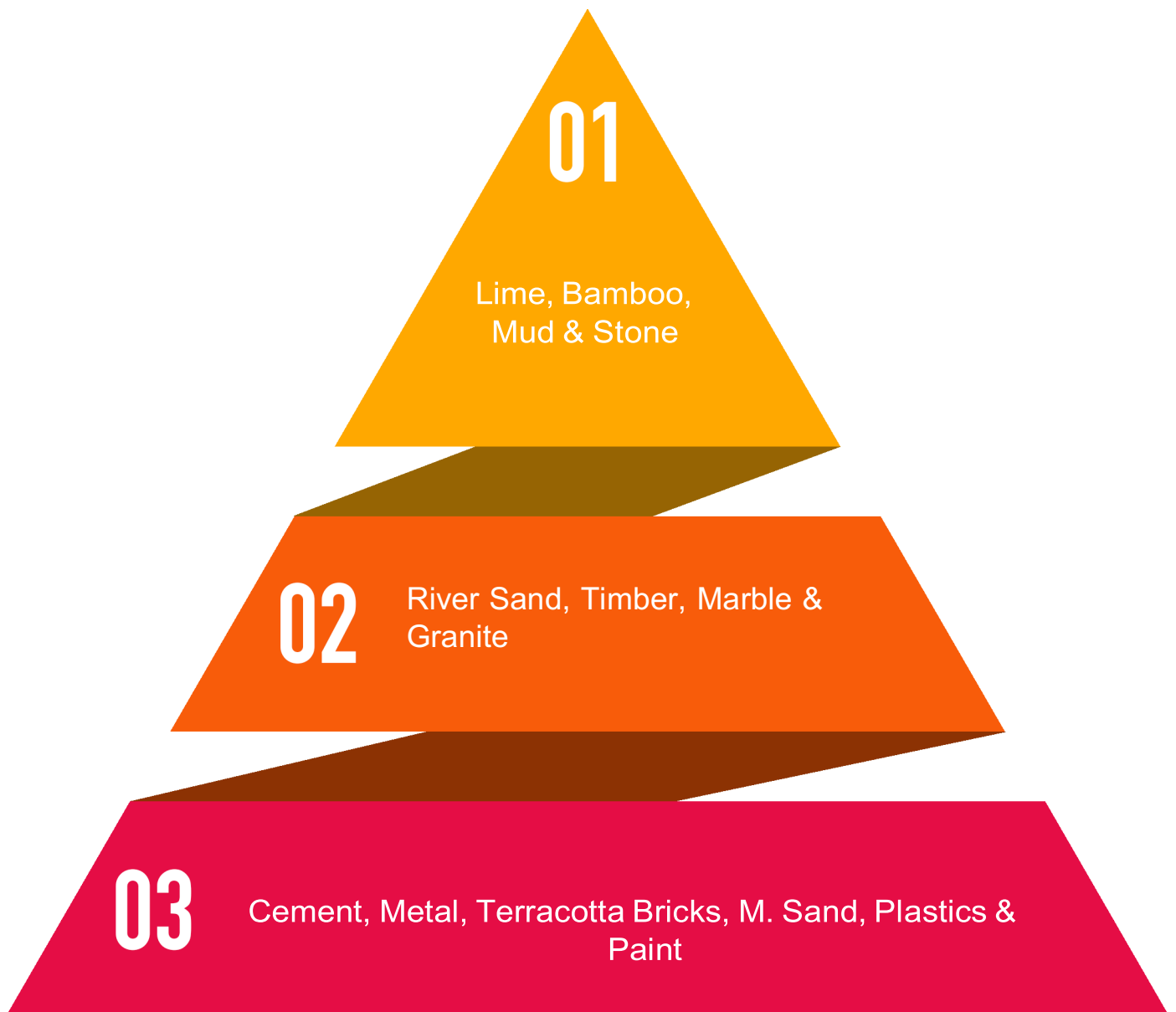


Fig. 2.7. Factors such as processing, embodied energy, toxicity of working with the material, amount of resource depletion it contributes to, use of renewable/non-renewable energy source for production, promotion of monoculture, contribution to deforestation, etc. are considered to arrange materials into three tiers of impact..

2.1.3. RESOURCE PROXIMITY

High  Low



Fig. 2.8. The materials are arranged in the spectrum in the following manner -

- A. In case of unprocessed materials, proximity from place of natural occurrence to site.
- B. In case of processed materials, proximity from source of raw materials to factories.

2.1.4. MARKET AVAILABILITY

High  Low



Fig. 2.9. Here, the term 'market availability' encompasses the convenience of procuring in large quantities, quality tested, standardised materials without transporting over large distances.

2.1.5. WORKABILITY

High  Low



Fig. 2.10. Workability in this context means the ease with which a material can be used while also taking into account the duration it takes to complete a particular task as compared to other materials. It is also about how easily a person can be trained with a given material/technique.

2.1.6. SKILL AVAILABILITY

High  Low














MATERIAL	EASE OF USAGE
Stone	
Mud	
Cement	
Bamboo	
Lime	
Timber	
Terracotta	
Metal	
Marble	
Vitrified Tile	
Paint	
Plastic	
Glass	

Fig. 2.11. Access to labour force with the skill to work with a particular material or technique without taking into consideration if those skills can be easily taught.

2.1.7. RECYCLABILITY/REUSABILITY

High  Low



Fig. 2.12. Considering a material's longevity, how easily it can be salvaged from an existing building, number of possible cycles with the material, etc.

