VAASTUSHASTRA CASE STUDIES ON COMFORT RESIDENCES IN DUBAI

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Abstract

This paper examines the comfort levels achieved in homes that are designed on the principles of *Vaastushastra,* specifically in terms of temperatures recorded inside homes in Dubai.

Vaastushastra is a vernacular architectural practice that comes from the Indian subcontinent. It is a theory that existed thousands of years ago and was used by artists, artisans and architects in order to understand the basics principles of design and its execution. The core philosophy of *Vaastushastra* deals with proportions, scale, orientation, placement of various internal functions, use of materials and the construction techniques that were used for architecture, sculpture and furniture design. The primary concern was that everything made by man should be in harmony with nature. The buildings that were constructed, used prescribed proportions, scale, indigenous materials and adequate construction techniques to blend into the environment.

The core aspects of *Vaastushastra* are, *Panch Maha Bhutas* (5 elements) and *Vaastu Purush Mandala* (Cosmic Grid). The *Panch Maha Bhutas* are earth, fire, water, wind and space, which represent the elements of nature. These elements are placed together on a grid known as *Vaastu Purush Mandala*. The functional use of the spaces is laid out on the plan based on the locations of the elements. The activities that are supported by the element are placed in the appropriate zone. Each element is a force of nature and therefore thought of as a source of energy.

Vaastushastra is commonly associated with good luck, prosperity and good heath when followed successfully but when the rules are not followed occupants of the house can experience the bad luck, misfortune and death. Thousands of years ago, many people would follow the rules of the *Vedas* possibly because the rules were accepted by the masses and the fear of ill fate was too engrained for anyone to take a risk of going against them.

In this paper key principles of *Vaastushastra* will be identified and five case study homes that are designed on these principles will be used to map the comfort levels of the houses. Principles of *Vaastushastra* are based on the five senses and the way to understand if this connection is to test the impact these spaces have on the senses. Sound is usually very controlled or stable within an average residential space and similarly smell is usually very pleasant unless there is a problematic area close by. Light differs within a space based on season and time of day but varies within a predetermined range of values. Temperature and humidity can vary drastically within indoor spaces based on the design principles applied to the house. In this paper the main focus will be to understand comfort through temperature and humidity.

The original texts of *Vaastushastra* state the principles of how homes should be designed but doesn't provide any explanations on why these principles should be followed. These rules were written before science, as it is commonly known today was understood, and therefore the rules of *Vaastushastra* aren't explained in this context. One possible explanation for following the rules of *Vaastushastra* is that the internal spaces stay close to comfortable temperature regardless of external temperatures.

Word Count: 7432

Principles of *Vaastushastra*

The core aspects of this theory are, *Panch Maha Bhutas* (5 elements), *Vaastu Purush Mandala* (Cosmic Grid), *Shad Varga* formulate and use of materials. Each of these aspects is interlinked and should not be examined in isolation. All of these topics are discussed in all the ancient manuscripts, each manuscript goes into different levels of details. The manuscripts simply list the rules that the architect should follow and do not provide any explanations.

The *Panch Maha Bhutas* (5 elements) are *aakasha* or space, *vayu* or wind, *agni* or fire, *jal* or water and *printhvi* or

earth. The explanations provided are based on traditional Indian scriptures such as the *Veda*s and aren't supported by western scientific foundation but forms the fundaments of understanding the theory.

Aakasha or space – this element incorporates all the cosmic energies such as gravitational forces, heat & light waves and magnetic fields. Its main characteristic is known as *shabd* which could be translated as 'sound'.

Vayu or wind – this element is the atmosphere around us, what causes movement and what transmits *prana*-universal breath. Its main characteristic is *sparsh* - touch.

Agni or fire – this element represents the heat and light of the fires, lighting and volcanoes, as well as the heat of fevers, energy, passion and vigor. Its main characteristic *drishti* is sight.

Jala or water- this element represents everything liquid, rain, rivers, the sea, as well as steam and clouds. It also represents all living plant material and its main characteristic is *ras* - taste.

Prithvi or earth- this element represents all solid matter, as well as everything we stand on – the Earth itself. It is also the element of *gandh* - smell. (Craze, 2001)

Element	Sense	Architectural feature
Ether (Space)	Sound	Auditory
Air	Touch	Tactile
Fire	Sight	Visual
Earth	Smell	Atmospheric (partially)
Water	Taste	

Table 1. Elements of Vastu, the Senses of human body and link to architecture

According to Hinduism the human body and the Universe are made of these 5 elements (K.Juyal, 2010). Therefore, it is suggested that the subconscious mind connects to the balance or imbalance of these 5 elements in the built space (Vir Singh, 2005). Each of these elements connects with one of the 5 senses – ether connects with sound, air connects with touch, fire connects with sight, water connects with taste and earth connects with smell (Pegrum, 2000). Table 1 above lists the possible connections between the elements, sensory organs and architectural features and shows that taste as the only sense that doesn't directly connect with any architectural feature.

The above mentioned five elements *Panch Maha Bhutas* are placed onto a grid of 9x9 squares which is an example of the *Vastu Prush Mandala* (Bubbar, 2005).This grid constitutes of three components, *Vastu*, *Purusha*, and *Mandala* that mirror the threefold nature of existence in terms of mind, body and spirit (Chakrabarti, 1998). There are 32 types of *Mandalas* ranging from a single site/plot to a combination of 100 sites/plots on a grid. For the purpose of this paper the (9x9) *Mandala* is the only one that will be discussed. This is a simplified grid that shows the locations of the elements on the grid. The elaborate 81 grid shows each square representing divine forces, demonic forces, animals, plants and other qualities/ adjectives (Dagens, 2000). ""The names of the forces or the processes involved in the evolution of the spatio-temporal cosmos are the *Devas* or *Devtas* (wrongly translated as gods because they are not personified)"" (Bhatt, 1979). The principles behind all the grids mentioned are the same; there is a specific corner of the grid allocated to each element. Fig.1 below shows how the *Mandala* represents the five elements of nature, which can be used to create positive spaces. The element mentioned in each corner is supposed to represent the allocation of the functions in the house.

