



A study on the Green Building Concepts in Vastu Sastra principles for sustainable development

V Balasubramanian*

Kalasalingam School of Architecture, Kalasalingam Academy of Research and Education, Krishnan Koil, Virudhunagar 626 126, India
E-mail: balasubramanian.v@klu.ac.in

Received 07 October 2019; revised 07 May 2021

The traditional Indian architecture provides us with deeper knowledge and experiential values, reflecting the essence of cultural and ritual aspects of its society through its intrinsic articulation of spatial and architectural elements that are governed by the strict architectural principles laid in early times of civilisation. It is interesting to note that these principles were aimed at providing guidance for perfect architectural productions and built environment believed to be sustainable, climatically responsive and enhance the well-being of the inhabitants. This paper tries to explore the Green Building Concepts promoted by our ancestors through the established Vastu Sastra principles which are being practised even today mundanely without recognizing the original spirit and intent.

Keywords: Green buildings, Sustainable development, Vastu Sastra, Traditional Indian Architecture, Well being

IPC Code: IntCl.²¹: E04B 1/00, E04G 23/00, E04H 5/08, G09B 25/04

The United Nations 2030 agenda for sustainable development focuses on three major components of People, Planet and Prosperity. It has developed 169 targets covering 17 goals to ensure a balanced economic development for prosperity without much compromising on the resources and environment of this planet. It is observed that out of 17 goals, the goal numbers 3, 11 and 13 elaborates on good health and well-being, sustainable cities and communities and climate action, respectively¹.

The role of architecture and built environment in ensuring the above 3 goals is very significant. Especially the Green Buildings Concepts try to provide sustainable architectural solutions for a better built environment which can ensure the well-being of the people.

Well-being of the inhabitants as the basic spirit, the traditional Indian architectural texts have meticulously laid down principles for the construction of not only the buildings of monumental scale like palaces, temples etc., but even for the buildings of domestic scale like ordinary residences and furniture. These stringent principles are collectively known as Vastu Sastra. The term architecture specified in the Vastu Sastra, in its broadest sense refers and implies anything built and constructed. Thus all

building typologies, planning of towns, sculptures, furniture and ornamentation are covered in the term architecture [Ch.III- 5-6]². This paper intends to study and relate the traditional Vastu Sastra principles with the Green Building Concepts of modern times.

Methodology

A set of Green Building principles are identified from IGBC³ and GRIHA⁴ guidelines and examined how this principles are in concurrence with the principles of Vastu Sastra. For the purpose of this study, five authentic translation of traditional Indian architectural text (as they were originally written in Sanskrit and Tamil) were selected and the generic common principles are identified across all the texts. These identified principles are checked for its concurrence to the contemporary Green Building Concepts.

The selection of texts was made based on different regional representation, written across different time line, broader acceptance and popular among the people involved in architectural production and sufficient availability of description on the architectural planning principles. The study is focused on the descriptions in the traditional texts of Vastu Sastra, that are related to the Green Building Concepts.

*Corresponding author

Green Building requirements

A. Green Building principles

In order to understand the correlation between Green Building concepts and Vastu Sastra, it is imperative to understand the concepts of Green buildings. Green Buildings refers to the buildings which adopts the principle of a conscious handling of natural resources.

Green buildings practices aims at increasing the efficiency of buildings in the use of resources [energy, water and materials] in order to reduce their impacts on human health and the environment through better site selection, design, construction, operation, maintenance, and reuse at the end of the life cycle⁵.

Conti⁶ had emphasized the impact of built environment on its inhabitants by stating that "Architecture is more than the art of constructing individual buildings. It is also the creation of environment. Buildings do not exist in isolation. They not only impose their character on their surroundings but also have an incalculable effect on the lives of human beings who inhabit them".

Various researches in Green Building suggest commonly the following criteria as basic requirements for green building approach^{1,3,4}.

1. Site selection
2. Building shape and orientation
3. Indoor environmental quality
4. Energy efficiency, and
5. Building materials

B. Site selection

The intent of this criterion is to select a suitable site which does not fall under the category of a farm land, land of hydro geological risk, land earmarked as habitat of endangered species and land with significant ecological values. The natural slope of the site is to be maintained without much intervention.

C. Building shape and orientation

The orientation of a building will influences its pattern of energy consumption due to the degree of its exposure to the solar radiation. Optimum orientation and arriving at the size of windows is dependent on prevailing outdoor climate and the utility of various rooms in appropriate direction in order to improve the energy efficiency. The building shape also influences the passive solar energy exploitation which in turn can reduce the energy consumption⁵

D. Indoor Environmental Quality (IEQ)

IEQ can be broadly achieved in two categories namely thermal comfort and visual comfort³.

