Adaptive Vernacular Options for Sustainable Architecture

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Abstract

This paper focuses on how vernacular principles can be employed to address solutions for sustainable design particularly for creating high-style sustainable architecture. Vernacular architecture is a consequence of local conditions as it tends to evolve over time to reflect the environmental, cultural and historical context in which it exists. With due recognition of the sheer responsiveness of vernacular architecture to the environment, it is far from the suggested 'primitive form of design, lacking intelligent thought', that it was once perceived as. Sustainable architecture is a general term that describes environmentally conscious design techniques in the field of architecture, an energy and ecologically conscious approach to the design of the built environment. In vernacular architecture, sustainability is manifested in the design of buildings, use of materials, heritage preservation, and environmental and social consciousness. In view of the dimensions of sustainability, that is social, economic etc., many vernacular elements can be adapted if not altogether adopted for providing sustainable solutions. In a world where majority of developing countries have such a high level of poverty that the right to adequate living space remains an elusive dream for many, there is a moral obligation to reach out to the bottom billion. We need solutions that are responsive to local conditions, economically viable and have a proven record in withstanding the test of time. There are indeed many lessons that can be learnt from vernacular architecture in this area.

Keywords: Vernacular architecture, sustainable design, environmental consciousness

Introduction

Vernacular architecture is a product of an evolutionary process of self correction which is often associated with but not confined to mud houses and thatch roofs, indeed far from the suggested 'primitive form of design, lacking intelligent thought', that it was once perceived as. Vernacular buildings are born out of local building materials, technology and architecture that are climate responsive and a reflection of the customs and lifestyles of a community. The typical vernacular forms of a building are in response to a particular environment: a sloping roof surface to bear the rainfall or a circular house form to combat cyclonic winds. According to Kazimee, "vernacular architecture represents more than a nostalgic longing for things and ways that have essentially become obsolete, but rather a learning method by which new global challenges can be addressed, which are global warming, housing crises, and economic equality" (2008:6).

Sustainable architecture is a general term that describes environmentally conscious design techniques in the field of architecture; an energy and ecologically conscious approach to the design of the built environment. Vernacular architecture tends to respond to climatic conditions often using passive, low-energy strategies to provide for human comfort, strategies that are integral to the form, orientation and materiality of the buildings, as well as demonstrating an economical use of local building resources. It is therefore an ideal source for sustainable design ideas. According to Oliver, "Traditional wisdom and lore in building, using renewable resources and indigenous skills, may still offer wisely managed, economically effective and culturally appropriate solutions to the world's increasing housing needs" (1997:xxviii). Thus, a great many times, sustainable design solutions can be realized by incorporating and integrating adaptive vernacular elements.

This paper stresses the importance of learning 'lessons from the past', and their incorporation into design solutions and emphasizes the need for the community to explore alternatives that are associated with local building traditions, inherited experience and knowledge. It does not discount the functional limitations that may manifest on account of vernacular purism. Rather, it emphasizes the need for an adaptive approach wherein existing vernaculars may be upgraded, improvised and then adapted in a modern context. Owing to the vastness of scope of research in this field, for this paper, only case examples demonstrating the use of vernacular passive design techniques and materials have been discussed.

Learning lessons from vernacular

Many recent studies have demonstrated both the value and appropriateness of learning from Vernacular for sustainability. Naciri (2007) for example emphasizes that the weather-oriented structures of vernacular architecture are full of lessons that could inspire the designers interested in passive climate controls. Sundarraja, et al. (2009) argue that the vernacular architecture studies will provide useful insights for designing contemporary buildings by taking design clues from Vernacular Buildings. Similarly, Dayaratne (1999, 2000, 2003, 2007) shows how indigenous architecture has been inherently sustainable and how some of the modern architects have employed their principles in creating architecture that is appropriate to culture and kinder to the environment. The case is abundantly clear. Learning lessons from Vernacular is not an option, but a must.

However, the onslaught of modern technology has gradually eroded our communities of traditional construction skills and an inherent aptitude for environmentally sensitive design of dwellings. Most of the buildings are dependent on mechanical means of ventilation which gives rise to increased energy cost of a building. Often modern buildings are poorly designed for the prevailing climate conditions leading to extensive use of electrical equipments and energy to maintain desired thermal comfort conditions in the indoors. In contrast to modern buildings, vernacular buildings tend to be climate-responsive in many ways. Traditionally, builders used knowledge passed from generation to generation to ensure that their buildings could modify the impact of a hostile outdoor environment. That is one of the reasons behind the pressing need to salvage the vernacular principles and use them in sustainable architecture.

