Chapter 16
Organic Stabilisers in Traditional Mud Homes of India

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16.1 Introduction

India is at the wake of a new era as the country rushes towards an idea of modernity and development. This hurried attitude towards development is reflected in the construction sector as well wherein everyday a new product is introduced to the market and it is almost immediately used in construction with little or no thought given about the material in question—embodied energy, origin, industrial processing, health aspect are seldom valuable concerns. Most often cost, aesthetics, speed of construction carry more weightage in material selection. This model of construction is unsustainable and will have dangerous implications on the environment. The Sustainable Development Goals by the UNDP that came into effect in January 2016 lists out 17 venues to ensure a sustainable development path to developing nations. In the domain of construction, the most relevant would be—sustainable cities and communities, responsible consumption and production, affordable and clean energy, industry infrastructure and innovation.

In our hurry to catch up with the developed nations what was unfortunately left behind or taken for granted was our past, rich in knowledge and skill. The traditional building practices of ancient India also fall under this cap of forgotten past—mud homes varying across different landscapes from palaces to quaint mud dwellings. This led to scarcity of such mud dwellings due to negligence and eventually loss of know-how.

Mud construction is seeing a revival in the construction sector today through its earth warriors and natural builders who strive to promote and create awareness on the

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various advantages of living in a mud structure. As a result, there are an increasing number of contemporary mud structures being built that act as the catalysts for change.

16.2 Life Cycle Assessment of Mud Buildings

LCA or life cycle assessment is quite an easy and simple way of looking at the environmental impact of any material or a built structure. It gives a view of the "cradle to grave" energy cycle of the built structure (Khasreen et al. 2009) (Image 16.1).

A life cycle assessment of an unstabilised mud building in comparison with concrete structures brings to light the reason why mud is one of the most sustainable materials to use in construction if it is easily available and usable.

The LCA is altered when mud is stabilised, taking the commonly used stabilisers of cement and lime. The mud used in the building becoming soil again at the end of its life is taken away as once these stabilisers are added the effect is irreversible. However, in comparison with the conventional materials used nowadays, it still performs better. A 2001 study in India focused on embodied energy in load-bearing masonry buildings. A brickwork building and a soil–cement block building were compared, and the study showed that the total embodied energy can be reduced by 50% when energy efficient building materials are used (Venkatarama Reddy and Jagadish 2003).

The goal, however, should be to further minimise the impact of mud buildings in present day construction even if the mud needs to be stabilised for site-specific reasons. This can be achieved by looking into organic additives as stabilisation using these additives can further lower the embodied energy in the earthen structure.

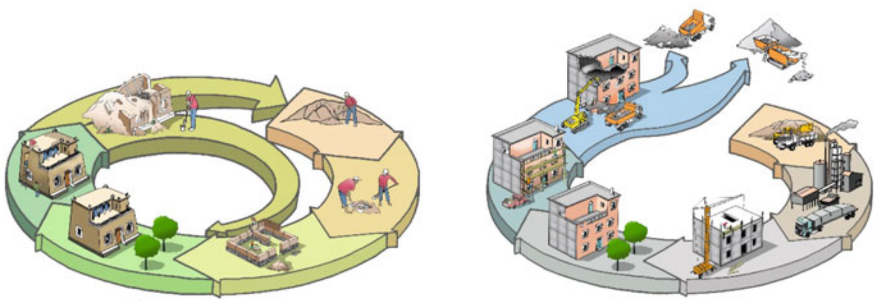


Image 16.1 Comparison of life cycles—figure by Sebastien Moriset, CRATerre

16.3 Stabilisation of Mud

16.3.1 Need for Stabilisation

The use of mud in construction does not necessarily mean that the soil requires reformulation or stabilisation of any kind. There are many examples across the world wherein mud has been used as is found when it is of ideal composition. Stabilisation is not compulsory and can be avoided if soil is found to be satisfactory. Stabilisation is carried out to achieve better mechanical characteristics, improve tensile strength, better cohesion, reducing porosity and improvement of resistance to wind and rain erosion (Houben and Guillaud 2001).