2.1.8. RENEWABILITY

Renewable  Non-Renewable 

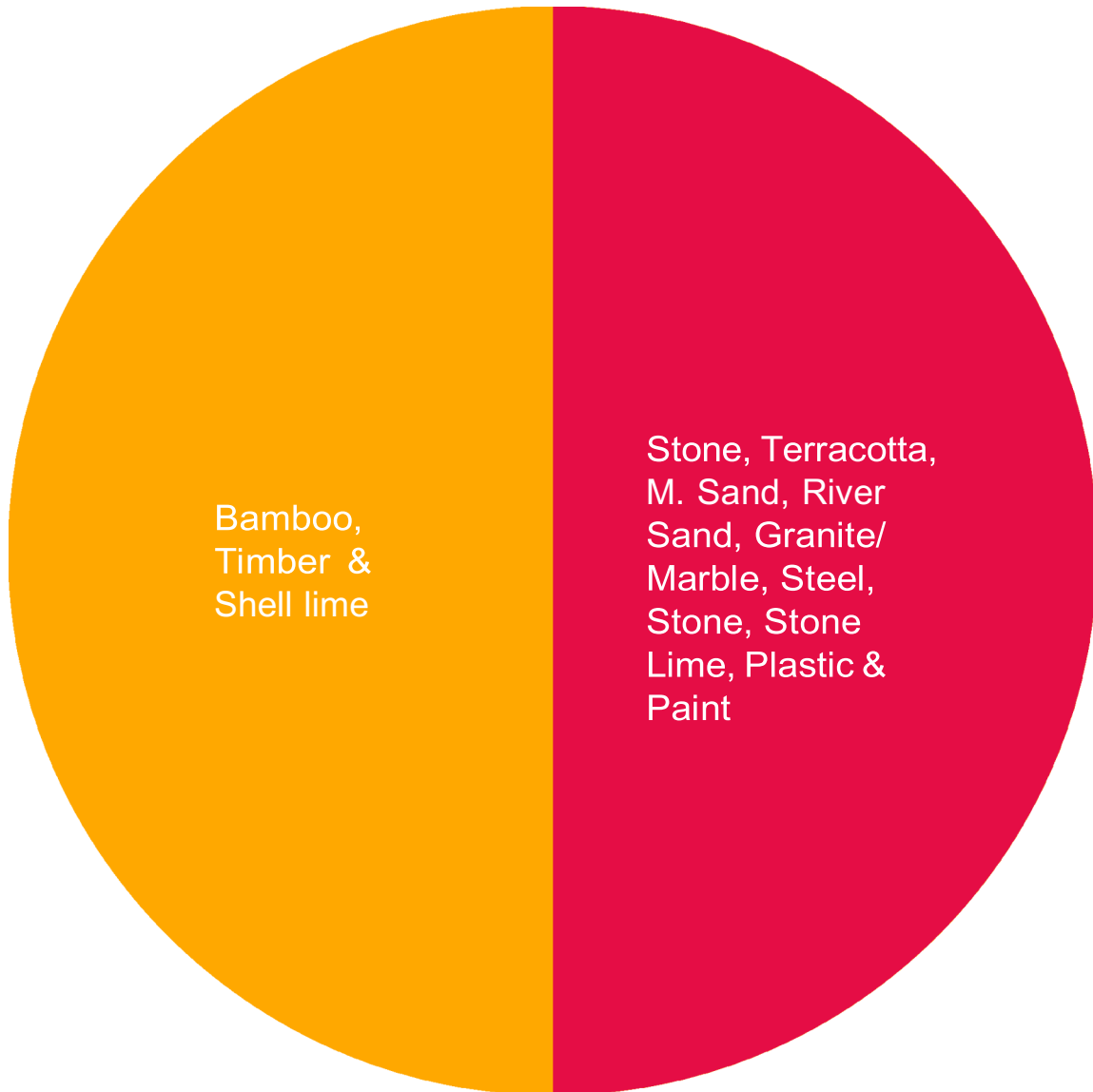


Fig. 2.13. On a suitable timescale, the characteristic of a material to be replenished after consumption. It is to be noted that biomass as a material, by its very nature, is renewable.

2.2. DESIGN

2.2.1. Minimising the required area by conscious decisions and suitable solutions.

The most cost reduction from a construction would be by reducing the requirements accordingly. A considerable idea would be to have less number of rooms, lesser toilets, more of multi-functional spaces. The next thing could be reduction in sizes of the required rooms to fit in the function. Corridors and spill-out spaces can be clubbed together or avoided by suitable planning in the design stage. The bare minimum size of the absolutely necessary spaces can be designed to fit the users' needs.

2.2.2. The conventional grid and breaking the rigidity

Design of the structure plays a key role in effecting the actual cost of realisation. The larger the building and more the rooms there is a possibility of consolidating them with minimal floor area and minimum wall lengths but the resultant maybe difficult to be built using conventional framed structures. Load bearing structures or masonry walls can be built in varied forms, angles and curves to better connect spaces. In the case of formwork less plastic material like mud even more organic forms, smaller niches, structural support elements are possible with ease.

2.2.3. Alternate layouts

Alternate layouts like stepped housing adds up more floors thereby reducing the crowding on the ground, still providing ample open spaces to individual residential units. This open space provides a comfortable

private front-yard with provision for a make-shift gathering space or a garden space, work space or even later addition of a room. Even a pent-house type addition on top is possible on the terrace area. This sort of a layout promotes social interactions and thereby community togetherness. Larger corridors can be used if more storeys can be added, which in itself can become open street like structures creating a stepped multi-storey hamlet like structure.

2.2.4. Omitting elements that are luxurious

- Wall finishes can be just pointing on bricks.
- Floor can be cement plaster without anything else going on top it.
- Toilets can also just be plastered with cement.
- These provide the user a possibility to add finishes later as per their own choices, providing the basic necessity fulfilled at a fair price.
- More of brick jallis can reduce the need for windows; and even those can be reduced to frameless windows.
- Reuse of salvaged timber joineries and stone wherever possible.

2.2.5. Inclusiveness and sense of ownership

2.2.6. The aspect of individuality and site characterised nature of planning

2.2.7. Elevating the personal and social value of the establishment

2.2.8. Passive strategies



Fig. 2.14. Thangassery Housing, Kollam, Kerala



Fig. 2.15. Karimadom Slum Rehabilitation, Thiruvananthapuram, Kerala

2.3. EXECUTION

2.3.1. Constructing many developments at a place at the same time has numerous advantages in terms of cost saving as well as general efficiency. The following are some illustrations of the same.

- Many of the required materials can be purchased from a single source at reduced cost and consistent supply.
- Materials like grillwork can be combined for transport.
- A large space allocated for storing of materials is more efficient than many smaller spaces scattered around.
- Aggregated storage provides a seamless workflow.
- Activities like excavation and concreting can be clubbed together for two or many buildings to save up on transport and rent of supporting labour and machinery.
- Drastic reduction in the wastage of materials due to under-utilization.
- Labour can be assured of continued work availability and as required can be amassed in larger numbers
- Amenities like stay for the labour can be better arranged and long-term continuous working on site can be guaranteed.

2.3.2. Similarly, in the case of a group housing, if a unit of a building with the same design is being repeated, the following advantages present themselves.

- The shuttering material and such can be reused in the same fashion.
- Repetition helps labour repeat and manage work better.
- Faster erection of structures and less time spent on setting up and reading of drawings.
- The team is well aware of the building unit being constructed and can refine the management of the construction.

2.3.3. Procuring the necessary skilled workforce and site supervision.

The market price of conventional materials is shooting up and widens the gap of cost of conventional and alternate buildings. Alternate approaches would tend to make a greater need of the future even without the many benefits to the environment it promises. More of the simpler yet time-tested techniques with natural buildings. More use of such techniques and skilled labour will promote skill development of similar labours and add value to the works of labours. More labour would be interested in the kind of work as the work is left unpainted as a sight to see, more appreciated for the effort put in and pay scale adheres to the skill level.



Fig. 2.16. SACON, Coimbatore, Tamil Nadu



Fig. 2.17. CMS, Azhagiyapandipuram, Tamil Nadu

3 SCAD ECO-HOME

- Overview of the site and location.
- Materials and technologies used in the project.
- Allied systems and energy efficient techniques.
- Cost analysis and comparison
- Element wise project cost breakdown.



3.1. INTRODUCTION

The site identified for the eco-house is located inside SCAD campus in Cheranmahadevi, Tirunelveli which is an education institution. The plot of land is next to existing staff quarters adjoining the boundary of the campus with the backdrop of the hills.

The completed eco-house prototype by nature of its location has a large footfall of students, teachers and parents. During the construction period civil engineering students from the college engaged in the construction of the house unit thereby increasing their exposure to such alternate building construction methods.

3.2. DESIGN

The design of the eco-house brought together various parameters and learnings from the study phase of the project including but not limited to the detailed analysis of the site, local materials, vernacular architecture of the region, alternative eco-friendly building techniques, and a design that allows for incremental expansion horizontally and vertically. Out of the design options presented to SCAD and URBED with different scenarios of expansion for each, the following design was finalised for construction. The final choice of the design was best suited as the guest house was going to be situated in the campus and subsequently used by SCAD's guests. The layout is modular and designed to accommodate an additional bedroom in the future if necessary.

