Traditional Indian architecture - The future solar buildings

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ABSTRACT

Built environment is a manifestation of the technological innovation. The way technologies are applied in design and construction of buildings, have direct implications on the amount of energy consumed. In modern context buildings represent enclosed, isolated boxes/systems where environment is artificially controlled. This requires considerable energy. *A problematic relationship between architecture and technology is evident.*

A large part of Indian Subcontinent has for majority of year ample ‘Sun’- renewable, non-polluting, abundant and direct source of all present natural cycles on earth. For building design in majority of these regions, the necessity is to control and utilize this abundance.

History shows the importance of relationship between human activity and nature. Human lives remained much dictated by solar and seasonal cycles, instead of trying to homogenize living conditions throughout the year. *The future is in living and working with nature rather than against it.*

In traditional Indian architecture this harmony with nature was an important design element. During the course of development, somewhere, harmony was subdued for artificial control resulting in buildings without context.

Can we revive and refine these forgotten principles of traditional Indian architecture?

The study deals with exploration and understanding of these principles. This approach is sustainable and a site sensitive approach. The fundamental principles of this approach are-

- Buildings to be a buffer against uncomfortable environmental conditions.
- Buildings to enhance the positive natural conditions to reach the internal space.
- Buildings to be environmentally responsive to their natural surroundings.

Case examples from different regions in Indian subcontinent were studied with respect to their climatic context. The results indicate that the buildings in harmony with nature have lesser need for energy as compared to energy hungry architecture of today.

1. INTRODUCTION

Sun is the source and sustenance of every aspect of life on the earth. Sun’s energy is essential for the formation of wind, clouds, rain and other weather conditions thus resulting in different climates on earth. Nature’s solar energy users have highly efficient and sophisticated ways of getting the most from their power source. Plants are efficient solar collectors and harvest solar energy, thus forming the starting point of food chain – the cycle of sustainability. Animals are consumers and are equipped with their own high performance energy management systems to allow them to survive in environmental conditions that could be otherwise fatal. Best examples are polar bear and camel, which have evolved to live in extreme weather conditions.

Human body gets acclimatized to a certain extent but human skin performance is limited. Clothing and shelter compensate for this. Buildings provide shelter, facilitates our activities and interactions, represent our desires and provide cultural expression.

Through out history, humans have been adaptable and have developed energy efficient building forms suited to varying climatic conditions thus achieving comfort.

With industrialization came the *technologies* of transforming energy into heat. Most innovations were in fossil fuel power, electricity and gas. The experience of being able to capture sunlight in greenhouses ignited the possibility of controlling vast areas of artificial environment. With globalization came a multinational corporate building style – sealed glass box that was dependent on a huge energy supply. A style, that gave rise to buildings without any consideration to their context (in particular, to the site and climate). Buildings are treated as an insulated thermos flask with their own internal environment and with their comfort level independent of outside conditions (Yeang, 1987). People no longer interact with the built environment to find an acceptable level of comfort. (Rather the concept of acceptable level of thermal comfort has also changed). The building with its incorporated technology takes care of everything but at the cost of large non-renewable source of energy. As of now buildings consume in both construction and operation, half of the total energy that is used by human beings (Behling and Behling, 2000).

This needs introspection by professionals in the field of settlement planning, building science and design. They are responsible for dictating the energy requirements at different levels. For example, if structures in tropical climates are designed, that use a lot of glazing on west, the energy requirements of buildings will necessarily incorporate the energy costs of artificially cooling the internal space. Similarly if a building has insufficient window space, use of artificial lighting has to be adhered to, thus, resulting into increased energy consumption. Urban settlements with improper considerations lead to heat island impact, leading to an even greater catastrophe.

This necessitates an ethical approach towards our environment. The technology alone can no longer be assumed to provide solutions; the key rather lies in re-evaluating our own ways.

The solution to this is a sustainable and site sensitive design approach. A glimpse of architectural practices in past shows an efficient use of this approach.

Traditional architecture in any place, as observed today, is not the result of a one-time effort but is the culmination of hundreds of years of understanding in response to a particular situation through trial and error. This articulation and its crystallization, is more evident in areas with extreme conditions and meager resources. It exemplifies a negotiation between man and nature.

These shelter forms have an important attribute of making its inmates comfortable in extreme climatic conditions. Overall a harmonious balance between built form, climate and lifestyle was achieved.

