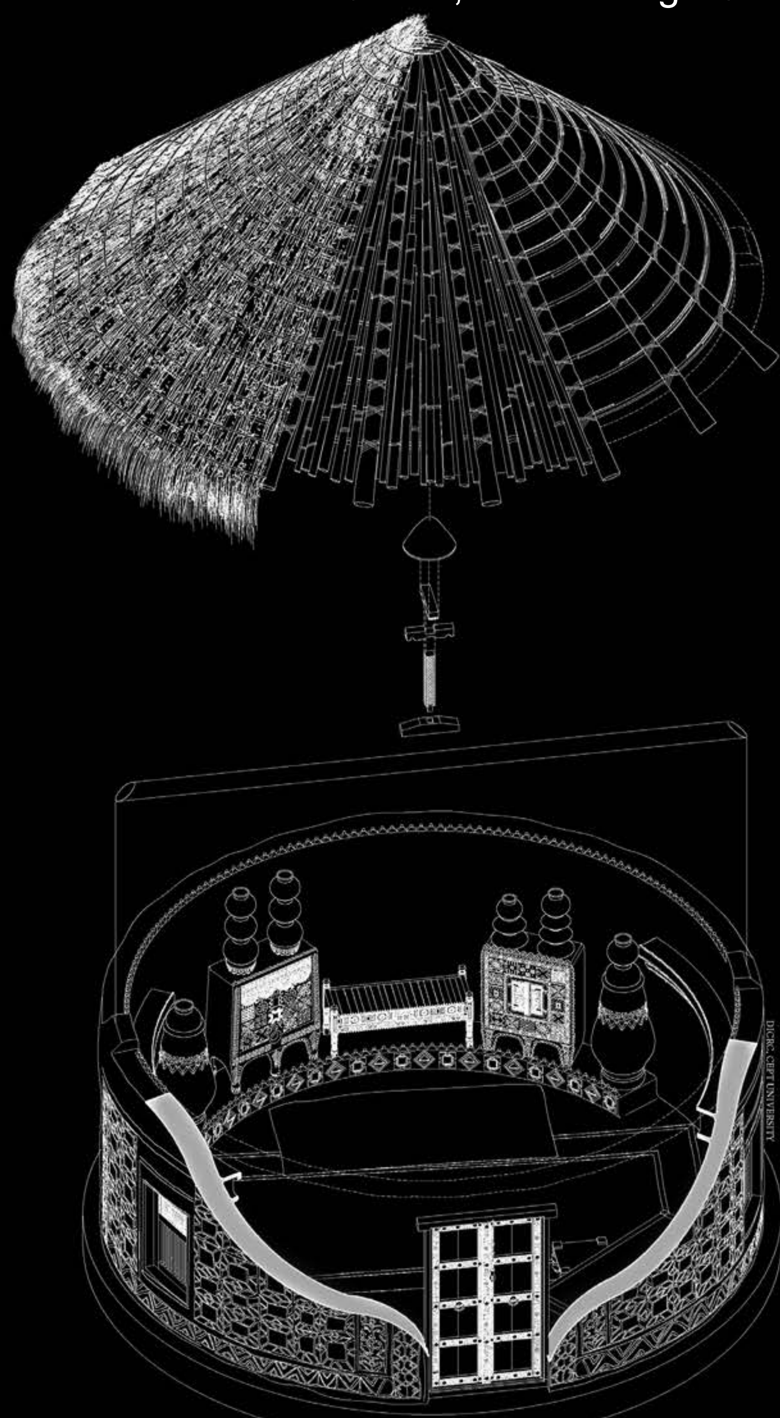
Context

Built, Living and Natural



Special Issue on Traditional Materials and Construction Technologies | Volume XI | 2015

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About the Volume

India is an invaluable repository of traditional building practices that emerge as a response to its diverse climatic, geological and socio-cultural expressions. This vast resource is continuously being threatened by the unprecedented growth of the construction industry and the quest for a ‘modern’ and/ or ‘permanent’ habitat. Many indigenous building approaches are losing their relevance and are being rapidly substituted, ultimately proving unsustainable, both economically as well as ecologically.

While substantial research on traditional building materials and techniques exists and is ongoing, its implementation, specifically for contemporary development, is often contested. This special issue provides a platform to discuss the various processes that document, disseminate, conserve and promote the use of traditional materials and techniques in contemporary building practice.

The first section focuses on specific traditional materials and architectural elements, their established use in historic construction along with challenges in their present use. While Bais discusses the existing lime practices across India, Das highlights the lack of research in contemporary standards for aggregates such as sand. The second section talks about architectural typologies, forms and traditional building techniques along with experiments towards contemporising these. ‘How’ and ‘how much’ to contemporise come across as highly relevant questions that Madan and Jain discuss through the case of Wai in Maharashtra. Residential typologies in Gujarat, Karnataka, Ladakh, Maharashtra, Punjab and Rajasthan, covered in the following articles, reflect diversity in use of materials, contextual responses as well as commonality in the underlying rationale for development of components, forms and techniques. The embedded knowledge systems and associations with socio-cultural frameworks are highlighted. The latter part focuses on implemented projects that attempt to bridge contemporary usage with traditional materials and technologies through bamboo and mud structures, in combination with non-traditional materials.

Highlighting challenges to the continuity of traditional building practices, this volume also acknowledges the ongoing research by institutions such as the Design Innovation and Crafts Resource Centre and the INTACH Heritage Academy. Concerted efforts are being made by the Institute of Research and Documentation of Indigenous Studies to document ethnic communities that have been neglected in most mainstream research. One major challenge is the disconnect between current government schemes for major construction works in rural and urban areas and traditional methods of building habitats as reflected in the Avas Vikas Yojna.

As a whole, this special issue encapsulates the significance of using traditional building materials and techniques for long term sustainability. The role of current technology in facilitating it, figures as part of the discussion, as does the curiosity of the researcher and designer in making the traditional building systems meaningful for the present.

— Editorial Team

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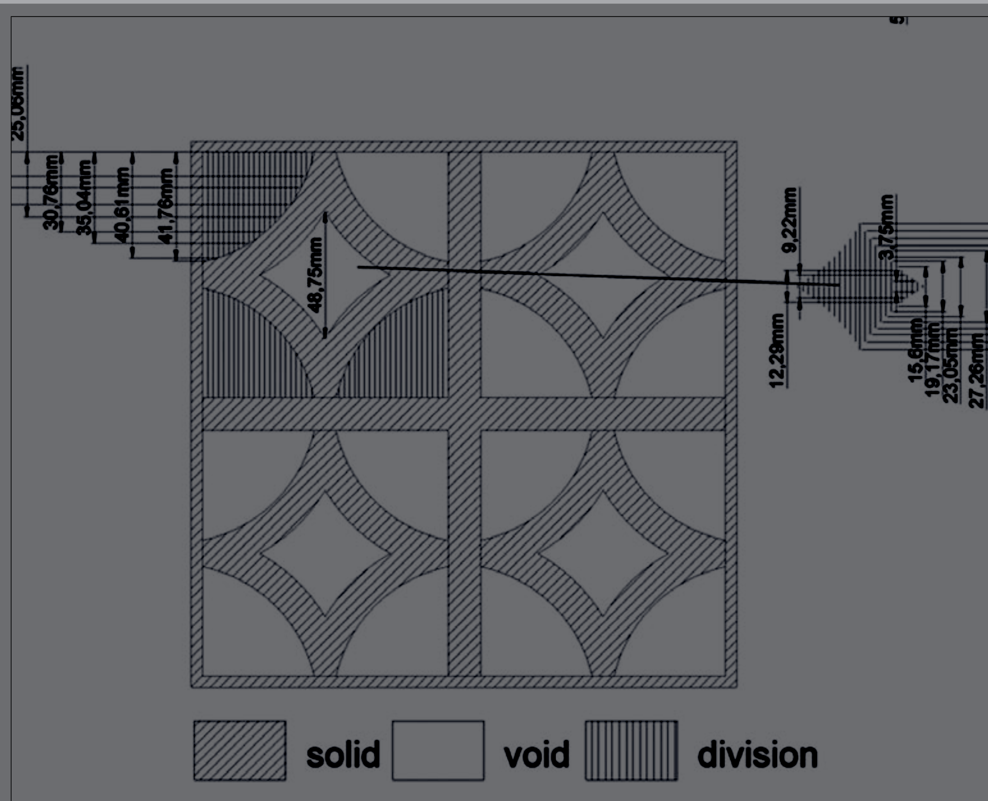


Lime Practices in India

SANGEETA BAIS

ABSTRACT

Since antiquity, lime has served as one of the most versatile binding materials for building construction across the world. Buildings constructed in lime, that have survived natural calamities and continuous weathering for more than a millennium throughout India are physical evidence of the longevity and the durability of this material. Building lime is still in use in several forms for the construction of new buildings in rural areas as well as for the conservation of historic buildings. In the Indian context, traditional practices of using building lime have several variations depending upon the locally available materials, climatic condition as well as the cultural traditions of the place. An attempt has been made to describe some of the existing lime practices of different regions of India.

Sangeeta Bais is working as a freelance conservation architect based in New Delhi. She believes in understanding and adopting traditional building knowledge for the conservation of historic buildings. Besides providing consultancy services, Sangeeta is carrying out research on traditional lime finishes. She has authored a book titled, 'Why Use Lime' published by the INTACH UK Trust.

INTRODUCTION

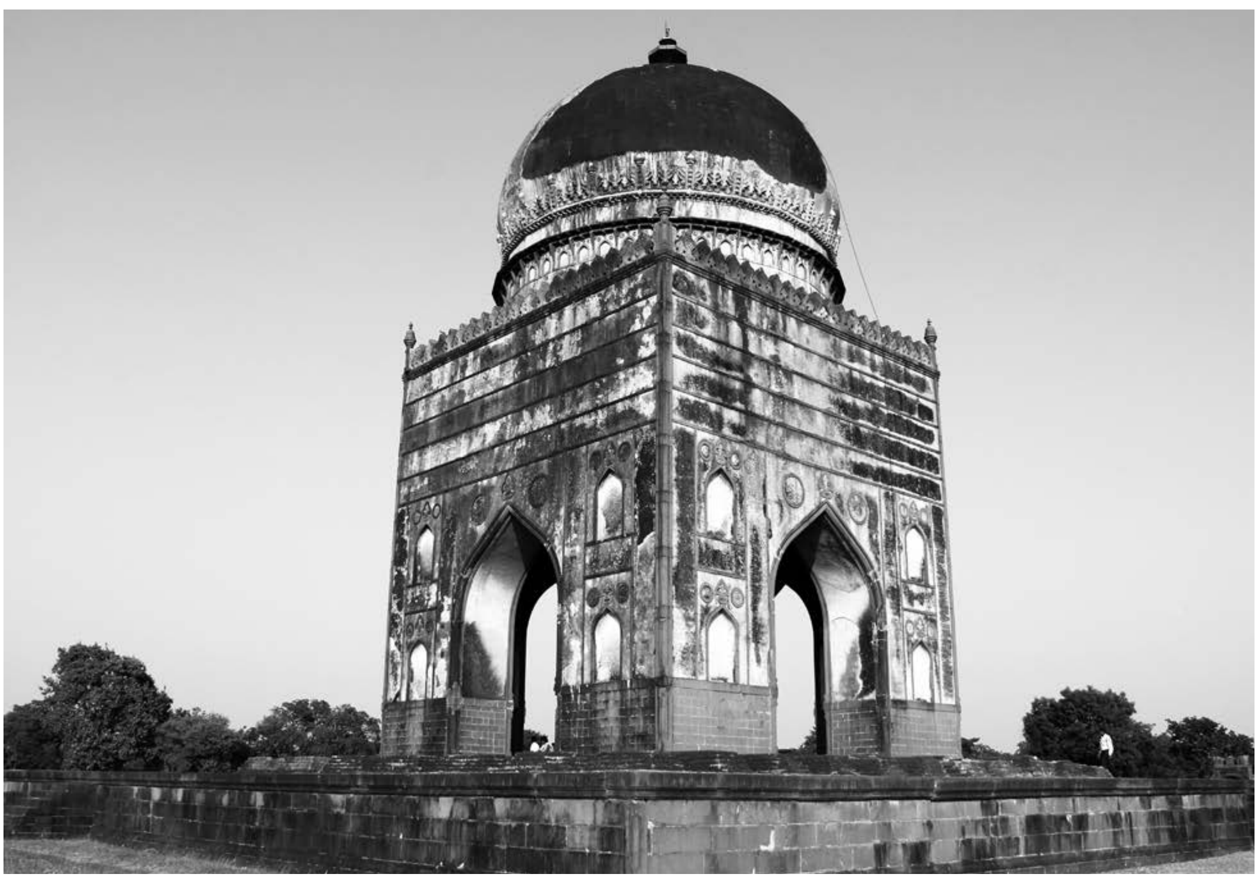
Ancient Sanskrit treatises describe the techniques of use of lime for various purposes. For instance, Vishnudharmottara Purana from third to fifth century AD, Mayamata and Silpa Ratna from 16^{th} century AD provide information about detailed specifications of lime mortars and their application. Besides these treatises, traditional knowledge systems that incorporate lime have been recorded in historic paintings in Shekhawati, Rajasthan, as well as in Mughal paintings. These descriptions indicate that traditional building practices were very extensive, precise and site specific. Unfortunately, most of this traditional knowledge does not survive today due to discontinuity of its use in modern construction. Though lime is still being used as a building material, its use is now largely limited to construction in rural areas and conservation practices. Furthermore, owing to the introduction of new building materials, such as Portland cement, conservation approaches have also evolved, leading to potentially damaging consequences to the historic building fabric.

Lime was used in different modes during construction for both structural and non-structural purposes, including masonry walls, domes, arches, bridges, water bodies, protective plaster layers and decorative works such as stucco, profile plaster, painting and finishing work. Each form of its usage required different specifications. For instance, building lime was traditionally prepared by firing calcium carbonate at 900°C, the raw ingredients of which include limestone, marls[1], Kankar lime[2], sea shells and chalk.

There are several lime clusters in India including Katni in Madhya Pradesh, Jodhpur in Rajasthan, Ponta Sahab in Himanchal Pradesh, Vani in Maharasthra, Pidurugalla in Andhra Pradesh and Tirunelveli in Tamil Nadu. Even today, these clusters provide lime for building conservation.

Historically, limestone was calcinated[3] in 'mixed feed type' kilns or 'clamp kiln' locally known as *chune ka bhatta* constructed in stone and brick. This type of kiln is loaded with alternate layers of limestone and coal from the top opening of the kiln to create channels between the materials that facilitate the passage. This results in circulating a down draft of warm air inside the kiln that can get uniformly distributed.

Crushed limestone pieces, of a fairly uniform size range between 20 to 60 millimetres are added at this stage. The crushing is often done by hand. After loading, the kiln is kindled at the base and the fire gradually spreads upwards through the charge. After thorough firing, the lime is cooled and raked out from the base. The remains of the fine ash, generally known as fly-ash, are rejected. The fired lime is packed in air tight bags and transported to different sites.



Baridi Tomb, Bidar

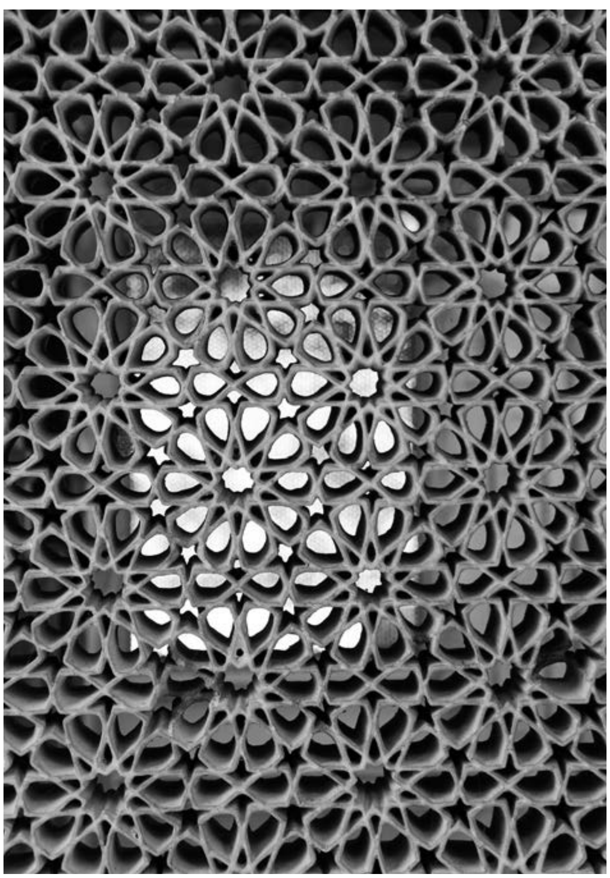
SOURCES OF LIME AND REGIONAL VARIATIONS

The variations in lime are found across different regions in India. Kankar lime, also known as red lime, was widely used in construction. It contains 5% to 25% of clay and can produce a hydraulic lime that hardens in the presence of water, like cement does. Traditional Kankar lime was calcinated in a simple type of clamp kiln similar to lime stone. After cooling the burnt Kankar, it is crushed to small pieces and then grinded to fine powder. Sir John Marshall's conservation manual also describes the use of Kankar lime in conservation works that might have been prevalent in early 20th century.

Shell lime is a popular binding material in coastal areas where it is available abundantly. Sea shells are collected from water sources such as large lakes or the sea coast, washed to remove salt and dust contents, mixed with coal and put over a layer of coconut shells in cup shaped kilns. The top of the kiln is covered with a layer of burnt lime to prevent loss of heat. Air is then supplied using electrical pump through a channel from the pump room for an hour and then put off. Firing takes seven to eight hours for complete calcination and then is left to cool down overnight. Next day, the burnt shells are sieved to separate the shell lime and ash. The fired shell lime is then immediately packed in air tight bags and can be hydrated in batches in powder with simple techniques. Sieved material consisting of ash and small pieces of shells is usually reused for construction. Special care is taken to convert the dry form of shell lime on the site.

First, the fired shell is kept in a bamboo bucket that has a perforated covering. This is immersed in water and withdrawn immediately. To initiate the hydration process, the wet material is then spread over polythene on the ground, converting it to powder form of calcium hydroxide in an hour. The powder is then sieved and packed in air tight bags. This is the purest form of the calcium hydroxide that is reserved for use in high quality of lime wash.

Lime can be used in dry form as commercial bag lime, as well as in putty form that is a tank slaking product, for conservation work. Building lime is



Decorative lime jaali, Paigah Tomb, Hyderabad

Lime stucco work, Bilhari

slaked in both dry and wet forms. To prepare dry hydrated lime, known as 'bag lime', the process of dry hydration requires a controlled environment with specific amount of water. However, bag lime often gets carbonated partially, due to inappropriate storage before its use, so it does not produce good quality lime works in construction works. Wet slaking is carried out in slaking tanks with excess of water to prepare a thick paste known as lime putty. Traditionally, wet slaking of lime is carried out over a longer period of time that gives better results since the mature slaked lime is less likely to crack under thermal or moisture variations. Presently, quick lime is also being slaked on a commercial basis, in a controlled environment. This has become a standardised format being used in building conservation all over India. As a result, the region specific art of slaking lime is vanishing. building conservation all over India.

LIME MORTARS: INGREDIENTS AND PREPARATION

For creating lime mortar, the most common ingredients are mature lime putty and aggregates. The type of aggregates adopted for creation of lime mortar depends upon its functional requirement, characteristics, required texture and colour. For instance, mortar for ashlar masonry work with bigger joints and base plaster coats requires a denser, heavier mixture, therefore coarse aggregates are used. Common aggregates used in lime mortars include natural sands and gravels and materials such as crushed shell, crushed rocks, particularly sandstone and occasionally limestone and crushed brick. Aggregates play an important role in deciding the colour of the resultant lime mortar. Historically, lime *surkhi* (brick dust) mortar was extensively used in construction during the Mughal period comprising of lime putty, using river sand and brick dust as aggregates.

The traditional specifications and method of preparation of lime mortar were originally derived from its functional requirements. Methods of mixing and grinding of the ingredients of lime mortar were derived with scientific calculations to achieve the right consistency and the desired workability of mortar. A stone grinder is a traditional method, followed in India, to grind the ingredients of lime mortar and achieve the fine consistency for the finishing layers of plaster, decorative plaster and stucco. In north India, the widespread practice is to prepare lime mortar using a lime *chakki* (mill) that consists of a channel below ground and a stone wheel to run over the channel to compress the lime particles and mix together with sand.

Lime kiln at Katni


Sea shells for shell lime production


Shell lime kiln, Chennai

Over time, several original resources of building materials have been closed and as a result different substitutes are used in place of them. According to craftspeople who continue to work in lime in Jaipur, traditionally, clay was collected from ponds and fired in kilns and subsequently powdered with lime on a stone grinder. This tradition of using and firing pond clay for lime mortar does not exist anymore and it has now been replaced with the use of brick dust. In case of Delhi and Badarpur, sand is now used for preparation of lime mortar and therefore the colour of the resultant lime mortar depends upon the colour of the mother stone crushed to prepare the aggregate. It imparts a colour variation that is easily noticeable in lime works done using these aggregates.

Presently, a lime *chakki* is used to prepare lime mortar for all kinds of construction, creating a more generic product. There is a great need to understand the classifications of historic lime mortars and its characteristics before adopting a method of its preparation especially for conservation of historic buildings that have great regional variations.

ORGANIC ADDITIVES USED FOR LIME MORTARS

In the Indian context, there is a strong tradition of using organic additives with lime mortar, the selection of which depends upon local climatic conditions and the functional requirements of lime mortar. Presently, several types of organic additives are used to improve its characteristics for a specific purpose such as imparting tensile strength, decreasing the setting time and making it more workable. There are no industry standards for the use of organic additives in India currently and most building professionals are not aware about their precise function in lime mortar. The method of their use as well as the quantities in which these are to be mixed varies from site to site and most of the time this knowledge lies with the craftsperson. In many regions in India, these practices have been modified to suit the artisans, giving varying results. Hence, it is important to understand traditional methods in depth.

Some commonly used organic additives are jute fibre, pulses, milk products, *gur* (jaggery), seeds, aloe vera and fruit pulp. Jute fibres are the most common organic additives used for plastering. Jute helps in reducing the shrinkage caused by carbonation process and gives tensile strength to lime. Clean fibres of 25 to 100 millimetres are mixed with lime mortar just before its use while knocking up or agitating and mixing the lime mortar. Fibres are never added in advance since they tend to get weakened on prolonged contact with water and un-slaked lime. *Urad dal* (split black gram) is the most common lentil which is used for lime concreting and finishing work. It makes a very sticky paste when mixed with water that helps in improving the workability of the lime especially for decorative plastering. The *dal* is ground to a powder and then soaked with water one night before its use and the paste is mixed with lime mortar in specific proportions.

Sugar compounds, in the form of molasses or *gur*, are added to improve the waterproofing characteristics. Several variations exist in north India. Jaggery is procured from sweet shops and directly added in lime mortar. In Rajasthan, *gur* and salt are added to lime while slaking and in some states *gur* is directly added

Stone grinding of lime mortar

Traditional lime chakki

to lime mortar. In south India, sugar is derived from palm, date palm and coconuts. The presence of sugar compounds in lime mortar provides the initial setting to the lime work and is used with lime concrete work during ramming and curing process.[4]

Fruit pulp is used in all the regions of India to improve the workability. The pulp of *belgiri* fruit is the most common additives, fruit of an indigenous plant and easily available in north and central India. The fruit is dried in sunlight and can be stored for long time. It is soaked in water over night and then properly mashed to separate the pulp of the fruit which is added with lime mortar in varied proportions. *Methi* (fenugreek) seeds are added to improve the workability of lime mortars for decorative work. The seeds are ground to make a powder and soaked in water overnight before use. This mixture is then mashed and sieved to remove fibres and other particles. The sieved water is mixed with lime mortar to impart adhesive quality required for profile plaster works.

LIME AS A FINISHING MATERIAL: PLASTERS AND WASHES

Lime being used ubiquitously as a finishing material is a practice that is still continued in rural areas and small towns, especially areas around lime kilns. Lime wash is essentially a dispersion of calcium hydroxide particles in an aqueous solution. Lime wash, like lime plastering, allows any moisture that enters into the masonry to evaporate again allowing the building to breathe. Lime wash proves to be a durable material if applied correctly. Most of the times, however, wash requires annual maintenance as it easily powders and wears off. Quick lime is slaked in hot water, then sieved and mixed with organic additives to improve its workability. Vegetable glue is the most common type of organic additive for lime wash gradually being replaced by synthetic gums. The dry natural glue is soaked in water overnight and then sieved next day to remove fibres and mixed with lime wash to improve its adhesive qualities. For better quality, the lime wash solution is prepared from matured non-hydraulic lime putty and clean water for thinning to achieve the consistency of thin cream. Lime putty is knocked up before the addition of water. Fresh lime wash is allowed to stand for a one day period to allow the water content to become lime saturated. The mix is thoroughly whisked to ensure complete dispersion.

The best quality of glossy lime wash is achieved by the addition of casein products to the lime wash solution. Caesin is a protein present in milk products and is sourced from the compound calcium caseinate that becomes insoluble on exposure to air. Caesin lime wash is prepared from skimmed milk or commercially available casein. The natural pigments are added in specified quantities to the lime wash mix for variety of colours, like earth pigments such as yellow ochre and red ochre used traditionally.

Lime Araish, Chettinad plaster and Madras plaster are the highest quality traditional techniques of producing an extremely smooth, glossy and crack free finish. These techniques produce glossy surfaces that resemble polished marble. Chettinad and Madras plaster were developed in South India and lime Araish flourished


Gur added during lime slaking in Rajasthan


Lime slaking carried out in earthen pots buried in earth for more than six months

in Rajasthan and adjoining states. All three techniques contain several layers of lime plaster of varied consistencies and textures.

For Araish, the process of preparing the plaster and its application technique is very unique. Quick lime is slaked for more than two years in a controlled atmosphere; for purification during the slaking process and removal of undesired minerals is achieved by adding yoghurt to the lime. Lime and water are stored in earthen pots, preferably in dark rooms, or below the ground in constantly shaded areas that help to maintain the desired hydration of lime. Lime Araish work is done in several layers. Each layer has different specification and technique of application. The base layer is known as *kada* plaster, comprising of local sand and lime putty and with the occasional addition of marble grains to impart pure white colour to the final layer of Araish work. Successive coats of fine plaster are known as *jhinki* where the lime paste is mixed and ground with *jhinki* powder over the grinding stone, along with other ingredients, and converted into a coarse paste, which is applied over the previous coats of lime plaster using suitable tools. The organic additives such as *gur* and *methi* are added as per the required consistency and colour. This mix is applied in three layers over the wet surface. Every alternate layer, up to five millimetres thick, is rubbed with a *cheer ka gutka* (wooden block) for compaction. The final layer of the lime, called as Araish, the matured lime putty, is sieved through *malmal* (muslin) cloth and is applied with a brush. The characteristic glossy finish is achieved by rubbing a special hard stone known as agate stone along with dry coconut fibres. The required glossiness is achieved by controlling the duration of the rubbing of stone. The total thickness of this layer is one to two millimetres. Good Araish plaster is so glossy that reflections can clearly be seen on a white surface. Several variations of the similar lime finish can be observed, with or without the glossy layer in North India that is achieved through a careful understanding and execution of each layer.


Lime Araish

Chettinad plaster technique is very similar to lime Araish but differs in composition of ingredients. This method involves six coats of plasters, a base

Finishing the final Araish layer

coat plastering that is basically a coarse layer and subsequent five layers that are white coats. The white coats consist of shell lime and quartz sand in different proportions. Each mix is ground well in a stone roller to achieve the required consistency and workability. The number of rounds of mixing over a stone grinder depends upon the required consistency as well as the particle size of the aggregates of the lime paste. The fifth coat is the final layer of the Chettinad plaster work for which lime produced from the conches or *sangu* is used. It is the purest source of white lime. This is an extensive process and is done in one round without any interval in between to achieve flawless surface. Madras *chunam* is a plaster carried out in several layers and finished with a fine layer of lime mortar containing shell lime and egg white. The plaster has a glossy finish like a mirror.

CONCLUSION

Existing traditional knowledge of using lime for construction has been passed on from generations and has undergone a steady process of evolution. The use of lime was suddenly discontinued in mainstream construction after the invention of Portland cement in early 20th century. This resulted in a shift in approaches of traditional craftspeople towards use of other modern materials. This has reduced the usage of lime based techniques to conservation of historic structures. Unfortunately, due to gaps in traditional knowledge systems and improper usage of lime, often new interventions do not match the original quality and application process and therefore have a limited lifespan. There is an urgent need of filling this gap through scientific understanding of the original traditional practices to achieve the perfection in lime works to ensure the long term survival of our vast stock of built heritage.

Bibliographical references

- Bais, S 2007, *Why use lime?*, INTACH UK Trust.
- Indian Minerals Yearbook 2011, *Limestone and other calcareous materials*, Indian Bureau of Mines, Governmnet of India, part 2, 50th Edition.
- John, M 1923, *Conservation manual, a handbook for the use of archaeological offices and others entrusted with the care of ancient monuments*, Caxton Publications, Delhi.
- Singh, M, Ramrao, B, Arbad & BR 2014, 'Ancient Indian painting recipes and mural art technique at Ajanta', *International Journal of Conservation Sciences*, vol. 5, issue 1, pp. 35-50.

Notes

1. A soft calcareous rock mostly made of shells and usually containing appreciable quantities of clay and sand.
2. In India, an impure concretionary carbonate of lime, usually occurring in nodules, in alluvial deposits, and especially in the older of these formations.
3. It is the conversion of calcium carbonate of calcium oxide which is achieved by firing the limestone in a kiln.
4. Ramming is the method of compacting the newly laid lime work after initial setting to treat the shrinkage cracks.

Curing is the process of watering the lime works to complete the setting process.

Deconstructing Sand as an Aggregate

NEETA DAS

ABSTRACT

When we started the Lime Center in Kolkata the real importance of sand as a building material dawned upon us. We had set out to do research on traditional building materials and eventually make 'lime recipes' for use on site. The only two materials initially that were under consideration were sand and lime. Since the goal was to standardise this research, for the first time we retraced our steps and referred to the IS code for sand: IS 383:1970 and IS: 2386 (1963). As we were to work in a lab, we started collecting samples of sand; but to our dismay we got sample after sample that was different! All we needed was a 'standard approved bag of well graded sand as per the IS code but what we were getting was well beyond our imagination. If the materials were not of 'standard' quality how were we to get a 'recipe' right? Here is an account of our tryst with sand as a building material in Kolkata.

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INTRODUCTION

After setting up the Lime Center laboratory in Kolkata for material analysis[1] with motorised sieves, weighing scales, industrial heater, and a microscope, we were ready to test some building materials. Confident in the knowledge that lime and sand were the two most important ingredients for preparing lime mortar for conservation and with the purpose of sourcing these two materials for conservation work we started our inquiry. Construction manuals directed us towards the Indian Standard (IS) Codes set up for 'standard methods of identifying and testing building materials' and maintaining 'uniformity in the variety of practices'. We were pleasantly surprised to find most of these IS Codes online under the Right to Information. The ones describing the specifications for sand are IS: 383 (1970) and IS: 2386 (1963). These codes provide the identification, grading, properties and testing of various types of sand, both for coarse and fine aggregates, that have been given in a table form for ease of reference.[2] However, these specifications are primarily for use in cement concrete so only the relevant sections have been referred.

Hoping to apply our newly acquired knowledge into practice we sent our lab assistant to the market to get a 'standard well-graded bag of sand' and this is where our adventure began.[3] He first went to our neighbourhood market who supplied sand for small scale work, like repair and maintenance in residences.

Industrial heater

Motorised sieves

USB microscope

Digital weighing machine

What are Rocks		
Definition	**Minerals**	**Physical Properties**
Rock may be defined as that portion of the earth's crust having no shape or structure. Almost all rocks have a definite chemical composition and are made up of minerals and organic matter. The minerals impart the properties to the rock	Quartz (SiO_2), Felspar (Alumino silicates with potash), Mica (Silicates of alumina with hydrogen), Amphibole (Silicates of iron, lime, magnesia or alumina), Pyroxene (Silicates of lime, alumina, magnesia and iron), Olivine (Silicates of iron and magnesium), Chlorates (Aluminium silicates with iron and magnesia), Garnet (Silicates of iron and alumina), Serpentine (Hydrous silicate of magnesia), Talc (Hydrous silicate of magnesia), Calcite ($CaCO_3$), Dolomite (Calcium Magnesium Carbonate), Gypsum (Hydrous Calcium Sulphate), Limonite, Magnetite and Pyrite (all iron componds)	These minerals give the physical qualities to the rock like hardness (talc is soft but quartz is hard); cleavage, streak (colour of the mineral in powder form, felspar is white); colour (garnet is red), lustre (quartz is vitreous or glassy), crystal (formation when mineral develops in natural shape).
Classification of Rocks		
Physical	**Geological**	**Chemical**
Stratified rocks show distinct layers and can be split eg. sandstone, limestone, slate, marble	**Sedimentary rocks** also known as aqeous or stratified, are formed by weathering of the earth due to rain, wind, etc. Rain carries the organic and inorganic material to the rivers; in the plains as the velocity of the water decreases the sediments settle and get consolidated in horizontal beds due to pressure of overlying layers forming sedimentary rocks. These rocks are soft and can be split easily. Rocks formed by drying salts in water basins result in gypsum, dolomite; rocks resulting from plant and animal remain are limestone, shale; and rocks formed from fragmented rocks are sandstone, gravel, and sand.	**Argillaceous rocks** have clay (Al_2O_3) as the principal constituent. They are hard and brittle like slate.
Unstratified rocks do not show any stratification and cannot be split eg. granite, basalt	**Igneous rocks** are of volcanic origin and are formed as a result of solidification of molten mass lying below or above the surface of the earth. The molten mass or magma when solidies above earth forms basalt and trap and when it solidifies below earth it forms granite. Principal constituents of magma are quartz, mica, and felspar.	**Silicious rocks** have silica (SiO_2) or sand as their principal constituent. They are very hard and durable like granite, basalt, and quartzite.
Foliated rocks have a tendency to split only in a definite direction. Most metamorphic rocks except marble and quartzite have foliated structure.	**Metamorphic rocks** are Igneous or Sedimentary rocks formed as a result of the earth movement, temperature changes, etc. Resultant mass may be a foliated structure like slate or non-foliated granulose structure like marble and quartzite.	**Calcarious rocks** have lime as their principal constituent eg. limestone, marble, and dolomite.
The weathering of these rocks as they are swept down the river results in the formation of sand. Sand is also obtained by crushing in quarries, the igneous, sedimentary, or metamorphic rocks. The most widely used aggregate are from igneous origin. Thus, sand would show the minerals, and their properties, of the source rock like quartz (silica or SiO2), mica, felspar, etc. The particle size decide whether it is gravel (2mm-0.64mm), sand (0.64mm- 0.0625mm), silt (less than 0.0625mm – 0.004mm), or clay (less than 0.004mm).		
Classification of Sand/ Aggregates		
Basis of Origin	**Basis of Size**	**Basis of Shape**
Natural aggregates are obtained from the river bed, sea, pit, or quarries.	**Coarse aggregates** are those retained by the 4.75mm IS sieve.	**Rounded aggregates** have minimum sand voids of about 32% (river or seashore gravel).
Natural sand is deposited by streams and glacial agencies, **Crushed stone sand** and **crushed gravel sand** is produced by crushing natural hard stone and gravel.	**Fine aggregates** are those most of which pass through the 4.75mm IS sieve.	**Irregular aggregates** have a higher sand void of about 36% (pit sand).
Artificial aggregates are brick bats, blast furnace slag, etc.	**Well graded aggregates** should have a good mix of all sizes (as per IS: 383-1970) so as to minimize air voids.	**Angular aggregates** have sharp and rough particles with a sand void of about 40% and provide good bonding (crushed rocks). **Flaky aggregates** have thickness smaller in relation to the width and length.

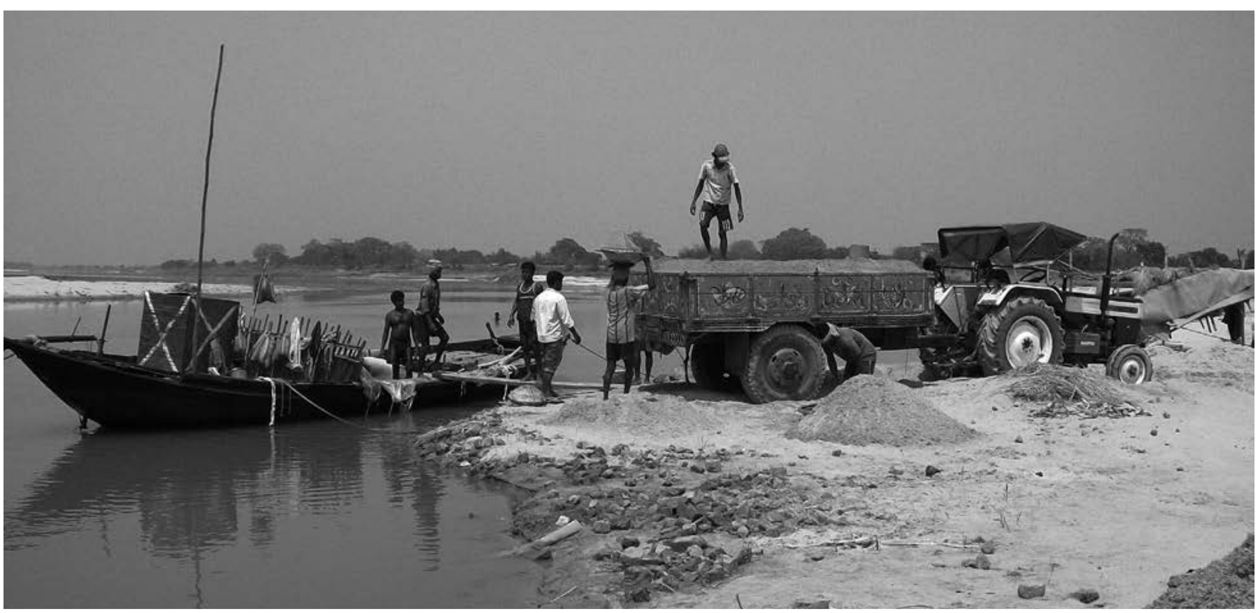
Source: Duggal 2010

These shops stocked only a few bags of sand sold loose or at the most in cement bags. The sand was very fine and did not look quite right so he was sent to a bigger building materials dealer. Here the sand could be bought in a small *theli* or cart for use in small extensions or larger repairs. The sand was of ostensibly a better quality than the one sold in small hardware shops. After discussion with these shopkeepers we ventured further to find wholesale dealers for sand. Surprisingly, in Kolkata we could find no wholesale shops or storage facilities but names and phone numbers of sand traders were made available to us and after contacting them they were ready to provide us samples of 'fine', 'medium' and 'medium-coarse' sand, though 'coarse' sand was not readily available. The traders told us that they would get sand from Burdhman[4] and promised to deliver truckloads of the sand after we had finalised the quality, straight to the site. They quoted the rates of sand per truck, which turned out much cheaper than the local suppliers.[5] Where legally mined, the rates of sand are based on the royalty paid to the government, plus the charges of the vehicle based on the distance to be transported. Thus, the rates were a direct function of quantity purchased and distance of transportation. When bought in bags from neighbourhoods, the sand was of much poorer quality but was more expensive.

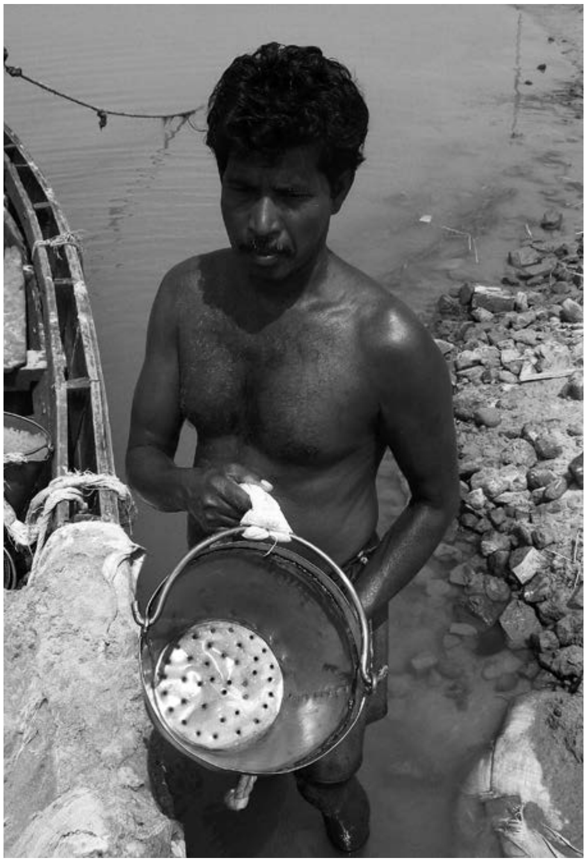
By now we had got very intrigued by the journey of sand and wanted to find out where it was being sourced from. Traders and dealers were not forthcoming and we later found that not all of the sand mining was legal, hence their hesitation. Bit by bit we collected the information that most of the sand in Kolkata was being sourced from the Damodar Valley between the rivers Damodar, Ajay and Hoogly. Depending on the speed of the river, sand is 'fine' or 'coarse' whereas its origins determine the mineral properties. Subsequently, we drove up the River Damodar trying to locate a sand mining site. We found one in a place called Jamalpur.

The river bed was nearly dry with a small stream of water flowing down the centre. A group of men were sitting under a temporary shed supervising the extraction and transportation of sand to various sites. The diggers went knee deep in the water and collected sand in perforated buckets that was then transported to the banks on boats. From the banks, the sand was loaded on trucks or trailers. When asked why the sand from the banks was not collected the contractors informed us it was very fine and not of good quality and that the ones being dredged was better. It would seem that it was the fine and poor quality sand was sold in the small neighbourhood shops. Some day we may go to a sand mining site where machines and dredgers are used, but we were satisfied with this process since it seemed closer to the traditional system of sourcing sand for the construction of buildings.

We now had a sufficient number of samples, having collected them from all the sites visited, for testing in our lab. We checked them for contamination by stirring in water and observing the floating organic matter and silt settling on top. These samples were then dried in



Sand mining loading on trucks



Sand mining perforated bucket for sand collection

Sand mining river bed

Sand mining sand reaching site

the heater and checked for their 'bulking'[6]. There is a considerable reduction in the volume of sand after drying that has to be compensated for when making mortar. We had collected a few samples from the sea shore. Our lab assistant would dry it every day and take the sand out for further testing but it kept retaining copious amounts of moisture. Thus, the sample of sand would be sent back in to the heater. The reasoning for this behaviour is that the salt in sea water, renders the sand hygroscopic[7], and thus needs to be properly washed before drying to remove the salt.

Eventually, we calculated the sand void ratio by slowly saturating the sand with water and calculating the volume of voids by the amount of water displaced. We learnt that it was these voids that were filled by the binders in making a mortar and since sand has nearly 30% voids, the common proportion used, that is one part binder for every three parts of sand is derived from this observation. We then matched their colour with the Munsell Soil Colour Charts[8]. Since the aggregates lend their colour to the mortars we would use this information later to prepare matching mortars for usage in heritage structures.

The next step was to run the samples in the sieves for testing their 'grade' as per IS standards. The samples were carefully dried, weighed, and after sieving the separated grains were weighted. This information was tabulated in a chart form that helped us determine how 'fine' or 'coarse' the sand was and we graded them as per IS standards.[9] Here we will use 'finer' or 'coarser' in reference to 'fine aggregates' only. Grade Zone 1 sand is coarser than Grade zone IV. The sand grains were put under a microscope. An expert was called and we went through the exercise again in order to correctly analyse the sample. The archaeologist[10] helped us identify different stones, crystals, and minerals in the sand. She showed us that a 'lighter' black grain was not stone but coal and a similar 'lighter' red grain was probably brick. Slowly the sand could be read as a collection of coal, brick and minerals. The very fine particles were identified as clay or silt and not desirable in a 'good' quality sand. We could identify the shiny mica particles that affect the water requirement and reduce the strength of the concrete, while all other factors are kept constant (Revie & Fookes n.d). Soon we started seeing the shape of the grains as being rounded or angular giving us some

Grading of Fine Aggregates (Sand)				
Designation	**Percentage Passing For**			
IS Sieve	**Zone 1**	**Zone II**	**Zone III**	**Zone VI**
10 mm	100	100	100	100
4.75 mm	90-100	90-100	90-100	95-100
2.36 mm	60-95	75-100	85-100	95-100
1.18 mm	30-70	55-90	75-100	90-100
600 micron	15-34	35-59	60-79	80-100
300 micron	5-20	8-30	12-40	15-50
150 micron	0-10	0-10	0-10	0-15

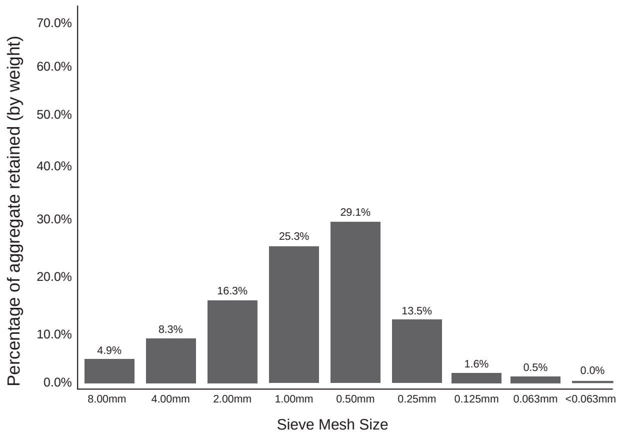
Testing of Fine Aggregates		
Heads	**Need**	**Test**
Cleanliness	Clean sand improves adhesion between the aggregate and binder. Chief impurities are clat, loam, and organic matter; the latter is liable to decay and cause problems.	Fill half a vessel with sand and water, agitate well, and allow to rest. Suspended particles will float on the top and silt will get deposited at the top. Percentage of silt and suspended particles indicate the impurity in the sand.
Bulking	Increase in the volume of sand when it is moist is called bulking. The finer the sand the greater the bulking. It is safe to assume that 20% of volume of sand is increased when wet; extra sand has to be added in proportion when making mortar. However, if sand is submerged in water, there is no bulking.	Take a small cubical box of sand. Dry well and return to the same box. Measure the difference in the depth. Calcute bulking as per ISC codes if needed. Bulking does not cause a problem if mixes are by weight
Sand Void Ratio	Sand has 30-34% air voids which are filled up with the binder to make a mortar.	Fill a known quantity (in units of 100 for easy calculation) of bone dry sand in a measuring cylinder. Slowly pour in water from another measuring beaker, in stages, into the sand, until the water level is equal to the sand level. The volume of water required to reach the top surface is equivalent to the void ratio in percentage terms.

Source: Mackay 1970

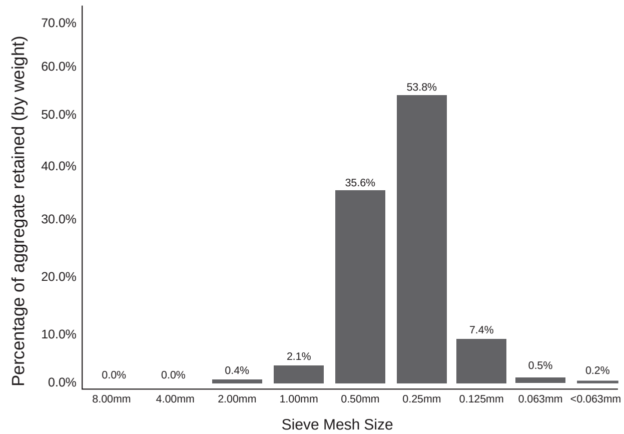
indication whether they came from the river or mines. What was the purpose of undertaking this research and survey of the locally available sand? We wished to prepare ‘matching’ mortars in colour and properties to the historical mortar from the Scottish Cemetery[11] that was being analysed in our lab. Thus the colour, composition, and grade of the sand had to be a close match. Our observations were surprising.

Firstly, none of the historical mortars had used the same sand that was locally available today. The colour of the sand used in the historic mortar was different to the colour of the sand available today. Sand was historically sourced from rivers other than the ones we surveyed and studied. Thus, there was a need to study and map other river banks from where sand may have been mined, if we wished to prepare a matching mortar. Secondly, the sand used in the historical mortars was ‘well graded’, implying that not more than 30% to 35% sand is retained in any one sieve. Also, it forms a gentle curve as compared to the poorer sands that retained more than 35% on any sieve and gave a more linear graph (Artis-Young 2010). We found that each of the sand samples collected were not ‘well graded’ and varied greatly from each other. This meant that we would not get consistent quality of sand and mortar in turn, if it was procured over a long period of time or in batches. Thus, maybe sand grains would have to be separated and remixed if we wished to match the grade with historical mortars.

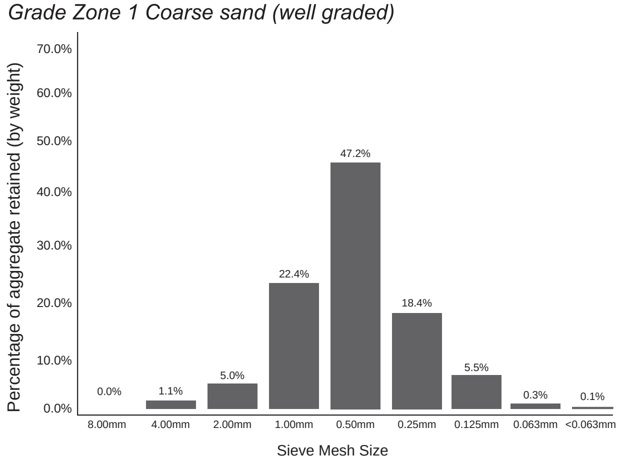
Finally, the historical mortar samples from the Scottish Cemetery indicated along with the sand, 20% to 60% of the fine aggregates were clay. Only further research can indicate the true nature of this other fine aggregate. Sands that were tested did not have such a high percentage of silt and clay. Did the historical sands come from pits or were they using Moorum? Moorum is



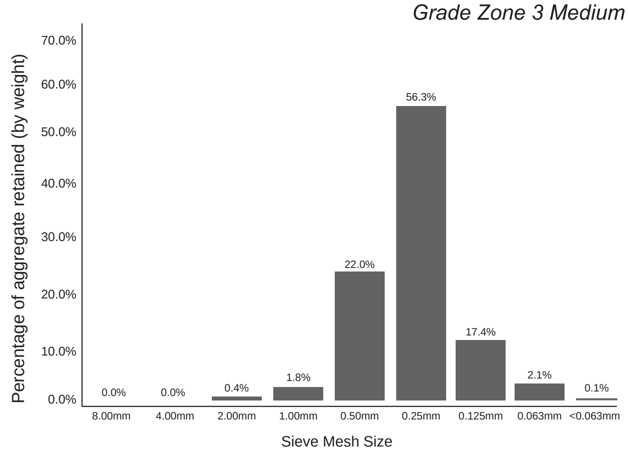
Grade Zone 1 Coarse sand (well graded)



Grade Zone 3 Medium



Grade Zone 2 Medium coarse



Grade Zone 4 Fine sand

Sand minerals as seen under microscope

broken rock that comes from the hilly areas of Jharkhand and has a high percentage of clay. Soils and *surkhi* (brick dust) would also require testing. These are some questions that need to be answered in the future before we can make 'matching' recipes for mortars.

What we learnt from this exercise is that equipped with the school book education and 'handed down' specifications to relying on the contractors for their ability to execute our conservation projects in 'compatible or matching lime mortars', we often fail to see the gaping void between the two. This survey opened our eyes to the harsh reality of the building material market in Kolkata and possibly in other parts of India, especially for conservation. Materials like sand, so crucial to our mortars, are coming straight from the rivers to our sites. Neither properly tested nor dried they are used straight into our mortars. When mortars fail it is often too late or too expensive for large scale repairs. Cement and polymers are being readily used as a quick fix and stealthily covered over to imitate lime. Our study reinforces there is a need to go to the root of the problem. More research, survey, and mapping of historical materials and their sources should be done if we hope to improve the quality of conservation. We came to the conclusion that a simple 'recipe' for lime mortars is still a distant dream and not to be realised without further research.

Acknowledgement

The author was trained at the Scottish Lime Centre, Charlestown and extends her gratitude to them for their continued support and for liberally sharing their information and knowledge for this study.

Bibliographical references

- Artis-Young, R 2010, 'Sands for use in lime mortars and renders in new building construction', *The Journal of the Building Limes Forum*, vol. 17.
- Duggal, SK 2010, *Building Material*, IS:383, New Delhi, New Age.
- Mackay, JM, 1970, *Building Construction*, Bombay, Orient Longman, Scottish Lime Center, Charleston, vol. 2.
- Revie, WA & Fookes, PG n.d., *Mica in concrete – a case history from Eastern Nepal*, n.p.

Notes

1. In collaboration with Kolkata Scottish Heritage Trust, Scotland and Scottish Lime Center, Charlestown for the purpose of conducting research for the conservation of the Scottish Cemetery, Kolkata.
2. Refer the complete IS codes IS: 2386 for further details.
3. Pappu Kumar Mandal.
4. Burdhman is a city in West Bengal,100 km north-west of Kolkata.
5. 8.5 cubic metres is the approved volume content of a regular truck.
6. Increase in the volume of sand as moisture content in it increases.
7. Tendency to absorb moisture from the air
8. Colour Theory developed by Albert H. Munsell that establishes a scientific system for accurately identifying every color that exists.
9. The Aggregate Grading Chart was prepared by Scottish Lime Center, Charlestown.
10. Dr. Banani Bhattacharya, consulting archaeologist for Scottish Cemetery conservation project.
11. More information on the Scottish Cemetery can be found here: http://kolscotheritage.org/scottish-cemetery/

Earthen Construction
Adapting vernacular technologies

HILARY D SMITH

ABSTRACT

Over the last few decades, the construction industry has come under fire for its massive contribution to climate change and environmental degradation. As an alternate, earth based building technologies present a viable solution by taking a locally sourced material to create a low cost, low-carbon and climate appropriate building and a continuing livelihood for local unskilled labourers and masons. India already has a long tradition of earthen architecture, evident from its built heritage in rammed earth, adobe, laterite and wattle and daub found throughout the country. The 20th century has brought about the advent of 'modern' building materials like reinforced concrete, steel and fired bricks. Even rural areas have seen a large influx of these materials. Yet, there is continued relevance of earth as a building material, since earth based techniques can be made competitive in strength and structural versatility by the addition of stabilisation and reinforcement.

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INTRODUCTION

India's landscape is changing at a dizzying rate as more sections of society are able to access and afford the costs of building construction. This is only the beginning of a trend. The rate of construction expenditure is estimated to grow at an annual rate of nine percent until 2018, according to Architecture, Engineering, Construction, Operations and Management's[1] (AECOM) annual 'Asia's Construction Outlook' report, making it the fastest growing national construction sector in the world (2013, p. 18). With the current bias towards heavily polluting, non-locally sourced materials such as steel, concrete and fired brick, it looks like the Indian construction sector will increasingly contribute to the greenhouse gas emissions that are triggering climate change. These building materials continue to maintain a near monopoly on public imagination, despite their irreversible resource depletion, polluting production procedures and requirements for long-distance transportation.

The alternatives for a more sustainable construction process vary from re-appropriation and reuse of recycled waste to adoption of renewable and locally sourced materials. One option slowly gaining attention in India is the use of earth based building technologies. These unite attributes such as cost-effectiveness, low carbon production, varied application and labour creation, making them appropriate at multiple levels. Additionally, building with earth reaffirms the long history of India's earthen construction.

EARTH AS A BUILDING MATERIAL

Earth, in great geological diversity, is available throughout the world at the ultimate local level. Some soil types are suitable for construction in their unadulterated form while others can be enhanced through minimal additions of sand, stabiliser or other soils that improve the particle distribution. Earth can be used to make a building with numerous techniques, including, Compressed Stabilised Earth Blocks (CSEB), rammed earth, wattle and daub, cob, adobe, earth bag, poured earth, light earth[2] among others. These earth building techniques present several desirable attributes that are listed below.

- Earth has a very ecological profile as a building material. It is a locally sourced material that is ideally taken directly from the construction site. Therefore, it requires minimal material transportation as only equipment, labourers and supplementary building materials need to be transported to the construction site. The raw earth taken for building requires excavation, but this does not lead to environmental degradation as the fertile top soil is kept aside and reused later for gardening purposes. The depressions created through excavation can be incorporated into the design, whether for basement levels in buildings, landscaping elements, rainwater harvesting, ponds or waste water treatment facilities. Many earth based building techniques employ manual methods, such as manual presses for blocks, hand forming for cob, wattle and daub and hand tamping for rammed earth. This reduces energy consumption during the construction process.
- Being taken directly from the site, earth buildings are very economical. The primary costs are simply the equipment and labour. This makes earth-based construction techniques particularly appropriate in contexts where labour is plentiful and inexpensive.
- Earth building empowers the community around the construction site. Earth based techniques are generally labour intensive, meaning that the bulk of the expense of building goes directly to the local workforce rather than to the corporations and middlemen who produce and distribute industrial building materials. In case of CSEB, the percentage of the block cost going back to the labourers producing the blocks is 45%. If the final construction employs vaults and domes for roofing and flooring, 65% of the total building cost goes to the workers and masons (Maïni *et al* 2013). Thus, both skilled masons and unskilled labourers are provided a livelihood through earth construction.
- Earth structures provide a superior interior living environment. Earth based walls can regulate temperature and humidity in a building. Walls absorb heat during warm daylight hours and slowly release it during cooler nocturnal hours. Earthen surfaces, either of earth based walls or plasters have been shown to control relative humidity inside the building. The porous surface automatically absorbs and releases moisture in the air to maintain an optimal range for human habitation (Torgal & Jalali 2011, p. 177). The natural origin of earthen buildings also means an absence of the chemical compounds that can be found in some industrial building materials that also pollute indoor air quality.
- Earth is adaptable to many structural types and can give many different effects in texture and colour. With the use of vaulting, even roofing can be done with earth, whether with adobe bricks, CSEB, cob, or shaped earth. It is not limited to simple structures and can be used for multi-storey buildings as well.

These positive attributes of earth as a building material are emphasised by India's long history of human habitation in earth dwellings during which the material was adapted and perfected to the diverse geological and climatic conditions found throughout India.

APPLICATIONS IN INDIA

India's history with earth based construction dates back to the Indus River Valley Civilisation, where archaeological evidence shows that dwellings made from unbaked earth bricks were made using the rich alluvial soil (Houben & Guillaud 1994, p. 13). Much of southern India has ferrous red soil and lateritic soil, ideal for building with earth, although the vegetation that has grown in abundance on these soils provided suitable building materials as well (Oliver 2006, p. 137). Earth has continued to be used as a building material throughout the Indian sub-continent up to the present day.

Starting from the north of India, in Ladakh, Zanskar and Spiti, earth is the only building material found in large quantities. With sparse annual rainfall, concerns of erosion have historically been very limited. Earth can be seen in diverse applications ranging from the towering rammed earth walls of fortresses and Buddhist monasteries dating back to the 10th and 12th centuries to simple village houses. Many of these constructions have multiple storeys (Gupta & Singh 1987).

In the Kashmir Valley, the locally available building materials include earth, stone and wood. Earth is used to make adobe bricks, used particularly for interior walls, constructed with earth based mortar and covered with an earth-based plaster. The traditional *dhajji*[3] timber framing, found both in rural and urban settings, is sometimes filled in with sundried adobe bricks as well. In rural areas, one also finds the flat mud roof, where timber beams are in-filled with earth (Desai & Desai 2007). The simple shepherd dwellings found in the grazing lands in higher altitudes are made almost entirely from earth. These are partially carved out of the hillside and then enclosed with earth walls (Gupta & Singh 1987, p. 2). This provides shelter from the winds as well as thermal insulation.

In the Kutch region of Gujarat, earth is one of the materials used to construct the traditional *bhoonga* house. These houses are circular in shape and are particularly suited to the dry hot climate and seismic activity of the region (Choudhary, Jaiswal & Sinha 2002). Earth is employed for walls in the form of adobe brick, cob and wattle and daub and the structure is covered with a roof generally made from thatch or tile.

The towering Basilica of Bom Jesus in Goa constructed with laterite block

Also in the west, the state of Goa has striking earthen heritage buildings constructed in laterite, a soil type that undergoes a carbonising chemical reaction when exposed to air, making it similar to stone. It is cut into large blocks in laterite quarries (Maïni 2009). The Portuguese built churches and public buildings are made from laterite and so are some houses. These massive edifices often exhibit ornamental relief work in the laterite facades, as seen in the Basilica of Bom Jesus, built by the Portuguese from 1594 to 1605, which is also a UNESCO World Heritage Site.