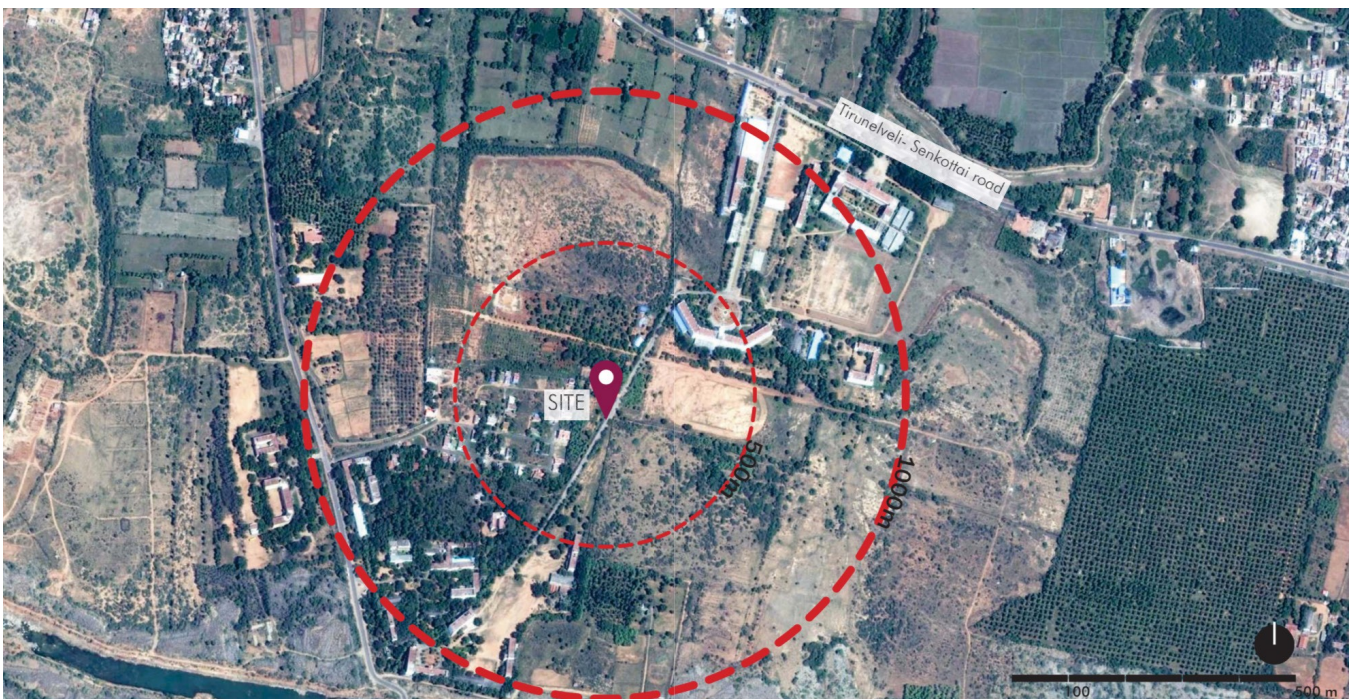


Fig. 3.1. Site location for the SCAD Eco-home



Fig. 3.2. Off-site features of the SCAD Eco-home



Fig. 3.3. Ground Floor Plan for the SCAD Eco-home

3.3. MATERIAL MATRIX FOR THE SCAD ECO-HOME PROJECT

	Inexpensive ----->			Expensive	
Foundation & Basement	Mud with Bamboo Reinforcement	Stone in Mud	Stone in Lime or Cement Plaster	Brick on Cement mortar on a concrete base	Stone in Cement Mortar on Concrete base
Main Walls	Mud Plaster	Laterite or stone in mud & pointed	Brick in mud & Cement pointing	Brick in cement or Lime mortar	Cement & other fancy blocks in cut
Mortars	Mud	Lime & Sand	Lime & Surkhi Sand	Lime & Cement & Sand	Cement & Sand
Plasters & Wall Finishes	No plaster	Lime wash over brick or mud	Earth dung & Lime	Lime & Cement & Sand	Cement & Sand
Door and Window Frames	No Frame	Country wood	Jack & Anjali	Metal Frames	R.C.Frames
Door and Window Shutters	Brick Jaali	Single Plank	Board & Batten	Wood Panel	Glass or wood panel
Flooring	Lime & Surkhi over brick bats	Cement plaster for brick bats	Burnt clay tile over brick bats	Black or red oxide & cement plaster over concrete	Mosaic/ tile over concrete
Intermediate Flooring	Planks over timber joists	R.C.C filler slab	Double funicular shell on ribs	Various prefab units	R.C.C Slab
Roofing	Thatch on Bamboo	Mangalore tile on timber	R.C.C Filler slab	Various prefab units	R.C.C Slab

Fig. 3.4. Material Matrix

3.5. Material-Technique Palette for the Building



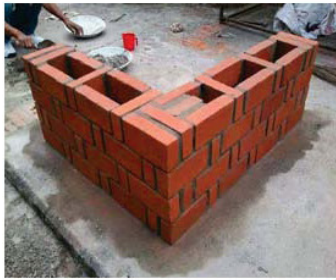
Stone foundation



Traditional stone Plinth



Load bearing structure



Rat-trap wall



Mud & line plaster



Clear coated brick finish



Filler Slab



Broken tile flooring



Planters as parapet



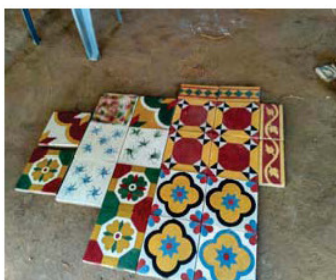
Granite lintel and arches



Local Vengai wood openings



Ferrocement Sunshades



Athangudi tile flooring



Metal spiral staircase



Built-in furniture & shelving

Fig. 3.5. Material-Technique Palette for the building

3.5. ALLIED SYSTEMS

An array of allied systems were chosen for the Eco-house to make it zero-energy and fully sustainable:

- Solar panels for generation of electricity and connect it to the grid.
- Rain water collection, filtration and storage systems.
- Waste water recycling systems to be installed that cleans and recycles grey and black water.
- Community garden and indigenous planting to reduce carbon footprint.
- Overall design that promotes natural ventilation and eliminates need for air conditioning.



Fig. 3.6. Construction of a bio-digester

3.6 PROJECT EXPENDITURE

The major components of project cost will fall in any of the following categories.

- Cost of materials used to build the structure. This also includes cost of renting non-consumables. E.g. Machinery, tools, scaffolding, formwork, etc.
- Cost of employing labour force to install the materials in/as building components.
- Cost of engaging engineer and/or architect to get design drawings, estimates and specification.
- Cost of construction management and project site management through a dedicated building contractor or through a construction manager.
- Cost of setting up and acquiring necessary

statute approval. E.g. Water supply for construction, electricity supply for construction, storage for materials, shelter for construction team, etc.

For the case of SCAD eco-house only the cost of materials and labour is considered. The primary data used to arrive at a final cost figure is the expense ledger maintained by the SCAD team of engineers who executed the project at site. The method of data collection however thorough was not done necessarily keeping in mind a cost analysis in the future.

- High pioneering cost of training labour team. The team of masons involved in the

construction process were exposed to new techniques for the first time. The process of training the team came at the expense of construction cost by means of slow construction pace, correction of mistakes and material wastage.

- The intent and motive of the project was to identify a model of construction which is cost-effective, sustainable and environmental friendly. Inspired by which certain aspects of the project were experimentative in nature.
- The management structure and implementation system needed for the entire construction process of an eco-home evolved through time. This was a deviation from the familiar system in practise for

conventional construction. (refer work flow charts)

- Cumulatively the SCAD eco-home cannot be considered as a realistic representation of alternate construction practice. However it proves to be a learning ground to understand the shortcomings and emphasises on areas of improvement for further eco-home neighbourhood development in TN.
- For the sake of comparison correctional works in the as-built model is not included in the final cost. And for the lack of conclusive data on management and supervision costs, it is substituted with conventional rates.