Thermal comfort

Doors or Windows and ventilators to the exteriors in all normally occupied spaces of every dwelling unit is to be provided with a minimum open able area of 8 to 12% of floor area³. The above openings are to be provided in at least two sides of the room in order to achieve the cross ventilation. No obstruction be found within 2 m from the exterior surface of windows and ventilators.

Visual comfort

Visual Comfort focuses on the connectivity between the interior and the exterior environment, through the provision of adequate day lighting. This can be achieved by providing multiple openings of appropriate window sizes and openings in appropriate orientation preferably north or east facing¹.

E. Energy efficiency

By improving the energy efficiency of the building the environmental impacts from excessive energy use can be reduced considerably. Careful choice of wall, roof and glazing materials for the building envelope improves the energy efficiency. Adopting passive architectural features, incorporating appropriate shading devices over external openings, optimizing ratio between Window to Wall, climate responsive concepts and design features are certain definite tools by which the energy efficiency in buildings can be considerably improved.

F. Building materials

The use of low-embodied energy materials for the building structure supports in reasonable energy savings. The use of locally available material is recommended as it minimizes the associated environmental impact due to transportation. The vernacular architecture systems can appropriately be adopted for better efficiency. Encouraging the use of materials which contain recycled content can reduce environmental impacts caused due to excessive use of virgin materials.

Relationship of Green Buildings and Vastu with well-being

A. Definition of well being

In 2006 the UK Government's Whitehall Well-being Working Group developed statement of

common understanding of well-being for policy makers, as follows:

“Well-being is a positive physical, social and mental state; it is not just the absence of pain, discomfort and incapacity. It is enhanced by conditions that include supportive personal relationships, involvement in empowered communities, good health, financial security, rewarding employment, and a healthy and attractive environment”⁸.

World Health Organisation [WHO] promotes the significance of Wellness and defines “Health as a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity”. Wellness as a critical element plays an important role in occupants productivity, creativity and talent retention.

B. Green Buildings and well being

The criterion of Green Buildings requirements referred earlier ensures the architectural production to be more sustainable and have less impact on the environment. Apart from being environmentally sensitive the green buildings are presumably enhancing the well-being of the inhabitants also. By analysing the occupancy of over 500 tenants who had shifted into LEED [Leadership in Energy and Environmental Design] and Energy Star rated buildings, Miller *et al.*⁹ established that healthy buildings reduce the number of sick days of the occupants,

Stemers and Manchanda¹⁰ have demonstrated a strong positive relationship between Sustainable design solutions and the occupants’ well-being. Joseph G Allen *et al.*¹¹ were able to consolidate the research studies on the impact of green building on well being. They have ascertained that the Indoor Environment Quality in Green Buildings positively affect the well-being of the inhabitants in terms of improved work productivity, fewer absenteeism, lesser sick building syndrome and better physical and mental health.

C. Vastu and well-being

According to Battacharya¹² in Hindu ideology, “the home refers to the harmonic relationship between human beings and earth”. The idea of home is derived from the word *vāstu*, indicating residence, but the same had been used to denote human habitat space including all the movable and immovable objects. Later it was also used to refer the context where humans attachment to the sun, the wind, and the water [Ch. III. 1.7]². Brenda¹³ indicates “the plan represents

the symbolic merger of body, space and cosmos”. In order to establish the relationship between use of space, cosmic order and human activities the structural plan developed through the principles are sanctified through various rituals, which are still being practiced universally¹⁴.

An over view of in Vastu Sastra in traditional text

A. Treatises

The reference of word Vastu can be found in various texts like Vedas, Brahmanas, Smrithis, Agamas etc. Apart from this, treatises like Manasara² (means the essence of measurement) – a monumental work, deals exclusively about architecture in all its 58 chapters. A complete technical treatise contains chapters on type of measurements, site selection methods for all type of buildings, determination of orientations, planning and design of various building typologies, villages, towns, cities etc., including the details for furniture, sculpture and ornamentation. According to Ramraz¹⁵, Manasara considered to be a perfect text available on architecture.

Other equally important technical treatises containing detailed descriptions on the aspects of architecture are Mayamatam¹⁶ claimed to be written by sage Mayamuni, Samarangana Sutradhara of Bhojadeva¹⁷ and Aparajita prccha. Sri Lalitha Manaiadi Sastram, Silparatnam, Manushyalaya Chandrika¹⁸, Manai Adi Sastram¹⁹, Citralakshana⁷ are the manuals developed by practitioners in later period prescribe the regional traditions of building, established over a period of time. A strong reflection of the tradition can be found all through the content, technology and language.