2. INDIAN CONTEXT

India is a tropical country with diverse traditional shelter forms, not only in vernacular architecture but also in spectacular architecture where comfort has been of primal importance.

The country has been divided into six different regions with distinct climate (Bansal and Minke, 1988).

A study of case examples from hot dry and warm humid zones has been made. The characteristic features for the same can be studied according to Table 1:

2.1 Case examples from hot dry zone:

Situated in the heart of the Thar Desert, Jaisalmer is a town where the builders in medieval times have created an urban environment that

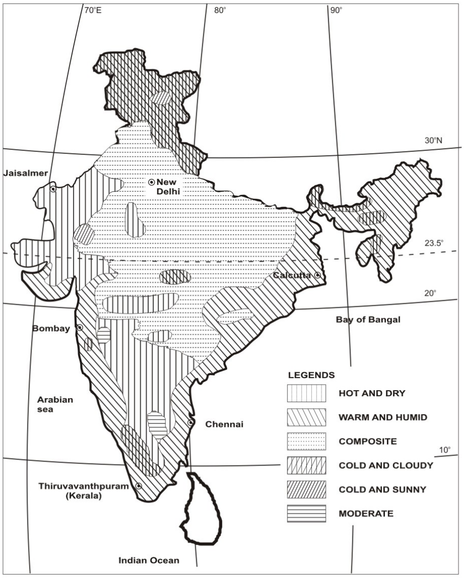

Figure 1: Climatic zones of India.

Table 1: Characteristic features of climatic zones.

Climatic features	Hot dry zone	Warm Humid zone
Landscape and vegetation	Relatively flat/sandy or rocky ground. Scarce vegetation.	Relatively flat regions with abundant vegetation.
Solar radiation	Intense (800-950 W/Sq.m per hour)	diffused radiation
Ambient temperature		
Summer day	40-45 ^{0}c	30-35 ^{0}c
night	20-30 ^{0}c	25-30 ^{0} c
Winter day	5-25 ^{0}c	25-30 ^{0}c
night	0-10 ^{0} c	20-25 ^{0} c
Diurnal variation	> 10 ^{0} c	
Relative humidity	25-40 % (very low)	70-90 % (High)
Precipitation	Less than 500 mm per year	Greater than 1200 mm per year
Winds	Dusty winds / sand storms in afternoons	Variable and generally high during summer
Sky conditions	Clear sky	Generally overcast

overcomes the problems of extreme climate conditions by special passive design features.

2.1.1 Site planning and design

Flat land with scarce vegetation and even scarce water, the town was planned with major streets oriented along E-W and minor streets at right angles to these. The heights of the buildings are 1 to 2 times street width of main street and 4 times the street width for N-S streets.

Buildings are of unequal heights with wind pavilions and high parapet walls, creating an uneven skyline and shading each other, thus reducing sol-air temperature. An uneven building form also increases the radiative heat loss from building to sky (sky acting as a heat sink) (Sodha, et al., 1986). Compact planning with 5-6 m high wall around the town takes care of sand storms.

2.1.2 Plan form and three-dimensional configurations

Depending on the socio economic status of inhabitant, there are three types of houses. The simple town house with single room, verandah and a courtyard, two to three storey structure with additional rooms and small enclosed terraces on upper floors, and most complex of all – *haveli* (four- five storey houses consisting of one or two courts with underground rooms in levels and terraces enclosed by wind pavilions and high parapet walls).

The plan elements incorporated are courtyards along with narrow vertical ducts and staircase shafts for deflecting wind into the built

Table 2: Solar shading analysis.

Street orientation	Solar exposure on facade	Solar alt.	Analysis
E-W	9.30 AM to 2.30 PM on south facade	54 to 86^0	Small horizontal projections suffice
E-W	Before 8.00 AM and after 4.00 PM on north facade	< 35^0	Shaded by opposite buildings
N-S	Up to 11.30 AM on east facade and after 12.30 on west	Varies from 0-79^0	Narrow street and hence shaded before 10.30 AM and after 1.30 PM. Incident solar radiation not more than one hour on each facade.