In the eastern region of Orissa, hard-crust laterite is cut into blocks for buildings. It is also one of the few rain prone regions where one finds earth used as roofing. These sloping roofs are coated with earth on the inside to protect against cooking fires and covered with plant fibres on the outside to prevent rain infiltration (Anon.1986).

In the southern states of Kerala and Tamil Nadu, timber, particularly in the form of coconut palm wood, is available in abundance and is used widely in construction (Tipnis 2012, p. 40). However, earth is also used for walls and in-fill. In rural areas of Tamil Nadu, some traditional houses are built with low walls made from adobe, wattle and daub as well as cob, which are then topped with a keet[4] roof made from woven palm leaves.

These geographically disparate examples of established earth based construction techniques all across India indicate the suitability of earth for diverse climates and landscapes. These earth building techniques have endured over the centuries in practice and even in structure, as attested by the adobe Tabo Monastery in Spiti Valley, dating to 996 AD (Maïni 2010, p. 1). But in recent decades these vernacular construction methods have been disappearing from the construction site to make way for industrial construction methods. ‘Mud’ is denigrated when compared to the perceived sophistication of ‘reinforced concrete’. But if earth demonstrated the characteristics of a modern material, could it be more successful?

MODERNISING EARTH

Earth as a building material has its share of constraints, both real and perceived. It is vulnerable when exposed to water. It also lacks in tensile strength (Norton 1997). Prospective building soils require some testing, either through field tests or laboratory analysis before they can be optimally employed. But these considerations do not preclude earth built structures from taking similar forms and exhibiting similar properties to buildings made from reinforced concrete, steel and fired bricks. Design and construction by knowledgeable and careful teams is a prerequisite but it is also to be kept in mind that the mechanical and structural properties of the earth-based building material can be improved through stabilisation and reinforcement.

Stabilisation

One of the main drawbacks of using earth as a building material is its inherent vulnerability to water. While this can be solved through design, for instance, eaves to protect walls from rain and substitution of other materials, such as fired bricks for exterior walls or stone or ceramic tiling in bathrooms, the water resistance of earth can also be augmented through addition of a stabiliser. Stabilisation is the process of adding an admixture to the soil that causes a chemical reaction to improve the mechanical properties of the material. Common stabilisers used today in earth construction are cement and lime. The dosage is on the basis of the soil constitution but on an average the cement quantity is kept as to three to eight percent of the total weight. A higher percentage of cement can always be used but the higher the quantity of cement, the more the mixture begins to lose its economic advantages (Maïni 2011, p. 5).

Stabilisation is not necessarily a new idea. Admixtures have been used throughout earth building history to improve the mechanical properties of earth for building. Some of the substances historically added to soil have been of animal origin, such as animal dung, urine, hair and even animal blood (Auroville Earth Institute unpub.). Vegetable matter like wood ash, vegetable oils, tannins, saps or natural latexes have been used as well. Salt and lye have also been used sometimes to enable a chemical reaction (Habert, Barbosa & Morel 2006). Research on these natural stabilisers continues, aimed at developing an alternative to cement and lime stabilisation. However, its applicability depends on local context, so as to implement an admixture of local origin with properties suitable to the local geological composition and the stabilising needs dictated by the climate and architectural traditions of the region.

Portland cement remains the most commonly used soil stabilisers (Waziri, Lawan & Mala 2013, p. 40). It is best suited for sandy soil types. When added to the soil, cement binds the large particles of the soil, minimising the overall porosity of the mix (Norton 1997, p. 28). Lime is better suited to clayey soils that have finer particles than sandy soils. When lime first interacts with clay minerals, plasticity of the soil is modified, making the mixture easier to process. Next, the grains are bound together through carbonation that increases its strength and water resistance.

The advantage brought about by stabilising earth has been quantified through compressive strength testing and the resulting building material retains more of its strength when exposed to water than unstabilised earth. According to Bush (1985, p. 13), an unstabilised block has been shown to maintain only 20% t 30% of its dry strength when in a wet state whereas a cement stabilised block can demonstrate a dry strength of 60% to 65% in similar conditions.

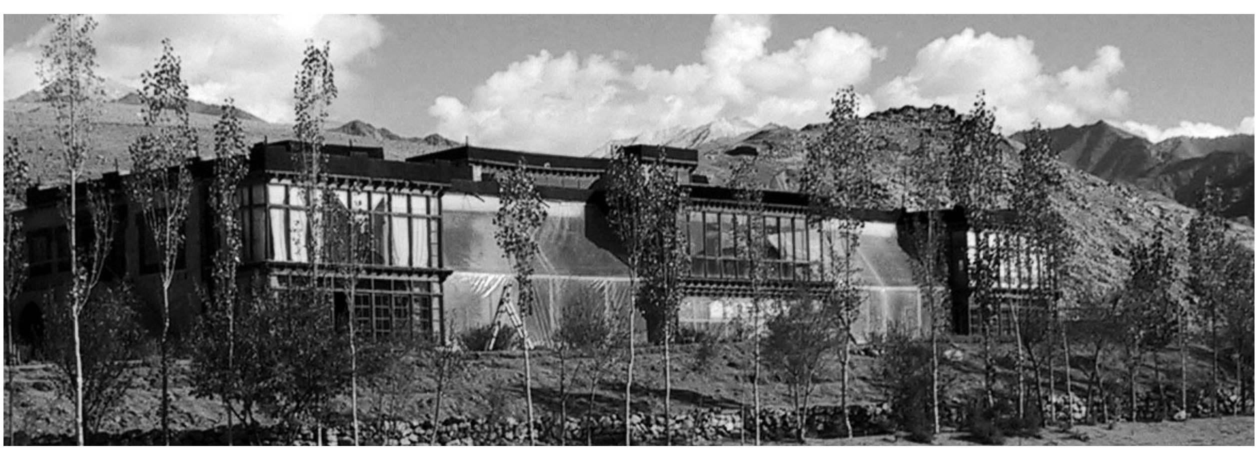
Reinforcement

While earth may be strong in compression, especially with the addition of lime or cement, it is vulnerable to tension and flexure, requiring thick walls and limiting its applicability in regions with seismic activity. This shortcoming can in part be corrected through use of reinforcement, either directly inlaid in the earth material or as a superstructure. Reinforcement is not necessarily a new technique and can be seen in the inclusion of plant fibres in soil mixtures and the construction technique of wattle and daub, where a woven wooden structure is filled in with earth. The *dhajji* technique prevalent in the Himalayan region uses evenly spaced timber framing around stone or mud brick. This technique demonstrated exceptional resistance to seismic activity during the 2005 earthquake in Kashmir in comparison to modern materials (Schacher & Ali 2009). Material reinforcement is one of the features of current building construction used to achieve the structural diversity found in modern architecture. Even concrete shows poor performance in tension and flexure (Lambert & MacDonald 1998), bringing about the advent of reinforced concrete.

Reinforcement can be incorporated into walls, beams and columns to provide the necessary support to build taller and slimmer structures, as well as to combat the effects of seismic movement. Classic steel rebar can be inlaid into techniques like rammed earth or poured earth or placed in hollow CSEB with mortar or grout. Reinforcement helps to build resistance to tensile stresses using different types of reinforced masonry, whether with bars or with mesh placed in the mortar (IITK-GSDMA 2005). Bamboo has been shown to be an ecological alternative to steel reinforcement. Shredded tyres, vegetable fibres or even textiles can be added to the soil mixture to create uniform reinforcement.

With the added benefit of reinforcement, the geographic suitability of earthen buildings can extend even to disaster prone areas. The State Government of Gujarat approved CSEB for rebuilding after the 2001 Earthquake. The State Government of Tamil Nadu also approved CSEB for rebuilding after the 2004 Tsunami (Maïni 2005, p. 2).

The modern application of earth with suitable planning, design and engineering has resulted in a larger variety of structural shapes and a wider area of applicability for the earth building medium. In India, some of the notable contemporary earth buildings demonstrating the well executed and modern use of earth include Students' Educational and Cultural Movement of Ladakh (SECMOL) campus in Jammu and Kashmir, Banasura Hill Resort in Kerala and Auroville Visitors' Centre in Tamil Nadu. Widening the scope to the global



SECMOL's glass and rammed earth walls soaking in the mountain sun near Leh

The rammed earth being compacted with hand-held mallets to allow air to remain within the soil mix

level, one can find Handmade School in Bangladesh, Mapungubwe National Park Visitors' Centre in South Africa, LKH Feldkirch Hospital in Austria and NK'Mip Desert Cultural Centre in Canada.

KAZA COMMUNITY CENTRE: A CASE STUDY

In 2011, the Auroville Earth Institute, a research institute located in Tamil Nadu that specialises in building with earth, was contacted by Spiti Valley Projects to build a community centre in the Spiti Valley town of Kaza, Himachal Pradesh. The aim was to design a building that would incorporate the local building techniques keeping in mind the changing needs brought about by modern requirements and recent meteorological changes.

Spiti Valley has a long tradition of rammed earth that uses a soil mixture which is closer in consistency to cob with its high water content. It is then hand rammed with much less force than is typically used for rammed earth so as to allow more air to remain in the walls, creating a better insulating barrier against freezing exterior temperatures. The traditional roofing system in Spiti is characterised by flat roof. Historically having only needed to protect against snow and sun, the roof is composed of multiple layers of earth, willow twigs, and scrub that is then coated with a layer of annually reapplied clay slurry (Maïni 2004, p. 4).

For the community centre, the rammed earth walls were made using the local mixture ratios and ramming technique on stone masonry foundations. The walls also included CSEB elements made with a manual 'Auram 3000' press on-site[5]. As wood was difficult to procure, it was used sparingly for trim lintels. A composite roof with steel beams and earth infill was used instead of the traditional timber roof that is inadequate to guard against the increased annual rainfall.

As earthquakes do occur in the region, the building included appropriate dimensioning for seismic resistance. The rammed earth was embedded with horizontally-laid bamboo and the CSEB composite ring beams. The ring beams were made of U-shaped


The construction of the Kaza Community Centre nearing completion

CSEB and reinforced cement concrete. Buttress walls, also reinforced, were spaced along the exterior walls (Smith 2013, p. 3). This community centre is being built in stages due to the harsh climatic conditions that dictate a short construction season in the Spiti Valley from May to September. However, the raw construction of the building completed in September 2014. The construction process is already drawing attention of the local community as the locals are noting the vernacular traditions being repurposed for a modern building (Davis 2013, p. 4).

TOWARDS THE FUTURE

Despite successful modern applications of earth based building technologies, as seen in the Kaza Community Centre, there is still a long road ahead before these can tout the same prevalence as concrete and fired bricks on the construction site. The economical, socially empowering and ecological nature of earth based building materials is still largely unrecognised and their fine history as a building material of choice for monasteries, town houses and country dwellings continues to be reduced to a snapshot of crude rusticity.

While researchers and practitioners alike are making great progress by re-examining vernacular techniques that use local materials and low energy methods for a climatically appropriate outcome, the crucial shift toward more conscientious building practices on a large scale cannot occur without expanded exposure and education. The general public needs to become more aware of the effects of current building trends and of the potential that alternatives like earth construction methods hold. Professionals in the construction industry need to be trained in earth construction techniques in order to fully exploit the capacity of earth for modern construction. Only then can the confluence of traditional knowledge and modern technology be reintegrated into the Indian built landscape to benefit the environment, society and the inhabitants.


A series of welcoming CSEB arches guiding tourists into the Auroville Visitors' Centre

Bibliographical references

- AECOM 2013, ‘Asia construction outlook 2013’, AECOM, viewed June 18, 2014, <http://www.aecom.com/deployedfiles/Internet/Geographies/Asia/Asia%20News/Asia%20Construction%20Outlook_2013%20_%20final2%20_%20small.pdf>.
- Anonymous 1986, ‘India: Diversity in traditional mud construction’, *Mud architecture,* HUDCO, New Delhi.
- Auroville Earth Institute 2009, *Natural stabilisers,* Research Report, unpublished, Auroville Earth Institute, Auroville.
- Bush, A 1985, *Understanding stabilised earth construction,* Volunteers in Technical Assistance, Arlington.
- Choudhary, M, Jaiswal, KS & Sinha, R 2002, *Traditional rural house in Kutch region of India (Bhoonga)*, EERI & IAEE, viewed on June 7, 2014, <www.world-housing.net/WHEReports/wh100080.pdf>.
- Davis, L 2013, ‘Concrete vs. earth in the Spiti Valley: Editorial’, *AVEI Newsletter*, no. 11.
- Desai, R & Desai, R 2007, *Manual for the restoration and retrofitting of rural structures in Kashmir,* UNDP, UNESCO & Government of India, viewed on June 24, 2014, <http://unesdoc.unesco.org/images/0015/001593/159333e.pdf>.
- Gupta, V & Singh, R 1987, ‘Energy Conservation in Traditional Buildings in the Mountains’, in TMV Kumar & DR Ahuja (eds.), *Rural Energy Planning for the Indian Himalaya*, Wiley Eastern Limited, New Delhi.
- Habert, G, Barbosa, NP & Morel, JC 2006, *Utilisation de pouzzolanes pour améliorer la résistance et la durabilité des constructions en blocs de terre comprimée*, Research Proposal, unpublished, Observatoire Midi-Pyrénées LMTG, Toulouse.
- Houben, H & Guillaud, H 1994, *Earth construction: A comprehensive guide,* Intermediate Technology Publications, Bourton-on-Dunsmore.
- IITK-GSDMA 2005, *IITK-GSDMA guidelines for structural use of reinforced masonry*, Indian Institute of Technology, Kanpur.
- Lambert, P & MacDonald, M 1998, *Reinforced concrete: History, properties and durability,* Corrosion Prevention Association, Bordon.
- Maïni, S 2004, *Nako Preservation Project: Training and evaluation mission, 20th to 30th May 2004*, Auroville Earth Institute, Auroville.
- Maïni, S 2005, *Production and use of hollow interlocking CSEB for disaster resistance,* Auroville Earth Institute, Auroville.
- Maïni, S 2009, *Cut blocks*, Auroville Earth Institute, Auroville, viewed July 1, 2014, <http://www.earth-auroville.com/maintenance/uploaded_pics/2-cut-blocks-en.pdf>.
- Maïni, S 2010, *Building with earth in Auroville: A case study*, revised edition, Auroville Earth Institute, Auroville.
- Maïni, S 2011, *Production and use of compressed stabilized earth blocks,* Auroville Earth Institute, Auroville.
- Maïni, S *et al* 2013, *CSEB 02a: Basic data and principles,* Lecture Summary, unpublished, Auroville Earth Institute, Auroville.
- Norton, J 1997, *Building with earth: A handbook,* 2nd edition, Intermediate Technology Publications, London.
- Oliver,P 2006, *Built to meet needs: Cultural issues in vernacular architecture,* Elsevier, Oxford.
- Schacher, T & Ali, Q 2009, *Dhajji construction for one and two storey earthquake resistant house,* Scuola Universitaria Professionale della Svizzera Italiana, Manno.
- Smith, H 2013, ‘Eco-community center in Spiti Valley’, *AVEI Newsletter,* no. 11.
- Tipnis, A 2012, *Vernacular traditions: Contemporary architecture,* The Energy and Resources Institute, New Delhi.
- Torcellini, P & Pless, S 2004, ‘Trombe walls in low-energy buildings: Practical experiences’, *World Renewable Energy Congress VIII, Denver, Colorado preprint.*
- Torgal, FP & Jalili, S 2011, *Eco-efficient construction and building materials,* Springer, London.
- Waziri, BS, Lawan, ZA & Mala, MM 2013, ‘Properties of compressed stabilized earth blocks (CSEB) for low-cost housing construction: a preliminary investigation’, *International Journal of Sustainable Construction Engineering & Technology,* vol. 4, no. 2.

Notes

[1] AECOM is a consulting firm that offers market forecasts such as the annually-published *Asia Construction Outlook.*

[2] CSEB are made from soil mixed with sand and a small percentage of stabiliser such as cement or lime. They are compressed using a manual or automatic press and can be used for load-bearing walls and vaulted structures.

Rammed earth is a technique used to make walls where a mixture of earth, sand, and gravel (which can sometimes be stabilised), is placed in formworks and compressed down with manual or pneumatic tampers.

Wattle and daub walls are made from timber lattice panels filled in with earth combined with sand, straw, or animal dung.

Cob is a small, moist ball of earth, sand and organic fibers that are stacked to form a solid wall.

Adobe bricks are moulded bricks made with earth and usually organic materials that are sun-dried rather than fired.

Earthbag is a technique where large, sturdy sacks are filled with earth and stacked to create walls.

Poured earth is a new technique using a pourable mixture of earth, sand, gravel, and stabiliser to create walls by casting them in formworks. Light earth is a mixture of highly liquid clay with a lightweight organic material such as straw to create non-weight-bearing walls.

[3] The word *dhajji* has its roots in the old Farsi word for‘patchwork quilt’, for which this traditional building technique bears a great likeness with its latticework of timber frames filled in with earth or stone masonry. *Dhajji* construction has also proven its earthquake-resistance over the centuries in Northern India and Pakistan.

[4] Keet is made from the fronds of local palm trees, braided together to create an effective thatch for roofing purposes. It is still widely used in southern India.

[5] The Auram 3000 is a manual CSEB press with 17 interchangeable moulds to produce 70 different blocks. It has been developed by the Auroville Earth Institute since 1990 and manufactured by the Aureka Workshop, also located in Auroville.

Timber Conservation
A brief overview

RAVINDRA GUNDU RAO

ABSTRACT

Timber can be named as one of the oldest known building materials in the world along with earth, lime and stone. It has been used as a construction material for centuries in Europe and Africa, and most of the buildings of the Vedic period of the subcontinent used timber in construction. In fact, bulk of the traditional construction of Europe uses the 'half timber' category and it continues till date. Timber, in India, has been extensively used in roofing, especially in the timber rich southern parts of the Peninsula and is still much in use in the west coastal regions, right from Kerala to Konkan. Structural distress of timber is a reason for concern and a cause for its decreased use in building construction. An attempt has been made to analyse and assess the decay of timber and look into the degree of intervention that is required to recycle good timber and restore heritage buildings.

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INTRODUCTION

Timber is one of the oldest and the most versatile building materials used in construction. In India, its usage in construction can possibly be traced to the Vedic period. Within the sub-continent too, timber continues to play a pivotal role in the construction industry, with a vast range of usage possibilities, from variations in timber types, joinery and carpentry techniques to its final appearance through ornamentation and finishes.

The short and sturdy variety of timber found in India is generally sourced from deciduous trees found in all parts of the country except towards the north, north-east and Himalayan ranges where a softer variety of timber is found. The trees used for construction grade timber include different kinds of Teak, Rosewood, Sal, Sandalwood, Sheesham, Oak, Pine, Jack, Irul, Mahua, Deodar, Mahogany, Mango, Neem, Palm as well as a host of locally available varieties.

In general, timber performs remarkably well within the Indian sub-continent. This is partly attributed to the climatic conditions prevailing in most of the countries that is conducive to its growth. Most parts of India do not undergo as severe a wet and dry cycle as seen in other parts of the world. The predominance of a hot and arid type of climate ensures the longevity of timber in the plains and deserts while the perennially wet and humid coastline also maintains a constant environment for timber to thrive in.

Widely used in the coastal states, such as Kerala, coastal and south interior Karnataka, parts of Tamil Nadu and Andhra Pradesh, it continues to be an integral part of the building vocabulary in some of these areas, particularly, Kerala. In Andhra Pradesh, one can find widespread usage of Burma teak that was brought in through British trading posts along the sea. The architectural language of the vernacular in the Central Provinces, namely Madhya Pradesh and Chhattisgarh, as well the north-east and the Himalayan belt have evolved around the extensive use of timber. In areas where access to timber was limited, its usage has been restricted to decorative elements, reserved for the buildings of royalty and rich merchant classes.

The structural use of timber is most often seen in the form of long sections of wood as beams or columns or as tie members at the foundation level. The greatest degree of variation seen in timber construction in India is with respect to joinery techniques that depend

Timber restoration of roof structure, Ahilya Wada, Maheshwar, RGRA, 2005 with old and new timber using variety of joinery techniques

After removal of decayed timber. Source: RGRA project in Anegondi, Karnataka

Finished Madras terrace from above. Source: RGRA project in Anegondi, Karnataka

Process of construction/restoration of Madras terrace in layers: small bricks on edge, bricks laid flat and then lime concrete, etc. Source: RGRA project in Anegondi, Karnataka largely on the type of timber used and the degree of craftsmanship available.

Timber use has been on the decline since the early 20th century in India. One of the reasons has been the fast depleting forest reserves. Potential fire hazards are also a major concern. A case in point is the disastrous fire in the Mysore Palace in 1910 that burnt down the entire wooden structure. British engineers and architects working across India preferred the usage of steel and iron over timber. Later on, cement also attributed to its decreased usage. These newer materials also reduced the labour input and time required for construction. Since then, the usage of timber in construction in India has been limited. In fact, the widespread use of timber for public works is banned in the country. The exorbitant pricing has also reduced its application in private construction. The skills involved in carpentry have also nearly vanished with the advent of easy to work with and cheaper wood substitutes such as plywood, particle boards, veneers among others.

Testing timber using Schmidt Rebound Hammer. Source: Jeernodhar Conservators Pvt. Ltd. project in Gulbarga, Karnataka

The cost of timber has been steadily increasing over the last few decades, with rates of well-seasoned quality teak wood reaching an astronomical ₹ 6000 per cubic foot. Availability of good quality natural timber itself is an issue and any restoration work done with less than well-seasoned wood would be akin to preparing ready feeding grounds for an already termite infested building. Termites prefer feeding on softer, sap wood and moist timber member compared to a harder, seasoned equivalent. Apart from perhaps Kerala, where carpentry skills are in abundance, it is difficult to find a skilled and experienced carpenter in the rest of the country. Due to the limited use of timber in contemporary construction, local knowledge of timber joinery and craft skills has decreased considerably. The availability of such knowledge and craftsmanship is thus the most valuable assets towards restoration of timber structures. Keeping all these issues in the mind, timber will increasingly become a high value intervention in restoration works, making it imperative to preserve every piece of the prized commodity possible in the process. To be able to achieve this standard, the restorer has to get a definitive insight into the condition of the timber element in the building before an informed decision on the nature and scale of intervention to be prescribed can be taken.

Testing timber using UPV meter. Source: Jeernodhar Conservators pvt. ltd. project in Gulbarga, Karnataka

CAUSES OF DECAY

Timber is a long lasting material when used judiciously. However, there are many reasons for its distress. Being an organic material, it is vulnerable to biological agents of decay. This makes timber selection is a key component of the overall construction process. The incorrect selection of timber, for instance, using soft-woods for structural work or using timber with inherent defects[1], improperly seasoned timber or timber that has split or warped may lead to an inherently vulnerable structure. Physical damage may result from an impact or collision or simply due to use of poor quality timber during the construction process and improper repairs to the structure.

More often than not, decay of timber may occur due to prolonged dampness in the environment, caused due to leaking roofs, flooding basements, faulty plumbing and drainage. These result in organic decay of the timber caused by fungi resulting in dry rot, wet rot, heart rot, brown rot, insects like beetles and termites, and marine borers. Hence, maintenance becomes a prominent factor contributing to increasing the life of the material. Often roof is the most distressed part of any heritage building in India and depleting roof maintenance skills add to this broad issue. Decay is more pronounced and difficult to address in abandoned historic buildings with no human activity. Extreme fluctuations in temperature and moisture lead to alterations in the moisture and oil content within timber, further accelerating its decay. In such structures, early detection of the issue and identification of its cause is improbable, therefore, the decay is generally detected when it is too late. In most cases, the decay starts at planes not readily visible to the human eye and often works its way through the section, leaving a skeletal section of the timber intact.

ASSESSMENT OF DECAY

Timber restoration has not been undertaken as a rigorous scientific endeavour in the country, while countries in Europe and the Asia-Pacific have a vast body of knowledge and skills in this area of study. A detailed assessment of the physical defects in timber is essential to show the location, trends of acceleration of the decay and even the possible causes of the distress, for instance, the location of plumbing lines, roof condition, presence of water bodies or trees nearby and so on. This would be done by inspecting every piece of timber in the structure by tapping with wooden, rubber or steel mallets or hammers, marking the suspect sections and areas.

The methods of identification of the arising problem include close and periodical physical inspection by timber experts, usually carpenters or conservation specialists in the area of timber restoration work. Interior spaces with timber develop a distinctly foul odour, which may offer some clues towards detection of damage. Laboratory tests help in establishing the price degree of damage and pinpointing its cause as well. Physical defects in timber can further be verified using a set of Non Destructive Tests (NDTs) using an experienced specialist. Globally used non-destructive tests for timber include:

- Visual inspection and species identification
- Pin driving and screw withdrawal method
- Stress wave and ultrasound methods
- Ultrasonic Pulse Velocity (UPV)
- Resistance drilling
- Digital radioscopy

Ultrasonic Pulse Velocity meter (UPV) and Schmidt Rebound Hammer may also help in locating hollow or decayed pockets in timber. These are equipment designed to test status of the cement concrete, hollow pockets if any, calibrated on site strength of the concrete and is a part of Bureau of Indian Standards. UPV works on the principle of sending an electrical impulse between two transducers and inferring the prevailing compressive strength based on the density of the material. Electrical waves traverse faster in denser media and, conversely, slower in rarer media. UPV test is employed for:

- Testing homogeneity of the material
- Testing soundness, presence of cracks, hollowness
- Comparison of two samples of the same material
- Comparison of the soundness and strength of two different materials

The equipment used for the UPV test is now available in India[2] and there is also a defined Indian Standard (IS) code for the conduct of the test, IS-13311- Part 1. Similarly, the impact of the rebound hammer would give an indication of surface strength. This equipment is successfully used in most cases of concrete testing and can be re-calibrated to do the same for timber too. Such tests coupled with physical examination will ensure minimising replacement, especially, as there is always a tendency to go overboard with respect to replacement. Mere physical visual inspections of timber can often be misleading.

DEGREE OF INTERVENTION

As in case of other NDTs, the UPV test results are useful in decisions regarding the degree of intervention in the historic timber structures. The comparison between samples of the same type of wood and also

Rebound Hammer

MS steel capping at joist end to reuse bulk of the original timber

Restoring the roof structure of Ahilya Wada, Maheshwar, RGRA, 2005 with old and new timber using variety of joinery techniques

between different types of wood informs about the condition of timber. For example, a UPV test performed for three samples of new wood using the appropriate equipment and relevant IS code for conducting the test, gave an average velocity as 1.42 kilometres/second. Of these, one result gave a higher value, hence standard was considered as 1.25 kilometres/second. Relative to this value, an old wood sample was tested, giving varying results when tested at various points. The point of crack gave a varying value compared to the remaining sample, as per which the crack could be detected. The suggested intervention would be to repair the crack. Similarly, completely decayed parts could be detected, that needed to be discarded. Having ascertained the defective areas, the logical solution would be to replace such timber element of the structure under consideration that cannot be salvaged, using matching timber in terms of the type, quality, and degree of seasoning and character of the original timber. As far as possible, parts of the removed timber should be reused in other locations. For instance, parts of the removed beams can be reused as purlins, rafters, reapers, in door or window repairs or even in new furniture for the reuse of the building.

If the timber is partly damaged or decayed, as in the end of the joists, beams, columns, struts, purlins, they can be reused on site by metal capping or even providing new timber using different types of joinery available for taking different types of loading patterns, such as, compression, tension, sheer, bending or torsion. Replacement of timber is best done with recycled timber from dismantled buildings as it would be the best selected timber at that time and assuredly well-seasoned too. Lastly, the replaced timber has to be treated against potential termite attack and other agents of decay before being placed in the building.

CONCLUSION

By and large building construction today is making less use of timber members. At a time, when we lack a scientific and precise body of knowledge on timber restoration and are faced with dwindling number of skilled craftspeople who know and work on timber, restoration of existing timber structures calls for special attention. Non destructive techniques for assessment of decay are extremely useful tools for enabling informed decisions with respect to intervention towards conserving this heritage. The need of the day is to develop scientific expertise and definitive intervention strategies to prevent timber decay and ensure restoration of existing timber structures.

Notes

1 Commonly found faults in timber include:
Burls: Excrescences or outgrowth on a tree due to injury in its younger days causing too many projections appearing on the body of timber.
Coarse grain: Obtained from a rapidly grown tree with opened annual rings producing weak timber.
Dead wood: Timber obtained from dead standing tree. This is light weight and reddish in colour.
Druxiness: White decayed spots on timber caused by fungal attack, concealed with healthy wood.
Foxiness: Red or yellow tinge in wood around the pith of the tree discolouring the timber. Results due to poor ventilation during storage or over mature timber grown in marshy land.
Knots: These are sections of branches that have been engulfed within the trunk as it expanded producing irregular grain surrounding them. These produce less than strong sections after cutting.
Rind galls: Abnormal growth in the bark caused possibly by improperly cut trees.

2 Ultrasonic pulse velocity meter: Ux-4600 (950205000), Roop ultrasonic electronics

Stone Jaali

Daylight performance analysis

DHARMESH GANDHI

ABSTRACT

The jaali is used extensively in medieval Indian architecture an aesthetic and functional architectural element that is a determinate of the quality of light in interior spaces. A documentation and analysis of jaalis used in tombs from 13th to 17th century in and around Ahmedabad was carried out to understand their daylight performance. On the basis of this primary information, a computer model was derived and simulated for an office space to test the applicability of the jaali in contemporary spaces. The results are promising, opening up possibilities of absorbing learning from traditional architecture in the contemporary context.

INTRODUCTION

Jaali is an Indian term for stone lattice screens used as punctures in the wall surface in ornamental or geometrical patterns extensively in Indian architecture, especially in Gujarat and Rajasthan. The physical function of a jaali is to reduce the amount of light admitted inside and to cut out its blinding glare. It also allows the passage of air but arrests powerful gusts, essentially making it a climate control device for various regions in India. Although the jaali was majorly used as an aesthetic element in the built form, it had a major effect with respect to interior day lighting. Building occupants generally prefer to live and work in an environment

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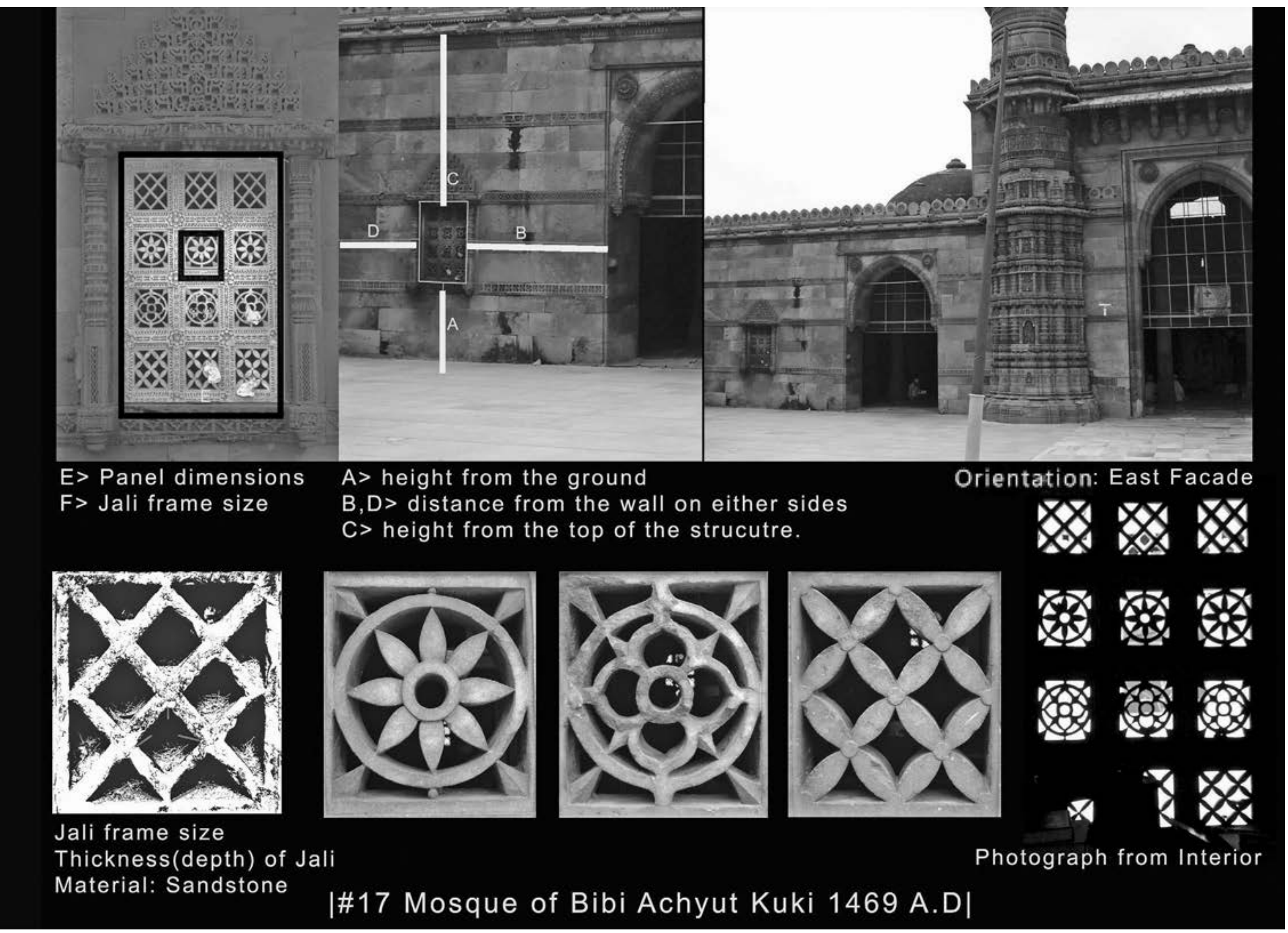
where there is particular admission of daylight for indoor illumination, as it affects the worker satisfaction and performance (Ali 2005). Also, a high availability of daylight levels can be disadvantageous for optimal visual conditions due to excess of sunlight (Bellia *et al* 2008). Along with quality of light, quantity of light also affects the building occupants as higher quantity of light invites glare. Daylight is a preferred light source for working spaces and day lighting through openings is critical for study as it provides higher task illuminance on work planes (Borisuit *et al* 2011). In this context, it is important to analyse the quality and quantity of daylight received from a jaali through simulations, to understand its properties in contemporary context. The current study is focused on understanding the role of jaali windows inside an office space, where the quantity and quality of daylight within the interiors are analysed through adequate illuminance, uniformity and glare.

ANALYSING THE TRADITIONAL JAALI

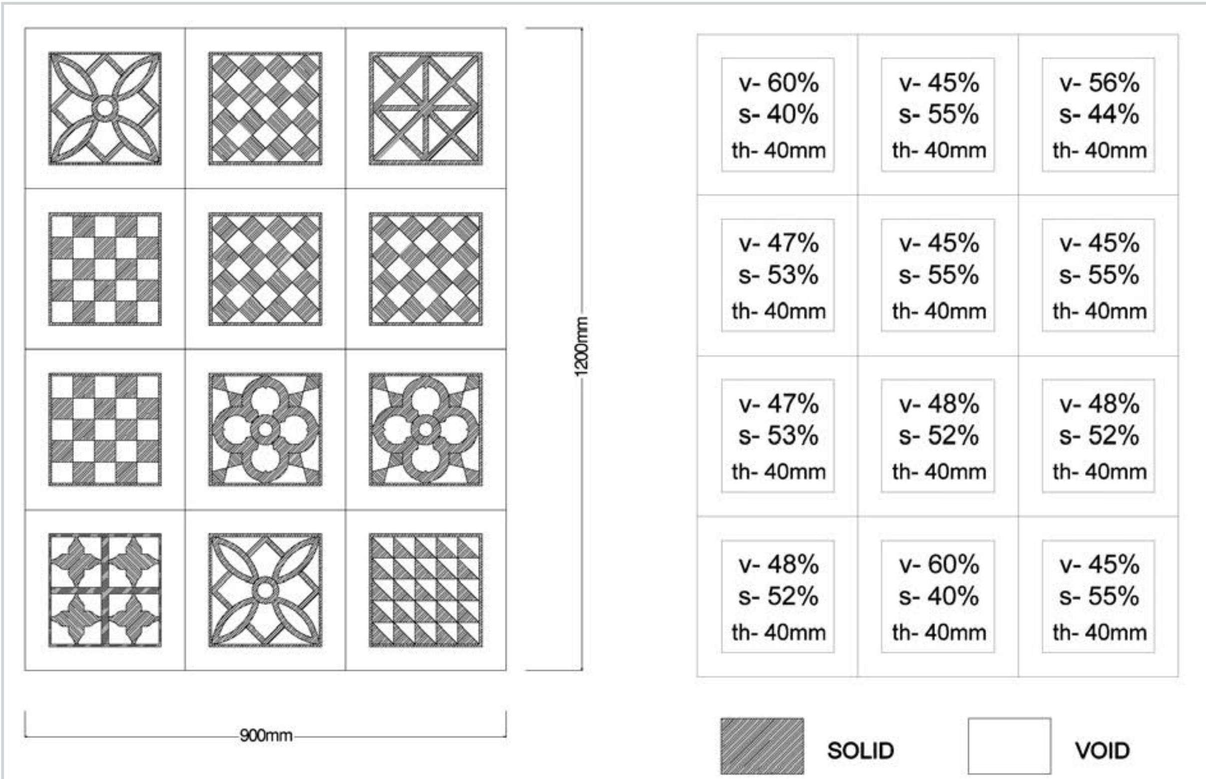
A documentation and analysis of the jaali used in 13th to 17th century mosques and tombs in and around Ahmedabad was undertaken with respect to form and aspect ratio to arrive at their day light performance. An extensive feasibility study was carried to compute all the required parameters of the jaali such as frame size, orientation, solid-void ratio, overhang ratio[1], position, size and thickness of panel and thickness of the jaali In the whole jaalipanel, each jaali was considered as a window and thickness was taken as overhang. On the basis of this information 27 representative jaalis were selected out of which three different thicknesses, solid-void ratio and overhang ratio were derived.[2]

Mass to void relationship

The mass and void relation seemed to be uniform for all jaalis for all the mosques and tombs. These were



Measurement position for each jaali panel and individual jaali in the Mosque of Bibi Achyut Kuki



Drawing of jaali panel illustrating solid-void ratio

found to be in between the range of 40% to 60% of mass and voids and vice-versa. The three typical solid-void ratios achieved were:

- 40 solid – 60 void (40s - 60v)
- 50 solid – 50 void (50s - 50v)
- 60 solid – 40 void (60s - 40v)

This aspect of jaali made clear that there is no co-relation between orientation and solid void ratios, as the mass to void relationship falls in the same range, irrespective of the direction in which it has been placed.

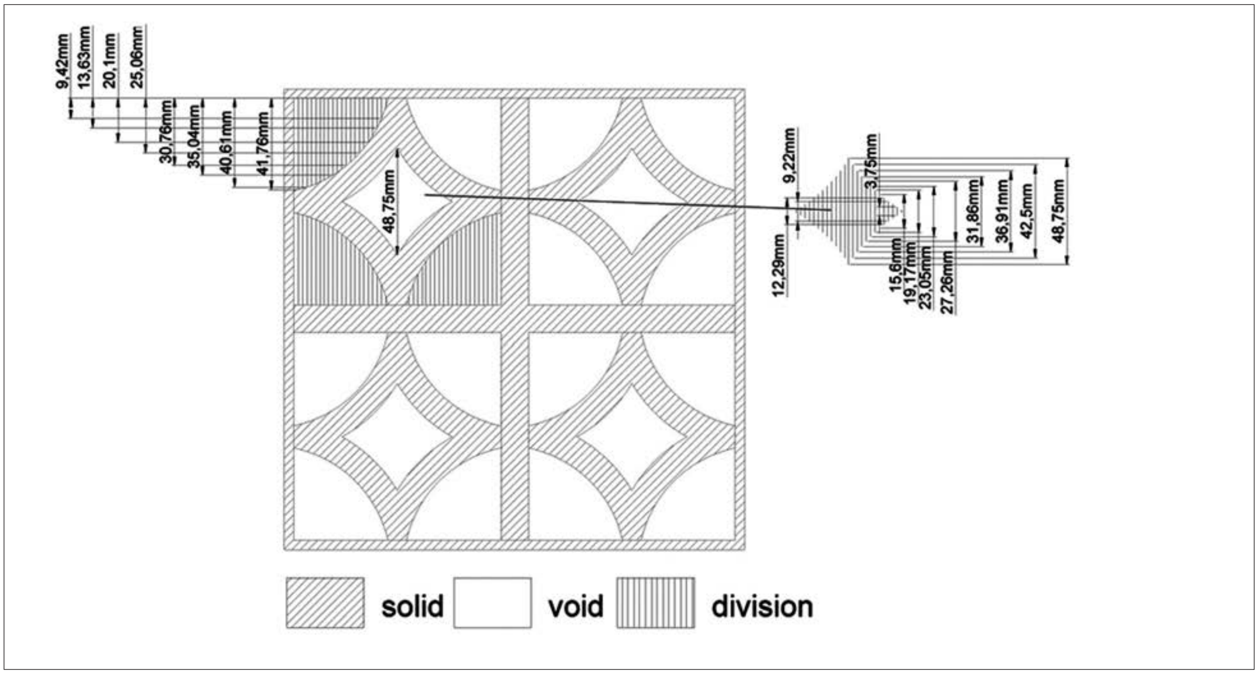
Overhang ratio

Another evaluation was carried out to determine what profile angles are made by the sun on the jaali. The concept of window and *chajja* (overhang) had been taken into consideration whereby each void was like a small window and the thickness of the stone was assumed to be an overhang.

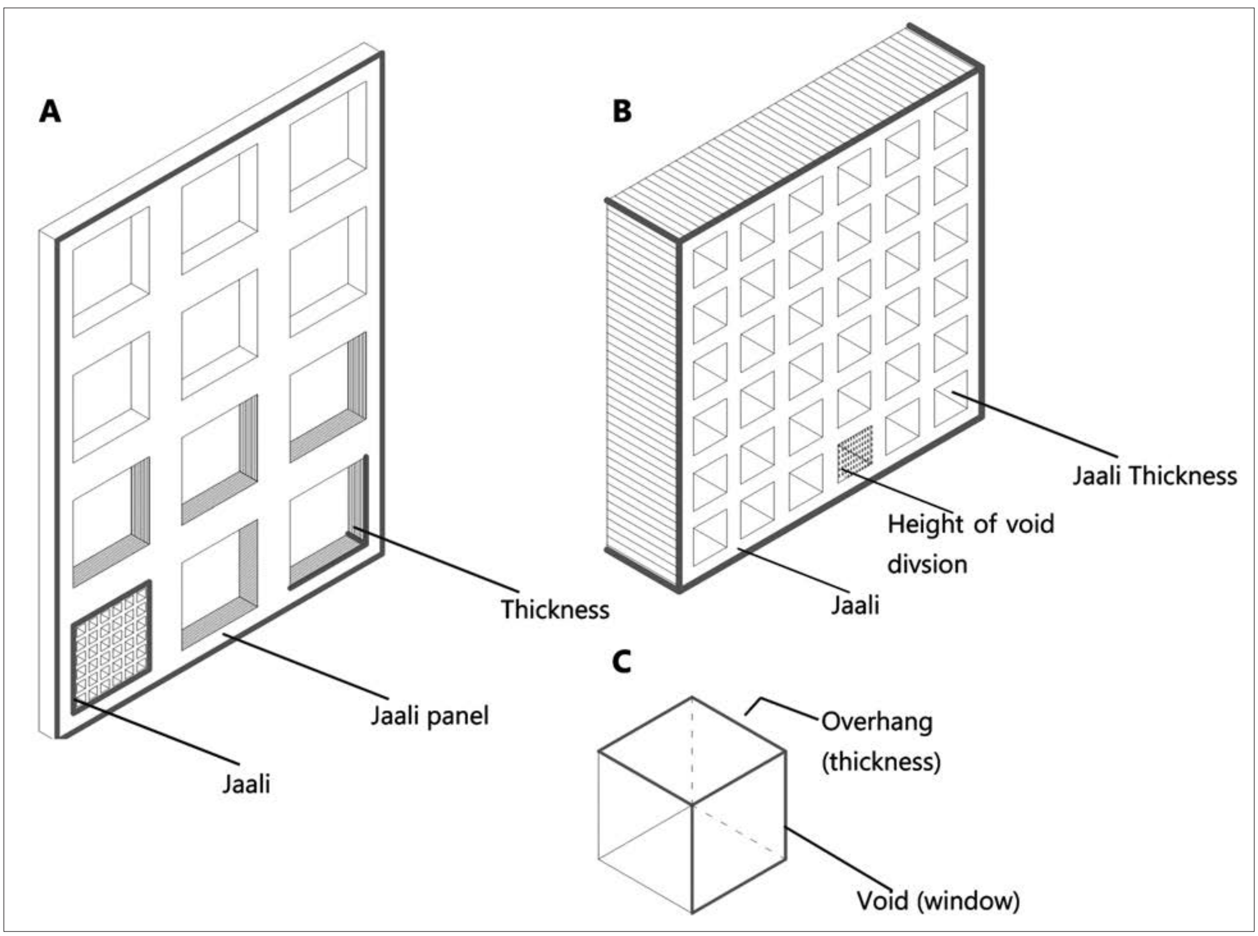
In this method the void of jaali was divided into equal number of parts, vertically with equidistant gap of two millimetres, throughout. The lengths were measured in the voids, plotted on a graph accordingly and the number of times the length appeared was counted. The results showed that with respect to the thickness of the jaali, the maximum depth of void fell into three ranges. The longest lengths achieved appeared less number of times and were almost equivalent to the thickness of the stone. The overhang ratios achieved, that is, thickness of the stone to the height of the void ratio were 0.8, 1.0 and 1.2.

SIMULATION FOR OFFICE SPACE

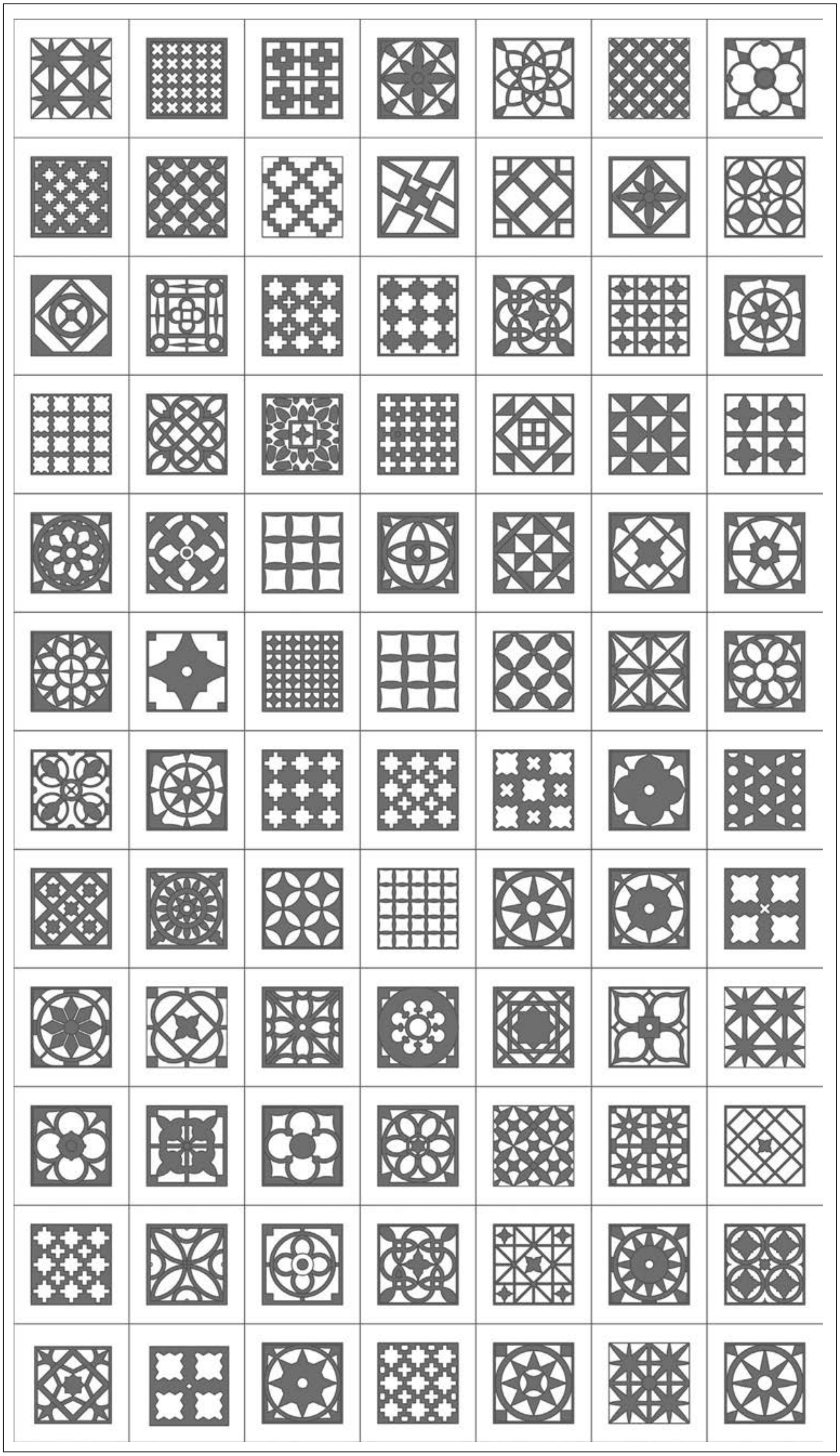
To understand the performance and application of the jaali in contemporary architecture, a small office of 3 metres x 3 metres x 3 metres size was considered in the context of Ahmedabad.[3] The jaali was placed on the southern side and was simulated with free horizon. The office model was configured through Autodesk Ecotect V5.5 and simulated through Desktop Radiance 1.02. Ecotect has Radiance Lighting System as inbuilt tool that extracts an illuminance map through radiance input values. Radiance employs backward ray-tracing algorithms. Input files specify scene geometry, materials, luminaries, time, date and sky conditions. Calculated values include spectral radiance or luminance + colour, irradiance or illuminance + colour and glare indices (Mardaljevic 1999; Aizlewood *et al* 1998). According to the study done by Kjeld (2003), a minimum study of sunlit situations should include the



Drawings of jaali showing height of void division, Jami Mosque (east wall)



Views showing sections of jaali depicting the relation between thickness of jaali and height of void. a. jaali panel frame with individual jaalis b. jaali showing height of void division with its thickness c. drawing showing void that is treated as a small window



Exploring solid-void ratio in jaali forms

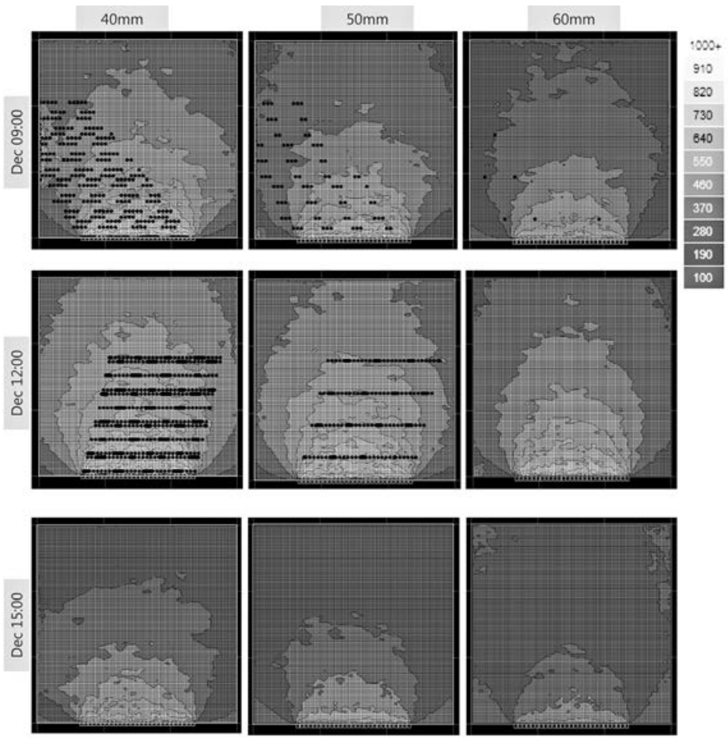


Figure showing ISO lux contour maps showing the variation of lux levels for different thicknesses of Jaali over a time period in a single day for 40s_60v ratio

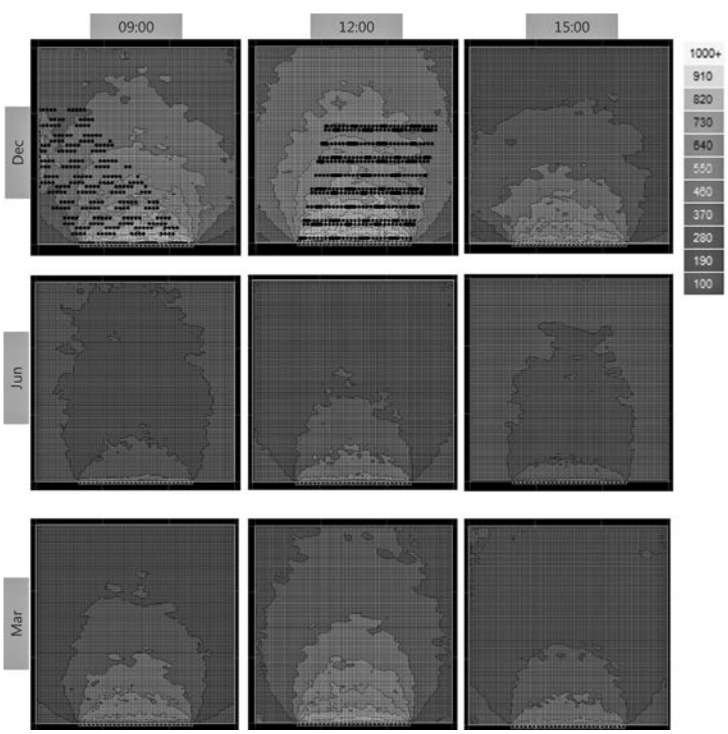
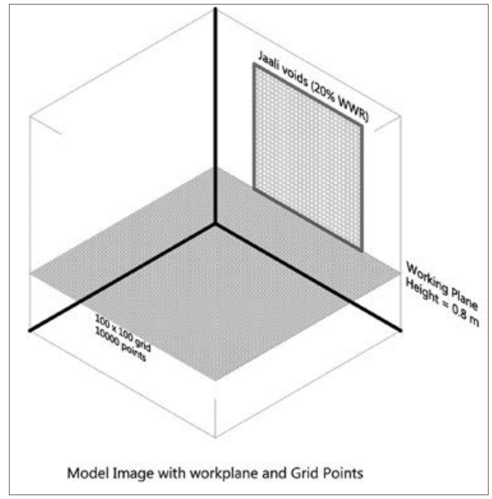


Figure showing ISO lux contour maps showing the variation of Jaali over a time period in a single day for illuminance on x-axis (center of room) - 40 millimetre thickness



Model image with work plane and grid points

winter and summer solstice days at noon time and once in the afternoon or morning. Different variations were made in the model with respect to change in thickness, solid-void ratio, overhang ration, months and time. The observations were noted 1.5 metres away from the jaali at the work-plane level for illuminance, uniformity and glare.

Illuminance

The illuminance levels are higher for 40-60 solid-void ratio when compared to 60-40 solid-void ratio for a 0.8 millimetres overhang ratio. 40-60 solid-void ratio has maximum illuminance and 60-40 solid-void ratio has the least illuminance with respect to all the cases. Similarly, a 0.8 overhang ratio has maximum illuminance level whereas 1.2 has the least with respect to all the cases. Illuminance level decreases with increase in the overhang depth from 0.8 to 1.0 to 1.2. It is identified that illuminance levels follow the linear trend of decrease from 40-60 to 60-40 solid-void ratio, with respect to overhang ratio. Maximum illuminance levels are found in December at 12:00 pm whereas minimum illuminance levels are observed in June at 3:00 pm.

Uniformity

Uniformity can be expressed as a ratio of maximum to minimum illuminance or minimum to average illuminance. A range of 0.29 to 0.89 is defined as a range for non-uniform level to uniform levels respectively.

Glare

The output was analysed through Radiance fish eye renderings and the values were extracted through Evaglare tool for different indices. It was observed that by following the index values of Daylight Glare Probability for all 81 simulated cases fall under the category of 'imperceptible' (<0.35), that is, difficult to perceive by the mind or senses. Through visual analysis of Glare images, it is identified that the jaali acts as a shading device, controlling the amount of direct light entering the room with respect to variation in overhang ratio. The amount of direct light entering the room increased with decrease in the solid void ratio. The maximum glare was found for 40-60 solid-void ratio that decreased with increase in overhang ratio.

CONCLUSION

The study of jaalis used in medieval mosques and tombs in and around Ahmedabad revealed that the thickness of a jaali is an important factor relating to its day light performance. The highest levels of illuminance and glare are achieved for solid-void ratio of 40-60 with an overhang ratio of 0.8. With increase in solid void ratio for a particular thickness, illuminance level decreases but gives more uniform distribution and less glare. With an increase in thickness, illuminance levels and glare decreases. A 60-40 solid-void ratio and 1.2 overhang ratio produces uniform distribution with fewer glares and desired illumination levels.

As per results of the computer simulation, the best configuration to achieve high illuminance levels for any jaali is a 40-60 solid-void ratio. Hence, this solid-void ratio can be used while designing openings, for achieving best illuminance. It was noticed that if an overhang ratio of 0.8, that is, 40 millimetre thickness, is combined with the 40-60 solid-void ratio, it gives a higher illuminance level relative to other cases. The simulation established that it is desirable to place the task areas in the central zone of the room, since the illuminance levels are uniformly distributed from the centre and the level is highest at the centre pertaining to all the cases. With reference to these cases jaali acts as a shading device also. The 40-60 solid-void ratio fails to be in the acceptable ranges of performing tasks with respect to glare. Considering the three parameters, the 40-60 solid-void ratio can be considered for achieving better illluminance levels and uniformity.

The jaali is rarely used in the current context and the provision of such an element has to be made more incremental. Contemporary designers have to re-think the idea of latticed screens in a new manner. Illuminance and glare are two most important aspects considering the use of natural light to artificial light. Most of the contemporary architecture with typologies such has offices rely and depend on artificial source of light neglecting the idea of natural light completely. Natural light in most of these buildings comes only by openings and not latticed screens. So the surface area of the façade becomes a challenge for the designers to get in the right amount of light and reduction of glare, which would vary 'with the kind of work place'. But instead of trying to develop a latticed screen façade, the designer in most cases decides to pack the façade without any openings thus relying completely on artificial light.

India is a developing country with minimum energy resources and as a designer, one should be conscious to use the methods that history has sought, suited to the contemporary process of design without compromising the time and context.

Bibliographic references

- Ali, N 2005, 'A new evaluation method for daylight discomfort glare', *International Journal of Industrial Ergonomics*, vol. 35, pp. 295-306.
- Borisuit, A, Scartezzini, J & Thanachareonkit, A 2010, 'Visual discomfort and glare rating assessment of integrated daylighitng and electric lighting systems using HDR imaging techniques', *Architectural Science Review*, pp. 359-373.
- Bellia, L, Cesarano A, Iuliano, G & Spada, G 2008, *Daylight Glare: A review of discomfort indexes*, DETEC – Universita degli Studi di Napoli Federico II, Napoli.
- Boyce, PR 1998, 'Lighting Quality: the unanswered questions', *proceedings of First CIE symposium on Lighting Quality*, CIE x015-1998, Vienna.
- Cantin, F & Dubois, M 2011, 'Daylighting metrics based on illuminance, distribution, glare and directivity,' *Lighting Research and Technology*, pp. 1–17.
- Gelil, N 2006, 'A new Mashrabiyya for contemporary Cairo: Integrating Traditional Latticework from Islamic and Japanese cultures', *Journal of Asian Architecture and Building Engineering*, vol. 5, no.1, May, pp.37-44.
- Johnsen, K, Dubois, M, Traberg-Borup, S & Grau, K n.d., 'By og Byg Documentation 047: Impact of three window configurations on daylight conditions', S*imulations with Radiance*.
- Kraus, J 2009. 'Evolutionary Performance: Passive Design for a Hotel in Central India',

Principles & Practices: An International Journal, November, pp. 9-53.
- Lainez, JMC 2008, 'The quest for light in Indian architectural heritage', *Journal of Asian Architecture and Building Engineering*, May, pp. 39-46.
- Omidfar, A 2011, 'A methodology for designing contemporary high performance shading screen- the integration of 'form' and the diva simulation tool', *Building Simulation*, November, pp. 1-8.
- Osterhaus, W n.d., 'Design Guidelines for Glare-free Daylit Work Environments', *Architecture and Civil Engineering, Lighting design research and development laboratory*.
- Wienold, J 2010, *Daylight Glare in Offices*, Thesis, Fraunhofer Verlag, Stuttgart.

Notes

[1] Overhang ratio is the ratio of height to the thickness of jaali that determines shading in each void.