TOTAL PROJECT EXPENDITURE					
S. No.	Work	Material Cost	Labour Cost	Total Cost (in Rupees)	
1	Foundation	74,720	39,848	1,14,568	115K
2	Brickwork	1,62,650	1,07,330	2,69,980	270K
3	Roof	37,500	48,445	85,945	86K
4	Finishes	59,605	1,20,350	1,79,955	180K
5	Roof Weathering	24,860	22,800	47,660	48K
6	In-built Furniture	10,500	18,400	28,900	29K
7	Flooring	51,290	15,400	66,690	67K
8	Staircase & Ramp	66,300	22,400	88,700	89K
9	Plumbing	86,000	11,000	97,000	97K
10	Electrical	1,12,300	10,300	1,22,600	123K
11	Carpentry	1,74,800	84,977	2,59,777	260K
12	Painting	18,430	19,600	38,030	38K
13	Bio-digester & Grey Water Treatment	97,950	12,800	1,10,750	111K
14	Rain Water Harvesting	46,420	41,260	87,680	88K
15	Site Development	33,130	49,350	82,480	82K
16	Correction Work (mud plastering, sanding, etc.)	6,800	76,250	83,050	83K
17	Solar Power	1,32,000	24,000	1,56,000	156K
TOTAL				19,19,765	1,990K

Fig. 3.7. Total Project Expenditure

3.5. CONVENTIONAL CONSTRUCTION WORK FLOW

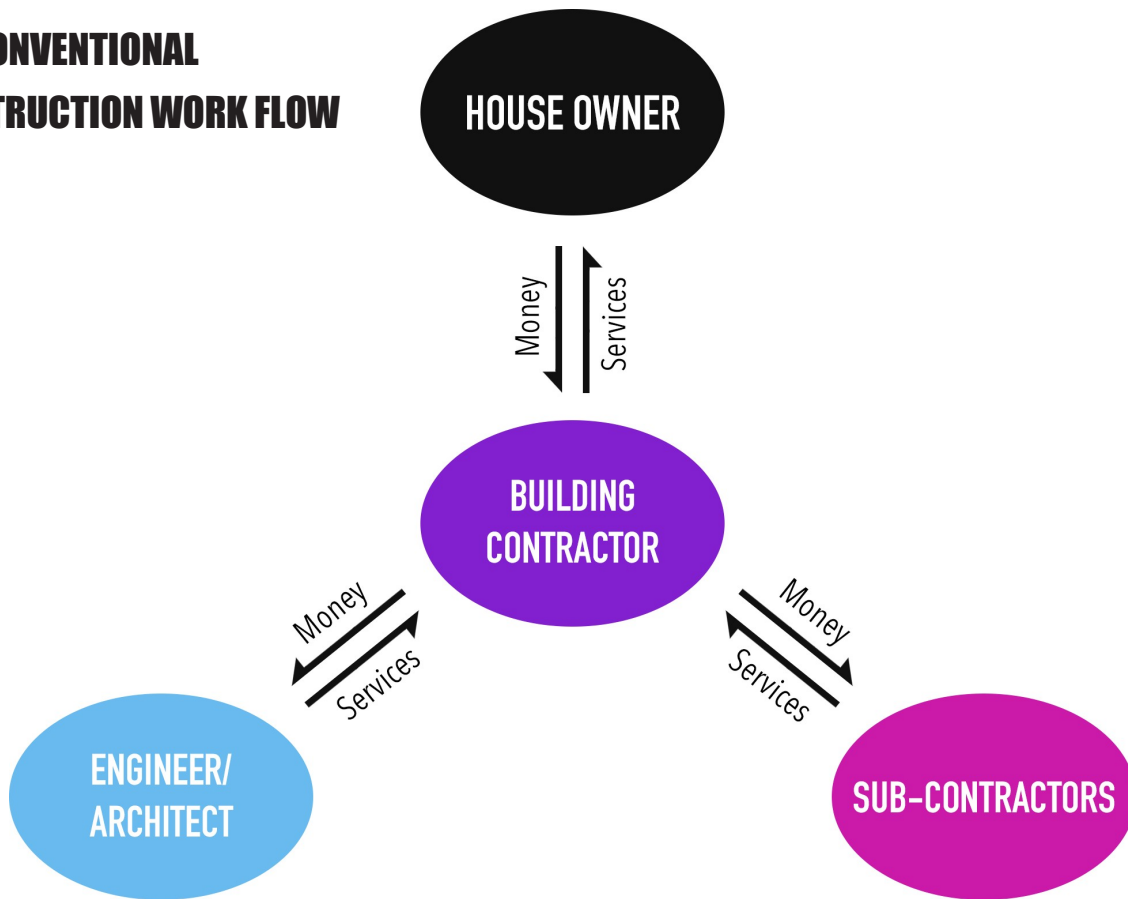


Fig. 3.8. Conventional Construction workflow

- In India the standard practice adopted by people wanting to construct residential housing units would be to do so through a building contractor. This applies both to standalone independent houses as well as consolidated housing units up to three storeys.
- The responsibility of finalising a design based on the specifications of the client along with engaging sub-contractors and procuring materials would lie with the building contractor.
- An architect or an engineer may be hired by the building contractor to provide the design layout, specifications and estimate. The direction of the design process will be dictated by the profit margin of the building contractor. To this end, building practices and material choices will eschew sustainable construction methods in the face of profit making.
- More so in urban areas, due to a multiplicity of reasons like lack of space, complexity in managing and storing materials, coordinating labour force and relative difficulty in general construction management, outsourcing building construction to a building contractor is the norm.
- This prevalent practice has made building houses a commodity rather than a personalised basic need.
- The pivotal role of executing the construction lies with the building contractor. One does so for a fixed rate per unit area of completed housing unit. This rate varies from locality, scale of construction, material specifications, finishes requested and various other factors based on context.
- An alternative model is where a building contractor owns or buys a piece of land to construct housing units and sell it to potential buyers.