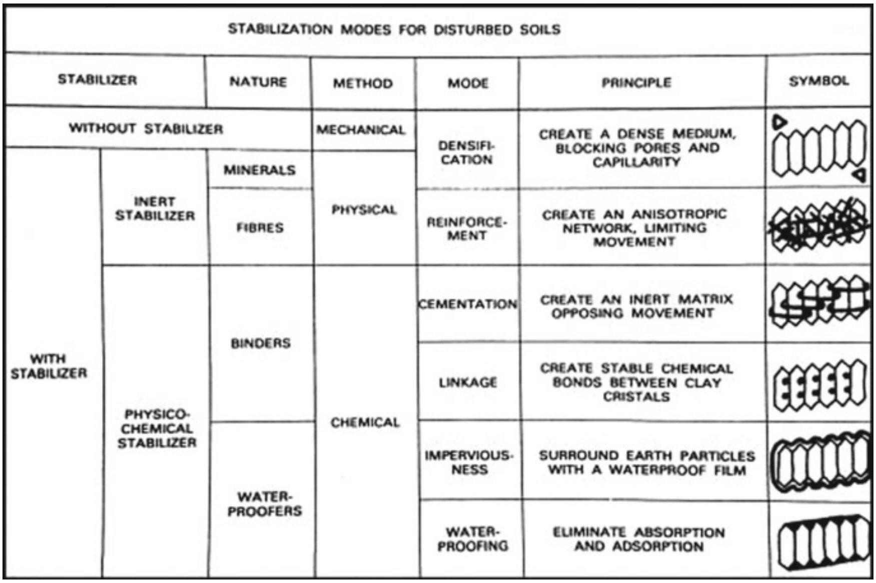
16.3.2 Types of Stabilisers

In case of very sandy or very clayey soils, soil reformulation is required which uses mineral additives such as sand and gravel to attain a good grain size distribution. Depending on availability, often natural fibres are also added to strengthen the structure of the soil. These fall into the category of inert stabilisers that help mainly in densification and reinforcement. The other category of stabilisers is physio-chemical stabilisers that improve cementation, linkage, imperviousness and water proofing. These physio-chemical stabilisers could be natural or synthetic, for example cement, lime, bitumen, asphalt, gypsum, plant or animal product. (Houben and Guillaud 2001) (Fig. 16.1).

16.3.3 Stabilisation in the Indian Context

India being a tropical country with its fair share of torrential rainfall and harsh summers—most of the traditional and contemporary earthen constructions in areas with high rainfall require certain additives to protect it against water, abrasion and general wear and tear or a final exterior coat/skin to protect the unstabilised interior mass.

The earlier earth dwellings when stabilised used mainly organic additives which later moved to using lime. Industrialisation led to cement becoming the additive that is added to protect/strengthen the mud mix against water and other factors. Today, the most common stabilisers used are lime and cement. Very often due to the unavailability and cost of lime, cement is the preferred choice of stabiliser for the common man. This is a matter of concern as cement may augment the mechanical characteristics of the soil but it greatly reduces the breathability of the soil. The use of lime or cement increases the embodied energy of the material and interferes with the cradle to grave lifecycle of mud buildings. In the hope of revival of earthen



STABILIZATION MODES FOR DISTURBED SOILS						
STABILIZER		NATURE	METHOD	MODE	PRINCIPLE	SYMBOL
WITHOUT STABILIZER			MECHANICAL	DENSIFI-CATION	CREATE A DENSE MEDIUM, BLOCKING PORES AND CAPILLARITY	
WITH STABILIZER	INERT STABILIZER	MINERALS	PHYSICAL			
		FIBRES		REINFORCE-MENT	CREATE AN ANISOTROPIC NETWORK, LIMITING MOVEMENT	
	PHYSICO-CHEMICAL STABILIZER	BINDERS	CHEMICAL	CEMENTATION	CREATE AN INERT MATRIX OPPOSING MOVEMENT	
				LINKAGE	CREATE STABLE CHEMICAL BONDS BETWEEN CLAY CRISTALS	
		WATER-PROOFERS		IMPERVIOUS-NESS	SURROUND EARTH PARTICLES WITH A WATERPROOF FILM	
				WATER-PROOFING	ELIMINATE ABSORPTION AND ADSORPTION	

Fig. 16.1 Stabilisation modes for disturbed soils (Houben and Guillaud 2001)

construction, it is imperative that we look not only towards the future but also to our past to learn and see how the ancient recipes can be used with modern technology to result in mud constructions that are truly sustainable in its holistic sense.

