Assessment of the Behaviour of ‘Courtyards’ as a Design Element in India and its Implication as an Environmental Solution

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ABSTRACT: The modern and contemporary architecture in India consists of elements that are derived of ancient cultural values and built forms. Courtyard as being one of these elements, through its multifaceted characteristics maintains the fine balance of the humane facet, poetic expression and environmental delight. These attribute and advantages of the courtyards help in ensuring the socio-cultural and spatial order of the built-form. Apart from these, this paper aims to investigate the real need of incorporating the courtyard as a design element in modern architecture by bringing out its importance as a microclimate modifier, environmental comfort provider and as an economic solution to the high density housing needs in an urban context. Designed by Charles Correa, two case study buildings which the courtyard is exploited as a key environmental design element have been studied in detail. Based on the findings from this study, this paper further explores the potential of achieving an optimum courtyard with desirable height to width ratios for housing design. As a conclusion, guidelines for designing a courtyard building in a warm climate of India have been proposed.

Keywords: Courtyard, spatial delight, environmental comfort, climate responsive architecture

INTRODUCTION

India being a source of infinite cultural significance, the modern architecture of India lays its roots deep into the ancient cultural values. The socio cultural, historical, spatial and environmental contexts of those times are reflected in these spaces that tend to evolve with time. Again, as India is a home of diverse climatic variations, these spaces vary in terms of their physical attributes and hence the fine balance of the humane facet, poetic expression and performance of these spaces becomes inevitable. Indian architecture has developed with time absorbing many aspects which were a result of the global dialogue with many other regions throughout its enriched old past. The contemporary architecture in itself has a growing realization, that just to build visually beautiful buildings would be useless, unless it has a backed inclusion of concern towards its climatic context and human comfort.

Moreover housing that consists of a significant proportion of national investment in India, plays an important role in the economic development plans. In the sector of housing, the courtyard typology is widely accepted to be responsive to low-rise high density urban housing and is an appropriate form within contemporary mixed use sustainable development. But nowadays, the building regulations and planning laws are greatly influenced and modelled on the Western practice with scant regards to the social and environmental aspirations or to climate. Hence the courtyard typology that was maintained throughout the traditions, found itself contravening the modern regulations.

The study undertaken here is to take issue with these controversial ‘Westernized’ modern regulations by pointing out the benefits of the courtyard in a dwelling as well as in a housing scheme. By addressing themes such as environmental performance, societal behavior, gender and privacy (in case of Muslims), religious importance, economic viability, the paper altogether with a theoretical framework and investigative analysis hopes to present the inclusion of courtyards as representing a better model for sustainable development in India than ‘imported’ housing typologies, aspiring for the betterment of the architecture to be approached in a more environmentally holistic manner, making the buildings
‘green’ rather than ‘green washing’ them. The sole hope is to influence the present and by implication, the future.

INFLUENCE FROM THE PAST
India, being an amalgamation of various traditions, diversity is found in its architectural styles that are derived mostly from the climate and the culture. Furthermore, Rapoport explains the importance of climate and culture by recognising them as two most important determinants out of multiple determinants, in contrast with other historians stating climate response as being the only factor to influence the built form.

An insight into the various traditional houses around India indicates that the courtyard evolved from an arrangement where separate small structures were built around a central open space, which eventually got covered under one roof. The traditional Hindu architecture of India saw courtyards in the palaces and havelis whose position were influences by the ancient Hindu scriptures being more extravagant in scale and architectural expression than the traditional houses. As shown in figure 1, in conjunction with the central courtyard, a series of colonnaded pathway looped on the four sides, which formed the spatial configuration of the building. This pathway acted as circulatory spaces serving to the rooms as well as acting as a buffer between the court and living areas. The use of double roofs, screens, fenestrations and buffers are an indication to the climate responsive architecture in the traditional buildings.

The Mughal architecture, one of the more dominant styles that influenced the traditional architecture of India, had an extensive use of courtyards, the function of which varied from more social to private, in palaces and houses respectively. Fatehpur Sikri, one of the finest and most impressive wonder of Mughal architecture, in Delhi, is indeed prodigious and romantic as an influence, but more impressive to us for its unique ability to assemble itself in the harsh climatic context, yet boast of its scale, quality, diversity of buildings and the spaces they define.