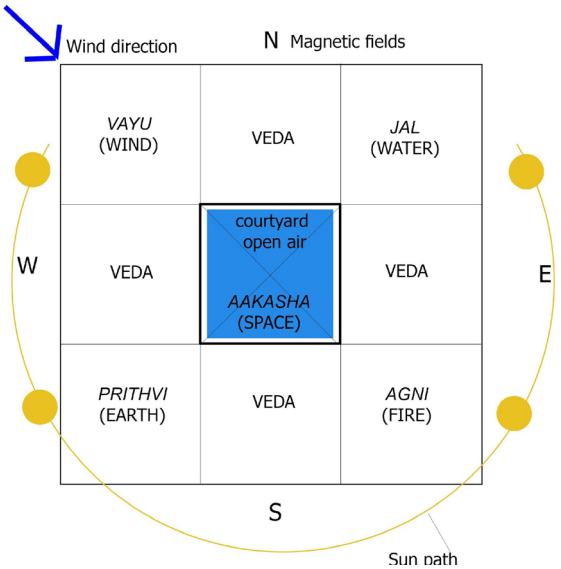

Figure 1. *Mandala* Grid with elements and influences of natural elements

Northeast corner is associated with water; therefore, the water features of the house should be placed in this corner. The possible explanation could be that water features placed in this corner would be outdoors and mainly exposed to the early morning sun when UV rays are the least. This doesn't mean that water can't be placed in other corners such as the southwest or other northwest, the optimal direction for placing water is the Northeast. Due to the combination of water and early morning sun, the northeast space is suggested for prayers (usually happen at sunrise) or any activity that happens in the morning.

Southeast is the fire corner this is possibly because it is exposed to maximum heat gain. It can be argued that the south side (both southeast and southwest) are equally exposed heat gain so why is the south east associated with fire? This thesis will test if there is a noticeable difference in the temperatures recorded in these rooms. Since it is the fire corner it is said to be the best place to locate the kitchen as it is the warmest location of the house.

Southwest is associated with the earth element. It is difficult to establish a link between the element and the direction in this case. Traditionally this corner is supposed to have minimal or no windows and is associated with heavy weight. The reason for the weight association could be because it is linked with the earth element which is a heavy material. Since the southwest direction is exposed to the setting sun it can make the internal space significantly warmer, which is the possible reason for minimal or no windows on the walls.

Northwest is the wind corner because it is the predominant wind direction in many parts of India. This is an example of the element reflecting the physical environmental condition of wind direction. The house should be designed so that this side should allow for wind circulation by either placing adequate windows or by creating low height-built structure.

The central space is associated with the element ether or space. The thought behind placing the element of space in the middle of the house is so that the center is kept empty. In an average size and larger house, the empty space means that this central location should be a courtyard. Based on the proportion of the site and the way in which the architect wants to include the courtyard, it's specific location can be altered. In a small house and can't allow for a courtyard it means that the central space should be free of any structural wall/ column.

After understanding the *Vastu Purusha Mandala* and the elements that link with it there is a possible reasoning behind the allocation of spaces based on the association with the elements. Table 2 shows the connection between the intermediate direction, element and the suggested function of the space.

Direction	Element	Function
North east	Water	Meditation
South east	Fire	Kitchen
South west	Earth	Master bedroom
North west	Wind	Bathroom
Centre	Space	Courtyard/ empty

Table 2. Elements of Vastu, the link to direction and function

The word *Shadvarga* translates to six-fold division and refer to a group of six proportions or six formulae which are used at the design stage when the volume of the house is created. The most important factor is perimeter of the building, i.e., the length and the breadth of the site must be in harmony with each other. The *Shadvarga* formulae are a series of simple calculations that use the length, width or perimeter of the plot to calculate whether the site is auspicious or inauspicious. When these rules were written, most people would comply with the rules without questioning them.

Based on the location of the site, the formulae are modified to accommodate the variations in climate conditions. Similar to the *Shadvarga* formulae is the *ayadi/ aya* formulae, which have different equations which are used to calculate different aspects of the site. The names of the six formulae each describe which aspect of the site it will calculate. The description of each formula is provided in brackets in English after the Sanskrit name which are as follows *Aya* (gains), *Vyaya* (losses), *Nakshatra* (asterisms) *Yoni* (matrices), *Vara* (solar days) and *Tithi* (lunar days). The results of these calculations should be within a specified range of numbers otherwise the measurements of the site are considered inauspicious. If the measurements don't give the desired outcomes by using the formulae, the perimeter size is adjusted so that desired outcomes would be achieved. There is no scientific explanation behind following these formulae, not to explain the aspects of gains, losses and so on that the formulae are titled. These formulae are used to calculate the ideal site proportions which in the authors opinion connect with the five core elements. My understanding is that these calculations were stipulated in the rules because they create guidelines for the proportions of the site. These guidelines underpin the proportions recommended as site proportions without having to list every specific combination.

User's Comfort factors

Comfort in any built environment can be assessed through many different criteria; some of these aspects are measurable through quantitative methods, some are qualitative and are expressed through feelings and others are ineffable such as the users' personal choices. Users' comfort in residential space is a vast topic, for this paper it will only be considered in homes that are designed based on the principles of *Vaastushastra* to be able to examine if there is a noticeable connection. This paper will consider the first two aspects of the users' comfort by measuring the quantitative aspects such as, temperature and humidity levels because these fluctuate the most during the day. Additionally, sound, smell and noise will be measured qualitatively through questionnaires in which the users' will be asked how they feel in the space. The quantitative and qualitative aspects of a space can possibly summarize the major comfort factors that the users identify with in built spaces.

This study was limited to understanding the touch or 'feel' of the houses which was achieved by recording the temperature and relative humidity. Since private homes were the main part of the study the sight, sound and smell were not measured because homes are very personal spaces and individuals who live there can usually control aspects of sight, sound and smell. The details of the sensory aspects are as follows-

• Sight is measured by the ability to be able to clearly see in a space by means of natural or artificial light. Light levels of a house can easily be modified to suit the occupant and the preferences they have based on the activity that is carried out. For example, some people like to sleep during the afternoon with the use of black out curtains and others prefer to read at night with artificial light.

• Sound doesn't typically vary too much within a home as the activities that create noise within a house are usually caused by its residents. Any noise that comes from the outside is filtered by the time they can be heard by the occupants and therefore shouldn't be too high. The sound level cannot be and should not be zero as constant silence is not always very pleasant. Some sound is needed but this sound should be minimal and nonintrusive. Reality is that sound is generated by the appliances in the house – heating or cooling systems or refrigerators or washing machines etc. and in Dubai due to the temperature outside the biggest problem of noise at home comes from constant use of air-conditioning.