Shifting attitudes: Green is in

Recently, there has been a turn around after years of environmentally unfriendly materials and ‘indifferent’ architecture to sustainable building materials and construction methods. The interest of the architectural community has been rekindled by the need to produce design solutions that work well with climate and environment, rather than against; hence the need to create more sustainable buildings. There are two groups of architects, staunchly endorsing sustainable buildings through their design; the first group favours a more technology-intensive approach–an increasing employment of advanced technological options while the second group favours basic solutions depending upon inherited experience and knowledge. Architects such as C.Y. Lee and Renzo Piano tend to favour the former while Hassan Fathy, Rasem Badran, and Raj Rewal belong to the latter. They are well connected to the local building traditions and reject architecture which is not familiar to the built environment. Lately, there has been an increase in the second category as more and more designers are turning to the vernacular to create the sustainable. The following case study is of *Sharanam* training centre designed by Jateen Lad and Trupti Doshi, one such project where the design is very much inspired by the vernacular response to culture and local environment.

Case Study 1: Sharanam Training Centre

The Sharanam training centre has been planned on a 5 acre plot located 10 kilometres west of central Pondicherry in Tamil Nadu, India a few kilometres from the Bay of Bengal. It was created not only for, but by local workers who were employed in the construction of their facility. The principal facilities at Sharanam include a multipurpose hall, administrative offices, a library, a computer room, demonstration technologies, stores, a kitchen and washrooms. Some of the challenges associated with the project were,

- To achieve comfort conditions in an excessively hot and humid climatic zone - summer temperatures reaching 40 degrees Celsius and annual average relative humidity - 70%. To construct a modern superstructure using earth as the primary building material and minimize the use of steel and cement.

- To upgrade the skills of local workers from the village and employ them in the meaningful creation of the Sharanam training centre–for them, with them.

The design and construction of Sharanam embodies a holistic approach towards development. The design team believes that the genesis of the design ideas must be derived from the culture and environment of the people who are to occupy the building. The design strives to reinforce these deep rooted cultural ties in a contemporary context.

There has been a conscious effort to address climatic, cultural, technological, environmental and socio-economic dimensions. The design of Sharanam has been inspired by the careful study of traditional Tamil buildings, namely, temples, Chettinad houses and local vernaculars, which demonstrate a strikingly similar response to the year-round hot and humid climate of Tamil Nadu, i.e. shade from the intense heat and maximum ventilation to combat the high humidity.

Several solar passive strategies have been employed to achieve thermal comfort in Sharanam. Some of them are: building orientation that is perpendicular to the predominant summer breeze, evaporative cooling through water bodies, large fenestrations, increased height of the building and roof overhangs for maximising 'stack effect'. The two main techniques of earthen construction used at Sharanam are Compressed Stabilised Earth Blocks (CSEB) and Rammed Earth Footings. The Soil Identification Tests revealed that the soil in Sharanam had the right composition required for both ramming and block making – i.e. 15% Gravel, 50% sand, 15% Silt and 20% Clay.

Fig. 1: Rammed Foundations
Source: UNEP-SBCI. (2010)

Fig. 2: Compressed Stabilised Earth Blocks
Source: UNEP-SBCI. (2010)

Compressed Stabilised Earth Blocks

Though figures vary, it is reported that about 25% of India's carbon-dioxide emissions are a direct result of its burgeoning building and construction industry; the production of high energy consuming materials such as aluminium, steel, cement and fired bricks being the highest contributors. For example, the firing of 100,000 bricks usually requires 20 tons of coal and releases 35 tons of carbon-dioxide and other polluting gases into the atmosphere. CSEBs were manufactured on *Sharanam* itself using the soil excavated from the lowest portion of the land – the resultant pit forming a reservoir to be used later for harvesting the rainwater. These blocks have been stabilized by using only 5% cement. Almost 100,000 custom-made CSEBs have been made in nine different sizes for the main superstructure. Enormous environmental, structural and cost benefits have been realised using CSEBs manufactured at *Sharanam*. In comparison to the locally available wire-cut bricks, the CSEBs are 4 times cheaper, 10 times less polluting, and 3 times as strong and are of a far superior quality.