B. Documentation and research in traditional Indian architecture

Ramraz¹⁵ [1812] the first Indian, attempted to understand and document the principles of traditional Indian architecture. The book titled “Essays on the Architecture of Hindus” [1834] was a significant research work done by him on Indian architecture. After him many scholars were started translating traditional architectural texts and documenting the ancient buildings.

Acharya² has translated and developed graphic transcriptions on the written texts of Manasara, dedicating almost two decades in his life. His works were published as “Indian Architecture according to Manasara Shilpa Sastra”² in number of volumes till 1946. Shukla¹⁶ has identified Samarangana Sutradhara for his research in Indian Architecture and published

the book in 1960. By translating the ancient architectural text *Mayamatam*, Dagen¹⁷ [1984] published the book “*Mayamatam – A Treatise of Housing, Architecture and Iconography*”. The treatise *Samarangana Sutradhara* has also been translated by Sharma¹⁸ and the book “*Samarangana Sutrdhara of Bhoja Deva*” [2012] was published by him. In addition to the above regional texts like *Sarvartha Chirpa Chinthamani* [Manaiadi Sastram] by Mudhaliar [1915] and *Sri Lalitha Manaiadi Satram* by Iyer [1914] were written in Tamil indicating the cosmic aspects of architectural production.

For the purpose of study, the treatises selected from the above are the translation work done on

- 1 *Manasara* by Acharya²
- 2 *Mayamatam* by Dagens¹⁷
- 3 *Samarangana Sutradhara* by Sharma¹⁸
- 4 An engineering commentary on *Manushyalaya Chandrika* Bashyam by Achyutan & Balagopal & Prabhu¹⁹
- 5 *Sarvartha Sirpa Chinthamani* (Manaiadi Sastram) by Veerasamy Mudhaliar²⁰.

C. Documentation of Vastu principles in the texts

The collective Vastu Sastra principles prescribed in the texts can be consolidated generically as follows.

1. Examination and selection of site (*Bhu Pariksha*)
2. Determining the orientation (*Dik Nirnaya*)
3. Vastu Purusha Mandala (*Padavinyasa*)
4. Zoning (*Sthana Vinyasa*)
5. Door openings (*Dwara Sthana*)
6. Choice of materials (*Dravya Parigraha*)

Green Building concepts in Vastu Sastra

In this paper the above principles stated in the selected texts are examined for the Green Building concepts.

A. Examination and selection of site - Bhu pariksha

Before the construction of buildings in any site, the site is to be examined for its suitability. The texts have prescribed various methods of examining the site for its shape, its ground contour and its soil [for odour, colour, taste, underground features [sallyyam] and touch]. The vegetation around the site and the nature of contours of the ground were also discussed extensively in the texts. Chapter III in *Mayamatam*, Chapter IV & V in *Manasara*, Chapter 8 in *Samarangana Sutradhara*, Verses 13-15 in *Manaiadisasttram* and Chapter I Verses 30-33 in *Manushyalaya Chandrika* prescribes in detail about the *bhu pariksha*. The detailed prescription stated in the texts for *bhupariksha* are listed in Table 1.

Table 1 — Bhu Pariksha

S.No.	Factors for consideration	Recommended in Text	Not Recommended in Text
1.	Levels on the land	Elevated levels in West and South	Elevated levels in East and North
2.	Colour of Soil	Pure White	Black
3.	Smell of Soil	Fragrance of Lotus and Jasmine,	Pungent smell
4.	Configuration of Site	Rectangular	Irregular
5.	Taste	Sweet	Bitter
6.	Texture of soil	Compact and Smooth	Loose and Hard

[Source: Author]

The texts strictly prescribes the site to be rejected if in case the site is found with any thorn trees (*Acacia* and *Prosopis juliflora varieties*), husks, gravels, ashes and large trees in the four corners. The ideal site should be devoid of pebbles, worms, ants, bones, charcoal, stumps, sludge and cavities [Ch.3 V7-10]¹⁷. Before the possession of the site, in order to evaluate the site for positive energies, allowing the cows to enter first into the site and performing the flower flow direction test (Identifying the direction of movement of flowers when they pour on a stirred water filled in a pit dug in the site)²¹ are prescribed as rituals in the texts. The testing methods are relatively less prescribed in *Manaiadi Sastram* when compared to other selected texts which shows elaborate methods for the same. By and large most of these texts are aimed to verify the suitability for the construction of the buildings, with more environmental sensitivity, so that the prosperity of human life inhabiting on the site is assured. *Brihat Samhita*²² a 6th AD century text in Chapter 54 very clearly elaborates on the method of identifying the water springs in a given site. This can be an evident from the fact that, our ancestors have excelled in understanding the coexistence of geo morphological and geo physical matters with that of bio organisms. For example the location of ant hill formation seems to be one of the key identification factor of water springs in the site.