• Smell is the level of pleasant or unpleasant odour that the user can detect. To an extent the odours of the house are also largely controlled by the occupants since the activities in the house determine the odours. At the same time there are some odourless gasses that are also harmful for the people. These smells and gasses are typically constant in houses and the variation is usually minimal depending on the air circulation of the house. The exceptions to this would be when the house is maintained with materials that contain VOC's, if natural ventilation is not provided in the kitchen then cooking gasses and odours can be troublesome to the occupants. In the case of the latter air fresheners (which don't contain VOC's) in the house can maintain pleasant odours.

• Touch is the aspect of the study that reflects how the user feels in the space. There are many factors that govern touch, from surface temperatures of the finishes used, to the clothing worn by the inhabitants of the space and to an extent by the way in which the space is built. This paper focuses primarily on the last aspect, which is the way in which the built space influences how the users' feel in the space. There are many aspects about the design and construction of the built space that have an impact on the temperature and humidity level and the comfort of the users.

Common principles of *Vaastushastra* and user's comfort

The common principles identified are as follows –

1. Orientation of the house – is a significant aspect in *Vaastushastra* because it one of the foundation principles and all other rules applied are based on the orientation of the house. Orientation have an influence on the internal temperatures that are achieved in the different corners of the house base on the direction. The assumption is that Northeast and Northwest are naturally cooler than the Southwest and Southeast side.

2. Placement and size of windows – *Vaastushastra* mentions the ideal locations for windows in the house which is predominantly on the North side for arid climates. Windows influence the amount of heat gained by the building therefore placing them in the appropriate direction with an appropriate size would mean less heat gain in the building. The North and East side are thought to favour windows and the South and West side are the unfavourable sides, especially in Dubai as the buildings are designed to avoid gain heat.

3. Proportion of the house – *Vaastushastra* stipulates that proportions of the site and the building through *Shad Varga* formula and one of the benefits of following this is the comfort of the users because of the internal temperatures. Overall the geometry and proportion of the house is thought to have an influence on the internal temperatures. Basic geometric shapes such as square and rectangle which have the required proportions should be able to help the indoor space stay at a temperature that is close to human comfort.

4. Proportions of the rooms in the house -the *Shad Varga* proportion system from *Vaastushastra* lays the rules for the proportions of the rooms as well as the site. Proportions of the rooms have an impact on the temperature recorded within the space. The preferred shape of the room should be square or rectangular and the rectangular shape is based on the specific proportions.

5. Use of courtyard in the house- *Vaastushastra* mentions that homes of a specific size and larger should have a courtyard. Mid-size homes and above can benefit from having a courtyard located in the centre of the house, as

this helps to achieve users' comfort in the house overall. The courtyard is also dependant on proportions itself and to the whole house.

6. Adding windows to the South or West side is possible if there are appropriate shading devices introduced. With the addition of shading devices, the heat from the sun could reduce solar heat gain.

Methodology

Two methodologies that were used for this paper are case studies and questionnaires. The case studies were used to understand the impact of applying principles of *Vaastushastra* to homes in Dubai. These principles were written in an abstract manner and might appear rigid at first, but architects who study these understand that there is an amount of flexibility suggested in them. Various devices can record physical attributes of a space, but this doesn't always equate to end users feeling comfortable. Questionnaires were used to identify how the residents experienced the spaces. The questionnaires were given to all the residents of the house to understand how each one of them felt in the space at different times of the year.

First methodology used is to understand the comfort level of touch in a space, which is associated with temperature and humidity and the feel of the space in terms of furniture and finishes used. The latter is constant in a space as the feel of the furniture and finishes remains the same till it is replaced. Individuals try to maintain the temperature at levels that suit themselves and since there are few people in residential spaces this is easier to achieve. Since UAE has two major seasons, internal measurements using data loggers were taken twice in each of the five case study homes. The quantitative data would show the temperature differences between internal and external temperatures during summer and winter months. External temperatures are very high in Dubai during the summer months; therefore, the occupants were allowed to use air-conditioning on occasion and maintained a log for this. The data below has been interpreted based on this factor. The winter months however are cooler, and the readings are taken without the use of air-conditioning. Case study homes are all different and comply with different principles of *Vaastushastra*, the data collected will help determine the impact these rules have on the internal comfort level of temperature and humidity.

Second methodology is to ask the occupants of the tested houses to fill in questionnaires about how they feel in the space. Temperature and humidity vary the most in a space and represents the sense of touch which was captured by placing data loggers. The other sensory connections of smell, sight and sound should be reasonably constant within residential spaces therefore loggers were not placed to measure these. However, it is important to know how the occupants feel about these sensations and were asked about them through the questionnaires. Meeting temperature requirements of a space doesn't always mean that it is comfortable for the users. The occupants were also asked how they felt about the temperature of the space in the questionnaires and the collected data will help to understand the comfort of the users in the space. This will help in understanding the impact the principles of *Vaastushastra* have on the five case studies.

Case Study Homes in Dubai

Dubai is a dessert and is predominantly a hot and humid climate, even though the humidity does not climb above the highest average level of 65% it is considered humid because the RH level does not fall below 55% throughout the year (ClimaTemps.com, 2009). The average highest temperature of Dubai is in the summer and is 41°C and low of 30°C while in the winter it is average high of 23°C and low of 14°C. These aspects of the environment have a strong impact on the research conducted and the data gathered for this thesis. For the purposes of this thesis mid-sized dwelling spaces which are three- or four-bedroom independent homes built on the principles of *Vaastushastra* in Dubai will be considered. The reason for the selection is based on size of the house, its adherence to the principles of *Vaastushastra* and the similarity of the users' profiles. The average size of these houses is kept between 250m^2 to 500m^2 which should be sizeable enough to record differences in comfort factors in different parts/spaces of the house. If small houses were selected the space would possibly have similar recorded measurements on all sides and parts as the limited dimensions would create similar conditions in all corners of the house. Larger homes are very limited in Dubai out of which very few are designed on the principles of *Vaastushastra* and therefore have been eliminated. The users' profiles for the different houses will be kept similar in terms of their requirement to live in a house that is designed based on the principles of *Vaastushastra.* This connects the users' in terms of accepting the requirements of vernacular design. The homes are located in residential neighborhoods in Dubai, namely Al Mankool, Al Jafliya and Jumeriah 1