[2] To evaluate the daylight performance of jaali, the output parameters considered are:

Output Parameter	Metric	Analysis
Illuminance	Calculating lux levels at work plane	Iso lux contour maps (100lx – 1000lx)
Uniformity	Ratio of uniformity across the room	Data analysis
Glare	Probability (number) rated according to Glare indices	Fish eye rendering through radiance

The input parameters used to configure model are described below:

Model Input

Model configuration	
Room dimension	3mx3mx3m
Work plane Height	800mm
Individual Void dimensions	50mm x 50mm
Solid-Void ratio	40s-60v; 50s-50v; 60s-40v
Overhang ratios	0.8, 1.0, 1.2 (corresponding thickness of Jaali: 40mm, 50mm, 60mm resp)
WWR	20%
Surface reflectance	
Wall	0.6
Ceiling	0.8
Floor	0.2
Jaali	0.6

Simulation input

Geographical conditions: Ahmedabad	**Coordinates: 23'02 N latitude 72'33 E Longitude**
Sky conditions	Sunny sky
Simulation day	21st March, 21st June and 22nd December
Orientation	South window
Ecotect grid size	100rows x 100 columns
Radiance Input Parameters	
Ambient bounces (-ab)	10
Ambient divisions (-ad):	1024
Ambient super samples (-as)	512
Ambient resolution (-ar)	41
Ambient accuracy (-aa)	0.08
Limit reflections (-lr)	12
Specular threshold (-st)	0.01
Specular jitter (-sj)	1.0
Direct jitter (-dj)	0.00
Direct sampling (-ds)	0.2
Direct pretest density (-dp)	4096

[3] The Danish Building and Urban Research, under the work carried out by Marie-Claude Dubois, Karl Grau, Steen Traberg-Borup and Kjeld Johnsen, suggests a method for the assessment of daylight quality in a room with simple geometry and window configurations with Radiance Lighting Simulation System as a simulation tool for its analysis.

Glazed Tiles
Historic use in Mandu and Agra

MALVIKA BAJAJ SAINI

ABSTRACT

Glazed tile work is a unique form of embellishment on historic fabric. A passionate eye for tiles can enchant one to pursue a trail searching for their rare remnants. An attempt has been made to document one such search through two cities in India: Mandu and Agra. Needless to say, wonders never cease as explorations continue. Due to their ornamental use on historic building elements, glazed tiles are prone to acts of vandalism in addition to the damage caused by forces of nature, thereby endorsing the need to document the remains.

INTRODUCTION

The earliest samples of glazed tiles have been unearthed from the ancient civilisations of Egypt and Mesopotamia. The Egyptians appear to be the first who used glaze on pottery, the art of glazing well known even in the pre-dynastic period before 4777 BC. Clay was universally available in Mesopotamia, the ancient civilisation of Babylonia and Assyria, and glazed colouring was used to relieve the monotony of the plain tiled surface. Ancient Persia inherited the traditional art of polychrome brickwork and preserved it from 539 BC to 331 BC. Brilliant works of Persian decorative artists have been seen from the 11th to 17th century AD. Glazing was a traditional art in pre-Islamic Iran. The early Arab invaders of Iran brought with them a religion, Islam, but no arts. The sacred tomb

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of the Prophet Muhammad, built in 707 AD, was lined with tiles that were probably obtained from Persia. This set an example to the faithful and tiling gradually became a feature of Islamic decoration (Nath 1989).

In India, there is evidence of handmade and wheel-thrown pottery making since the Neolithic age. Faience[1] was known in India as early as 4000 BC and the technology was used on beads, bangles and other clay ornaments. The technique for glazed tiles probably travelled from Iran to India with the Kushanas. Between the 12th and the 15th centuries, the art of tile work was imported into India from Persia, during the Delhi Sultanate period. The Delhi Sultanate court offered prosperous patronage and was an attraction to the fugitive artists of Central Asia where political conditions were fast deteriorating. Effectively, tile glazing seems to have been confined to a few regions; mainly Sindh and Bengal, introduced here by the great Pathan builder Sher Shah Suri and practiced later traditionally (Nath 1989). There is evidence of Afghan craftspeople being brought in by Rajput kings as well, for use of glazed tile work in their forts and palaces (Ravindranath 1998), as in case of Chittor, Ranthambor, Gwalior and Jodhpur.

Tiled architectural decoration was used in the provincial capitals also, chiefly at places where independent dynasties were established. It spread from Sindh and the Punjab to Kashmir at an early date in the pre-Mughal era. The arts flourished during the Mughal Era, from the middle of the16th century to the middle of the 17th century. The Mughal artisan adopted tile decoration and blended it with indigenous architectural traditions. The technique continued to be Persian but put to an Indian use. By 1818, the entire Sub-continent, except Punjab and Sind, was under British control. Due to British economic policies, Indian artists and craftspeople were marginalised. The use of tiles as embellishment also ceased (Ravindranath 1998).


Crenellations with blue enamels, Dihli Darwaza, Mandu


Band of tiles on ground floor domical ceiling seen in Jahaaz Mahal in Mandu


Tiles in miniature arches at interior of porch, Hoshang Shah's Tomb, Mandu


Tilework on the interior, Jami Masjid, Mandu

Tilework on gate, Agra Fort, Agra

EXPLORING PRE-MUGHAL AND MUGHAL TILEWORK

Pre-Mughal tilework in Mandu

Mandu, the capital of the Khalji Sultans of Malwa, contains specimens of glazed decoration that were used for better colour effects even though stone was abundantly available. Blue and yellow tiles were used on the borders and panels throughout the buildings, dating from the 15th century. The workmen were expert artists who knew the techniques of the art perfectly well and were probably brought from Multan or Persia (Nath 1989). A majority of the monuments at Mandu were raised between 1401 AD and 1526 AD, when the Muhammad kings of Malwa ruled independently from Mandu. The Mandu rulers and builders disdained at efforts to produce luxurious ornamentations or decorations on exteriors and interiors of buildings. The tiled decorations were an expression of the limited ornamentation that extended to all typologies: mosques, tombs and secular structures spread across Mandu.

Mughal tilework in Agra

Glazed tiles were used at Agra predominantly during the Mughal reign of Akbar, Jehangir and Shah Jahan, spanning over a century from 1568 AD to 1658 AD. The Mughal artisan continued the Persian technique but it was put to an Indian use in a resourceful manner by accommodating native modes of decoration along with the colour effects of glazed tiling.

During the reign of Akbar, glazed tile work in green, blue, yellow, red and white colours was used in geometrical designs, as seen in the Naqqar Khanah at Agra Fort. The Jehangiri Mahal within the Agra Fort built by Akbar has many forms of decoration. The glaze colours pink, blue and green were used here on stone surface, as in the southern chamber while glazed tiles along with stone have been used on the western façade on the frieze and fortifications. An isolated example of the use of glazed tiles for covering the roof is at Fatehpur Sikri in the so-called palace of Jodhabai. The roof of the north and south upper pavilions is overlaid with plain, flat and blue enamelled tiles which measure 19 centimetres x 9 centimetres. The purpose of their use here has been dictated as much by aesthetics as by utility. Some domes and cupolas of *chhatri*s (domed pavilions) of Fatehpur Sikri also seem to have been covered with glazed tiles originally. Use of tile work in religious architecture during Akbar's reign was seen limited to the Qiblah wall of the Jami Masjid at Fatehpur Sikri, around the central and side mihrabs. Green, blue and yellow tiles have been inlaid along with white marble and red stone in geometrical designs.

Akbar's successor Jehangir used glazed tile decoration on the third storey cupolas of his father's tomb at Sikandra. These are tessellated tiles in geometrical patterns, both straight and curved lines with floral border. Here the star pattern dominates but the ancient Hindu swastika has also been used. The Kanch Mahal from 1605 AD to1610 AD built by Jehangir near Akbar's tomb at Sikandara is named so due to the glazed tiling used in the hunting lodge. Blue, green and orange tiles have been used on semi-hexagonal cupola roofs of *jharokha*s (projecting balconies). The friezes have blue and yellow tiles. Blue and green tiles in geometrical patterns adorn the canopied roofs of the balconies on the eastern and western sides and of the bay-windows above the northern facade. Orange and blue tiles have been used on the frieze and parapet.

The Tomb of Firoz Khan Khwaja-sara and Chini ka Rauza are two significant structures dating from Shah Jahan's reign in which there was used of glazed tiling as means of ornamentation. Glazed tiles with floral designs were used in the tomb of Firoz Khan Khwaja-sara that are traceable on the friezes. It appears that the cupolas and domes were originally embellished

Tilework on chhatris, Sikandara, Agra

Tilework on parapet and roof of balcony, Kanch Mahal, Agra

with the same kind of decoration, but the glazed tiling has completely fallen off from those areas. The glazed tilework used on Chini ka Rauza is one of the most unique forms seen in India. A masterpiece built between 1628 AD and 1639AD, it is the mausoleum with remnants of tilework seen on the facades that are substantial enough to make one visualise the building's original magnificence.

The architecture of Chini ka Rauza abstains from the use of building elements such as brackets, *chhajja*s (balconies and *chhatri*s) since the effect of the façade tilework was envisioned to be of paramount importance. These are tessellated tiles, that is each tile represents part of the whole, and thus is a true mosaic in tiles. Tiles cover building elements in various forms here: blue Quranic inscriptions on white tiles enclosed by narrow floral borders in blue, yellow and green tiling; arch spandrels with blue and orange tiles in floriated arabesque patterns; orange and white tiles in zigzag pattern on the sides of arches; and cobalt blue bands in parallel rows horizontally. The facades are divided into panels and do not have identical patterns. The patterns are essentially Persian but have been conventionalised artistically (Nath 1989). The dome was covered with blue and yellow square tiles laid in diagonal bands. Remnants of multicoloured tiling are seen around the drum. The cornices, frieze and parapet were also tiled.

Natural weathering, neglect and vandalism have combined to rob the richness of the original ornamentation; nevertheless it is awe-inspiring and undoubtedly a unique example of remarkable tilework, a culmination of Iranian influence on Mughal culture and art. Some representative samples of this form of decoration exist in Lahore, Pakistan: the picture wall of Lahore Fort dating from 1612 AD to 1619 AD, Wazir Khan's Mosque from 1634 AD and Asaf Khan's Tomb from 1641 AD to 1645 AD.

STYLES AND TECHNIQUES OF APPLYING GLAZED TILES

The study points towards two distinct styles of glazed tiles used in architecture, square-style and tessellated. The square-style involves the whole design being divided for convenience into a certain number of comparatively large squares of uniform size. When put together these form the complete design. Thus each square tile represents not a single figure or geometric shape but a part of the whole design. On the other hand, tessellated is technically the true mosaic style. In this style tiny separate tile pieces of different sizes are cut up and assembled according to a certain design to form part of the whole figure or pattern or letter. Patterns were first traced upon the plaster prior to its hardening. Tiny tile-mosaic pieces were then carefully embedded like true mosaic into the face of the plaster covering the brickwork. This style was far more challenging and expensive.

In the exceptional tile-covered monument, Chini ka Rauza, the patterns of the tile mosaic are made up of countless tiny pieces of tiles. The following technique is used: first the face of the brickwork was covered with about five centimetres of plaster upon which two and a half centimetre plaster coat was applied. The patterns for the tiles were drawn on this plaster when in a plastic state. Tiles were prepared in accordance with this pattern. Each tile, about measuring 5/8th of two and a half centimetre thickness, was then expertly embedded in its allocated place in a pure mosaic style. Tiles were made of siliceous materials, resembling porous sandstone (Nath 1989).

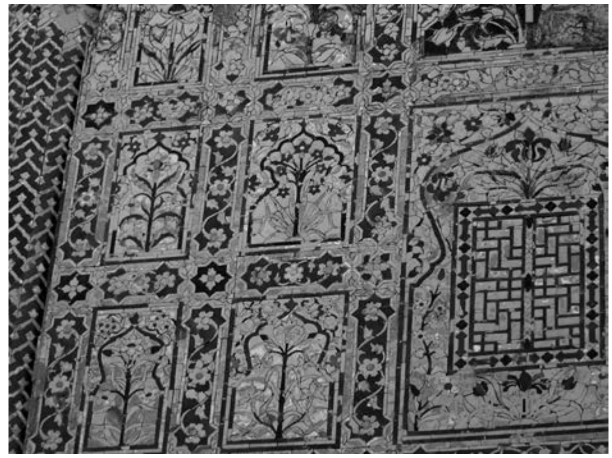
CONCLUSION

Architectural tilework is not only a form of ornamentation, it is a joyous fusion of science and art. It involves a keen sense of architectural detailing, knowledge of chemistry of glazes and an artistic composition of the whole. The centuries of traditional knowledge and the learnings from the various levels of experimentation have achieved these pieces of inspiring works. There is ample scope for generating sensitivity towards historic fabric as it is unparalleled yet undervalued. Guidelines should be prepared by experts for care and handling of historic material and that holds especially for embellishments such as tilework. There is a need to document and prepare inventories of the remains and delve further into scientific studies, since fragile remnants of tile decoration are vulnerable to acts of nature and humankind.

A documentation and inventory format for historic architecture with tilework should include:

- Architectural description
- Information on history
- Time period and region
- Location and distribution of tile work on building
- Physical attributes (colour palette, appearance, texture, size, patterns)
- Digital colour images of building and tiles (semi-rectified images to document)
- Schematic drawings of layout of tiles (measured drawings processed in CAD)
- Existing condition including typical defects
- Archival photograph, if accessible

Oral traditions and experimentation continue among traditional potters and artisans with regard to the use of traditional glazes and techniques. In northern India,



Exquisite tilework with a variety of patterns as seen in Chini ka Rauza, Agra

Detail of tilework on facade, Chini ka Rauza, Agra

Jaipur and Khurja glazed works are examples of the craft in continuation. Scientific studies of glazed tilework have been carried out in different parts of the world: to decipher composition and techniques, though these are limited when it comes to India. A renewed interest in various forms of glazed ware and research into this intriguing sphere would give an impetus to the revival of the exemplary art.

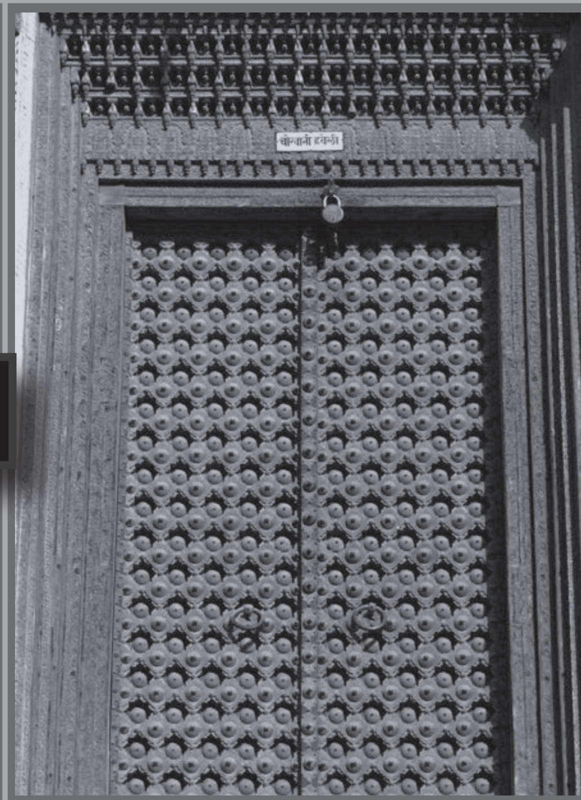
Bibliographic references

- Koch, E 1991, *Mughal architecture: An outline of its history and development, 1526-1858,* Prestel, Federal Republic of Germany, München.
- Nath, R 1989, *Colour decoration in Mughal architecture: India and Pakistan*, The Historical Research Documentation Program, Jaipur.
- Nath, R 2004, *Indigenous characteristics of Mughal architecture*, Indian History and Culture Society, New Delhi.
- Patil, DR 1992, *Mandu*, Archaeological Survey of India, New Delhi.
- Ravindranath, A 1998, *Pottery and the legacy of Sardar Gurcharan Singh*, Blue Pottery Trust, New Delhi.
- Riley, N 1987, *A history of decorative tile*, Grange Books, Kent.

Note

[1] Fine tin-glazed pottery on a delicate pale buff earthenware body.

Forms, Techniques and Experiments



Contemporary Explorations of Traditional Material Systems
Wai, Maharashtra

AMRITA MADAN AND NITISH JAIN

ABSTRACT

The hunger for 'modernising the built' in today's India is acute, widespread and has seeped far beyond the metropolis. Especially in small towns and settlements, the idea of modernisation ambiguously considers local systems to be inept for progress because of their inability to contemporise. Skills and knowledge systems of sustainable traditional building techniques either decay as neglected heritage or are simply replaced over time.

Potential solutions to this burgeoning issue may perhaps be found in an ideological shift that allows systems and techniques to contemporise; thus, modernise sans replacement. Indigenous construction systems in conjunction with contemporary materials can yield parallel visual languages while allowing life systems to be modern, yet local.

The settlement of Wai in Maharashtra, serves as a classic example for the above discourse.[1] At the foothills of the Western Ghats and along the Krishna River, the historic town offers a particularly regional and unique built heritage, threatened with annihilation.

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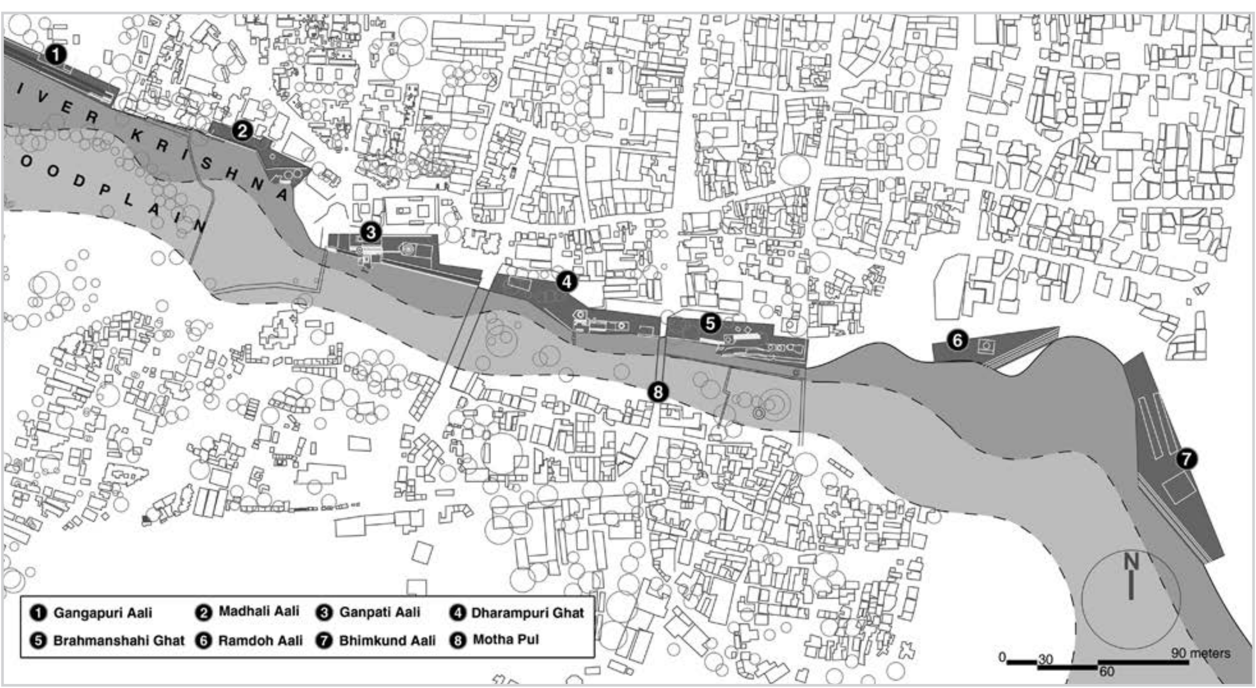
The Dharampuri Ghat and the Ganpati Aali as the face of Wai. Source: Ravali 2013

Gangapuri Ghat and the entrance of Krishna into Wai

INTRODUCTION

Wai originated as a settlement of weavers, its name is an adaptation of the word *vaya*, which means 'thread' in Sanskrit. Even though one cannot accurately pinpoint the timelines of Wai's origin, its current built heritage is witness to the style associated with the Marathas in the 1700's. Situated at the foothills of the Western Ghats, Wai welcomes the Krishna river onto southern plains after its origin near Mahabaleshwar. This geographical positioning, coupled with Krishna's reverence (Markham 1877) in India, historically allowed Wai to thrive as a religious centre. Seven *ghat*s (flight of steps leading down to a river), one apiece for offering prayers to Krishnabai[2] each day of the week, define the breadth and are the face of the settlement. This expanse of the seven *ghat*s from west to east: Gangapuri Aali, Madhali Aali, Ganpati Aali, Dharampuri Ghat, Brahmanshahi Ghat, Ramdoh Aali and Bhimkund Aali, is dotted all along with various temples using basalt and lime (Cousens 1897). Prominent amongst these are the Mahaganpati Temple, the Dholya Ganpati and the Kashi Vishveshwar Temple. These layered relationships of the *ghat*s and the temples, similar to those of the Ganges in Varanasi, led to Wai being hailed as Dakshin Kashi or 'The Benaras of the South' (Bakker 1990) and Virat Nagri or 'The Majestic City'.



The town of Wai: The seven ghats, River Krishna and the southern floodplain

With such an articulated riverbank on the northern edge of Krishna, the ‘mass’ of the city developed to the rear, inwards, and in conjunction with the *ghat*s. The city, therefore, has a network of primary streets, spreading into the landscape, defining districts and suburbs. The advent of the British rule and their pioneering civil technology connected the city with the southern bank of the river and it grew correspondingly as the ‘new’ side of the town. Other than the specific building systems of the temples, whatever remains of the traditional urban fabric of Wai opens a window into the very specific construction techniques and wide material palette that were prevalent in the region. Buildings such as the century old Govardhan Sanstha ‘Gowshala’ (SPA, Conservation Studio 2013) can be credited with propagating these techniques and materials into the region at large because of their inherent iconic nature within the socio-cultural and religious context.

The traditional building systems used profusely in these structures of Wai and its surrounding areas combined exposed and plastered brick, structural and decorative timber, stone in foundations and as flood resistant walls, lime mortar, terracotta tiles, and Galvanised Iron (GI) sheets. Worthy of the current discourse and interesting to note is that this combination of materials and systems do not seem to be part of a larger building tradition of Maharashtra and Wai with its surroundings[3] stands out within the built landscape.

Today, despite the historical relevance of Wai, with its temples and *ghat*s, relatively unknown to the outside world, the city has become (in)famous due to Bollywood’s penchant for using it in film shoots, lending a ‘made up’ character to its environs and paying almost no real importance to its built heritage, comprised of its unique building system that combines materials creating a very different visual language within its context.

The degradation of the built heritage is to such an extent that even the long time inhabitants of Wai do not realise the value of this system. Under the garb of modernisation, undercurrents of ‘monolithising’[4] the built are forcing replacement of traditional materials and techniques more and more by concrete and cement

The various traditional building systems of Wai

Monolithic concrete structures, perceived as 'modern', seen replacing the traditional systems across typologies throughout the town

plaster. In some cases, entire buildings are being replaced by monstrosities created using the latter.[5]

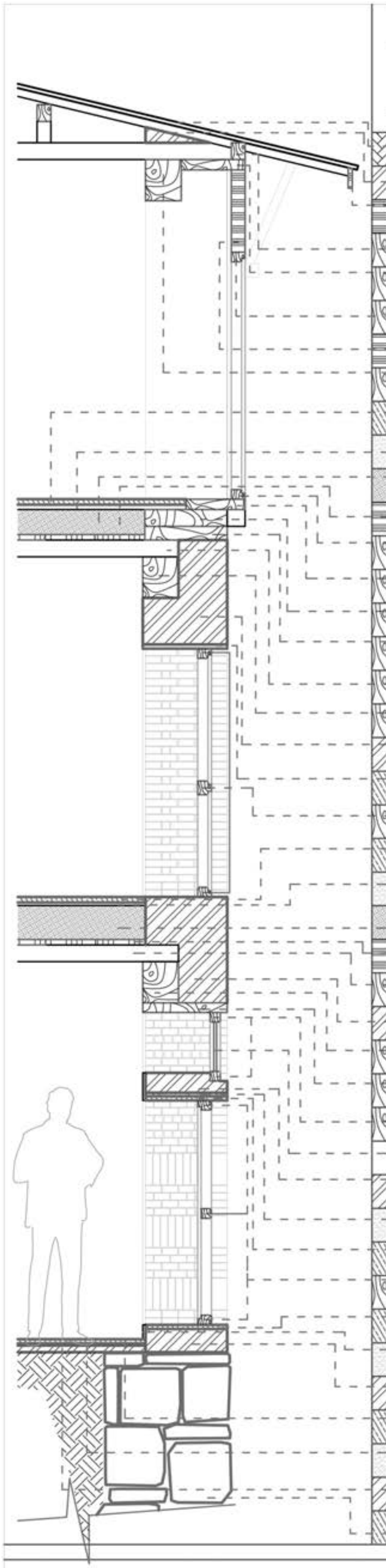
TRADITIONAL CONSTRUCTION AND MATERIAL PALETTE

The archetypical building section in Wai comes across as composite and layered in a way that is very specific to the region as far as the kind, range of sizes, attributes and type of usage of materials is concerned. The materials used are those typically seen in traditional settings combined with ones that often appear in contemporary scenarios. Timber, brick, stone, lime, clay and GI, all make appearances in various ways in the buildings. A visual language develops out of this blend of common materials such as brick, timber and stone being used not only in co-existence with each other but also simultaneously in different roles; their location on the section, their sizes, attributes and type of usage all evolving to form a flexible yet cohesive construction system. In order to understand the myriad roles played by each, classification of most materials can be done as follows:

- First Degree Structural (FDS) for primary elements such as columns and beams
- Second Degree Structural (SDS) for secondary elements such as lintels and brackets
- First Degree Protective (FDP) for creation and protection of internal space or the first degree of protection
- Constructional Infill (CI), can be a binder, insulator or a filler
- Second Degree Protective (SDP) that protects any one the above three or non-essential space.

In most cases, the material and construction systems achieved are flexible to the extent that the 'materials' used in the buildings appear under at least three out of four of these categories.

When read ground upwards, any classic external wall section of a traditional building indicates the following: the foundations and the plinth are made in *khadi* (basalt stone) that would at times extend to form a dado against flooding. Above this, the ground floor is realised either in a load bearing brick masonry or in a timber frame structure using *saangwaan* (teak wood). In case of the latter, brick masonry creates walls between the timber columns. Since most buildings have an upper superstructure, horizontal load distribution ensues through timber beams on the columns or walls, and a secondary timber beam grid is used for bracing.



MATERIAL		FIRST DEGREE STRUCTURAL	SECOND DEGREE STRUCTURAL	FIRST DEGREE PROTECTIVE	CONSTRUCTION INFILL	SECOND DEGREE PROTECTIVE	ATTRIBUTES		
ORDER & SYSTEM	APPLICATION	FDS	SDS	FDP	CI	SDP	KIND	SIZE (mm)	FORM
CORRUGATED SHEET	ROOFING			■			GALVANIZED IRON	2400 X 1200	LAMINAR
BRICK	FILLER				■		CLAY	230 X 115 X 50	BLOCK & AGGREGATE
TIMBER	EAVE					■	SANGWAAN (TEAK)	150 X 30	LAMINAR
TIMBER	PURLIN	■					SANGWAAN (TEAK)	120 X 100	POST
TIMBER	LINTEL		■				SANGWAAN (TEAK)	465 X 75	LAMINAR
TIMBER	WINDOW FRAME			■			SANGWAAN (TEAK)	80 X 100	POST
BOARD	WALL			■			COMPRESSED HUSK	65 THK	LAMINAR
TIMBER	BEAM	■					SANGWAAN (TEAK)	80 X 100	POST
STONE	FLOOR FINISH			■			KHADI(BASALT)	40 THK	LAMINAR
MORTAR	BINDER				■		LIME	35 THK	
SAND AND HUSK	FLOOR SLAB				■			180 THK	BLOCK
TIMBER	FLOOR SLAB		■	■			SANGWAAN (TEAK)	40 THK	LAMINAR
TIMBER	WINDOW FRAME			■			SANGWAAN (TEAK)	80 X 100	POST
TIMBER	SILL			■			SANGWAAN (TEAK)	430 X 75	LAMINAR
TIMBER	BEAM	■					SANGWAAN (TEAK)	600 X 120	POST
TIMBER	STRINGER		■				SANGWAAN (TEAK)	600 X 100	BLOCK
TIMBER	BEAM	■					SANGWAAN (TEAK)	120 X 120	POST
TIMBER	BEAM	■					SANGWAAN (TEAK)	260 X 300	POST
BRICK	WALL	■		■			CLAY	230 X 115 X 50	BLOCK
TIMBER	LINTEL		■				SANGWAAN (TEAK)	615 X 30	LAMINAR
TIMBER	WINDOW FRAME			■			SANGWAAN (TEAK)	100 X 100	POST
STONE	FLOOR FINISH			■			KHADI(BASALT)	40 THK	LAMINAR
MORTAR	BINDER				■		LIME	20 THK	
SAND AND HUSK	FLOOR SLAB				■			270 THK	BLOCK
TIMBER	FLOOR SLAB		■	■			SANGWAAN (TEAK)	40 THK	LAMINAR
TIMBER	BEAM	■					SANGWAAN (TEAK)	120 X 120	POST
BRICK	WALL	■		■			CLAY	230 X 115 X 50	BLOCK & AGGREGATE
TIMBER	BEAM	■					SANGWAAN (TEAK)	260 X 300	POST
TIMBER	LINTEL		■				SANGWAAN (TEAK)	615 X 70	LAMINAR
TIMBER	WINDOW FRAME			■			SANGWAAN (TEAK)	70 X 75	POST
WIRE MESH	VENTILATOR					■		2 THK	LAMINAR
BRICK	WALL	■		■			CLAY	230 X 115 X 50	BLOCK & AGGREGATE
MORTAR	BINDER				■		LIME	25 THK	
STONE	LINTEL		■				KHADI(BASALT)	40 THK	LAMINAR
TIMBER	WINDOW FRAME			■			SANGWAAN (TEAK)	70 X 75	POST
STONE	SILL			■			KHADI(BASALT)	40 THK	LAMINAR
PLASTER	FINISH					■	LIME	20 THK	LAMINAR
BRICK	WALL	■		■			CLAY	230 X 115 X 50	BLOCK & AGGREGATE
STONE	FLOOR FINISH			■			KHADI(BASALT)	30 THK	LAMINAR
MORTAR	BINDER				■		LIME	15 THK	LAMINAR
BRICK BATS	FILLER				■		CLAY	230 X 115 X 50	BLOCK & AGGREGATE
STONE	PLINTH	■		■			KHADI(BASALT)	900 THK	BLOCK

An example of the analytical matrix of the construction systems and material palette

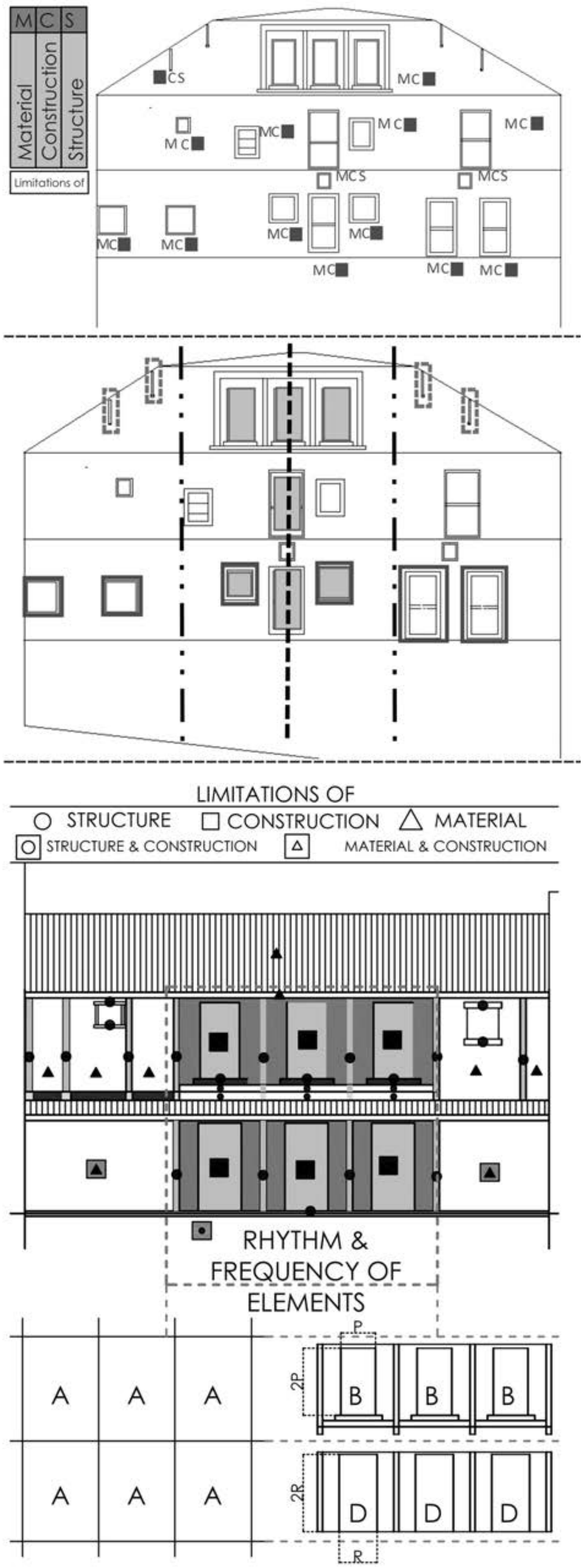
Concrete mimicking timber: early examples of introduction of concrete in the town

The microsystem of apertures and perforations integral to the visual language of the region

Layered above this is a composite slab with a base 'tray' of timber planks or stone slabs, onto which is filled a dry mixture of sand and husk or brick. This thick amorphous concentrate provides both thermal and acoustical insulation to the habitat below. The beam and slab system extends as a running balcony or an extension of an enclosed space cantilevering from the wall behind. In most cases, the cantilevering internalised space is supported by exposed and non-decorative timber brackets providing a rhythm to the facade. The floor is finished in stone slabs. The upper floor, regardless of the lower storey, remains a timber frame structure with wall panels varying from timber planks, husk boards or a continuation of brick coursing. A filigree timber railing, the most visibly ornamental component in the façade, wraps around the balcony slab and is intercepted with leaner timber posts rising to the roof level.

The structural system for the first floor limits the possibility of creating an accessible terrace above and as such across Wai, pitched roofs cap the buildings. The framework for the roof is a timber truss tied to the columns. In case of a gable or a gambrel roof, the gable end seamlessly continues upwards in the same material as the wall from below and becomes a part of the floor's external syntax. Capping of the hip and pitch is in clay tiles or GI sheets and timber eaves, both decorative and plain, finish the roof.

The logic of construction is conveyed not only through the building section but evidently presents itself on the elevation. As such, the structural material tends to be the most visually expressive on the façade. In the case of load bearing brick structures, countless examples are available that emphasise the effort paid to the 'design' of brick coursing. The same may or may not be true where brick lends itself as FDP material. Similarly, buildings or floors realised through a timber frame structure, explicitly express the material by 'presenting' its various structural occurrences such as columns, cantilevered beams, brackets, lintels and sills. Timber used indoor and window shutters, or the minimally used fascia bands, SDP in nature, are seldom carved



Examples of elevation assessment: limitations of material, construction, structure and ideas of rhythm, frequency and repetition

or decorated. Through such expressions, one sees the structure becoming a generator of the visual language. The idea is so strong and evident that some of the first expressions of reinforced cement concrete use have columns along the balcony that are 'lean' and mimic the proportions of timber posts.

The façade is a composite system with a balance of the penetrable and the impenetrable. The span between two columns is a non-load bearing panel, centred on which is an opening. The fenestration on an opening ranges from a door, a door-window, casement and clerestory[6] windows, and fixed perforations. This range becomes important in the visual vocabulary of Wai as the height of the opening is the only unconstrained factor, ideas of balance and symmetry limit its location on each panel, asking for it to be centred horizontally. Furthermore, the construction system limits the span of the aperture. The openings are commonly spanned through a timber or stone lintel, accompanied by an equally visible sill of the same material, or through brick arches. The arched openings appear to have evolved over time, originating from the simple segmental arch and flat arch to a relieving arch[7] that involves brick and timber lintels.

Particular to the region, access to most buildings is through a characteristic *aala* (externally projecting plinth at the entrance threshold), forming a semi-public space between the building and the street. With its location and volume on the façade, the *aala* identifies the main entrance of any structure. Else, the primary opening would not get conveyed as being unique from the other fenestrations present on the elevation.

The construction system reflects itself on the visual language even through the rhythm and frequency of the fenestration types. Structures that have the ground storey realised in brick masonry have smaller sized, lesser number of openings, as against their upper counterparts of frames and infill panels where the system allows for a higher frequency of fenestrations.

IDEAS OF CONTEMPORISATION

Currently, Wai is in a state of flux with the general perception of the inhabitants being that the traditional building systems do not meet the challenges of urbanisation and the way forward is by their termination and replacement. The major apprehension is of the traditional construction system's inability to allow control of the internal environment to the user. Similar to many towns of semi-urban India, Wai seems to be heading for a vocabulary that unites it with the 'urbane' surroundings and the world at large: a 'global-modernism' that is sooner or later scrutinised for its validity in the country. In an attempt to investigate the limitations of the traditional building systems towards an altering lifestyle, several concerns became evident. The first concern is that of overall volumes that is related to floor heights, floor spans and internal areas. Neither of the two structural systems present are capable of delivering internal spaces higher than the existing, without a loss of effective floor space and an increase in the structural mass. The timber beams, although present as primary and secondary grids, cannot span excessively, hence controlling the depth of the system. Spanning in either direction would mean a consequent increase in the number of columns, thereby reducing the floor efficiency.

Column heights and beam depths together control the clear height of internal spaces, rendering these compact. This limitation restricts the overall number of floors possible within each building. Noticeably, most buildings following the traditional systems cannot extend beyond two floors in the case of timber based structures and a handful go up to three floors in cases where the load bearing element is brick.

The second concern is that of surfaces, particularly cantilevers and terraces. Beyond balconies and the small cantilevers possible with timber beams, the traditional system is starkly devoid of exposed horizontal planes such as terraces and flat roofs. In the case of vertical planes, infill materials such as husk boards and timber panels of the used thickness lose their durability over time, with the exception of exposed brick coursing. Hence, these materials call for surface treatment or replacement with sturdier materials that result in a compromise of the visual language.

The third concern is that of perforations and the microstructure, particularly their span, frequency and types. Timber and stone become limiting in their application as lintels. This results in restricting the width of all fenestrations and the possibility of freedom to this microstructure would have a variety of reflections on the spaces, both internal and external. The limitations, as is clear, are 'part-based' and do not necessarily require a complete replacement but can be addressed through modern supports, to strengthen and add value to the traditional.

The parameters of choosing the material insert being critical, aspects such as material strength, its capacity to fit into the composite building system of Wai and a presence in the environment became the drivers of the process of insertion. One tool to aid this hypothesis is the analytical matrix of the material palette, by checking the ability of any sample to fit into at least three of the defined categories, preferably all four.

For example, a material would be deemed fit for introduction if it could be used as FDS or SDS, FDP and CI, giving the SDP category a miss. This means that the material is adaptable to different 'forms' such as laminar, post or block, allowing for flexible individual expressions making the inserted material itself a potential trigger for parallel visual languages. Mild steel may thus take the form of structural sections, girders and reinforcement, protective surfaces and panels and SDP as railings, eaves, flashings or perforated metal sheets. Concrete may be used in the form of structural cement concrete or ferroconcrete[15], protective pre cast modules and panels, infill through plain cement concrete and SDP through cement plaster and *jaali* (perforated screens).

PARALLEL VISUAL LANGUAGES

In order to successfully re-introduce these new materials into the building palette in such a way that these do not 'replace' but 'resolve' existing issues, the following parameters may be explored:

- Addressing the limitations of the traditional building systems by inserting either mild steel or concrete at 'target' locations in the building section.
- Facilitating composite systems by limiting the use of the above said materials in a way that its application did not exceed a margin of 30% of the overall composition.
- Generating a variety of expressions by using the inserted material in different roles as a subtle addition to the visible material palette or as a volume generator or to establish alternates within the existing visual and constructional language.

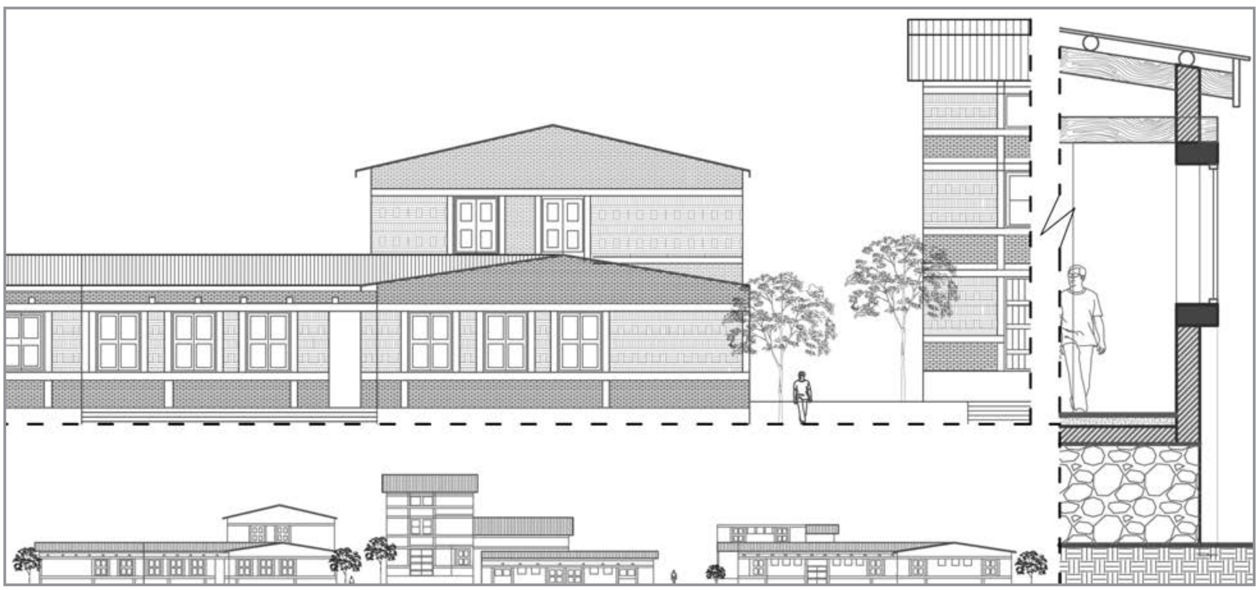
Given these objectives, an analysis of the nature of inserts indicates that the extent of adaptation is a product of the target locations of the inserts. When correlated with attempts at resolution of the limitations, an indication of both the type: structural, protective or infill and the level: first or second degree, at which the inserts need to be made, is given. A few examples are catalogued herein and highlight the following:

- Singular inserts addressing singular limitations
- Singular inserts addressing multiple limitations
- Multiple inserts addressing multiple limitations

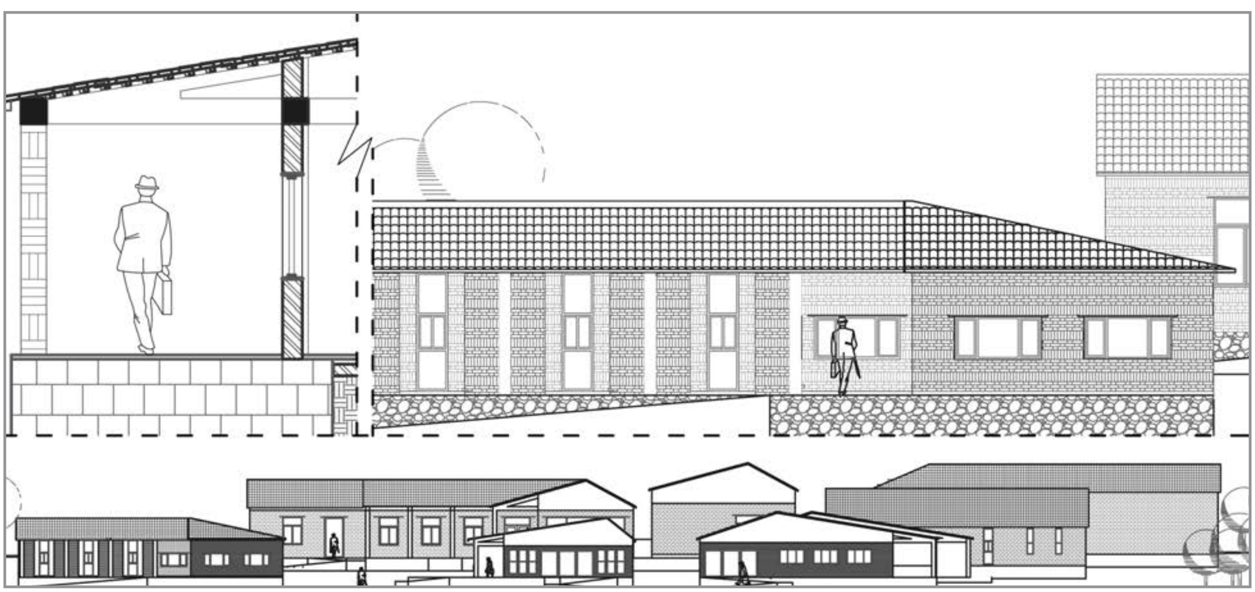
Singular inserts addressing Singular Limitations
Output one and two explored for this approach offer evidence to the fact that addressing singular limitations through singular inserts leads to the duplication of existing systems and will eventually result in the local knowledge systems being redundant and replaced completely. In both scenarios, the result is a 'blind' application of the new material. The features of the output are not in tandem with the features on the existing systems.

Singular inserts addressing multiple limitations
Output three and four explored using this approach provide substantive grounds for the understanding that singular insertions at either FDS or FDP levels can be valid as long as multiple limitations are addressed. An FDS insert engaging with both volumes and surfaces results in a product that is composite at various levels and does not dilute the roles of the existing materials, components therein not eliminated and where micro systems are generated in a cohesive manner.

Multiple Inserts addressing Multiple Limitations
Noticeably, when multiple inserts are made, these tend to engage multiple limitations. The idea of 'multiple' attains clarity through the following:



Output 1: FDP Insert for perforations - concrete for wall and window panels[8]



Output 2: FDS Insert for spans - concrete in form of beams and columns[9]

- When inserts are made at multiple levels within the same type, such as the combination of an FDS and an SDS level insert, as explored in output five and six, it leads to the new material, mild steel, entirely replacing the role of timber. The 'loss' of an existing material is, consequentially, a deterrent for the continuity of local knowledge systems. Here, the proposed built form can be 'of anyplace' and such a process, a catalyst for 'monolithisation'.
- When inserts are made at multiple or same 'levels' across 'types', it leads to the formation of cohesive and inherently composite visual languages. The proposed systems remain relevant and limitations are sufficiently addressed. A second-degree insert of one type needs to be supported by a first-degree insert of another type for the proposed built to 'belong' and take local knowledge forward. However, it is to be noted that, multiple second degree inserts across types are, by their own definition, insignificant and might not address the given limitations.

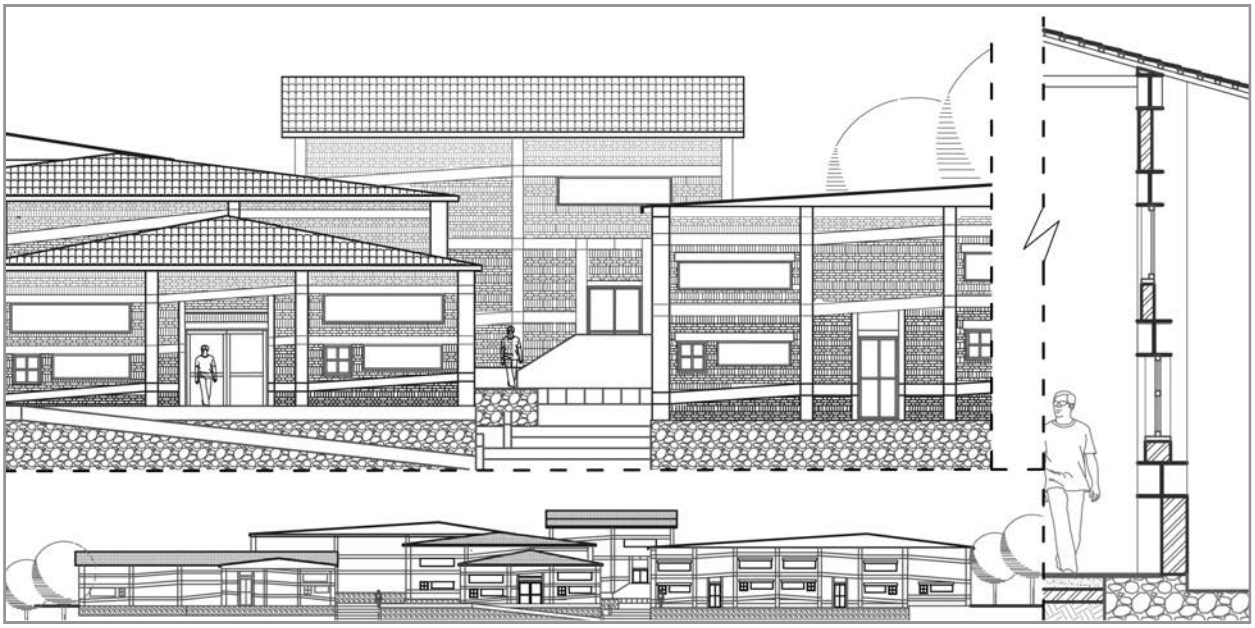
Output 3: FDS insert for volumes and surfaces - concrete in form of beams and columns[10]

Output 4: FDS insert for volumes and horizontal surfaces - concrete in form of beams and columns[11]

CONCLUSION

The output of exploration in to parallel visual languages clearly demonstrates that the particular knowledge, along with building and construction systems of this region are capable of adaptation and can be moulded to respond to contemporary needs. The need is to generate alternatives that address the three major limitations of the existing system, extend the features of the current system and initiate possible expressions that are valid for the continuity of the existing in the contemporary.

Firstly, it is essential that a new or contemporary material does not fully take away or ‘replace’ even a single material from the existing material palette. In this way, the system remains composite and non-reductive. Secondly, the intrinsic composite nature of the existing system should be further highlighted in such a way that no building component appears with a singular material output. Rather, it is expressed in different materials within the same system. Thirdly and lastly, continuity of systems will be ensured when a building’s structural system whether it is traditional or



Output 5: FDS and SDS inserts for volumes and perforations - mild steel in form of beams[12]

Output 6: SDS and FDP inserts for vertical surfaces and perforations - concrete for wall panels, masonry blocks and jaali walls[13]

Output 7: FDS, FDP and CI inserts for volumes and vertical surfaces: concrete for beams, concrete blocks for cavity walls and plain cement concrete for floor infill[14]

modern, becomes the generator of the visual language beyond being simply expressive on the façade. Not only is it imaginable to contemporise a decaying system but the idea of 'deriving contemporary from traditional' can be explored in diverse ways. This particular method, based on the choice parameter of 30% insertion of a new material, establishes a framework for manifestation and realisation, within the ideology of preventing new and modern materials from taking over and replacing older systems. A further discourse is propelled on the nature of materials and technologies that are appropriate for plugging in such traditional building systems.

A 30% insertion is assumed to ensure that the composite nature of the local systems will be maintained. However, it becomes clear that a 30% insertion can also result in monolithisation if done in a singular manner alone. If done compositely, can an insertion be made with a higher ratio in the material palette? At what volume of insert does the system detach from its roots and simply be modern?

Looking beyond materials and expressions, another way of engaging with the same question could be the consideration of the space 'behind' the façade. A multitude of processes along similar lines can be developed on the modernisation of space, both urban and built, taking cues from the visual language or establishing new systems of their own. When combined with usage and related spatial issues from the users' end, the process can acquire added layers for developing on-ground approaches.

In various contexts globally, architecture regularly strives to mediate between the past and the present, questioning its own future. This investigation has been able to articulate and propose one actual method pertaining to the idea of derivation and synthesis. As the fruits of an intellectual exploration, it is no longer in the realm of theory and can feed means and ways to develop practices, both academic and professional. This built environment's value as heritage, in the current times, is seen through freezing[16] the traditional systems as a way of preservation, causing the system to decay nevertheless. However, it is possible to augment the lifespan of this rich heritage and its value is only heightened when the composite system is viewed as an opportunity; the local skill and knowledge it comes with, as the appropriate trigger for a way forward.

Acknowledgements

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Bibliographic references

- Bakker, H (ed.) 1990, *The History of Sacred Places in India as Reflected in Traditional Literature: Papers on Pilgrimage in South Asia*, Brill, The Netherlands.
- Conservation Studio 2013, *Urban Conservation at Wai*, M. Arch, unpublished, School of Planning and Architecture, New Delhi
- Cousens, H 1897, *Lists of antiquarian remains in the Central Provinces and Barâr*, Office of the superintendent of government printing, India.
- Markham, C 1877, 'Irrigation in Southern India', *The Geographical Magazine*, vol. IV, p.307.
- Ravali 2013, Hindu Temples on the Krishna River at Wai, Satara, Maharashtra, India ca. 1855-1862, India, Old Photos, viewed June 26,2014, <http://www.oldphotos.in/2013/09/hindu-temples-on-krishna-river-at-wai.html>
- Scenic Nature Beauty 2012, Metrica the resource development centre's photostream, Flickr, viewed June 26, 2014, <https://www.flickr.com/photos/metricaphotos/7942115272/>

Notes

1 The case study for this paper was carried out as a part of the Second Year Design Studio 2014 at the Sushant School of Art and Architecture, Gurgaon.

2 As is the case across the country, most major rivers carry a strong mythological association, generally in the form of a female deity. In case of River Krishna, the deity is colloquially referred to as Krishnabai.

3 The traditional building systems discussed herein are known to be prevalent in other parts of Satara District and can also be found in nearby areas including Kolhapur, Pune and Nashik.

4 The term is used to mean making something monolithic by building excessively in one material, mainly concrete, leading to a very uniform visual language that stands in stark contrast with the traditional built form of the region.

5 In order to understand whether the existing systems and techniques continue to be relevant and usable in contemporary times, an academic investigation was undertaken as a part of the Second Year Design Studio exercise in Winter Semester 2013–2014 at SSAA, Gurgaon. Here, an attempt was made to simultaneously assess the traditional systems, their capacities to evolve while introducing a fresher and more contemporary material into the mix in such a way that it augments the lifespan of the existing systems while answering present day needs. Within this idea of the built lay another objective: of integrating newer systems into an older system to allow the older system to thrive, giving value to the building traditions of the area and the artisans of the dying system.

6 A window that is placed above eye level or at the topmost part of a wall, close to the roof of the building.

7 A segmental arch is comprised of a circle segment and functions like a regular arch. A flat arch is flat and horizontal in profile. Its application is similar to that of lintel and load distribution is the same as a regular arch. A relieving arch is built over a lintel and is a visual combination of a lintel and an arch. It relieves the pressure on the lintel by distributing the dead load of the wall above.

8 This work by Megha Khandelwal attempts at an enquiry of another possible output of the visual language and delves into ways of assigning new roles to both the 'inserted' material (concrete) and to materials from the existing palette (timber and brick). Concrete is used only as a visual element of the façade and not in its usual structural role. Timber is used as blocks and panels on the same façade and brick is employed as a secondary infill element, playing no role in either generating the 'look' or in the structure. Timber beams and columns used as primary structural components much in the same way as in the traditional, are neither generators of the 'alternate' language nor expressive on the façade.

9 In this particular output by MananTalwar, considerable focus has been on designing the brick coursing in detail; however the overall result is that of a system that has been unable to adapt or generate a language. The systems are not composite and the inserted material is not expressed. Materials such as brick in a FDP role become most expressive, essentially negating the local knowledge base. This work neither tends to belong nor derive contemporary from the traditional. It builds on focused expression of a single material (brick) resulting in the loss of materials in multiple roles as in the local system.

10 Here, Naina Thakur has made an effort to generate alternate expressions by inserting concrete essentially as 'Structural' resulting in a contemporary interpretation of use of concrete. Structure does not generate the visual language but its use is rather as a tool to extrapolate newer outputs from local systems. The final result can be seen as a manner of increasing overall building heights without the expected 'monolithisation'. It builds on a few specific local knowledge systems: a particular typology, a specific micro system and a singular building and spatial system present in the region.

11 Aiming at 'resolving' limitations of the existing system, this solution by ArshiyaVij makes 'structural' inserts to that effect only in places where a certain result was desired: to create surfaces and making more than two floors possible in the timber frame construction system. The output is a composite system where the structure is the generator of the visual language. Easy incorporation of micro systems within this overall premise is evident. Concrete columns and beams only at specific

locations leave the possibility of building in indigenous strategies allowing for the use of local knowledge systems.

12 The attempt made by Mukul Gehlot is to generate an alternate expression of the visual language with the unconventional 'structural' use of mild steel as beams to create surfaces and volumes. Noticeably, structure is the generator of the visual language, creating a sub-language even while the overall system is not composite. Even though this exploration seeks to address most limitations of the traditional construction system, this type of insert might not result in adapting local knowledge systems.

13 Shreya Anand carries out 'Structural' or SDS level inserts in order to generate a viable visual language and to resolve limitations, wherein the structure is expressed and is the generator of the alternate language. Structural inserts are made on the skin of the building (within the FDP layer), evolving the skin into a composite system, a combination of inserted and existing materials, and leading to the incorporation of specific micro systems. This output, showing the possibility of alternate expressions, results in a composite system and pushes local knowledge forward.

14 Aimed at solving the basic concern of control of internal environment and making it conducive to contemporary lifestyles, Sanjivni Gupta's work hinges on the idea that all else remains the same; the built language, the construction technology, the visible material systems, etc, i.e. the external visual volumetric output is the same as in the traditional systems. While giving validity to the continued use of local knowledge systems, this approach addresses the issue of volumes and surfaces and maintains that the microstructure is reusable in the contemporary scenario as long as the basic issue of habitability is addressed through control of the internal environment.

15 Ferroconcrete (or ferrocement) is a thin, lightweight compound material created using cement and sand over layers of steel meshes. It can be used to prefabricate building components and is ideal for constructing curvilinear surfaces.

16 Interactions with the people of Wai, in January 2014, brought to light the fact that many of the 'traditional' structures are being permanently sealed and the residents being shifted out to curb the buildings' deterioration.

Building Processes and Challenges
Ladakh

DEBASISH BORAH

ABSTRACT

The mud, stone and timber construction of Ladakh region in Indian Himalayas is both brilliant and perplexing. The region receives very less rainfall and thus mud is extensively used in Leh and adjoining areas. As one moves westwards towards Batallik, Turtuk and Kargil ranges, stone work becomes more prominent primarily because of drop in elevation and warmer summers. Climate change and modernity have brought on a change in the usage of mud as a building material. A documentation of the traditional construction process and technique has been carried out for a better understanding of their interrelationship with the context. The relevance of these has also been explored for contemporary use along with the possibility of integrating modern technology with traditional mechanism in order to respond to the climatic change and present day functional requirements.

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INTRODUCTION

Ladakh is a high altitude valley tucked between Kunlun ranges on east, Karakoram ranges on north and west and the Himalayas on south, with an average altitude of 3657 metres. At crossroads of civilisation for a prolonged time in history, the region was a part of the old silk route and thus prospered from trade between China and near east. Rapoport (1969) defines the dependence on the house form on climate, material and construction technology. An enquiry into the construction of Ladakh helps in understanding the physical determinants of the prevalent house form. Traditional building materials in Ladakh are not very varied. The dry barren landscape offers earth, stone and a little timber for construction. Typically, buildings in Ladakh are rectangular in shape, broad at the base and gradually tapering towards the top, with flat mud roofs. Since it is low rainfall region, receiving only about five centimetres of rainfall per year, flat roofs are desirable.

The materials available in the region are smartly used by local people to meet their requirements. Earth is extensively used from walls to roofs successfully, supported by the low rainfall level. Stone is used widely, particularly in the lower portions of a building for stability of the superstructure. It also helps in making a sloping terrain flat by filling up stones. Timber is also a very crucial material in the region but is scarce, mainly found along the flow of Indus. Its heat retaining property is the reason for its wide usage in floors. Timber is also conveniently used as trusses for supporting flat mud roofs.

The choice of material is not fixed but mainly dependent on local conditions. There are certain regional variations, such as in Turtuk, deep Nubra valley, there is more use of stone and timber than mud. One of the primary reasons for this is the poor quality of soil, having high sand content. It is noticed that within the high altitude areas like Leh valley and Zanskar, located further east of Leh, there is more use of mud and timber for building construction. On the other hand, in lower areas such as Batalik, Kargil, Turtuk, or west of Leh, stone and timber are mainly used for construction. These areas get good summer months so stone houses are comfortable. Rammed earth is also in use in the lower altitude areas that include Achinathan, Apati, Batallik and Kargil.