As shown in figure 2 and 3, it consists of a series of animated urban squares that are defined by the structures around it, thus making a formation of interlocked courts united to each other by means of structures. This specific arrangement thus involves the creation of different spaces for different seasons, with light airy courts to catch the prevalent south west breeze, combined with the shaded courts with implicit use of landscape. The ceilings in the rooms around the courtyards were relatively higher, to provide cross ventilation as well as prevent excessive heating in the dry season, while the extensive colonnades provide shelter from the sun and rain. A wind movement from court to court is created due to the pressure difference, the landscape and water bodies present in the court, these winds become cooler, thus cooling down the temperature in the structures that are present in between.
THE CLIMATIC CONTEXT
The core principle behind climate responsive design is the understanding of the climatic parameters in which the building is situated.

For the study of implication of courtyards in warm climates of India, the hot climatic conditions of Mumbai are taken, where it remains humid throughout the monsoon, or else wise dry. Ahmedabad, a city on the western interior of India, has a similar characteristic to Mumbai, but experiences less humidity throughout the year except for the monsoons.

The main characteristic of this climatic zone is that it has three seasons, experiencing seven months of dryness with the rainfall peaking in July. The cool season from November to February is followed by the summer season until early June. The monsoon periods are from June to September, where the temperature remains moderate with high levels of humidity.

The wind direction is mostly from the southwest, that brings rains to the city, whereas the direction changes from north-east to north during the cooler period in December. The average annual temperature in Mumbai is 28.2°C, whereas it is 31.5°C in Ahmedabad. The daily mean maximum temperature ranges from 29.6°C to 34.7°C, while daily means minimum ranges from 16.8°C to 26.4°C, thus the diurnal variation in temperature useful for night ventilation. The significant difference in Ahmedabad is that it experiences a tinge of hot and dry climate characteristics with its highest temperature shooting above 40°C.

The temperature remains out of the comfort level generally in summers in both the cases of Mumbai and Ahmedabad except for late monsoons and winter. The comfort range established here is from 23°C to 30°C for medium labour activities. Hence there is a need of a strategy which enhances ventilation in summers and monsoon and methods of improving the effectiveness of mass cooling by night time ventilation.

COURTYARDS: THE PENETRATING SPACE
(PAREKH HOUSE, CHARLES CORREA)
In the midst of the modernist hue and cry for ‘green architecture; surfaces the architecture of Charles Correa, whose designs have evoked a notion of climate responsiveness equally balanced with the intricacy and refinement of his spaces, illustrating how sustainability can be achieved through passive strategies.

A degree of climate ‘control’ that involves the physical characteristics i.e. the section, the plan, and the courtyard, which is the ‘heart’ of the building, for Correa, these have been the tools for dealing with the elements of the nature especially for a warm climate, which is clearly seen in the Parekh House, Ahmedabad. 
As shown in the Figure 6, the development of the sections of the residence along with the orientation of the court with solid walls blocking the harsh radiation from the east-west orientation enables in shading the courtyard. The overall building form through its summer and winter sections coagulate the architect’s environmental concerns of having a protective layer over the habitable spaces as well as the courtyard, which is the sun roof. The conjunction of the height-width ratio with the solar angles shades the court at different times of the day, thus making it more functional.

Figure 6 Diagrammatic representation of the evolution of the concept (Source: Correa')

Figure 7 Diagram showing the ventilation route in a system formed by the courtyard and the 'summer and winter sections'
(Source: Author from Ecotect)

Figure 8 Graph showing the (a) Comparison of average dry bulb temperature in both sections with the external temperature (b) Comparison of average dry bulb temperature within both the sections (Source: Author from TAS simulation)

Thus, the development and evolution of the form of the residence and internal conditions achieved through a ‘system’ of courtyards and terraces, draws a clear intent of the architect, which is the interrelation of the spatial configuration around the courtyard (tangible) with the movement pattern of the occupants in the residence (intangible) in coherence with the activity and time of the day.