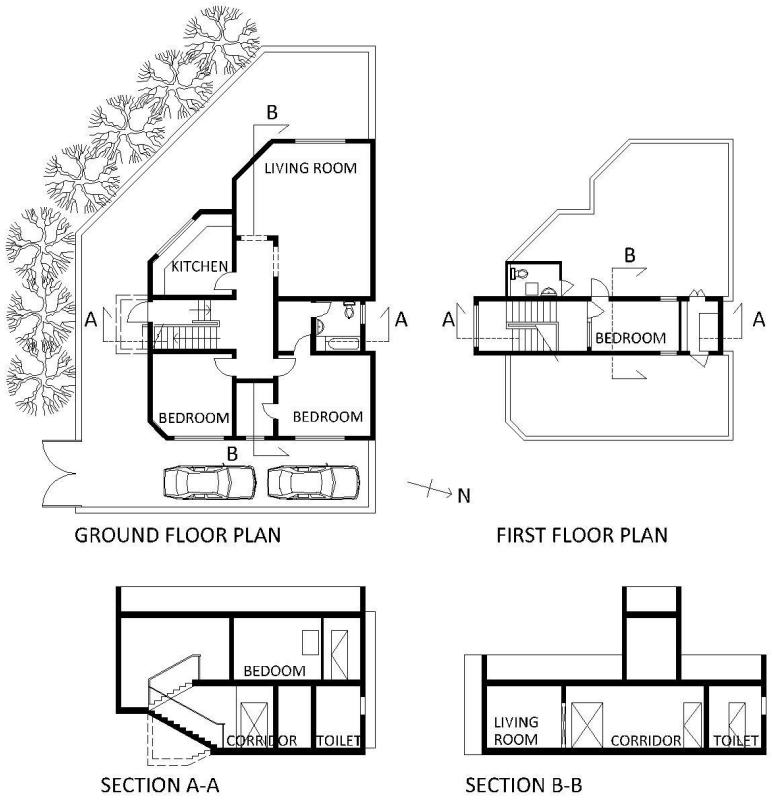

Figure 2. Plans and sections of Case study 1

Case study 1

The house selected for the first case study was a mid-size family home which was approximately 250m^2; it was built on two levels with an internal staircase and a back-garden space. The cooling system used in the house is individual air-conditioning units. In addition to this the house has a ceiling fan in the living space and floor fans around the house and these are used in suitable weather conditions. There are openable windows on both levels of the house, of which there is a sliding glass door that opens into the garden area and is also used as a window.

The house is not thoroughly aligned with all the rules of *Vaastushastra* but does follow some of the crucial ones which are the following –

• This building is oriented around the North/ South axis, but it is aligned with the short axis of the building. It is important that the main axis of the building (short or long) aligns with the North/ South axis and isn't aligned at an angle higher than 15°.Therefore this house complies with the principle of orientation.

• Most of the windows of the house are placed correctly on the North and East side. But there are a few windows on the South and West side which is not in line with the principles of *Vaastushastra*. The windows on the South and West side will help determine of the impact these have on the users' comfort levels in the space.

• The proportions of the house itself comply with the proportions that are established by *Vaastushastra* as the house is rectangle as an overall shape.

• The rooms within the house also follow similar proportions as each room is rectangular and based on similar proportions as the whole built space. The concern is that some rooms are cut off at corners, this helps examine if the pure geometry has an impact on the comfort levels of the users.

• This house doesn't have an existing courtyard and therefore doesn't comply with this specific requirement.

• The house has windows on the South and West side, but these windows do not have any window overhangs or shading devices. This will help determine if there is heat gain from these sides of the building and if it has an impact on the users' comfort factors.

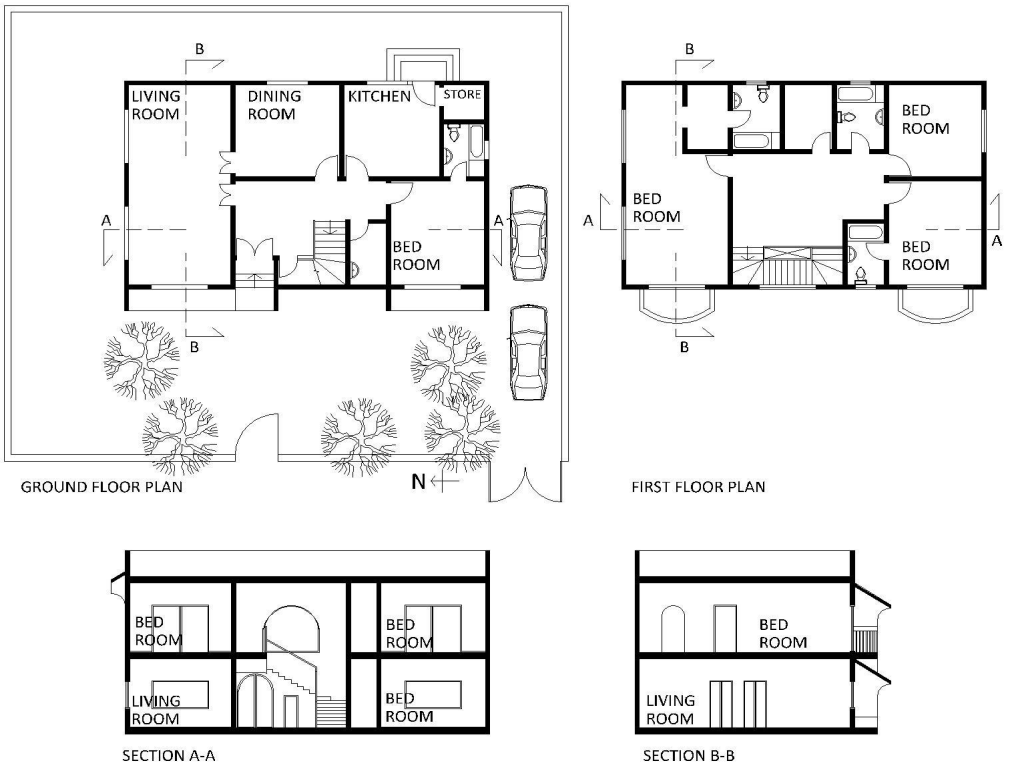

Figure 3. Plans and sections of Case study 2

Case Study 2

The second case study selected was similar to the first case study in terms of size as it was 260m^2 with two levels, an internal staircase and open garden space. Each of the rooms that are occupied have individually controlled air-conditioning units and the corridor spaces do not have any operable cooling systems. No other cooling systems are used in the house. There are openable windows on both floors and balconies on the upper floor with openable glass doors which are utilized as windows allowing ventilation in the cooler months.