The construction process includes the following stages:

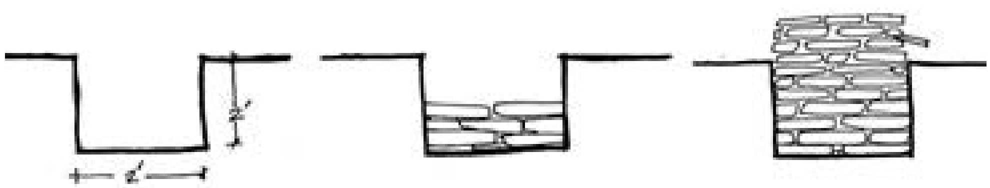
- Site selection and foundation
- Building the superstructure
- Making the roof with beams and columns

Old town of Leh

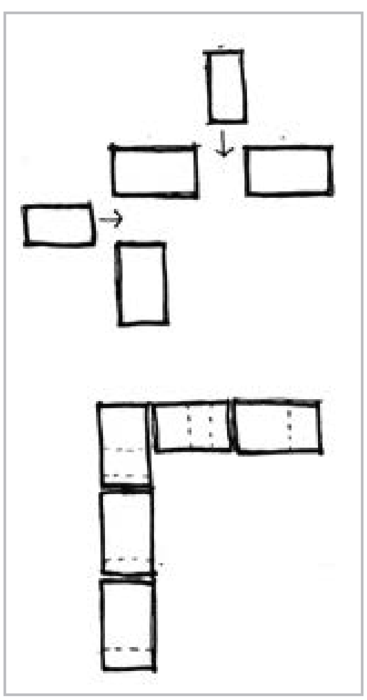
Material palate in Ladakh: mud bricks, stone and timber

SITE SELECTION AND LAYING FOUNDATION

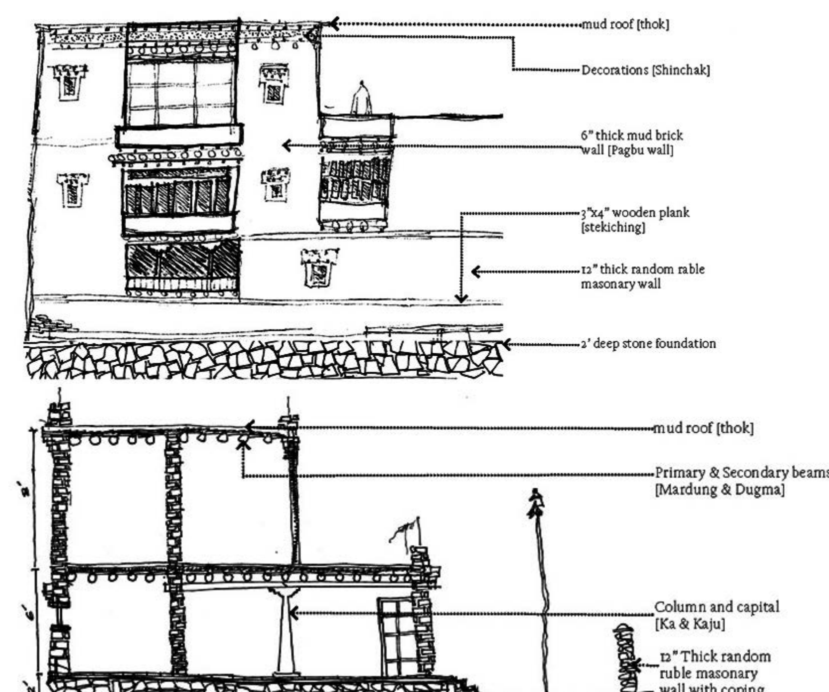
Site selection is a tedious process, decided through the engagement of a monk from the village monastery. Tests are carried out on site to check ground conditions. To test the ground condition on a sloping site, a knee high pit is dug and refilled with earth previously dug. If there is more than enough to fill it, the site is good while if the earth is not sufficient to refill, the soil is not suitable as it is too light or airy to bear the weight of the foundation. Another is the water test where a pit is dug and filled with water. After leaving it for some time, the water level is checked. If the pit retains water, it is good and if the water level decreases, the ground is not good for foundation, as the absorption of water suggests that the soil is sandy and loose. When water level remains same, the soil is firm and provides excellent load bearing capacity. In a flat terrain, foundation trenches are dug and random rubble masonry is built till the plinth level. Normally mud mortar is used to hold the stones together.



Process of foundation



Process of brick laying



Elevation and section of a typical Ladakhi house

A house in Turtuk, Balti area, Ladakh

In case of uneven terrain, no foundation trenches are dug. The foundation masonry is laid directly onto the irregular rock base and stonewalls are taken up to the desired level when a flat space can be made for placing the superstructure. Once the plinth level is achieved, joists are placed for placing the floor. Those buildings which are built on relatively flat ground, compacted earth walls are built on top of stone plinth. It is important to use stone in lower levels, to prevent dampness from ground to move up and also to achieve a firm base for the building.

BUILDING THE SUPERSTRUCTURE

Stone and mud are chiefly used in building of the superstructure almost all over the Himalayan belt. Scarcity of rainfall enables the locals to use mud as basic bonding and building material. The construction of superstructure follow systems as listed below:

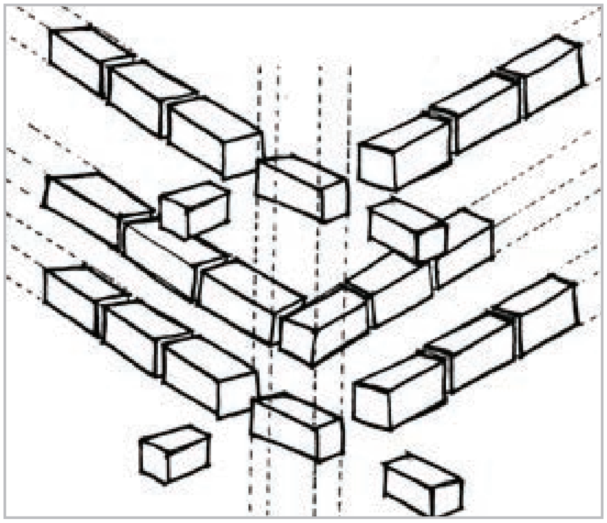
Mud walls built from sun dried mud bricks

The bricks are laid from above the stone plinth. Space for openings is left and frames are fixed by external supports. Normal floor to height is 2.4 to 3.6 metres. Most Ladakhi homes are low height, helping preserve the internal heat in winter months.

In most cases, the local soil from the site is used for mud bricks, the soil procured for making bricks are generally from a marshy place with good water content. Soil with high sand or stone content is avoided. The soil is dipped in water for at least 24 hours before preparation of mortar referred to as *kalak* locally. Water from soaked apricots is also used for dipping the soil in it. About two percent of barley hay or *phugma*, preferably not machine cut, is also ideally mixed. The excellent tensile strength of hay helps avoid crack in bricks. About 15% clay soil or *markalak* is also mixed. It decreases the water penetration its excessive use tends to make the brick brittle.

Random rubble with mud mortar

It is practically not possible to get stones of desirable size and dressing of stones has to be done. It is preferred that stones are rough, with edges and not round; mountain stones are better suited than river



Process of brick laying, corner joint

Typical stone masonry in Ladakh

stones. Round stones do not have good grip and the construction tends to fail, while longer stones are preferred because they will have fewer joints. Stone size is 30 centimetres x 213 centimetres x 213 centimetres. During the laying, a slate like flat stone is introduced between every stone course. This provides cushions for stones in case of an earthquake and space to move. At about sill level, a wooden member is introduced called ‘skitching’. This member helps in binding the stone walls together. The timber member also helps in countering any developing vertical joints.

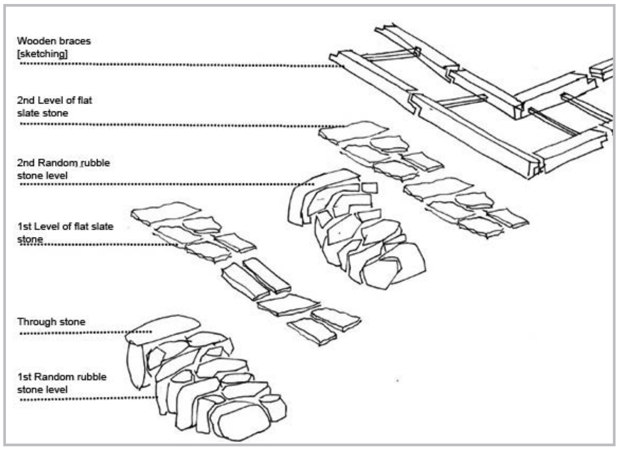
Rammed earth walls, mud laid between timber planks

Rammed earth is an ancient system of building walls that is now rapidly going out of use. The process of preparing mortar for rammed earth walls is same as mud bricks, but the soil has about 15-20% of aggregates. The mortar is poured up to 10 centimetres, followed by a series of pebbles for 10 more centimetres. Mortar is again poured till the rim of the formwork. All the mortar poured is rammed and compressed till it drops five centimetres. After a drying period of two days, the formwork is removed and used for upper layers.

BUILDING THE ROOF AND STRUCTURAL MEMBERS

The mud roof has many layers to it. The whole process of construction of a roof has many layers and stages. After achieving desired height of the rooms, *dugma* or secondary beams are placed on top of it. Ideally, a stone or a wooden base is prepared, to rest the wooden beams on the mud bricks. The number of *dugma*s is usually odd, in rooms of size less or equal to 30 centimetres on either side, *dugma*s of diameter 20 centimetres are used. If any of the room size exceeds by 30 centimetres, the *mardung* or primary beam is introduced. The *mardung* runs on the longer side of the room, which is supported by a *kaju* (capital) that in turn rests on a *ka* (column). The *ka* rests on a flat stone on the ground. In case of along primary beam, joints are inhabitable, *mardung*s are joined on the same axis as the column and it falls on the centre of the *kaju*. On top of *mardung*, perpendicular *dugma*s are fixed on the shorter side of the room. The centre to centre distance between *dugma*s does not exceed 45 centimetres. The *tallu*s (willow sticks) of diameter 3.8 centimetres are placed on top of *dugma*s. If the centre to centre distance between *dugma*s increases above 45 centimetres, the *tallu*s tend to sag.

Once all the wooden structural members are fixed, the mud roof laying process starts. On top of tallu, a local grass called Yakzess is spread. Yakzess is commonly found everywhere in mountains. After Yakzess is laid out evenly, a 7.6 centimetre layer of mud mortar is laid. The process of preparation of mortar is similar to mud bricks; in this case barley is not added to the soil. The 7.6 centimetre mud mortar is compressed manually, using a flat wooden plank. Once compressed, a five centimetre layer of *markalak* is laid. The *markalak* helps in absorbing water. It is crucial that the *markalak* is sandwiched between two layers of mortar. On top of *markalak* another 10-12 centimetres of mud mortar is



Layers of a stone wall

evenly laid and compressed. On top of this compressed mud mortar another five centimetre *markalak* layer is laid evenly. Finally, a thin layer of dry soil on top of *markalak* is spread. This dry soil prevents removal of *markalak* when one walks on top.

APPLICATIONS IN CURRENT CONTEXT

Excessive usage of steel, concrete and glass in Ladakh requires specialised masons and craftspeople, thus triggering migration of workers from mainland India which in turn is threatening the traditional knowledge pool. More and more Ladakhi young men are now working with contractors or workers from outside, who have no working knowledge of Ladakh and aim to earn quick money. This is initiating a new social order, in which Ladakhi people depend on resources from outside to built homes or shops. The environmental damages from such large scale constructions are unpredictable and at the same time modern materials also pose multiple threats on significance of built heritage. Besides being easily available and cheap, there are multiple reasons for local materials being desirable in building construction. For example, timber floors are predominantly used all over because timber as a material has the ability to retain heat and transmit it slowly, unlike ceramic tiles that are inert.

Similarly, the random rubble masonry rooms at lower floors of a Ladakhi home is for cattle, as their combined body heat transfers upward to living areas. It is observed that concrete houses become extremely cold as the material doesn't retain heat and transmits it quickly. An excellent example to put across this case is traditional Ladakhi toilets. These are usually placed at upper floor and simply consist of a square opening in the floor over which one squats. The excreta is collected in the space below from where it is periodically removed and used as a rich source of manure. Modern toilets with western water closets and flush not only deprive one from much needed manure for difficult Ladakhi soil, but are also kept dry for six to seven months as water pipes could burst open when water freezes and turns solid. These simple examples explain why there is an urgent need for revival of traditional knowledge.

It is extremely vital to appreciate the local and understand that everything foreign might not be beneficial. There are lot of areas where newer technologies can be useful, like problems of open drainage in Leh old town or disposal of solid waste management. The modern techniques of laboratory tests to understand earth composition and their properties will be beneficial when used smartly. One can scientifically determine, which soil is better for mud bricks and which is good for plaster, what age of timber might sustain loads and which cannot, thus science is actually aiding and helping in local endeavours with modern perspectives.

Bibliographical references

- Alexander, A 2005, *The temples of Lhasa; Tibetan Buddhist architecture from the 7th to 21th century*, Serindia publications, Chicago.
- Benjamin, W 2009, *One way street and other writings*, Penguin.
- Khosla, R 1979, *Buddhist monasteries in the western Himalayas*, Ratna Pustak Bhandar, New Delhi.
- Rapoport, A 1969, *House, Form and Culture*, Prentice Hall, New Jersey, USA.
- Shankar, P 2014, *Himalayan cities, settlement patterns, public places and architecture*, Niyogi Publications, New Delhi.

Conserving Buddhist Monasteries
Ladakh

BHAWNA DANDONA

ABSTRACT

Buildings in Ladakh, India are exemplary for their construction in response to the hostile climate with limited available materials and artistic accomplishments. The main building types include forts, monasteries, palaces, residences and religious landscape elements built with techniques that employ rammed earth, sun dried bricks, stone and timber. An attempt has been made to introduce the monastic architecture types present in Ladakh and describe their construction techniques with the use of indigenous materials. Emphasis has been laid on presenting the native techniques to achieve seismic resistivity. A discussion on the current state of conservation and issues faced by these buildings is also dealt upon.

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INTRODUCTION

The Buddhist monasteries or *gompa*s (temples) in Ladakh, in northern India, command a special place among all the buildings to be found there, by virtue of their distinctive architectural features. The origin of these can be traced back to the 10th century when they were constructed under the guidance of Lhotsawa Rin-Chen Zang-Po, who is also known

Lamayuru, an Early Period monastery

Ridzong, a Later Period monastery

as the great translator. The monastic complexes that started to develop during 10th century in Ladakh are generally referred to as the Early Period monasteries. Some of these buildings are now regarded as the most significant examples of the earliest extant buildings to be found in Ladakh. Following these, the period from 13th century onwards witnessed development of larger monastic complexes as the various Buddhist sects established their presence in the region These Later Period monasteries emerged as a result of direct impact of religious and political influences during that time from central Tibet. The monastic architectural style was very different from that of the Early Period.

The monasteries in Ladakh are significant not only because of the conceptualisation of their architecture but also because of the use of the indigenous materials used in their construction, which makes them environmental friendly. What is particularly pleasing about such structures is the attention paid to details, such as the use of ornate columns, capitals and ceilings, mural paintings and sculptures.

These monasteries were designed not only as religious spaces with monks' residences but also to house sacred texts and objects, such as *kanjur*, *tanjur*, and *thangka*s or the banner paintings. There are some essential differences between the Early and the Later Period monasteries.The Early Period monasteries exhibit a rich fusion of Indian architectural styles, decorative elements from Kashmir and construction techniques from Tibet. A few monasteries of this period include Alchi, Lamayuru, Mangyu and Sumda. These monasteries are planned on relatively flat ground, its functions are spread out and the whole area is enclosed by wall in some cases. The Later Period monasteries, on the other hand, are compactly built and located on top of a hill, appearing like fortifications in contrast to the Early Period. A few monasteries of this period include Chemrey, Hemis, Lekir, Matho, Ridzong, Sktana, Themisgam and Thiksey.[1]

Ladakh is considered a cold desert, as historical records show, its average annual rainfall is no more than 90 millimetres. Most of the precipitation occurs during the winter months; the area remains snow-bound for nearly seven months of the year. However, the precipitation pattern has become rather unpredictable in recent years: years of drought are followed by sudden bursts of unseasonal precipitation and flash floods as seen in 2010. Ladakh falls in the high-risk Zone 4 of the Seismic Zoning in India (Bureau of Indian Standards 1993). It is remarkable that the monasteries have survived these disasters over a period of many centuries. This fact is indeed a testimony to the natural genius of the natives who built these monasteries.

These monasteries contain special features that make it immune to natural catastrophes, most important of these being the materials used and the techniques of construction employed.

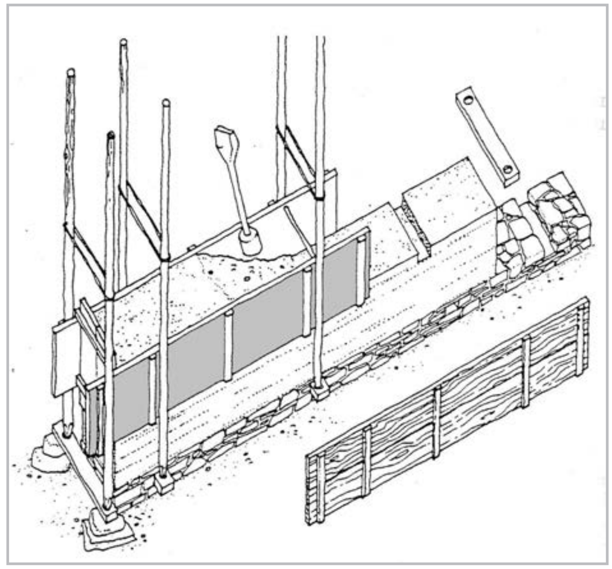
CONSTRUCTION TECHNIQUES AND MATERIALS

The monasteries are characterised by the use of materials found locally like rubble, earth and timber and are put together with very simple construction techniques. Earth has been employed in this region as the main building material due to its abundant availability, workability, ease to repair, and simple technical skill requirements (Kuang 2005). Since wood is a scarce material in such a climate, it is employed mainly as a structural member in form of columns and capitals, to support the earthen roofing as lintels, and occasionally for flooring. It is also used to construct decorative ceilings in these monasteries. Juniper was the most favoured variety of wood for its strength and resistance to decay but its overuse has led to its near extinction. Other local materials like stone are used, for example, as a coping in parapets while dried grass and willow twigs form an integral part of the roofing along with earth and wood. The buildings follow a load bearing system of construction where the external walls carry most of the load of the building and the structural components can be resolved into support, spanning and opening systems. The non structural elements mainly include parapets, balconies and steps.

The support system of these structures mainly comprises foundations along with the load bearing walls. The foundations up to the plinth level are generally constructed with random rubble where roughly stone is laid with thick mud mortar; around 100-150 centimetre deep, following the existing terrain (Kuang 2005). In case of a rocky site on hilltops, the digging of the foundation is eliminated and the rocky base is utilised to locate the monastery. A sound foundation contributes to the stability of the building by reducing the risk of uneven settlement.

Rammed earth construction

The walls in the superstructure are usually constructed out of rammed earth or sun dried brick with mud mortar on the upper levels. Rammed earth is considered as the oldest, cheapest and simplest construction technique in western Himalayan region. Wet clay based soil, often with aggregate, is placed between a movable wooden board formwork and stamped with wooden rams. Shrinkage is avoided in such a construction by the use of a well graded soil, addition of straw and heavy compaction. This process is then repeated and the wall is constructed in layers. The formwork consists of two wooden planks held in place by wooden poles driven into the ground and the wall thickness is established by wooden cross bars set between the planks. Often the junction between layers and holes created by the cross bars becomes an architectural feature on its own (Chayet, Jest & Sanday 1990). The walls are very thick and taper slightly, the angle of taper ranging from three to six degrees in the cross section. In certain locations a variation of this type of construction is observed where sun dried mud bricks laid in mud mortar are used at upper levels. The mud bricks are made from local soil with river sand and chopped straw.The partition walls are thinner as compared to the external walls. For large interior spaces, slender wood columns are provided that are located symmetrically in the room. The columns are founded on shallow stone pads and are mostly topped with ornate brackets with decorative capitals that transfer the loads from the roof. This represents a very simple yet efficient mechanism of load transfer. The exterior surface is finished with coarse mud or lime wash with rough dripping texture (Kuang 2005). In case of multi- storey buildings, it is often observed that the walls are laced with timber at regular intervals in the form of ring beams.This can be particularly observed in case of Themisgam Monastery.

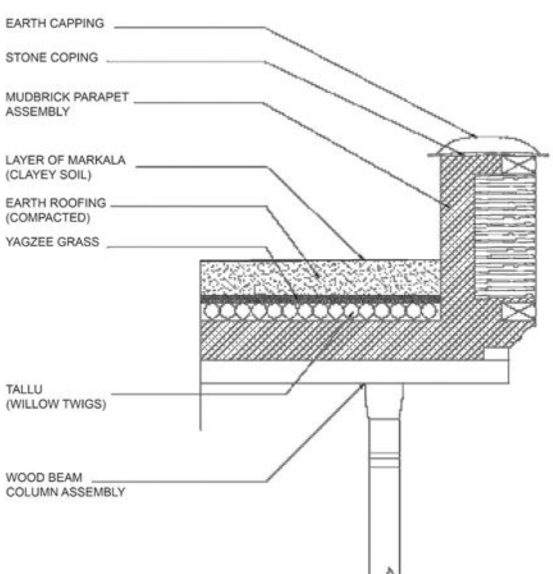


Rammed earth construction, Source: Harrison 1995

Typical section through the roof

The spanning system constitutes a flat roof supported over load bearing walls and columns. The provision of flat roof is due to lack of rainfall in the region in the

Markala, clayey soil used for water proofing, sourced from mountains



A typical section through the roof (not to scale)

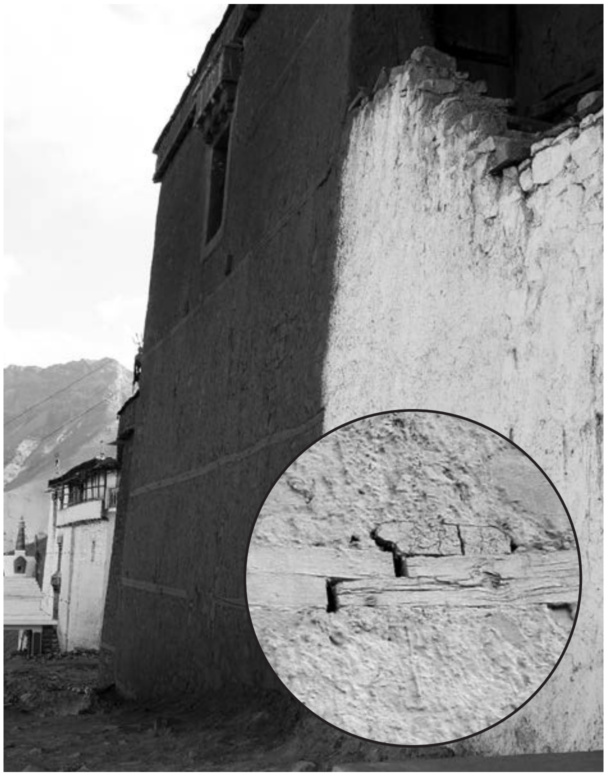
past. It also provides a functional use of the roof top and provides extra space during harsh climates. The roof is constructed with composite materials like wood, twigs, grass and thick compacted local earth. The roofing is supported on two or more primary beams spanning the rooms. In single storey monasteries, these beams simply rest on the walls without a wall plate or bond beams. In case of multi-storey buildings the beams rest on wall plates located at the walls that also tie the structure together. These beams are circular in cross section and are sometimes supported on brackets near the wall ends. The configuration and number of wooden beams varies and depends on the span of the room. A series of joists are placed perpendicular to the main or primary beams. A layer of wooden planks is usually added above these joists just below the rest of the roofing for finishing. These planks act like a false ceiling that is usually decorated with paintings. *Talbu* or willow twigs are then placed above these planks close together in rows, usually creating some pattern, which ultimately covers the whole ceiling. A layer of *yagzee* or a type of local grass is laid between the planks and the twigs for water proofing.

The finishing material is earth, which is poured and then compacted in several layers. This multilayered roof is then finished with a fine, locally available clay called *markala* that acts as a water-proofing layer. Wooden water spouts are seen in some monasteries, though very rarely. Another important component of this system is the ornamental parapet which is essentially made of willow twigs with stone and mud bricks, finished with mud plaster and mud coping. The parapet projects out from the external walls and is often supported by protruding roof joists.

The openings are kept to minimum in Early Period monasteries but are more in number in Later Period monasteries. The lintel is a wooden beam that forms the support system for openings and also supports the end of the floor-ceiling system. Below this assembly, frames are usually placed and connected to the lintels and sills. These openings are ornate and are crowned by continuous rows of corbelled timber brackets.

TRADITIONAL KNOWLEDGE SYSTEMS

Buddhist monasteries in Ladakh are equipped with inherent building systems to resist stresses from natural disasters like earthquakes. In an attempt to review the existing technologies, some structural aspects contributing to good engineering structure have been discussed. In addition to reviewing the strengths, it is also necessary to assess the weaknesses of such systems in order to prepare against future calamities. The walls are quite thick, almost one metre as compared to the height which varies from small rooms to high towers to accommodate the massive sculptures.



Wood ring beams placed at intervals, Themisgam Monastery. Inset: Details of wood ring beams highlighting the joints, Themisgam Monastery

Floor beams resting on primary beams serving as wall plates, Chemrey Monastery. Source: Peeysuh Sekhsaria

Slenderness ratio or the height to thickness ratio is usually low in the case of Himalayan buildings and varies from 8 to 10 (Prakash 1991). This slenderness ratio of the wall is one of the fundamental structural considerations in case of earthen walls. Lower ratio helps in providing stability to the walls and helps to avoid overturning in event of an earthquake (Tolles, Kimbro & Ginell 2002). Thick walls also aid in providing thermal comfort in extreme winters. The walls are very thick and as mentioned earlier, they slightly taper in the cross section. The taper in the walls serves as buttresses to support the height of the walls and provide stability[2].

Horizontal wooden members in form of ring beams are a well known technique found in many parts of the world and in the Himalayas from Hunza to central Nepal (Howard 1989). This system is one of the most essential components of earthquake resistance for load bearing construction. Most monasteries in the western Himalayan region also utilise a framework of horizontal wall ties or ring beams embedded in the load bearing walls. These elements run along the periphery of the building and are flushed with the exterior walls. A scarf and peg joint is used to join these horizontal members. A ring beam is also known as a crown, bond or tie beam or seismic band depending on the location in the building. The importance of these horizontal beams is that they serve to tie the un-reinforced walls making them work as single unit. It prevents the distortion or displacement of walls in the event of an earthquake. Ring beams provide added tensile strength to the walls to prevent the development of vertical cracks. These reinforcements assist to resist any movements due to earthquakes. This can be very easily seen in the monasteries of Themisgam and Basgo.

In case of multi storey buildings, in Later Period monasteries, the floor beams rest on a primary beams resting on at the walls that double as wall plates and tie the structure together. The timber beams at floors are well connected act as diaphragms and keep the individual wall sections from separating.

STATE OF PRESERVATION

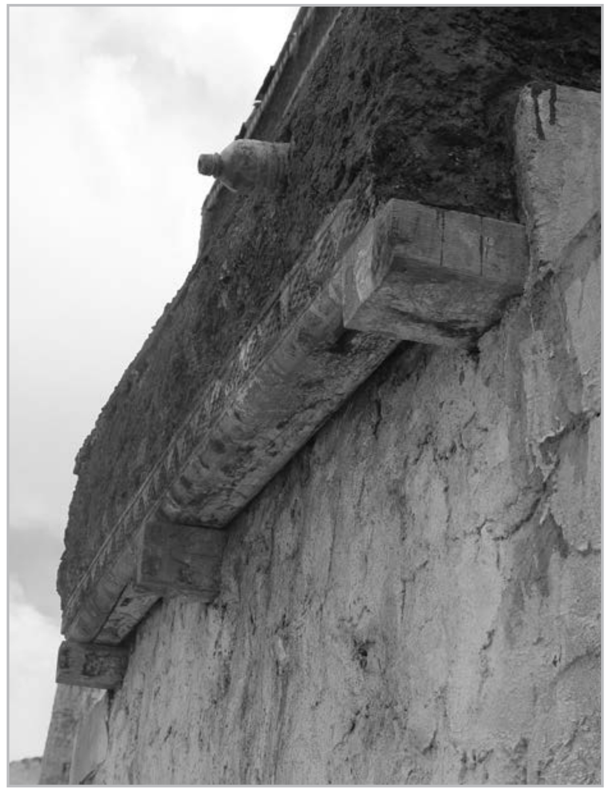
Most monasteries in Ladakh are in poor state of preservation due to lack of maintenance owing to various factors like lack of funds or manpower. Over a period of time, this has resulted in deterioration of the built fabric and therefore weakening of the structures. A majority of monasteries show signs of deterioration like cracks, erosion of base on the exterior and leaking roof.

One of the major issues in monasteries is the earth roof and the problem of water percolation in times of heavy downpours or snowfall especially with changing scenario like more precipitation that was in no way anticipated when the structures were constructed. Also, with a decrease in maintenance, the snow on roof is not shovelled off frequently, leading to additional seepage. It is important to note that the roofing system in these monasteries had very little or no provision for water drainage outlets and slopes on terrace or surface drains. With more rainfall over the years and to fight water seepage because of inadequacies in design, layers of earth have been added over the roof. In some cases, the original roof has been covered with corrugated sheets which work to protect the original roof. The original wooden water spouts are being increasingly replaced by Poly Vinyl Chloride (PVC) pipes.

Several structural problems like cracks, sagging beams and twisted columns are also observed in these buildings. This is caused due to additional load of earth layers on top of the roof to stop the water seepage. The loads then gets transferred to the walls that have not been designed to take such loads and result in cracks along the wall. The cracks, mostly untreated, due lack of expertise or knowledge make the walls weak. During an earthquake or floods, the forces exerted on these weak walls sections can cause the walls to collapse. Cracks are sometimes repaired by filling with materials like cement that is not compatible with existing material and further complicate matters.

The wall paintings and painted surfaces like wooden ceiling planks in many of these structures are also showing signs of distress due to seepage from above. The existing foundation seems inadequate especially after addition of new roofing layers every few years and results in settlement and differential structural movement. The base of many of these monasteries has also deteriorated due to lack of surface drains and water rushing back against the wall from the spouts leading to erosion. Erosion at the base of the walls makes them weak and reduces their load carrying capacity and these weak walls fail easily in event of a disaster.

Well-intended interventions made with the objective of improving the infrastructure and the condition of the buildings have often proved unsatisfactory due to inadequate knowledge of the traditional technique and materials. Inappropriate repairs can be very dangerous and can cause more damage. New materials are being introduced for their durability like cement, bitumen, PVC pipes and but their long term effects on the traditional built fabric has not been studied or evaluated.



Plastic water bottle being used as a part of water disposal system from roof

CONCLUSION

In addition to an opportunity to understand the Ladakh's monastic heritage, its important features and its present state of conservation, some concerns have been raised that need to be addressed in the future. It is important to study the effectiveness of traditional details in more depth in today's context. Actual impact of climate change on heritage buildings and data related to rain needs to be researched. Professionals from various fields could collaborate for studying possible solutions to impact of climate change on the heritage of Ladakh.

Periodic workshops or training programme on disaster preparedness should also be started to impart awareness to avoid the risk of major damage and loss of life. For a more sensitive approach to addressing the building issues, training programmes should be conducted to educate the occupants and users. This will enable them to choose appropriate materials and technologies and undertake better maintenance and upkeep of monasteries. The use of new materials, like cement, Corrugated Iron sheets and PVC pipes, needs to be evaluated and studied. The roof form poses one of the major issues in the area therefore new roof designs should be explored so that the addition of extra layers could be stopped.

Bibliographic references

- Bureau of Indian Standards 1993, *Indian Standard IS 13827: 1993 Improving Earthquake Resistance of Earthen Buildings: Guidelines*, New Delhi.
- Bureau of Indian Standards 1993, *Indian Standard IS 13827: 1993 Improving Earthquake Resistance of Earthen Buildings: Guidelines*, New Delhi.
- Chayet, A, Jest, C & Sanday, J 1990, 'Earth used for building in the Himalayas, the Karakoram, and central Asia - recent research and future trends', *proceedings from sixth international conference, t*he Conservation of Earthen Architecture : Adobe 90 preprints,14-19 Oct, 1990, Las Cruces, New Mexico, USA, Los Angeles, Getty Conservation Institute, pp. 30.
- Dandona, B 2006, *Evaluation of repair methods for structural cracks: Early Period monastic architecture Ladakh case: Mangyu Monastery*, Masters Thesis, unpublished, University of Pennsylvania.
- Dandona, B & Sekhsaria, P 2011, 'Risk Assessment and Disaster Preparedness for Vernacular Earthen Architecture, Ladakh Context: Flash Floods 2010', *proceedings from 11th international conference,* Study and Conservation of Earthen Architectural Heritage, Terra 2012, Peru.
- Gupta, D 2003, 'Conserving the Heritage in Ladakh case study of Basgo temples', *proceedings from ninth international conference,* Conservation of Earthen Architecture, 29 Nov - 2 Dec. Tehran, Iran, Deputy of Presentation, Iranian Cultural Heritage Organization (ICHO), pp. 221-254.
- Harrison, J 1995, Himalayan buildings: Recording vernacular architecture, Mustang and the Kalash, The British High Commission, Islamabad, Pakistan.
- Indian Seismic Codes 1993, I*ndian Standard IS 1893:1984, Criteria for Earthquake Resistant Design of Structures*.
- INTACH, Ladakh Chapter 2010, *Post Flood Damage Assessment of Heritage Site in Ladakh*, unpublished, for Ford Foundation.
- Khosla, R 1979, *Buddhist monasteries in the Western Himalaya*, Kathmandu, Nepal, Ratna Pustak Bhandar, Delhi.
- Kuang, H L 2005, *Conservation approaches to sustaining traditional Ladakhi roofing systems, the advanced certificate in architectural conservation and site management*, unpublished, University of Pennsylvania.
- Luczanits, C 2004, *Buddhist Sculpture in Clay: early western Himalayan art, late 10th to early 13th centuries*, Serindia Publications, Chicago.
- Prakash, S, Revi, A, Sawhnay, RL, Goyal, IC, Goyal, A & Sodha, MS 1991, *Solar architecture and earth construction in the northwest Himalayas*, Vikas Publishing House Pvt Ltd, New Delhi.
- Sharma, J 2003, *Architectural Heritage Ladakh*, Har-Anand Publications, Pvt Ltd, Delhi.
- Tolles, EL, Kimbro, EE & Ginell, WS 2002, *Planning and engineering guidelines for the seismic retrofitting of historic adobe structures*, Getty Conservation Institute, Los Angeles, USA.

Notes

[1] The Early Period monasteries are built on a small scale of with rooms facing in one fixed direction. The building height usually varies from single to double storey, to house large clay sculptures. On the exterior, the main structure is flanked by a small porch. The elevation of these buildings is simple with the exception of the main façade, which has decorative columns, doors and parapets. The interiors are usually dark, the only source of light being the door opposite the altar, a clear storey window, possibly to avoid weakening of the wall. Heavily adorned walls with paintings and ceilings, wood elements and decorated clay sculptures are the main feature of this building type.
The Later Period monasteries exhibit individual structures with different functions, scattered across the hill with no exact arrangement; the constraint being the slope. Most of these house a courtyard, which is the only piece of flat land on hill top meant for gatherings. The buildings of this type are much larger: two storeys or more in height. The decorative features are not as defined in this type as compared to the Early Period: while the decorative styles in Early Period are a blend of western Himalayan as well as Indian styles, the ones established during Later Period are influenced by central Tibetan style.

[2] It is wider at base and narrow near the top.

Exploring Residential Typologies
Katra Dulo, Amritsar

RACHAN PUNEET SINGH

ABSTRACT

The historic walled city of Amritsar is composed of traditional residential neighbourhoods known as katras. The courtyard is the intrinsic characteristic of the inward looking traditional urban houses of these katras. An attempt has been made to understand the traditional courtyard houses of Amritsar through the study of Katra Dulo, one of the oldest katras in the city. There are variations in the typology of traditional courtyard houses that express the various concerns of their design philosophy. The shape and size of plot and type of courtyard of these houses have played a significant role in defining their spatial planning and typologies. The building materials and techniques adopted are influenced by the local climatic conditions.

INTRODUCTION

Katra Dulo was founded by Bhangi Misl Sardar Karam Singh, in the mid 18th century, popularly known as *dulo* (kind) because of his bravery and kindness. Located in the south-west quarter of Amritsar[1], it is one of the oldest *katra*s (a residential neighbourhood, enclosed by walls and entered through a gate)[2] in the walled city. The *katra* extended up to Lohgarh gate in north, Churasti Atari in east, Katra Mohar Singh in south and Katra Sant Singh and the Darbar Sahib in the west. Due to its prime location, it became a thriving centre for trade with several prominent merchants

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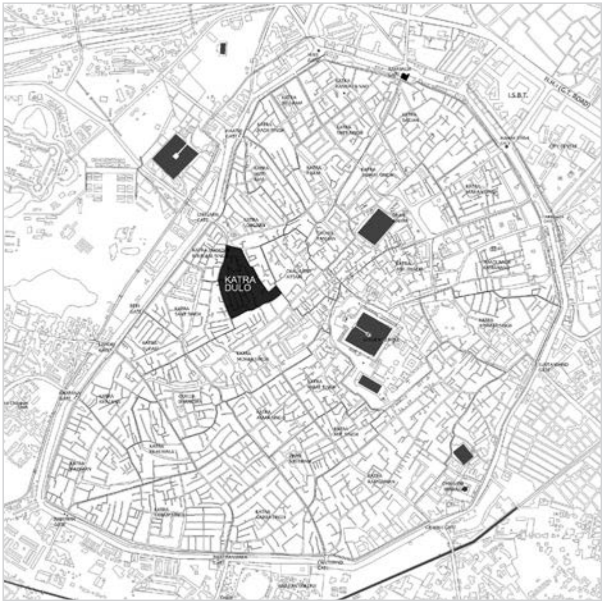


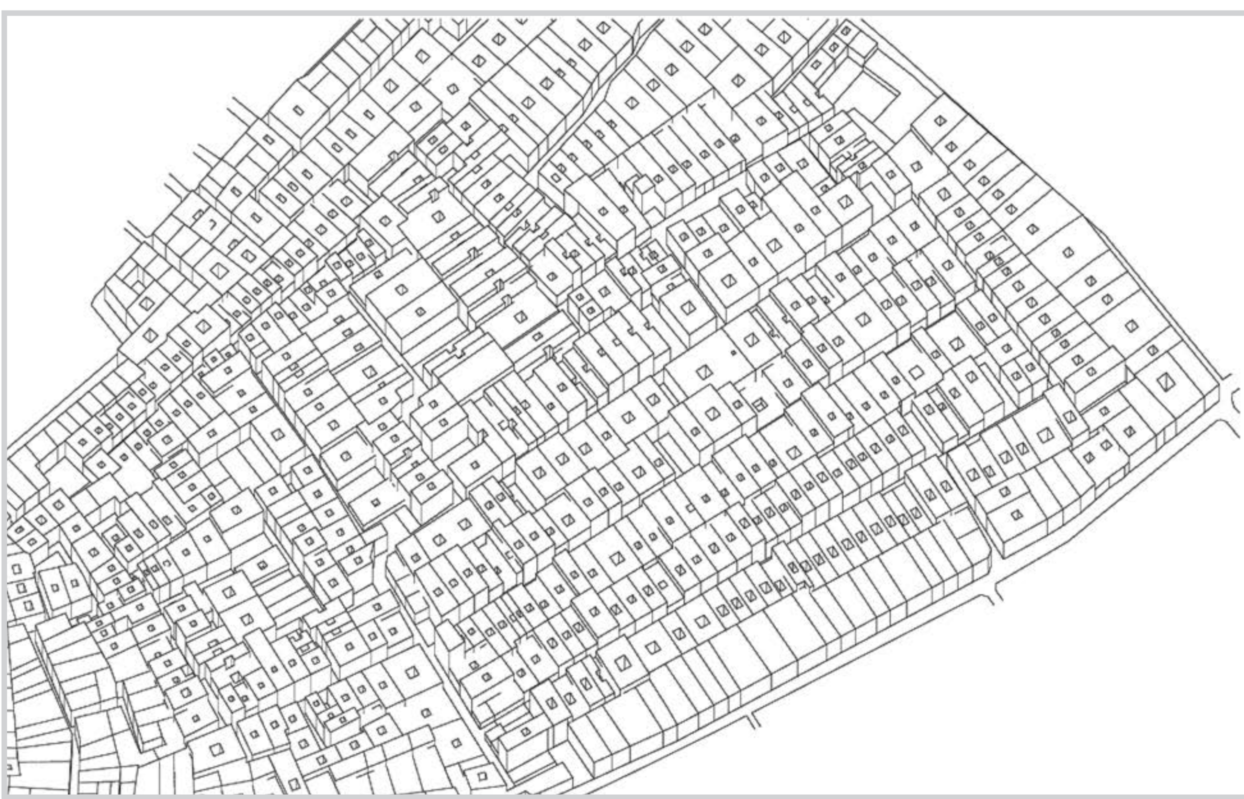
Location of Katra Dulo in walled city of Amritsar

setting up their business along the main approach road. Evidence suggests that Katra Dulo is the only historic residential area left with its original planning patterns, housing typologies and architectural styles intact, while the planning of other *katra*s, traditional houses and their construction systems have undergone extensive transformation due to commercialisation of the whole district in recent years.

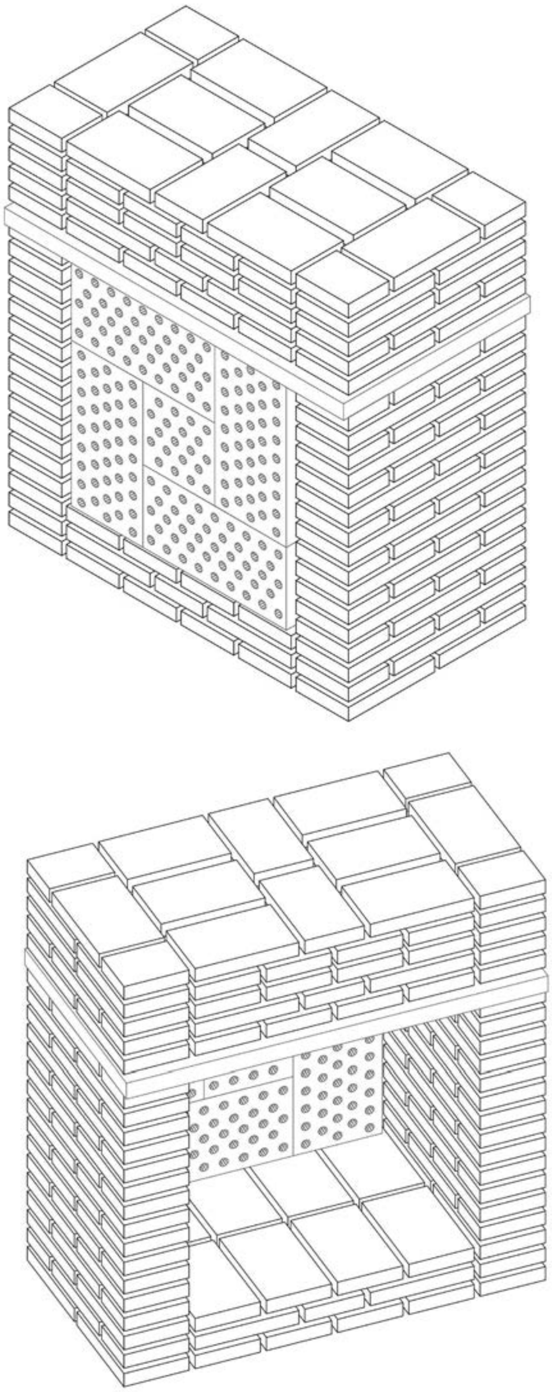
TRADITIONAL COURTYARD HOUSES IN KATRA DULO

The courtyard house has its roots in ancient civilisations. It is one of the enduring architectural forms surpassing regional, historical and cultural boundaries. There are many intrinsic characteristics and attributes of this inward looking dwelling but the most important is its central and private open space, the courtyard. This is considered as the heart of the traditional house since it provides light, air and water to the house.

Most houses in Katra Dulo can be accessed via stepped entrances. The stepped entrance may be located in the centre of the front facades for larger houses in wider streets, while steps are located on a side in case of smaller houses or narrow streets. Sometimes the entrance of the house has a *tharra* (seating platform) on both sides, which is used as an informal sit-out by inhabitants to interact with each other. The first space after entering the house is the *deori* (entrance hall) that acts as a semi-private space offering privacy to the inner sections of the house through a winding



Three dimensional visualisation of Katra Dulo showing built-open relationship



Construction detail of parapet with perforated bricks using nanakshahi bricks, stone jaali and sandstone slab

entrance from *deori* to courtyard. The staircase is also located on one side of the *deori* and upper floors are accessible without passing through the intermediate floors. The rest of the rooms are placed around the central courtyard and used for various purposes such as the sleeping area, cooking area storage, living rooms or a veranda. Small niches are common on both sides of doors are used to place candles or oil lamps and sometimes to place a deity for the well being of the house. Storage rooms also have the overhead wooden shelf called *parrshati* (overhead storage). Sometimes a wider wooden shelf is used for sleeping.

Residents at the upper floors can interact with others through the courtyard and things are exchanged with help of a rope hanging through the courtyard. Another rope is hung outside along the facade to buy various things of daily use from street hawkers. Social interaction and exchange of goods also happens from the openings of one house to another across the street, made possible only due to the narrow streets of the Katra. Finally, the terrace with *chaubara* (room at terrace level) is an important space within the house. It is used extensively during summer nights. The terrace parapet has a stone *jaali* (lattice work) that provides cool breeze to pass through as well as privacy.

The central courtyard provides an appropriate micro-climate to the house. As compared to a detached house, it is covered from all the three sides, excluding the front entrance. So, it is less exposed to direct sunlight. The front facade is also protected from sun and dusty winds by narrow shaded streets. The courtyard can be modified for comfortable levels of air, temperature and humidity with the use of plants, shading devices and water fountains. The central open space adapts to the needs of the household members. Since most rooms face this court, it provides sufficient diffused light to the interiors for daily activities.

VARIATIONS IN HOUSE TYPOLOGIES

Housing types in Katra Dulo are analysed on the basis of four primary criteria, namely, plot shape and size, type of courtyard, entrance space and plinth.

Courtyard configurations and typologies

Typically, in Katra Dulo, the three types of plot configurations found are square, rectangular and elongated. In the square configuration, size of plot is approximately 12 metres x 12 metres. These kinds of plots can be described as traditional *haveli*s (mansions) with central square courtyard, *deori* embellished with rich decorative features and architectural elements. The houses are designed keeping in mind the sufficient light and ventilation in the habitable spaces. In the rectangular configuration, plot width varies between three to five metres, depth 9 to 12 metres and proportions are 1:2 to 1:3. These are houses


Courtyard without projections


Courtyard with projection at each floor level

with a wide range of traditional house typologies, architectural elements and decorative features. Some have colonnaded veranda on one or two sides of the courtyard. Transformations in courtyard in this type include a cut out in the roof, partially covered with steel grill. A removable metal sheet can be placed over it to prevent rain water so that the ground floor can be used as a living room. Also, these houses have marble or ceramic flooring in the courtyard while open to sky types have brick flooring.

Finally, in the elongated configuration, the plots have very narrow facades that vary between 1.5 to 2.4 metres, with 9 to 10 metres depth and proportions between 1:4 to 1:6. These kind of houses do not have any *deori* but offer a direct entrance through a narrow passage into the room. Instead of a courtyard, a cut out is provided in the roof over the entrance passage, which serves as a light source. Another transformation observed in this type is the reduced size of the courtyard at upper floor levels resulting in more floor space. Toilets are constructed at the entrance, under the staircase or in the courtyard. On upper floor levels, kitchen and bathing areas are constructed by partially covering the space of courtyard. These transformations show how changes in lifestyle of the inhabitants have altered the spatial planning and utilisation of these traditional houses in an insensitive manner.

Courtyard Configurations and Typologies

All the traditional houses in Katra Dulo have a single courtyard. The only exception is a temple house located in the main bazaar, which has a double courtyard. It might be possible that one courtyard was used for public while the other was for the private use. Square courtyards are centrally located in square or rectangular type of plots with traditional railing around the court at upper floor levels. This offers rooms or enclosed spaces all around the courtyard. Square courtyards have been found in the *haveli* or in the larger houses and are usually centrally located. Often, the courtyard may also be aligned towards one edge of the plot, in which case the courtyard is surrounded by rooms on three sides and sometimes gallery on one side. This makes the courtyard a double height space at ground floor that offers the view of ground floor through gallery or windows of rooms at first floor level. These types of courtyards are most often seen in narrower plot configurations. Rectangular shape of courtyard is common in linear houses and a rarity in larger houses. Generally, these are smaller rectangular open to sky cut-outs over the relatively narrow passage in elongated houses.

Forms

In terms of three dimensional form, four configurations are usually observed. The simplest of these is a square courtyard type, open to sky and surrounded by rooms without any projections on upper floors. The second type is parallel with projections type. Generally, it has a square courtyard with projections all around on the upper floors and thus, reduced open space on the upper floors. The traditional type in this category has decorated wooden railing around the opening and is open to sky. In the third configuration,the courtyard is in form of a double height lobby with opening at the second floor. Double height space includes either gallery on one side or sometimes on both sides. The


Entrance steps from front in wider streets for low plinth


Entrance steps from sides along external wall in narrow streets for high plinth


Entrance steps from sides within external wall thickness for high plinth

fourth type has stepped terraces or set back on the upper floors around the opening that increases the size of courtyard. In some houses, the size of courtyard reduces in the upper floors.

Entrances

The *deori* is the typical entrance configuration seen in larger houses and *haveli*s in Katra Dulo. One enters from the public street into the private courtyard through the semi private *deori*. This space may also include the staircase and a toilet. In narrower houses, entrance is through a corridor into the room. There is also an open hall type of entrance that has been observed in Amritsar. In this case, there is no *deori* or a corridor but an open hall that has a bathroom along the entry and a staircase next to it. The landing provides a partial barrier to the living room towards the rear. This condition is either observed in newly constructed houses built after demolishing the older houses where the old planning is completely altered or in a house with narrow plot width.

Plinth

Some houses in Amritsar were observed to have their floor level equal to that of the street. In all likelihood, these houses are among the oldest houses as the street level has risen since then, making the floor levels lower. The typical plinths vary between 45-90 centimetres and are approached through steps. Elevated houses can also be seen in the neighbourhood. These are built on the platform provided by a semi basement floor that raises the ground level of these houses comparatively higher than others. This results in a different type of elevation.

TECHNOLOGICAL ASPECTS

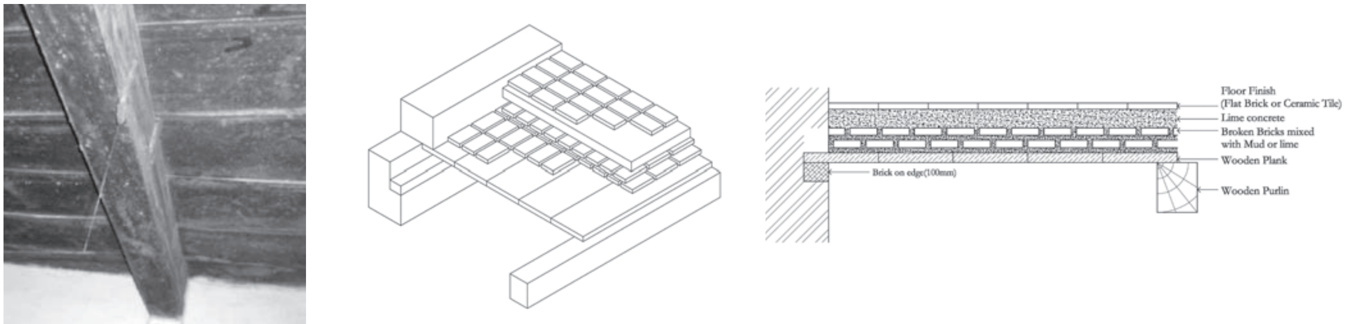
Walls

Wall thickness varies from 33 to 90 centimetres. Wall masonry is done with Nanakshahi bricks (traditional brick of size 18 x 10 x 3.5 centimetres) and mud mortar or lime mortar that varies with the time of construction and the status of owner. It is said that some 10 to 12 additives were mixed with lime for construction such as *surkhi* (brick powder) jaggery, flour of *maah di daal* (whole black gram) and straw. Walls are plastered with either mud or lime mixed with some other components such as straw in case of mud mortar while *surkhi*, jaggery and flour for lime mortar. The cabinets built within wall thickness provide earth quake resistance while use of wall thickness for storage provides optimum space-utilisation. Transformations include the replacement of such walls with modular brick and cement mortar as well as reduced wall thickness.

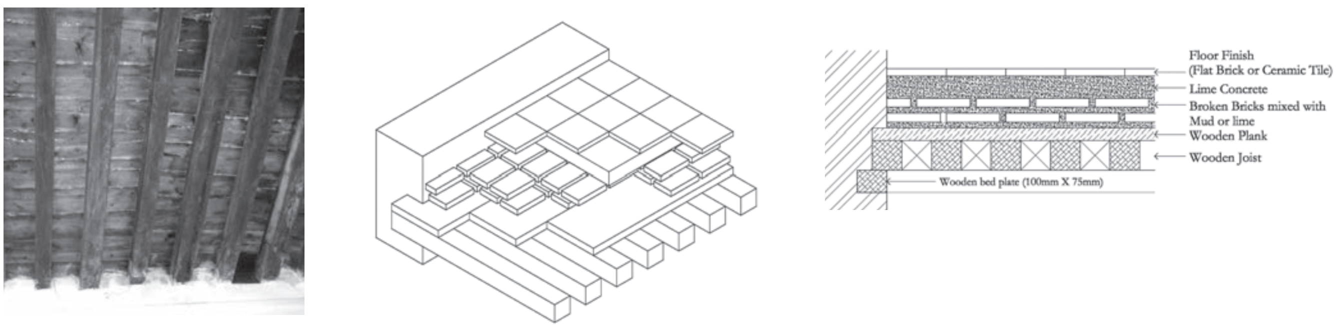
Roofing

Traditional roofing systems made extensive use of timber members. The main components include the *khatambandi* (false ceiling with painted wooden panels in intricate patterns), *shateeri* (main wooden beam or purlin), *balli* or *baaley* (wooden joist), *phattey* (wooden planks) followed by a layer of lime or mud mixed with broken bricks. Finally, the terracing done in mud is laid to slope with flat bricks on the top. The width of *shateeri* is 15-20 centimetres and depth is 18-20 centimetres. The width and depth of wooden joists varies between 75 to 100 centimetres. Width of planks is 20-30 centimetres and thickness varies between three

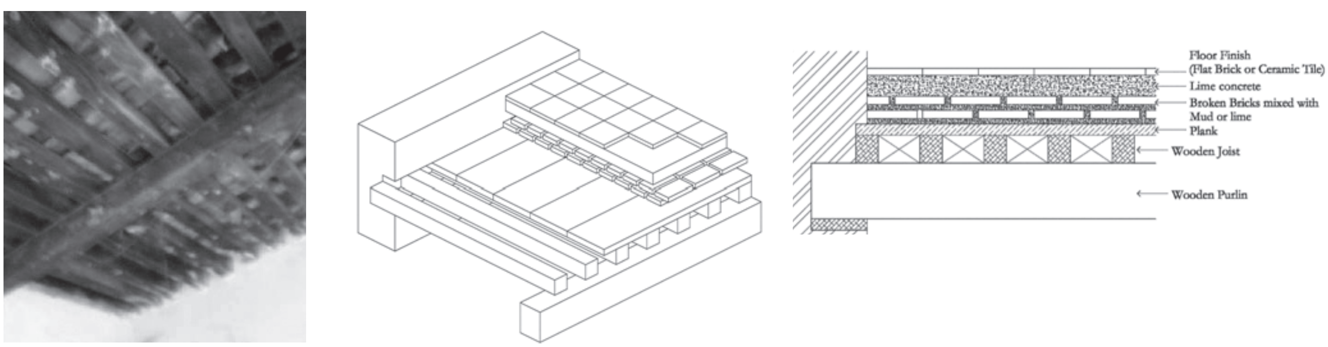
Roofing Type 1: Three dimensional view, photo and section



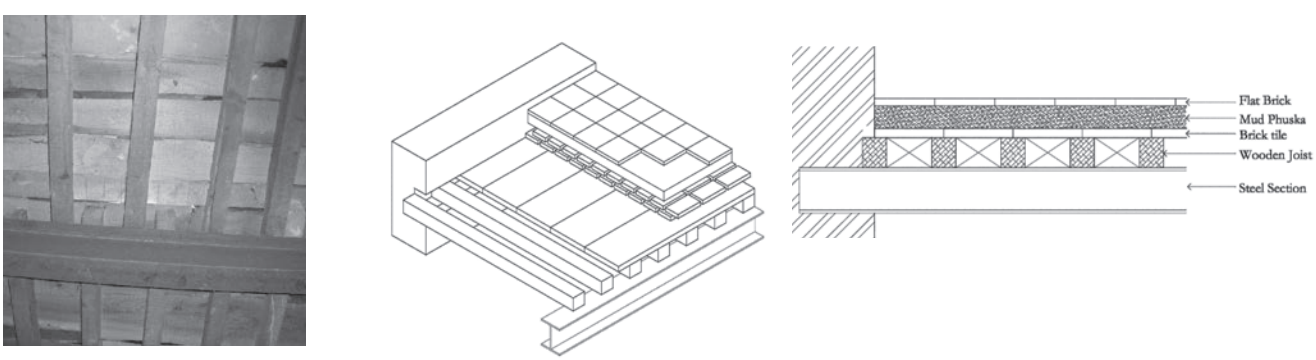
Roofing Type 2: Three dimensional view, photo and section



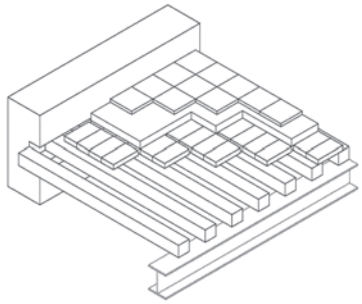
Roofing Type 3: Three dimensional view, photo and section

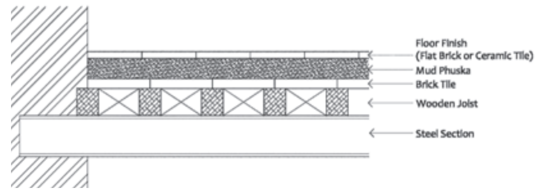


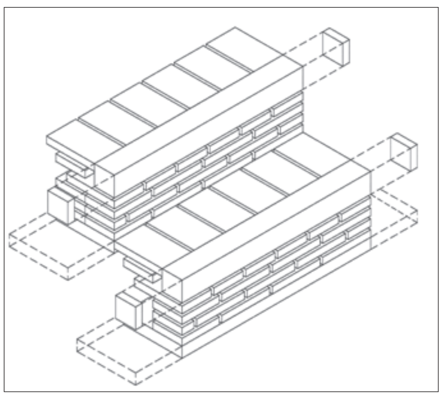
Roofing Type 4: Three dimensional view, photo and section



Roofing Type 5: Three dimensional view, photo and section







Construction detail of staircase using wooden joist and traditional masonry in nanakshahi bricks and lime

Room used during summers on terrace level to four centimetres. Later constructions include the use of brick tile instead of wooden planks over wooden joists and modifications of this type would make use of steel girders or I-sections instead of wooden joists.

Flooring

The three types of floor finishes used are flat brick, brick on edge and ceramic tiles. Brick flooring was done in different design patterns using the mud or lime as base. Flooring in ceramic tiles has been seen in various colours and patterns.

Staircases

Traditionally, the staircase is constructed using *nanakshahi* brick masonry in lime, timber beams and timber planks. Timber planks act as main load bearing members embedded into walls on both sides, while the beam on the edge of each step holds the masonry together and provides stability.

CONCLUSION

Many of the grander historic houses in Katra Dulo, in the square and rectangular configuration, have minor issues related to the condition of the physical fabric but are generally in a better state of conservation as compared to the smaller houses on elongated plots owned by poorer residents or occupied by tenants. Some of the houses built on rectangular plots have not undergone much transformation but these are few and far between. In most houses, courtyards have typically been converted into rooms or partially covered to use space on upper floor. These interventions have not only led to a significant loss of authenticity but often cause serious physical issues for the original structure.