B. Determination of orientation - Dik Nirnaya

The orientation of building towards the appropriate direction is considered to be of paramount importance in the traditional text. The cardinal and ordinal directions are fixed with reference to the Sun's position and movement of earth. Since Sun is providing life energy to the entire earthly objects, the buildings are to be appropriately oriented in order to get the maximum benefit. This concept of proper orientation is believed to ensure spatial harmony of

the building with the Earth. The recommendation for East as most preferred direction for the benefic results, can be found in Manushyalaya Chandrika [Ch 3 V23], Samaranganasutradhara [Ch.15] and Manasara [Ch.6 V87 – 88]. All texts considers west to be of least auspicious direction. The cardinal directions are more preferred than the ordinal directions. True East –West line [Sudha Prachee]²³ is to be followed for those seeking liberation from earthly affairs and wish to enjoy the eternal bliss. For those interested in material pleasure and physical welfare it is preferable to slightly shift the true East – West Axis [Isa Prachee]²³ only to a minimum angular of Imatrangula towards North East. It is to be noted that all the texts strictly insist on the orientation of the buildings towards cardinal directions only. As per the texts, the North East - South West axis and North West - South East axis directions, which are known as Ordinal Directions, were not considered good for the purpose of orientation of buildings. The intersection nodes of these axes in the Vastu purusha mandala are noted to be the ‘marmas’ and construction of any element of structure on the marmas are strictly prohibited in all the texts.

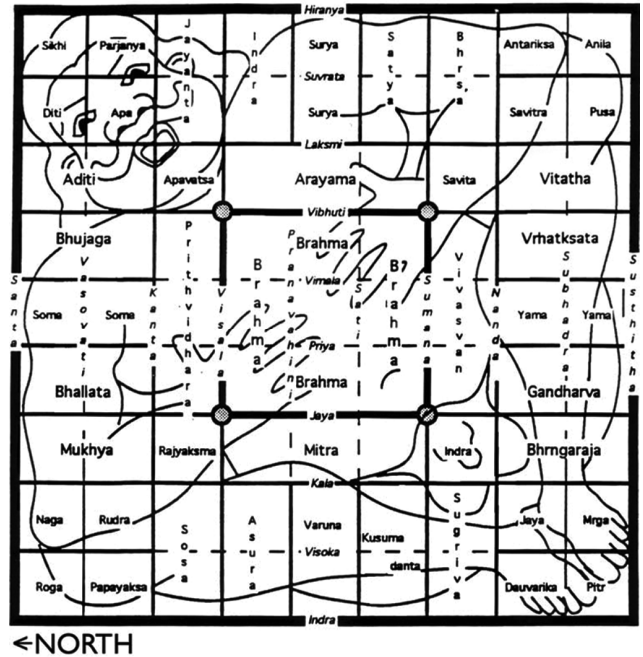
C. Vastu Purusha Mandala - Pada vinyasa

As per the Texts, the site which is designated for construction of buildings is considered to be the body of a demon called Vastu purusha as shown in Figure 1 [Ch.VII², Ch.7¹⁷, Ch.11 and 14¹⁸, Ch.V¹⁹ and p 64²⁰].

Bonier²⁴ has indicated that “When art forms take their being from fundamental cosmic laws, they participate in the essential structure of the universe and contain a natural symbolism to which unsophisticated human beings respond instinctively, unconsciously”. The act of imposing a Vastu purusha in a Mandala is believed to establish a relationship between *Sthula* Space (gross/material/physical) and *Sukshuma* space (subtle/cosmic/metaphysical). As Ganapathi Sthapati²³ said Vastu purusha Mandala is the abstraction of space and its qualities in miniature form and indirectly means that this miniature space is the first manifest form of the unmanifest energy.

Padavinyasa is the method of dividing the site into various numbers of squares. The number of squares ranges from Single square (1x1 grid) to 32x32 (1084) squares and each square is called as padas. The subdivided squares are assigned with a Pada devatas (Demi God) named after the deity assigned. The texts prescribe allotment of individual activities of the house on the subdivided squares named after a

specific deity. The Texts gives a detailed account on the various types of activities and corresponding deity name. *Manduka* type of mandala which divides the site into 64 squares and *Paramasayin* type of mandala which divides the site into 81 squares were the most recommended for all types of building activities. In the 9x9 *Paramasayin* grid, which is primarily applied for residential buildings. Figure 2 shows the number



