Residential Cluster, Ahmedabad:
Housing based on the traditional *Pol*s

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ABSTRACT: Ahmedabad, a prominent city in west India is one of the fastest growing urban centers of the country. There is an increasing danger of energy crisis due to the rapid urbanization and extreme building activity in the city. The intention is to explore, in particular, the future of residential development in the city such that the predicted energy consumption values in ***the housing sector can be reduced*** *For developing a residential cluster which can be used as a model for future developments in Ahmedabad the* ***inspiration lied within the old traditional pol housing of the city.***
Keywords: outdoor comfort, pedestrian comfort, shading, street design

INTRODUCTION
This paper is based on a thesis which explores the future of residential development for the city of Ahmedabad, India. Various driving forces in the residential sector of the city have been recognised and interpreted to propose a model for future development which is in coherence with the existing. This is of particular importance to Ahmedabad as the city has various extremely diverse and contrast built environments that contribute to its urban fabric. This evident contrast has led the city to be perceived as divided into old and new city (Fig. 1[2]). The generic morphology of the urban fabric in the old city is called the *Pol*. It is believed that the *Pol* housing sustained itself for almost over two centuries but did not adapt itself to the rapidly changing lifestyle and perception of the people of Ahmedabad. The thesis focuses on developing a model residential cluster which interprets the *Pol* to modern needs, for the people moving out of the old city. The inspiration for this work largely lies in the essence of the traditional *Pols*, the street life, use of outdoor spaces etc. Thus, the proposal deals with urban issues of comfort in the context of the hot climate like that of Ahmedabad overlaid by the cultural background of India.

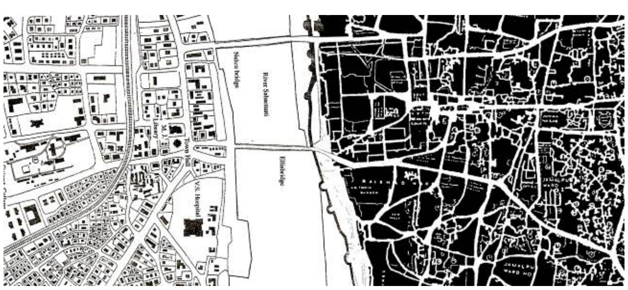


Figure 1: Contrasting footprint-old & new city, Ahmedabad [2]

CONTEXT - AHMEDABAD

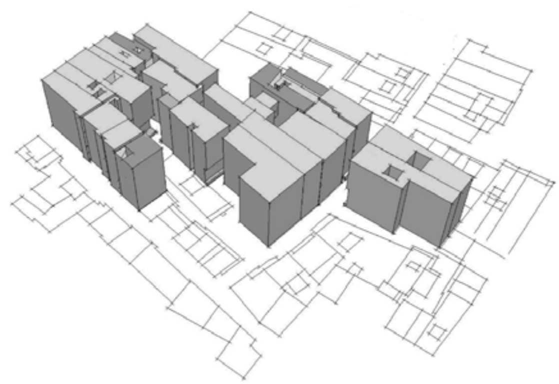


Figure 2: Diagrammatic representation of a typical Pol housing in the old city of Ahmedabad.

The *Pol*, a small residential unit consisting of a single street (usually a dead end street) with a group of houses is generally protected by a massive gate at the entrance. They are densely populated and when put together they look like a maze with winding narrow lanes forming a series of micro- neighbourhoods. The character of the *Pol* itself is defined by the transitional spaces called '*Otlas*', a small verandah like space connecting the house to the street. Individual houses have a deep plan with the small side facing the street. A pol would get organised generally by people of the same social group or community. Thus the city characteristically grew very organically into a dense built fabric (Fig. 2) reflecting not only the culture of the local people but also the climate it was set in.

CLIMATE

The city is considered to have summer all the year round. It can be described as a hot climate with average outdoor temperatures between 20°C and 34° C. May is the hottest month with peak temperatures rising up to an intolerable 42°C and January the coldest with an average day temperature of 20°C. The city really never faces winters except a few months (December, January) when the night time temperatures reach as low as 10-14°C. For most part of the year Ahmedabad is hot and dry, with tropical rains for only three months from August to September. Mild season (November to February) is within the comfort zone for most parts of the day.