16.4 Organic Stabilisers in Traditional Recipes

16.4.1 Research Methodology

The methodology followed a tripartite approach to find traditional recipes used in mud construction. In order to study the recipes in greater depth, the premier research was restricted to southern India with special focus on the South Canara region. Future research will extend to other regions following the same methodology with a vision of covering the country in the next few years (Fig. 16.2).

16.4.2 Classification of Organic Stabilisers

The stabilisers of animal and plant origin can be broadly classified based on their molecular nature into polysaccharides, lipids, proteins and others (Vissac et al. 2017)

Fig. 16.2 Research methodology chart

Polysaccharides—cellulose, gums, starch, etc.
Lipids—wax, oils
Proteins—casein, albumine, etc.
Others—resins, tannins.

16.4.3 Recipes Found Through Living Heritage

Research carried out in living heritage refers to learning from present examples and recipes that are still used today by the people of that region. This involves field studies conducted in remote villages and tribal communities in the Western Ghats like Wayanad, Nagercoil, etc., where people continue to live in mud homes. It throws light on mixes of mud and natural ingredients that were passed on from generation to generation and provides insight into the type of additives mixed into mud to form durable and resistant vernacular mud houses.

The constraint here however is that information of the exact quantities of the ingredients was not found as the tribals added the ingredients through intuition and experience, than calculated precise quantities.

Many recipes included natural additives commonly heard of like cow dung, soil from termite hills, egg whites, natural fibres—rice straw, rice husk. The lesser known ingredients are mentioned are.

16.4.3.1 Glue from Bark and Leaves of Kulamavu (Scientific Name—*Persea macrantha*)

Slices of the bark of this tree give a gluey mix when water is added to it. It is left to rest overnight and mixed with the soil. This when added into the soil visibly increases the viscosity of the mix and is said to render it stronger and more resistant to mechanical shock (Thirumalini et al. 2011) (Images 16.2 and 16.3).

Images 16.2 and 16.3 Kulamavu Tree and Glue

16.4.3.2 Juice from Kadukkai Seed (Scientific Name—*Terminalia chebula*)

The seeds of Kadukkai or common name Gall Nut are wrapped in a cloth bag and left in water and left to macerate. After 24 h, the water becomes blackish in colour. This is then added into the mud mix (can be added to the entire mass or given as a final coat). It has been proved to have water proofing qualities (Vissac et al. 2017).

Kadukkai water is still used in construction today for water proofing in conventional buildings as well. The old Madras terrace roofing also uses this water for water proofing in its final layers.

16.4.3.3 Paste of the Hibiscus Leaf (Scientific Name—*Hibiscus rosa-sinensis*)

Hibiscus leaves and flowers are drenched in hot water, ground and strained, and this oily paste is taken rubbed over as a final coat in 2–3 layers. This gives a shine to the wall and renders it water resistant. This finish with hibiscus paste is seen in the final finishing of the walls and floors of traditional mud homes in Wayanad. This same mix has been used extensively as a herbal shampoo in the Kerala region even today.

16.4.4 Additives from Recipes Found Through Built Heritage

Under this section, the main source would be from ongoing best practice restoration projects that use mixes that are true to its original fabric and does not incorporate any modern additives. Thirumalini et al. (2011) who talks about a herbal juice mix used to improve performance of lime found on an ancient manuscript in the Padmanabhapuram temple detailed below.

16.4.4.1 Herbal Juice Used in Restoration Work in East Fort—Trivandrum

Aqueous extract of herbs such as oonjalvalli (*Cissus glauca* Roxb.), pananchikaai (*Cochlospermum religiosum*), kulamavu (*Persea macrantha*), gallnut (*Terminalia chebula*) and palm jaggery (from *Borassus flabellifer*) was used in this herbal mix. 0.25 kg (wet weight) of each herb and palm jaggery is taken and crushed well. Crushed herbs and jaggery were soaked together in water for 15 days. At the end, the juice is separated and used. For preparation of one kg of lime putty, equal amount (one litre) of herbal cocktail juice is used. Thirumalini et al. (2011).

16.4.4.2 Herbs Used in Restoration Work at Vadakkunnathan Temple—Thrissur

The UNESCO award winning restoration project of the Shri Vadakkunnathan Ksethram Temple used 9 different herbs along with lime in the external plaster restoration. Interactions with the architect Vinod Kumar co-ordinator of the renovation project and artisan Vijay Kumar, we found that similar herbs were used as in the earlier example—oonjalvalli, gallnut, kulamavu and jaggery.