[Source: Bonie G Macdougall 2008]28
Fig. 1 — Vastu purusha

MARUT	NAGA	MUKHYA	BHALLATA	SOMA	MIRGA	ADITI	UDITA	ISA
ROGA	RUDRA	RUDRA-JAYA	BHUDHARA			APAVATSA	APAVATSYA	PARJANYA
SOSMA								JAYANTA
ASURA			BRAHMA			ARYAKA		MAHENDRA
VARUNA	MITRA							BHANU
PUSHPA-DANTA								SATYA
SUGRIVA	INDRA-JAYA	INDRA	VIVASVAT			SAVITRA	SAVITRA	BHRISA
DAUVARUKA								ANTARIKSHU
PITRU	MRTSA	BHUBHAGA-RAJA	BANDHARYA	YAMA	GRINA-KSHATA	VITATHA	PUSMAN	AGNI

[Source: PK Acharya , 1933]
Fig. 2 — Pada Vinyasa

of grids allotted for each *devata*. Eight directions are allotted with eight major deities in the order of, *Adhitya, Agni, Yama, Pitr, Varuna, Vayu, Soma and Isa* occupying East, South East, South, South West, West, North West, North and North East respectively. The deities of the ordinal direction symbolically represent the four elements as *Isa* for Water, *Agni* for Fire, *Pitr/Nruti* for Earth, *Vayu* for Air and central *Brahma* for Space. There is not much variation found with regard to the allocation of deities to their respective location amongst the selected texts. Sonit Bafna²⁵ gives a deeper insight into the application of this Mandala in traditional architectural production. According to him *Vastupurusha* in the grid format (an early practice from Vedic period) and Mandala with the specified deities are two independent devices which were unified at a much later date. Together they control the architectural program, design and proportion. The allotment of Gods over the square grid is claimed to be a later addition to the practice of using only the Grid System for the construction of any building. It is evident that these Mandala forms the basis for all the other building activities.

The *Paramasayin Mandala* has been divided into four concentric belts called as *Koshas* (Sheaths). The center part of the innermost division is the ***Brahma Padam*** (a high energy field marking the center of the microcosm –Space of God). The adjoining zone is called the ***Deivika Padam*** (a luminous space) meaning the zone of *Devatas* (Deities/Demi Gods). Ideally these two *Padams* are not recommended for habitable space and should be kept open to sky so that abundance light spread to inner portion of the other *padams*. The third zone is called ***Manushya Padam*** a zone of human space intended for habitation and final outer zone is called ***Paisachika Padam*** (demonic space) a space of Gross matter and highly materialistic quality and hence recommended for intense labour activities (Ch.9 V61-63)¹⁷. Figure 3 shows the *koshas* of *Vastu Purusha Mandala*.

The idea of concentric zone is based on climate responsive and energy efficient solution especially in warm humid climate as the central open space (court yards) facilitates the movement air within the building and thereby controlling the humidity and heat. The kind of activities allocated from the center towards the periphery is in line with regards to the illumination level and the activities require more physical stamina. It is evident from Figure 3 that a hierarchical division has been made spatial through concentric zones in

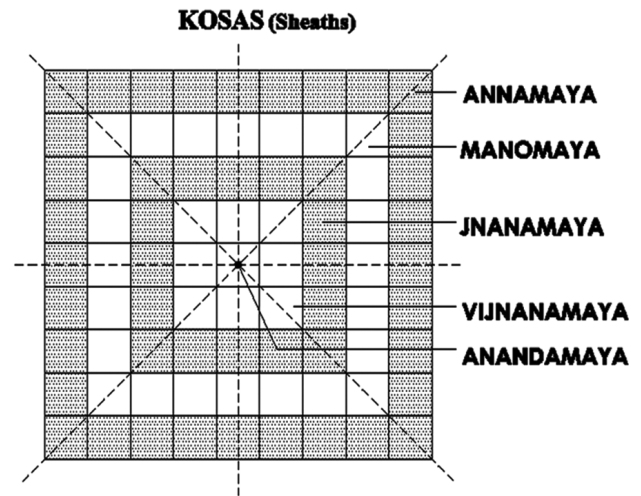


Fig. 3 — Kosas [Source: Ganapathy Sthapathi, 2001]

mandala in order to symbolically represent the sequential progress of happiness and well-being (*Kosas*), as envisaged by Upanishads, in terms of outer sheath the *paisachika padam* representing the *annamaya kosa* to the inner most *bindu*, the origin point in the *brahma padam* representing the *anandamaya kosa*. This spatial connotation had deeper implications in the layout of settlement in temple cities.

D. Zoning - Sthana vinyasa

The texts describes the allotment of various functional activities (zoning) of a house on the *padas* of the *Vastu Purusha Mandala*, which are assigned with various Gods (Ch.15, 19, 20 & 21¹⁸, Ch.7¹⁹, Ch.27¹⁷, Ch.36² and p 4 & 5¹⁹).

