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Assessing the Impact of Horizontal Surfaces on User Perception of Outdoor Comfort in High-rise Group Housing

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Abstract: Covid-19 Pandemic and associated restrictions have posed several challenges on our everyday living environment with an increasing gap between private and public realm. The feeling of being cooped up within the indoor residential environments have increased the value of surrounding outdoor spaces as a relief to the associated mental and physical stress. In case of high rise group housing societies the common spaces, shared parks, plazas, pathways and parking areas have emerged as s paces for physical activity, recreation, and social interaction. The spatial characteristics of the common areas are being looked at as felicitator for multi-use opportunities. It is crucial to enable these private-public spaces to be comfortable and accessible for all where the physical quality of horizontal surfaces are critical for activity in outdoor environments. This paper investigates the impact of the outdoor surfaces materials, accessibility and thermal properties on the user choice and selection for performing outdoor activities in high-rise residential environment of Greater Noida. A close link between the surface properties and user spatial preference was established by documenting the materials and form aspect ratio, measuring surface temperatures in sun and shade, mapping user activity pattern for 4 intervals, and then analysing the data thus obtained with respect to solar and wind orientation of active versus non active spaces. It was understood

that the user preference for outdoor residential spaces are closely determined by the thermal comfort and accessibility, however there is a pattern with respect to age, gender and activity level of each user group. The accessibility of a space plays a crucial role for people with special needs such as senior citizen, people accompanying pram and wheel chairs etc. To ensure the wide range of user with varied physical abilities in a public space the appropriate mix in spatial qualities has been found to be desirable.

Keywords - ***Urban Design, micro-climate, high-rise Housing, urban climatology, urban surfaces***

Introduction

A pregnant lady walks gently in the walking track assisted by her partner from racking young bicyclers. A group of mid-aged men spread wide over the parks talks so loudly that catches attention of people watching the scene from their balcony on 7th floor. Several groups of senior-citizen lady occupy almost all the benches in the park, while gossiping in low voice. Among the many basic needs of people is that for recreation, including relaxation and socializing. People are not meant to work constantly; nor are they meant to live alone. Ideally these different needs — to escape from the pressures of work, to feel part of a community, to be around and possibly interact with others — can all be met in the same place. When people are drawn to public spaces they can perform multiple roles for others as well as for themselves (Efroymson, Ha, & Ha, 2009). In the wake of pandemic situation, regularly visiting an urban public spaces is not an option. The neighbourhood parks have come to resort, for engaging with people and nature. The age group of 18- 60 years (college students and working population) who seldom visited their neighbourhood parks due to their social life associated with

their institutions and workplaces are also seen in the parks. Craving out a small time for outdoor activity has become possible due to proximity of parks and the flexibility associated with work from home culture.

"One of the most important initiatives in urban places worldwide is the integration of more parks and green spaces with trees and plants that can dampen noise levels, filter pollution, absorb carbon dioxide and produce oxygen, absorb rainwater, reduce run-off, and provide shade. These spaces also encourage physical activity, and may help address worrisome health issues such as the rising level of child obesity." (Ryan 2006) The parks have been crucial not only for environment, but for mental and physical well-being of citizen. In case high-rise housing societies the connection with the earth at the ground level is established only when the user walks down to the common areas of the society. This need act as a driver to explore how these shared open spaces can become inclusive, empathetic and accessible for all.

Spatial Empathy and Comfort

"Intricacy is related to the variety of reasons for which people come to neighbourhood parks. Even the same person comes for different reasons at different times; sometimes to sit tiredly, sometimes to play or to watch a game, sometimes to read or work, sometimes to show off, sometimes to fall in love, sometimes to keep an appointment, sometimes to savour the hustle of the city from a retreat, sometimes in the hope of finding acquaintances, sometimes to get closer to a bit of nature, sometimes to keep a child occupied, sometimes simply to see what offers, and almost always to be entertained by the sight of other people." (Jacobs, 1989) The humanistic perspective of

looking at the role of public spaces initiated a dialogue on the value of empathizing with the varied user group in public spaces as a crucial element of successful public spaces. The idea of 'empathy' in urban spaces have been looked through various lenses, and 'it is possible to set a merger in motion, a special consonance that connects the 'me' to the ambiance. We can therefore feel that a certain place is friendly or that a certain space rejects us; that a majestic construction intimidates us with its arrogance; that a park packed with people is either happy or, on the contrary, frightening.' (Duarte & Pinheiro, 2016)