There are already examples of most of these herbs being used in mud mixes. Hence, a well-grounded hypothesis is made that these combination of herbal mixes should work in earthen plasters, and this will have to be tested as part of the future research in order to be found conclusive.

16.4.5 Additives from Recipes Found Through Oral History

Unlike the western world that passes on information through written documented facts, India has a rich tradition of knowledge transfer from one generation to another through apprenticeship. It is very rare to find written texts on practical skills that are used. Thus, any research in India would be incomplete without a section on Oral history which needs to be validated through test samples and laboratory analysis.

Image 16.4 Varaal Fish

16.4.5.1 Mucous-like Residual Water from the Bral Fish (Scientific Name—*Channa striatus*)

Bral or Varaal is the local name given to the fresh water fish, which releases a sticky mucous as it swims. The mucous content in the water if added to mud is said to increase viscosity of the mix. The approximate proportions would be about 5 fish in 200 L of water—left to swim in it for 2 days. The fish releases a mucous as it swims making water sticky. This water is then used to mix the mud used in plasters. It was used extensively in Kerala especially in Thrissur and Alleppey regions 50 years ago. The varied benefits of this are still unknown till further testing is carried out (Image 16.4).

16.4.5.2 Arabic Gum (Acacia Senegal)

Arabic gum was the other ingredient commonly used in the context of Mural wall paintings—a coat is applied on the wall before the mural is done to improve the durability of the paintings (Mini 2010) Though examples of it being used in India have not been found, it is used extensively in mud plasters in the African continent as a stabiliser and acts as water proofing (Vissac et al. 2017).

16.4.5.3 Karingota (Scientific Name: *Quassia indica*)

The leaves are mixed in water and this water is used in the mud mix which is said to work against termites and hence were also used in the attic of the traditional mud roofs as a layer between the wood and the mud filling to prevent the rotting of wood.

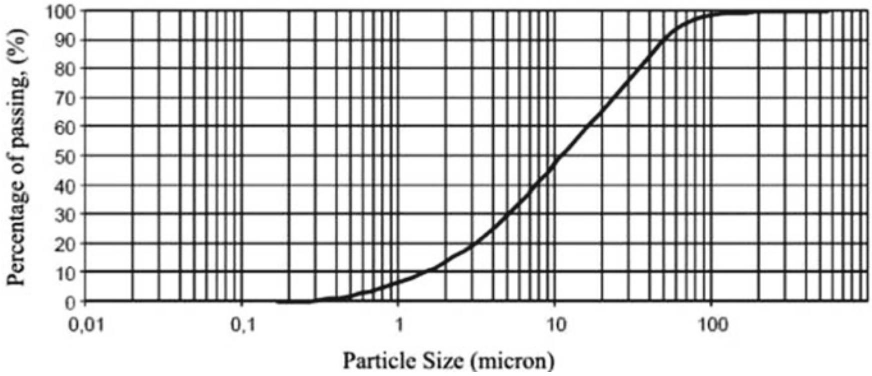


Fig. 16.3 Particle size distribution of soil

16.5 Performance Tests on Organic Additives

Certain laboratory tests were conducted taking specific ingredients from the broad classification of polysaccharides, proteins, lipids and others (Vissac et al. 2017). This was done to understand in detail how ingredients from each of these families perform and the specific property they bring to the mud mix in terms of water resistance, resistance to mechanical shock etc.

The testing was done in a laboratory in France and hence is constrained to the availability of the ingredients. The soil that was used is the residue from washing sand, locally known as FAC—Fine Argilo Calcaire. The soil can be better understood from its grain size distribution and composition chart (Fig. 16.3 and Image 16.5).

Test Samples—The ingredients of each sample have been mentioned (Table 16.1). The ingredients taken to be tested are organic stabilisers used around the world (Vissac et al. 2017). Though the ingredients differed, the size of the samples was kept similar and base ingredient the same.

Base Ingredient—1 Soil: 4 Sand.