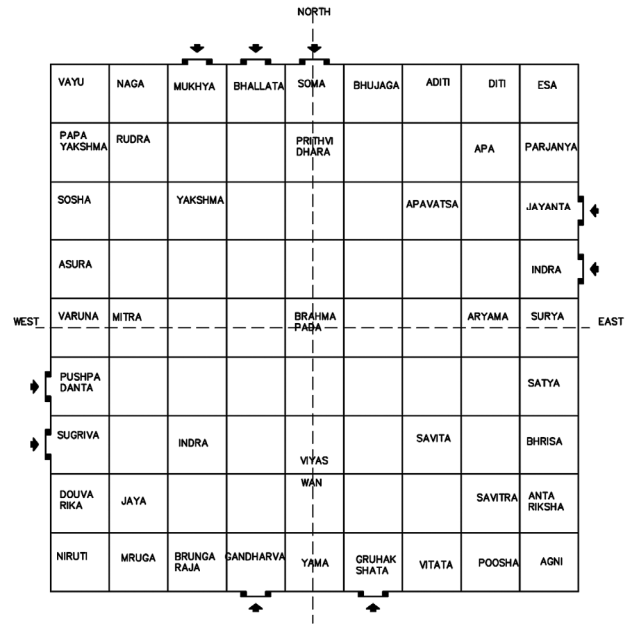
The texts strongly recommends to leave the Central *Brahma Sthana* to be open without any element of construction as it was believed to be the connect between the cosmos and the house. The spatial allocation for various activities of a house in *Vastu purusha Mandala* and the corresponding orientations for those activities allocated are found to be similar from all the texts taken for study. From the four activities (Living, Master bed, Dining and Kitchen) chosen for study, all the texts are concurring the placement of Kitchen in South East. Except *Manaiadi Sastram* the other texts concurs on the allotment of the bath in North East. Living varies from North and predominantly West whereas dining varies from South and West. As far as the bed room location is concern while other texts indicating it in South, *Manasara* alone peculiarly suggests in South East. The placement of activities is found to be very much in harmony with the environmental aspects.

Sun ray consists of invisible infrared and ultraviolet rays. Morning infrared rays from 6 am are beneficial to the human health and have very positive effects²⁶. Hence, it is recommended in the texts to locate water features in the east, north or northeast so that bacteriologically it can be safe. The entrance door is also recommended to face the above directions so that cool air comes into the house and the water body could be visually pleasant. Morning rays of the sun are cooler and as the day progresses it becomes hotter. The radiation from the Sun is the hottest from 11 Am to 3 PM when it passes through the South west and the ultra violet rays during that time is higher and harmful²⁶. With reference to the Sun position in the sky during the day time, the coolest zone in the house is in the northern direction. The rooms of higher usage are preferred to be located in the northern direction for better advantage of the coolness. The South east direction provides sufficient light throughout the day which is considered to have a sanitary effect, hence it is recommended to locate the kitchen in this corner²⁶. The light and heat of the sun in the southern portion is relatively higher and the bedrooms are recommended to be located in this direction. While bedrooms are mostly used during the night the harmful rays radiated in this direction will not disturb the occupants.

E. Door openings - Dwara vidhanam

In all the texts the prescribed location for the main door is same. The recommended door location (*pada*) prescribed in the texts are herewith. In East – *Mahendra*, South – *Grihaksata*, West - *Pushpadanta* and North – *Bhallata*. Mayamatam (Ch.30), Manasara (Ch. 38), Samarangana Sutradhara (Ch.24), Manaiadi Sastram (p-29) and Manushyalaya Chandrika (Ch.7 V25) provides detailed information on the position of Main door. In spite of the slight variation in the name of *pada devatas*, the auspicious location prescribed for Main Door in all directions is exactly same across all the texts. Figure 4 shows primary and secondary options for main door location.

In Mayamatam and Manasara, the size of the door is determined in relation to the width of the facade and the height of the column. Mayamatam recommends 25 possible values of door widths and Manasara recommends 27 possible values of door widths for Small, Intermediate and Large size of building. However all the texts confirm the height of the door should be two times the width of the door. For every corresponding width the height should be



[Source: Ganapathy Sthapathi, 2001]
 Fig. 4 — Primary and secondary options for Main door location

accordingly modified. The various options of widths for the door has facilitated the appropriate selection of size of opening that provides adequate lighting and ventilation. The contemporary Guidelines for illumination and cross ventilation are duly taken care with the above number of Door width options. The total number, size and design of windows as per texts is, absolutely left to the discretion of the Shilpis (architect) so that a creative design can be executed that is fully climate responsive and energy efficient.