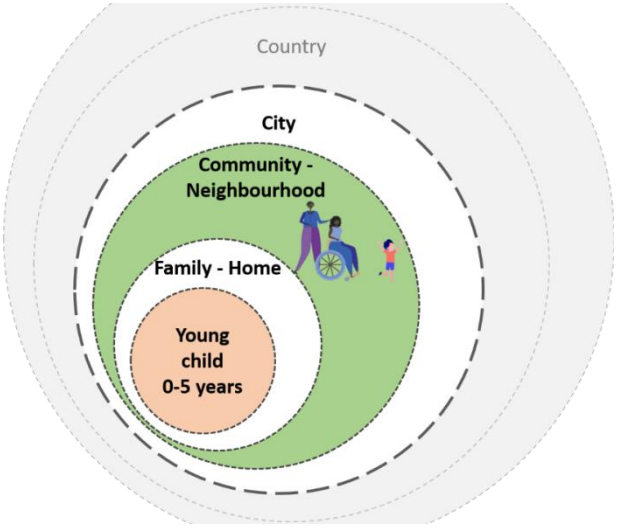


Figure 2: Neighbourhood as a Spatial and Social Entity, Source: Elisabeth Belpaire (National Workshop on Accessible Cities)

The public spaces in case of residential societies goes beyond the parks and plazas, and any space that is open and accessible to all can be a place for social activity. Social activity occurs in this in-between interstitial space (for example, the front porch) as this space has an ambiguous character where we negotiate both 'publicity' and 'privacy'. (Dovey & Woods, 2015) In the case of a residence and its premise, there are different levels of transitions occurring. The wall separates the inside and the outside, clearly defining the private and the public, whereas a transition of space happens at the gate, as it bridges the public and private realms. Therefore, this interface is both where we welcome and exclude

strangers and is essentially double, separating and connecting levels of a socio-spatial hierarchy – part/whole, individual/collective, self/society (Ivenson 2006 cited in (Dovey & Woods, 2015)). A public spaces should be safe, relaxing, with opportunities to stop and linger, for example, with good quality, comfortable and preferably moveable formal seating, informal seating opportunities (on steps, kerbs and walls), toilet facilities, soft landscaping and careful consideration given to microclimate (places to sit in the sun, and to shelter from the wind and the rain).. (Carmona, 2003)

Comfort can be thought of as the balance between relaxation and stimulation. The study conducted by William H Whyte on Plazas of Manhattan in 1970s, affirms that presence of sun, wind, shade, trees, water and how much accessible they are for public (e.g. can you touch them, take a bath etc.) is an elemental point of a good urban space (Whyte, 1980). This was one of the first studies that looked at human comfort as a determinant of successful public space. The study has been a milestone in framing principles for sociable public spaces such as adding value to the provision of ample amount of comfortable and 'sittable' spaces. His research proves that variety in use is widely regarded as one of the prerequisites for a successful urban space. He tried to find out how activity patterns interrelate with the physical dimensions of urban spaces. (Efroymson, Ha, & Ha, 2009) His work indicates how an inclusion, accessibility and comfort can bring in more people to public spaces and add to the overall experience of the public space."Thermal comfort is that condition of mind which expresses satisfaction with the thermal environment. Because there are large variations, both physiologically and psychologically, from person to person, it is difficult to satisfy everyone in a space." (ASHRAE, 2017). Thermal comfort plays a

crucial role in selection of outdoor space for activity. While the rage of thermal comfort experienced depends on the age, gender, clothing and activity level of the user. In high density - roof details, material, urban surface albedo, surface emissivity, shade and diffused lighting, day length, aerodynamic roughness of surfaces, interaction between street and the air above roof level are determinant of human comfort at street level. (Givoni, 1998). Hence, the study expects to find an overlap between the idea of comfort and accessibility in public spaces with reference to its horizontal surfaces. The study specifically examines the surface material characteristics along with dependent variables such as location, orientation, aspect ratio or enclosure.