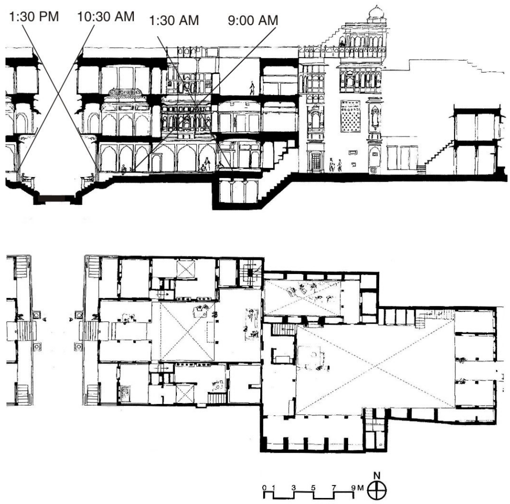

Figure 2: A haveli, Jaisalmer: Plan and section.

form. Coupled with high thermal inertia, these shafts act in a similar way as Iranian wind towers. Basements are there invariably in all houses but are used as storage/strong rooms and not as living spaces.

Surface area to volume ratio (Krishnan et al., 2001) is low for the basic urban form but is increased manifolds by ornamentation and by arranging the building mass in an uneven form.

Although domical or vaulted roofs would have performed effectively, the built forms have a flat roof owing to functional reasons. The terrace acts as an activity space in winter days and sleeping area for summer nights. Also this has resulted into high-rise compact forms with cooler lower floors.

2.1.3 Building Envelope

Walls are 45 cm or more in thickness built of light yellow sandstone. At upper floor level projections of 5 cm thick panels of limestone, deep carved in geometric patterns are used as wall elements. Roofs are 45 to 60 cm thick (closely spaced timber beams covered with reed or grass matting and a thick layer of earth on top). Stone slabs have also been used in later times owing to scarcity of timber. Such roofs have a low decrement factor (0.162) and large (24 hr) time lag (Nayak et al., 1999). This shows that ceiling, roof surface and ambient air reaches their peak at about same time (Contrary to the modern belief). Psychologically a higher temperature can be tolerated well in the day than at night.

Openings are generally small and windows fitted with solid timber shutters. Fenestration acts as an important design element. Large number of projections like sunshades and balconies acted as effective shading device not only for the openings but also for the walls. Micro shading of surfaces i.e. deep carving on flat wall surfaces on the upper floors was done, thus, achieving the benefits of extended surface. It results into increased convective heat transfer to air thus cooling the wall early, in the evening.

As per a study, made by Gupta (1984) temperatures were measured for various types of buildings and following inferences were drawn:

1. The street maximum daytime temperatures in summers were 1.5 to 2.5 ^{o}C lower than metrological data while in winter this difference was less than 1 ^{o}C. The night street temperatures on the other hand were elevated by 3 to 5 ^{o}C in winters, while in summers the corresponding elevation was only 0.5 to 3.5 ^{o}C. This shows the positive impact of urban form on microclimate.
2. Thermal performance of *haveli* is best of all houses. Maximum indoor temperature was 8 ^{o}C lower than the outdoor maximum.
3. Smaller decrement factor reduces the heat flux entering the building.
4. The compact built form with courtyard system is more effective than modern bungalow type development.

An important aspect of these structures was arrangement of activities in space and time. Cooler lower floors and shaded courts were used for daytime activities and upper floors and terraces for nighttime sleeping.

2.2 Case examples from warm & humid zone

This type of climate is mainly found in the coastal belts. Traditional settlements in Kerala typically highlight a positive influence of the built form and natural resources available.

2.2.1 Site planning and design

The houses are detached type with extended open spaces all round, thus enabling good air access. Excessive vegetation helps in giving the much-needed shade and low reflected radiation for the tropical conditions. The orientation of main streets is along E-W axis (with a tilt up to 20^{o} in some cases) along the prevailing wind direction thus enhancing comfort conditions.

2.2.2 Plan form and three-dimensional configurations

The basic house module is *nalukettu,* four blocks built around a courtyard into which the roof slopes on four sides, protecting an internal verandah from rain and sun. Depending on the size and importance of the household the buildings have one or two upper storeys or further enclosed courtyard by repetition of the *nalukettu* to form *ettukettu* (eight blocks building) or a cluster of such courtyards. The enclosed courtyard is usually sunk such that cooler air settles down. The external slope descends low over the outer walls, covering another verandah at the front of the building. The inner verandah around the court is open. The outer verandahs along the

