Context Based Building Materials Used for Contemporary Structures to Achieve Thermal Comfort

Ar. Bhavana Patil[1] and Sheeba Valsson[2]

[1] *Vaishnavi College of Architecture and Planning, Hyderabad, India*
[2] *Smt. Manoramabai Mundle College of Architecture, Nagpur, India*

ABSTRACT

The modern building construction movement had initiated in the second half of the twentieth century and was adopted by many influential architects and architectural educators. This style became popular after the Second World War and continues to be a dominant architectural style of the world. Originally, the main aim of the structure was to provide thermal comfort to the occupant regardless of the external temperature. However, modern architectural style gave birth to mechanical ways to resolve the problem of thermal comfort. Designers then started thinking about the solution for thermal comfort which was directly related to energy efficient design.

Keywords: Context Based Materials, Ecofriendly, Sustainability, Thermal Comfort, Traditional.

Thermal comfort is directly related to climatic conditions, topography of the region, built-form, vegetation and the selection of building materials. The type building materials play important role in thermal comfort. The thermo-physical properties of the building materials determine the rate of heat exchange within any building. In India, most of the regions are climatically hot. Hence to construct buildings of thermal comfort in these regions is challenging.

In India, the designers were familiar with traditional building materials and their effect on built-form. It was a proven technology for thermal comfort and it was known that the context based materials played significant role in the built form. The only drawback was the strength, stability and sustainability. Traditional building materials combined with modern building materials can produce a suitable architectural style and help in solving the problem of thermal comfort

This paper deals with context based building materials and its construction techniques that can be used effectively to produce good architectural style which is sensitive as well as sustainable and tackle thermal comfort.

1. INTRODUCTION

There is an energy crisis in the world due to which the term “Green Architecture” is getting more prominent and significant. Due to the energy crisis, most of the buildings are also getting judged by the energy rating system. India is one of the most populated countries in the world and it is

predicted that the consumption of artificial energy is going to be higher in India as the affordability of common man is going to be increased. Artificial energy is creating ozone layer depletion and pushing global warming level up. Hence there needs to be an economical solution for energy crisis and it is making architects to search for an appropriate solution. Tremendous use of modern building materials increases the artificial energy use, on which people are becoming more dependent.

In the context of growing ecological imbalance and the threat of global warming, the environmental dimension of the discussion is pressing and urgent. The salient lesson of vernacular tradition has been the ability of human creativity to construct a life of reasonable comfort, of grace and beauty in concert with local climate and natural resources available locally. [1]

Today conservationist are trying to conserve the traditional structure as these structures are the reflection of the past culture, tradition and social life. Mainstream architects are constructing buildings using synthetic building materials that become the main cause of heating. There are very few architects practice green and sustainable architecture to generate energy efficient design. There is a need to develop sensitive architecture which incorporates all these aspects and keep the link intact with traditional architecture.

The well-known architects such as Hasan Fathy, Louis Kahn, Laurie Baker, B V Doshi, Charles Correa and Raj Rewal worked in this direction and contemporary architects such as Revathi Kamath, Shirish Beri, Anupama Kundoo are also contributing their efforts in this.

2. THERMAL COMFORT AND BUILDING MATERIALS

The American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE) define thermal comfort for a person as “that condition of mind which expressed satisfaction with the thermal environment”. [2]

Givoni (1976) reports that, there are four ways the heat transfer takes place in buildings such as conduction, convection, radiation and evaporation/condensation. When the solar energy reaches the outer surface of a wall in the form of radiation, it gets absorbed and flows inside through the wall material by conduction. If there is an air gap in a wall then convection and radiation takes place. The amount of heat transfer, heat resistance, heat capacity, surface characteristics etc. depend on the thermo physical properties of the building materials which affect thermal comfort.

A. Use of Context Based Materials

The materials which are context based are all natural building materials such as timber, stone, clay tiles, compressed earth block (CEBs) bricks etc. Sometimes these context based materials used in

raw (crude) state but most of the time these materials get treated and used as per the function and of the built form and climatic condition of a particular region.

These context based building materials are important as they are economical, climate friendly, and generate the relationship with atmosphere. These building materials not only provide thermal comfort but also help in bringing ecological balance. The amalgamation context based building materials with the modern building materials produces a sustainable style.

B. Thermal Properties of Building Materials

The traditional construction method and process provides thermally comfortable shelter to the occupants by giving due considerations to local climatic conditions. The thermal mass, of a material or element in the building that absorbs, stores and later releases heat to great effect, plays significant role in achieving thermal comfort. Thermal mass has two main properties; the ability to absorb and release heat, known as 'Thermal Lag' and its capacity to store heat, known as 'Volumetric Heat Capacity'. The effectiveness of Thermal Mass to absorb and emit heat is measured in terms of thermal conductivity. [5]

Denser materials such as concrete, tiles, stone, and bricks have high thermal mass. Lightweight materials have low thermal mass. Higher density materials have higher heat storing capabilities. A higher thermal mass material is generally not a good thermal insulator. Table-1 shows the thermal properties of few building materials.