Spatial Context:

The site selected for the study is located in the urban periphery of Delhi NCR. It is a high rise group Housing Society, in Greater Noida. The site is surrounded by green-fields, under construction sites, urban village and high rise housing with a great variety if landscape elements as spaces ( )

- **Urban Density = 5000 people per sq km**
- **Site Density = 490 people per Ha**
- **Plot Area = 11.30 acre**
- **Ground Coverage = 23%**
- **FAR = 200**
- **Building height = 42 meter**
- **Building type = tower**
- **Large trees on the periphery, small trees in central park due to basement below.**

Figure 3: The urban form of selected group housing, Source: Author

1. **Tot-lot with swings**
2. **Open air theatre with clock tower**
3. **Gazebo/ Pergola/ pavilion**
4. **Central axis with fountains**
5. **Lawn**
6. **Basketball cum tennis court**
7. **Seat walls with tree court**
8. **Swimming pool**
9. **Pathways with surface parking (along site boundary and buildings)**
10. **Temple**

Figure 4: The Site Plan showing key activity zones

Identification of Parameters

The key parameter being assessed here are the horizontal surfaces in outdoor spaces. The properties of surfaces that influence comfort and accessibility are the kind of paving materials, their maintenance, and the horizontal and vertical connection across levels. Apart from surfaces spatial enclosure, orientation (Solar & wind) and the amount of light also influence the overall sense of comfort experienced by the user. Further, how the user perform activities, at what time of the day and for what duration helped us to evaluate the actual influence of the key parameter.

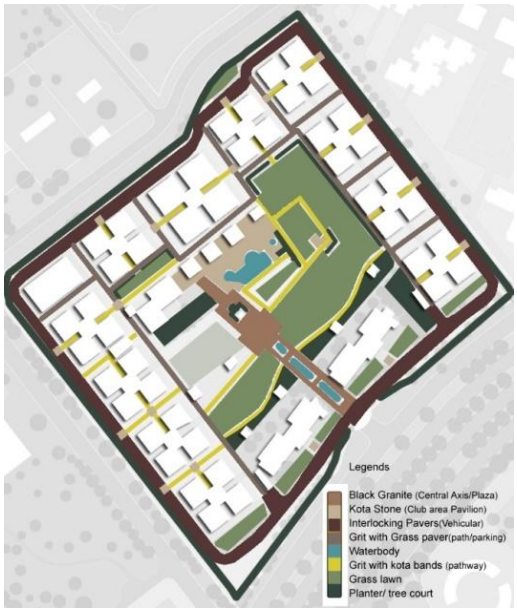
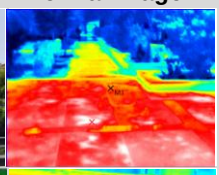
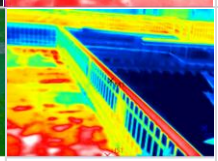
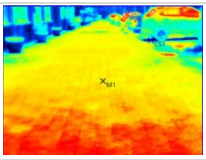
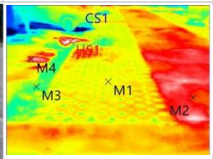
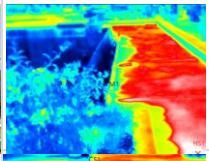
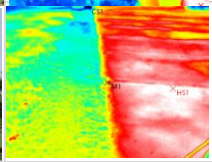
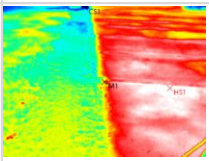
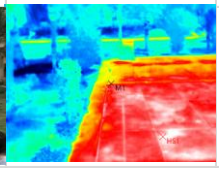


Figure 5: Site plan showing key horizontal surfaces and materials

Urban Surfaces: The surfaces are crucial to ensure that the public realm is accessible to all without compromising their dignity. The provision of 'visual cues' to the change in spatial context by additional design elements (such as landscape, curbs, barriers, lights, furniture) and alternative pavement and texture/material at intersection and crosswalks.

This also ensure a clear segregation of pedestrian and vehicular domain. The universal design norms suggest that surface material should be stable, firm, smooth and slip resistant. The use of contrasting or bordering materials, bollards also helps to demarcate the vehicular and pedestrian area. The reflective and absorptive properties of surface material impact the thermal and visual comfort, while the texture and level of surfaces influence the ease of movement and accessibility. The thermal properties of surfaces determine the thermal comfort in the immediate environment. The map below shows the horizontal surface materials on site (). Table 2, presents a comparative analysis of the materials used in outdoor horizontal surfaces are compared on the basis of their location, thermal properties, and texture.