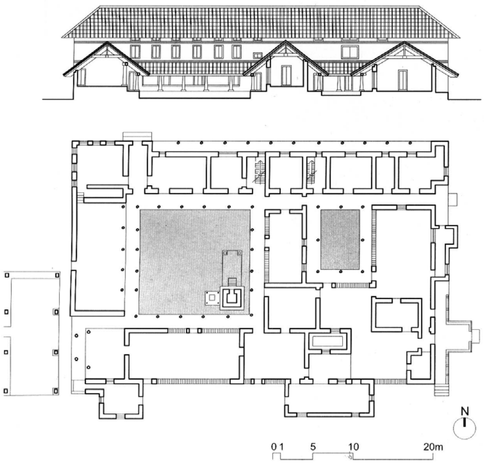

Figure 3: Traditional house, Kerala: Plan and section.

four sides of the *nalukettu* are enclosed differently. While both the western and eastern verandahs are left open to ensure good inlets for day and night breeze, the northern and southern verandahs are enclosed or semi-enclosed.

Roofs have steep pitches almost 40-45 degrees. Further gable windows are there at the two ends to provide attic ventilation when ceiling was incorporated for the room spaces. This ensured air circulation. Even in the absence of the ceiling these gables have an opening with a decorative *jali* from where hot air rises and flows out. The roofs enclose a large insulated air space thus, keeping the lower areas cooler.

2.2.3 Building Envelope

Walls in the upper floors comprises of ranks of struts connected by spaced slats thus becoming a part of fenestration design for the ease of good airflow, thus keeping the rooms cool and gently lit. On the lower areas the walls are of laterite (for privacy reasons) but being shaded by sloping roofs and extended verandahs, the sol-air temperature is low thus reducing heat gain.

An important aspect of these settlements is usage of courtyards both external and internal not just as green areas but they were major activity spaces where bathing, cooking, sleeping and socializing could take place at different points of time.

3. LIFSTYLE TRENDS AND ENERGY

The typology of spaces that evolved in both the cases due to extremes of nature are reflections of the lifestyle of the inhabitants as well. The activity patterns were in turn governed by daily and seasonal solar cycles.

Today, with the technological twists to lifestyles, building typologies gets dictated by

Table 3: Activity pattern and energy usage.

Daytime/Night time activities		Space in hot dry zones	Spaces in warm humid zones	Present state
Men	Trade / Ritual performances / meetings	Semi covered platforms on lower floors abutting the shaded street	Shaded corridors of temples	Glass faced air conditioned spaces. Mechanically controlled comfort achievement.
Women	Household	Courtyards/ rooms abutting courts	Rooms abutting courts with louvered openings	Artificially lit rooms, exhausts / fan induced ventilation.
children	Study/playing	Courts/Shaded streets	Trees / Semi covered verandahs/external open spaces	Artificially lit classrooms with fan induced ventilation.
Men, women and children	Social gatherings, entertainment (afternoons and evenings)	Open streets and *chowks*	Shaded temple *mandapas*	Large air conditioned/ mechanically cooled spaces. Generally in late evenings and hence artificially lighted.
Men, women and children	Night time activities	Summer- terraces and open courts Winter – rooms on upper floors	Monsoons – Rooms with louvered walls Dry – internal court of *nallukettu*	Throughout the year in air conditioned or closed rooms with air coolers/fans

them. The most important difference is the use of mechanical devices for conditioning and lighting of spaces. Another important consideration is the user adaptability to the ease of comfort.

A comparison of activity patterns of users and the related spaces indicates the changes in energy requirements in the same regions today.

4. CONCLUSION

Control of the microclimate was always an important aspect of indigenous Indian architecture. In this one may find appropriate concepts, if not models to address today's problems. This does not mean reverting back to uninformed folk culture. Rather these concepts can be clubbed with the benefits of global information and nurtured with intelligence of the technology, thus easing of, relationship between architecture, its context and technology. The major issues here are

1. Design of microclimate (as respecting the immediate out side conditions results into satisfactory indoor conditions).
2. Integration of comfort sources – passive techniques adaptability
3. Climate as an architectural generator – along with many others such as culture, traditions and trends.

An important factor is the willingness and the ability of the user to organize his daily activities in space and time so that not all spaces required to be maintained at equal levels of comfort all the time. At any given time, active use of a building could be restricted to the areas most comfortable at that time. This requires transformation of lifestyles to be more concordant with natural environmental systems.

Architecture is at the forefront of energy and resource consumption. Energy guzzling mega structures randomly spread through out the world, irrespective of climate, location on the planet and cultural context are symptomatic of a global havoc.

The future solar buildings are to redefine architecture beyond technical and performance values, collectively designing with context of place.

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