The house is compliant with the rules of Vaastushastra in the following ways –

The orientation of the house aligns with the cardinal directions and the length of the house lines up with the North/ South axis which is a core principle of *Vaastushastra*.

The windows in the house are on most sides which includes the sides that are thought to be positive North, East and the side that are thought to be negative West.

• The proportions of the whole house are based on the proportions of *Vaastushastra*; the house is rectangular in proportion which is one of the recommended ratios and shape.

• The rooms within the house are rectangular and square and match the overall proportions of the house.

• This house doesn't have an existing courtyard and therefore doesn't comply with this specific requirement.

• In this house there aren't too many windows on the South side of the house, just one small window on the South-east façade and this doesn't have an overhang. The West side of the house has many large windows, but these are set back into the house and have an overhang to possibly prevent heat gain.

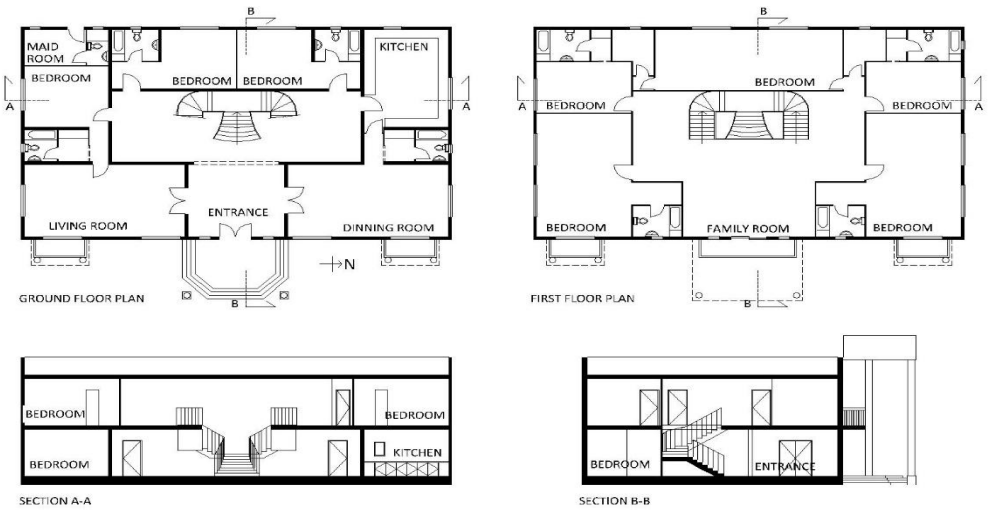

Figure 4. Plans and sections of Case study 3

Case Study 3

The next house is larger than the first two and is 350m^2 in built up space. This house is also a two-storey house with an internal staircase and an elevator, but the outdoor space is not utilized as a garden or green space. The compound space in this house is used primarily for parking the remaining space is paved and used as an outdoor seating space. The house has central air conditioning units with individual controls for each room. There are no other cooling systems used in the house. There are openable windows that can be used for cross ventilation when the weather gets better.

The house is compliant with the rules of *Vaastushastra* in the following ways –

• The orientation of the house aligns with the cardinal directions and the length of the house lines up with the North/ South axis which is a core principle of *Vaastushastra*.

• The windows in the house are on all sides. Windows on all sides help to determine if these windows have the expected impact on the interior space and on the comfort levels of the users.

• The proportions of the whole house are based on the proportions of *Vaastushastra*; the house is rectangular in proportion which is one of the recommended ratios and shape.

• The rooms within the house are rectangular and square and match the overall proportions of the house.

• This house doesn't have an existing open courtyard but there is an existing central space which has a roof. Without an open courtyard the house doesn't comply with this specific requirement.

• The house has windows on the South and West side, but these windows do not have any window overhangs or shading devices.