Ahmedabad is marked by strong solar radiation throughout the year and it is understood that solar control is the one of the most effective strategies. It is seen that while the mild season experiences lower temperatures the amount of solar radiation received is still very high especially on the south vertical face. With regards to residential indoor comfort, where the indoor environment does not need to be fully controlled, ceiling fans offer a good compensation for coolers and air-conditioning.

TECHNICAL RESEARCH

At **latitude of 22.42°N** with a remarkably high incident solar radiation throughout the year, the streets of the *Pol* remain shaded and ensured outdoor comfort. In the survey done in Ahmedabad during the field study, it was observed that more than 72% of the people standing in shade felt comfortable outdoors at a temperature as high as 31°C even with very little air movement. As aptly stated by *Steemers et al, 2004* (1), in hot climates a shaded street is always preferred over a street exposed to direct solar radiation even if temperatures were lower by a degree or two.

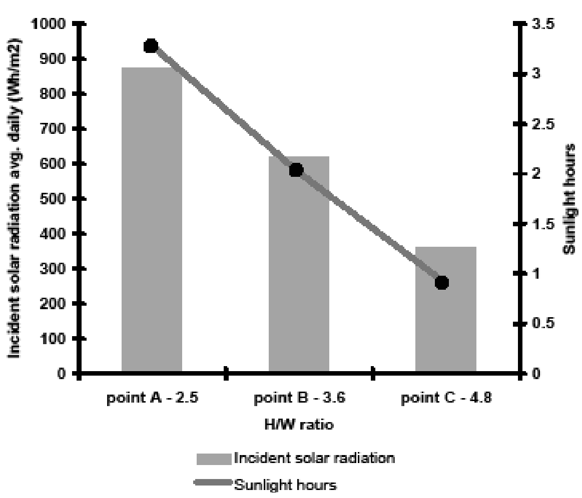


Figure 3: Street hierarchy analysis in an existing pol [5]

Technical analysis showed that at the time when the unobstructed incident solar radiation was around 4800Wh/m2 a street in the old city was able to obstruct more than 50% of the direct radiation. Three points on different street canyons in a Pol were simulated and the results as seen in fig. 3 indicate that a hierarchy of micro-environments was created by this morphology which helped a pedestrian gradually transit from the completely shaded and dark inner street to the partially exposed and then to more exposed main road. Thus it was clear that whilst outdoor shade by built environment is determined largely by street morphology, street canyon, street geometry and street orientation pedestrian comfort depends upon street hierarchy.

Some generic studies were done to establish basic guidelines in the climatic context and for the context of the residential typology. Simulations showed how the street orientation and street canyon affect the percentage of shading on a street. It was found that for N-S street orientation and a height/width ratio of 1.2 the % shading on street was in the same range as a E-W oriented streets with a height/width ratio of 2.6. As seen in Table 1 this data has been tabulated and then it is categorized into three different levels of shaded streets, representing three street hierarchies.

Table 1: Street hierarchy based on degree of shading which is a function of street canyon and street orientation

	obstruction angle 50°, H/W ratio 1.2	obstruction angle 60°H/W ratio 1.7	obstruction angle 70° H/W ratio 2.6	obstruction angle 80° H/W ratio 5.7
N-S	74% shaded	81% shaded	87% shaded	94% shaded
E-W	52% shaded	61% shaded	71% shaded	82% shaded
NW-SE NE-SW	68% shaded	76% shaded	84% shaded	93% shaded

Street Hierarchy: main road | secondary | inner street

This matrix was the starting point of an urban massing guideline for the project. However, it was observed during the field trip to Ahmedabad that narrow streets, compactness and densely shaded urban streets could have an adverse affect on the indoor environment. This was studied by measuring and then comparing possible cooling loads and lighting levels that would occur indoors in different urban situations. The idea was to have a better understanding of user's comfort by bringing together the indoor and outdoor comfort criteria for an efficient urban residential model.

In an example it was found that there could a reduction of 77% of cooling loads if the degree of compactness was to be increased. While thermally, compactness was extremely beneficial for both outdoor and indoor comfort, it led to lighting levels in inner rooms at times to be lower than 50 lux. Various design options of courtyards were tested to see if one could maintain the thermal performance and yet improve the daylighting and ventilation performance.