Table 1: Thermal Properties of Building Materials ***(Source: ECBC User Guide, BEE)***

Thermal properties of these materials are given below: Material	**Conductivity (W/m K)**	**Specific Heat Capacity (KJ/ Kg. K)**	**Density (Kg/m3)**
Brick	0.811	0.88	1820
Mud	0.750	0.88	1731
Stone	1.5	0.84	2200
Timber	0.072	1.68	480
Concrete	1.09	0.75	2400
Mild Steel	48.8	0.49	7850

3. COMPONENTS OF STRUCTURE

The thermal properties of building components such as roof, walls, and floors together determine the energy consumption and thermal comfort in an enclosed area. The major component to transfer

heat is roof, walls and flooring. The type of building materials and construction techniques used for these components to generate thermal comfort is discussed in the following paragraphs.

A. Roof Construction

Roof is the major factor of a building which transfers heat directly into the building. It is the highest contributor of heat.

The filler slab construction is made up of RCC. The bottom half (tension) concrete portions of the RCC slab are replaced by filler materials such as bricks, tiles, cellular concrete blocks, etc. and are so placed as not to compromise the structural strength of the slab. This results in replacing unwanted and non-functional concrete, thus resulting in economy. These filler materials are safe, sound and provide aesthetically pleasing pattern ceilings and also do not need plaster.

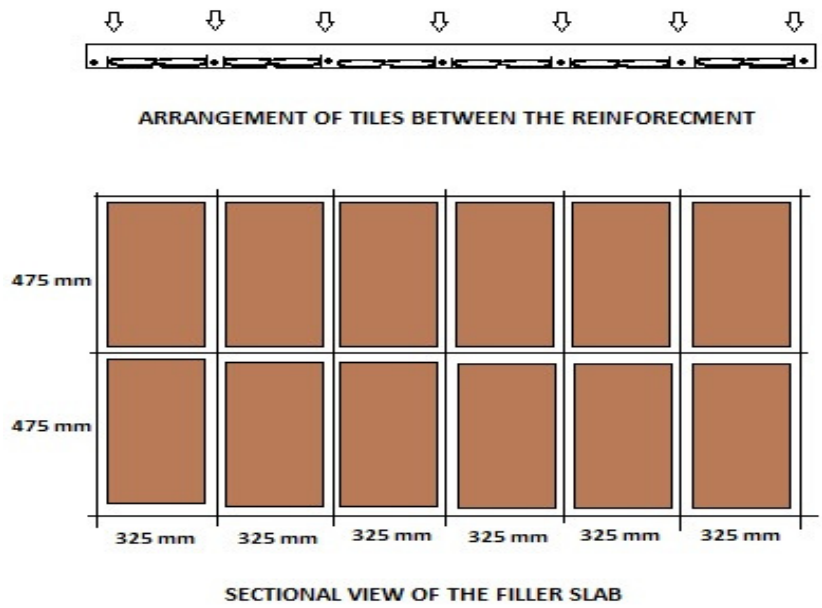

Figure 1: Filler Slab

The main features of the filler slab are:

- Less concrete and steel is consumed due to reduced weight of slab by the introduction of lighter and low cost filler material like two layers of burnt clay tiles.
- Thermal comfort is enhanced inside the building due to heat-resistant qualities of filler materials and the gap between two burnt clay tiles.
- Cost saving of about 23% is achieved on this slab compared to the traditional slab.
- The use of concrete is reduced and saving of cement and steel is achieved by about 40%. [3]

B. Masonry Wall Construction

There are various types of building materials used for masonry construction. The context based building materials and their construction techniques that are used to achieve thermal comfort are discussed below.

i. Compressed Stabilized Earth Blocks (CSEBs)

The manufacturing of wire cut bricks affects most of the soil because the good agricultural land i.e. topsoil gets used for the manufacturing of these bricks. The alternative method is to use CSEB blocks to save energy. The advantage of CSEBs is the subsoil gets used for its manufacture and topsoil gets used for agriculture purpose.

CSEBs are of accurate dimensions, have excellent surface finish, better thermal insulation and result in cost effective technology. For this technology, raw materials are - soil with minimum 20% clay, cement 5-10% (depending upon the strength requirement) and lime (used as a stabilizer for clayey soils) with 6% as an average. These blocks have a good thermal insulation and are produced of accurate dimensions. In India, the Meghwal the traditional building and craft community for *the Maldharis* (Nomads) of Banni region, trace the origin of the circular mudroom with a thatched conical roof (*The Bhunga*) way back to the earthquake of year of 1819. The designs of low and circular walls prevent cracks from developing.