Earthquake Resistant Piers

At Sharanam, 28 tall exposed piers of the superstructure are constructed of special CSEBs with an integral earthquake resistant feature. A 5cm diameter hole at the centre of the blocks allows passage of vertical steel ties which are tied to stirrups set in the mortar at regular intervals (Figure 3 and 4). This has the effect of embedding a large spring within the masonry, greatly increasing the shear strength of the piers. The hole is filled with a low cement mix mortar while an earth mortar is applied to the horizontal courses.

Fig. 3: Special CSEBs with 5cm hole
Source: UNEP-SBCI. (2010)

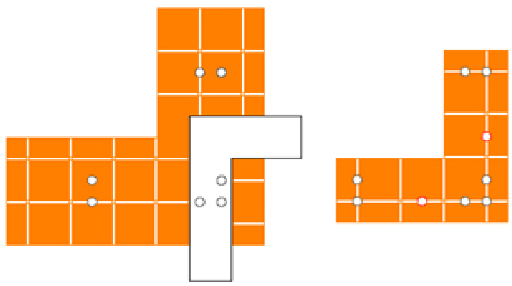


Fig. 4: Earthquake Resistant Piers
Source: UNEP-SBCI. (2010)

Rammed Earth Foundations

Foundation pits have been precisely dug and the same excavated earth sieved, mixed and rammed to ensure zero wastage of raw material. Within a single month, a total of 95 m^3 of foundations were rammed for the superstructure alone.

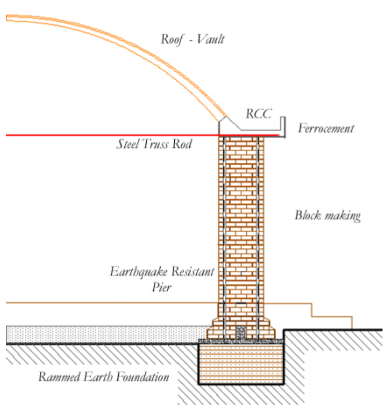


Fig. 5: Rammed earth foundations
Source: UNEP-SBCI, (2010)

Vault

The large vault of the superstructure has also been designed using CSEBs as the primary material. After detailed studies, the profile considered most suitable for the 9.5 metre wide span was the shallow 'Segmental Arch' which rises 2.26 metres at the centre and extends 41.5 metres in length. The total area of the vault is 425 square metres. The arch has been designed with a thickness of 17.7 cm at the Springer beam reducing to a mere 9 cm at the keystone. The tapering profile required CSEBs of 4 different sizes. In total 40,000 CSEBs had been custom manufactured for this alone.

Comparison with conventional manner of construction:

Through the adoption of earth technology at *Sharanam*, the superstructure–from foundation to roof– has a very low embodied energy in comparison to buildings of a similar scale. The use of *Sharanam's* own earth for both rammed and stabilized blocks vault has allowed the superstructure of *Sharanam* to be constructed in a very cost-effective and sustainable manner with a greatly reduced ecological footprint. Had the entire superstructure been designed and constructed in the conventional manner using reinforced concrete foundations, columns and roof slab with brick infill walls, then a further 108 tonnes of carbon-dioxide would have been released into the atmosphere. The cost of this unique superstructure is also 40% cheaper than conventional reinforced concrete buildings. It is this integral approach towards building *Sharanam* which includes not only the cultural, technological and climatic context, but also the wider human dimension and the social context of rural development which has contributed to the 'sustainability' of *Sharanam*.

Case Study 2: Torrent Research Centre (TRC)

Project Period: 1994-99
Size: Built-up area is approximately 19700 m²

Vernacular architecture in India is rich with examples of passive cooling systems. The TRC at Ahmadabad, Gujarat, India was completed and occupied in 1997, and has been reported as a unique example of climate responsive design integrating a Passive Downdraft Evaporative Cooling (PDEC) system, a modified adaptive vernacular technology.