Figure 7 shows how the courtyard serves the purpose of a light distributor in the centre, as the plan of the residence being deep. A continuous circulation of cool air is induced as it draws the warm air from the surrounding spaces that get replaced by cool air. Hence the internal temperature in the habitable spaces is reduced which is inveterated by the graph in Figure 8. The winter section is cross ventilated, keeping the living spaces habitable. The cool overnight air is entrapped by the rather indistinctive courtyard, which in turn helps to cool down the interiors in the hot afternoons the following day.

The graph in the Figure 8 indicates that the internal temperature is lower than that of the external during summers, whilst in winters a comfortable thermal environment is experienced. There is a difference of 2°C between the spaces of both the sections that enables the movement of the users throughout the dwelling diurnally as well as seasonally. As inferred from the graph, the conditions remain out of the comfort zone, yet due credit is owned by the architect for his belief in his environmental concepts of keeping the internal conditions within the comfort zone almost throughout the year, through the presence of a courtyard.
COURTYARD AS A MICROCLIMATE MODIFIER (BELAPUR HOUSING, CHARLES CORREA)

There are certain unique characteristics of the Indian socio-cultural setup that drives its housing scenario, the most common being the structure for the joint family to live under the same roof.

The economic viability of cost reduction and its urban implication through enhancing social interactions, is illustrated by Charles Correa, in Belapur Housing, a courtyard housing project in the urban scenario of Mumbai. The main feature of the project is the pattern in which the units are packed close enough to achieve high densities, yet having open spaces acting as courtyards (within the unit as well as between the units); and separate enough to have an individual identity and growth. Hence, a new dimension of urban equity is added on with this type of courtyard housing.

The physical plan is based on the open/enclosed space trade off. Within the plot each family has a courtyard that forms the kitchen yards, terraces, etc. to compensate the built up area. Each of these courtyards within the space can act as a room in itself, thus adding to the multi functionality aspect. These units are clustered around an intimate courtyard of 8 x 8 mts. that forms the communal space of the particular cluster. The hierarchy continues until the spatial organisation is achieved on a larger scale where social facilities are made available.

The aspect that is to be laid stress upon in the configuration of the courtyards that at all different levels they are set strategically orientating towards the southwest in order to capture the cool air coming from the river, which being the predominant wind direction throughout the year in Mumbai. These winds help in creating a microclimate of its own and altogether with the system of courtyards and vegetation on the site, it keeps the environment cool.

As shown in the figure above, the courtyard in the centre draws the warm air from within the dwelling, hence it getting replaced by the cool air. The warm air as it being light escapes through the courtyard. Also the presence of the trees in the central communal courtyard helps in maintaining a cool microclimate surrounding the dwellings, hence keeping the place naturally ventilated and thus keeping the internal environment comfortable.

Belapur Housing makes a statement in itself that combines the principles of equity, incrementality, environment and sustainability, spatial hierarchy, individual identity allowing participation to form one’s own environment. As such it is robust architectural solution based around the concept of courtyards that help in achieving the above attributes that are essential in housing for the poor. Hence the extensive and relevant use of courtyards for spatial hierarchy and a territory defining element, justifies Charles Correa’s notion of sustainability.
INVESTIGATION OF SHADED AND EXPOSED AREAS IN THE EXAMINED COURTYARD FORMS

![Diagram of a courtyard form with sun path](Image)

Figure 12 Investigation of the courtyard form with the annual sun path of Mumbai (Source: Author)

The following investigation presents the interaction between the sun and the geometry of the courtyard. It is aimed to develop an optimum width to height ratio of the courtyard form that remains shaded mostly through the summers and monsoon, whilst in winters letting the sun in. This is done by calculating the shaded areas of the internal envelope of the courtyard form. As a thumb rule it is well established that the temperature in the shaded area is comparatively lower than that of the exposed area, hence making the whole atmosphere cool.

The above research and analysis is not intended as a generalization, as it represents only a partial picture of the complexity of the factors underlying it. The findings of the research are based on a particular type of courtyard that is the enclosed open court, standing as an island, without the urban context.