Table 2: Comparison of Surface material properties of outdoor Urban Surfaces (summer)

Material		Location	Site Image	Thermal Image	Temperature (Sun) ◦C	Temperature (Shade) ◦C	Texture
Black Granite		Central Axis & Plaza			56	36	Polished
Kota Stone		Club area & pavilion			54	46	Honed
Interlocking paving		Vehicular Path in periphery			48	38	Rough
Grass paver		Parking area			42	33	Rough / natural
Waterbody		Pool and Fountain			31	36	Natural
Grit paving with kota bands		Pathway			52	45	Rough
Grass lawn		Lawn			45	32	Natural
Planter & Tree court		Park edges			36	33	Natural

Enclosure: The spatial enclosure crucial to the experience and activities in a public space. In thermal comfort studies the aspect ratio is used which is defined as the ratio between the heights of the adjacent building to the width of open space. The Canyons are 2D cross-section, with dimensionless ratio i.e. H/W. It is relevant for evaluating radiation access, shade and trapping, wind effects,

thermal comfort and the dispersion of vehicle pollutants. Literature suggests that users' preference of urban space enclosure is an inverted U-shape relationship (Carmona, 2003). Extreme high values of enclosure evoke claustrophobia and confinement, while extreme low values of enclosure evoke discomfort because of lack of psychological shelter. The preferred values of enclosure exist in between the two. (Alkhresheh, 2007) The high rise built form surrounding a central park in the selected case study creates a large range of spatial enclosure (Figure 6). It was observed that each user group find comfort in different amount of enclosure. E.g. the Children age 3- 14 years tend to prefer spaces with lower degree of enclosure as opposed to adult women.

Figure 6: Building Height Map

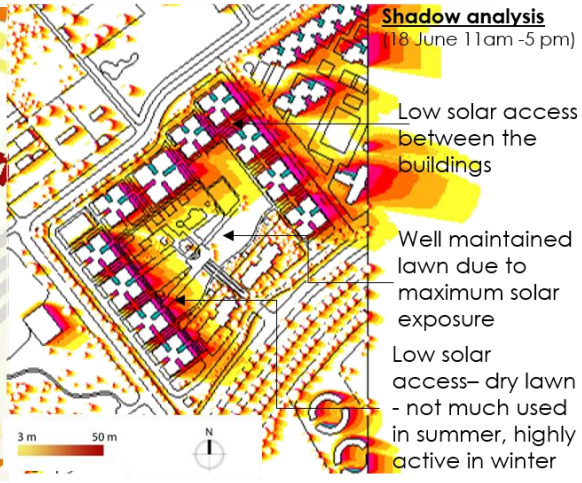


Figure 7 : Shadow Analysis Map

Orientation: Orientation of buildings with respect to sun and wind have direct influence on thermal comfort. The height of the building and solar orientation create varied shadow pattern throughout the day. Presence of direct solar radiations create 'hot spots' supported by indirect reflected radiations from the surface materials. (Figure 6) In the case of rectilinear building forms, faster winds at higher altitudes are drawn down to the ground-level (downwash) and becomes turbulent. The 'corner effect'

causes greater wind velocities. The narrow gap between two buildings causes accelerated winds through a channel (Venturi effect). This have direct impact on spot level wind conditions and contribute to the spot level thermal comfort experience. The wind flow pattern at 11 am and at 3 pm during summer month have been shown in the map below. (Figure 8)

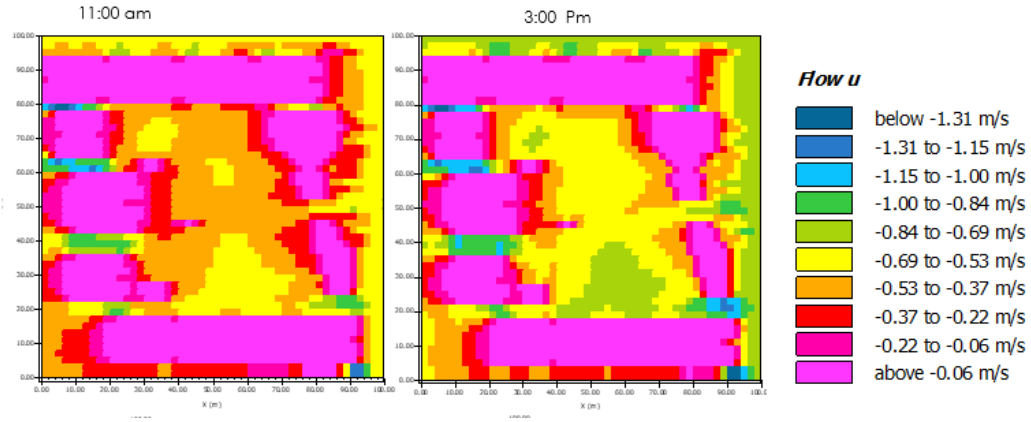


Figure 8: Wind Analysis Map using Autodesk Flow Design Software

User Profile: The profile of residents range from people employed in IT companies, Educational Institutions, Business and Industry owners. Most of them have migrated from nearby small towns and villages. Some of the families have migrated from Delhi NCR after retirement and next generation is studying or working. Based on the general profile of users in the outdoor spaces the following categories were identified.