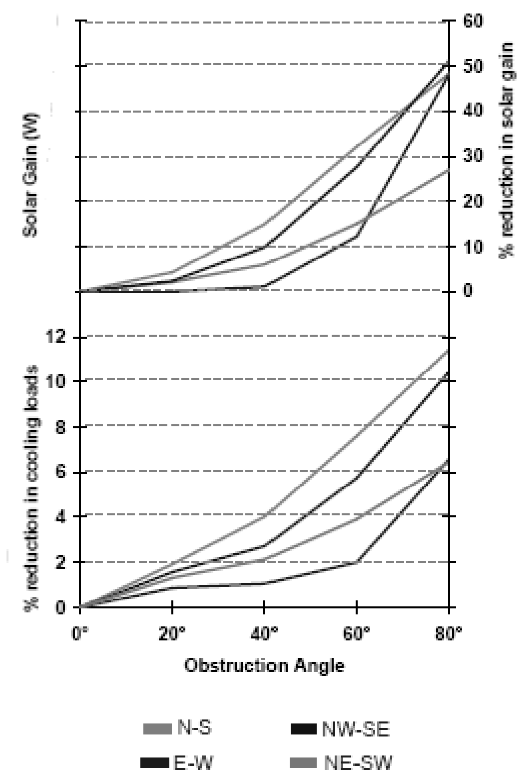


Figure 4: Effect of street canyon and street orientation on internal cooling loads. [4]

Four orientations and four street canyons are considered to be tested to know the impact of the street orientation and street canyon on the indoor environment [3]. It can be seen in fig. 4 that NE-SW street imposes the minimum cooling load and thus the effect of changing street canyon on NE-SW is not as much as the others. The effect of increasing obstruction angle is the most on the N-S street (10% reduction). An E-W street with no obstruction has the same effect as the N-S and NW-SE street with 50° obstruction angle. The difference in cooling loads between different orientations starts to reduce as the obstruction angle increases. In conclusion, for any orientation, for obstruction angle beyond 60° the cooling loads do not show considerable variation. Thus, for a deep and narrow street, orientation is no more an issue.

Street geometry from planar facade to recessed facade decreases the amount of radiation received along the edges of the street (fig. 5) and self-shades the facade of the lower floors effectively reducing the solar exposure of the building envelope. A wider street at the pedestrian level is possible with the same amount of lighting levels at the centre of the canyon. Thermal simulations indicated that the cooling loads reduce by 10.5% for ground floor of N-S street and 16% for the same floor in an E-W street. Similarly for the first floor of a N-S street the reduction is 9%, but is still 16% for an E-W street**.** Hence, the changing of geometry is clearly more effective in an E-W street

This information when combined with the previous tests allows us to have wider streets in E-W Ratio by changing the street geometry. There is an attempt to translate this into design at a later stage.

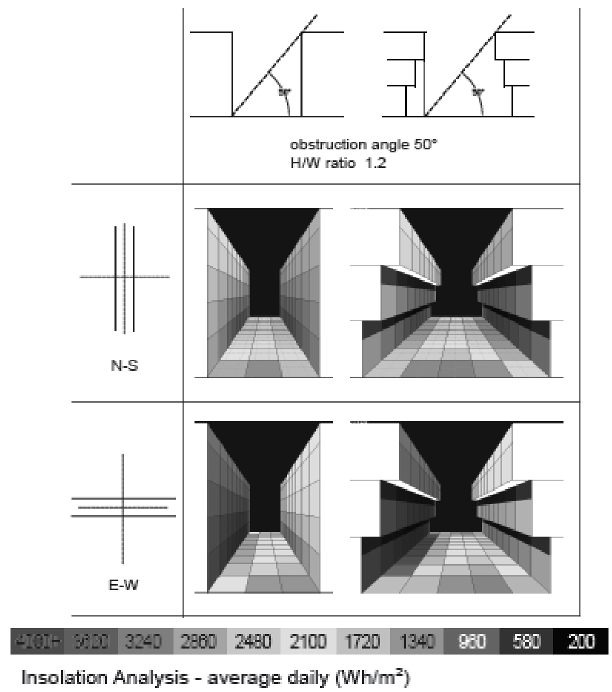


Figure 5: Incident Solar radiation received on street of different geometries. [5]

However, the aim for outdoor comfort remains that solar exposure of open spaces and streets should be minimised to minimum number of hours of the day. Parts of street should be in shade at a given point in time. This could be possible (in the latitude of 23°N) by a combination of all the factors identified in the built form and any other shade giving features like canopies, overhangs and dense trees.