The complex comprises of pharmaceutical research facilities and related support services. Two of the five laboratory buildings are air conditioned, while the other three equipped with the PDEC system. The entire complex covers 22,600 square metres of floor space of which around 3,200 square metres is air-conditioned. The PDEC system is designed to operate under critical climatic conditions during hot-dry season when mid afternoon outside temperatures regularly reach 40°C or more.

Fig. 6: Torrent Research Centre
Source: UNEP-SBCI. (2010)

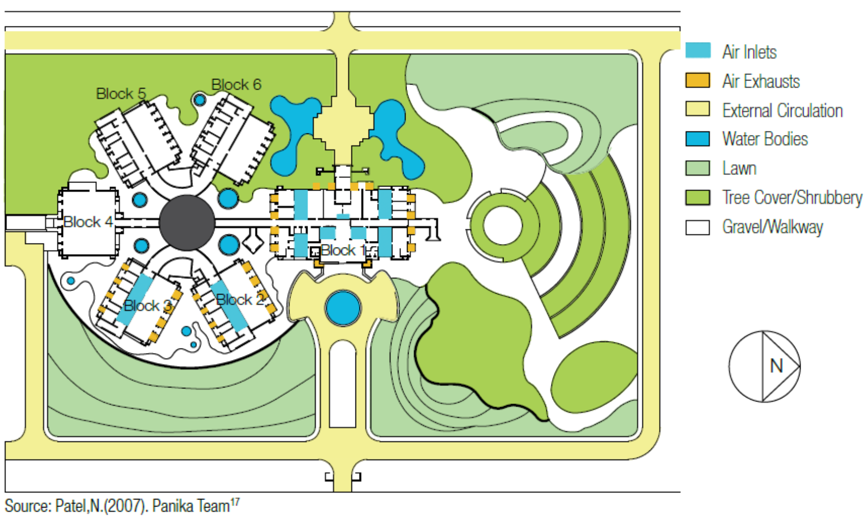
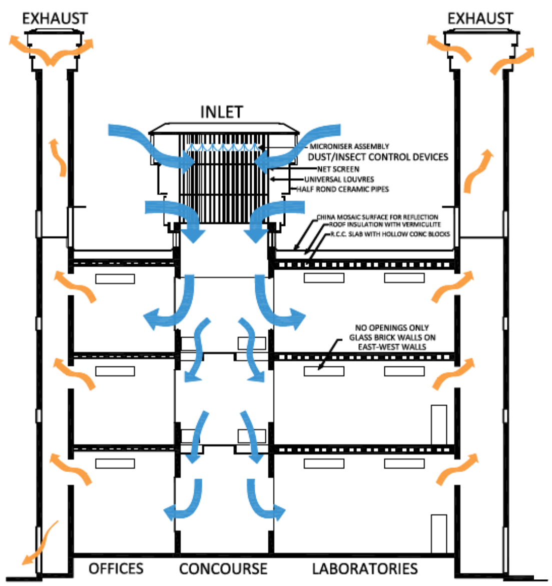
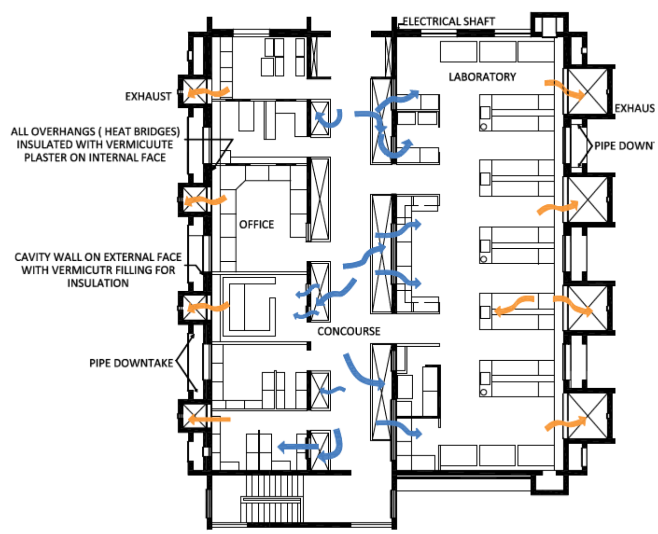


Fig. 7: Lay-out of the Torrent Research Centre
Source: UNEP-SBCI. (2010)

The design of the building facilitates generating an air draft, assuming still air conditions. The air heats up in the peripheral shafts, rises and escapes through the openings at the top. The air in this volume gets replaced from the usable spaces, which in turn receives its own replacement through the concourse area, on top of which the air inlets are located. The PDEC system pipes water through nozzles at a pressure of 50 Pa to produce a fine mist at the top of the three large air intake towers located above the central corridors of each laboratory building. Evaporation of the fine mist serves to cool the air which then descends slowly through the central corridor space via the openings on each side of the walkway.