The investigation is done for the climate of Mumbai. The geometrical parameters to be considered of the internal envelope of the courtyard are its height to width proportion, orientation, size. For the current investigation, a single orientation and rectangular shape as shown in the figure above is considered. \( W_1 \) is the width cross to the north-south axis, while \( W_2 \) is the width in line with it. \( W_1/H \) and \( W_2/H \) form the width to height ratios perpendicular and parallel to the north-south axis respectively.

<table>
<thead>
<tr>
<th>P= Incident Wind Angle</th>
<th>( W/h=0.5/1 ) Ratio</th>
<th>( W/h=1/1 ) Ratio</th>
<th>( W/h=2/1 ) Ratio</th>
<th>( W/h=4/1 ) Ratio</th>
<th>( W/h=6/1 ) Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>HSC</td>
<td>91%</td>
<td>76%</td>
<td>68%</td>
<td>65%</td>
<td>66%</td>
</tr>
<tr>
<td>VSC</td>
<td>76%</td>
<td>71%</td>
<td>67%</td>
<td>65%</td>
<td>66%</td>
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<tr>
<td>TS</td>
<td>83%</td>
<td>73%</td>
<td>72%</td>
<td>67%</td>
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<tr>
<td>Not Preferable, as wind movement generated is very low, though it depends on other factors</td>
<td>Not Preferable, as wind movement generated is very low and winter shading is high</td>
<td>Not Preferable, as winter shading is high</td>
<td>Preferable, as winter shading is high and summing shading being low</td>
<td>Preferable, as wind movement generated is very low, though it depends on other factors</td>
<td>Preferable, as wind movement generated is very low and winter shading is high</td>
</tr>
<tr>
<td>W/h=0.5/1 Ratio</td>
<td>Same as above</td>
<td>Preferable, when the fenestrations are located properly</td>
<td>Not Preferable, as summer shading is low</td>
<td>Not Preferable, as winter shading is high and summer shading being low</td>
<td>Preferable, as wind movement generated is very low, though it depends on other factors</td>
</tr>
<tr>
<td>W/h=1/1 Ratio</td>
<td>88%</td>
<td>73%</td>
<td>72%</td>
<td>67%</td>
<td>67%</td>
</tr>
<tr>
<td>W/h=2/1 Ratio</td>
<td>85%</td>
<td>72%</td>
<td>66%</td>
<td>56%</td>
<td>56%</td>
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<tr>
<td>W/h=4/1 Ratio</td>
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<td>62%</td>
<td>66%</td>
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<td>57%</td>
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<tr>
<td>W/h=6/1 Ratio</td>
<td>70%</td>
<td>62%</td>
<td>66%</td>
<td>59%</td>
<td>57%</td>
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| Source: Author from IES Virtual Environment |

HSC=Horizontal Shading Component  VSC=Vertical Shading Component  TS= Total Shading

CONCLUSION

It comes to ‘putting together all of the bits’, to achieve a final design solution as a totality, that achieves the objectives intended while designing. Based on the above research and investigative analysis, the following conclusions have been reached. These can also be recommended as general design strategies that can be incorporated together with the courtyard to work as onesystem, while designing in warm climatic conditions:

1. Advantage should be taken of the minimum night time temperature to cool down and keep the internal environment comfortable throughout the day.
2. It is recommended that the interior of the courtyard be well ventilated at night to ensure effective structural cooling.

3. External openings and windows should be preferably towards the north shaded wall.

4. Through previous research done on the same, it is been concluded that a semi covered courtyard or an open courtyard works better than that of the closed courtyard, as the heat trapped inside cannot escape thus making the internal temperature undesirable.

Finally, the analysis that has lead to the design of the optimum courtyard will lead to an understanding of its vast implementation as per site condition. The application of the findings of the study should help not only the architect but also the policy makers with a coherent approach towards achieving an integrated bioclimatic design with respect to courtyards. It is also hoped that the findings together with future research on the subject would represent as a good source of practical guidelines and information for designing climate responsive buildings in India.

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