3.6. ECO-HOME CONSTRUCTION WORK FLOW

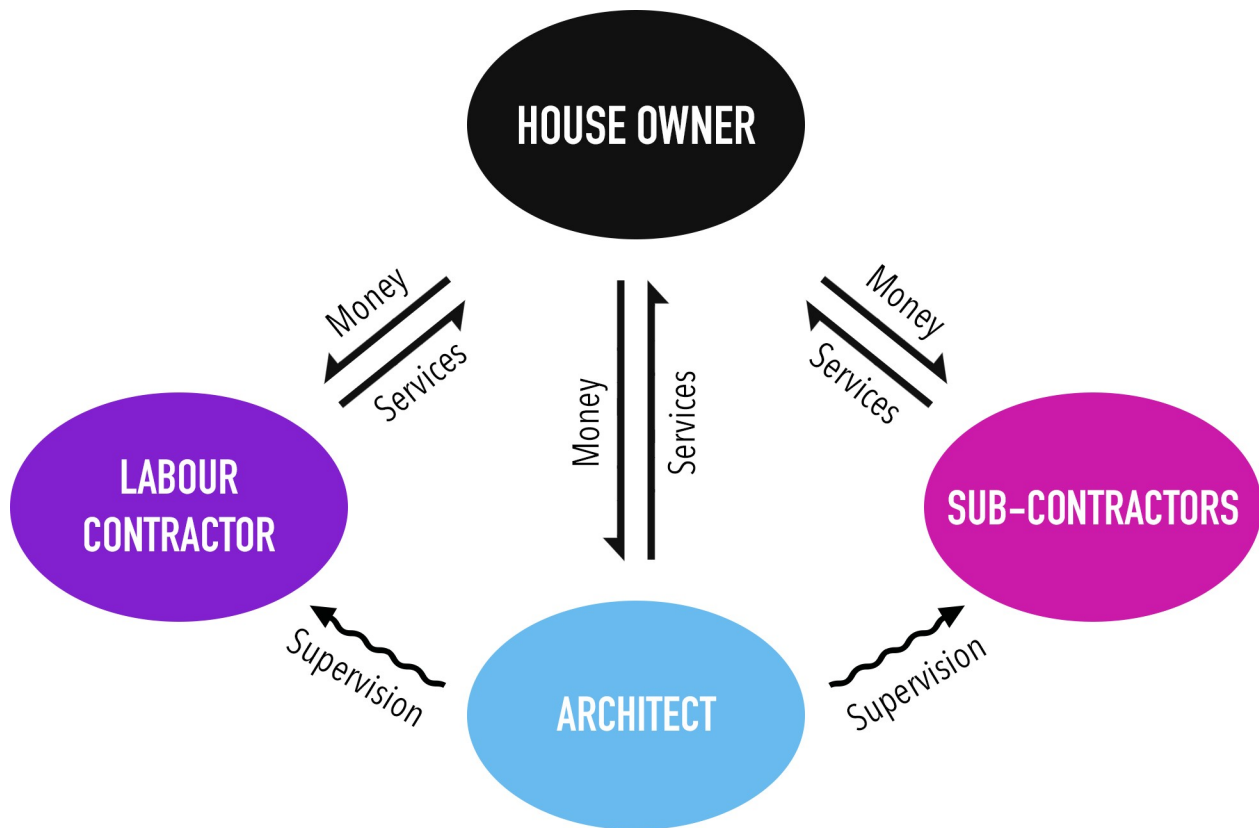


Fig. 3.9. Eco-home construction workflow

- The major difference in the work flow is that the responsibility of executing the construction lies equally with all three parties – house owner, architect and the labour contractor. The job of construction management, procurement, supervision, site management is primarily shared by client and labour contractor. This allows greater freedom in personalising and customising the house to the needs of the occupant.
- Unlike the conventional model, the house owner or a person deputed by the same is responsible for coordinating various teams involved in the entire construction process.
- The house owner and the contractor are assisted by the architect in terms of design execution and alternate building practices. The constant involvement of an architect's team is critical as on-site decisions related to design and execution are dependent on their insight.
- However as in all cases, cost of building construction is a primary mover. The majority of cost saving is in the choice of materials used and distance of transportation. But the cost of labour force increases slightly as the level of skill involved will be much higher than regular construction.

3.7. GROUP ECO-HOME CONSTRUCTION WORK FLOW

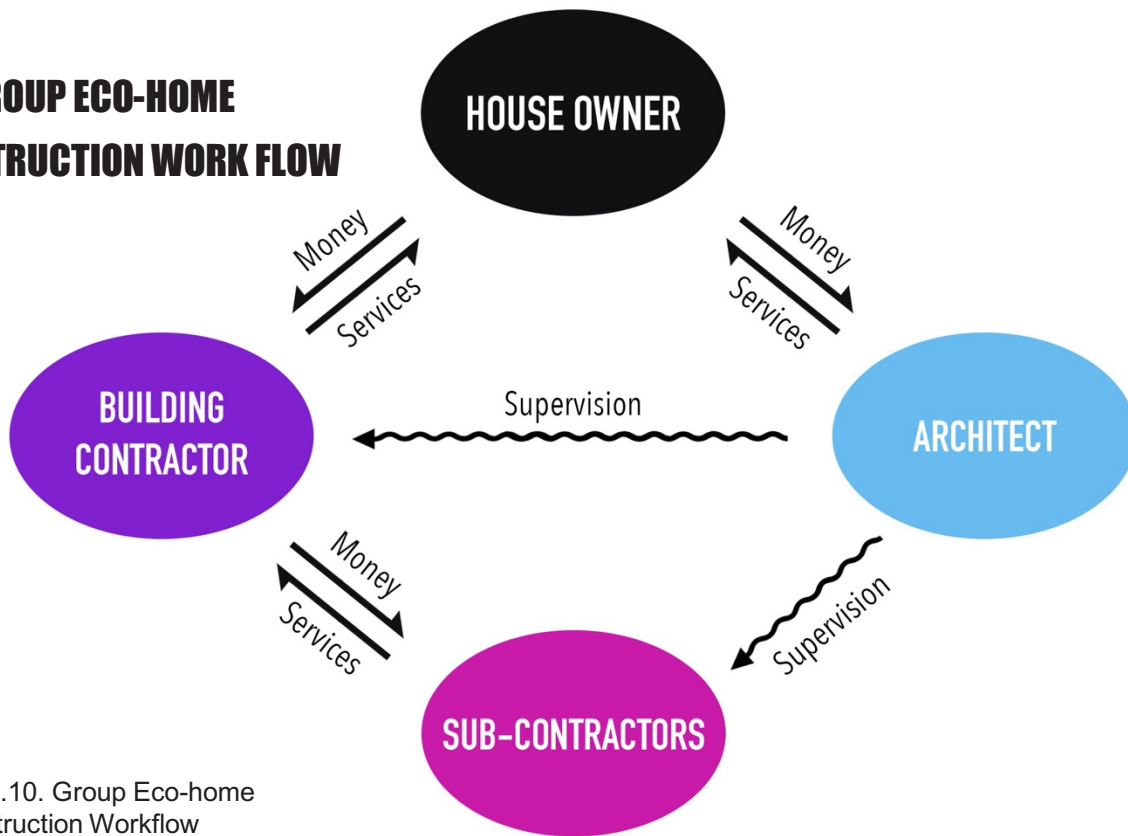


Fig. 3.10. Group Eco-home Construction Workflow

- A project with group housing in a single plot with shared amenities and services constructed in the eco-home model would have ample opportunity to reduce cost when compared to conventional models. However the timeline of construction would be relatively longer as the amount of human labour involved is more. Therefore the level of management needed can only be satisfied by a building contractor.
- As there is a need for frequent technical support and guidance in alternate building in such a construction, there is a necessity for better coordination among the building contractor, architect and the house owner. And therefore unlike in case 2, the building contractor cannot lead the construction but has to work in tandem with the architect's team.
- As the scale of the building increases there will be a need to selectively adopt certain methods, materials and techniques in the construction scheme to optimise construction time and cost.
- For eg. 1 - Framed structural system up to first floor slab and load bearing structure; 2 - In case of a three storey structure the last floor can be built with mud excavated for the foundation of the building; 3 - Inferring from all three work flow cases, to scale up eco-home construction there is a need for a "specialised builder/contractor" with following attributes. 4 - Ability to amass labour force of specific skill sets and sustainably provide employment for the same; 5 - Ability to appreciate the work of artisans and keen interest in learning from traditional practices; 6 - Good understanding of alternate construction and first-hand experience in using environmental friendly materials and techniques to incorporate them in the construction process; 7 - Willingness to take up projects which deviate from the norm as it necessitates require concerted effort in labour management. In order to incentivise the extra effort so required, the contractor's profit margin must be increased. This extra cost can be offset from savings achieved by adopting alternate construction practices.

3.6 COMPARISON

3.6.1. Foundation

Primary difference in eco-house as compared to framed structural system in conventional construction is the use of load bearing foundation using stones. For a majority of residential buildings in India, which are not more than two storeys, load bearing foundation system is sufficient in terms of strength and performance.

As a result the cost of construction of concrete footing and deep grade beams is avoided. In fact the cost of construction of load bearing foundation in the eco-house is one-third of a framed foundation.