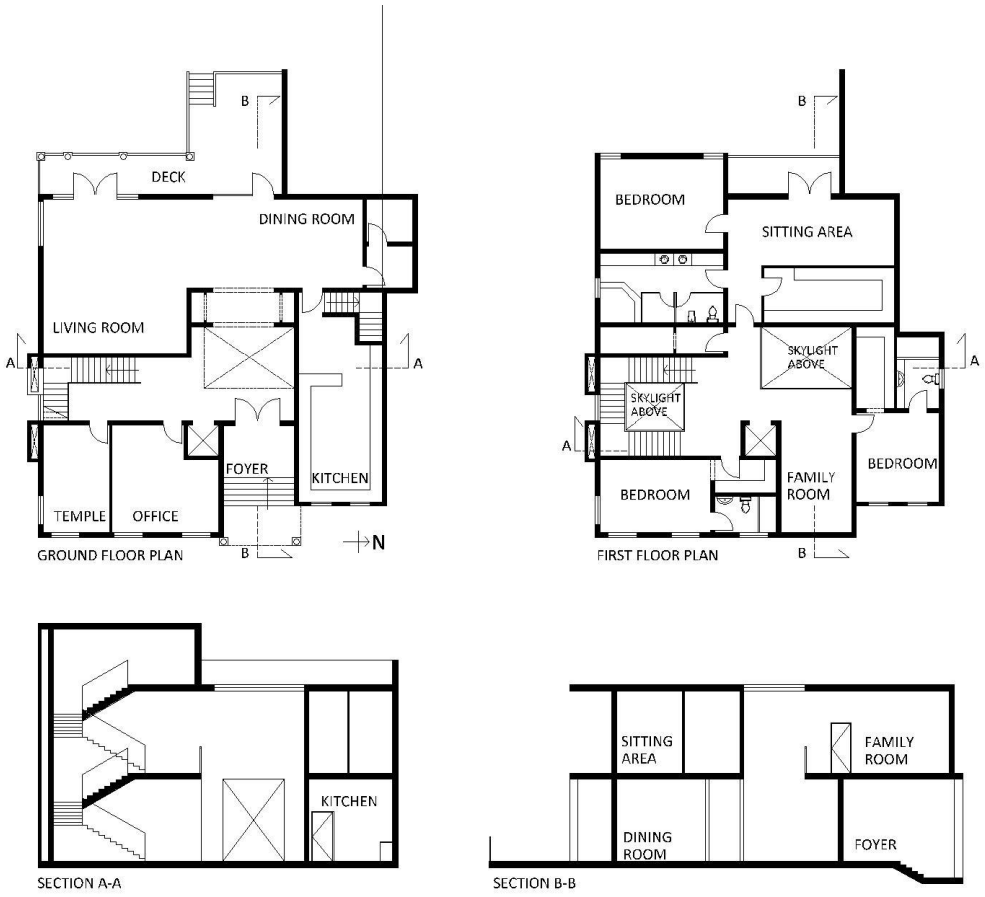

Figure 5. Plans and sections of Case study 4

Case study 4

The fourth house is also larger and has a built up of 500m² built up space. This is a two-storey house which has two sets of internal staircases and one elevator. This house is part of a compound of three villas and therefore sharing its compound space with the other houses. The shared compound space is primarily used as car parking space and each house has its own deck space which is used for outdoor private sitting in the cooler months. The outdoor space is completely hardscaped only without any trees, plants, shrubs or lawn. The geometry of the house isn't an exact square, but the overall proportions and shape match those stipulated in *Vaastushastra*. Main source of cooling in the house is the central air- conditioning and each space has a control of its own. No other cooling systems are used in the house. The house does have openable windows that can be used for cross ventilation when the weather gets better.

The house is compliant with the rules of Vaastushastra in the following ways –

• The orientation of the house aligns with the cardinal directions and the length of the house lines up with the North/ South axis which is a core principle of *Vaastushastra*. Since the house is close to the proportions of a square, either dimensions of the house are similar and therefore can be considered as the length of the house. The house is aligned with the true North and is therefore highly recommended in terms of alignment with the cardinal directions.

• The house doesn't have too many windows and is used to study the impact this condition has on the internal conditions and users' comforts. There are maximum windows on the East side, with a couple of windows on the South side and openable glass doors on West side. The room in the Northwest corner is the only one that doesn't have any window. By measuring temperature and humidity on all sides it is easy to compare the recorded temperature and understand the impact that the design of the house has on the internal space.

• The overall shape of the house is rectangular and therefore follows the principles of *Vaastushastra*.

• The proportions of most of the rooms are either rectangular or square which follow the rules of *Vaastushastra*, except for the one room on the ground floor which is very long in comparison to its width.

• This house doesn't have an existing courtyard and therefore doesn't comply with this specific requirement.

• The house has windows on the South and West side, but these windows do not have any window overhangs or shading devices. This will help determine if there is heat gain from these sides of the building and if it has an impact on the users' comfort factors.

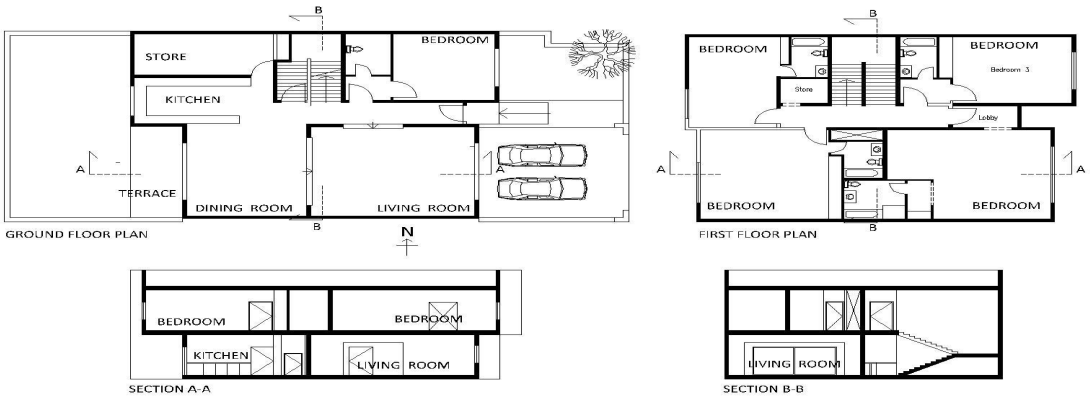

Figure 6. Plans and sections of Case study 5

Case study 5

The last house selected as a case study has a built-up area of 500m^2. This is another two-storied house which has an internal staircase and outdoor green space. The house is independent and doesn't share the compound with any others. The compound space is used for parking and has a front garden and a patio at the back with an outhouse. There are portable fans to support the air-conditioning system. There are openable windows on both levels of the house, of which there is a sliding glass door that opens into the garden area and is used as a window.

The house is compliant with the rules of Vaastushastra in the following ways –

• The orientation of the house aligns with the cardinal directions and the length of the house lines up with the East/ West axis which is accepted in *Vaastushastra*. The house is aligned with the East and is therefore studied to understand how the variation will impact the space.

• The house doesn't have too many windows and is used to study the impact this condition has on the internal conditions and users' comforts. There are maximum windows on the East side, with a couple of windows on the West side. By measuring temperature and humidity on all sides it is easy to compare the recorded temperature and understand the impact that the design of the house has on the internal space.

• The proportions of the whole house are based on the proportions of *Vaastushastra*; the house is rectangular in proportion which is one of the recommended ratios and shape.

• The proportions of most of the rooms are either rectangular or square which follow the rules of *Vaastushastra*. Use of rectangular and square geometries as the shape of the rooms and the house will help determine the impact these have on the comfort levels of the users.

• This house doesn't have an existing courtyard and therefore doesn't comply with this specific requirement.

• The house has windows on the East and West side, but these windows do not have any window overhangs or shading devices. This will help determine if there is heat gain from these sides of the building and if it has an impact on the users' comfort factors.

Case Study findings

Summer temperatures can be very high in Dubai ranging higher than 40°C and not dropping below 30°C. These temperatures make it very difficult for people to go outdoors for extended amounts of time, or to stay indoors without the use of air-conditioning, which made it difficult to record temperatures of the house in the summer. One option was to place the data loggers in the case study houses when the occupants were on holiday, but since there were different families they would go away from the house at different times in summer. To understand the impact that the design of the house had on the internal temperature of the house the external temperature had to be a constant factor and therefore it was important to conduct these tests on the same dates. Occupants of the house were asked to maintain a log of the time that the air-conditioning was switched on and off in the house and was considered during the analysis of the temperature and humidity data collected.

Data loggers were placed in four intermediate directions of the house during both summer and winter. Each time the loggers were placed at the same location in the house and were kept there for the same duration of 10 days. The temperature and humidity readings where recorded at intervals of 10 minutes to be able to understand the times at which changes occurred. The data was collected from all the houses and the below bar charts show the outcome.