Section of PDEC system
(a)

Typical Floor Plan
(b)

Fig. 8: Passive Downdraft Evaporative Cooling (PDEC) system
Source: UNEP-SBCI. (2010)

At each level, sets of hopper windows designed to catch the descending flow can be used to divert some of this cooled air into the adjacent spaces. Having passed through the space, the air may then exit via high level glass louvered openings which connect directly to the perimeter exhaust air towers. During the warm humid monsoon season when the use of micro ioniser would be inappropriate, the ceiling fans can be brought into operation to provide additional air movement in the offices and laboratories. In the cooler season, the operating strategy is designed to control the ventilation, particularly at night, to minimize heat losses by the users adjusting the hopper windows and louvered openings in their individual spaces to suit their requirements.

Advantages associated with Passive Design

Some of the benefits of this approach are,

- 72% of the central building has achieved human comfort by using PDEC
- The building has been able to establish extremely low levels of energy consumption per square metre.
- Summer temperatures are maintained at 28°-32°C;
- 6 to 9 air changes/hour on different floors in summer
- The temperature fluctuations inside do not exceed 3°-4 °C, over 24 hour period, when outside fluctuations are 14°-17° C.
- Air-conditioning plant capacity saved, is about 200 M. Tons. The annual savings in the electrical consumption including the savings on account of less use of artificial lighting during the day is in excess of 100,000 dollars per annum.

Vernacular: A muse for Sustainability

Vernacular Architecture is the proverbial mine of information pertaining to responsive design. Numerous examples of its relevance viz viz local conditions are evident from across the globe. In Asia itself, there is a rich diversity in vernacular architecture with its regional vagaries that supply ideas for our quest for sustainable solutions. For instance, in Iran, various natural cooling systems were employed in traditional buildings. The wind catcher (Fig. 9) is one such contribution that has a marked presence throughout the middle-east leading up to the subcontinent. Sindh in Pakistan, formerly in pre partitioned India too has its share of "mangh" or wind catchers. Available in various designs: unidirectional, bi-directional, and multi-directional, this architectural feature lends its applications to hot climates as part of a heat management strategy.

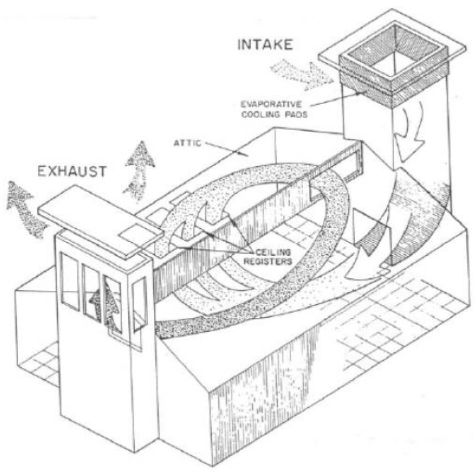


Fig. 9: Passive Air Cooling Tower
Source: Ford, 2001

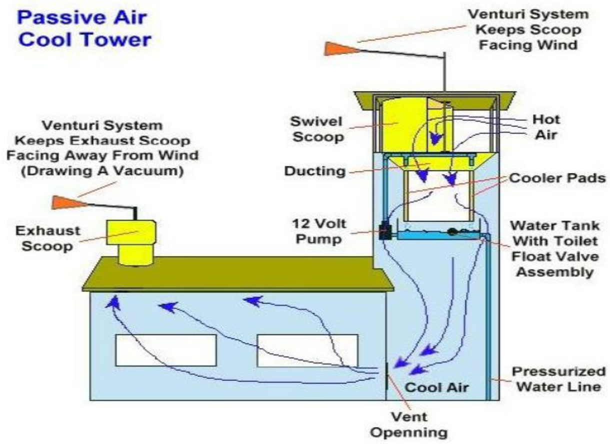


Fig. 10: Contemporary cooling tower - Modified Wind Tower
Source: Ford, 2001

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Bahadori (1994) describes the limitations of traditional wind tower designs, including the admission of dust and insects into the building. Integration of modern technology with this vernacular feature can help overcome the limitations (Fig. 10).