3.6.2. Brickwork

The Brickwork in eco-house is an important component of the building as the brick walls are the load bearing structural members. As there are no columns and beams there is additional brickwork necessary to hold up the roof. Hence

As Built			
S. No.	Work	Total Cost (in Rs.)	
1	Foundation	74,720	74K
2	Brickwork	1,62,650	163K
3	Roof	37,500	38K
4	In-built Furniture	10,500	11K
5	Plastering & Pointing	59,605	60K
6	Roof Weathering	24,680	25K
7	Flooring & Tile Laying	51,290	51K
8	Staircase & Ramp	66,300	66K
9	Plumbing	97,000	97K
10	Electrical	1,22,600	123K
11	Carpentry	2,59,777	260K
12	Painting	38,300	38K
13	Labour	3,94,973	395K
14	Bio-digester & Grey Water Treatment	1,10,750	111K
15	Rain Water Harvesting	87,680	88K
16	Solar Power Installation	1,56,000	156K
17	Architect's Fee	1,40,000	140K
TOTAL BUILDING COST		18,94,325	1,894K
18	Site Development	82,480	82K
TOTAL PROJECT COST		19,76,805	1977K
Cost per unit sqm. of Carpet Area		26,822	
Cost per unit sqm. of Plinth Area		23,257	

Conventionally Built			
S. No.	Work	Total Cost	
1	Foundation	2,34,400	234K
2	Brickwork	1,02,000	102K
3	Roof	55,000	55K
	Columns and Beams	1,25,000	125K
5	Plastering	93,200	93K
6	Roof Weathering	31,500	32K
7	Flooring & Tile Laying	72,700	73K
8	Staircase & Ramp	57,000	57K
9	Plumbing	97,000	97K
10	Electrical	1,22,600	123K
11	Carpentry	1,50,000	150K
12	Painting	64,000	64K
13	Labour	3,20,100	320K
14	Septic Tank	1,00,000	100K
15	Sump	1,80,000	180K
16	Solar Power Installation	1,56,000	320K
17	Contractor's Profit	2,29,000	229K
TOTAL BUILDING COST		21,89,500	2,190K
18	Site Development	82,480	82K
TOTAL PROJECT COST		22,71,980	2,272K
Cost per unit sqm. of Carpet Area		30,827	
Cost per unit sqm. of Plinth Area		26,729	

Fig. 3.9. Cost Comparison between conventional & alternative building techniques

there the cost of brickwork is more in the case of eco-house.

A. Rat-trap Bond

- Rat-trap Bond involves placing the bricks on edge with alternate headers and stretchers in each course, resulting in a cavity or gap between the bricks in a wall. The cavities thus formed help in improving the thermal properties of the wall by providing insulation from heat and cold.
- Moreover, this type of brick bonding saves 20% material (bricks and mortar), i.e. 1 out of 5 bricks is saved.
- It increases labour cost by 10%, therefore resulting in an overall saving of 10%, as compared to a conventional brick bond, such as: English Bond or Flemish bond.
- The reduced usage of mortar ensures reduced usage of cement, thus less dependence and exploitation of resources producing cement, considering cement has high embodied energy and is not considered a green material for construction.

B. Country bricks vs Wire-cut semi-mechanised bricks.

The best choice of bricks for the construction would be first grade country burnt which have a much lower embodied energy in comparison to a wire cut brick because they don't make use of machineries for manufacturing. Moreover, the manufacturing of these bricks do not entirely make use of coal as a fuel but the collected firewood are used for burning the bricks.

However in this project the choice of semi-mechanised bricks was based on the following factors,

- Better finished as compared to country

bricks.

- Dimensional consistency: Variations in the brick sizes are minimal when compared to country bricks.
- Easy to train new masons in the method of rat-trap bond because of the first two reasons.

3. Roof

Filler-slab R.C.C vs Conventional R.C.C

Filler slab is an alternative roofing technology for the construction of slabs, where in, the 'un-productive' or redundant part of the concrete is replaced by a filler material. As opposed to conventional slabs that are constructed of reinforced cement concrete and are at least 15 cm thick, filler slabs can be as thin as 10 cm and it ensures 30-35% reduction in material, due to the usage of filler materials such as: Mangalore tiles, coconut shells, earthen pots etc. In case of a filler slab, every cubic meter uses 30-45 kg of steel as opposed to 80 kg of steel in case of a conventional slab.

The combination of steel and concrete, resulting in reinforced concrete is used for the construction of slabs in order to deal with the tensile and compressive forces that the slab is subjected to. When subjected to load, the upper half of the slab experiences compressive forces, taken care of by the concrete and the lower half experiences tensile forces taken care of by the steel reinforcement. Since, the lower portion doesn't undergo compression; therefore the concrete at the lower half of the slab doesn't serve any structural purpose apart from covering the reinforcements, hence the redundant concrete can be replaced by a filler material. The filler materials used are cheaper, light weight, and neutral in character (so as



Fig. 3.10. Construction of a rat-trap bond wall



Fig. 3.11. Random rubble masonry for foundation & plinth

to not react with the concrete or steel). The reduction in overall weight being transferred to the foundation has a direct relation with the size of the foundation. The usage of filler materials reduces the cost of construction since it reduces the amount of concrete used and the size of the foundation too. In case of eco-house, the filler material used is Mangalore tiles. It is cost effective to use Mangalore tiles as a filler material because the discarded tiles are available at a standard size (33cm x 40 cm), which is apt for a regular reinforcement grid.

Frame (Columns & Beams)

The framed and load-bearing structural systems vary based on the load-bearing structural components taking part in the load transmission. In the load bearing structural system, the loads gets transferred from slabs to foundations through walls, while in framed structural system, loads from slabs gets transferred to beams, beams to columns and finally from columns to the foundation.

The structural elements involved in a framed structural element are:

Slabs >> Beams >> Columns >> Foundation

In case, of Load bearing, structural system the path followed is

Slabs >> Walls >> Foundation

In this case the cost of structural frame is completely avoided. The primary cost being materials, i.e. cement, steel, sand and aggregates.

4. In built-furniture

The utilization of construction material to build permanent furniture in a building is referred to as in built seating. Providing inbuilt furniture reduces the cost and the usage of materials required for building exclusive furniture. When using dedicated furniture dedicated circulation pathways around the furniture takes up additional floorspace. Whereas In-built furniture also makes use of least used corners, edges, etc. and puts it to better use thus maximising the usage of internal occupiable floor space.

5. Plastering and Pointing

The eco-house exhibits exposed brickwork. Plaster accounts for up to 10% of the total cost of the building. Exposed brick work is a characteristic of the buildings in the campus. In order to avoid plastering, yet achieve a flushed neat surface, pointing is done, which effectively eliminates the unnecessary usage of cement (in plastering). In addition areas like kitchen and toilets are plastered to further make the walls water-resistant by fixing tiles or painting.

6. Roof weathering

Traditional flat roof weathering course was made out of surkhi, lime and seed extracts. This is not feasible now because of unavailability of skilled labour, low demand for the materials required and resultant high cost.

Burnt clay tile roof weathering course is most common and best suited for geo-climatic conditions of TN. The cost of construction is comparable to newer alternatives in the market.

Alternatively reusing discarded ceramic or



Fig. 3.12. Kollam Jilla Panchayath

vitrified tiles result in reduced material cost and comparable labour cost.

7. Flooring and Tile laying

A. Vitrified and ceramic floor tiles

Vitrified and ceramic floor tiles are the most sought after flooring materials available on market because of the following reasons:

- Wide price range.
- Readily available skilled labour.
- Faster installation time.
- Inherently waterproof

For all the above reasons it is possible to have a basic flooring using ceramic tiles for very low

cost.

B. Athangudi tiles

Traditional floor material handmade using locally available sand, cement, and colouring agents. Once a symbol of affluence used in the construction of huge mansions of rich merchants, is now available in comparable rates to a good quality vitrified tiles.

C. Cheapest and most durable is a simple cement flooring. It is easier to finish and best suited for cost-effective housing needs. Additionally multi-coloured cast-in-situ flooring can be made with simple geometric shapes. This technique can be used with terracotta flooring to make simple yet elegant floors at comparable cost.

11. Carpentry/Joinery

Conventional construction practices has numerous options in terms of materials for doors, windows and other joinery. Namely Aluminium, uPVC, cPVC and steel are most common. They can be customised easily, fabricated in factory setting, produced in large numbers, have standardised specifications, skill required to handle and install is less or easily to train. As a result of which this is cheaper or comparable with traditional wooden joinery. Therefore these products are the most convenient for faster construction needs, as in urban areas.