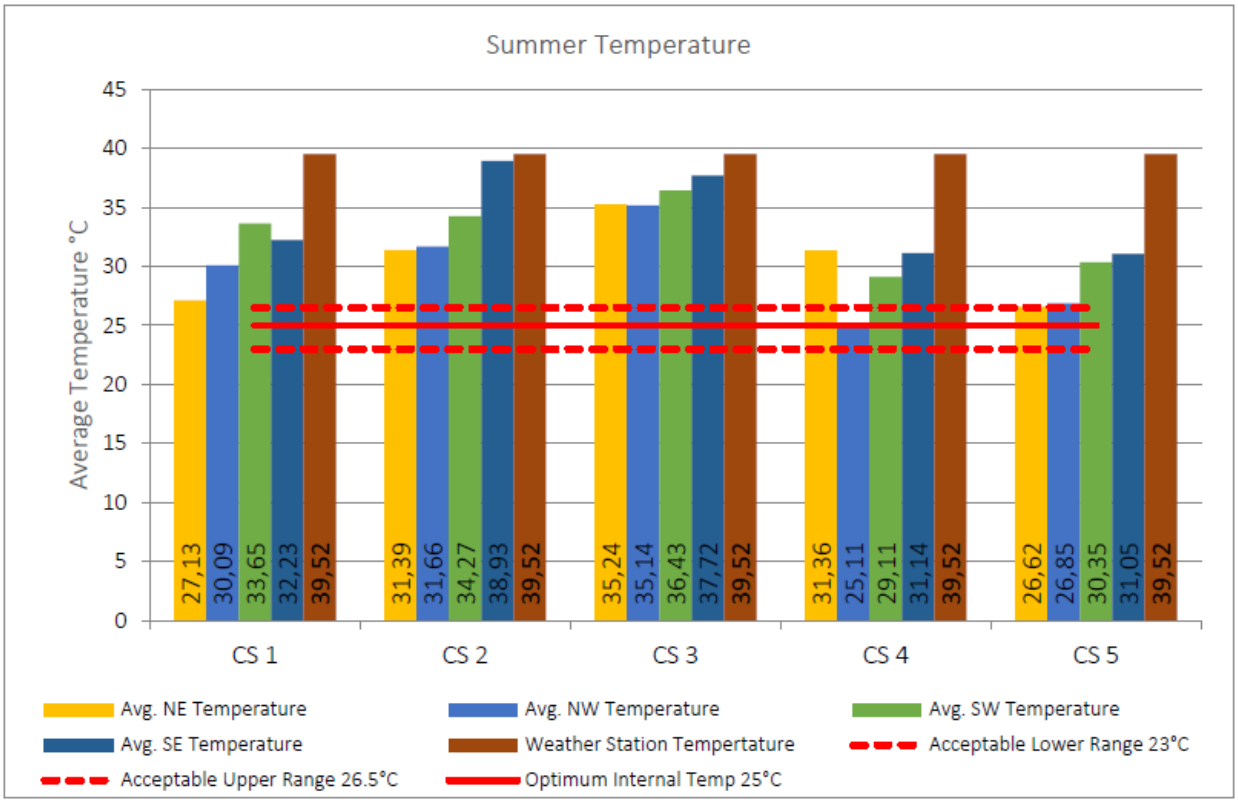

Figure 2- Comparison of Average Internal Temperature of Case Studies (CS) in Summer

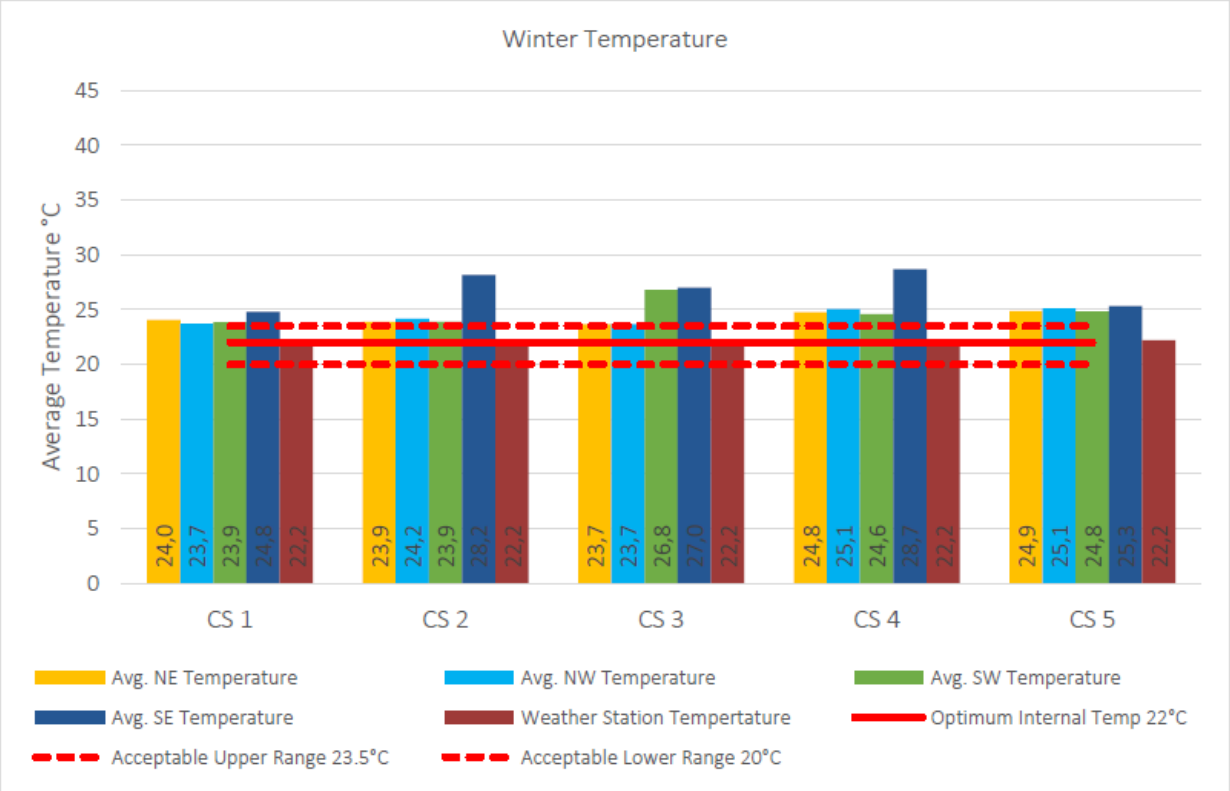

Figure 3- Comparison of Average Internal Temperature of Case Studies (CS) in Winter

The following observations can be made from the data collected -

• In comparison to the outside temperature the warmest corner is the Southeast corner, followed by Southwest, Northwest and Northeast, with a couple of exceptions. In case study 1 the Southwest corner is the warmer than Southeast and in case study 4 the Northeast temperature is as warm as the Southeast during the summer months only.