DESIGN METHODOLOGY

Firstly, a set of design criteria is suggested which imbibes both the social and environmental qualities of *Pols* based on theoretical research and field study. Sketch ideas (fig. 6) based on these principles are developed and then the guidelines drawn from the technical analysis (table 2) is mapped on to these ideas. The result is an urban built mass model (Fig. 7) which is essentially a consolidation of all the factors discussed in the thesis. Further on, a street equivalent to a Pol street is detailed and modelled to understand the performance of the urban morphology, built form, and street character of the final proposal.

DESIGN DEVELOPMENT

A set of brief design aims were set which were mainly inspirations and observations from the Pol itself as stated below. These ideas are translated into design considerations.

• shade: street canyon: street hierarchy	pedestrian comfort
• movement through squares	community and social interaction
• urban situations like otlas's	street character
• voids in built mass	day light and ventilation
• provision of courtyards	connection to the outside
• parking facility	changing needs
• aperture design	indoor comfort + privacy
• flat roofs for sleeping	enhance local habits

The principles of the Pol have come together and developed, through centuries of organic evolution. Not one principle can be single out and replicated to achieve the whole essence. The open/built ratio of the 'pol' and the urban planning concepts (like interconnectivity, multi- urban squares, dead end streets etc) of the old city formed the initial driving forces and is mapped on the site. The basic idea is to maintain a strict hierarchy of streets throughout. The last plan in Fig X shows the result of an experiment of getting all the underlying rules of the Pols together and interpreting it such that it does not resemble the pol itself, yet represents the same structure. The open to built ratio is maintained similar to that of the walled city of Ahmedabad. In the walled city, only 17.3% of the area is street and the proposal indicates a 20.2% proportion of street area.

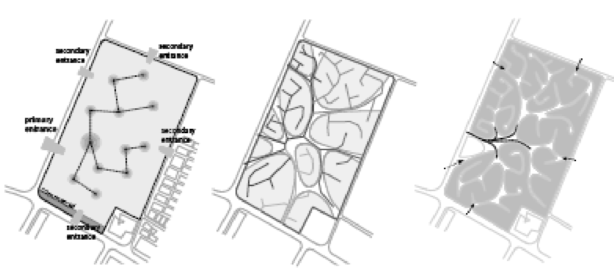


Figure 6: Design development, ideas in plan

Table 2: Guidelines for design based on technical analysis

to achieve,		70% shaded	to	90% shaded
when,	**Street Width**	12m to 8m	8m to 4m	4m to 1m
then progressively,	**H/W Ratio** (for all streets except E-W)	1.2 to 1.6	1.7 to 2.5	2.6 to 5.7
and	**H/W Ratio** (for E-W)	2.6 to 3.5	3.5 to 5.7	5.7

Each level of hierarchy defined by its performance criteria which is the % shaded area of the street as set in table 1. In an attempt to generate a 3d built from plan ideas, the information from table 1 was mapped on it. To maintain the performance criteria of each street hierarchy rules were set based on which street canyon proportions were derived. For instance, a street width between 12m-8m should have on an average 65-75% shaded area. To achieve that, a H/W ratio between 1.2 to 1.6 would be required. Similarly, other street hierarchies were defined and a total range of H/W ratio from 1.2 to 5.7 was set to achieve the % shaded area between 70% and 90% as shown in table 2.

Data from table 2 when overlaid on the plan shown in Fig. 6 generated varying heights of the built mass corresponding to the varying street width for to achieve what for the purpose of the thesis can be termed as an ideal situation. Fig. 7 below shows the resultant roof profile and massing for the urban plan.

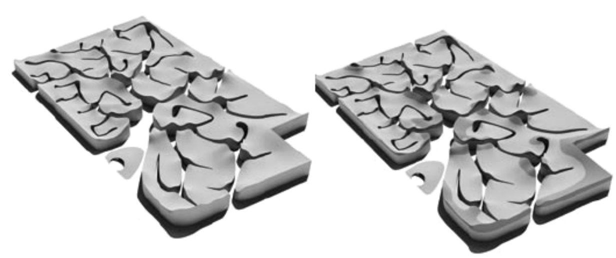


Figure 7: Resultant built mass models

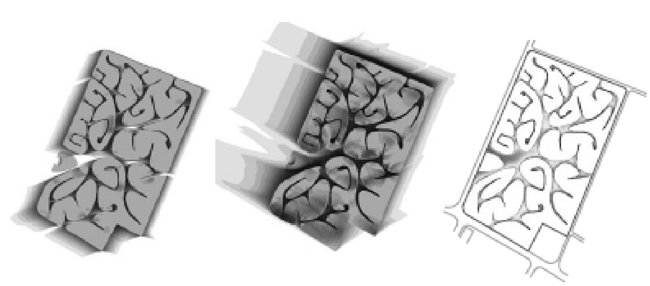


Figure 8: Shade and radiation analysis of the proposal [5]