Comparatively making wooden doors and windows out of new wood is expensive, labour intensive and also detrimental to environment as it increases demand for virgin timber.

A better practise to treat openings and doorways in the built structure would be:

- Judicious placement of openings with controlled size and scale responsive to the climatological conditions of the site.
- If possible disperse the openings instead of concentrating it in a wall.
- Eg. Use of jalli opening in semi-private and public spaces instead of windows as it costs a fraction of a window. Windows cost multiple times the cost of wall volume that it replaces.
- Use innovative ideas to fix shutters or opening controls.
- Pivot Windows, frameless windows.
- Most importantly wherever necessary

maximise reuse of old doors and windows from buildings that are demolished.

- If it is not feasible to reuse windows wood from other sources can be repurposed, recycled and up scaled to make new windows.

12. Painting

As there is less plastered surface in eco-house the cost of painting and repainting is reduced significantly.

13. Labour

The primary difference between eco-house and conventional house is the level of skill expected of the labour force. The cost of labour increases with the quantity and quality of work. Thus Labour cost is more in eco-home.

14. Waste water Management

Conventionally method of solid and waste water management is managed by building a sub-surface septic tank built out of concrete which typically costs at the rate of Rs.18-20 per litre of internal volume. It also require regular cleaning and the removed waste poses a risk to environment and public health as it is by general practise disposed irresponsibly.

Bio-digester plant is a cost-effective solution of managing waste. In addition to converting waste to usable energy over a period of time it offsets the cost of construction. Built with bricks and cement bio- digester uses less material by virtue of its design.

SELLING COST

There are several parameters considered to set a selling price in housing markets all over the world.

1. Construction cost + fixed profit based on the scale and/or time of construction cost.
2. Construction cost + fixed profit percentage over construction cost.
3. Cost calculated at a rate per unit area of construction.

Here the rate per unit area is dependent on the following factors:

- Locality and land-use of the area where the plot falls. I.e. residential, commercial, mixed-use, industrial, etc.
- Finishes used for painting, flooring, tiling, wood for joinery, etc.
- Access to transportation networks: distance from railway stations, bus stops/depots, distance from arterial roads leading to nearest urban centre, etc.
- Access to educational institutions, primary health centres, government offices, etc.
- Typology of housing: group housings, apartments, row houses, villas, etc.
- Other contextual factors like flooding risk in the locality, pollution, ground water quality, crime, etc. affect the price of housing stock.

This rate of construction is usually derived organically by unregulated consensual pricing. The price is thus a range depending on all the

above factors. It is to be noted that even when unregulated it cannot be priced exorbitantly at the risk of not being able to sell the house.

While the means to arrive at a selling cost might be different, the general prevailing selling cost will fall within a range. In most cases the final selling cost in a locality for a house of a particular built-up area will be comparable.

In this case, the mean selling cost of an individual house of 85 sq.m. built-up area in a residential locality within Tirunelveli suburb will be around INR 27,00,000 or INR 2700K. [At the rate of INR 26,900 per sq. m. or INR 2500]

Since the cost of construction for an eco-home is significantly less, there is better chance of obtaining the same profit margin even with a lower selling cost than prevailing market rate or relatively higher profit margin, if sold at INR 2700K.

4 CASE STUDIES & RECOMMENDATIONS

- Built project case studies from Tamil Nadu and Kerala with cost.
- Possibilities of saving using alternate techniques and materials.
- Recommendations for scaling up eco-home construction in Tamil Nadu



CASE 1:

Residence of Mr. Satheesh & Mrs. Bade, Pondicherry

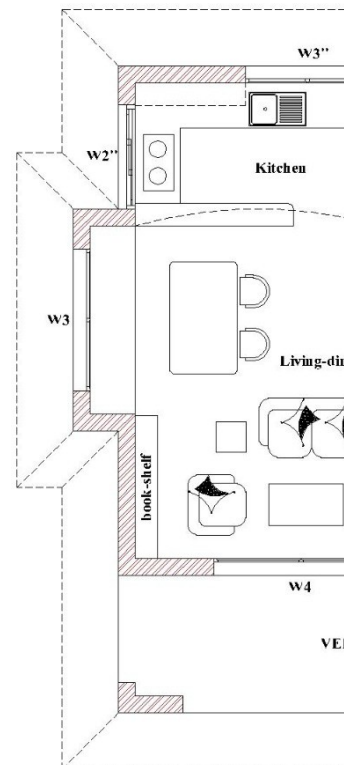
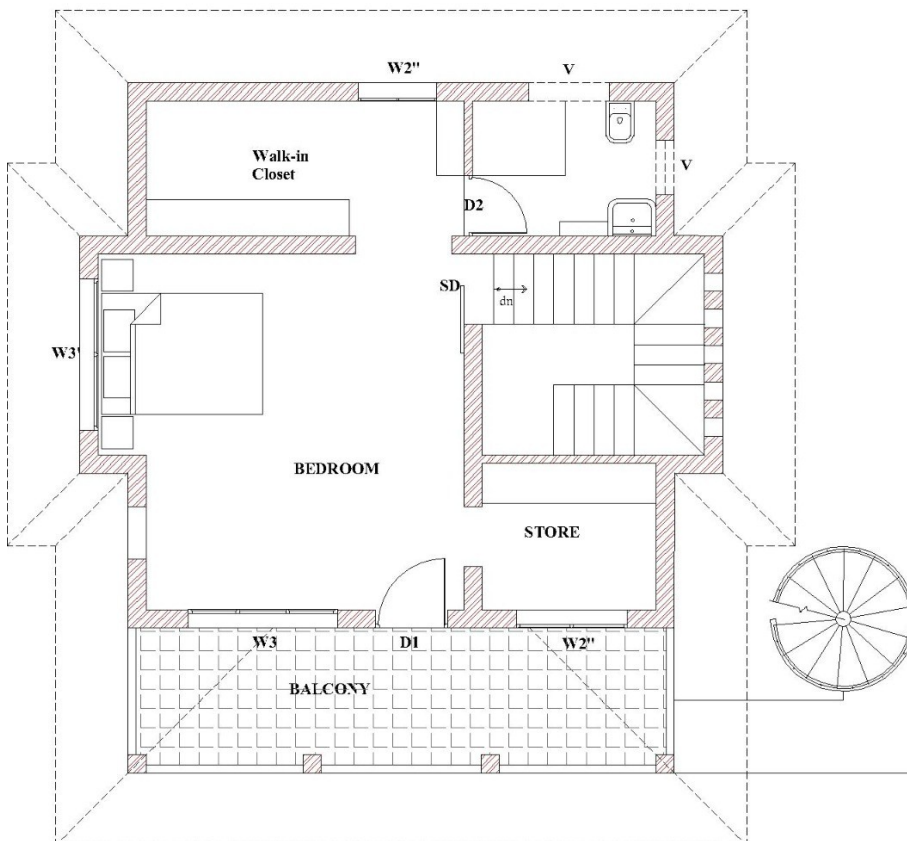
Built-up area: 127.44 sq.m.

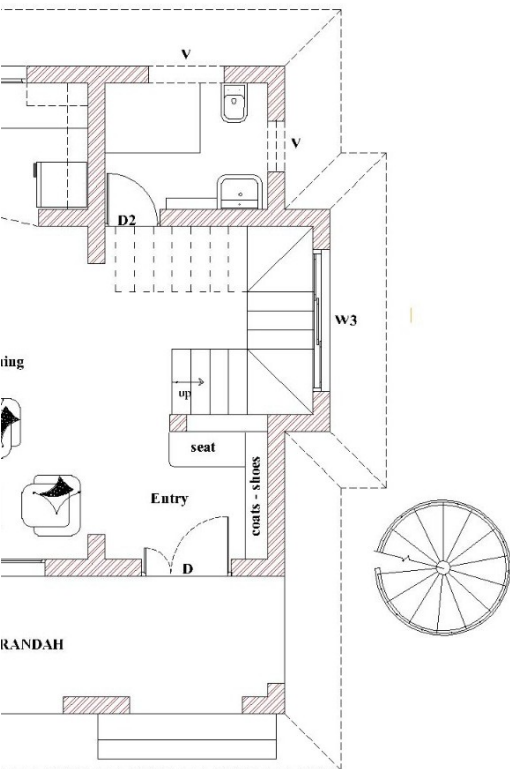
Total cost: Rs. 23,38,318

Cost per sq.m. of carpet area: Rs. 21,586.39

Duration: June, 2019 to February, 2020.