Table 16.1 Test samples

Sample No.	Description
0	Base ingredient (pure)
0A	Base ingredient with two coats of linseed oil
1A	Base ingredient with 1% Egg white
1B	Base ingredient with 5% Egg white
1C	Base ingredient with 10% Egg white
2A	Base ingredient with 1% Arabic gum
2B	Base ingredient with 5% Arabic gum
2C	Base ingredient with 10% Arabic gum

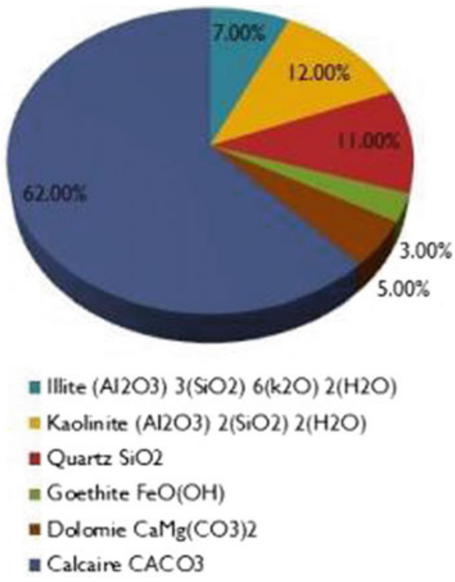


Image 16.5 Mineral composition

16.5.1 Water Erosion Test—Drip Test

The principle of this test is to take the test samples and subject them to the falling of water droplets from a height and in a certain time. This test makes it possible to observe the behaviour of each mixture to continued exposure to water and therefore deduce its behaviour in the wall and water resistance (Images 16.6, 16.7 and Table 16.2).

16.5.2 Abrasion Test

A metal brush weighted to 3 kg is used to scrub the face of the test sample. A single back and forth motion of the brush is regarded as one cycle of abrasion. Brushing is continued for twenty cycles. The measurement consists of weighing the material before and after brushing (Table 16.3 and Images 16.8, 16.9).