It can be clearly seen in fig. 7 that the heights of the roof increase as the street widens and vice versa. At the junctions when the street widens, the heights reach up to 20m. The massing is then tested for areas which potentially go higher than 4 storeys and are marked out in red in fig. 7. The idea was to replace this shade providing bits of built mass by other urban features like trees, canopies etc. The optimised massing of a maximum of 4 storeys was then simulated to understand the shadow patterns and the direct incident solar radiation received on the street (fig. 8).

There is an attempt to zoom in to a street and see how the street character and performance is achieved by definitions of plots. When the generic massing was divided into plots based on information on plot frontage and the size of family each plot would need to house the resultant was as seen in Fig 9. The transitional spaces and apertures in the built mass in the form of courtyards were added to allow for increased ventilation and natural light. All throughout the year; the ‘otla’ (transitional space between house and street) and the courtyard is one of the most comfortable urban areas due to the high degree of shade on it throughout the day.

Figure 9: Detailed Plan of a section of the proposal showing the plot divisions, plot entrances and courtyards

ACHIEVING COMFORT

The variation in heights to maintain H/W ratio of the street canyon helped mutual shading of individual flat terraces and resulted in solar protection of horizontal surfaces of an individual plot. Fig. 10 illustrates an example of two adjoining plots and the reduction of incident solar radiation on the lower roof.

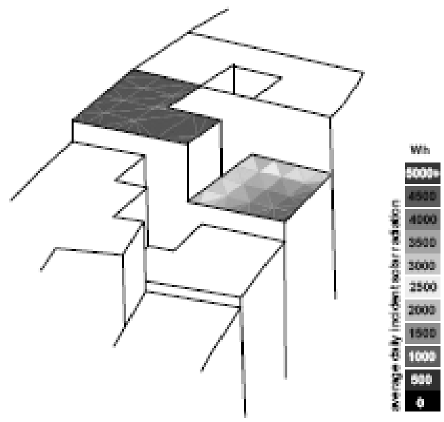
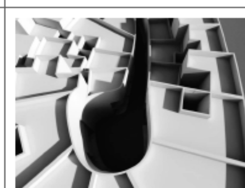


Figure 10: Insolation Analysis on a terrace of the detailed block illustrating the reduced incident solar radiation due to overshadowing by adjacent terraces. [5]

The contrast between the exposed roof and shaded street is clear from Table 3. The roof represents an unobstructed condition receiving direct radiation as opposed to the fairly shaded street ensuring pedestrian comfort even in a high latitude like that of Ahmedabad.

Table 3: Shading analysis of inner most street-top view

	21st June	21st December
09:00		

CONCLUSION

The project was set out to achieve the two aspects of urban sustainability, the social structure and the environmental performance. During this research it was found that the two are not separated. In a climate like Ahmedabad, where the direct and diffused solar radiation is found to be very high all through the year, shade was considered and analysed to be the most important aspect for urban design. Thus, the proposed design of the residential cluster is considered successful in achieving outdoor comfort by ensuring shaded streets, shaded masonry walls, and shaded semi-outdoor space through, street patterns, morphology of the built form and urban features like trees at exposed critical nodes**.**

FUTURE EXPLORATION

Of all the principles that determine outdoor comfort, this project largely dealt with the urban morphology and built form. It would be worthwhile to take forward this study, into other areas of research that contribute to outdoor comfort, like materiality, finishes of exposed surfaces, air flow patterns, and features like water bodies et**c.**

One of the other interesting steps would be to review all the factors that would ensure indoor comfort and design of interior spaces and then use it as information to execute program distribution based on the thermal environment of the houses. As the houses and plots in the proposal are so varied, the idea would be such that the program distribution for each house is unique to it.

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