• A possible cause for these exceptions could be the proportions of the rooms in case study 1. The Southwest

room in this house has a cut and doesn't follow the proportions of *Vaastushastra* which is the reason for the variation in temperature.

• The exception seen in case study 4 is that the Southwest room is much cooler than the Southeast room, which is because the Southwest room has no windows and therefore there is no heat gain or heat loss. This also verifies that if the rooms on the South side do not have any windows it will be a cooler space.

Findings from users' questionnaires

To understand whether the principles of *Vaastushastra* had an impact on the comfort levels of users they were asked to fill in questionnaires. Even though user's experience of a space is subject to their age and gender as these factors have an impact on the way people experience spaces; the data on age and gender of the user was not collected as this would create too many variations in understanding the different levels of comfort that were experienced in the house. The questionnaires were used to understand the levels of comfort that the users' felt regardless of their age and gender. The findings of the questionnaires are summarized into the main ideas for this paper.

All the houses selected for the case studies follow the basic principles of *Vaastushastra,* some of the houses are more adherent while some are less. Findings from the questionnaires support that the houses which align more with the principles of *Vaastushastra* are more comfortable for the users. Most of the occupants didn't complain about noise levels from outside because the houses were in residential areas. Only case study 5 had an issue with sound when they left the windows open because the window opens to a noisy street. Some of the occupants had problems with amounts of natural light received in the house, which could relate to the orientation and number of the windows. All the occupants were comfortable with the smell around the house since there was nothing around that caused any bad odors. Touch links to the temperature and humidity of the house. The occupants' answers in the questionnaires were similar to the findings from the data loggers mentioned above. The residents of case study 3 mentioned that they relied most on air-conditioning during summer and winter months equally, which ties into the fact that the house has windows on all sides and therefore is warmest of all the case studies.

Conclusions

Case study 1 follows most of the principles of *Vaastushastra*, except that the southwest room is not rectangular, there is a cut in one corner of the room. Since this room doesn't follow the principles of proportions and geometry it is warmer than the southeast corner of the house in the summer months. The temperatures of the house during the winter months are within acceptable comfort levels even without the use of air-conditioning. The house has acceptable internal temperatures in the winter months with the exception of the southeast side which is completely glazed and therefore increased heat gain is observed. In this case study the window extends over both the floors as it is a window and this causes heat gain.

Case study 2 is the warmest in the Southeast side during summer (higher levels than case study 5) because there is a southeast window which causes heat gain, whereas the southwest side isn't as warm because there is no glazing on the south side. The window on the southwest side is covered by an overhang and therefore helps to maintain lower temperature. The west windows allow for cross ventilation of the air and the shaded structure helps to prevent excessive heat gain. During the winter months the house is comfortable except for the southeast corner which is naturally warmer by 5°C due to exposed glazing on the south side.

Case study 3 remains the warmest of all the houses in the summer, which is due to the fact that there are windows on all sides of the house and that the central space is covered with a roof. The windows on the south and west side should have shading structures to prevent any heat gain. If the central space had been used as an open courtyard the overall heat might have been reduced. The courtyard allows for cross ventilation and gives an opportunity to shade some of the openings on the south and west sides. During the winter months the north side of the house is within comfort levels and the south side still stays warm without the use of air-conditioning.

Case study 4 the northwest room is the coolest and the northeast room is warmer than the southeast room during the summer. This is because the northeast room of this house is not of ideal proportions, it is too long and narrow which is the reason for the heat gain in summer. Due to glazing on the south wall the southeast room remains warm during the summer and the winter. The southwest room has a temperature which is lower than expected because there are not windows on either walls of this space which helps maintain a comfortable space which doesn't receive any direct natural light. This space is open to the room in northwest which allows for indirect light to filter through.

Case study 5 is the coolest house from all the studies because of several factors. The house is oriented around the North to South axis which in this case is aligned on the short axis rather than the length. This explains why the principles of *Vaastushastra* are written in an interpretive manner to suite the site. Even when the length of the plot is on the East to West axis the house confirms with the rules. Placement of windows plays a key role because there are windows on the East and West façade and the windows on the latter have an overhang above them which prevents heat gain. The summer and winter temperatures of the house stay within the comfort zone except for the South side during the summer which sees a significant gain in temperature.

From the studies of the five houses during summer and winter some common principles are suggested –

• Houses that are designed based on the principles of *Vaastushastra* create spaces in the house that are relatively more comfortable than the other parts of the house.

• The use of the internal spaces should be decided based on the orientation of the house, so that the spaces that are most comfortable are used by the residents. For example, the Southeast space is the warmest in the house, therefore the living room or family room should not be placed here because it might be uncomfortable for the users.

• The variations in temperature gain or loss could be due to placement of windows, size of windows in proportion to room size or the orientation of the plan in relation to the North South axis.

References

Bhatt, R. K., 1979. *The Vedanta of Pure Non-Dualism.* Virginia: The Donning Company/ Publishers.

Bubbar, D., 2005. *The Spirit of Indian Architecture.* New Delhi: Rupa & Co..

Chakrabarti, V., 1998. *Indian Architectural Theory: Contemporary Uses of Vastu Vidya.* Surrey: Cruzon.

Craze, R., 2001. *Vaastu: The Indian Spiritual Alternative to Feng Shui.* s.l.:Carlton.

Dagens, B., 2000. *Mayamatam Treatise of housing, architecture and iconography Vol I,II.* 3rd ed. New Delhi: Indira Ghandhi National Centre for the Arts.

K.Juyal, M., 2010. *Hinduism-The Sanatan Dharma.* New Delhi: Aravali Printers & Publishers (P) Ltd.,.

Pegrum, J., 2000. *Vastu Vidya: The Indian Art of Placement.* s.l.:Gaia Books.

Vir Singh, D., 2005. *Hinduism An Introduction.* 4th ed. Jaipur: Surabhi Prakash.