Many houses have also emerged as a result of sub-division of the original properties. These houses have a narrow street like shape with linear planning and offer a very poor quality of life. These houses are in such a deplorable condition that extensive conservation work would be required in order to bring them to their original state. Unfortunately, even this may not be possible in some cases, where the only answer may lie in demolition or reconstruction.

The most historic of house forms seen in the city of Amritsar, the traditional *haveli*, where the architectural, spatial and technological aspects of historic courtyard houses are best preserved, along with their setting within the traditional neighbourhoods, point towards efforts at conservation so that the significance of Amritsar's urban form can be sustained and enhanced.

Bibliographic references

- Datta, VN 1967, *Amritsar: Past and Present*, the Municipal Committee, Amritsar.
- Edwards, B 2006, *Courtyard Houses – Past, Present and Future*, Taylor and Francis, New York.
- Grauba, A 1988, *Amritsar: A Study in Urban History*, 1st Edition, ABS Publications, Jalandhar.
- Kaur, M, n.d., *The Golden Temple: Past and Present*; GNDU Press, Amritsar.
- Schoenauer, N, 2003, *6000 Years of Housing*, WW Norton & Company, Michigan.
- Singh, F (ed.) 2000, *The City of Amritsar – An Introduction*, 3rd Edition, Publication Bureau, Punjabi University, Patiala.
- Singh, RP 2009, *Conservation plan for regeneration of Katra Dulo: a traditional neighbourhood in Amritsar walled city*, M Arch. Thesis, unpublished, School of Planning and Architecture, New Delhi.

Notes

1 Amritsar is one of the most significant walled cities in India, located in the north-west state of Punjab. The city was founded by Guru Ramdas, Third Guru of the Sikhs, in 1573 AD and derives its name from the site of the Holy Shrine Darbar Sahib: Amrit-Sar (pool of nectar). Guru Arjun Dev, Fifth of the eleven Sikh Gurus renovated the Amrit Sarovar in 1586 and since then this city has been known as Amritsar, after the name of the Sarovar: Amrit da Sarovar.

2 Katra has a main spine as a bazaar to fulfil the commercial needs of the inhabitants. Most often, there is a network of *gali*s (narrow alley ways), *kucha*s (street), and *chatta*s (when the upper storey of a residential structure crosses over a street) reaching out from the spine to the interior. The *katra* is also a social unit that relates to the occupation, trade, language, religion or geographical origin of the *katra* dwellers. It was in the form of number of *katra*s that Amritsar city flourished around the Darbar Sahib. The city is composed of 37 *katra*s spread over an area of 3600 square metres. Originally, Amritsar was enclosed by a wall with a moat on its outer periphery, secured with 12 gates, all constructed during the reign of Maharaja Ranjit Singh during the early 19th century. At present, there are a total of 16 gates of which Ram Bagh Gate is the only one that dates to the Sikh Empire.

Timeless Traditions
Ainemane of Kodavas, Kodagu

POONAM VERMA MASCARENHAS

ABSTRACT

The ainemane or the ancestral house of the Kodavas predominate the traditional architecture of Kodagu along with the temple and the independent house. The various built components of the ainemane that include the main house, granary, ancestral shrine and outhouses have been explored in details, highlighting their significance, functions and historical development. Embodying ritualistic expressions within its spaces, the main house of the ainemanes has maintained its built fabric over the years, while the outlying structures have been visibly transformed owing to changes in lifestyles and social association.

THE AINEMANE

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The ainemanes of Kodavas[1] are more than just family homes; these are also sacred living spaces. Each ainemane is unique to a particular *okka* (family) and plays a central role in its rituals. Built overlooking the land cultivated by the family, the ainemane as a whole is a kind of altar to a founding ancestor, the *guru karana* (original ancestor of the family). Several features of the ainemane are oriented towards this role. The pride of place is given to the *nellaki bolca*, a lamp that is regularly lit each morning and evening in honour of the *guru karana*. The term ainemane is believed to be derived from ayyangada mane, meaning the house of *ayyas* (respected elders or ancestors) or house built by ancestors (Najamma &

Chinnappa, 2003, pp. 88-128).The primary traditional built form of Kodagu, it is perhaps best imagined as a complex of structures including the main house, the granary, the *kaimada* (ancestral shrine) and the *ale pore* (outhouses or extended wings) with varying significance, functions, and historical development. The main house has tended to be most impervious to the passage of time, its built fabric maintained on account of the ritualistic meaning embodied in its spaces, while changes in lifestyle and social association have most visibly transformed the outlying structures.

While Rice (1927, pp. 88-89) recorded a description of Kodagu domestic architecture in 1878, another description, with some emotional connect, of ainemane has been collected in 'Pattole Palame', an anthology of traditional Kodava folksongs and traditions prevalent in the late 19th and early 20th century. The description of a Kodava family home occurs in the second part of 'Batte Pat', translated 'Song for the Way' by Najamma and Chinnappa (2003, pp. 88-89).

Going by the description of the ainemanes, when a team set out to survey these traditional structures in 2002, none were found with thatched roofs, all had tile roofs. While the descriptions of golden wall plates and silver beams in 'Batte Pat' are perhaps metaphorical, the carved wooden pillars described in the song can be seen in several of the ainemanes. The practice of drawing on the walls has died out, and is barely even part of living memory.[2] New approach roads have limited the regular use of the ancient approach passages from the field. Yet, in spite of such often dramatic historical changes, several of the ainemanes retain a basic spatial order similar to what has been described in literary records.

Literary research indicates three types of ainemanes (Najamma & Chinnappa, 2003, pp. 88-89). These are the *mund mane*, also known as *totti mane* or *ual kett mane*, a four-sided structure with an open inner courtyard; the *otte pore*, a structure with one hipped roof over double bays and no inner courtyard; and the *madake pore* or *madake mane*, a variant of the *otte pore*, having an L-shaped plan.

SITE SELECTION AND ORIENTATION

Oral history suggests that a pattedara (Kodava family headman) who desired to build a house, would first approach the village elders. They would then select the site together with the village *kaniya* (Brahmin priest) (Srinivas 1952).

Description of ainemane in 'Batte Pat'

Behold the lane leading to the house of this *okka*,
The lane is paved with *pandava* slabs:
Behold the beauty of the boundary wall,
The wall built with stones from the jungle;
Behold the shed at the gateway to the house,
The gateway built with cut laterite stones.
On crossing the gateway we are in the courtyard,
The courtyard where the oxen are tethered,
The courtyard paved with polished stones.
Behold the work on the steps to the house,
The steps built with ruby like stones:
On climbing the steps we see the veranda,
The decorated veranda we walk across.
On crossing the veranda we see the threshold,
The carved threshold we cross over.
Behold the beauty of the house of this *okka*!
Five hundred carpenters worked on it for five years;
The golden wall plates, the silver beams,
The four *aimara* slabs, and carved pillars.
What are the figures carved on the pillars?
Figures of birds, figures of snakes,
The figure of God Vamana is carved,
The figure of a tiger, lord of the rocky cave,
The figure of a wild bison in the forest,
The figure of a barking deer is carved,
The figure of a crowing cock is carved,
The figure of a mewing cat is carved,
The figure of god Nadatta is carved.
The thatch of the house is like a silken cover,
Its walls are plastered with four kinds of mud-
White mud that is white as milk
Yellow mud, the colour of saffron,
Black mud, dark as eye-black,
And red mud, the colour of drops of blood,
With these four kinds of mud the walls are plastered,
The walls of the central hall, the walls of the veranda,
The walls of the veranda and the wall in front.
On these walls are painted pictures,
A picture of the sun god is drawn,
A picture of a lotus flower in water,
A picture of a sword that cuts is drawn,
A picture of a kembatti flower is drawn,
A picture of a white tortoise in water,
A picture of a creeping snake is drawn,
A picture of a beehive in a red pot,
A picture of the Nandi bull is drawn,
And a picture of her own husband,
Along with it, a picture of herself,
These the lady of the house has drawn.
Behold the beauty of the house of this *okka*.

Recorded in the early 1900s and first published in 1924 in the original language, such folksongs were part of longstanding oral traditions and one can assume the description to predate Rice's observations. Recurrence of this song of praise in so many ceremonial contexts signifies the ritualistic importance accorded to the ainemane.

Ainemane courtyard mukkatira[3]

Building the house was a communal activity in which all able-bodied males of the village participated. A sizeable elevated site, overlooking the family fields with a gradient towards the east, was considered appropriate. Kodavas conformed to mainstream Hindu custom in regarding east, the direction of the sun god Surya, as auspicious. As a result, the ainemane faced east. The south was associated with Yama, the god of death, and hence was considered inauspicious. Consequently, no doors opened onto the south. A well would also be present, located in a favourable direction, towards the north-east of the main house.

The ainemane evolved to address a range of needs and constraints that prevailed in Kodagu. This included housing for an extended family; protection from climate, wild animals, and attacks by rival clans; and providing for the ritual practices of the okka. The design of the structure made use of locally available building materials such as mud, laterite, timber, bamboo, reeds, and rice thatch. Skilled craftspeople, carpenters, and temple builders from neighbouring states of Malabar and North Kanara contributed to this process of evolution of a local architectural vernacular.

THE BUILT COMPONENTS

As in Rice's description, an *oni* (a narrow winding lane) forms the approach pathway to the house from the fields. This pathway is carved out of the sloping *bane* lands, now frequently used for coffee plantation. Architecturally, the *oni* is a very important feature of the complex, providing, through a calculated sequence of ancillary structures, a key vantage point from which to approach and view the ainemane. In the past, the *oni* was known as *mummadak oni*, meaning pathway with three turns. This was used as a defensive device, so that attackers would not get a clear line of vision to the house.

The *oni* culminates in the *patti* (forecourt) of the main house. This court is not formally walled in and is usually flanked by ancillary structures to the north and east and occasionally also to the south. The west end fronts the plinth of the ainemane. Invariably, the forecourt is hard paved with stone or laterite blocks. In the past, a guard-post controlled access to the forecourt. Traditionally, supporting agricultural activities such as threshing, piling, and sorting of paddy were carried out in the forecourt. The court often housed a single stone pillar in the centre known as *kalbotti*, topped with either an inverted floral motif or a *basava* (bull head) or sometimes a sitting bull's sculpture at its centre. Traditionally, the *kalbotti*, also called the *sutrakhambha*, had a lamp lit on it after sunset. The pillar was also used for threshing. Bullocks were tied to it and would then go round in circles thrashing paddy spread in the forecourt. Spatially, the *kalbotti* defined the court and provided a focus. The ainemane or the main house sits on a raised plinth of compacted earth that extends beyond the vertical walls. This extension was called *thetthi*. Laterite was used for the plinth if the family had access to it. It provided for a sturdy, impervious base for the mud structure, an important line of defence against the torrential monsoon rains.

All building activity was normally interspersed with work in the fields, with the latter taking precedence. In the case of courtyard houses, the centre square was marked from the very beginning and the layered-earth plinth would be restricted to this portion of the plan. The level of the inner courtyard would ultimately be higher than the forecourt, to permit easy drainage of water. A spout on the east face of an ainemane plinth was a common sight. While the plinth was under construction, banana tree-trunks were placed at an angle and encased with laterite blocks. Eventually the trunk dried and shrunk and was easily removed, resulting in an appropriately sloped water drain from the inner courtyard to the forecourt.[4]

The walls of the house were made of a mixture of mud, rice husk and resin, which was left to ferment for three days. The rice husk acted as a binder and reduced the water content in the paste, resulting in fewer cracks due to shrinkage. Prevention of rising damp was also achieved by employing husk in the mud paste, resulting in microscopic funnels that allowed the absorbed water to evaporate quickly. The blocks of prepared cured earth were placed side by side and in layers. Each layer was lightly compacted before the next layer was placed. Walls would be built to the height of a *cole* (timber pole measuring 60 to 90 centimetre) at each stage and then left to cure for at least seven days, or longer if further time could be spared from the fields. After achieving the required height for installing the ceiling, the mud walls were dressed and brought into an even vertical plane. According to oral history, about 400 years ago, walls would be plastered with mud mixed with resin from tree bark, cow dung and other materials. The practice was discontinued at some point when lime

Detail of mud wall, lime plaster and laterite plinth

Nadikerianda window

Adikerianda ainemane[5]

plaster came into common usage, though the exact date is not known.

Living quarters are usually on the ground floor and very rarely on the first floor, which usually features an attic. Thus, short walls extend on the periphery above the flat ceiling to receive the pyramidal sloping roof. The high-pitched roof and high plinth together added grandeur to the ancestral houses, giving it an impressive façade while retaining a human scale. All ancillary buildings in the compound were built so that their rooflines would not overshadow the main house, attesting to its pre-eminence within the complex. *Otte pore* houses are more linear in plan as opposed to the *mund mane*'s square plan. The hipped timber roof with Mangalore tiles on top extend on all sides sheltering the mud walls. These houses also have ceilings made of wooden planks topped with *macci* (mud). The facade of the ainemane is embellished by the *kaiyale* (front veranda), imparting a unique character to it. It is reached by steps made of dressed stone slabs projecting out from the plinth, often flanked by carved single-stone parapets on both sides. A facade is prevalent at the north-east end of the ainemane and never occupies the centre. Common elements of the *kaiyale* include wooden columns topped with brackets, often tapering in shape, and carved. Wooden planks, four to five inches thick, can be seen mounted on the wall space between the columns to form comfortable seating spaces termed *aimara*. Occasionally, half columns may be employed where the wooden seating plank meets the wall at the two ends. The visual impression of a series of solids and voids is a key aesthetic feature of the façade.

The *kaiyale* in an ainemane is the space assigned to receive visitors and to hold family meetings. The plank or seat nearest to and facing the main door is accorded special ritualistic significance, being associated with the first ancestor of the family, who may also have built the house. This is termed *karanavanda aimara* and is often reserved for the eldest male family member in the family meetings. It is never used for sleeping by anyone. In addition, only men are usually allowed to make use of the space.

The wall separating the inner living spaces from the *kaiyale* accommodates the entrance doorway on the northern end. The doorway is adorned with intricately carved door frames supporting double-leaf solid wood doors, with wooden pivots at the vertical ends which are housed in the floor below and the thick wooden lintel on the top. The front doorway and the veranda window, being the most elaborate feature of an otherwise modest dwelling type, exhibit the family's intention to impress visitors with their affluence.This

Kodendera rear side of the central window with stand for firearms

explains the presence of ornate wood-carvings laden with motifs of birds, animals and other patterns. While the rest of the dividing wall would be of mud plastered with lime, exceptions to this do exist as in the *kaiyale* of the Kodendera family ainemane. The entire veranda is highly ornate, with three sides constructed as a wooden partition wall exhibiting superior carpentry and joinery skills, along with intricate wooden carving. The walls, doors, and window form one integrated assemblage of beautifully carved wooden elements. The timber selected for construction had to be termite-proof. Thus, teak was prized, but since it was found aplenty only in the plains toward Mysore, other woods such as jackfruit, rosewood, *ajini* (wild jackfruit), *balangi*, *nandi*, *deodar*, *noga*[6] or red cedar were also popularly employed.

The *nellakki nadubaade* (central hall), is reached from *kaiyale* through the ceremonial doorway and is the main ceremonial and living space. In *mund mane* (courtyard houses), the open court is adorned with four wooden pillars at its corners with four large wooden planks fixed on short parapet walls, the *aimara*. These together enclose the hard paved, laterite faced courtyard. The most ritually significant common feature of the ainemane is the placement of the *nellakki bolca* (wall lamp) on the western wall of the *nellakki nadubade*, facing the entrance doorway. During any important event taking place in the central hall, whether a marriage ceremony, naming of a child, settlement of a dispute, commencement of a long journey or an important negotiation between families, the lit lamp is present to represent the combined body of the ancestors. It serves as witness, and its blessings are invoked. These practices highlight the entire ainemane's significance as a sacred living space. Consequently, along with other caste-based restrictions, footwear, especially if made of leather, is not permissible inside the ainemane.

The living quarters of the family members are structured around the central hall. The kitchen, located in the northern end, and the *kanni kombare* (south-west corner room) are the other two sacred spaces in the ancestral house. The south-west corner room, which can vary in size from a full-fledged room to a narrow passage, is the assigned dwelling space for the combined body of the family's ancestors. A daily ritual in the past, a lamp placed in a niche on the western wall is only lit on important occasions nowadays, such as the yearly propitiation to the ancestors. Sometimes images of ancestors are also kept in this room. Thus, within the ainemane, the south-west direction is accorded ritual significance and even the south-west pillar of the courtyard is assigned this importance. An occasional feature is a wooden inverted pyramid-shaped container called *bhasma kutt* suspended near this column to hold *vibhuti* (sacred ash), which Kodava men tend to smear on their forehead before setting out from home.

The remaining sides are walled in to create rooms for the members of the family. Wooden double-leaf doors opening into the room are formal but not ornate. These rooms feature square or rectangular windows of

Maletira ainemane sacred lamp

ordinary proportions and with plain wooden shutters, opening inside. These have square wooden vertically fixed transoms in the openings as means of protection. While in the past family property was indivisible and all family members lived together, with changing times each of the rooms now belongs to a certain strain of the family, depending on the division of rights decided upon. Unlike most other Indian communities, Kodavas do not tend to sit on the ground. Thus, there is a more extensive usage of domestic furniture.

The attic of the ancestral homes, also accessed from the inner veranda, has low walls at both ends, on the outside and towards the central courtyard, in the case of courtyard houses. The roof, thus, becomes a pitched covered with Kollivaate, a type of reed found in streams or at riverbanks. These reeds together with their broad leaves would be embalmed with a mud paste and used to finish the top surface of the ceiling, which was the floor of the attic. Ceilings were an important addition to the mud and thatch houses, as the temperatures in Kodagu can dip considerably in the winter months; during the heavy monsoon rains they also helped to ensure a drier living space within. Being topped with layers of mud and cow dung perhaps rendered the ceiling fire retardant, an important attribute since in olden times the *okka*s had rivals and were frequently attacked. Below the *aimara* of the inner courtyard, shelves called *thood gud* would hold rosewood or reed sticks about 45 centimetres in length, dipped roof, running all around the central open space. Wooden columns with crossed wooden footing extend from the floor of the attic and and support the beams that in turn support the rafters and purlins on which the tiles are supported. Some of the courtyard houses have two floor levels. The lower level serves as the living quarters and the upper level is used predominantly for storage but is more habitable than regular attics. The

Nadikerianda kitchen

Eichetira ainemane mund detail

floor of the upper level is made of wooden planks laid on joists. A paste of mud and cow dung is spread over the planks to form a floor. This system of flooring is called *macci* and a house with such a floor is called *macci mane.*

According to oral history, roofs were constructed using small logs called *kabbu* to form a triangular-truss roof structure, which was then covered with *baripatti* (reapers made of bamboo or reeds)[7]. These logs, mostly of ajini, unsawn and rough dressed by knives, were used for making the ceilings as well. The logs, placed close together, were with a flammable oil (Kaikole fruit oil, oil from the Paniyathali seed, or pork fat) to be used as burning torches when it became necessary to defend the house.

Eventually, the use of sawn timber became popular. Mangalore tiles are said to have been in use in Kodagu since the 1880s.The roof structure became more formal, as did the ceilings which were built with a pinwheel structure, with solid wood members running the entire width of the roof contained within blocks, aligned in the cardinal directions. However, the attic floor continued to be finished in mud paste and cow dung. Another kind of roof, known as the *thombake* (banana flower) owing to a resemblance in form, exhibits the skill of these carpenters and can still be seen in some of the surviving temples and *ambala*s (roofed structures on raised platforms where villagers and their headmen met to settle disputes and discuss matters of concern).

CONCLUSION

The preceding account demonstrates the centrality of the ainemane in traditional Kodava family life. Indeed, the ainemane complex might best be understood as a three-dimensional document that embodies, in microcosm, the ordering principles of traditional Kodava society. Every aspect of these buildings, including choice of materials, construction methodologies, patterns of building activity, spatial organisation, and above all the ritual meaning assigned to various spaces, reflects the governing principles of a highly organised and hierarchical traditional society. Above all it is the ritualistic significance of the ainemane that has ensured its continuity through changing times.

Acknowledgement

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- All photos are by the author unless mentioned otherwise. Photos commissioned and bought by the HECAR Foundation: www.hecarfoundation.org

Bibliographic references

- Rice L 1927, *The gazetteer of Mysore and Coorg*, vol. 3, pp. 88-89.
- Nanjamma & Chinnappa, B, 2003, trans. *Pattole palame: Kodava culture- folksongs and tradition,* English translation of 1924 compilation in Kannada and Kodava by N Chinnappa, Rupa, New Delhi.
- Srinivas MS 1952, *Religion and Society among the Coorgs of South India*, p. 39.

Notes

[1] The Kodavas, anglicised as Coorgs, are a patrilineal ethno-lingual group from the region of Kodagu, in the state of Karnataka, who natively speak the Kodava language. Traditionally, they were landowning agriculturists with marital traditions.

[2] Very recently, translators of *Pattole Palame*, Mr. and Mrs. Chinnappa, met a few elderly ladies who remember getting different kinds of soil from the river and stream beds and painting the walls.

[3] Mukkatira is a particular Kodava family. All family homes in Kodagu are known by family names such as Nadikerianda, Kodendera, Maletira and Eichetira. Image credit: Mallikarjun B Katakol.

[4] It is said that the same technique was used to create tunnels through which a person could crawl in and out of the house and at times of emergency, such as, an attack on the house. However, any such tunnel was not seen during the field survey.

[5] Image credit: Mallikarjun B Katakol.

[6] *Balangi, nandi, deodar, noga* are species of trees found in the region.

[7] This account draws heavily on information provided by BP Appanna, a writer and scholar on Kodava culture who researched traditional construction methodology in the 1940s.

Construction and Ornamentation of Havelis
Shekhawati, Rajasthan

URVASHI SRIVASTAVA

Urvashi Srivastava is an architect and heritage conservation expert with more than a decade of experience of working in Indian historic cities. She has worked extensively in several historic cities, towns and villages of Rajasthan and has special interest in interdisciplinary approaches towards the study of the historic built environment. She is the Director of Centre for Advancement of Traditional Building Technology and Skills (CATTS).

ABSTRACT

The tradition of building construction in the Shekhawati region has been a significant part of its local culture. The region's traditional building types have had a unique style of planning and design and their construction was based on structural principles that evolved over centuries involving specific technologies. Amongst these, the traditional courtyard houses called the havelis, dotting the small towns and villages of Shekhawati, stand out as a distinct built form. An attempt has been made to study the building components, materials and ornamentation skills employed in construction of these beautifully painted traditional havelis that have given Shekhawati the status of an 'open-air art gallery'.

INTRODUCTION

Building construction technologies, ornamentation techniques and skills were perfected by the craftspeople of Rajasthan over centuries. In the Shekhawati region, traditional technology was used to construct a variety of building types namely forts, palaces, havelis, temples, *chattri*s (cenotaphs), *dharamshala*s (inns), shops and water harvesting structures such as *baoli*s (step wells), wells and *johara*s (water tanks). Each of these

Beautifully painted haveli

structures had a unique style of planning and design with a range of ornamentation techniques employed. The enchanting and colourful region of Shekhawati has the largest concentration of painted structures in the world. Traditional buildings especially havelis are profusely decorated with frescoes and dot the small towns and villages. Over the years, this region has come to be known as an 'open-air art gallery'.

TRADITIONAL BUILDING CONSTRUCTION IN THE REGION

The varied and unique built environment of Shekhawati not only served the diverse functional needs of the community but also gave expression to the aesthetic aspirations of individual inhabitants. Within the urban fabric of the towns and villages, havelis are the most distinct of all built forms and encapsulate the complete spectrum of building construction technology and ornamentation techniques. These havelis demonstrate the pinnacle of traditional construction technology and skills achieved by contemporary artisans.

As the predominant component of the traditional building stock in any town of Shekhawati, they are also representative of the transformation trends in contemporary construction.

The design process for construction of havelis was primarily guided by the cultural norms of the society. The construction technology that developed was based on traditional inherited knowledge, perfection of skills achieved over several generations, a deep understanding of building materials and appreciation of user needs for designing an enclosure for meeting them. Locally available building materials were adapted and improvised to achieve the best quality in construction within the limited resources. Apart from the functional and structural aspects of construction that were very skilfully achieved in a haveli, aesthetic aspects were also equally exemplified.

Architectural style and construction technology drew majorly upon Mughal as well as Rajput traditions. Founding of Jaipur, the new capital of the Kachhwaha

Rajputs, in 1727 AD, had a major influence on construction activity in Shekhawati. Eventually, interface with European cultures in the late 19th century deeply influenced the planning and design of later havelis as well as the use of materials.

Building construction trade in Shekhawati was well organised. It included the processors and manufacturers of building materials and tools, the craftspeople who assembled them on the building site, as well as the master crafts persons who employed and coordinated the work of the craftspeople. A local community of Hindu and Muslim masons, who called themselves Kumhars and Chejaras respectively, were traditionally involved in the construction and painting of havelis. The masons who specialised in painting frescoes called themselves Chiteras. Knowledge of construction was transmitted orally and passed down from one generation of craftspeople to the next.

DEVELOPMENT OF BUILT FORM AND ARCHITECTURAL STYLES

The built form of the haveli continuously evolved. Commencing with the construction of the main residential space, the building expanded with the affluence and size of the family. The oldest havelis to have survived in Shekhawati were built towards the end of 18th century. In the beginning, these demonstrated a defensive character due to political instability within the region. Later on, these were transformed into palatial buildings. Hence, the older havelis in the region had a fortified character with outer walls mostly blank with minimal openings, finished in coarse plaster applied in a crude manner.

As the 19th century progressed emphasis lay increasingly on the decorative appearance of the exteriors. The number of windows and openings increased. Murals or burnished white plaster or *loi* became popular. Stucco decoration also became popular, often accentuating architectural forms as with the arch or duplicating them with false pillars. Flat wooden ceilings decorated with polished pieces of metal commonly used in earlier havelis gradually disappeared around the middle of the 19th century and were replaced with vaults. Also in the 19th century, a new class of merchants and traders emerged and the havelis underwent a transformation. Prospering Marwari businesspeople competed with each other to build residential buildings, shops and other structures. Integration of technological innovations in building construction, new materials, European architectural elements and ornamentation could be seen. By the early 20th century, many havelis had colonnades of slender pillars on the ground as well as on the upper floors.

Elements like semi-circular arches replaced the traditional cusped form. Circular columns began to be placed instead of the tapering fluted ones with bell-shaped capitals. Use of coloured glass was introduced in the semi-circular windows above the doors of the *baithak* (reception space). Cast iron elements in buildings such as iron grilles, gates, fences, columns, brackets and iron joists, very popular in Europe, were manufactured in England and brought to India. With industrial production and technological innovations, the wooden beams supporting the ceiling were replaced with girders and wrought iron grilles, railings replaced steps and parapets, brackets, gates, fences. On some occasions, slender circular columns began to be used.

English porcelain tiles and mirrors, crystal chandeliers and panelled doors imported from Europe could be seen in the havelis of prosperous business families. Large mirrors and chandeliers, Venetian blinds in windows, elaborate stucco decorations, floral motifs, stone and iron railings for steps and parapets got assimilated into the traditional haveli. Earlier architectural elements like the elaborate *toran dwar* (entrance gateway) and *gokha* (semi-covered seating spaces) were replaced with the addition of an elaborate veranda in front of the haveli. The *jharokha* (cantilevered enclosed viewing space especially for women) also got eliminated and to the older havelis porticos[1] and ramps were added in place of steps.

BUILDING COMPONENTS AND CONSTRUCTION TECHNOLOGY

The primary elements that formed the structural system of the building were the plinth, walls, columns, beams, arches, lintels and brackets. These components were used in combination to transmit the load of the super-structure imposed on them to the ground below through the foundation. The spanning components helped cover the space defined by walls and columns. They were broadly in the form of vaulted and flat ceiling. In some of the later havelis sloping roofs made of corrugated sheets supported by wooden rafters and columns were also used.

Doors, windows, *jaali*s (screened opening), *chabutra* (raised platform), *gokha*, *jharokha*, balcony, niche, *chajja* (shading device), cornice, parapet, grilles, ramp and stairs constituted the architectural components

Stucco plaster on facade

of the haveli. These additional features incorporated within the main structure of the building served both functional as well as decorative purpose.

Finishing components such as wall finishes, floor finishes and terracing were used to strengthen the main structure of the building by providing surface protection as well as to add to the aesthetics. Terracing locally known as *dar* was commonly used to protect the roof and acted as an insulation layer cutting off the transmission of heat to the interior. Ornamental components, the purely aesthetic elements of a haveli, were used to add richness to its otherwise blank and monochrome façade.

BUILDING MATERIALS

The difficult terrain of the Shekhawati region did not permit easy transportation of building materials over a great distance. Few passable stretches of road existed only when not enveloped by moving sands. Transportation was mainly by means of camels. The choice of materials used for constructing grand havelis as well as the various other typologies of built structures therefore entirely depended upon their availability in the region. Use of local materials and a common construction technology resulted in a visual order in the entire built environment of the region. In the absence of good quality building materials in the region, the artisans had no choice but to exploit the available resources to the utmost. In the process, they developed a detailed and precise body of knowledge of the behaviour and characteristics of the available materials. Locally available materials such as lime, stone, brick and wood were used mostly in construction.

Walls were constructed using three materials depending on local availability. These were brick, stone fragments and greyish lumps of hardpan known as *dhandhala*. *Dhandala* is characteristic of desert topography found just below the surface of the soil, formed over centuries. Masonry work was done using stone or bricks in combination with stone. While mud bricks were handmade, hills in the district of Jhunjhunu and Sikar provided stone for building purposes. Away from the hills, brick was commonly used in the south and south-east of Shekhawati. In Jhunjhunu, Khetri, Singhana and Udaipur flat fragments of stone predominated as stone from the nearby hills could be easily quarried. Over the central and northern part of the region, the local craftspeople exploited the lime-rich hardpan. This was dug from shallow pits as ragged, shapeless lumps and was used as an important building material in the form of ashlar or even paving and also as a major source of impure lime for preparing mortar. The carved stone elements brackets, pillars and decorative panels used in the local buildings were worked near quarries along the foothills of the Aravallis, particularly at Raghunathgarh.

Lime was a significant building material for construction in the region. In fact, the traditional construction technology of Shekhawati was primarily a lime based technology. Lime was used in the preparation of mortar, plaster and fine decorative stucco work as well as making a highly burnished lime plaster, produced by adding many layers of fine plaster. In the absence of good quality stone for cladding and ornamental purposes, most of the havelis were covered with lime plaster and decorated with fresco paintings using mineral and vegetable pigments. Best quality lime, essential in fine lime plaster work was derived by burning the blue-grey marble, which was dug at Kirod and Bhasawa, near Nawalgarh.

Timber was a rare commodity since vegetation cover in the region was mostly sparse. Lack of plentiful timber for beams resulted in most of the rooms being fairly small and vaulted. This, however, did not limit the use of wood in the havelis of Shekhawati that boast of some of the very fine carving work in beams, doors, window shutters and frames. Durable hardwood called Rohira, a local species, was the source for much of the fine carved woodwork. Churu, Ramgarh, Mandawa and Bissau display finely carved wooden door frames while Fatehpur has some of the finest carved beams.

Apart from the locally available materials, building materials were also sourced from outside Shekhawati and even imported from outside the country. Most of the mineral colours used in mural paintings were sourced from different parts of Rajasthan. Cast iron elements in buildings, chemical pigments, ceramic tiles, and decorative items such as Belgian glass, chandeliers and large mirrors were some of the materials sourced from outside the region. The 'Made in Britain' mark embossed on fittings used in havelis attests the same.

ORNAMENTATION SKILLS

Several ornamentation techniques were used in havelis. Wall painting on lime plaster was extensively used as an artistic medium for expression. Surfaces were painted with beautiful figures, geometrical and floral patterns, and borders. Stone carving, wood carving, brass inlay work, coloured glass work, gold painting

Alagila or fresco work

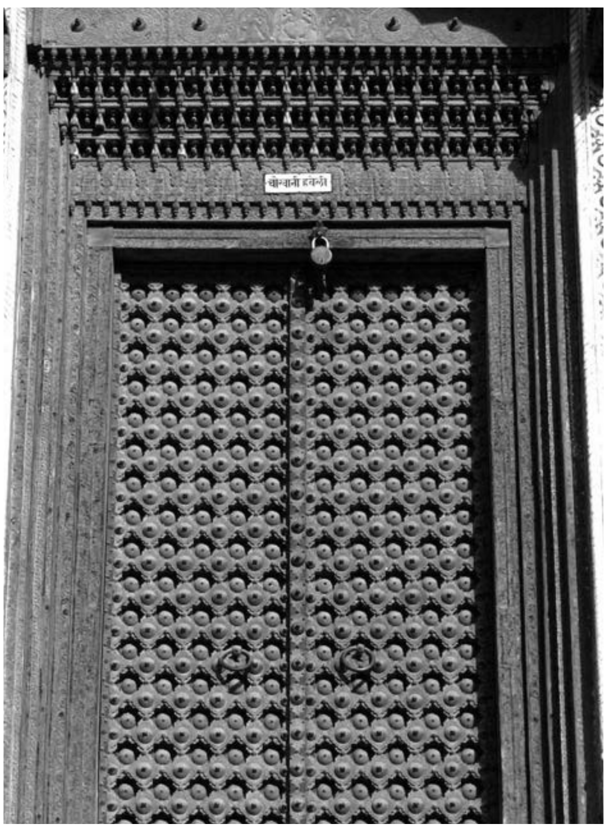
Mirror work in combination with alagila

and mirror inlay work were other ornamentation techniques employed with utmost perfection.

Wall plastering and stucco

Traditional lime plaster was extensively used both for providing a protective breathable covering to brickwork and stone masonry as well as for aesthetic purpose. Variations in methods of preparing the plaster mortar resulted in different types of finishes. *Lipai* was the most elementary type of plastering. A finer version of the same plaster used for *lipai* was known as *loi* and an even finer version was Shimla. This technique was quite frequently applied on a wide range of surfaces, external as well as internal not only in the form of plaster but also as a floor finish, dado and as a fine coat on architectural elements imitating marble. This technique widely used all over Rajasthan for centuries is also popularly known as Araish. Stucco plaster detailing was also used in later havelis, especially in the form of fine plasterwork, for classical or Baroque decorative work, columns, rustication and in imitation of stone.

Coloured glass used in semi circular opening



Intricately carved woodwork

Alagila or fresco work

Intricately painted frescoes are one of the most striking features of the majority of the Shekhawati havelis. The front façade had the most intricate paintings while the side and back walls had little or no ornamentation. The frescoes on the exterior and interior surfaces of the haveli portrayed the social, religious and cultural values of the occupants and their economic status as well. Two types of fresco techniques were popular in the region. One was *fresco buono* (true fresco) where fresco is made on wet plastered surface, the Rajasthani technique for which is known as *alagila*. In Shekhawati, walls were decorated with alagila often used in combination with glasswork. The second method was *fresco secco*, which involved painting on a perfectly dry wall surface.

Gold painting

Gold was used to highlight and add richness to the fresco paintings done using the *fresco secco* technique. Only very few of the wealthy Marwari merchants had this type of work executed in their havelis.

Mirror work

Mirrors were used in conjunction with *alagila* to produce spectacular ornamentation on building facades of havelis and other traditional buildings. It gained tremendous popularity because of its application to a wide variety of motifs and three-dimensional finish.

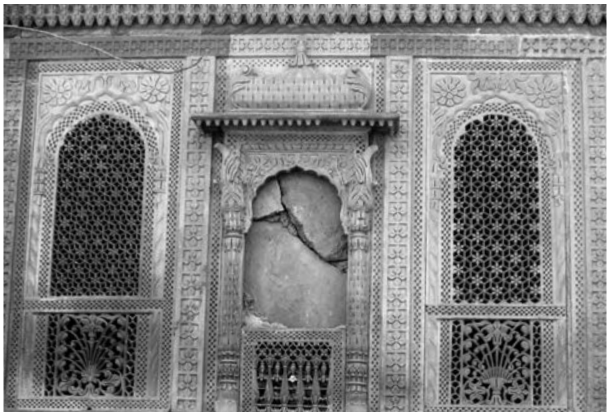
Coloured glass work

This was a very popular method of adding richness to the interior spaces of rooms. Originally, green, blue and red Belgian glass was used in tiny openings created in the walls to let in coloured light. Havelis built in the latter half of the 19^{th} century had large semi-circular windows above the doors of the baithak, where coloured glass was used. Pieces of coloured glasses were fixed in a metal frame with putty sunlight passing through the glasses created a wonderful effect inside the room.

Wood carving

Wood carving was a highly developed craft in Shekhawati. Door and window shutters had carved geometrical patterns in combination with embossed brass sheets having impressions of floral patterns. Their frames were adorned with one to five bands[2] of linear floral patterns running along the entire length. Both sides of the lintels of doors and windows, opening towards the inside of the *chowk*s (court), had intricately carved hooks. The entrance door to the inner chowk was the most intricately carved in the entire haveli. The door shutters of the *parindo* (water storage space) had specially designed panels with carved *jaali* (lattice screen) work in wood. Wooden beams and brackets supporting the wagon vault ceiling were also intricately carved. Some of the finest carved beams can be seen in the havelis in Fatehpur.

Some of the ceilings in the sleeping chambers were also decorated with wood. Wooden sections were



Stone carving on façade of haveli

Brass embossing work on windows

Haveli Owners Awareness Program

A Haveli Owners Awareness Program was initiated by the author in which orientation workshops for havelis owners, caretakers and users were organised. A Haveli Owners Awareness Kit comprising of 12 Conservation Notes was published to sensitise owners, caretakers and users towards the urgency for conserving havelis, apprise users about benefits accruing from it and extend technical help to them.

The kit introduced a scientific understanding of traditional construction techniques and processes amongst the users of havelis. It familiarised the owners and occupants with the process of preventive conservation and highlighted the need for regular repair and maintenance of havelis instead of one time expensive restoration projects.

placed parallel along the entire width of the room. In between these, square panels, formed of thin wooden strips, ran along the entire width of the room. In the centre of each, circular brass discs were placed. This gave a beautiful effect of the lamp light reflecting from the shinning brass surface at night. This type of wooden ceiling was common in the earlier havelis built prior to the 19th century.

Stone carving

Good quality carving stone was not readily available in the Shekhawati region. This, however, did not discourage the craftspeople. Columns, beams, arches, brackets, plinth slabs, cladding panels and *jaali*s were all carved in stone. Stone *jaali*s were carved out in thin slabs of stone and were used in window openings. Carving was done in geometric and floral patterns that created beautiful patterns when light filtered through these. Doors and windows opening out into the *tibari* (semi-covered space) and *chowk*s had panels of stone *jaali*s fixed above that provided ventilation and light in the rooms. Stone *jaali*s can also be seen in the inner wall of the *poli* (transitional space separating the inner and the outer chowks). Relief work in stone cladding panels was also popular.

Brass embossing

Brass embossing was done in combination with carved geometrical patterns on the door and window shutters of havelis. These brass sheets not only added to the aesthetics of the space but also strengthened and protected the shutters. Brass sheets were beaten and desired floral patterns were embossed on them. These were then fixed on the wooden shutters with iron and brass nails, strips and ornamental brass knobs.

CONCLUSION

Shekhawati had a rich tradition of construction and building crafts and the large numbers of traditional buildings in the region bear testimony to this. The traditional building crafts of Shekhawati that were used to construct beautiful havelis and other buildings, however, are now almost on the verge of extinction. Gradual decline in the inherited skills of the local craftspeople, lack of emphasis on oral knowledge of traditional construction and absence of written records for the same have resulted in the virtual disappearance of traditional building crafts. Moreover, with the advent of modern materials and techniques, traditional construction knowledge, skills, materials and techniques have been relegated to the background. Aggressive marketing of modern materials especially cement has led to its wide spread usage in repair of buildings constructed with lime ignoring the disastrous consequences of its use. In addition, demands of the market mechanism have forced traditional craftspeople to jettison their traditional knowledge in favour of modern construction skills.

Traditional construction knowledge is no longer being put to use and therefore the oral tradition of transferring knowledge from one generation of craftspeople to the other has seen gradual discontinuation. With the passing away of the older generation of craftspeople, the oral knowledge about traditional construction systems has been substantially eroded.

The biggest challenge in preserving the built heritage of Shekhawati has been to bring together various stakeholders on a common platform and synergising their efforts. In an attempt to achieve this, a grassroots initiative was undertaken in association with the Department of Science and Technology, Government of India and UNESCO New Delhi Office. A detailed project focusing on havelis and revival of their traditional building construction technology and ornamentation techniques was initiated. As part of the project, a campaign Shekhawati Virasat Abhiyan was launched to encourage and empower the local community to participate in heritage conservation works. Through the campaign, for the first time, an effort was made to reach out to the local community. Initiatives like these are a step towards preserving the traditional buildings in Shekhavati, especially the havelis and the dying building crafts of the beautiful architectural heritage of this region.

Bibliographic references

- Cooper, I 1994, *The painted towns of Shekhawati*, Mapin Publishing pvt. ltd., Ahemdabad.
- Gupta, M, *Jaipur: zilewar sanskritik ewam itihasik adhyan.*
- Khedwala, D 1976, *Fatehpur Shekhawati ka itehasik digdarshan*, Shri Lakshminath Press, Fatehpur.
- Misra, R 1990, *Mandawa nagar ka itihas*, *kala samaj ewam sanskriti*, Nagar Vikas Sansthan, Mandawa.
- Pande, R 2005. *Rajasthan ke bhitti chitra*, West Zone Cultural Centre, Udaipur & Shodhak, Jaipur.
- Prakash, TC. *Shekhawati Vaibhav*.
- Pratap, R 1996, *The panorama of Jaipur paintings*, D.K. Printworld (p) ltd., New Delhi.
- Seth, M 2003. *Wall Paintings of Rajasthan*, National Museum, Delhi.
- Sharma, U & Jangid, A, *Bissau digdarshan*, Taran Shaitya Parishad, Bissau.
- Sharma, HS & Sharma, ML 1992 *Geographical facets of Rajasthan*, Kuldeep Publications, Ajmer.
- Shekhawat, SS 1884, *Nawalgarh ka sanshipta itihas*, Panchpana Committee, Jhunjhunu.

Notes

[1] Entrance porch

[2] Depending on its thickness, the frames were adorned with one to five bands.

Tectonic Study of Jain House Form

Khambhat, Gujarat

SAPAN GAJJAR

ABSTRACT

'There may lie a great lesson of vernacular building for our own day: the value of constraints to establish generalised, 'loose' frameworks where the interplay of the constant and changeable aspect of man can find expression', Rapoport (1969). An examination of how climatic response of a house form through changeable and constant architectural elements and features affects the spatial configuration is attempted. The area of study displays the same socio-cultural practice but varying climatic condition from the sub-region. In such cases, adaptation of the regional house form leads to avail such climate-controlling elements and features, which adopt local climatic conditions.

An attempt has been made to investigate the basic house form, varying climatic and micro-climatic conditions on selected cases, and how climate-controlling elements are evolved to adapt to the regional house form. The presence or absence of certain elements in each case due to varying micro climatic conditions makes the role of each such element evident. Thus, each house form changes architecturally and tectonically, and so changes its human expression.

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INTRODUCTION

Vernacular architecture has always been an important part of the cultural heritage of every region and country. Vernacular settlements and house forms demonstrate the cultural ethos of a community, response to climatic forces and socio-cultural practices. The adaptive nature of vernacular house form gives the freedom of communal and personal expressions. These forms are often adapted or migrated to sub-regions along with the migrating community. For instance, the generic house form in Gujarat has evolved as response to the arid conditions prevailing in the region. However, the town of Khambhat in Gujarat, due to its vicinity to the sea experiences humid climate. As a result, the house form of Khambhat deviates from the generic regional house form through specific responses to its micro-climate.

Khambhat (Cambay), a *taluka*[1] town, is situated at the head of Gulf of Khambhat, which is the point at which River Mahi discharges into the sea on the fringe of the city. The physical aspect of the *taluka* is flat and open, with moderate undulations. The soil found is alluvial and due to proximity to the coast, is also saline. Climate can be identified as a Tropical Sub-Humid, with less temperature variations than the central Gujarat region. The average annual rainfall varies from 800 to 1,500 millimetres. A rich variety of vegetation is found in abundance within the *taluka*. Winds are generally constant and light, strengthening in force during south-west monsoon season. Primary desired direction of wind is south, which brings in the sea breeze.

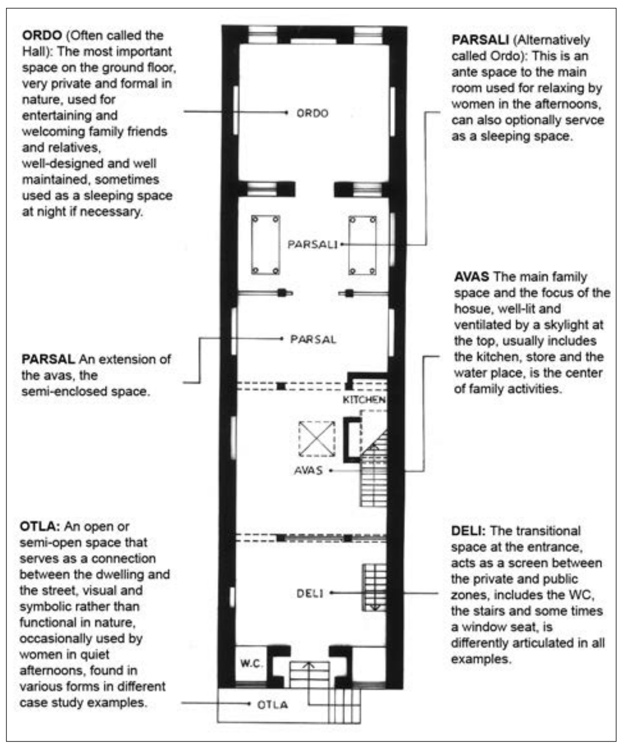
Khambhat is of immense historical importance. It had been the gateway of 'Hindoostan' between 9th and 13th centuries. Due to its location and significance, various communities settled within the town and various religions flourished. Its population comprises of Hindu, Jain, Muslim, Bohra and Parsi communities. Two parallel north-south roads create the main artery of the town. One of these leads to the ancient port southwards. Subsidiary roads run perpendicular to these, leading further into internal streets, which open up to form small courts in each of the individual settlements called *wada*s or *pol*s.

The main streets are aligned along the prevailing wind direction, as if to deliver the breeze throughout the town. The tunnelling effect induced by this closely bound network of streets, along with the ratio of building height to road width assists in creating comfort for the passers-by. At least half of the main streets remain shaded almost throughout the day and the proportion of shade goes on increasing as the street width narrows down in the interiors of the town. The internal streets open up into small courtyards, which are called *khadki* that form social spaces in almost every individual settlement. These courts are the only spaces apart from main streets that received direct sunlight. The internal streets, shaded throughout the day, develop a higher density of air; the courts on the other hand open to sunlight develop a lower density of air, causing convection current to flow from the internal streets to the court.

REGIONAL HOUSE TYPE OF GUJARAT

The typical house in Gujarat region is a deep rectangular shaped plan, sharing longer walls with other houses. Restricted from all sides, such a house grew vertically. Fear of invasion and the consequent need to cling together, mostly within fortified walls, led to the involvement of this house form along with the prevailing dry and arid climate of the region. The source of light and ventilation in the house is the central courtyard, which gave natural light and fresh air to the hearth of the house.

Focussing on traditional houses of the Jain community in a defined Jain neighbourhood, all the selected houses were built about hundred years ago and are still



Regional house type of Gujarat. Source: Desai 2007

House at Kharwado

functional. Selected case studies are located in a formal settlement types of *wada,* s*heri* and *pada*[2] and all the selected houses are located on the tertiary streets of the urban fabric.

Residence at Kharwado

Located in the central *chowk* (court) of the settlement, the house faces the *chowk* with its shorter edge. The house is linear on its east-west axis, with only the east façade exposed, the remaining three sides share common walls. The façade has extensive fenestrations with full size window openings and ventilators above the windows. The hierarchical ordering of space is developed to maintain privacy; hence the front has *otla* (low plinth) that acts as an interactive communal platform. The ladder-like stairway is accessible from the front façade, thus the upper floors are accessible from the outside. At the second storey level, two *ordo*s (rooms) are separated by a terrace in the middle and the front room has a balcony. These rooms are made to be airy and well ventilated. Since the south is unexposed, two wind-catchers are provided on the top storey rooms to keep rooms ventilated during periods of humidity. A tank has also been provided for rainwater storage. In the Khambat region, tanks are usually found below the *parsaal* (living room) that acts as a natural thermal cooling system for the interiors as well.

Residence at Bhonyara Pado

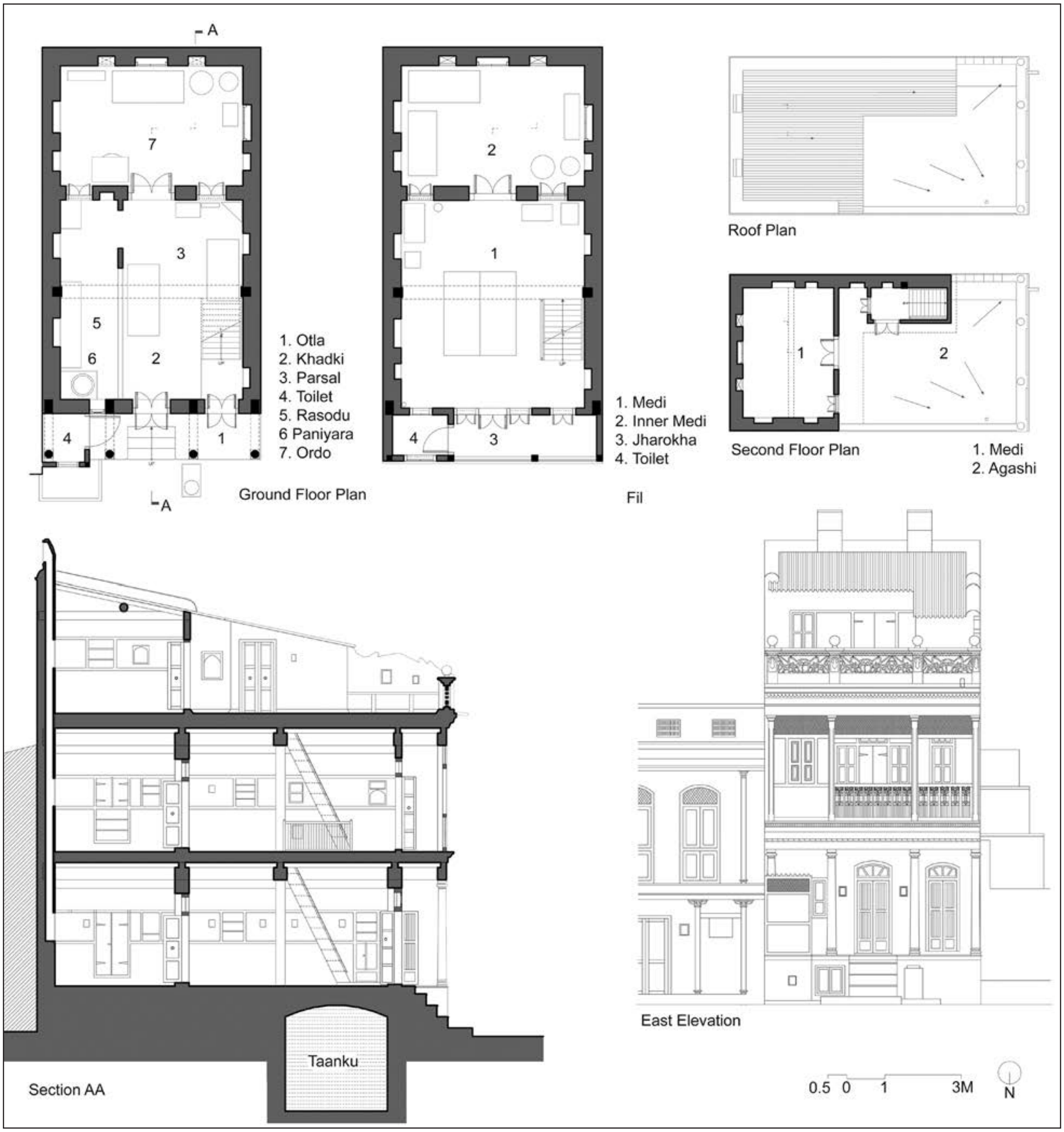
The house faces streets on both shorter sides. The longer sides share a wall with adjoining houses. The longer axis of the house is east-west. The house is narrow and deep. It is one storey high above ground with only one small room on the second storey that

House at Bhonyara Pado

comprises of a stair cabin. Full size windows on either facade maximise the fenestration. A very small court has been provided in the middle of the house, inducing air movement, though there is strong cross ventilation in the house. Unlike other houses, the *ordo* is on the upper floor and ground floor only has semi-public spaces such as *parsaal* (living space) and *rasodu* (kitchen) due to a street on the rear. The layout of the house is relatively modest. The rainwater storage tank is located below the *parsaal*.

Residence at Manekchowk

This example appears to be very different compared to former ones as the house is positioned on north-south longer axis. The north façade is exposed to the street, the rest are sharing walls. The façade is fully fenestrated. This configuration has lesser possibility for ventilation, so to compensate for it, the house is of shorter length. The courtyard is absent in this structure that is two storeys high above ground, with the northern half of the top storey used as a terrace. The absence



House at Manekchowk

of fenestration and court leads to the added feature of a wind-catcher in this house. The tunnel projects above the roof, opening southwards, in a windward direction and extends to the ground floor level, opening towards the interiors like a window. The provision of a shutter makes it operable. This wind-catcher receives sea breeze, which is moderately cool and needs no additional cooling treatment. The house has a higher plinth due to low-lying topography of this settlement.

Residence at Kapadia ni Sheri

This structure is aligned along north-south longer axis, exposed on both the shorter faces. Having adequate fenestration on both north and south facades, the house remains windy most of the time. The structure is two storeys high, with a major portion of the top storey used as a terrace. It has a low plinth and smaller *otla* space and a rainwater storage tank below the *parsaal*. The full-length windows on the first floor gives the sense of a balcony. While the configuration of spaces

Table showing materials used for construction

Elements	Structural Members	Filling Materials
Wall	Timber, Brick	Mud, Lime
Floor	Timber	Brick, Lime, Mud
Roof	Timber	Country Tile, Metal Sheet, Mud, Lime
Façade	Timber, Brick	Lime, Mud
Stairs	Timber	
Doors	Timber	Timber, Metal Strips
Windows	Timber	Timber, Metal bars, Glass

House at Kapadia ni Sheri

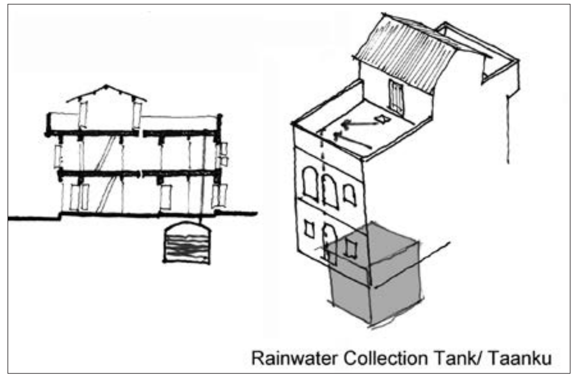
in this residence has a strong hierarchical diagram and formal layering of private spaces, this example appears to be devoid of all additional architectural and climate-controlling devices and features.

COMMON ELEMENTS AND FEATURES OF THE HOUSE FORM

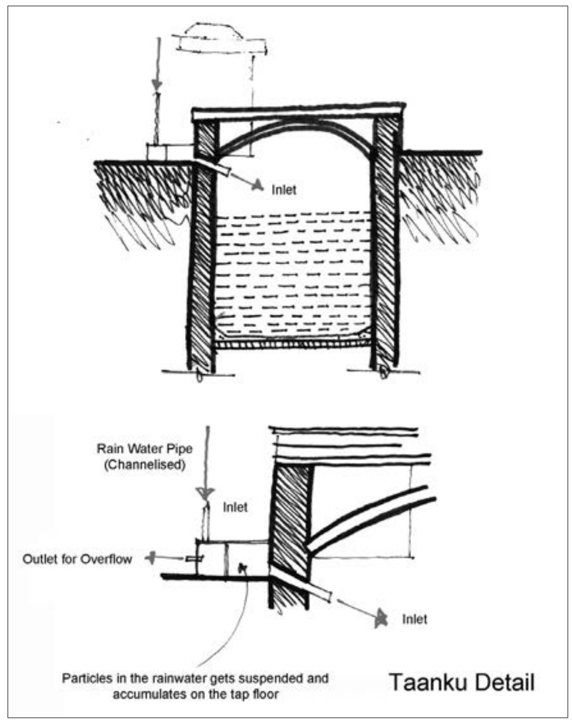
The common elements and climate-controlling devices found in the traditional house forms studied are the *taanku* (rain water storage tanks), full height windows, terraces, ventilators whereas some features such as wind-catchers, courtyards and balconies appear in specific examples. These elements have evolved directly as a response to the prevailing micro-climate. Although some elements are commonly found in the house form of Gujarat region, some of these are specific to the Khambat region. The planar organisation, construction methods and spatial scales of the cases studied are found to be the same as the regional house type. The materials used are also the same, such as mud and lime plaster over brick wall construction, which helps retaining inside temperatures. The variations are found in the settlement patterns, street formulations and such added climatic features to the house. Some specific elements and climate-controlling devices of these houses have been elaborated.