Three small residential units was positioned in the coconut grove. Each unit is two storeys and in addition a covered semi-open terrace area is built as a passive technique to reduce heat gain from roof to the spaces in the first floor. A combination of load bearing brick walls, compressed stabilised earth bricks and concrete is used to build the structure. Filler slab RCC is used to make the intermediate levels. Reused tiles are used to make sunshades.





CASE 2:

Oor: Abraham's Homeland, Kottayam

Built-up area: 830 sq.m.

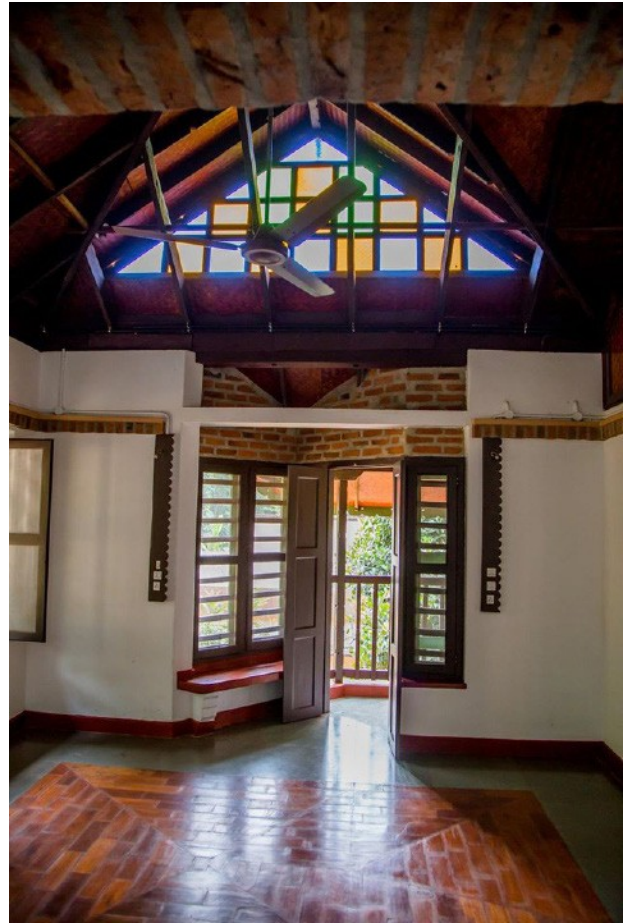
Total cost: Rs. 1,80,00,00

Cost per sq.m. of plinth area: Rs. 21,686.39

Duration: January, 2015 to June, 2017.

Designed & Built by **COSTFORD**

OOR - Abraham's Homeland assisted services, a well thought solution for the aged community who are in need of a home. The Institute was brainstormed by leaders determined to find a solution, for the impact of the demographic shift in the current society. Meticulous planning and strategizing of the project reflect a global perspective of retirement living and environment friendliness.





CASE 3:

Residence of Mr. Sathyanarayanan and Mrs. Sangeetha.

Built-up area: 186 sq.m.

Total cost: Rs. 38,00,000

Cost per sq.m. of plinth area: Rs. 20,430

Duration: December, 2018 to November, 2019.

Designed & Built by **AAKAMURU Architects**

Located in a residential area in the outskirts of Coimbatore city the house is built for a family of 5. The design accommodates 3 bedrooms, Living room, Dining, Kitchen, Study, Balconies, Kitchen garden and open terrace within the small plot. The construction was a exercise in remote management of a project as a result of limitations due to COVID lockdown.





RECOMMENDATIONS

While the savings cannot be quantified definitively component wise, cumulative savings can be determined to be in the range of 15 – 30 % of conventional construction cost. The savings achieved in Eco-home construction is 13% even with all the shortcomings and pioneering cost. The following components contribute to major cost saving as inferred from Table 3.6.

- Structural system: Foundation
 - Brickwork and plastering
 - Roof slab : Filler-slab
1. Constructing many developments at a place together has advantages from savings in cost by
 - Combined material procurement for continuous supply and cost reduction.
 - Combined transportation and storage.
 - Drastic reduction in the wastage of materials due to under-utilization.
 - Repetition helps labour repeat and manage work better.
 - Faster erection of structures and less time spent on setting up and reading of drawings.
 - Team well aware of the building unit being constructed and can refine the management of the construction.

This is true for group housing vs constructing multiple individual houses even in conventional construction. Adopting cost-effective construction methods adds to the

saving of cost in addition to all intangible qualitative benefits.

2. It is the finishes that can be altered without compromising the structure's strength.
 - Wall finishes can be just pointing on bricks. Plastering walls alone comprises 10 % of overall cost which can be cut down.
 - Floor can be cement plaster without anything else going on top it. These provide the user a possibility to add finishes later as per their own choices, providing the basic necessity fulfilled at a fair price.
 - More of brick jallis can reduce the need for windows; and even those can be reduced to frameless windows. The cost of windows is as much as 10 times the cost of brickwork that it replaces.
 - Reduction of painting as a consequence of limiting plastering contributes to the reduction in recurring cost of repainting.
3. Mud and bamboo are the best alternatives for compressive and tensile materials respectively, but the availability of both locally is a factor that determines the relative cost of the construction with the above said materials. On an average mud construction can save cost up to 30 – 50 %. It is easy to incorporate mud as alternative finishes. In case of multi-storey apartment complexes the final storey can be easily constructed with mud sourced from excavation.
4. The most cost reduction from a construction would be by reducing the requirements accordingly. A considerable idea would be to have less number of rooms, lesser

toilets, more of multi-functional spaces. The next thing could be reduction in sizes of the required rooms to fit in the function. Corridors and spill-out spaces can be clubbed together or avoided by suitable planning in the design stage. The bare minimum size of the utterly necessary spaces can be designed by study to fit the users.

Design of the structure plays a key role in effecting the actual cost of realization. The larger the building and more the rooms there is a possibility of consolidating them with minimal floor area and minimum wall lengths but the resultant maybe difficult to be built using conventional framed structures. Load bearing structures or masonry walls can be built in varied forms, angles and curves to better connect spaces. In the case of formwork less plastic material like mud even more organic forms, smaller niches, structural support elements are possible with ease.

5. Alternate layouts like stepped housing adds up more floors thereby reducing the crowding on the ground, still providing ample open spaces to individual residential units. This open space provides a comfortable private front-yard with provision for a make-shift gathering space or a garden space, work space or even later addition of a room. Even a pent-house type addition on top is possible on the terrace area. This sort of a layout promotes social interactions and thereby community togetherness. Larger corridors can be used if more storeys can be added, which in itself can become open street like structures creating a stepped

multi-storey hamlet like structure.

6. The market price of conventional materials is shooting up and widens the gap of cost of conventional and alternate buildings. Alternate approaches would tend to make a greater need of the future even without the many benefits to the environment it promises. More of the simpler yet time-tested techniques with natural buildings. More use of such techniques and skilled labour will promote skill development of similar labour force and add value to the works of construction labourers. More labour would be interested in the kind of work as the work is left unpainted as a sight to see, more appreciated for the effort put in and pay scale adheres to the skill level.