It is considered inauspicious if the axis of the door is obstructed with a tree, boundary, corner, a pillar, a well, a temple, an ant hill or a heap of ashes, a vein or vulnerable point i.e., the ‘marmas’²³. This seems to be an obvious implementation of not having any obstruction (discussed elsewhere in this article in section (D of Green Building requirements) as stated in the Green Buildings norms to ensure the Indoor Environmental quality.

F. Choice of materials - Dravya Parigraham

Mayamatham (Ch 15 and Ch 33), Manaiadisasttram (p-49-54), Brihat samhita (Ch53 and 55) and Samarangana Sutradhara (Ch- 16) thoroughly discusses on the application of various building materials in detail like the types of timber from various trees, brick manufacturing processes and selection and cutting of stones.

Trees

All the texts concur on leaving 1 cubit (2 feet 9 inch i.e., 83.5 cm) from the bottom of the tree before cutting it for building construction purposes. This seems to be one of the key sustainable ideas as once you leave the bottom of the tree without cutting; it is evident that it will grow again further. Mayamatam and Manaiadi sastram have categorically prohibited the use of timbers from the following trees:

1. Trees in temple complex
2. Trees affected by thunder
3. Trees extinguished by forest fire
4. Trees grown within the villages
5. Trees where animals and birds stay
6. Trees broken by air and elephant
7. Trees occupied by people
8. Trees with hole
9. Trees nearby graveyards
10. Trees surrounding water bodies

The list of prohibition of trees for construction stated in the texts stands as a testimony for the sensitivity towards environmental consideration and the belief they had in Green development.

The trees are classified into male, female and neuter. The male trees are used for the beams and columns of the structure whereas female trees are used for roofing purposes. Neuter trees are normally not used for building construction.

Brick

The earth suitable for making bricks, tiles should be free from gravel, pebble, roots and bones. Its colour should be homogeneous and pleasing to touch. The sizes of brick are with a width of 4 to 8 digits (inches), the length of twice the width and the thickness of quarter or one third of width.

According to Mayamatam, the thickness of the brick wall is normally determined by the size of the Court provided in the center of the house whereas *Brihat Samhita* states the thickness should be one in sixteenth part of the width of the wall. *Manaiadi Sastram* suggests a minimum of 1'6" (45cm) for wall thickness. By and large all the texts suggest a relatively thicker brick wall than that of modern brick wall which is normally 9" (23 cm) in thickness. These thick walls are intended not only to carry the structural load but also to reduce the heat transfer from outside to inside with a very low U-Value and provide necessary thermal comfort to the inhabitants.

Remaining bricks used in other buildings and bricks obtained from destroyed buildings are strictly

to be prohibited. This rule stated by the texts tries to ensure the use of new and good quality bricks for new construction of houses. In a way the recycling of materials is not permitted in texts.

Stone

Texts suggest that the stone should be of uniform in colour, dense, smooth and deeply embedded in earth. It should be matured and of pleasing appearance. Mayamatam suggests different colours of stone for the different varnas.

Stones are also classified into male, female and neuter. Each of them are further classified into young, matured and aged. Male stones are with smooth surface, uniform colour and gives bell like sound. Female stones are having wide bottom and gives cymbal like sound. Neuter stones are narrow stones and do not give any sound. Matured stone is preferred for all construction among the other two stones (young and aged) as they are smooth, round, without fragmentation, glows and gives off a deep sound.

Stones affected by wind, sun and fire, with shaky nature, used in previous constructions, with rough texture are to be prohibited for any construction purpose.

It can be inferred that the Vastu Sastra texts have stipulated stringent principles in the selection and application of materials for construction in order to ensure minimum impact on the environment.

Conclusion

The above study tries to identify the Green Building concepts in the Vastu Sastra principles that are basically designed for environmental features but due to lack of scientific knowledge, it has been considered as a myth and ritual by the later generation. Our ancestor's wisdom in the Laws of Nature and its impact on human health and well-being seems to be the fundamental cause for the application of Vastu sastra principles. This core idea is being passed on from generation to generations. As the architectural forms are resultant of a response to the environmental features, the Vastu sastra principles are applied not merely as a superstitious tool but to generate the architectural forms duly responsive to the context of the given environment, which is essentially a Green Building concepts.

This study attempted to establish the relationship between Vastu Sastra principles and Green Building concepts for the well-being aspects of the inhabitants. This study is also an initiation towards keeping the

faith on the traditional Indian architectural knowledge system sustaining over a millennia and its utility for contemporary generations. It is hoped that this research would serve the future generations in creating harmonious built environment in line with Green building concepts and Vastu Sastra principles attributes to the well-being of the humanity.

Conflict of interest

The author declares no conflict of interest.