The energy consumption associated with buildings can be divided into two main categories: energy that is used to construct the building and energy that is required to service operate and maintain the facility (A third category can be energy required to demolish the building). In vernacular Architecture, locally available building materials are employed. As a consequence, energy consumption for transportation is significantly less resulting in relatively reduced embodied energy. Further, local labour being familiar with use of regional materials and techniques, can therefore be easily employed. Buildings designed to be compatible with climate by relying on appropriate orientation, natural ventilation, and passive cooling techniques etc. will enable reduction in operational costs. In view of the dimensions of sustainability, that is social, economic etc. in vernacular architecture, sustainability is manifested in the design of buildings, use of materials, heritage preservation, and environmental and social consciousness.
While designing for sustainability, emphasis should be laid on compatibility with regional context, finding local solutions from local resources, finding ways of decreasing high energy consumption levels and learning from our own traditional wisdom for simple cost effective solutions.

CONCLUSION

The principles and elements employed in vernacular architecture are inherently low energy and often economically and socially viable as evidenced in the previously discussed case examples. For instance, aspects of earth technology incorporation (as evidenced) in Sharanam Training Centre lend themselves not only to low cost and climate friendly architecture but also encompass the wider human dimension of stakeholder participation and employment generation. However little has been done to incorporate them as standard practice in contemporary buildings. Traditional materials and techniques are thought to be temporary, "sub-standard," or "second class," while modern materials are seen as civilized or a symbol of affluence. Oliver in (Built to meet needs) points out that "vernacular architecture suffers from the indifference and ignorance of its historic or social value, and from being assigned to low status housing. Vernacular buildings are seen by politicians and populace alike as representative of a backward past opposed to their modern ideas and expectations" (2006:25). Thus, there is a pressing need to uplift vernacular architecture from the indifference, ignorance and 'low status' label that it often suffers from.

Admittedly, even though vernacular technologies, resources or forms are often suitable and sustainable, yet they may have functional limitations because of changed cultural, social and technological contexts. However to discard them completely would tantamount to throwing out the baby with the bath water. The challenge is to find out how the achieved knowledge, skills and experience of the world's vernacular builders may, as Vellinga (2006) has said, be fruitfully applied in a modern context.

As stated by Foruzanmehr and Nicol (2008), what is needed in this area is research that critically and systematically tests the actual performance of vernacular technologies and generates an understanding of how they may be upgraded and integrated to provide truly sustainable buildings for the new millennium.

REFERENCES

AlHinai, H., Batty,W. and Probert, S. (1993) Vernacular Architecture of Oman: Features that enhance thermal comfort achieved within buildings in Applied Energy. 44 (3), pp. 233-244.

Asquith, L. and Vellinga, M. (2006) Vernacular Architecture in the 21st Century, UK: Taylor & Francis Group, pp. 111-119.

Bahadori, M. (1994) Viability of wind towers in achieving summer comfort in the hot arid regions of the Middle East in Renewable Energy. Issue 5 No 8, pp. 879–892.

Brunskill, R. (2006) Traditional Buildings of Britain: An Introduction to Vernacular Architecture. USA: Yale University Press. pp. 45-56.

Brunskill, R. (2000) Vernacular Architecture: An Illustrated Handbook. UK: Faber and Faber, pp. 171-177.

Dabaieh, M . (2009) Conservation of desert vernacular architecture as an inspiring quality for contemporary desert architecture: theoretical and practical study of Balat Village in Dakhla oasis, Universitas 21 International Graduate Research Conference: Sustainable Cities for the Future:Melbourne & Brisbane.

Dayaratne, R. (1999) The *Vernacular settlements and Sustainable Traditions of Sri Lanka.* in the Proceedings of the First International Conference on Vernacular Settlement, Depok, Indonesia.

Dayaratne, R. (2000) *Learning from Tradition for an Environmentally Responsive Architecture: A Formal Practice*, in Open House International. Vol. 25. No. 03 pp 10-15.