Taanku

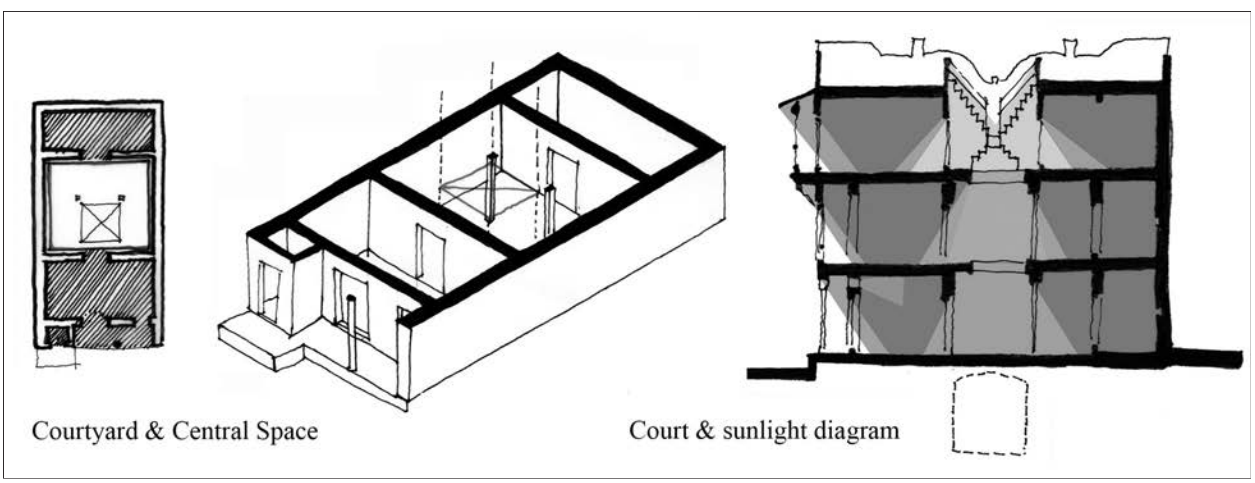
This is a traditional system of storing rainwater wherein in each unit the water need of a family for the whole year or more is served. Similar systems for rainwater harvesting can be found across Gujarat and Rajasthan. Most *taanka*s in Khambhat today are 100 to110 years old. The rainwater collected on terraces is channelised through pipes to the



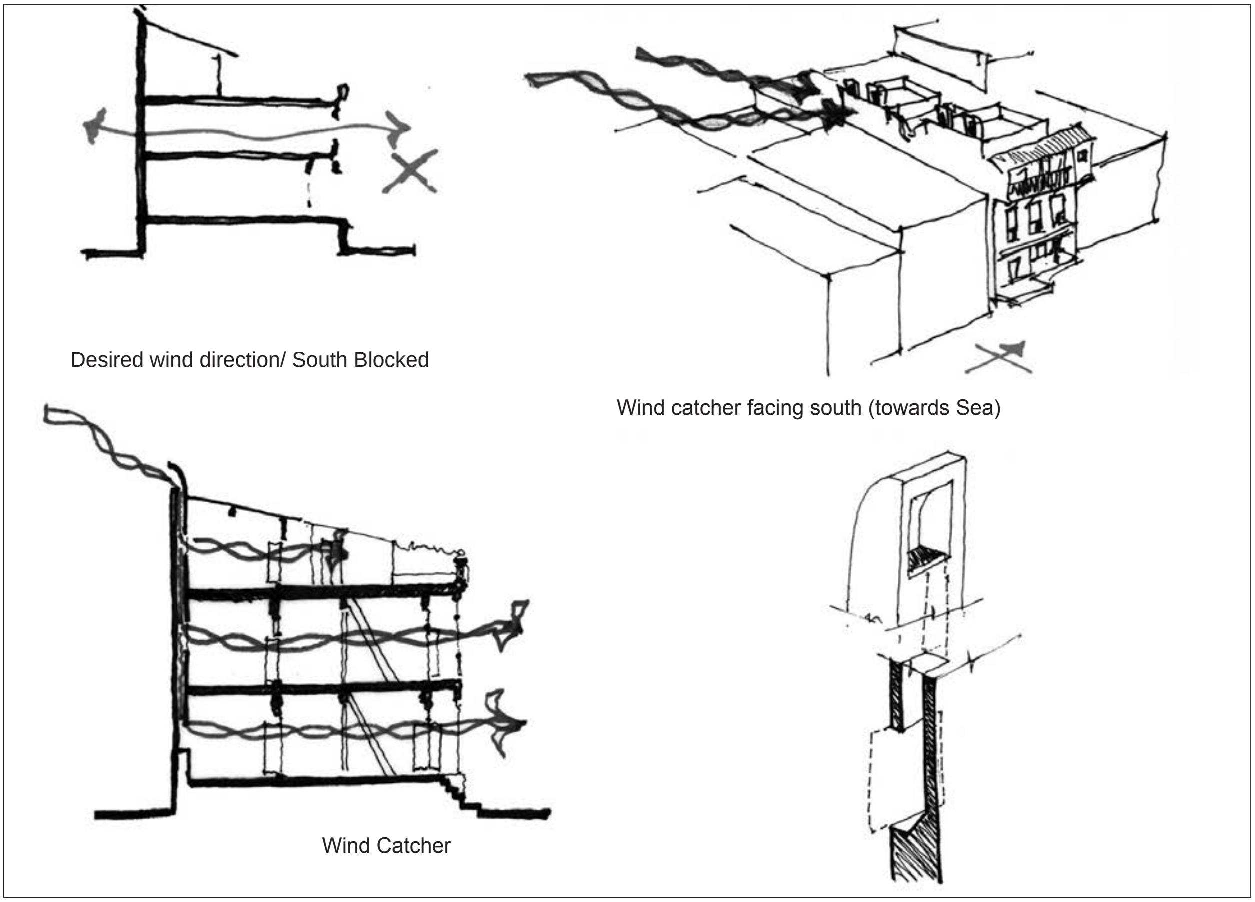
Taanku



Taanku detail



Courtyard configuration



Wind catcher detail

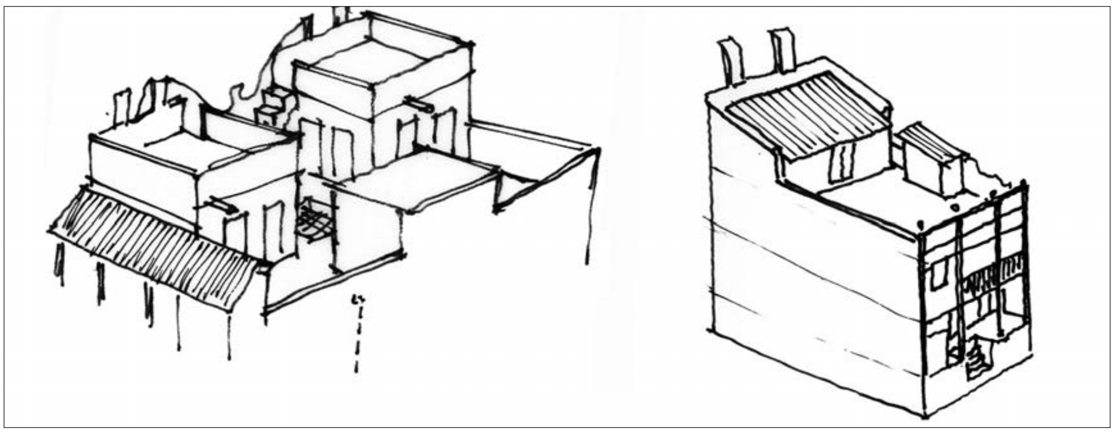
tank. Terraces are cleaned before rains, and initial rains are not used for collecting, but to wash the terrace surfaces. From the pipe, water has to pass through the trap in which any suspended particles accumulated from surfaces settles down. The trap also has an overflow outlet to discharge surplus water when tank gets filled till the desired level.

The water is sometimes used for two to three years during scanty rainfall. Hence, regular cleaning of the tank is very important. For this purpose one side of the tank has foot-holds made by removing bricks from alternate courses. Alum wrapped in a clean cloth is also hung from the tank ceiling for activating sedimentation. A layer of yellow soil is placed on the tank floor for the same purpose. The water is collected during Mriga Nakshatra, since there is a belief that water remains drinkable for longer periods than normal if it is started collecting during this time.

The construction system for the *taanku* uses thick brick walls and floors with vaulting for the ceiling. The internal parts of the walls are made waterproof by applying slaked lime plaster. The mouth of the tank is marked with a high stone rim and covered with a copper lid that protects the water from any litter or spilled liquid around. Such system of storing water prevents sunlight from touching the water so the formation of algae or other organic form is discouraged and water remains potable for extended periods. The evaporative cooling taking place because of water tank keeps the living room cooler than the rest of the house.

The sewage system is also influenced by the *taanka*s. For sewage disposal, almost every house has a cesspool known as *kharkuvo* under the toilet. Normally cesspools lose their capacity in 15 to 20 years as the soil gets saturated, but in Khambhat, as the ground water is not drawn out, the cesspools are dug towards the level of the ground water table. This works not only on soil's capacity but on capillary action by which the water is drained, hence, they have been in use for over a 100 years. This is possible only because the ground water is not used in the town, in any other place this system would have caused serious epidemics.

Full height windows



Roofscape

Hawaa-baari

Wind catchers, locally known as *hawa-baari*, are shaped like pipes and are built within the walls, facing the predominant wind direction to catch the wind and pass it to the interior spaces of the house that are not well ventilated due to the linear compact layout of the houses. Since they face seawards, they catch the cooler sea breeze and pass it to interior spaces. They also act as ventilation tunnels bringing hot air out in case of opposite pressure difference.

Due to humid climatic condition and higher wind speeds, this component is not as complex as found in desert and arid climatic condition. The air doesn't need to be treated, since the air is cooler and doesn't comprise of fine dust particles unlike the desert regions, so the simpler design of tunnel like wind catcher is suitable. This device is often paired with a court in the centre of the house for efficient performance.

Chowk

Courtyards are not found so commonly here as the rest of the state, the obvious reason appearing to be humidity due to proximity to the sea. They are found in houses that are narrow and share walls with neighbouring houses, to bring the natural light within the interior spaces. Often courtyards are provided for the purpose of ventilation through air circulation and are devised along with another element such as the wind catcher, as the court allows hot air to escape, forming convection currents.

Full height windows

Unique to the Gujarat region, these windows are as large as doors with two parts and double doors. Different parts of the external shutters can be operated to obtain desired amount of light and breeze. Internal shutters are made of metal *jaali* (lattice screen) for ventilation. The *jaali* accelerates incoming wind flow. During the day, due to difference in the luminosity, it allows enough privacy without hampering proper ventilation.

Agashi

Due to the dense settlement pattern, terraces of the adjacent houses are linked. Many day-to-day activities take place on terraces including sleeping in the summer nights. Terrace surfaces are sloped to channelise rainwater to be collected. Terrace is given priority in the design and layout of these structure due to its day-to-day importance and festivals like Uttarayan (kite flying day) that is of a great importance for the town, and so the terrace is utilised to its fullest for the celebration. Due to these factors, sloping roofs are minimised and terrace surfaces are maximised.

Ventilators

Ventilators are situated above doors and windows as hot air outlets. They are hinged or pivoted. Ventilator acts as a hot air outlet and keeps the house ventilated without providing visibility to outside. They are commonly found in houses of Khambhat and form an important part of building fenestration, responding to the climatic condition.

CONCLUSION

The climatic variation of the sub-region and adaptation of generic house type have resulted in the adaptations in standard climatic devices to bring comfort in the humid climate of Khambhat. These devices are introduced in each house as per the micro-climatic conditions to maintain thermal comfort. Parallel bay construction system of the generic house form of the Gujarat region does not offer the constant air circulation within the house due to sharing walls and absence of excessive fenestration. Within this constant and 'loose' framework of a generic house form, such climatic devices appear as specific responses. Elements meant for climatic comfort, change the spatial configuration. For instance, the *parsaal* has been adapted as a space for family gathering due to presence of the court and tank below. The windows and fenestrated façade starts performing as gallery like spaces and day-to-day activities are performed there. The terrace also acts as a space for celebrations and gathering due to the room projecting above and providing shade. The wind catcher brings breeze within the depths of the house. Due to the meaningful assembly of these elements, a dwelling responds both to the urban fabric and the community's requirements while ensuring comfort and sensitivity to a set of specific ecological conditions.

Bibliographic references

- Desai, M 2007, *Traditional Architecture: house form of the Islamic community of Bohras in Gujarat*, Council of Architecture, New Delhi
- Keni, M 1972, *A study of house form of the temple town Nathdwara,* Undergraduate Thesis, unpublished, School of Architecture, CEPT University, Ahmedabad.
- Krier, R 1983, *Elements of architecture,* St. Martins Press, USA.
- Pandya, Y 2007, *Elements of space making*, Mapin Publishing.
- Rapoport, A 1969, *House form and culture,* Prentice-Hall Inc, NJ.
- Solgama, N 2007, *Understanding the cultural influences and transformations in traditional house form; the study of traditional house form in Mangrol,* Undergraduate thesis, School of Architecture, CEPT University, Ahmedabad.

Notes

1 A subdivision of a district, comprising of several villages, organised for revenue purposes.

2 *Wada* is defined as a neighbourhood with a sense of enclosure. *Sheri* is a narrow lane that connects different neighbourhoods. *Pada* refers to the main entrance of a street or a lane or a neighbourhood.

Contemporary Explorations in Mud Construction
Kerala

SHAILAJA NAIR AND PB SAJAN

ABSTRACT

Mud is essentially a mixture containing varying proportions of silt, clay and soil with water. It is truly a versatile material; eco-friendly, reusable and biodegradable, it can be moulded to any shape and used in all parts of a building, including foundations, walls and even roofs. Mud is also climate friendly, keeps the interiors cooler in summer and warmer in winter. An account of construction of a house using mud as the main building material after investigation into local knowledge, discussions with masons, researchers and trial and error is presented.

Shailaja Nair, Associate Professor in Architecture at the College of Engineering, Trivandrum, has 14 years of experience in academic field. She worked at the Centre of Science and Technology for Rural Development (COSTFORD), an NGO founded by Laurie Baker in Thrissur, Kerala for 10 years.

PB Sajan is Architect and Joint Director at COSTFORD. He has been with the organisation for 28 years, of which 20 years were spent under Laurie Baker's mentorship.

INTRODUCTION

Mud is one of the most widespread used construction materials in the world. Through the ages, several different approaches to using mud for construction have evolved, the most common being cob, adobe, wattle and daub and rammed earth.[1]

Mud has never gone out of use and is witnessing resurgence due to its low energy properties, making it eminently suitable for sustainable building practices. The reason why mud construction has been on a decline is

Initial portion and foundation in mud mortar

because of its susceptibility to moisture and biological attack, that calls for regular maintenance. Another weakness, in the present conventional construction scenario, is that it is labour intensive and does not lend itself easily to prefabrication. To counteract these weaknesses newer forms and combinations of this traditional material are being used such as cement stabilised mud blocks and plastic bottle filled mud construction. The former involves adding 5 to 10% cement as a stabiliser. It makes mud highly durable and weather resistant and therefore, necessitates less protection during the construction stage. The key disadvantage of using cement as a stabiliser is that unlike unstabilised mud that can be reused with practically no loss or returned back to the environment, the same cannot be done with mud to which cement has been added. Plastic bottles filled with earth are also gaining popularity, though mostly in low cost construction. This technique is an example of incorporating waste materials with mud construction and addresses its vulnerability to moisture and is low energy construction. However, being a newer method, its wider acceptance and any potential disadvantages in the long run are yet to be ascertained.

CONSTRUCTION OF THE HOUSE

The authors, both architects, built their own residence, Visala, in 2012.[2] The materials used included mud, granite and renewable materials such as bamboo, coconut wood and casuarina, and reused wood and roofing tiles, with minimal use of energy intensive materials like cement and steel.

Cob construction

Water repellent paint finish

Different finishes. Source: Prakhar Tandon

The house has a total built area of 202 square metres and is built on a sloping site of 344 square metres. The soil conditions varied even within the small plot. One portion of the plot had hard laterite with roundish stones. The mud used for construction was obtained entirely from the site itself. The mud was suitable for construction and was used without any stabilisers. Only traditional additives were used and these were fully bio-degradable.

An initial portion, 30 square metres, of the superstructure was built with brick walls, to meet certain procedural requirements. Two sections of the outside wall, approximately three metres each, were built using mud mortar. The use of mud mortar made it possible to dismantle these sections when the rest of the house was built as an extension. The mud mortar was washed off the bricks and reused without any damage. The random rubble masonry foundation is built with mud mortar except for a few places where it is dry packed. The plinth of the extension to the initial portion accommodates the water harvesting tank of 56 cubic metres (56,000 litres) capacity. Most of the mud used in the construction was obtained from digging into the ground for the tank, which has an average height of 1.5 metres. The mud joints in the mortar were scraped and filled with cement mortar in the proportion 1:6. The inside of the tank was finished with ferro-cement, chicken mesh plastered with cement mortar in the proportion 1:2.

The walls, approximately 23 centimetres in width were constructed using cob. The mud was heaped and in this process the bigger stones rolled off and were separated. In cob construction, small pebbles, one to two centimetres in size, are necessary for proper bonding. Water was added to the mud to get the desired consistency and was mixed by stamping with feet. Two percent lime was added to the mud, to kill any termite eggs or insects. The spherical cobs were pressed down while being placed in position and smoothened immediately, so that the wall was one single unit. The shrinkage cracks were filled using mud paste. For smaller cracks, the paste was brushed on. This is purely cosmetic in nature and does not affect the structural stability of the wall.

The initial plan was to leave the external walls without plastering, to retain the rough, natural texture of mud. However, during construction, it was observed that due to the location of the plot on one of the highest hillocks in the area, when the winds blew, rain was lashing near horizontally from all directions. The cob walls at that portion of the house were over seven metres high. Giving 1.2 metre overhangs on pyramidal roof of the second floor alone would not be able to protect the bare mud walls. It was thus decided to plaster the walls with mud plaster and use water based, transparent, water repellent paint to protect it. This type of paint is normally used for roof tiles, exposed fired bricks and clay tiles. For the initial coat over the mud plaster, the paint was diluted with 50% water. In the second coat, 20% water was added. Successive coats covered more areas per volume of diluted paint. The last coat was required to be undiluted but was not applied to test how the initial two coats would stand up to the elements over time. Two years after construction, the paint has required no further maintenance.

Two coats of mud plaster were applied. The first coat was the levelling coat. Mud plaster was prepared using one part lime, two parts manufactured sand and four parts mud, where the mud was too clayey, making it difficult to apply the plaster. Where the mud was workable, the plaster was one part lime to six parts mud. In both cases, rice husk in the proportion 1:10 was added, to increase binding.

For the final coat of mud paint given in the interiors, mud was taken from the same spot to obtain the same colour. To five litres of mud mixed with water to produce a paint like consistency, half a litre of white synthetic resin adhesive was added. This was brushed on like paint. This type of coating was done to prevent wearing away by daily use in the interiors. A small quantity of light coloured mud from a nearby field was initially brought to attempt a lighter colour. The corners and edges of the interior walls were rounded as it is difficult to get straight edges in mud and rounded edges are less susceptible to erosion. Several finishes of the final coat of mud on the walls were attempted at different places. Some parts were smoothed with sponges and trowels. On one portion, gentle rubbing by hand was attempted but was not extended to other areas, since the finish was more even but it was time consuming and hard on the hands.

Mud over bamboo floor. Source: Prakhar Tandon

In Visala, mud was spread over the structural bamboo floors to get a level surface. Ferro-cement was used to plug the gaps between treated bamboo poles to prevent the mud from falling through. Mud was then spread, five to seven centimetres thick, depending on the size of bamboo, levelled and left to dry. It was then plastered with cement mortar in the proportion 1:6. The final floor finishes were either reused wooden ceiling planks or cement oxide[3]. Concrete was totally avoided in the bamboo floors. The gaps between the bamboo poles were filled with cement mortar from below, for easier maintenance, to avoid narrow inaccessible gaps.

Terrace parapet. Source: Prakhar Tandon

The 23 centimetre parapets in and near the sit out or front porch, terrace and topmost storey were all made of cob. But they were treated in different ways depending on their location. In the sit out, the tops of the parapets were finished with cement plaster to withstand erosion and the rain and to serve as seating.

In the parapets on the terrace, reused Mangalore Pattern roofing tiles were used as coping. One portion had two tiles on both sides, capped with burnt clay ridge tiles. While this affords good protection for the walls, it took more time and material. So in the other parts, only one tile was placed tilted on the walls. The terrace mainly came over the family room and to avoid pooling of hot air between the parapet walls, holes were included in them to cool the terrace at floor level. Bamboo pieces were used to make the holes and pulled out when just set. No other finishing was done.

In the final storey, the walls are essentially parapet walls, with the gap between the roof and parapet being bridged with tilted bamboo poles with wooden reapers nailed horizontally on all four sides. On the outside, this is an extension of the portion of cob wall protected with the water repellent paint. On the inside, this is treated like the interior walls. A wooden coping is placed nearly level but slightly tilted to the outside. This doubles as seating, does away with contact erosion and throws off any rain water.

The boundary wall along the access road, also of cob construction, is partly constructed as a retaining wall to bridge the level difference between the road and plot. Some of the original mud was removed for the wall to be built. During construction, plastic sheets were used to protect the cob walls during rains. These plastic sheets were folded along the boundary wall and over it to prevent it getting soaked from moisture

The finished house. Source: Prakhar Tandon

seeping through the ground. The gap was then filled again with earth and the larger pebbles, which were initially set aside while preparing the mud. Another layer of cob was added. Two roofing tiles were placed tilted along the wall after it dried. It is not fastened and the interlocking of the tiles keeps them in place. The boundary wall of the road shared with the plot on the rear is almost at ground level and here too plastic sheets have been folded over the cob wall and tiles placed horizontally to accommodate potted plants.

CONCLUSION

There are proven methods of building and of maintaining mud buildings, honed over thousands of years, using materials which are locally available. Non-traditional building typologies and availability of new materials have opened up possibilities of innovation in current approaches to mud construction, to enhance its strengths and mitigate its weaknesses. The benefits, at the individual level, include lower construction costs, particularly if mud is available locally. It is the larger benefit to society and nature that surely puts mud among the top materials in sustainable building practices. The authors have attempted to incorporate mud in their own residence in various ways, keeping in mind this larger picture. The house is an ongoing experiment where the advantages and disadvantages are being assessed and the lessons learnt are being applied in newer constructions.

Notes

1 Cob is the simplest of all mud construction approaches. Mud is mixed with water to achieve the desired consistency required to make it into spherical balls. Where it is used in conventional wall sizes, each is slightly elongated into cylinders along the width of the wall, before being placed in position. These cylinders of mud are placed perpendicular to the direction of the walls and are known as cobs. In both cases, the cobs in the immediate upper course are placed between the cobs below. This ensures better bonding and minimises any gaps within the wall. The pace of construction depends on the time the construction takes to dry, allowing the upper courses to be placed without unduly flattening the lower courses. Depending on the finish required the mud is trimmed appropriately.
Adobe construction refers to the method of construction using sun dried bricks. Mud is packed into rectangular moulds, with size varying according to use. Specially shaped bricks can easily be made by introducing suitably shaped blocks, usually wood. The mud bricks are stacked and dried preferably in shade. This prevents rapid drying that could lead to uneven shrinkage and cracks. It can be plastered with mud or any other mortar or finishes. Adobe is normally used for load bearing walls up to two storeys.
Wattle and daub is a type of mud construction where mud is used along with other materials. These materials which provide a framework, mostly in the form of woven timber strips are known as wattle, to which mud is applied. Sometimes, the framework may be bigger sticks or small trunks tied together. It is possible to have much thinner walls with the wattle and daub method.
Rammed earth construction, as the term implies, is earthen construction that has been rammed or beaten and compressed. This increases the strength and durability of the earth. Rammed earth can easily be used for construction up to five storeys. They require moulds that can be removed and repositioned as the walls get built. A section of mould is made of pieces of formwork placed at the distance of the desired wall width. These are braced and clamped to withstand lateral forces while ramming. Ramming is done with a ramming rod, traditionally though mechanical means are also employed. Compressed mud bricks are also considered a version of rammed earth.

2 Their residence Visala in Thiruvananthapuram, Kerala, was awarded commendation prize under Green Building category, HUDCO design awards 2012.

3 Cement mixed with coloured oxide, usually red or black, applied in a slurry form and finished with trowel. It was earlier used very commonly in Kerala.

Experiments in Bamboo and Mud

Tapovan, Udaipur

GAURAV GURJAR

ABSTRACT

Bamboo is a versatile and economical material offering great opportunity in construction of ecologically sustainable structures. A lightweight structure to maximise indoor space was constructed between two parallel hill ranges in Tapovan, Udaipur. An account of this experiment to build a structure incorporating innovative ways of using bamboo and mud as primary building materials to a previously existing structure is presented.

Gaurav Gurjar has done Engineering in Electronics and Communication from Jodhpur Engineering College and Research Centre. His interests in sustainable living, eco architecture, natural farming and bio-mimicry took him to Sadhana Forest in Auroville, Sambhavana Institute in Palampur and Abhikram in Ahmedabad where he interned and gained some practical knowledge. He joined Swaraj University in Udaipur in 2011.

KEY ISSUES AND CONSIDERATIONS

Bamboo is one of the fastest growing species of grass and one of the most eco-friendly and valued materials used traditionally across India. Its elasticity and strength make it adaptable to a large range of structural approaches, from load-bearing structures to the framed and hybrid. The usage of bamboo extends beyond structural elements to decorative objects, utility objects and the production of fibre and paper. According to multiple studies, bamboo offers greater resilience to earthquake than timber or cement concrete structures. A lightweight structure to maximise indoor space was constructed between two parallel hill ranges in Tapovan, Udaipur. This location created a gully effect[1] that enabled the structure

Bamboo treatment by soaking it in lime and salt water

Bamboo embedded into pillars

to endure horizontal wind thrust. Natural, local and resilient materials that needed less maintenance were used. The design of the mud and bamboo structure entailed adding a structure over an existing concrete building. This meant several constraints in construction. The structure had to be light-weight and needed to have spacious interiors. This called for construction of thin walls. Using bamboo and mud as building materials, the traditional technique of wattle and daub construction was employed to build thin yet robust and elastic walls that would be resistant to both earthquakes and strong winds.

Big windows were constructed in the south to allow maximum sunlight during winters. This also provided a scenic view of the lake and the Aravallis. In the north, small windows were built to allow only minimum sunlight during summers. The room had effective ventilation on top, designed to create puncture effect[2] for the thatch roof to withstand extreme winds. The same vent helped in creating the draft of air for passive cooling, much required in of Rajasthan. The structure was framed with brick and cement columns to join it with the concrete structure below. Beams used were of completely dried eucalyptus logs.

Basic roof structure using eucalyptus logs under construction

Interior framework of ceiling

Basic wall structures using bamboo

Mud plastered over woven bamboo mesh acting as walls

Sliding glass windows being fit to protect from extreme winds and simultaneously maintain the view from the house

METHODS AND TECHNIQUES

Several kinds of treatments were employed to enhance the properties of bamboo, to increase its life as well as to make it resistant to pests and biological decay, extreme temperature variations and fire. Many methods of treating bamboo based on location, availability of materials and environmental conditions of the area have been developed traditionally. Villagers from Nai Gaon, located on Ahmedabad-Udaipur highway, who have worked with bamboo for generations, were consulted. The project area, being in Rajasthan, had limited supply of flowing water or infrastructure to smoke bamboos. The members were therefore immersed in a pool that had lime and salt mixed with the water for several days to extract the entire cellulose residue. Holes measuring three centimetres were drilled near almost every node for lime water to percolate in them. After the treatment, the bamboo members were strategically dried horizontally.

THE STRUCTURE

A basic hybrid structure, using eight brick and cement pillars with bamboos embedded into pillars horizontally, was built. Horizontal bamboo members provide structural strength and counter horizontal thrust of winds as well as support wattle and daub walls. The ends of the members were finished in oil based paint to avoid swelling due to moisture that might lead to cracks in the columns.

Beams of dried eucalyptus were used over the pillars and two heavy central beams of the same wood were used to take the roof load. Beams were joined to brick pillars with U-shaped iron strips and screws, and covered with plaster. To keep the load light and use as much natural options available, a thatched roof was built. The hip and gable roof had a top vent to allow the sun light in and let out the hot air. The central load of hip design of roof was on two central large beams


View of the completed structure


Woven bamboo mesh as wall over bamboo support structures

Interior spaces of the structure

of eucalyptus. Structural strength was provided by the bamboo frame. Over that a ultra-violet stabilised plastic sheet, to protect against rain and extreme weather, was placed and the thatch was laid over it. The walls had bamboo mesh, woven in together, tied with bamboo members already placed horizontally and plastered with mud on both sides.

After analysing locally available mud and testing for content of clay and sand, several mixtures were experimented with, varying in ratios of cow dung and several other mixtures with lime for plastering the exterior. Several layers of thin plaster were applied to minimise the occurrence of cracks. Other experiments for improving water proofing ability of plasters were done by mixing oil and casein protein (milk protein) to it. Also, several insect repelling herb mixtures were added to it to ensure the longevity of the plaster.

CONCLUSION

This experiment that employed local techniques and local wisdom of the area is a small step towards more such design models in architecture that are ecological and sustainable. The rising concerns over environment have led to value the traditional building techniques systems that are driven by nature. Such experiments may help develop long term solutions which adapt to contemporary needs while taking clues from the vast repository of traditional knowledge.

Bibliographic references

- Benyus, JM 2002, *Biomimicry: innovation inspired by nature*, William Morrow Paperbacks, New York.
- Bhatia, G 2003, *Laurie baker*, Penguin Books, New Delhi.
- Lloyd, A 2008, *Bamboo houses stand up to earthquakes*, June 3, <http://www.treehugger.com/green-architecture/bamboo-houses-stand-up-to-earthquakes.html>
- Meinhold, B 2011, *Unique bamboo living pod concept is a study in disaster proof design*, August 8, < http://inhabitat.com/unique-bamboo-living-pod-concept-is-a-study-in-disaster-proof-design/ >.
- Mukhopadhyay, P 2008, 'Role of bamboo in seismic architecture', I*ndian Architect & Builder*, vol. 22, no. 2, pp. 102-106.
- Rocca, A 2007, *Natural architecture*, Princeton Architectural Press, New York.
- Shhen D, *First earth*, California, United States, PM Press (documentary) <http://www.davidsheen.com/firstearth/>
- Sinha, R, Brzev, S & Khatri, G 2004, 'Indigenous Earthquake-Resistant Technologies – An Overview', proceedngs of *13th World Conference on Earthquake Engineering* Vancouver, B.C., Canada, Paper No. 5053.
- 2013, *Bamboo reinforced concrete in earthquake proof housing*, Engineers without borders, UK.

Notes

1. The gully effect is created when high speed winds flow between two high mountains or hills forming a gully or a 'V' shape due to which air flow is directed towards it with high pressure.
2. The puncture effect is created by puncturing the roof to provide ventilation channels so that air circulation is maintained and serves as a safety valve that prevents the roof being lifted away due to increased air pressure inside.

Bamboo Habitats
Icra, Darjeeling

ARUNA BHARDWAJ

ABSTRACT

Walking around Kalimpong town with regards to a residential cum commercial project as architects, the structures that caught our fancy the most were the traditional 'Icra' or houses. In pursuit of understanding the exact building technique of these traditional houses we encountered extreme resistance and confusion on the part of the locals. The type of construction used easily available wooden or bamboo battens, mats made of slit bamboo as wall infill, in conjugation with galvanised iron sheets as replacement to the thatch roofs. In contrast, there was an enthusiasm shown by everybody to build a house designed using metal girders, unplasticised poly vinyl chloride windows, imported hardware and toughened glass panels.

Bamboo as a material is one of the most versatile, traditional building materials, having a worldwide history of sustainable usage in most sub-tropical and tropical countries. Besides individual houses, it acts as the formwork for a large part of our building industry. Unfortunately it is unable to break itself from the tag of 'temporary' building material. An attempt has been made to explore, taking the example of 'Icra' and comparing it with the modern day construction technique, trying to identify the reason why bamboo habitats are dying a slow but definite death and whether there can be a course correction.

Aruna Bhardwaj is an entrepreneur and partner at Vertex Inc., New Delhi for over a decade and presently is also teaching at the Sushant School of Art and Architecture, Gurgaon. She has been working on design projects that include the Gallery at Jaigarh Fort and Maharaja Sawai Man Singh II Museum at City Palace, Jaipur, besides the Deolo residence and cottages at Kalimpong, West Bengal. Presently, Aruna is pursuing the study of sustainability in the urban realm and implications of urbanisation in the Indian context.

A Bamboo house at Kalimpong showing the construction technique of Icra

INTRODUCTION

The traditional bamboo houses known as Icra of Kalimpong caught our attention while we were exploring the town located in Darjeeling District, West Bengal, during the initial site visit for a project. As architects, we could perceive how the scale and proportion, textures, the whole ensemble created a habitat that seemed to exist in its rightful place. In comparison, the all prevalent brick mortar constructed houses seemed to be implanted, jarring and an ill conceived juxtaposition of traditional aesthetics.

We encountered extreme confusion and resistance from the locals during our pursuit of understanding the exact building technique of these traditional houses. The locals were unable to understand the interest being shown in the 'poor man's' house. The local construction made use of easily available wooden or bamboo battens and mats made of slit bamboo as wall infill, in conjugation with GI sheets as replacement to the thatch roofs. In contrast, there was an enthusiasm shown by the locals in building a house designed by 'Delhi' architects[1] using metal girders Unplasticised Poly Vinyl Chloride (uPVC) windows, imported hardware and toughened glass panels. We wondered about the value attached to modern building techniques. This prompted us to dig deeper and question the utter disregard for bamboo as a construction material.

Could we incorporate the vernacular knowledge in the project we were designing? Could we imbibe the something of the Icra maybe in the smaller units we were proposing without it being just a superfluous gimmick? On another level, could we understand the reasons for the replacement of vernacular materials by the omnipresent Reinforced Cement Concrete (RCC), brick and mortar construction?

TRADITONAL ICRA OF KALIMPONG

As is the case with most vernacular architecture the Icra also is an example of judicious and advantageous use of readily available local material, that is bamboo, stone, thatch, wood and mud. Bamboo is fairly common to Darjeeling, Siliguri and Cooch Bihar Districts of West Bengal and traditional bamboo houses in villages are more or less similar in construction.

Kalimpong is located at a height of 1,219 metres and because of its relatively lower altitude compared to Darjeeling or Gangtok, the weather is milder and pleasant for most part of the year. Rainfall reaches a maximum of around 55 centimetres during the monsoon months resulting in landslides during this period. Due to the mountainous terrain, the location for building the Icra is chosen keeping in mind the natural topography, flat contours in comparison to steep contours, protection from strong winds, assessing the water flow down the mountain at the time of rainfall and collection of water which becomes an enormous task in the mountain terrain. A base or a plinth is prepared by using rocks cut from the mountain and dressed *in-situ*, unlike a bamboo habitat in other hilly and coastal areas where the floor is often raised on stilts made of bamboo. The super structure is constructed on this plinth. A wall is constructed in either brick or mortar till approximately 38 centimetres to 90 centimetres, or in stone as a base on the periphery, depending on the availability and funds. The bamboo mat wall is constructed over the brick or stone wall, providing protection from the splash of rain water.[2]

Site and setting of Icra houses

Wooden batten framework with bamboo mat in external and internal wall

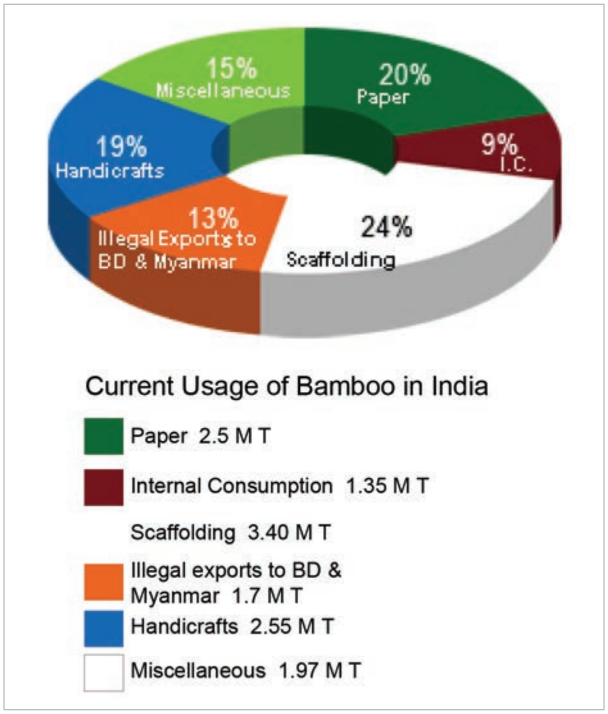

Window frame fixed in the wall on the backside of the cottage

The construction that we observed at Kalimpong is interestingly, quite common to many parts of Asia where bamboo is abundantly available. Even when other materials are used, bamboo[3] forms a major part of the traditional house. Traditionally, a frame-work is made from the splits of *bombasa* (a variety of bamboo with thicker diameter of stem or culm). Round bamboo is used for posts, beams, trusses and rafters for supporting and transmitting the roof load. Long, straight and thick-walled culms are selected for these purposes. The roof and wall are generally made of split and flattened culms from the thin-walled varieties (Jagadeesh & Ganapathy 1995).

In Kalimpong this practice has been replaced by 60 centimetres x 60 centimetres wooden battens in many instances due to their ease of workability, availability and affordability. The framework is done keeping in mind the various openings for doors and windows. It also acts as the basic structure that supports the roof. The *chechara* (split bamboo mat) is fixed to this framework to make the wall. The type of bamboo splits taken to weave the *chechara* again depends on the finishing material that fits in the budget. Traditionally, the slimmer bamboo splits were used along with *kalli mitti leep* (black soil paste) that is locally available. At

A short comparison between the two typologies of habitats

	PHYSICALCRITERIA	MODERN BRICK & MORTAR HOUSE	TRADITIONAL ICRA
1	Availability of material	Easily available but transported from outside	Locally available
2	Know how of working with the available material	Specialised labour like mistry etc	Native know how passed down through generations in poor households
3	Availability of Labour	Easily available	Easily available
4	Availability of technologies	Civil engineers/site supervisors from outside	Locally available
5	Access to specialised tools/ equipment	Imported from outside	Not being used
6	Costs of construction	800 sq ft	200 sqft
7	Maintenance Intensity post construction	Low Maintenance	Repair & renovation every 2 years
8	Strength of structure	High	Low
9	Storeys	Multiple Storeys	Ground Floor only
10	Insulation	Low	Low
11	Sustainability Factor	Low	High
	PSYCHOLOGICAL CRITERIA		
12	Security	Higher	Lower
13	Lifestyle	Compliant with urban living	Traditional living
14	Perceptions	Associated with growth, acquiring wealth, symbol of success	Poor and backwardness



Current usage of bamboo in India.
Source: National Bamboo Mission

many places the bamboo mats were made of bamboo splits of thicker culms and then a layer of cement mortar paste was applied from outside and inside to reduce frequent maintenance, further painted over by using lime.

More than 50% of the roofs are a combination of bamboo and some form of thatch, as per Jagadeesh and Ganapathy (1995). At times thatch is replaced by corrugated GI sheets for roofs by the comparatively richer rural people and urban dwellers. Some rural houses in many parts of Asia too had walls of mud reinforced with bamboo. The traditional Icra is morphing into the contemporary brick and mortar type of construction as the locals who are in pursuit of a more secure and maintenance free habitat replace various components of the structure in degrees, depending upon their budgetary constraints. Thus, despite being more expensive the non-traditional brick and mortar building technique is the preferred choice as it symbolises success and reflects the lifestyle change that is evidently filtering in.

DEVELOPMENT OF THE NEO-ICRA COTTAGE

The fact that our site had abandunt bamboo growing plus all the existing residences dotting its periphery were traditional Icras, made a strong case for the use of bamboo in costruction of atleast the smaller units in our project. Conversations with local craftspeople or carpenters who themselves lived in such houses helped in understanding the shortfall of bamboo in the long run. Bamboo has a high content of starch and is extremely suceptible to borer or fungal attacks. Thus, the usage of bamboo was restricted to the dry areas while the wet areas like kitchen and bathrooms were to be built in a more resistant material such as bricks or stone depending on the availability. A cottage unit of two bedrooms cum bathrooms plus verandas were the first that we designed using this basic principle.

The first prototype that was built became an interesting study in the collaboration of local and contemporary thought processes, morphing into a stand-alone unit that could function as a residence if so required, complete with an open kitchen, two rooms, a bathroom and a loft. A raised plinth of dressed stone and mortar acted as the horizontal base with 15 centimetres x 15 centimetres RCC columns located at the corners and the middle provided strategic support and bracing to the structure. Most of the walls were built in brick till a height of 76 centimetres and in continuation, a wooden framework with the bamboo matting infill extended till the roof. The wall at the back was built in complete brick and the kitchen and bathroom piping and fixtures were fixed on it. The loft itself became a composite structure where the slim RCC beams acted as the main members and the wooden rafters as the secondary members that supported the pine wood planks. The roof was made of Galvanised Iron (GI) sheets, finished with wooden ply sheets on the underside, allowing an air gap that provided thermal insulation. The topmost framework was left at places as unplastered bamboo mats, thus fulfilling the function of ventilators allowing air circulation.

The structure was neither a pure bamboo construction nor did it strive to be an example of intense exploration and experimentation with vernacular building methodology. It was an alternative that allowed incorporaton of both vernacular and modern materials without going into a lengthy discourse or additional technical knowledge inputs. The structure questions our never ending need for security that has become mandatory in contemporary thought process. It promotes a variable architecture accomodating local thought. Alternatively, it could also be the manisfestation of a cost effective home for the middle income population that accomodates the present lifestyle needs with dignity.

CONCLUSION

As soon as we think of environment friendly material, 'bamboo' is the first and foremost choice that comes up. Unfortunately though, it is facing a dichotomy, on one hand to live up to the tag of 'designer sustainable' material that it is being marketed as, whilst fighting the perception of being poor man's only option. According to Rubens (2012, p. 83):

> Besides the traditional crafts products available contemporary designers love the Bamboo material for its versatility. It has an enormous potential today as it obediently morphs into different forms to suit different function. Production loves it because it is conveniently indigenous to the regions global chains are shifting to, making it a cost effective material. Marketing loves it because consumers are clamoring for well designed, cost effective and sustainable lifestyle option.

This is evident through the fact that if one searches for a local traditional lifestyle bamboo product in any given town of India, it will be mostly available in one or two shops of its historic marketplace or in a tourist shop. Presently, there is a general rush towards new age consumer products associated with progress while the traditional, usually sustainable products are replaced thoughtlessly by cheap imported plastic goods. As rightly observed, the Indian demographic has witnessed enormous changes in the past few decades and the Indian consumer today wants to lead a life full of luxury and comfort (Joseph & Singh 2013, p. 862). Whether the luxury and comfort come with additional benefits like environmental hazardous or fatal side-effects seem to be of no consequence. Also many a time, the comfort is more perceived than real.

Bamboo as a traditional building material has a worldwide history of sustainable usage in most sub-tropical and tropical countries. Besides individual houses, it was and is still used to build bridges, public usage structures, temporary structures and even today acts as the formwork for a large part of our building industry. But unfortunately for the building industry, despite its versatility, bamboo has not been any competition to the sweeping trends of modernisation. Till a few decades ago, traditional rural bamboo houses in the Indian sub-continent were constructed with emphasis on comfort and space. However, for most of the rural population, the once-cozy bamboo houses have now been reduced to small, flimsy structures, the maintenance of which is a constant drain from the meagre family income (Dunham 1994). Thus bamboo is never the final choice of construction material for even a small house if monetary constraints do not exist, even in places where it is available in plenitude and the traditional know how of building with it still exists. For the bamboo habitat to save itself from a slow but definite death, a concentrated effort needs to be made by the designer community. The amazing properties of bamboo such as its tensile strength, its flexibility to adapt to different scales, its beauty and its ability to support entire communities needs to be harnessed. The issue of durability needs to be addressed by treating the bamboo for shrinkages and various insect attacks. Bamboo as a contemporary material needs to be marketed by professionals in the building industry and as architects or designers we need to relook at our practice and maybe guide our clients towards a more sustainable and human approach.

Acknowledgement

- Image credits to Abhay Narkar, author's partner at Vertex Inc.

Bibliographic references

- '*Bamboo growing areas in India*' n.d., National Bamboo Mission, viewed November 3, 2014, <http://nbm.nic.in/grow_bamboo.html>.
- Boughton, GN 1990, 'CIB-W18B: activities towards a structural design code for bamboo', in IV Ramanuja Rao, R Gnanaharan & Sastry (eds.), *Bamboos: current research*, *proceedings of the International Bamboo Workshop*, 14-18 November 1988, Kerala Forest Research Institute, Cochin, Kerala, India, International Development Research Centre, Ottawa, Canada, pp. 280-282.
- Dunham, DC 1994, 'Upgraded bamboo a housing material: the step from science to shelter' in *Bamboo in Asia and the Pacific*, *proceedings of the fourth international bamboo workshop*, Chiangmai, Thailand, 27-30 November 1991, International Development Research Centre, Ottawa, Canada, Forestry Research Support Programme for Asia and the Pacific, Bangkok, Thailand, pp. 317-322.
- Espiloy, ZB 1994, 'Effect of age on the physico-mechanical properties of some Philippine bamboo' in *Bamboo in Asia and the Pacific*, *proceedings of the fourth international bamboo workshop*, Chiangmai, Thailand, 27-30 November 1991, International Development Research Centre, Ottawa, Canada, Forestry Research Support Programme for Asia and the Pacific, Bangkok, Thailand, pp. 180-182.
- Gnanaharan R, Mohanan, RC, Basha, SC 1993, 'Post-harvest technology of reed bamboo', *Bamboo Information Centre India Bulletin*, vol. 3, issue l, pp. l-6.
- Gupta, V & Singh, R n.d., *Energy conservation in traditional buildings in*

the mountains, School of Planning and Architecture, New Delhi, viewed October 10, 2014, <www.space-design.com_upload_ r0008.pdf>.

- Hidalgo, AO 1992, 'Technologies developed in Colombia in the bamboo housing construction field', in S Zhu, W Li, X Zhang & Z Wang (eds.), *Bamboo and its uses*, *proceedings of the international symposium on industrial use of bamboo*, Beijing, China, 7-l1 December, 1992, International Tropical Timber Organization, Chinese Academy of Forestry, Beijing, China, pp. 217-254.
- Indian Standard Institution 1973, *Methods of tests for round bamboos, IS: 6874*, New Delhi, India, p.14.
- Jagadeesh, HN & Ganapathy, PM, 'Traditional bamboo-based walling/ flooring systems in buildings and research needs', *proceedings from fifth international bamboo workshop & fifth international bamboo congress*, Bamboo People and the Environment, viewed October 10, 2014, <http://www.inbar_pr_05_3_1.pdf>.
- Janssen, JJA 1981, 'The relationship between mechanical properties and the biological and chemical composition of bamboo', in T Higuchi (eds.), *Bamboo production and utilization*, *proceedings of 17th IUFRO world congress*, Kyoto, 1981, Kyoto University, Kyoto, Japan, pp. 27-32.
- Janssen, JJA 1987, 'The mechanical properties of bamboo', in AN Rao, G Dhanarajan, CB Sastry (eds.), *Recent research on bamboo, proceedings of the International bamboo workshop*, Hangzhou, China, 6-14 October, 1985, Chinese Academy of Forestry, Beijing, China, International Development Research Centre, Ottawa, Canada, pp. 250-256.
- Janssen, JJA 1988, *Building with bamboo*, ITP, London, UK, pp. 88.
- Janssen, JJA 1990, 'The importance of bamboo as a building material', in IV Ramanuja Rao, R Gnanaharan, CB Sastry (eds.), *Bamboos: current research, proceedings of the international bamboo workshop*, Cochin, India, 14-18 November 1988, Kerala Forest Research Institute, Kerala, India, International Development Research Centre, Ottawa, Canada, pp. 218-222.
- Joseph, S & Singh, V 2013, 'Changing lifestyles influencing Indian consumers', *Global Journal of Management and Business Studies*, vol. 3, pp. 861-866, viewed October 10, 2014, <http://www.ripublication.com/gjmb-spl>.
- Mohmod, AL, Kasim, J & Zin, J 1992, 'Culm characteristics of Bambusu blumeana and Gigantochloascortechinii and their effects on physical and mechanical properties', in S Zhu, W Li, X Zhang & Z Wang (eds.), *Bamboo and its use, proceedings of the international symposium on industrial use of bamboo*, Beijing, China, 7-11 December, 1992, International Tropical Timber Organization, Chinese Academy of Forestry, Beijing, China, pp. 118-128.
- Sattar, M 1995, 'Traditional bamboo housing in Asia: present status and future prospects', *proceedings from fifth international bamboo workshop & fourth international bamboo congress*, Bamboo People and the Environment, <http:// www.inbar_pr_05_3_1.pdf, viewed on 30.10.2014>.
- Tewari, DN 1992, *A monograph on bamboo*, International Book Distributors, Dehradun, India, p. 498.

Notes

[1] Team of architects from Delhi-Gurgaon.

[2] Based on primary observations and discussion with residents and workers on site at Kalimpong February, 2012.

[3] There exist about 75 general and 1250 varied species of bamboo worldwide. Different types of bamboo depending on their maturity are put to different uses: thinner bamboos are for non structural purposes, strips are used to weave baskets, household products and the like; mid thickness bamboo are used as mats, fencing, as in fill elements in construction; larger Culm bamboos are used as structural members in construction. Once extensively used as scaffolding, temporary pavilions frameworks, in present times these are being replaced by MS pipes.
Factors determining the usage of bamboo depend upon: the diameter of the Culm of the species, wall thickness, internodes and age of the plant. Following are the physical and mechanical properties of bamboo:

- Density of bamboo: This varies from 500 to 800 kg/m3, depending on the anatomical structure such as the quantity and distribution of fibres around the vascular bundles.
- Moisture content: Bamboo possesses high moisture content which is influenced by age, season of felling and species. Moisture is lowest in the dry season and reaches maximum during the monsoon. Because of the differences in anatomical structure and density, there is a large variation in tangential shrinkage from the interior to the outer-most portion of the wall. This leads to drying defects, such as collapsing and splitting, and affects the behavior of bamboo during pressure treatment.
- Tensile strength: Bamboo possesses excellent tensile strength. Mostly this depends on the species, and the climatic conditions under which they grow.
- Maturity period of bamboo may be 3-4 years with respect to density and strength. Maturity of Culm is a prerequisite for the optimum utilisation of bamboo in construction and other structural uses.
- Natural durability: This is very low and depends on the climatic conditions and nature of use as chemical constituents present in bamboo do not have enough toxicity to impart any natural resistance to fungal or insect attack. Observations based on the performance of full-sized structures show that untreated bamboos may last up to five years under covered conditions.

Tunnelling Techniques
Water Management in Medieval India

MUKTA LATKAR-TALWARKAR

ABSTRACT

Traditional knowledge and vernacular technologies developed in the yesteryears were a matter of response and reaction to the existing contemporary situations. Abundant water supply for the ever growing population was planned with utmost sensitivity towards the geographical, geological and topographical knowledge of the region as also the economic, political and community concerns. The traditional wisdom of water management with its appropriate usage and harvesting has sustained human survival and growth in the region over centuries. Various examples for developing a sustainable water supply system for the public at large using the traditional knowledge in different parts of the Indian peninsula as well as outside has been dealt upon.

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TRADITIONAL SYSTEMS FOR WATER MANAGEMENT

'It was all a case of learning to live with their environment!' (Agrawal & Narayan 1998). The tunnel technology of water management is a sophisticated engineering feat with the precise alignment and grade of the excavated tunnels. These ancient, gravity-flow water supply systems are one of the most significant hydraulic technologies in areas with acute water shortages. Built of local materials, they tap aquifers,[1] through gently sloping subterranean tunnels, using no source of power other than gravity and transport water over substantial distances in the subterranean conduits

Air shaft on the surface of qanats also used as wells, Burhanpur[2]

with minimal loss through evaporation and with little risk of pollution. Water from the aquifer then filters into the upper reaches of these channels, flows down their gentle slope, and emerges as a surface stream of water at or near a settlement (English 1997).

A variety of geographical factors, including the local slope conditions, the surrounding topography, subtle changes in vegetation, available groundwater, and the proposed destination of the water decide the location of the shafts. The gradient of the tunnels play a crucial role in the planning. Qanat is the Persian term for one of a series of vertical shafts, connected by gently sloping tunnels. This elaborate tunnel systems first appeared in the mountains of Kurdistan in western Iran, eastern Turkey, and northern Iraq more than 2,500 years ago in association with early mining in that region. Qanat system of water supply made it possible to establish permanent settlements with distant water sources, defining the built environments of towns and rural settlements.[3]

INFLUENCE OF THE QANAT TECHNOLOGY IN INDIA

The arrival of the Mughals in India resulted in a surge in population along with agricultural expansion, leading to an increase in the demand for domestic water. Since local surface and sub-surface water resources were insufficient to meet these escalating needs, the rulers having Persian background and linage very wisely chose to adapt this traditional system of water management to solve their water woes. In Burhanpur, Aurangabad, Ahmadnagar and Pune, one can still find, with indigenous variations, this borrowed system of water works for local use.

Burhanpur

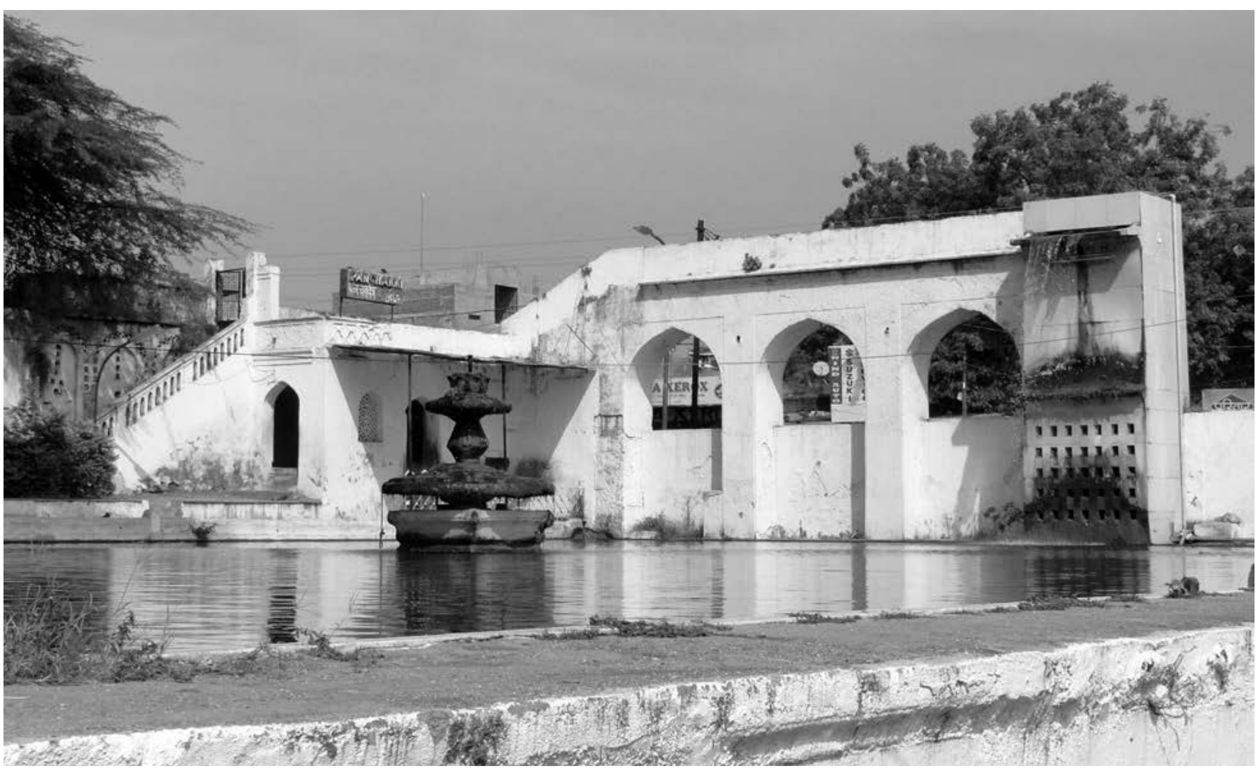
Burhanpur lies on the banks of River Tapti in the Khandwa district of Madhya Pradesh. It served as the boundary of the Mughal Empire and the huge army posted in the city increased the water demand of the entire population. Due to frequent battles with other kingdoms, there was always the fear of Tapti being poisoned in the event of a war, and thus, could not be relied upon as the sole source of water. A Persian geologist named Tabkutul Arz was invited, in 1615 AD, by the then ruler Abdul Rahim Khan to investigate the recharge valley in the Tapti plains. He devised the water work system of Burhanpur that consists of eight qanats, of which six still exist[4]. The bhandaras (storage tanks) collect groundwater from the underground springs flowing from the adjacent Satpura hills towards the Tapti, which is intercepted at four places north-west of Burhanpur town[5]. It then flows through subterranean conduits linking a number of connected wells to a collection chamber called Jali Karanj and from there to the town. This system, that once supplied 1,00,00,000 litres of water to the town during the Mughal period, today, supplies a much reduced 18,00,000 litres a day but still functions at zero cost.

Aurangabad

The great water engineering feat achieved in the city of Aurangabad, earlier known as Fatehgarh, is credited to Malik Ambar[6]. He introduced the well organised system of water supply for public utility known as Nahar-e-Ambari. During military activities in 1617 AD, he discovered the Kham river valley and its large natural basin (Sadgir & Kahalekar 2007). The subterranean water table of mountainous elevated valleys to the north of Aurangabad was practically manipulated to procure a stable perennial water supply for a population by constructing a unique aqueducts[7] named Khair-e-Jari. Population grew further when Aurangzeb, appointed as the Subedar[8] of Deccan, made Aurangabad his capital leading to water scarcity. In order to supply water to the growing population, 12 canals were excavated. The 4,450 metre long subterranean water supply canal lies to the north of Aurangabad (Sadgir & Kahalekar 2007). The canal is like an underground stream of water with varying sectional area along its length. The floor of the canal is dug in the porous layers of the ground at different levels so that large quantity of water may be collected by percolation. It is dug very deep under the ground and there is no masonry on its two vertical sides. Above the vertical sides, an arch of lime and brick is constructed. It has tall and strong manholes to ease its cleaning and maintenance.

The subterranean water tunnel carrying water from the Khooni Bhandara to the town areas[9]

This water supply system has been in use for the past 300 years by the inhabitants of Aurangabad, free of cost. The uniqueness of these canals lies in the fact how well these exploit the geographical location of the city, situated in a valley surrounded by mountains from all



Nahar-e-Panchakki which brings water to this site through the wall in front. In the past a flour mill was run using incoming waters sides. All the canals, thus, originate in the mountains to terminate in various parts of the city.

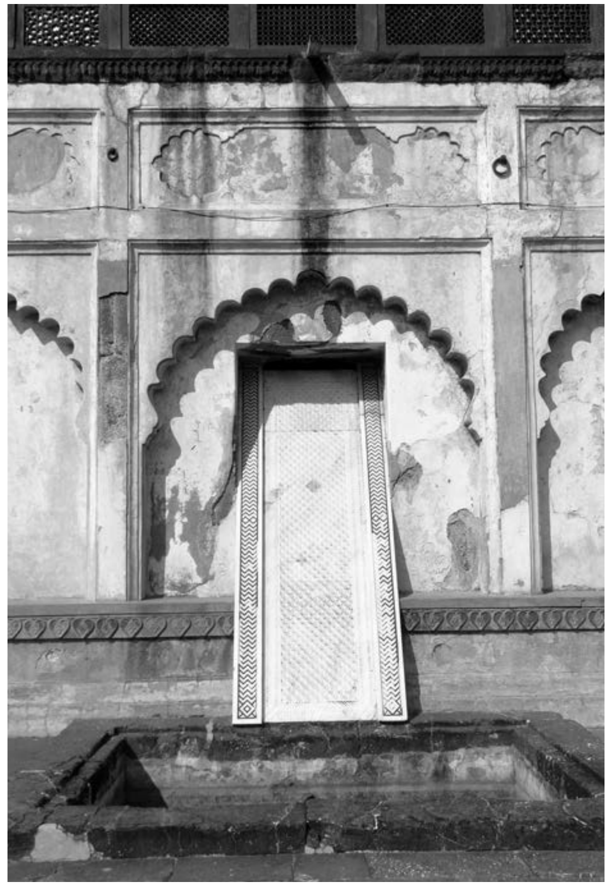
Pune

The intricate water supply system in Pune, the capital of the Peshwas of the Maratha Empire, was developed during the reign of Chhatrapatu Shahu.[10] In 1720 AD, when the invincible Balaji Bajirao was appointed the Peshwa, he selected Pune as his base and constructed the Shaniwar Wada, his palace, on the banks of the river Mutha. Water was dammed in 1749-50 by constructing two reservoirs at different levels at Katraj, the highest point of the terrain, about 10 kilometres south of Pune city, on the Ambil Odha[11] to hold water in the mountainous regions. The dams stored water from the catchment areas during the rainy season.

Pune is situated in slightly saucer shaped basin on the banks of Mutha river, on the eastern slopes of Sahayadris. There is a gradual drop of 40 metres from Katraj gaon (village) towards the Mutha river, which was taken advantage of to create the water systems (Kamalapurkar 2011). The nine kilometre long underground limestone tunnel measures about 75 centimetres in breadth and 1.8 metres in height. The tunnel had air wells[12] and using the principles of hydraulics the water was made to flow at higher pressure and speed. The aqueduct branched to give rise to intricate network running through the *peths*[13] (the city areas). The tunnel opens into a series of *haud*s (water tanks) at Shaniwar Wada and the nearby houses, some of which like the Nana Haud, are still functional. The water supply also provided for the fountains in the palatial mansions and worked wonders with the pressure system of differential heights, such as in the Shaniwar Wada. This underground water supply system could supply approximately 29,00,000 litres of water per day to practically the whole of Pune then, without the need for pure energy.

CONTEMPORARY CONCERNS

The study of the vernacular adaptations of the traditional sustainable water supply and distribution systems strongly highlight the role of administrators in the development and sustenance of the technology for urban development. Water was made available for all and not restricted to the royals or the nobles only. This free provision of water ensured indigenous support towards maintenance of this vital amenity. Today, most of these set-ups and their constructions are being encroached upon or falling to ruins due to misuse as well as negligence.



The beautiful water chaddar at the Bibi Ka Maqbara lies dry due to diminished waters of the Nahr-e-Begumpura

Nana Haud, a tank provided by the waters from the built aquaduct still in use by the common public

What needs to be highlighted is that some of the answers to the present day water crisis scenario may well lie in the wisdom of our own traditional systems. Mere water supply to the increasing settlement population was never the only concern of the providers. Sustainability in the usage and distribution patterns with due respect to the source of water was laid stress on and climatic and geological conditions were given due attention. An encouraging observation is that the areas that have maintained their traditional water systems, even after the arrival of the modern piped supply, face no scarcity even during low rains. However, areas that neglected the traditional knowledge wisdom for modern provisions face drastic water shortages even with normal rains. The traditional water supply and distribution managed intelligently used the perennial and non perennial sources for uninterrupted water supply in huge quantity. Serving the significant function of providing water in the past, these water management systems can still efficiently take upon the same task today.