As shown in Fig. 2, instead of mud wall the Compressed Stabilized Earth Blocks have been used. Beams at plinth, sill and lintel level and vertical rods have been used to reinforce its anti-earthquake qualities. Each Mangalore roof tile is secured to the wooden framework by a wire to withstand high speed wind load. [3]

Figure 2: Use of CESB - NIRD Hyderabad

(Source – Author)

Figure 3:Ar. Arundhati Vishwanath Residence

(Source - downtoearth.org.in/content/keep-it-flowing)

The CSEB blocks absorbs the heat in a day time and releases it at night. There are other examples, such as the Visitors' Centre of 1200 m² was granted the "Hassan Fathy Award for Architecture for the Poor" in 1992. Built of compressed stabilized earth blocks, it demonstrated the potential of stabilized earth as a quality building material. Vikas Community was a finalist for the "World Habitat Award 2000: and its 3rd building was built on 4 floors. Since then, the value of earth as a building material has been acknowledged for its economic advantage, as well as its comfort and quality.As shown in Fig. 3, Architect Arundhati Vishwanath used context based building materials to build her residence cum office in Bangalore, India and is one of the best examples of vernacular tradition in contemporary architecture. She kept in mind the local climatic conditions and achieved the energy efficient design.

ii. Rat Trap Bond Brick Masonry

The Rat trap bond Brick Construction, developed by architect Laurie Baker, is a popular technique in which the bricks are placed on their edges in 1:4 cement mortars and after the first layer of bricks is laid, a gap is left between the bricks in remaining courses.

The advantages of this technique is, simple, cost-effective, strong insulation properties, it is as strong as ordinary solid 9" brick walls and saves around 25% of bricks and 40%-50% of cement and sand.

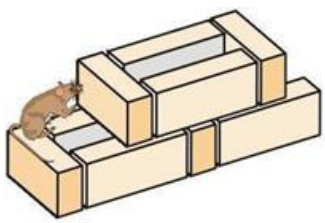

Figure 4: Rat trap bond
(Source – Contractor Talk.com)

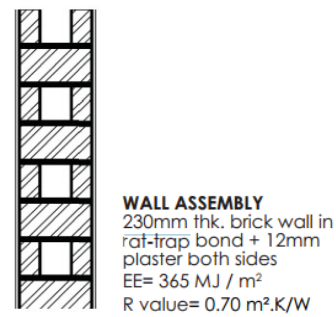

Figure 5: R Value - Rat trap bond section
(Source – cpwd.gov.in/)

Note: Thermal resistance (R-value): Property denoting a material's resistance to heat. It is dependant on temperature and the thickness of the material. Unit: m².K/W
Embodied energy (EE): It is the sum of all the energy required to produce a material, considered as if that energy was incorporated or 'embodied' in the material itself. Units MJ / kg or MJ /m3. (MJ= Megajoules)

iii. Stone Masonry

Stones are a widely used material in masonry, particularly because of its high thermal mass due to its high density. Thermal mass is the ability of a material to absorb heat energy. This heat storing capacity of building materials helps achieve thermal comfort conditions by providing a time delay to the flow of heat. Thermal mass is most appropriate for climates with a diurnal variation of more than 10º C. [8]

Figure 6: NIRD RTP Hyderabad (Source - Author)

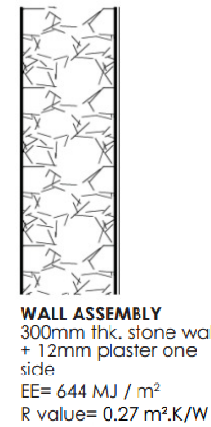

Figure 7:R Value – Stone wall section

(Source – cpwd.gov.in/)

4. CONCLUSION

The traditional construction techniques are been used since generations. The building materials used for these techniques are outcome of trial and error methods. Local craftsman were the masters of these construction techniques. The combination of context based building materials and modern building materials give new dimension to the architectural style which is quite appropriate for today's world.

The study shows that the use of local building materials in modern way not only create interesting architectural style but also helps in bringing climate responsive design, which also helps in reducing CO_2 emissions. This seems to be a solution to reduce global warming. There is a need to act swiftly to achieve clean environment with economical means. All government bodies and Municipalities in India need to accept the above mentioned construction techniques and style and encourage people to adopt it.

The construction techniques used in the architectural style are very simple and any common person with minimum knowledge can work with it. Since, in India 60% people live in villages, people can

easily learn and adopt this style & techniques. These construction techniques and architectural style discussed above should also be the part of the study curriculum. This would make students to understand and use it in practice. The skill up-gradation program is already started in few government centers but need to be spread out in large extent.

REFERENCES

[1] Tipnis, A. (2012). *Vernacular Traditions Contemporary Architecture.* New Delhi: The Energy & Resources Institute.

[2] Baruch, G. (1994). *Passive Low Energy Cooling of Buildings.* Canada: John Wiley & Sons Inc.

[3] Development, N. I. (2005). *Blending the traditions with the modern...* Hyderabad: National Institute Of Rural Development.

[4] Development, S. f. (n.d.). Environment Friendly Inidan Building Material Tchnologies for Cost Effective Housing. New Delhi, New Delhi, India.

[5] Krishan Arvind, Baker Nick, Yannas Simos, Szokolay Steve. *Climate Responsive Architecture: A Design Handbook for Energy Efficient Buildings 1st Edition.* London: Tata Mcgraw Hill Education Private Limited, 1999.

[6] Geoffreybawa.com

[7] Infolanka.com/org/srilanka/people/88.htm

[8] books-for-brickwork.blogspot.in/2011/07/rat-trap-bond.html

[9] cpwd.gov.in/Publication/IGDBooklet.PDF