Dayaratne, R. (2003) *Earth Architecture for Contemporary Urban Living: Prospects and Potentials* in Open House International. Vol. 28. No. 03.

Dayararatne, R. (2007) *Is there a Future for Earth Architecture*, A paper presented at the SLIA Annual Conference in Colombo.

Djalilian, S. and Tahbaz,T. (2008) Challenge of Vernacular Architecture and Modern Life Style – Case Study in Iran, 25th Conference on Passive and Low Energy Architecture, Dublin.

Djalilian, S. and Tahbaz,T. (2004) Minimization of energy consumption based on Vernacular Design Strategies: The 21st Conference on Passive and Low Energy Architecture. Eindhoven, The Netherlands.

Fathy, H. (1986) Natural Energy and Vernacular Architecture: Principles and Examples with Reference to Hot Arid Climates. United States: University Of Chicago Press, pp. 67-73.

Ford, B. (2001) *Passive downdraught evaporative cooling: principles and practice* in Environmental Design. 5 (3), pp. 271-280.

Foruzanmehr, A. and Nicol, F. (2008) Towards new approaches for integrating vernacular passive cooling systems into modern buildings in warm-dry climates of Iran: Air Conditioning and the Low Carbon Cooling Challenge, UK: Windsor.

Gallo, C. (1994) Bioclimatic Architecture. *Renewable Energy*, 5, 1021-1027.

Heath, K. (2009) Vernacular Architecture and Regional Design: Cultural process and Environmental response. Oxford, UK: Elselvier Ltd. 13-14.

Kasraian, N. (2011) *View of Yazd's wind towers.* http://www.iranonline.com/iran/yazd/images/tower.html. Accessed 25th November 2011.

Kazimee, B . (2008) *Learning from vernacular architecture*, in: Broadbent,G.et.al. (edited) Architecture: Harmonisation between Architecture and Nature. UK: WIT Press. pp. 3-13.

Khanghahi, T. and Maleki, P . (2011) An overview of the Iranian Vernacular Architecture with particular reference to the air traps. *International journal of Academic Research*. 3 (3), pp. 793-799.

Liu,J. Hu, R. Yang, L. (2010) Regeneration of vernacular architecture: new rammed earth houses on the upper reaches of the Yangtze River. Frontiers of Energy and Power Engineering in China. 4 (1), 93-99.

Mabaleka, B. (2009) The Vernacular architecture as a model for Sustainable design in Africa. http://www.tbher.org/index.php/bher/article/view/6/4. Accessed on 25th November 2011 .

Naciri, N. (2007) Sustainable features of the Vernacular Architecture, Available: http://www.solaripedia.com/files/488.pdf. Accessed on 25th November 2011.

Oliver, P. (2006) *Built to Meet Needs: Cultural Issues in Vernacular Architecture*. UK: Architectural Press, pp. 21-27.

Oliver, P. (1997). *Encyclopaedia of Vernacular Architecture of the World*. UK: Cambridge University Press. 1108-1115.

Rao, S. and Schierle, G. (1995) Sustainability: The essence of vernacular, http://www-classes.usc.edu/architecture/structures/papers/GGS-Rau.pdf. Accessed on 25th November 2011.

Roshan, M. (2011) New methods in modern architecture by employing natural element with helping technology, Proceedings of the first Iranian Students Scientific Conference in Malaysia.

Sharanam. http://www.sriaurobindosociety.org.in/activity/activity.html, Accessed on 25th November 2011.

Soflaee, F. and Shokouhian, M. (2005) Natural cooling systems in sustainable traditional architecture of Iran, International Conference on Passive and Low Energy Cooling for the Built Environment, Greece.

Sundarraja, M., Radhakrishnan, S. and Priya, R. (2009) Understanding Vernacular Architecture as a tool for Sustainability, 10th National Conference on Technological Trends, Trivanduram.

Taylor, T. ,Nikolopoulou, M. ,Mahdjoubi, L. and Cullen, N. (2009) *Vernacular architecture and contemporary design in Oman: challenges in a changing climate in* Detail Design in Architecture, Translating sustainable design into sustainable construction, Cardiff, UK.

UNEP-SBCI. (2010) The State of Play of Sustainable Buildings in India'. Available: www.unep.org/sbci/pdfs/State_of_play_India.pdf. Accessed on 25th November 2011.

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