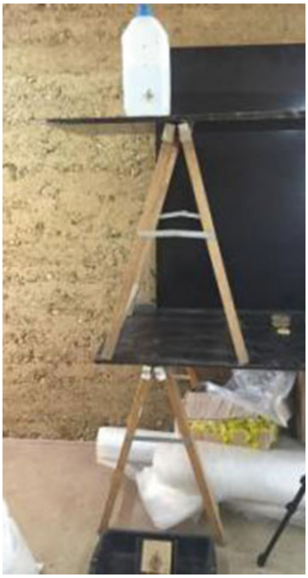


Image 16.6 Drip test

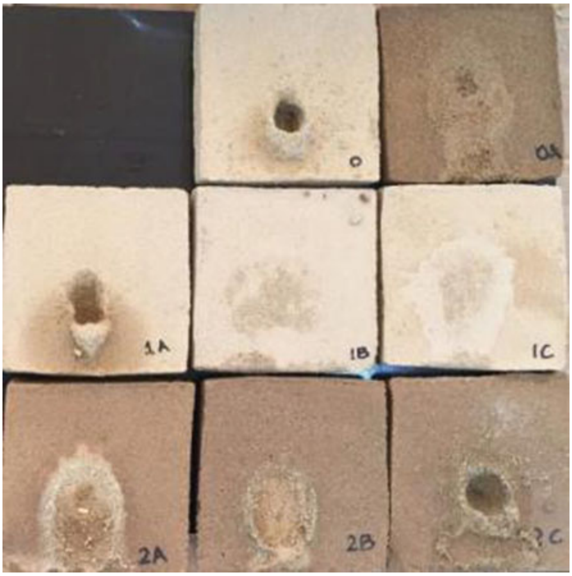


Image 16.7 Test samples—drip test

Table 16.2 Drip test for water erosion

Sample No.	Dry weight (in gm)	Wet weight (in gm)	Size of the hole (in cm)	Observation
0	365.57	367	Diameter: 2 Depth: 2	A hole through and through is formed
0A	375.95	After 10 min: 376.75	Diameter: – Depth: –	
		After 30 min: 377.64	Dimension: 1 × 1.5 Depth: 0.2	Earth easily comes off. Wet edges
1A	375.68	379.78	Dimension: 1.2 × 2 Depth: 1.5	A depression is formed
1B	385.76	After 10 min: 387.64	Diameter: – Depth: –	No change
		After 30 min: 389.62	Diameter: – Depth: –	No change. Water has spread over the surface making the edges sensitive. But the wet surface was not soft or deformed
1C	377.21	After 10 min: 378.33	Diameter: – Depth: –	No change
		After 30 min: 379.05	Diameter: – Depth: –	No change. Lesser amount of water has spread over the surface. The sample was resistant to deformation
2A	374	After 10 min: 378.33	Diameter: – Depth: –	The damage is concentrated and the wet portion easily comes off
		After 30 min: 382.66	Dimension: 1 × 1.2 Depth: 0.3	
2B	360	After 10 min: 360.56	Diameter: – Depth: –	The damage is spread out
		After 30 min: 360.38	Dimension: 2 × 3 Depth: 0.2	
2C	343.77	After 10 min: 344.03	Diameter: 1.2 Depth: 0.5	There is a very large hole. It is very delicate and sensitive
		After 30 min: 344.69	Diameter: 2 Depth: 1.2	

Image 16.8 Abrasion test

Image 16.9 Test samples—abrasion test

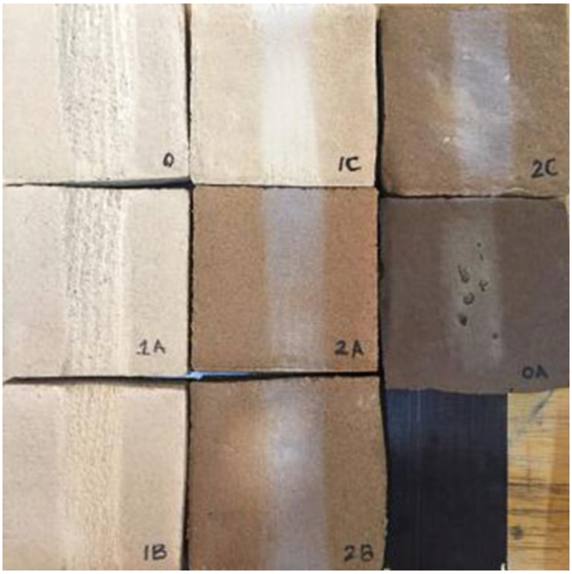


Table 16.3 Abrasion test

Sample	Weight before	Weight after	Observations
0	365.55	354.6	It is not resistant
0A		361.7	
1A	375.77	366.89	Did not show a great difference between 0 and 1A
1B	380.78	378.03	It was much more resistant compared to 0 and 1A
1C	369.46	368.98	It is very resistant
2A	372.1	372.05	It is very resistant
2B	368.89	368.86	It is very resistant
2C	346.2	346.14	It is very resistant

16.6 Conclusion

To summarise the above technical paper, the main objective of all the studies conducted is to be able to bring to the forefront the use of these natural stabilisers into conventional practice. The main constraint that was observed in the use of these natural stabilisers was the availability of some of the ingredients—either they were in remote locations and were inaccessible or they were not available in the required quantities. This constraint could be addressed by cultivating required ingredient in large quantities and make it available for commercial use. Alternatively, a study of existing indigenous fauna can be done and suitable replacements could be found and further tested for performance.

There is a huge potential to further the research already conducted in this paper. Firstly, the testing of the ingredients has to be continued for all ingredient identified in the traditional recipes and compared it in terms of performance with those stabilised with lime/cement. This would further inform the performance of each ingredient used in the mix. Secondly, to ensure success of bringing the natural additives onto a larger platform for accessibility to more people, an inventory can be generated with area/region specific additives, with information on location of availability and the particular performance enhancing properties it would bring about.

References

Houben H, Guillaud H (2001) Earth construction. ITDG Pub., London

Khasreen M, Banfill P, Menzies G (2009) Life-cycle assessment and the environmental impact of buildings: a review. Sustainability 1(4):674–701

Mini PV (2010) Preparation techniques of pigments for traditional mural paintings of Kerala. Indian J Tradit Knowl 9(4):635–639

Thirumalini P, Ravi R, Sekar SK, Nambirajan M (2011) Study on the performance enhancement of lime mortar used in ancient temples and monuments in India. Indian J Sci Technol 4(11)
Venkatarama Reddy BV, Jagadish KS (2003) Embodied energy of common and alternative building materials and technologies. Energy Build 35:129–137
Vissac A, Bourges A, Gandreau D, Anger R, Fontaine L (2017) Argiles & biopolymères. CRAterre éditions, Villefontaine