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Bibliographic references

- Agrawal, A & Narayan, S 1998, *Dying wisdom: rise, fall and potential of India's traditional water harvesting system*, Center for Science and Environment, New Delhi, India.
- English, P 1997, 'Qanats and lifeworlds in Iranian plateau villages', *proceedings of Conference, T*ransformation of Middle Eastern Natural Environment: Legacies and Lessons, Yale University.
- Kamalapurkar, S 2011, 'Traditional ways of building in the age of globalisation', *proceedings of state level conference*, Teaching of Building Technologies and Services In Architecture, Pune.
- Pangare, G, *Mughal system still supplies water at zero cost*, <www.downtoearth.org.in/node/30245>.
- Pathak, A & Kulkarni, U 2007, 'Influence Of Chalukya Architecture On Hampi Stepwell', *Proceedings of the national seminar on w*ater and culture, Hampi, Bellary Dist.
- Sadgir, P & Kahalekar, U 2007, 'Dying Wisdom of Medieval Water Management of Aurangabad City', *Proceedings of the national seminar on water and culture,* Hampi, Bellary Dist., p. 2.
- Siddhanti, V 2011, 'Water management and conservation systems in the Adil Shahi dynasty of the Bijapur Sultanate - a study', *South Asian Journal of Tourism and Heritage*, vol. 4, no.1.
- Sutcliffe, J, Shaw, J & Brown, E, 'Historical Water Resources in South Asia: The Hydrological Background', *The Journal of Hydrological Sciences*, vol. 56, issue 5, p. 1.

Notes

1 Aquifers are underground layer of waterbearing rock through which groundwater can be extracted.

2 The tunnels conveying water from source are about 80 centimetres wide and about 200 metres long with air shafts every 20 metres along their entire length from the bhandaras to Jali Karanj.

3 Iranian cities like Tehran, Hamadan, Yazd and Kerman received virtually all of their water from the underground tunnel layouts. The spread of Persian rule extended the qanat technology well beyond the confines of the Iranian Plateau.

4 Three of the six existing qanats continue to supply water to Burhanpur and the other three supply water to Bahadurpur, a nearby village, and Rao Ratan Mahal.

5 The four places are Mul Bhandara, Sukha Bhandara, Khuni Bhandara and Chintaharan.

6 The commander of the Nizam Shahi Kings and Subedar of Daultabad, Malik Ambar was a great engineer.

7 A bridge like structure that carries a water conduit or canal across a valley or a river.

8 Subedar refers to the appointed administrative head or in charge for a defined region.

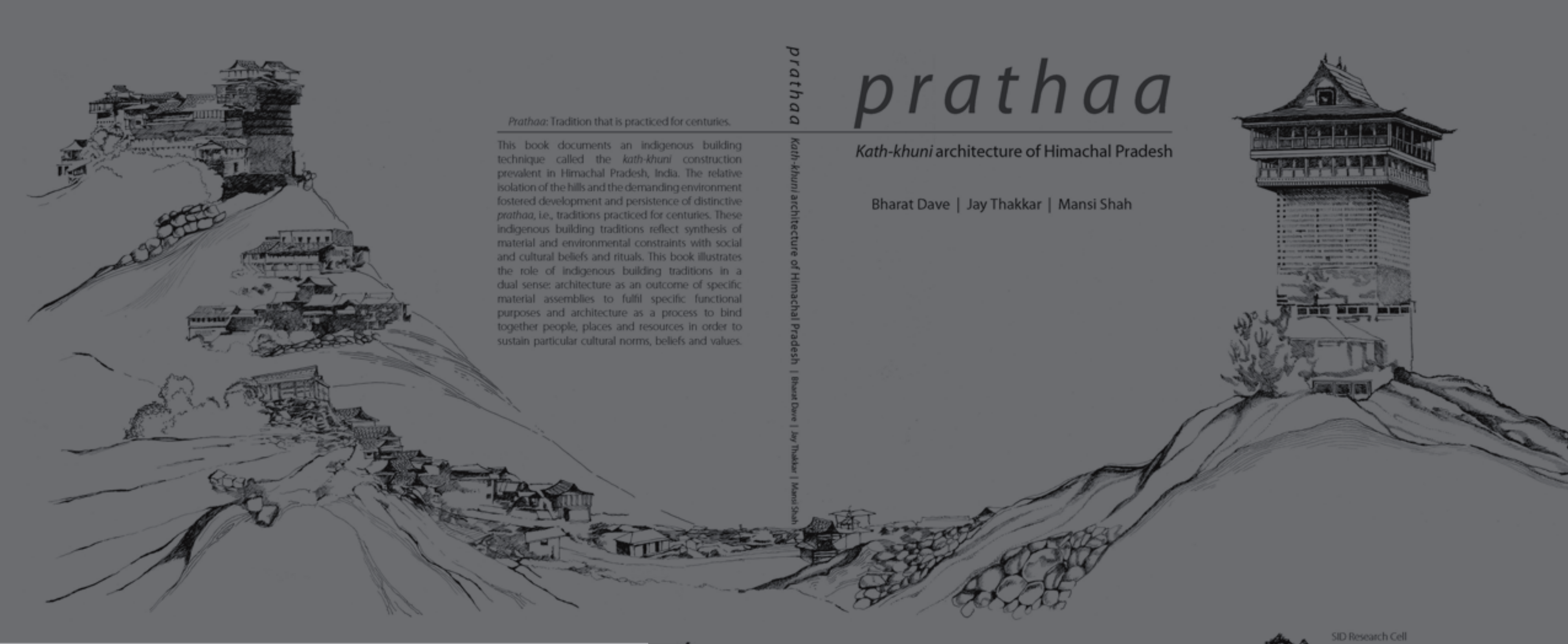
9 The Khuni Bhandara receives water by gravity from Mul Bhandara and Chintaharan and collects it at a depth of about 10 metres. Jali Karanj is where water from the other four bhandaras meets and is then supplied to the town.

10 Chhatrapati Shahu was the fourth Chhatrapati of the Maratha Empire created by his grandfather, Chhatrapati Shivaji, and was officially the Raja of Satara (now in Maharashtra, India). He reigned from 1708 – 1749 CE.

11 Ambil Odha is a *nullah* (watercourse) flowing from Katraj lake to Mutha river.

12 The air wells so designed thus acted as water purifiers and speed boosters.

13 Peth is a Marathi term for a neighbourhood development in the city of Pune during Maratha and Peshwa rule in the 17th-19th century AD. Today, a part of the historic central core of the city, the Peth areas were generally named after the week days or after the person who established or developed the neighbourhood area.



Institutional Initiatives

Training, Research and Capacity Building

INTACH Heritage Academy

NAVIN PIPLANI

The INTACH[1] Heritage Academy (IHA), formerly Centre for Conservation Training and Capacity Building, is envisioned to be a 'centre of excellence' for training, research and capacity building in matters related to natural and cultural heritage in India. The Academy has been set up to strengthen the implementation of the mission and objectives of INTACH across the Sub-continent and expand within a wider international context. It is the first of its kind in the country, running programmes for capacity building in all aspects of heritage conservation and management. The Academy is based at the INTACH headquarters in New Delhi, and it complements the initiatives and activities taken up by the Technical Divisions, Conservation Centres and Local Chapters of INTACH in different parts of the country.

IHA focuses on training needs, research gaps and capacity building potentials of conservation specialists, academic institutions, professional bodies, government departments and authorities, non-government organisations, craftspeople, local communities and the general public. The inter-disciplinary nature of courses and programmes offered by the Academy encourages a wide range of participants from within the Sub-continent and overseas to attend these courses.

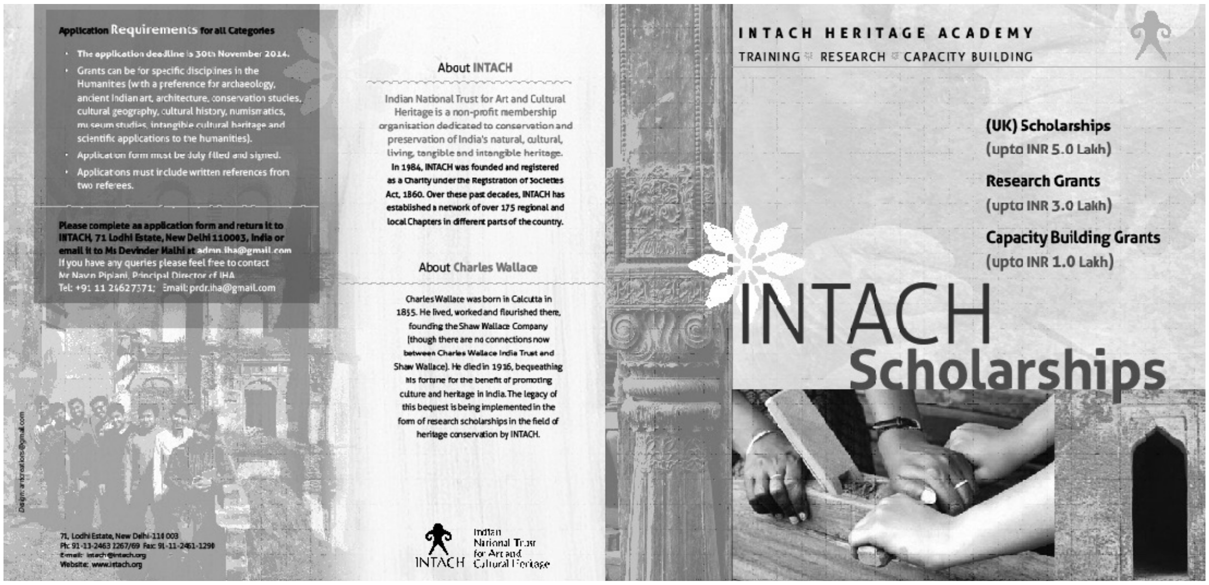
Some of the key objectives of IHA are to:

- Encourage capacity building by developing skills through hands on training programmes.
- Develop guidelines for conservation training at various levels.
- Promote and undertake research and documentation of traditional knowledge systems as well as building craft skills.
- Offer special courses on conservation and management of heritage.
- Connect the training and capacity building needs and potentials across professional bodies, government departments, non-government organisations, academic institutions and so forth in the country.

Currently, IHA offers short courses, and aims to grow into a state of the art institute running longer courses in the future. The structure of these courses is as follows:

Introductory courses	2 - 3 days
Continuing professional development	up to 5 days
Practical conservation courses	5 - 10 days
Sponsored research projects/ courses	6 - 8 months
Diploma courses (Full time/ part time)	1/ 2 years
Degree courses (Full time/ part time)	2/ 3 years

Participants at World Heritage Course working session, INTACH Library, New Delhi



INTACH research scholarships brochure[2]

In the future, IHA will run full time and part time diploma and degree courses in Conservation and Management of Natural and Cultural Heritage in affiliation with a national university or as an independent institution recognised by the Government of India.

INTACH as an organisation is structured around the fields of architectural, natural and material heritage, as well as intangible cultural heritage. It undertakes training, research and capacity building, heritage tourism, heritage education and communication, documentation and listing and craft, community and heritage. In addition to this, there are Conservation Centres and Laboratories in Bangalore, Bhubaneswar, Delhi, Jodhpur, Lucknow and Mysore. Considering the knowledge resource of INTACH and its various technical arms, the logical next step is to undertake inter and trans disciplinary research at various levels, not only within India but in collaboration with international organisations. In the field of heritage conservation, and particularly cultural heritage conservation, there is huge gap between theory and practice. Both these areas need urgent attention and efforts for inter-linking and advancement. Therefore, one of the key objectives of IHA is to undertake and promote cutting-edge high quality research.

One of the critical areas for research, training and capacity building is 'traditional materials and skills in conservation' and IHA regularly conducts courses, workshops and practical hands-on sessions. Some of the key training courses are mentioned below.

CONSERVATION OF TIMBER IN HISTORIC BUILDINGS

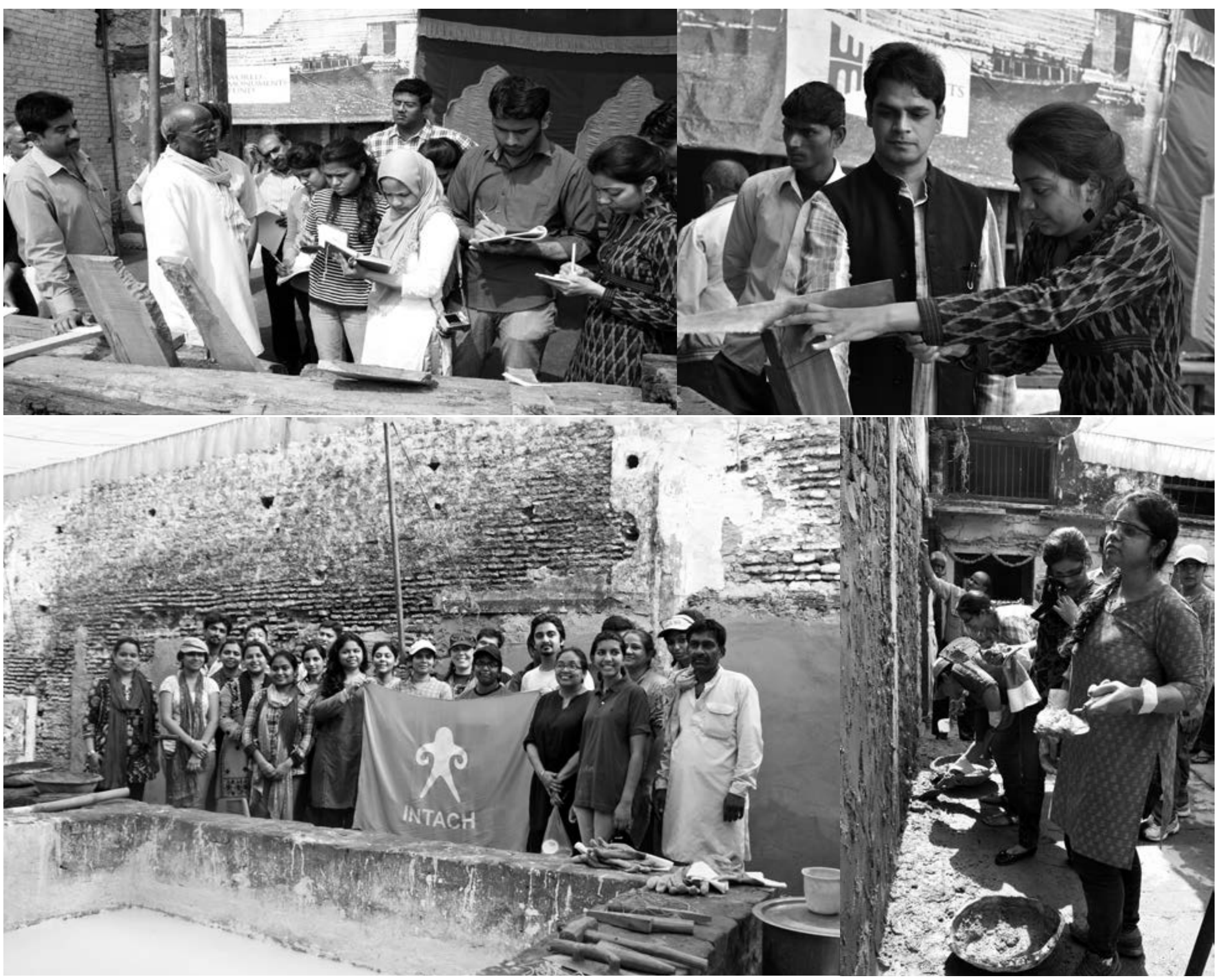
A three day practical hands-on training course to understand the nature, use and conservation of timber in historic buildings was organised at an ongoing project site at Balaji Ghat in Varanasi. The broad aim of the course was to introduce some of the key philosophical issues and practical challenges related to the conservation of timber in historic buildings. The participants explored the use of timber in the construction and conservation of historic buildings. The lectures provided a brief understanding of various types of timbers, their properties, types of uses, decay mechanisms, sources of conservation issues, weathering phenomena and so forth.

We examined a variety of practical techniques for timber conservation with the help of case studies from southern India. A specially designed practical session provided a unique opportunity for participants to work alongside craftspeople and gain hands on experience of conserving timber members. The discussion introduced some of the key principles and practices for conservation in India with references to the 'INTACH Charter for the Conservation of Unprotected Architectural Heritage and Sites in India' (2004). The course intended that upon completion, the participants would develop an understanding of the use of timber in historic buildings. It introduced the documentation, analysis and interpretation of timber buildings, enabling participants to assess the problems and threats associated with structural and decorative timber members. The course also served as an introduction to some of the key approaches and techniques to the conservation of timber buildings. The feedback received from all participants confirmed that the above learning intentions were achieved with a fairly good success rate. In fact, a majority of participants expressed dissatisfaction with the duration of the course and unanimously recommended to increase the duration by another two to three days.

STUDY, USE AND CONSERVATION OF LIME IN HISTORIC BUILDINGS

A three day practical training course on the 'Study, Use and Conservation of Lime' in historic buildings was organised at the Balaji Ghat conservation site in Varanasi. The course was attended by a wide range of participants that included architects, architecture students, conservation professionals, engineers and even an anthropologist.

The broad aim of the course was to introduce the key philosophical issues and practical challenges which arise in the use and conservation of lime in historic buildings, particularly at the Balaji Ghat in Varanasi. The course was designed to provide an understanding on the preparation and use of lime in a historic building. It dealt with various stages of lime preparation, from slaking, sieving, mixing and application of lime mortars. The theory behind understanding and applying lime was supported by illustrative discussions and practical hands-on sessions at site. This practical training course was held at an ongoing conservation project site, which helped illustrate a range of problems *in-situ* and discuss these issues with experts on building limes, fellow participants and traditional lime masons. The theoretical discourse was led by experts from INTACH and Archaeological Survey of India, and the practical sessions were conducted by lime masons and master craftsmen working on site.



Three day practical training course on the study, use and conservation of lime in historic buildings, being held at Balaji Ghat,Varanasi

The feedback from participants highlighted the importance of this training programme and appreciated the practical hands on component of the course. None of the participants had actually worked with their own hands on a conservation project site previously, and therefore enjoyed the learning by doing aspect of the course. Another enduring experience was their first hand interaction with traditional lime masons. A selfless attitude towards sharing the age old knowledge and skills was hugely gratifying and humbling for course participants, a unique aspect that many of them were not exposed to in their professional lives. Both these courses were organised in collaboration with the Architectural Heritage Division of INTACH, and the project is supported by World Monuments Fund and the US Ambassador's Fund for Cultural Preservation. Many such programmes are envisaged in the future plans for IHA. The task is hugely challenging, and IHA is fully committed to undertake this mostly uphill journey. With the support and cooperation of partners, we hope to achieve the targets set out under immediate, medium and long term strategic planning. In addition to training, two other critical areas that need urgent and sustained attention are research in heritage studies and capacity building in heritage conservation. The establishment of IHA, as a nation wide initiative, has successfully provided the much needed impetus in these areas as well.

CONCLUSION

To summarise, there is a need for in-depth understanding of traditional knowledge and craft skills and its effective transfer to the future generations. This is possible only by investing in 'conservation people', rather than in 'conservation projects'. The entire heritage conservation landscape needs to be examined with a critical view. Public awareness, higher education, professional training, institutional capacity building, advanced research, economic viability, lives and livelihoods and several such issues need to be revisited in the context of contemporary realities and future prospects. The broad and long term vision of the Academy is to engage with these challenges and complexities and develop new paradigms for philosophical approaches, create new opportunities for inclusive practice and cultivate new environments for integrated research.

Navin Piplani *is the Principal Director of INTACH Heritage Academy, New Delhi. He is a conservation architect and has worked on a range of projects in India and Europe. Navin is Vice President of ICOMOS*[3] *International Training Committee and National Scientific Councilor of ICOMOS India. He has researched and published widely on heritage conservation education, training as well as capacity building.*

Notes

1 INTACH stands for Indian National Trust for Art and Cultural Heritage.

2 The largest research scholarship grants by INTACH, launched on its 30th anniversary, are offered for advanced and interdisciplinary research demonstrating potential impact on conservation philosophy, practice or policy, and aims to advance knowledge and understanding of heritage conservation; or contribute to critical and creative thinking in this field.

3 ICOMOS stands for International Centre for Monuments and Sites.

Studying Ethnic Communities

Institute of Research and Documentation of Indigenous Studies

DEEPA DUTT

The Institute of Research and Documentation of Indigenous Studies (IRDIS), Assam is committed to inter and multi-disciplinary research and documentation in fields relevant to the diverse ethnic communities in Assam. Being a non-profit, civil society organisation, the institute works towards the benefit, empowerment, skill development, socio-economic upliftment and preservation of their culture, traditional and indigenous knowledge and language. The members of IRDIS work in partnership with the members of the ethnic communities in the rural and semi-urban areas of Assam to design and implement projects related to their culture, socio-economic status, agriculture and environment, health, education and traditional knowledge, traditional architecture, crafts, handicrafts and art forms.

IRDIS in the past has undertaken scholarly, ethical community-based study and research to acknowledge, affirm and raise awareness for preservation of indigenous culture, traditional knowledge and history of the myriad ethnic communities of Assam in all its richness and diversity. The state of Assam is home to rich and diverse ethnic cultures with their indigenous traditions, crafts and knowledge, which is a consequence of subsequent waves of human migration in the past from South and Southeast Asia, Tibet and the great Indo-Gangetic Valley since 3000 BC. Each community adapted to their place of settlement in Assam, innovating methods relating to their mode of living and livelihood in conformity with the location and environment around them and evolved within the boundaries of their ethnic culture, traditions, beliefs and indigenous socio-economic status.

The knowledge resource bank on the communities evolved thus is recycled back into the communities by designing projects based on research data and implementing those within the communities. A few of the many projects initiated by the institute include ethnographic study of the ethnic communities of Assam, skill development by setting up centres for the digital literacy curriculum in partnership with Microsoft to turn a large population computer literate in the remote rural regions of Assam. Some of the projects on the anvil include:

- Documentation of the indigenous architecture and cultural geography of the ethnic communities.
- Documentation of the tangible and intangible cultural heritage of the ethnic communities.

The 'Documentation of indigenous architecture and cultural geography of the ethnic communities' project is to include the ethnic people of Assam in documenting the scientific methods of construction of their homes and other living structures in the villages in the remote rural areas. These methods and structures make use of natural environmental material while conforming to the climatic conditions, natural hazards and to the traditional cultural and social requirements associated with their vernacular architecture.

The project shall focus on settlements of the communities through their varied architectural forms throughout the length of the state, documenting the influencing factors which determine the type of architecture that exists in the tribal settlements. These could be in the nature of physical needs, visual and structural needs, forms and meanings, anthropological and geographical aspects and the designs, techniques and building materials associated with such vernacular architecture. The documentation of the indigenous architecture of the communities will be specific to each community and conform to the geographical terrain, cultural and social needs along with the environment and the biodiversity around them in their locations. As such, there is no one architectural concept, technique or common building material for all the communities throughout the State.

The traditional 'Assam-type house' is generally a single or double-storeyed, single dwelling unit with a lawn in front and a *bari* or kitchen garden in the backyard. The houses do not have common walls with adjacent buildings. The Assam-type houses were traditionally made using wood-based materials, bamboo or reed with roofing of thatch or Corrugated Iron (CI) sheets. The walls are made of a reed called *ikora* or of bamboo reinforced with biomass. The roof is of thatch or of CI sheets supported by bamboo or timber trusses. The floor of the house has a clay topping. With time there has been a gradual shift to the use of burnt brick masonry walls taking the support of reinforced pillars and bands at the lintel levels and the roofing of CI sheets supported by timber or tubular steel trusses.

These houses were considered to be safe for habitation in Assam, a region prone to earthquakes. But with demographic changes and rise in population leading to scarcity of available land as well as environmental and climatic changes, reinforced high rise buildings have taken over the traditional Assam type houses, particularly in the urban cities and towns along the Brahmaputra Valley.

It is important to note that even in the present times the ethnic population in the remote rural areas of Assam still showcase their traditional mode of architecture, the knowledge of which has come down orally from past generations. As we move from the east to the west of the state, the above project shall document the various designs, techniques and a gamut of traditional weeds, palms, reeds, bamboos and other building material that the tribes use for the construction of their homes.

One of the myriad tribes inhabiting the state of Assam is the Singpho.[1] It is an amazing experience to view the interior of a Singpho home and to see the scientific methods involved in its construction in the foothills of the Patkai Range bordering Myanmar of the Margherita sub-division of the Tinsukia district of Assam. A Singpho dwelling stands on stilts on a raised platform known as the *chang ghar* (elevated structures on bamboo or wooden stilts) where a hand-crafted staircase leads one to the main landing of the household. The intricate details of their traditional building techniques in such a location are quite baffling. The walls are made of intricately woven bamboo strips treated for termites and other tropical pests. The floor is also of woven bamboo strips leaving gaps between the weaves for air to enter from the floor and allow for cross ventilation. The roof is of specially treated palm leaves, woven closely to withstand the heavy rain and wind in the region bordering the Patkai Range. Such a house is said to need no maintenance and would last for over 60 years, considering that the basic natural materials available in their immediate locations have been utilised for construction. Such are the traditional methods generally applied in the construction procedure.

The dwellings of most ethnic communities of Assam are *chang ghar*s but their designs and layout of the structure and building material could vary depending on the available raw material and the traditions and social customs associated with each tribe. Also, the architecture of the village structures associated with religious traditions whether it is animism, Buddhism Christianity or Hinduism, the common dormitories, and other institutions call for detailed architectural study. The architectural as well as the cultural aspects associated with these centres of religion, constructed through the different historical regimes, will be studied in detail in the project.

***Deepa Dutt** is Founder and Executive Director of the Institute of Research & Documentation of Indigenous Studies, Assam. She was a Visiting Scholar at the Centre for Comparative Studies in Race and Ethnicity, Stanford University, USA from 2009 to 2010. Deepa is presently engaged in interdisciplinary research on the various ethnic communities of Assam and in the collaborative and comparative studies on the ethnic peoples in India and abroad.*

Notes:

1 The Singpho tribe is also found in China and Myamnar; and Arunachal Pradesh in India apart from the state of Assam.

Re-evaluating Built Heritage

Design Innovation and Crafts Resource Centre

RAJDEEP ROUTH AND MITRAJA VYAS

INTRODUCTION

India, with its geographical diversity, showcases a wide array of traditional and vernacular built form. In today's context, our country is constantly undergoing a change in the built environment that is brought upon by rapid globalisation and technological advancement. In this scenario, cultural heritage of the country is diminishing gradually, causing local settlements to lose their distinctiveness. Thus, there is a critical need to look back at traditional building systems as distinct responses to their local environments. The first step towards addressing this need is to develop a database of these buildings and their different aspects to understand and revive our traditional knowledge systems. The Design Innovation and Crafts Resource Centre (DICRC) at Centre for Environmental Planning and Technology (CEPT) University recognises this need for studying, recording and utilising the knowledge incorporated in the traditional and vernacular buildings. It functions as a research centre for the development and understanding of building crafts of traditional and vernacular buildings of India.

A Banni settlement at Kutch, Gujarat

TRADITIONAL AND VERNACULAR BUILDINGS OF INDIA

India in itself is a microcosm within the Sub-continent, both in terms of geographical features and cultural traditions. Responses to these varied physical conditions present within the country are visible in the form of the wide range of building materials that range from stone to bamboo, earth and wood. Traditional buildings are built in response to the micro-climate and are in harmony with local surroundings. Today, we can see various styles within India that range from the *kath-khuni* construction prevalent in Himachal Pradesh to the timber framed houses of Ahmedabad, the stone masonry houses of Kutch and Saurashtra and bamboo houses in south Gujarat, as some of the examples of countless traditional and vernacular buildings across the country.

Along with the tangible influences, these developments within the traditional and vernacular crafts can be credited to the skilled craftspeople associated with the sector. The craftspeople, have responded to individual needs of buildings and developed indigenous construction techniques. The innovative material usage and craftsmanship are visible in the traditional houses in various places. The empirical knowledge systems, developed through frugal innovations, make the buildings inherently responsive to the natural calamities and climatic hazards. With this large agglomeration of built heritage, it becomes imperative to conduct a detailed research on the traditional buildings associated crafts. With this intention at the forefront, DICRC has initiated a research process that provides a platform where there is an effort to identify and understand a range of traditional building crafts and inherent empirical knowledge systems and engage them with current design thinking.

OUTLINING OBJECTIVES AND DEFINING PROJECTS

DICRC, CEPT University was established to function as an interface to understand and develop regional Space Making Crafts (SMCs) and Surface Narrative Crafts (SNCs) of traditional and vernacular buildings of India and integrate them in the current design education as well as practice. According to the research

A traditional house type at Nadiad, Gujarat

undertaken at DICRC, SMCs are the crafts that are directly or indirectly related to the making of buildings, elements, furniture and its details while SNCs are the crafts that are applied to the buildings, elements, furniture and its details. Coupled together, these two form a large repository of building craft techniques. DICRC provides a platform where design thinking engages with a range of traditional building crafts and imbibed knowledge.

The main aim of the research centre is to identify, understand, research, reposition and re-engage building crafts and craftspeople within building sector. The underlying objective is to combine crafts related to built environment and spatial design to explore new paradigms and solutions in current milieu. It seeks to be a hub for craft-design practices to engage and interact. Its major activities are to conduct research, documentation, organise programmes, workshops and projects related to SMCs and SNCs. Within these focus areas, DICRC has initiated various activities to identify, document, analyse and disseminate data pertaining to traditional and vernacular buildings.

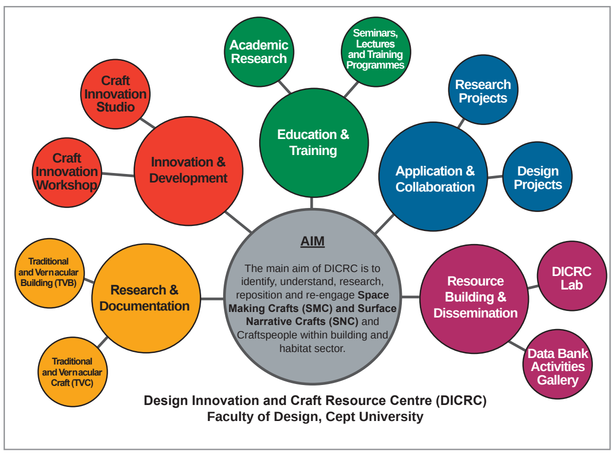
Although there are varied categories of traditional and vernacular buildings, the emphasis of documentation at DICRC lies with domestic architecture. The research and survey also encompasses buildings with religious importance, apart from public and commercial buildings. The buildings selected for documentation showcase the highest point achieved in building crafts. An effort is also made to identify buildings that show the varied construction techniques along the primary material of construction like wood, stone and earth.

Amongst the larger gamut of research activities focused towards developing an understanding of built heritage and associated building crafts, there are projects that specifically focus on traditional building materials and techniques. Following are a few such projects, along with their sub-projects undertaken by DICRC through which there is an attempt to answer the need of substantial understanding of the traditional buildings and crafts.

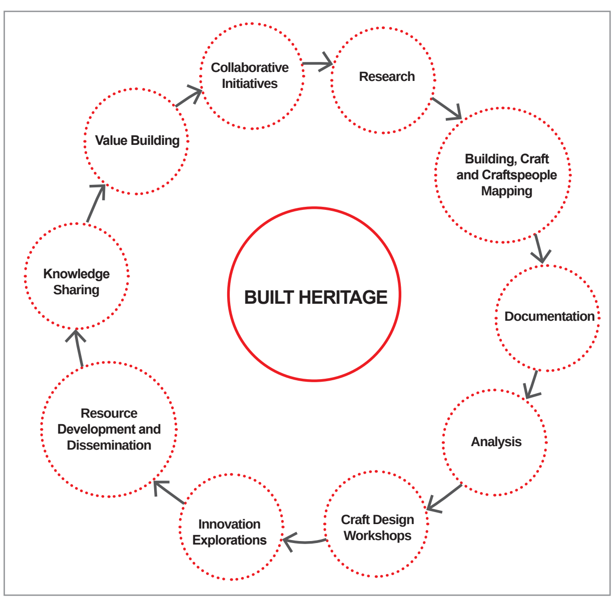
Building Mapping

Building Mapping is a first of its kind visual based mapping technique in India conducted using interactive mobile tablet survey along with photographic survey and interviews. It is an approach towards identifying, understanding and developing a detailed inventory for different aspects of traditional and vernacular buildings and is broadly divided into Building Mapping and Element Mapping. This visual mapping is carried out through mobile or tablet, using a mobile application form developed by DICRC. Depending on the mapping category, the researcher uses either the building mapping form or the element mapping form.

Building mapping form is relevant for gathering information related traditional buildings that are worth documenting. The form collects information ranging from the name of the building, its typology, historic or other name(s), location, approach and accessibility, current ownership and historic usage, along with a facade image for reference. The mapping form also collects physical specifications of the building, starting from its construction materials to the condition of the



DICRC focus areas



DICRC projects focusing on traditional buildings

building. The mapping limits itself to collecting the tangible information about the building along with communication details.

Building documentation

The Traditional Building Portfolio (TBP) is an outcome of the Building Documentation project undertaken at DICRC. Documentation is a process of recording, categorising and dissemination of information through meticulously made drawings. These drawings comprise of two dimensional, three dimensional and exploded drawings of the architecture, interior architecture and furniture elements.

The TBP contains plans, sections, elevations, details and interpretive drawings for all the categories, architectural, interior architectural and furniture elements. Moreover, exploded views for selective interior elements are made based on the criteria of richness, number of crafts expressed, craftsmanship and features amongst the type of elements. Till now, DICRC has produced six traditional and vernacular building portfolios, containing five houses at Gujarat and three at Uttarakhand.

Selection of these houses was based on the primary material used and the construction technique. The documented houses depict varied construction techniques like timber infill and adobe, using a range of materials including brick, stone, timber, bamboo and earth. The preparation of the TBP is achieved through three stages:

- Background research: Involves gathering of existing information related to the building to be documented.
- Field work and documentation: This stage involves gathering information on site through field drawings, photographs and interviews.
- Data cataloguing and digitisation: This includes compilation of field data in a systematic manner by cataloguing in separate sets and preparation of vector based drawings.

Educational initiatives: Traditional Building Interactive Kit

It is as an online educational application aimed at generating awareness regarding the traditional and vernacular buildings as well as crafts of India. This first of its kind kit in India, is intended to bring the embedded knowledge within the traditional buildings back to design education and practice. The application provides a virtual tour within and around the buildings using three dimensional computer modelling. These

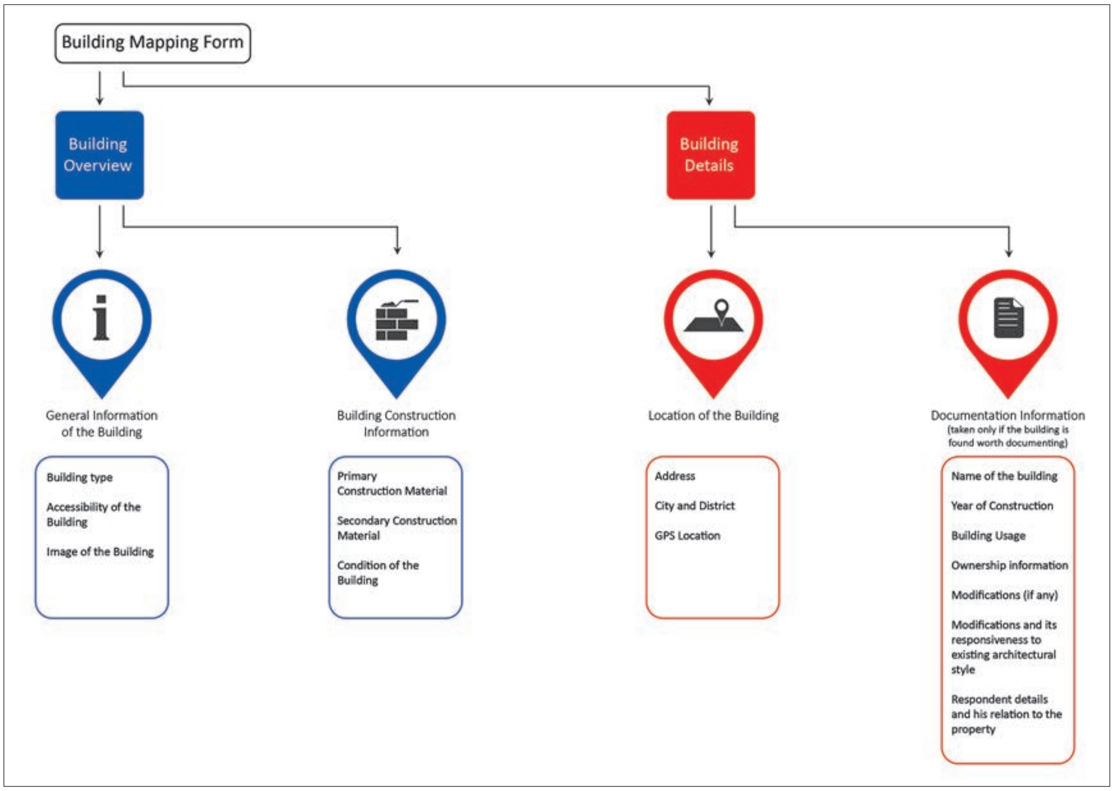
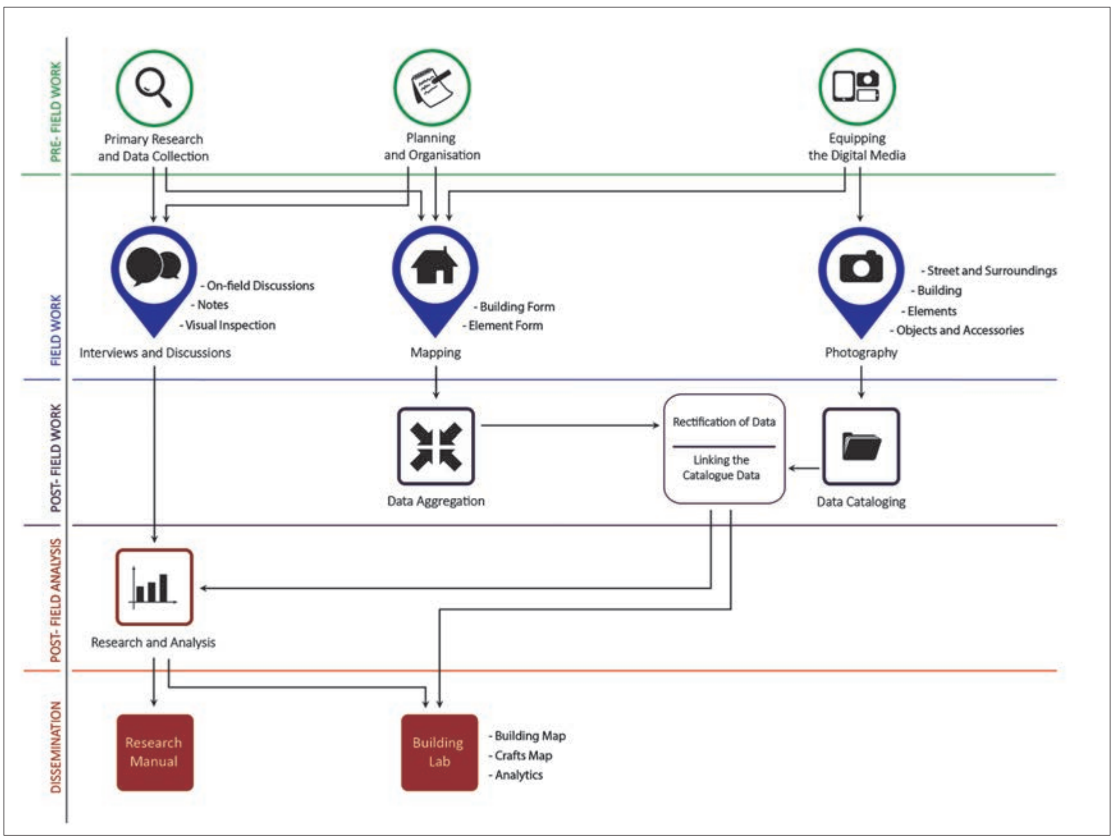


Chart representing the mapping form



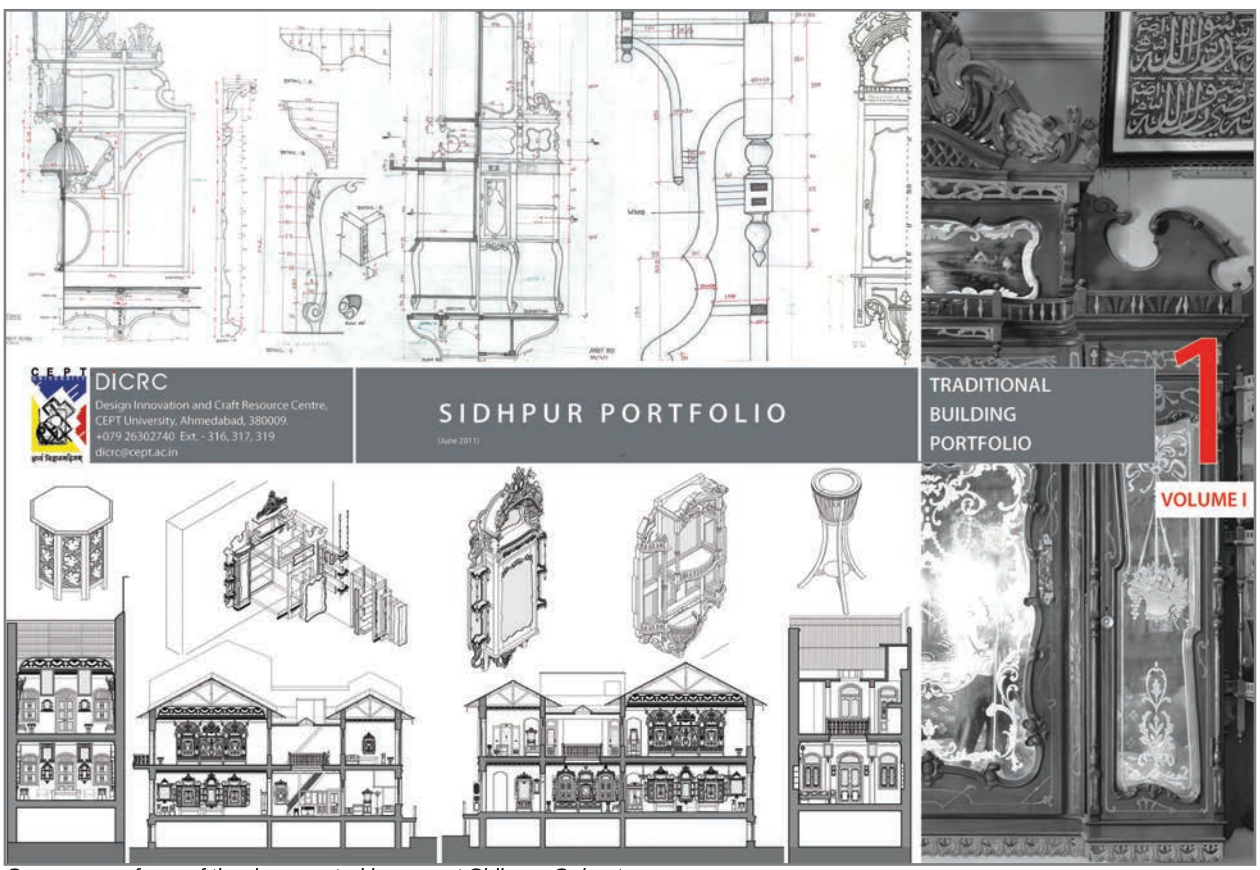
The building mapping process

visuals, accompanied by informative text, present virtual and detailed information about the building and its contents. The process of carrying out this research involves various stages of desk and on-field research, leading to a thorough inquiry into various tangible and intangible aspects of these buildings. These aspects largely include physical and socio-cultural context, building materials, construction techniques, craft techniques, ornamentation and so on. The first traditional house to be included in the Building Interactive Kit is located in Siddhpur, a small town situated in the Patan district of north Gujarat.

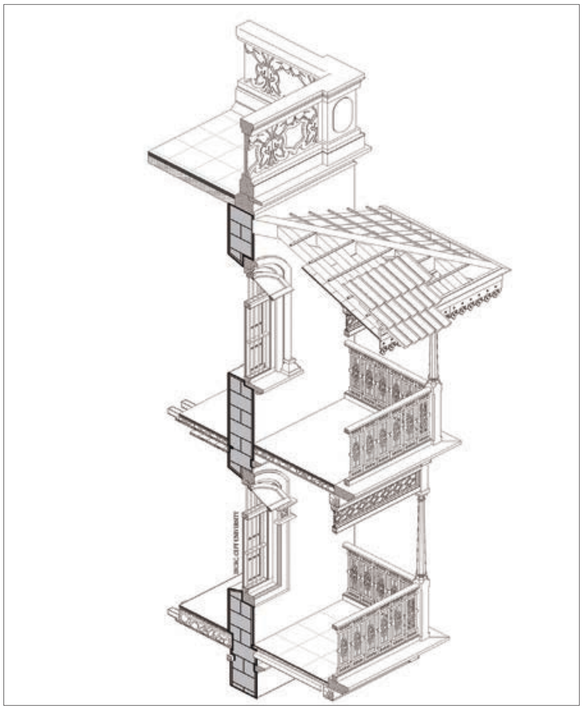
Space Making Craft Workshops: Earth Craft

SMC Workshop is the primary activity of the Craft Innovation Workshop series. It is also an integral part of the DICRC's focus area of Innovation and Development. SMC workshops largely deal with traditional building crafts and focus on diverse craft techniques related to primary materials like wood, stone, earth and grass along with other associated materials with respect to a particular craft. In these workshops, the craft participants included master craftsperson, craftspeople and craft students along with design participants that comrpised of designers, architects, professionals and students.

An exploded view of the Bhunga house showing the construction system



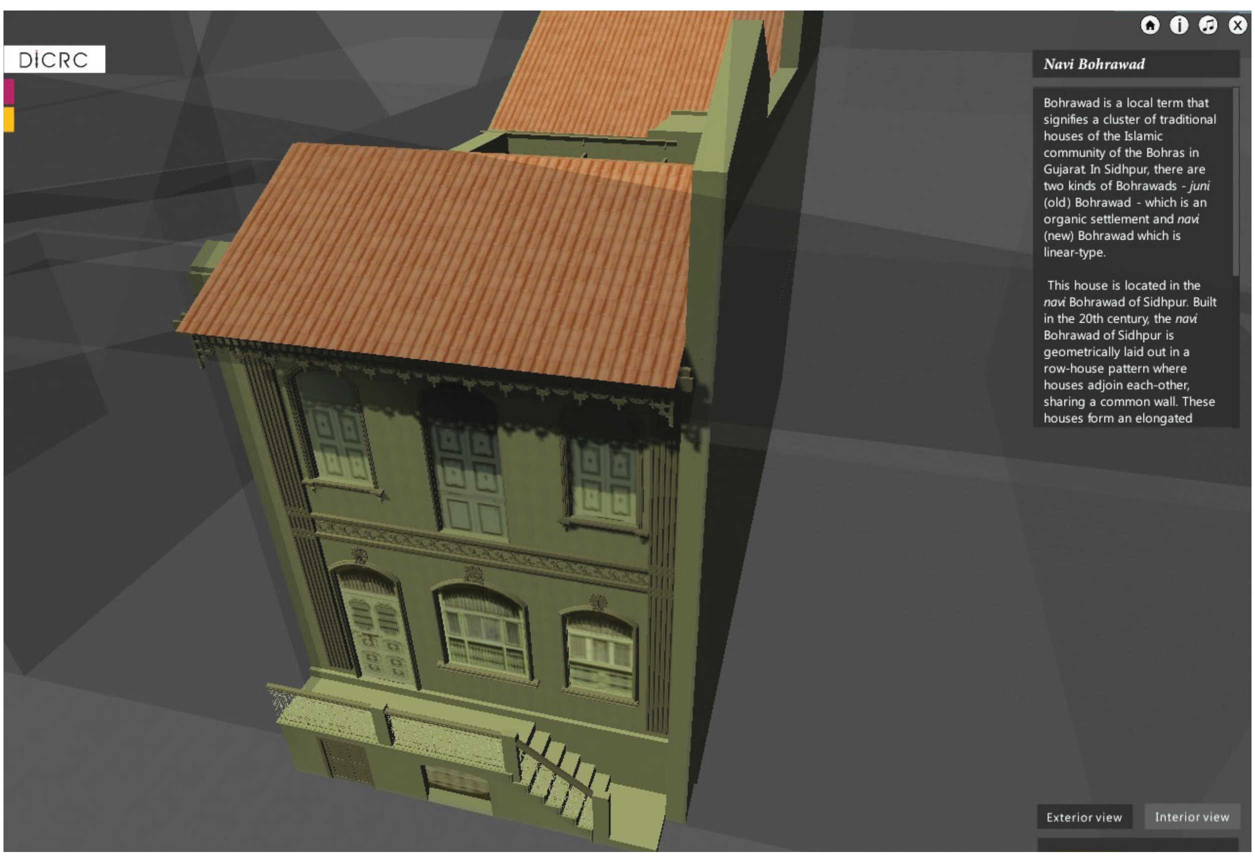
Cover page of one of the documented houses at Sidhpur, Gujarat



A drawing showing traditional construction system in Mandvi, Gujarat

Participants worked together on on bases of the skills and knowledge embedded in craft and craft practices. Till date, DICRC has conducted seven SMC workshops: Wood Turning and Lacquer, Bamboo, Stone, Wood, Earth, Metal and Glass.

The Earth Craft Workshop, envisaged for 10 days, was based on the Craft Innovation Workshop (CIW) model experimented and developed for the SMC workshops. The workshop focused on different techniques used in earth craft including clay, mud, terracotta and ceramics as the prime focus areas of exploration. It was a collaborative effort between DICRC and Hunnarshala Foundation and was largely divided into two major parts. The initial part, at CEPT University, dealt with input sessions, material understanding, site visits, brainstorming and design thinking sessions. The later part of the workshop, at Hunnarshala Foundation, dealt with material and technique demonstration, explorations, hands on session, visit to villages in Kutch and craft design innovation and prototype development. The participants worked together as a group on the specific design brief dealing with interior applications. Six prototypes; in adobe, wattle and daub and rammed earth, were developed



Three dimensional model showing street view of one of traditional houses of Sidhpur, Gujarat, accompanied with information regarding the building typology

A team of craftspeople and design participants with their prototype

during the workshop showing the amalgamation of craft knowledge and design thinking. The workshop was held at DICRC, CEPT University, Ahmedabad and Hunnarshala Foundation, Kutch. It consisted of 28 design participants, 30 master craftspeople and 27 craft students.

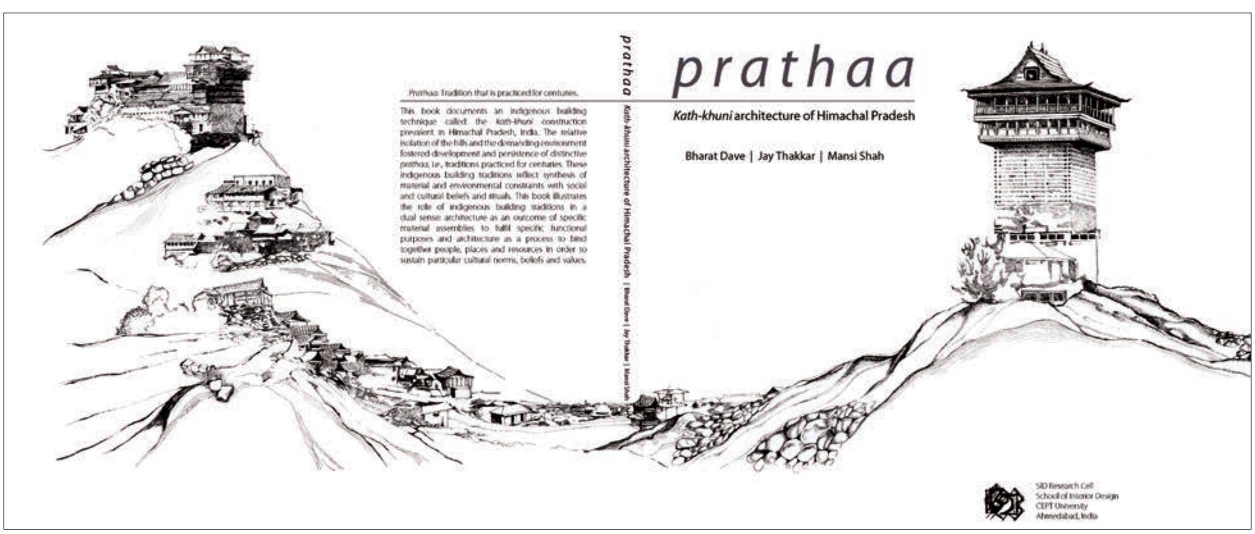
Training courses: Training course on Stabilised Rammed Earth Construction (SREC)

At DICRC, answering the need of the lack of substantial educational material about the traditional and vernacular buildings is a vital criterion. With this thought, DICRC, in collaboration with Hunnarshala Foundation at Bhuj, has developed a unique Training Course on SREC as a two week module. The goal of the training course is to strengthen professionals with knowledge and skills required for designing and building with sustainable technology like rammed earth. The training course lays importance on collaborating with artisans and strengthens the participants to take the traditional knowledge of earth construction forward in the present day context. An interactive approach with artisans and other course facilitators lays the foundation of the course methodology. The training course was specifically designed to familiarise the participants with eco-logic and economics of using rammed earth technology. The course had emphasis on developing understanding of materials, tools, and construction methodology and design principles. The course enabled students and young professionals to address the challenge of designing and building using rammed earth.

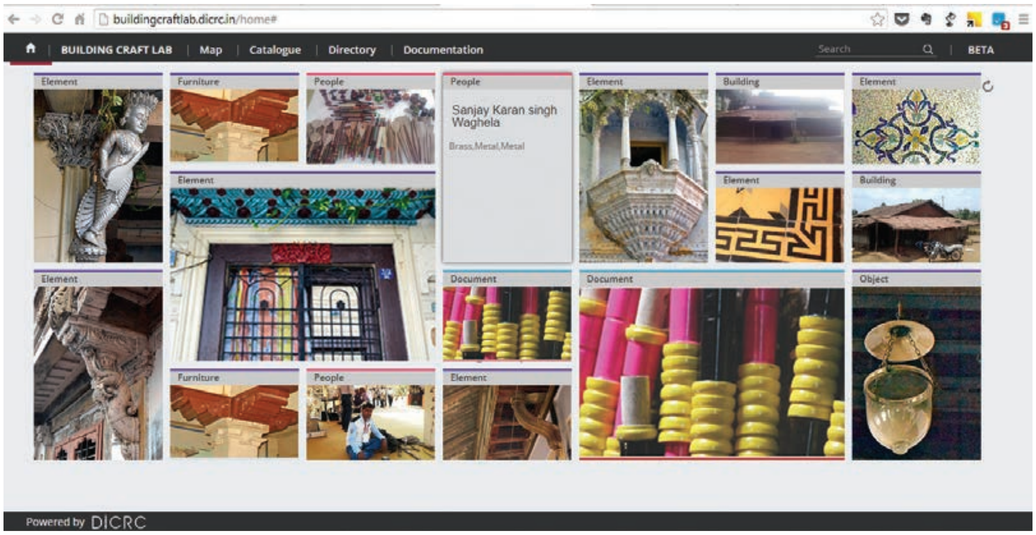
Publication: Prathaa: Kath-khuni architecture of Himachal Pradesh

'Prathaa' published in 2013, is a result of a collaborative research between DICRC, CEPT University and Critical Research in Digital Architecture (CRIDA) in the Faculty of Architecture, Building and Planning, the University of Melbourne, Australia. This is a research project on a distinctive traditional building technique called the *kath-khuni* construction prevalent in Himachal Pradesh, India. This indigenous tradition of construction reflects excellent sustainable and earthquake resistant building techniques using local materials and human resources.

This project aims to help preserve and sustain *kath-khuni* building techniques and local skills by undertaking collaborative research on existing and emerging building practices. 'Prathaa' illustrates the role of indigenous building traditions in a dual sense; architecture as an outcome of specific material



Cover page of Prathaa: Kath-khuni architecture of Himachal Pradesh



Home page of the Building Craft Lab

assemblies to fulfill specific functional purposes and architecture as a process to bind together people, places and resources in order to sustain particular cultural norms, beliefs and values.[1]

The Building Craft Lab

In India, most of the inventories and documentations conducted for built heritage have been very academic in nature and completely negate their utility at the community level. This creates an imperative need of disseminating the understanding gathered about the traditional buildings and reroute it towards the contemporary design practice. With this intention, DICRC has initiated the Building Craft Lab that is an online collaborative platform to explore the world of craft and built environment. Its vision is to generate, amalgamate, catalogue and disseminate resources related to Indian crafts and traditional built habitat. The idea of the lab is result of many discussions and interactions between the researchers of DICRC, and has four components: mapping, catalogue, directory and documentation. The data will be generated and shared by institutions, craft organisations, non-government organisations, government bodies, craft and design enterprises and individual scholars and academics.[2]

CONCLUSION

DICRC has been committed towards the identification, research and re-engaging of the traditional building practices in contemporary times. It talks about the larger vision of looking at traditional buildings in reference to the embedded knowledge repository, cultural values and possibility of craftspeople to earn a better livelihood by enriching the value of craft.

DICRC approaches research through four stages; namely, mapping, documentation, analysis and innovation.It also tries to re-engage traditional practices in contemporary design education, through initiatives like educational material development and training programmes. DICRC goes a step ahead by creating awareness about built heritage through the media of exhibitions and online resources.

Rajdeep Routh *is an architect, currently working as a Senior Researcher with DICRC, CEPT University, India. He has been involved in the field of cultural heritage, distinguished conservation practices and projects of international repute. Rajdeep has also authored three research papers focusing on heritage management.*

Mitraja Vyas *is a Senior Researcher at DICRC. She is involved with research and documentation of crafts and craftspeople across various districts of Gujarat. Mitraja is an architect with Masters in Interior Architecture and Design from the Faculty of Design, CEPT University.*

Notes

1 An article on the *kath-khuni* indigenous construction system of Himachal Pradesh was previously published as Dave, B, Thakkar, J & Shah, M 2012, ‘Details of Resistance: Indigenous Construction System in Himachal Pradesh’, Context: Built, Living and Natural, vol. IX, issue 1, pp. 5-17.

2 Further details and data about the Building Craft Lab can be availed at http://buildingcraftlab.dicrc.in/.

Reviewing the Indira Awas Yojana

The Politics of an Awas

SHARDUL PATIL

Meta-economic crisis in India has led people to be uprooted from their nourishing origins so much so that the harm done is not visible anymore

Nothing drives the imagination of the modern civilisation more than the idea of the 'perpetual'. In a cyclic, finite and limited world as ours, the idea gives humans hopes of eternal structures, of unyielding economic systems, of unlimited resources, of weather proof wall finishes, of the anti-ageing creams and of perennially available mangoes. Mountains are being carved out to harvest the steel on which our 'immortal' civilisation is being built. According to The Extinction Crisis, a social programme of the Center for Biological Diversity, Arizona, we now are on the brink of a mass extinction with 30% to 50% of the existent species heading towards it by the mid-century as we dig out hills for extraction of limestone for the cement that helps us build tall skyscrapers. Ancient forests are being destroyed to make way for a mono-culture of timber trees to generate wood to aid the race towards eternity. The breathing thatch is now being replaced by the cancer inducing asbestos sheet and the mud wall is being replaced by burnt brick, for the production of which 35,00,00,000 tons of cultivable soil is consumed in India annually and burns 2,40,00,000 tons of coal (*The Times of India*, Dec. 7, 2013). The rush of the idea of the immortal civilisation blinds the ecological and cultural limits that have bound Indian civilisation for centuries and helped it attain a state of permanent evolution rather than a pseudo-permanent existence.

The strength of the Indian civilisation lies in its belief in an all-pervading soul. The belief in the cyclical nature of the soul, an ever regenerating, ever improvising being, is what we have been basing our decisions on. The Indian civilisation described by Kumarappa (1984) as 'Natural Economics', is now challenged by a unidirectional, falsely permanent, an all promising and individualistic industrialised global economy. Such an economy suffers from what EF Schumacher describes as 'meta economic crisis', that is, a crisis in which absolute factual reduction and standardisation turn the wheel of the economy in such a way that there is no place for regional ethics and socio-cultural diversity to exist.

Such a socio-political atmosphere gives rise to architecture that responds to it. It is, thus, not a wonder that Mumbai aspires to be a Shanghai, or that people want to live in Mediterranean type of houses in Ulhasnagar, or that there is an attempt to sell a building like the Kohinoor Heights[1] as a green building while each and every floor of the building is designed to have artificial air-conditioning because of the flashy glass-facade. A similar motivation is expressed in projects such as Antilia[2] that takes architectural inspiration from the Babylonian Gardens and projection of man's ability to build palm tree-shaped islands on water as the greatest architectural achievement of the century.