References

- 1 Bauer M, Möslle P & Schwarz M, Green Building – Guidebook for Sustainable Architecture, Callwey Verlag, Munich, 2007.
- 2 Acharya P K, 'Architecture of Manasara', Oxford Univ. press, Chennai, vol. IV, 1933.
- 3 IGBC, IGBC Green New Buildings rating system® Abridged Reference Guide, Hyderabad, India, 2014.p85-98.
- 4 GRIHA, GRIHA- Abridged Document, GRIHA Council and The Energy and Resources Institute, 2015.
- 5 Croome D C, Sustainable Intelligent Buildings for Better Health, Comfort and Well-Being, University of Reading, UK,p31-33.
- 6 Croome D C, Creative and productive work places, In: Intelligent Building International, Taylor & Francis, p-1.
- 7 Laufer B, Goswamy B N & Dahmen A L, An early document of Indian Art: The Citralaksana of Nagnajit, Ramesh C. Jain publication, New Delhi, 1976
- 8 Steuer N & Marks N, 2008, Local Well being – Can we measure it?, New Economic Foundation and Young Foundation, London, p-9
- 9 Miller N G, *et al.*, Green buildings and productivity, *J Sustain Real Estate*, 1 (1) (2009) 65-91.
- 10 Steemers K & Swetha M, Energy efficient design and occupants well being: Case studies in UK and India' building environment, doi/10.2016/builenv.2016.08.25
- 11 Allen J, MacNaughton P, Laurent J G C, Flanigan S S, Eitland E S, *et.al.*, Green buildings and health, *Curr Environ Health Rep*, 2 (2015) 250-258, DOI 10.1007/s40572-015-0063-y, 2015, 2: 250–258,.
- 12 Bhattacharyya T, The Canons of Indian architecture or a study on Vastuvidyā, 1st edition: Calcutta: Firma K.L. Mukhopadhyay, 1947, p- 371.
- 13 Brenda E F, The symbolic merger of body, space and cosmos in Hindu Tamil Nadu, University of British Columbia, Contribution to Indian sociology (NS), Vol 10, NO. 2,1976.
- 14 Singh R P B, Nature and cosmic integrity- A search in Hindu geographical thought, *GeoJournal*, 26 (2) (1992) 139-147.URL: <http://www.jstor.org/stable/41145345>, 1992.
- 15 Rámráz, Essay on the aarchitecture of the Hindus, London: Published for the Royal asiatic society of Great Britain and Ireland by J W Parker, [Partial translation and comments on first chapters of the Manasara], 1834.
- 16 Shukla D N, The Hindu science of architecture (Engineering, Town planning, Civil architecture, Palace architecture, Temple architecture and an anthology of Vastu-Laksanas) and Hindu canons of iconography and painting 1st edition, Vastu Vanmaya Prakasana Sala, Lucknow, 1958.
- 17 Dagens B, 'Mayamatam – Treatise of housing, architecture and iconoraphy, IGCA Publications, New Delhi, 1994.
- 18 Sharma S K, Samaranagana sutradhara of Bhoja deva', Piramal publications, Delhi, 2012
- 19 Achyutan, A & Balagopal T S, 'Manushyalaya chandrika bashyam An engineering commentary', Vastu vidya publication, Cochin, 2006.
- 20 Veerasmy M, Sarvartha sirpa chintamani (Manaiadi sastram), B. Rathna Naicker and Sons, Madras, 1915.
- 21 Murugan I and Natarajan C, Reinforcing traditional Indian construction with modern construction - Investigation - Execution phase, Indian J of Tradit Know, Vol 8 (4),October 2009, p-629-632
- 22 Bhat M R, Varahamihira's Brihat samhita, Rev. edition, Vol. I & II, MLBT Publishers, Calcutta, 2003.
- 23 Ganapathi S, Building architecture of Sthapatya veda. Chennai: Dakshinaa Pub. House, 2001, p 238-244
- 24 Boner A and Sarma S R, eds. New light on the Sun temple of Konarka: Four unpublished manuscripts relating to construction history and ritual of the temple. Varanasi: Chaukhamba Sanskrit sansthan, Jaikrishnadas-Krishnadas prachyavidya granthamala, 1972.
- 25 Sonit Bafna (March 2000), "On the Idea of the Mandala as a Governing Device in Indian Architectural Tradition." The Journal of the Society of Architectural Historians 59: 26-49.
- 26 Fazeli H & Goodarzi A, The principles of Vastu as a traditional architectural belief system from an environmental perspective, WIT Transactions on Ecology and the Environment, 128, WIT Press, 2010.
- 27 Macdougall B G, Text into form –Dwelling, Cosmos and design theory in traditional South asia, Cornell University, 2008. <http://hdl.handle.net/1813/10307>