This socio-political situation calls the zero carbon footprint generating, handmade, climatologically relevant bamboo wattle-and-daub wall of the Warli as a *katcha* structure and the brick wall, made of materials which have been made by burning ounces of natural resources and required skilled labour to be built, as a *pakka* structure. The *katcha-pakka* logic demeans the very roots of sustainability laid in the bio-diverse regional architecture of the country. The words themselves play the politics. The word *katcha* suggests 'raw, unripe, crude, uncooked, unmade, careless and superficial', while the word *pakka* leads us to believe it is 'cooked, ripe, solid, complete, inerasable, thoroughgoing'. By naming certain structures as *katcha* and the others as *pakka*, based on classifications of permanence of their techniques and materials in themselves shows the absolute simplistic reduction that we as a society face today. All the other aspects of the materials then do not matter, the materials are then graded only by one and only one quality, which is its durability. It is proven later through documentation that this is also a question to be critically thought upon.

This very situation has given rise to the Indira Awas Yojana (IAY), a flagship policy of the Government of India launched in 1986 that has transformed the country's 2,55,00,000 culturally rich, architecturally diverse, socially, climatologically and ecologically appropriate homes into standard, sociologically demeaning, unhealthy and ecologically unsound structures, till date. Under the undefined context of *katcha-pakka* logic, the policy has lured the age-old technologies of the villages to an untimely death, and replaced them with technologies which continue to 'ghettoise' settlements[3].

HOUSING AS A PROCESS

The idea of a house in the above discussed situation becomes a unique one. A house is now an entity, something that is a final product, lasting for an eternity and requiring minimum amount of maintenance. A house is now a commodity to buy and to sell; a finished product that becomes immaterial if not finished. The basic need of shelter now takes a shape of a resource consuming, harmful waste generating and health deteriorating system. Building and construction industry today consumes 8.9% of our Gross Domestic Product (Sugden 2013). In a country where the richest of industrialists live in their posh mansions, 4.5% of the population are homeless (*The Times of India*, Dec. 7, 2013). Such an attitude towards housing is a victim of speculation and the market economy.

On the contrary, documentation of any organically grown settlement in the country reveals a zeal that embodies the very idea of human sustenance. Housing in these settlements is a continuous process and a house is a 'homegrown entity' something that grows with you and supports your daily activities (Srivastava & Matias 2008). Maintaining a house is an act of engaging with it, knowing it and understanding the systems that run it so well that it becomes possible to repair the house without any expertise. It is the simplest expression of the need to give shelter to one self and the layers of civilisations which have nurtured one's existence. It is an entity of immense value that is not open for sale. It is a part of the ecology that surrounds it and houses within itself the biodiversity that abounds the region.


The representation of a 'home' drawn by a Warli artist: the 'Awas' (structure) is incomplete without the context (ecology and the economy) that surrounds it

Such observations were drawn while documenting the traditional rural housing in the state of Maharashtra, in order to study the context which the IAY has resolved to change. The State unfolded a vast range of architectural typologies which represent the climatological, socio cultural, economic and the ecological situation they find themselves in. This housing is a live manifestation of the phenomenon of 'emergence' as described by Nabeel Hamdi (2004). Governing this phenomenon of emergence is a matrix of factors ranging from topography, vegetation, climate, rainfall, soil cover, hydrology, sociology, economy, traditions and available resources. Any change in the matrix builders would change the housing typology drastically to incorporate the change. This attitude in housing captures the essence of the place and is the key factor in making it the ideal shelter for that context.

Deriving the materials for the house is an act of borrowing from nature, only to give back what has been borrowed after exhaustion. Unlike the modern *pakka* materials that result into an annual 10 to 20 million tonnes of mostly non-degradable, heavy, high density and *pakka* waste that litters our settlements, posing a critical question of sustenance of such techniques[4]. Material here is free of cost and does not require transport, because it is abundantly available in the vicinity. Good, liveable and spacious houses are still being built in the state, using local techniques and materials that cost as less as ₹ 6000.

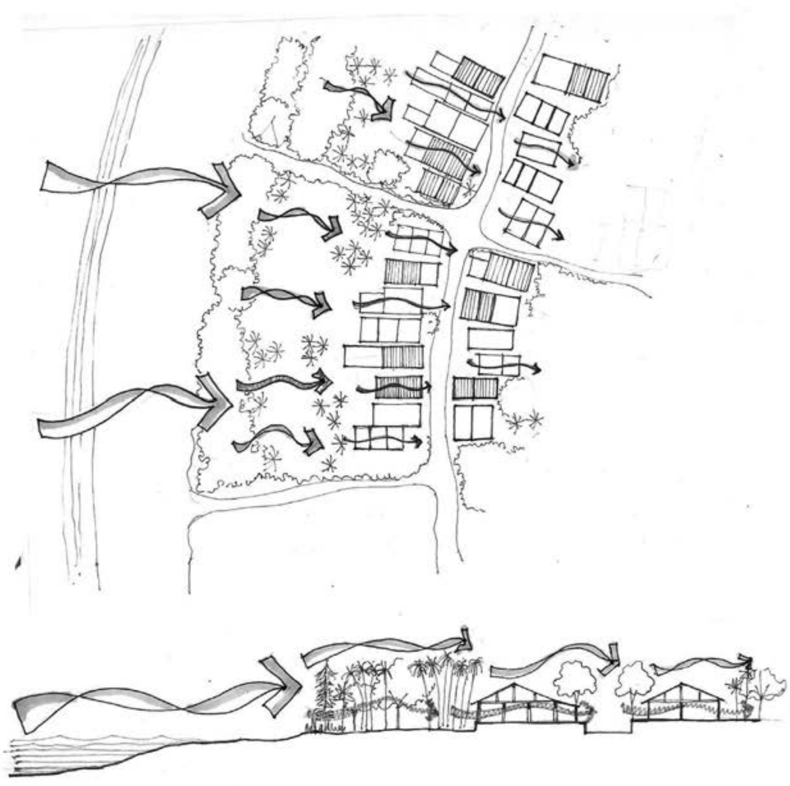
INDIRA AWAS YOJANA AND ITS SALIENT FEATURES

The IAY, today, justifies its existence in the 48.4% of houses in the country which are *katcha* or semi *katcha*[5]. It assumes that the country needs 'disaster resilient housing' while disregarding the disaster resilience of the houses in the rural sector built with local techniques. It aims at removal of poverty through self-employment and self-construction, but promotes techniques which are impossible without skilled, external labour. It considers a house to be a poverty uplifting effort but terms them as 'poor' in the first place before actually giving them subsidy. It further tries to tag the poverty of its beneficiaries by forcing them to fix the Yojana seal on their door. An ecological and social disaster, the IAY is, in principle, giving subsidised housing to the 'rural poor'.

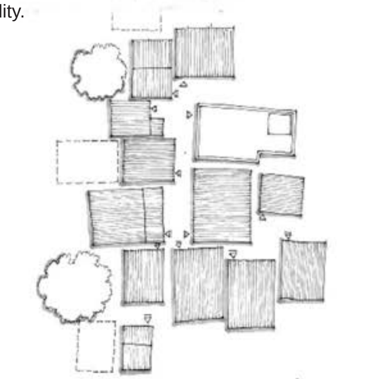
A survey is conducted every ten years since 1985, to note the families under the poverty line in the rural areas. Assumption is made that these families live in a *katcha* house and need to be provided for. An annual target is then decided and requisite funds are released for the implementation of the Yojana from the Centre to the States.

The beneficiaries then receive the sum of money that is now upgraded to around ₹ 90,000. A minimum area of 25 square metres is to be constructed by the beneficiary out of *pakka*, disaster resilient and sustainable technologies which are specified by the Sectional Engineer. Building a toilet becomes necessary. The beneficiaries are supposed to build the house themselves with a design that suits their requirements and needs. Use of *katcha* materials is

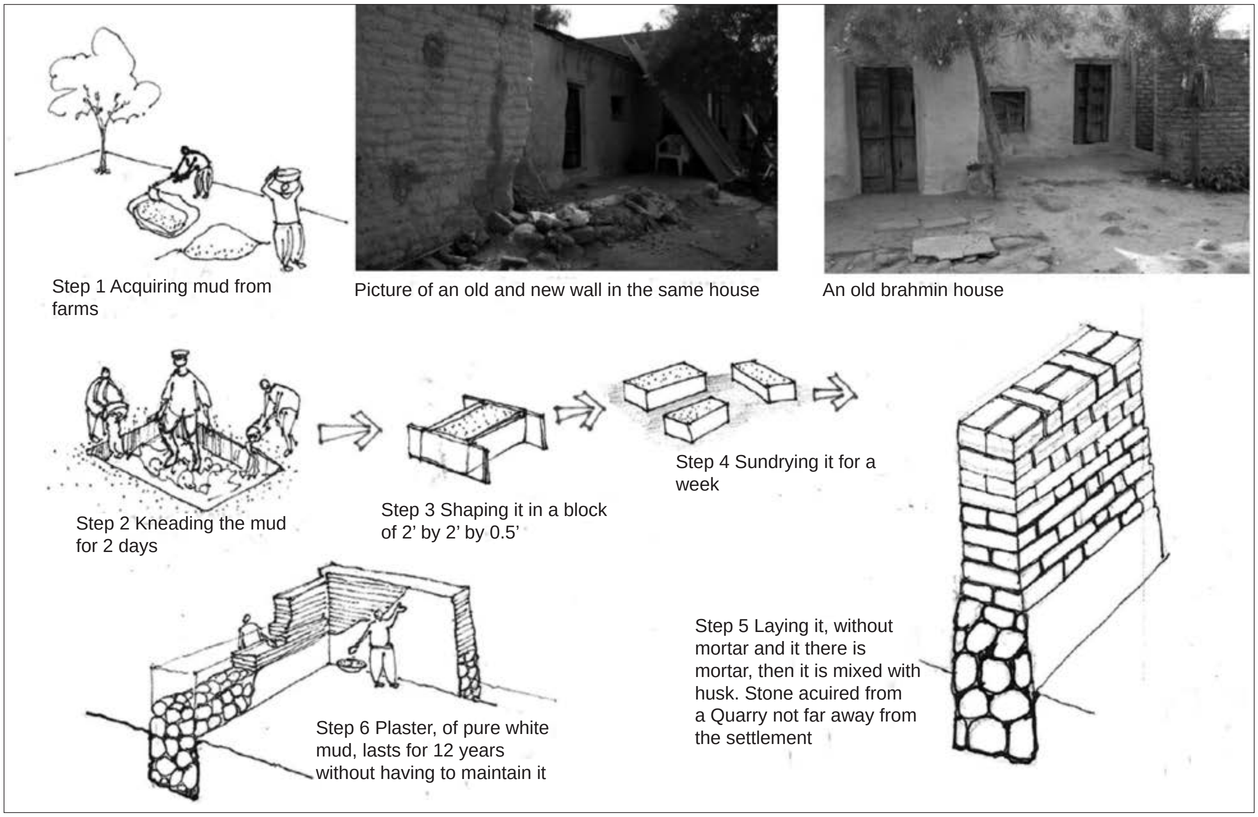
Plan and the section of the traditional settlement showing its resistance to winds



The IAY ghetto with staggered non linear house planning and trapped unhealthy humidity.

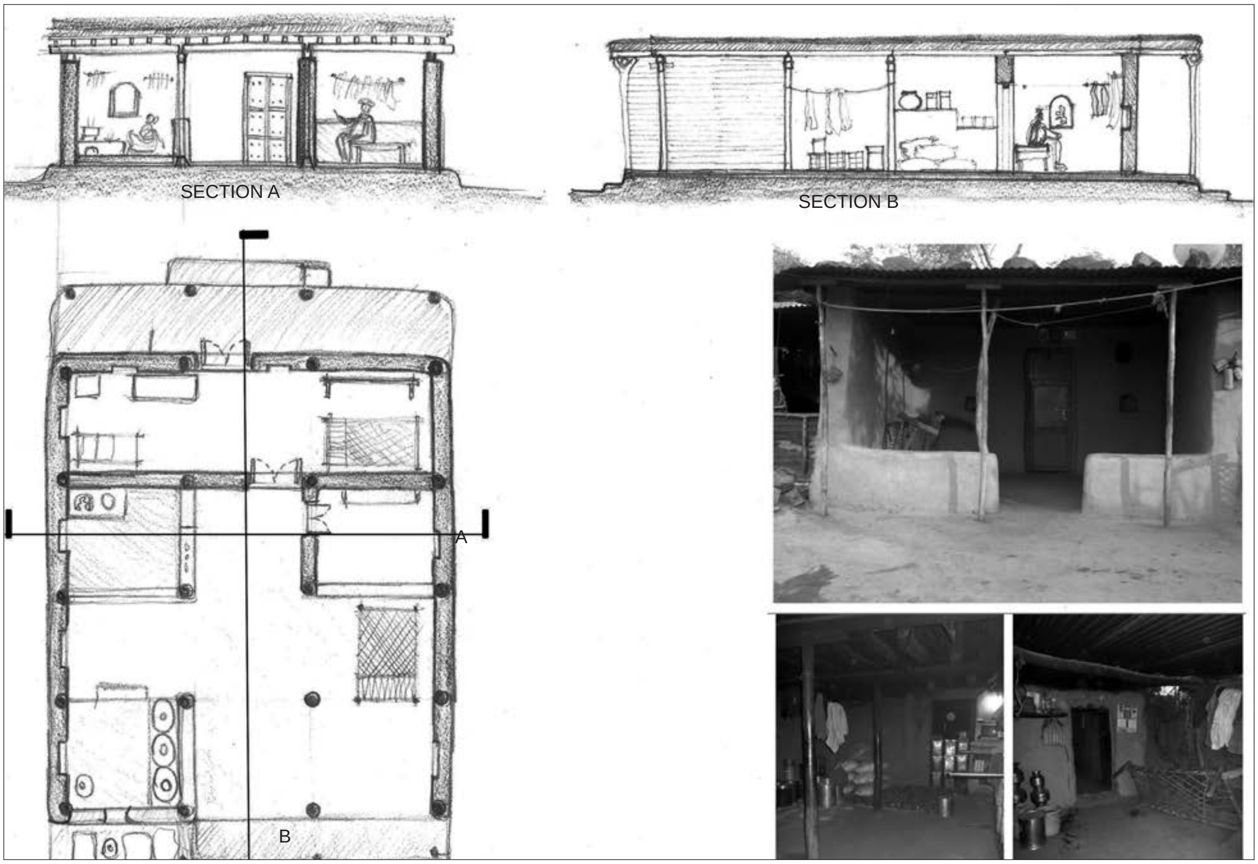


Traditional 'koli' settlement layout of the village of Chinchani versus the IAY settlement layout in the same village



Steps for making mud bricks and construction of houses using these in Shedgaon, Ahmednagar

IAY settlement of Asangaon, Shahpur Taluka, Thane district: the ghettoisation of a settlement



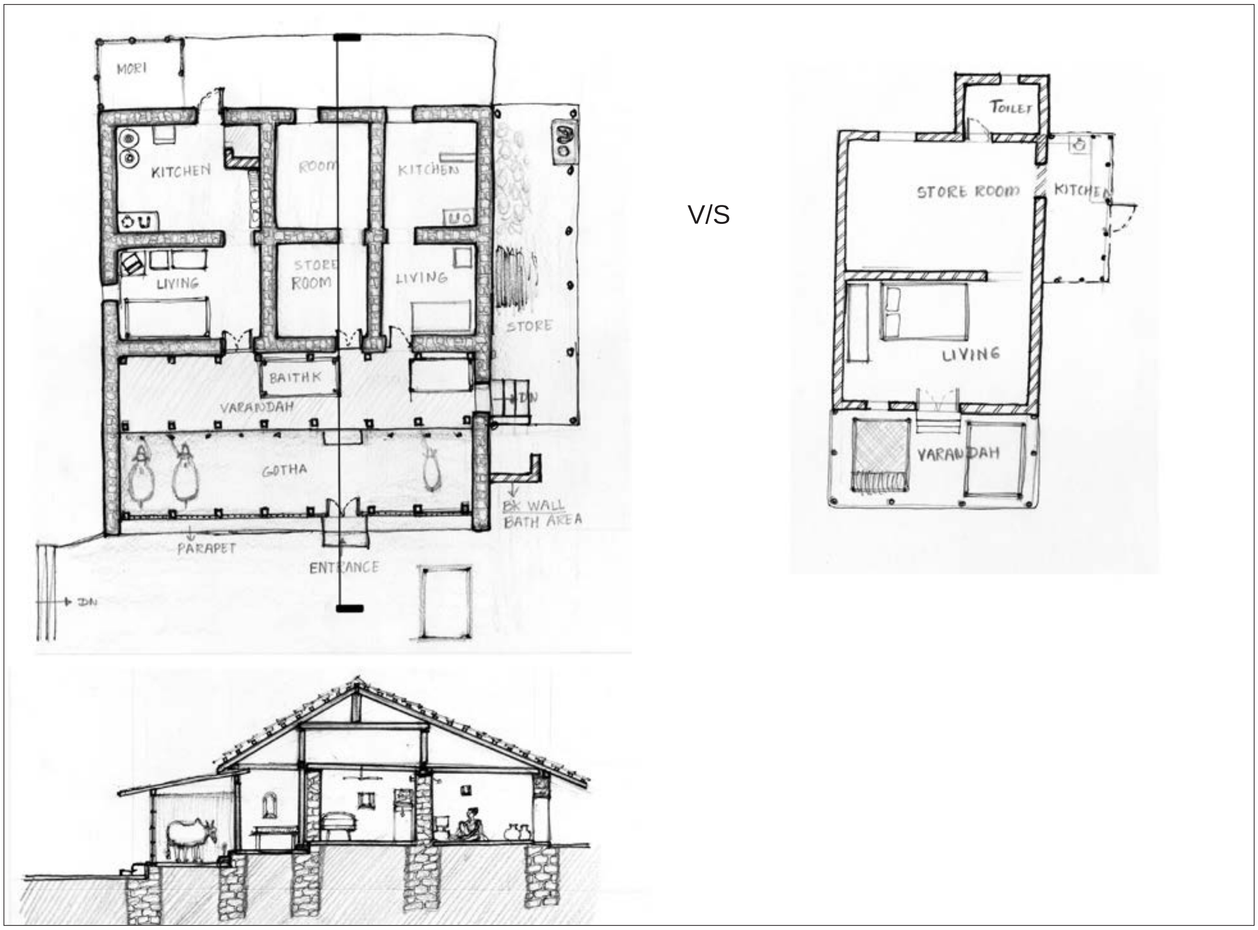
Typical house in the Ramdeo Wada, Jalgaon without any interior walls to separate spaces. This is representative of the nomadic life of the Banjaras who inhabit it

prohibited and if done so, funds that are released in three instalments are curtailed. The individual Gram Sevaks[6] are given a pamphlet that states the 'dos and don'ts' of the Yojana, as vaguely as the Yojana follows it. Along with this an engineer's plan is also given that is designed 'specifically' for a district. However, both these requirements many a times do not land in the hands of the Gram Sevaks and the Yojana is carried across merely by word of mouth.

The Yojana was revised in the year 2012 to include techniques involving mud and bamboo in the construction, with a view of 'greening' the construction practices undertaken, stating that any material including mud and bamboo or a technique can be called as *pakka* unless it stands the test of time for at least 30 years without any major maintenance. However, the method of execution on site does not show any change and continues to be driven by the engineer's imagination of the *pakka* which is standard Reinforced Cement Concrete (RCC) and brick with Asbestos Cement (AC) sheet roofing.

DOCUMENTATION OF LAY HOUSES BUILT IN TRADITIONAL VILLAGES

The Yojana, currently implemented across Maharashtra, has caused significant impact upon the village fabric and general lifestyle of the people, as is evident from the extensive documentation of the IAY cases that have been studied in combination with their traditional context. In the Thane district, along the coast of northern Maharashtra, the traditional, linearly planned coastal villages are oriented in a direction perpendicular to that of the dominant sea-breeze. This arrangement not only breaks the wind but also channels it to vent out humidity from the interiors of the houses. The new IAY houses, being organic in their arrangement, trap heat and humidity. These are square with *jaali*s (screened openings) instead of being linear with aligned openings, making them inefficient in quick ventilation and thermal performance. Hence, they fail in matching up to the climate-responsiveness and effective space planning of the traditional alternative. The documented village of Chinchani, in the Dahanu

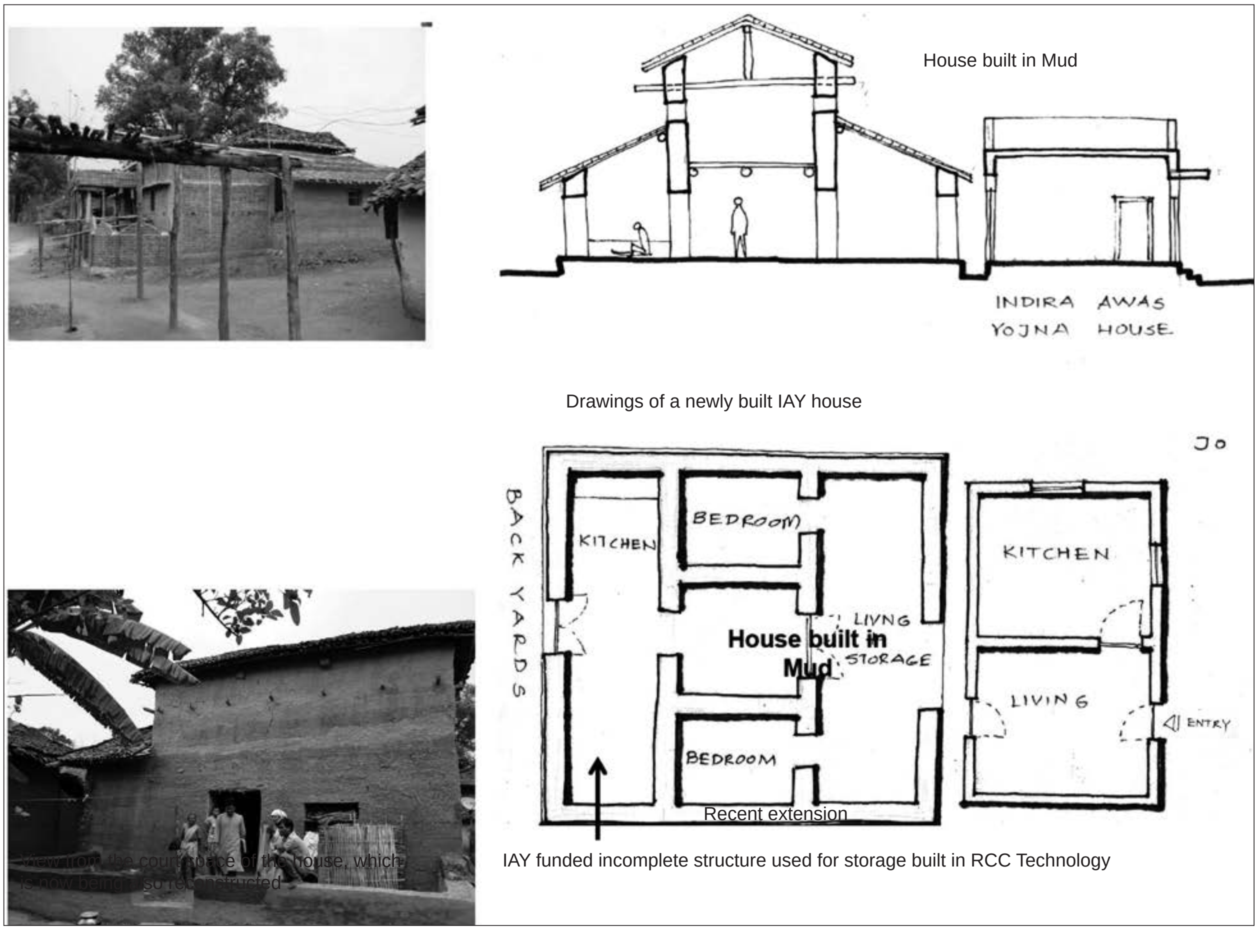


A well equipped Maratha house in the settlement of Bhatti, Velhe Taluka, Pune, showing all the agrarian needs of the user as compared to an IAY house in the same settlement showing the use of an external space, the veranda, for living[7]

Taluka in the Thane District, shows this pattern very evidently, where the IAY has resulted in creating stark ghettos in the village.

The sustainability of the settlement is affected too, as is seen in the Shedgaon village in Ahmednagar district. The village lies in the arid zone of the district where repelling the hot breeze and having a thermally insulated house becomes of utmost importance in order to lead a healthy life. White mud, collected right from the backyard and made into sun-dried adobe bricks, is used to make houses. These homes get stronger and more water proof over the years as the lime content in the mud slacks. The houses are constructed purely out of local material and labour that is free and abundant. The brick and cement houses that the Yojana insists upon are neither a sensitive solution to the climatic and environmental constraints that the site offers, nor do they provide thermal comfort in the heat and aridity of the region.In addition to these spacio-climatic impacts, drastic sociological repercussions are not uncommon in the areas under the IAY influence. More often than not, the beneficiary is forced to take loans to ensure the completion of the houses, when the funds provided by the Yojana prove to be insufficient.[8] The new IAY houses are built in addition to the traditional house, in the same backyard. This results in the death of the backyard and front yard spaces along with the public nodes in the village like *chowk*s (courts) and *chabutra*s (raised platforms), and the sustainable practices that occur within it. This set-up increases dependency on the local markets, and also creates ghetto spaces, where the downtrodden poor thrive. The village of Asangaon in the Thane District shows this pattern. The village has been designed to perfectly sit on the existing contours and houses are built along with front and backyard spaces which not only help the house resist landslides that happen due to the steep slope of the terrain, but also are a material and sociological repository for the house. The Yojana houses have encroached upon these very spaces.

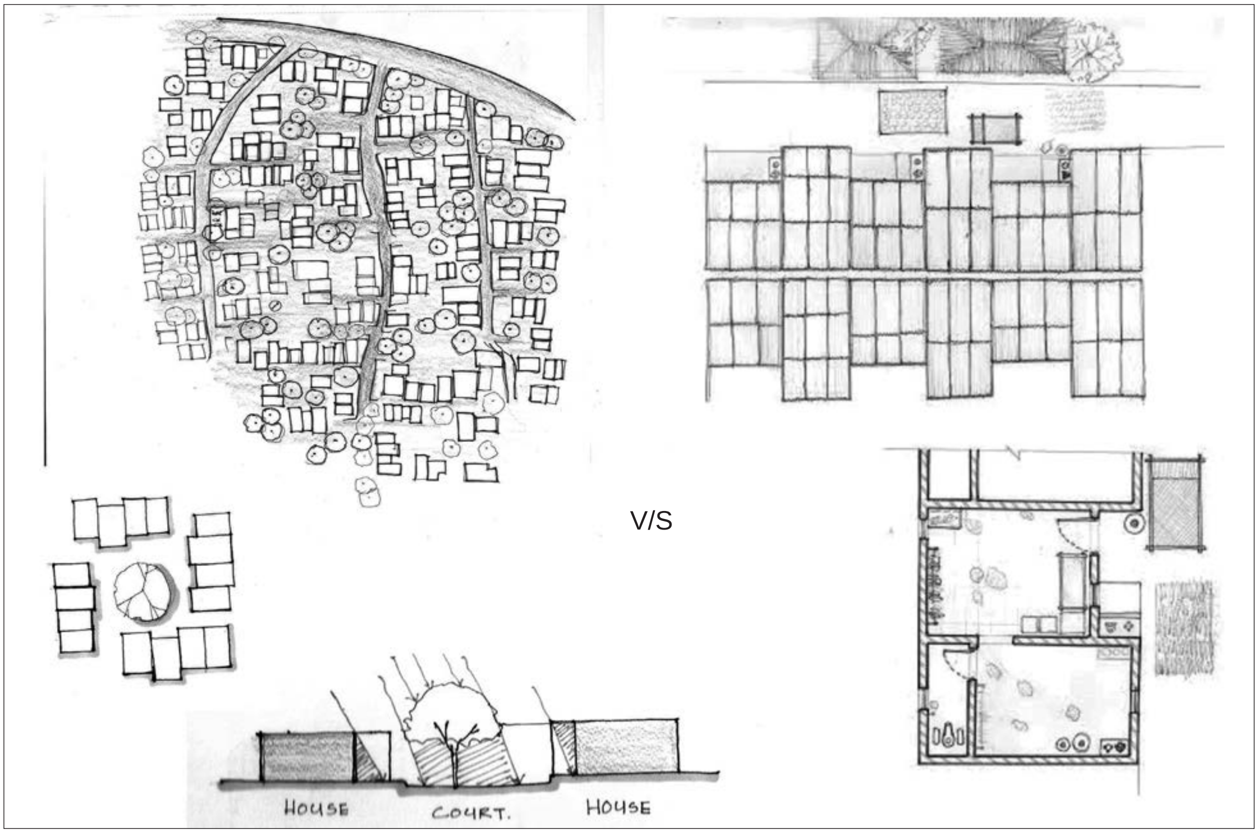
Traditionally, the occupation of the family dictates the design of the rural house. There are no internal walls



IAY structure of Nawatola village, Salekasa Taluka, Gondia district. The structure given by IAY is used for storage while IAY is an impetus to the building of a new mud house

present in many homes, except for areas that require intimate privacy. The best example of such a condition is that of the open plan houses of the nomadic Banjara tribe of Jalgaon district. The tribes live a pastoral life and the house reflects their lifestyle in form of an open plan without any walls, doors and windows. The only space that has been given privacy is the nursery, used by the pregnant ladies. The IAY shows no consideration to this functional diversity, forcing just two rooms in the plan of the house, with a brutal reductionist zeal that has now vehemently unified all the IAY houses built in place of the original ones. Since peoples' needs remain mostly unchanged, living space in the IAY house gets compromised upon and the house is reduced to a storage space, with people having to stay outside it. Whether the Yojana is creating homelessness or solving it, is thus a question.

Even with all the repercussions in terms of the materials implied by the IAY, there is scope for local reinvention within the process of its actual implementation. This is observed in the river plains of the Thane District, where the people have realised that the money given by the Yojana is not enough to build a new house from scratch. The insufficiency of the funding has led to them into bribing the Gram Sevaks to accept part of that money which is granted to build a complete house. With the remaining amount and the approval of the Sevaks, the villagers carry out improvisations in an already existing house instead, using local technology. This tendency is an outcome of the numerous incomplete houses which dot the settlement that are in the state of ruins because of the incomplete funds from the Yojana. The 'pakkaness' of the materials and techniques used in the structures also comes into question when the IAY structures in the settlement start to crumble and the residents do not have the requisite funds to maintain the houses. The maintenance which earlier was a ritual carried on freely as the materials required were local, now becomes an economic burden and something that is difficult to be executed, resulting in ruinous conditions. In the village of Kelthan, located in the plains of the Thane District, people have built their houses out of the same



Highly interactive village fabric of the Ramdeo Wada, equipped with chabutras, self-shading streets, community cattle sheds and courts, as opposed to the IAY fabric in the Avhani village of Dharanpur Taluka, Jalgaon district

traditional mud and brick, using the subsidy from the IAY. The key to this construction is improvement rather than reconstruction. Using the subsidy, people have improved their houses rather than attempting to construct new ones.

The people in the Bagh river basin of the Gondia Taluka have found out an ingenious way of dealing with the Yojana. They build the house as prescribed by the Yojana but more importantly see the Yojana as an impetus to build a new house. The Yojana house is built only till the level that it can serve as a storehouse and is accompanied by a house in local cob technology which is three times the size of the Yojana house built generally at costs which range from ₹ 3,000 to ₹ 15,000. Like the people of these villages, many are now returning to their indigenous traditional techniques after the settlements have been laden with the debris of ruinous IAY houses.

On account of their planning, structure, open and semi-open spaces and function, the traditional houses in rural Maharashtra form the base for a system of dynamic exchanges. These exchanges have been the exact reason for the permanence and longevity of these structures, even though they use non-permanent material. What is required for such an exchange is a spacious structure that can be built using the freely available local resources. However, with the IAY, people have to buy materials and pay the skilled labourers. In the village of Karali of Gadchiroli District, Vidarbha, people have been living in ground plus two houses that become impossible to construct with the current sum provided by the Yojana. The wish to continue to live in such houses and at the same time to benefit from the Yojana makes the people indulge in malpractices of bribery in order to make use of local materials in some respects like mud mortar and bamboo reinforced concrete, reduce the cost of the structure and not fall in the vicious cycle of loans that they eventually do.

The social, climatic, environmental and economic implication of the IAY causes the entire village fabric to get slowly disturbed, as is seen in the Ramdeo Tanda Village of Jalgaon. The District Rural Development Agency (DRDA) enforced a layout plan of the proposed house on the village that replaces the interactive accessible mud terraces of the traditional homes with the inaccessible AC sheet roofing of linearly planned houses. This has resulted in the shifting of the functions originally carried out on the terrace of the house, bang on to the streets. The village sections shows interactive *chowk*s connected visually to the terraces, all in an organic cluster of densely packed houses that effectively resist the arid winds of the Kandeshi plains. IAY houses fail to do so.

Once the house is built, maintaining it is an undeniable obligation. Designing a policy against it is a flaw within itself. Be it pakka or katcha, houses eventually crumble, if not maintained. The key is to look at maintenance as a part of the process of housing. Such maintenance thus has to be with locally available skills and materials that enable the act of maintaining to be zero cost or cost effective expression. Once made, the IAY houses are difficult to maintain due to the need of exotic and locally unavailable materials and skilled labour. This results in houses that crack, crumble and are eventually abandoned, leading to the village-scape getting corrupted with more and more defunct houses. The people of the villages in the Melghat forests, in the Amravati District of Maharashtra, have realised the insignificance of the Yojana, its inability to save them from the harsh and extreme climate that the traditional dwelling protects them from, its non-economic and un-sustainable nature, its sociological impact and its poor architectural quality. They call IAY houses *jhopdi*s (huts) and prefer not to have one. They are so confident in their resource based natural economy and sustainable ways of life that they reject the Yojana, many a times leaving them as some of the best thriving self-sustaining villages seen across the state.

CONCLUSION

The IAY is a strong reminder of one of very famous quotes by Thomas Jefferson (1953), 'If your government is big enough to give you everything you want, it is big enough to take away everything you have.' The documentation lays bare the bruises to the very basic Indian root values. Subsidisation for the poor, to give them everything in order to make them self dependent and self sustained and in the process taking away from them the very foundations of them and their settlement's original existence forces us to draw links of the IAY to the cotton farmers' suicides and the all providing, all subsidised and land wrecking Bt Cotton seeds[9]. As the Yojana now sets itself to survey for the prospective beneficiaries, it brings with it new hopes for the poor, whose eyes have been

Houses under construction using local techniques, traditional practices of Semadoh village, Amravati evolved to match the need of the modern settlement shadowed by the silver foil of an omnipresent media which compels them to believe a cement house is a status symbol and mud is *katcha*. The same foil makes them leave their villages, move to the city in the hope of a better life. The statistics, the personal comfort, the sustainability of the fabric, loss of age old skills goes for a toss and all that matters is how relatively *pakka* is your house in the eyes of the society.

Shardul Patil *is an architect and co-founder of the design, research and rural development firm, Design Jatra based in the village of Veti Murbad, in the Dahanu Taluka of the Thane District of Maharashtra. He graduated from Academy of Architecture, Prabhadevi, Mumbai and has been awarded the JK Architect of the Year Award for the best national thesis in 2014 by the National Institute of Advanced Studies in Architecture, Chennai.*

Acknowledgement

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- All illustrations apart from otherwise mentioned are works of Design Jatra. Drawings done by Ar. Pratik Dhanmer, Ar. Prajakta Kabra, Ar. Maitreyi Marlewar and Ar. AnuradhaWakde, 2014, unpublished.

Bibliographic references

- Dalvi, Mustansir, 2009, 'The blue tarpaulin: what it bares about Mumbai's high-rises', *asanyfuleknow.blogspot.in*, posted December 12 2011, Mumbai, viewed 4 July 2014, <http://asanyfuleknow.blogspot.in/2011/12/firstpost-mumbaithe-blue-tarpaulin.html>.
- Greenwald, N (n.d.), *The extinction crisis*, social program of the non-profit organization, Center for Biological Diversity, Tuscan, Arizona, viewed July 12 2014, <http://www.biologicaldiversity.org/programs/biodiversity/elements_of_biodiversity/extinction_crisis/index.html>.
- Kumarappa, JC 1984, *Economy of permanence*, SarvaSevaSanghPrakashan, Rajghat, Varanasi.
- Nabeel H 2004, 'Small change', *About the art of practice and limits of planning in cities,* Earthscan, Oxon.
- Schumacher, EF 1973, *Small is beautiful: Economics as if people mattered,* Blond and Briggs
- Singh, I 2011, Indira awas yojana, first viewed July 14 2014, <http://en.wikipedia.org/wiki/Indira_Awaas_Yojana>.
- Srivastava, R & Echanove, M, since 2008, URBZ: user generated cities, Dharavi, Mumbai, viewed May 5 2012, <http://urbz.net/>.
- Sugden, J 2013, 'Why India has a sand mafia', The Wall Street Journal, India, August 6 2013, viewed July 13, 2014, <http://blogs.wsj.com/indiarealtime/2013/08/06/why-india-has-asand asand-mafia/>.
- 'The Population of the Homeless in Rural India dips', The Times of India, Dec 7 2013, viewed July 12, 2014.

Notes

[1] Kohinoor Heights is a semi twin, mixed-use skyscraper located on the land previously owned by Kohinoor Mills in Shivaji Park, Mumbai.

[2] Antilia is a residential complex in South Mumbai, owned by Mukesh Ambani, chairman of Reliance Industries Limited.

[3] This was the case until the revision of the Indira Awas Yojana in 2012.

[4] National Informatics Center, 2010, 'Construction and demolition waste', *Solid Waste Management Manual*, chapter 4, Department of Information Technology, Ministry of Urban Development, Government of India, <http://www.urbanindia.nic.in/publicinfo/swm/swm_manual.htm>.

[5] Ministry of Statistics and Programme Implementation, 2013, 'Housing', *Statistical Year Book, India 2013,* Chapter 28, Central Statistics Office, Ministry of Statistics and Programme Implementation, Government of India, <http://mospi.nic.in/mospi_new/upload/SYB2013/index1.html>.

[6] Gram Sevaks are village assistants in the village Panchayat or the local self government.

[7] Only the veranda (which is built by the user himself without the IAY) is the space which the beneficiary used for daily activities, while the house becomes a structural equivalent to the extremely hot, efficient storage space and extremely inhabitable attic of the old structures.

[8] In most of the construction that happens under the Yojana, the Funds are found to be insufficient.

[9] Bt Cotton is a genetically modified variety of cotton producing an insecticide.

Events and Conferences

THE 3RD INTERNATIONAL CONFERENCE ON DESIGN CREATIVITY

Date: January 12-14, 2015
Location: Indian Institute of Science, Bangalore, India
ICoRD'15 is the fifth in a series of conferences intended to be held every two years in India to bring together the international community from diverse areas of design practice, teaching and research to: showcase cutting edge research about design to the stakeholders; aid the ongoing process of developing and extending the collective vision through emerging research challenges and questions; and provide a platform for interaction, collaboration and development of the community in order for it to take up the challenges to realise the vision. The conference is intended for all stakeholders of design and in particular for its practitioners, researchers, teachers and students. The theme of ICoRD'15 is 'Design Across Boundaries'.
Organised by: Centre for Product Design and Manufacturing, Indian Institute of Science, Bangalore
Contact: Amaresh Chakrabarti
Email: ac123@cpdm.iisc.ernet.in
Website: http://cpdm.iisc.ernet.in/icord15/
www.designsociety.org

FIRST NATIONAL CONFERENCE ON SUSTAINABLE AND SMART CITIES (SSC-15)

Date: January 16 & 17, 2015
Location: Surat, Gujarat
Government of India has declared to design and create 100 Smart Cities. Therefore, this conference will create a platform for researchers, policy makers and consultants to meet and deliberate on Infrastructure, Land Management, Green Building and Urban Housing.
Organised by: PG-Section in Urban Planning, CED, SVNIT, Surat
Contact: Dr. Joel Macwan
Email: jemm@ced.svnit.ac.in
Website: http://svnit.ac.in/conferences/SSC15.pdf

INDIA STONEMART 2015: 8TH INTERNATIONAL STONE INDUSTRY EXHIBITION

Date: January 29-February 1, 2015
Location: Jaipur, Rajasthan
India Stonemart 2015 is the largest international exposition on stone industry which would showcase the world of natural dimensional stones, ancillary products and services comprehensively. The event would bring together various stake holders of the stone industry: domestic and overseas producers, exporters/importers, consumers and buyers, experts, technology providers, architects, builders, developers, corporates, etc. under one umbrella.
Organised by: Centre for Development of Stones (CDOS) in collaboration with Federation of Indian Chambers of Commerce and Industry (FICCI)
Email: info@cdos-india.com
Website: http://www.stonemart-india.com/

1ST INTERNATIONAL CONFERENCE ON FORTIFICATIONS AND WORLD HERITAGE: CHALLENGES IN INTERPRETATION AND SITE MANAGEMENT-2015

Date: February 5 & 6, 2015
Location: New Delhi
To be secured has remained one of most primal requirement of the human being since time immemorial. From one's home to a cluster, a city to a fort or the social system, the aspect of defense has been omnipresent. In this Conference, ICOFORT India seeks to explore different forms of defense architecture with a special focus on forts of South Asia and little explored history of military organisation, intelligence and weaponry that have simultaneously developed with the Forts.
Organised by: ICOMOS (India) National Scientific Committee for Fortification and Military Heritage
Email: icofort2014@gmail.com
Website: http://icofort2014.wordpress.com/about/

3RD INTERNATIONAL CONFERENCE ON ARCHI-CULTURAL INTERACTIONS THROUGH THE SILKROAD

Date: March 25-27, 2015
Location: Istanbul, Turkey
This conference intends to explore the range of cultural interactions of design with a special emphasis on built environment and its elements in all scales and practices within the broader geography and network of Silkroad -stretching from Europe to the Far East and Japan.
Organised by: Bahcesehir University
Email: iasu@bahcesehir.edu.tr
Website: http://ia-su.com/

2ND GLOBAL ACADEMIC MEET, GAM 2015

Date: April 1-4, 2015
Location: New Delhi
GAM 2015 will gather researchers from universities, companies and government executives from all around the globe. The participants will present their scientific attainments in various academic disciplines. Papers in the field of social sciences, humanities and life sciences are acceptable. The event will connect different cultures and attitudes thus contributing to: knowledge transfer, sharing best practices and research skills improvement.
Organised by: Jawaharlal Nehru University (JNU), The European Scientific Institute (ESI)
Email: contact@gameeting.net
Website: http://www.gameeting.net/

SOCIETY FOR ARCHITECTURAL HISTORIANS 68TH ANNUAL CONFERENCE

Date: April 15-19, 2015
Location: Chicago
Marking the 75th anniversary of the Society of Architectural Historians (SAH), the 2015 Conference, seeks to curate a balance between paper sessions and a direct experience of the dynamism of Chicago through evening events and tours. The Chicago Seminar continues SAH's commitment to moving discussions of built environment into the present day and bringing together two important audiences: conference attendees and local participants, including students, practicing architects, and professionals in related fields.
Oganised by: Society of Architectural Historians (SAH)
Contact: Beth Eifrig
Email: beifrig@sah.org
Website: http://www.sah.org/conferences-and-programs/2015-conference-chicago

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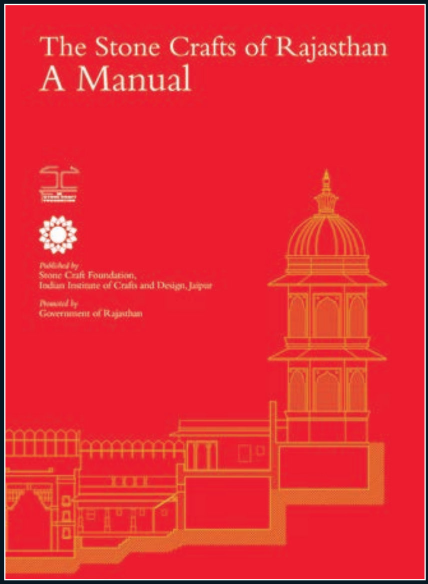
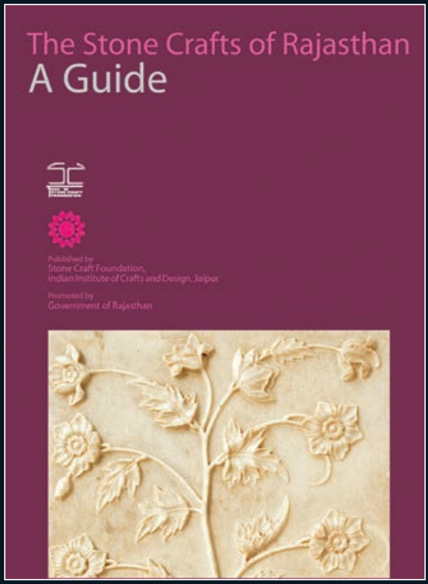
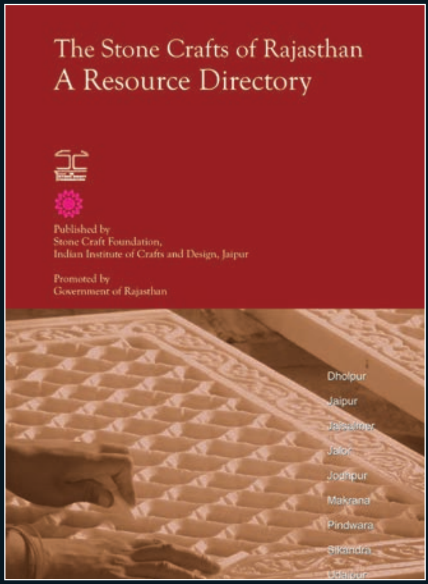


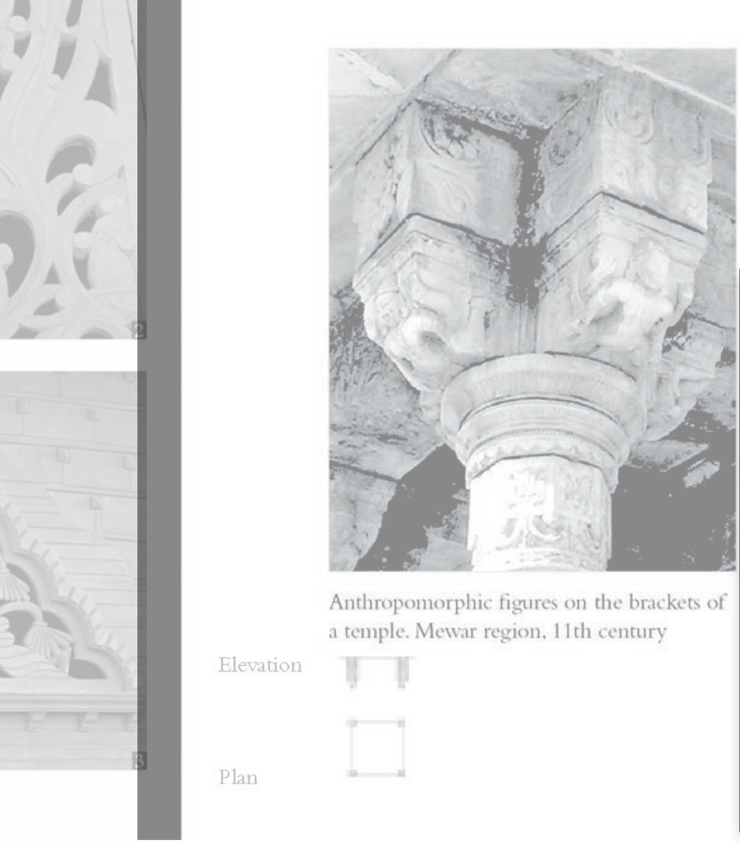


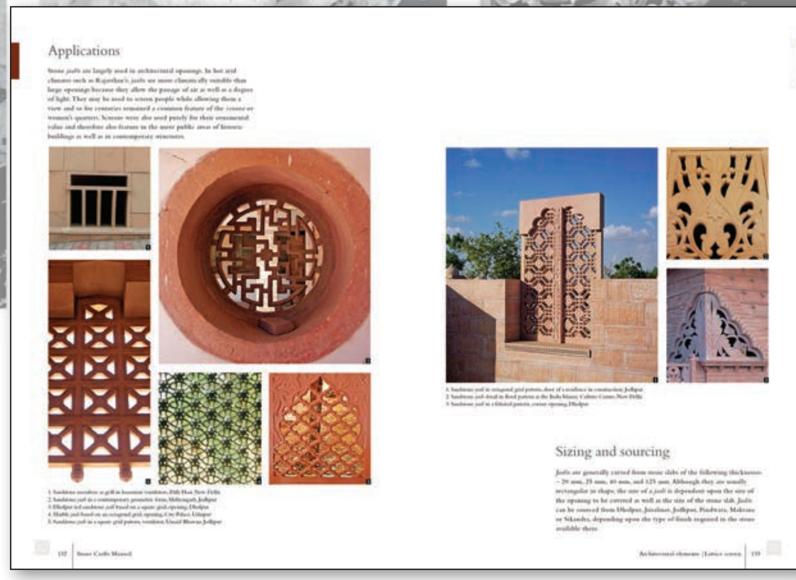


MANUAL

This Manual addresses two urgent problems. On the one hand, Rajasthan's or iginal stone craft techniques have been grossly neglected and the region's last resources are on the verge of disappear ing. Only a few master craftspeople, inheritors of an indigenous way of design and building that goes back centuries, continue to practise in the region. On the other hand, the more sensitive consumer and designer wanting to bring stone crafts into contemporary usage has no resource or information in order to do so, even if they wished to encourage them or to integrate them into contemporary applications.

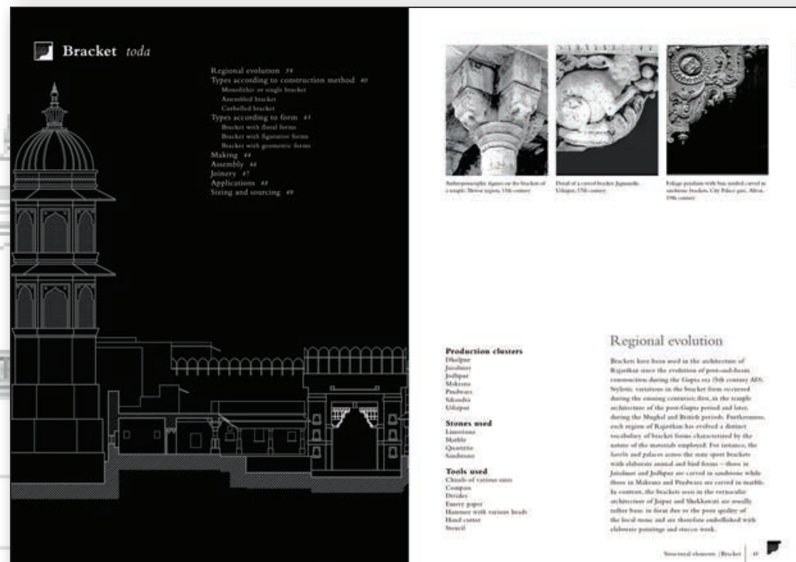
This comprehensive publication provides a ready reference to the potential of using stone throughout the building industry in a contemporary and practical manner. Written after more than two years of intensive fieldwork and industry-wide consultation, and amply illustrated with photographs, sketches and architectural drawings, the Manual has been designed to be referred to independent of - or in conjunction with - its companion Guide and Resource Directory, both also published by the Stone Craft Foundation, Government of Rajasthan.





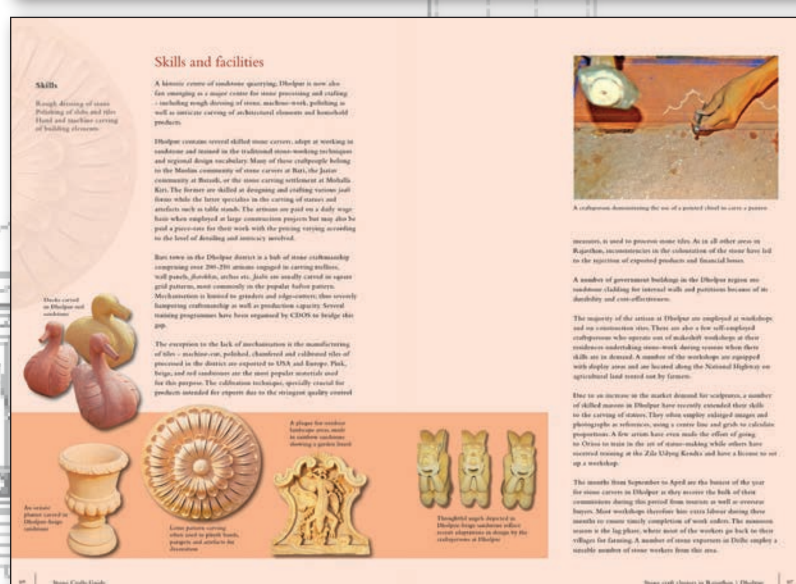
GUIDE

It is an exhaustive well researched Guide to the stone crafts of Rajasthan, aimed at introducing the reader to the stone industry as a whole. The book frames its descriptions of the or igins and material characteristics of different stone types in a detailed review of the architectural history and geology of stone in Rajasthan: its most significant contr ibution to the industry is a categorisation and listing of skilled stone Craftspersons. Substantial data on each cluster complete the picture.



RESOURCE DIRECTORY

Resource Directory of stone craftspeople in Rajasthan, lists practitioners working throughout the region. It is a useful ‘ready reference’ for those interested in the sourcing, purchase and supply of stone products and building elements. Besides fieldwork information, the directory also lists the craftspeople registered with the Department of Industries, Government of Rajasthan.



STREMAH 2015: 14TH INTERNATIONAL CONFERENCE ON STUDIES, REPAIRS AND MAINTENANCE OF HERITAGE ARCHITECTURE

Date: July 13-15, 2015

Location: A Coruna, Spain

Rapid development and the inappropriate conservation techniques are threatening many unique sites in different parts of world. This conference aims to provide the necessary scientific knowledge required to formulate regulatory policies, to ensure effective ways of preserving the architectural heritage. Because of that the series has been successful and continues to attract a wide range of high quality contributions since it started in 1989.

Organised by: Wessex Institute, UK

Contact: Gemma Breen

Email: gbreen@wessex.ac.uk

Website: http://www.wessex.ac.uk/15-conferences/stremah-2015.html

REHAB 2015: 2ND INTERNATIONAL CONFERENCE ON PRESERVATION, MAINTENANCE AND REHABILITATION OF HISTORIC BUILDINGS AND STRUCTURES

Date: July 22-24, 2015

Location: Porto, Portugal

REHAB 2015 is the 2nd International Conference on Preservation, Maintenance and Rehabilitation of Historic Buildings and Structures that aims to proceed with the discussion on built heritage and the preservation of its legacy.

Organised by: Green Lines Institute for Sustainable Development

Contact: Rogerio Amoeda

Email: rehab2015@greenlines-institute.org

Website: http://rehab.greenlines-institute.org

Institutes dealing with Building Materials

Anangpur Building Centre, Faridabad, Haryana
Email: connect@anangpur.org
Website: http://www.anangpur.org/

Auroville Bamboo Centre, Auroville, Tamil Nadu
Email: aurovillebamboocentre@auroville.org.in
Website: http://www.aurovillebamboocentre.org/

Auroville Earth Institute, Auroville, Tamil Nadu
Email: info@earth-auroville.com
Website: http://www.earth-auroville.com

Building Materials and Technology Promotion Council (BMTPC), New Delhi
Email: ska@bmtpc.org
Website: http://www.bmtpc.org/

Central Building Research Institute, Roorkee, Uttarakhand
Email: director@cbri.res.in
Website : http://www.cbri.res.in/

Centre for Application of Science and Technology to Rural Areas (CASTRA), Bangalore, Karnataka
Email: chairman@astra.iisc.ernet.in
Website: http://www.astra.iisc.ernet.in/

Confederation of Construction Products and Services (CCPS), New Delhi
Email: ccps@ccpsindia.com
Website: http://www.ccps.in/index.htm

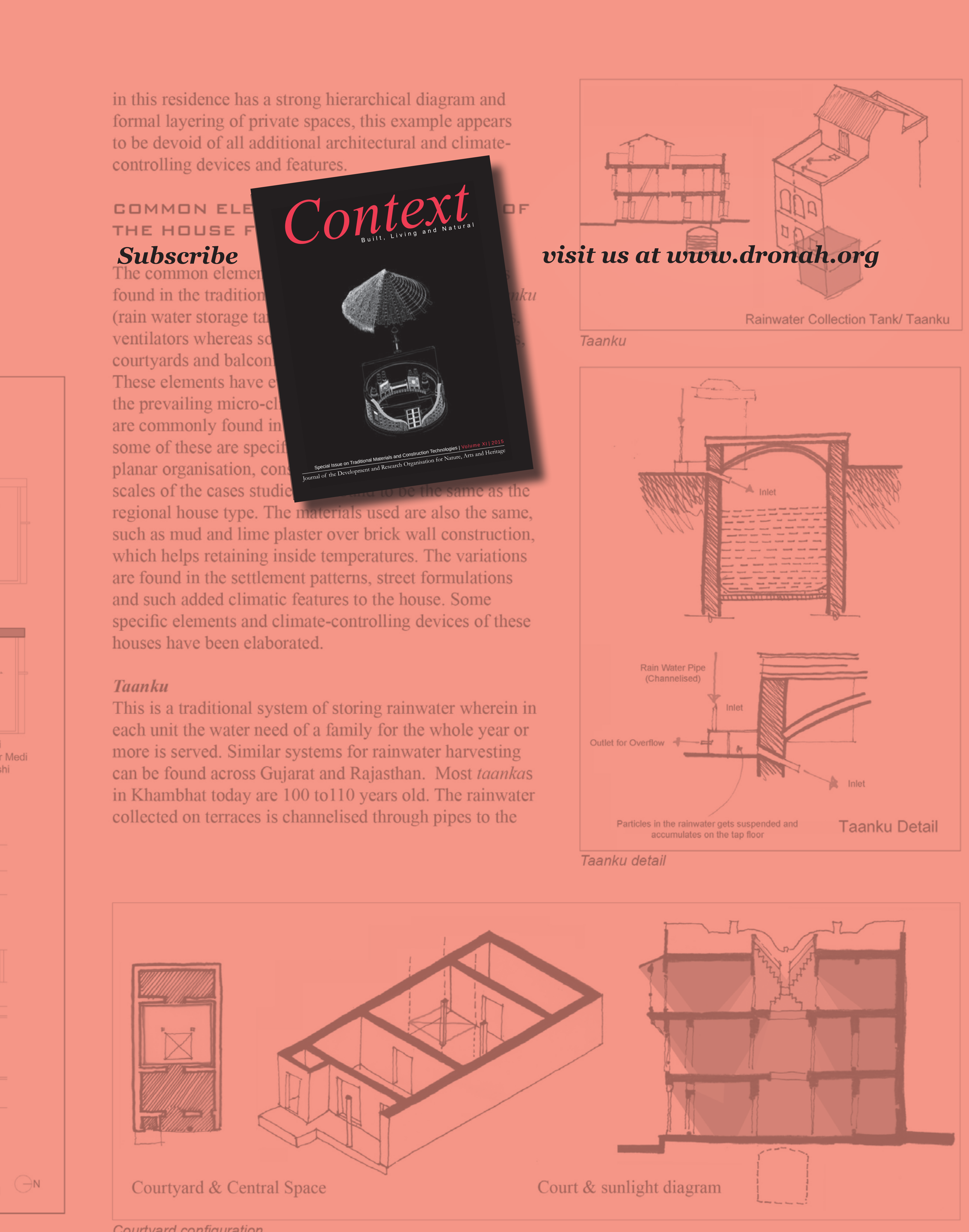
Centre for Development of Stones (CDOS), Jaipur, Rajasthan
Email: info@cdos-india.com
Website: http://cdos-india.com/
Development Alternatives, New Delhi
Email: mail@devalt.org
Website: www.devalt.org

Eco Brick, New Delhi
Email: http://www.ecobrick.in/
Website: tara@devalt.org

Housing and Urban Development Corporation Limited (HUDCO), New Delhi
Email: mail@hudco.org
Website: http://www.hudco.org/
Hunnarshala Foundation, Kutch, Gujarat
Email: hunnarshala@yahoo.co.in
Website: http://www.hunnarshala.org/index.html

Laurie Baker Centre for Habitat Studies, Thiruvananthapuram, Kerala
Email: lauriebakercentre@gmail.com
Website: http://www.lauriebakercentre.org/index.php

National Mission on Bamboo Application, Department of Science and Technology (DST), Government of India, New Delhi
Email: bamboo@bambootech.org
Website: http://www.bambootech.org/index.asp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Dronah is an interdisciplinary organisation constituted by highly motivated professionals from various fields who share a vision for a better quality of life – one that is sustainable, environmentally sensitive and draws on the contemporary without foregoing the strengths of the traditional. It is our aim to actively promote sustainable development through conservation, utilisation of traditional practices and modern technologies, knowledge sharing and mutual interaction. The organisation is focussed on conservation and development of the built heritage, environment; and art and crafts with the involvement of local community, in addition to being engaged in documentation and educational activities.

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