a. 0 to 3 Year old children (accompanied by parent/ caretakers) (10%)

b. 4 to 18 Years (Children/teenagers) (50%)

c. 18 to 60 Years (Adults) (25%)

d. 60 + Senior Citizen (15 %)

Activity: The following activity components were observed in the outdoor spaces –

a. ***Passive Engagement*** *– Sitting, Sitting with a child/ pram / wheelchair, standing, Standing with a child/ pram/ wheelchair, Lying Down, Walking alone with a purpose*

b. ***Active Engagement*** *– Cycling, Exercising, Taking pictures/videos, Playing, Walking with pram/child/ wheelchair*

The distribution of activities across the outdoor spaces is as per the maps below. Active recreation is shown as circles whereas passive recreation is represented as triangle. The map is color-coded showing age and gender categories. The activities were recorded for 4 time slots -

a. ***Morning: 5 am to 9 am,*** ***b. Afternoon: 9 am to 4 pm,***

c. Evening: 4 pm to 7 pm & ***d. Night: 7 to 11 pm respectively.***

Figure 9: Activity Mapping: Morning

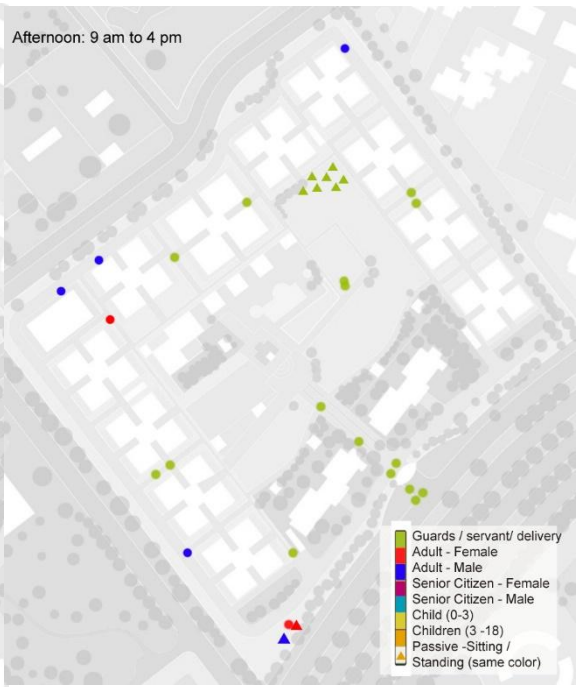


Figure 10: Activity Mapping: Afternoon

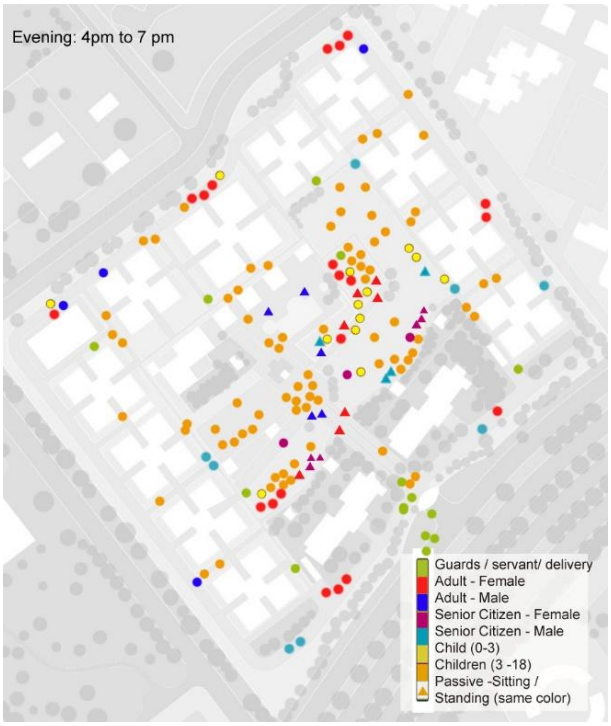


Figure 11: Activity Mapping: Evening

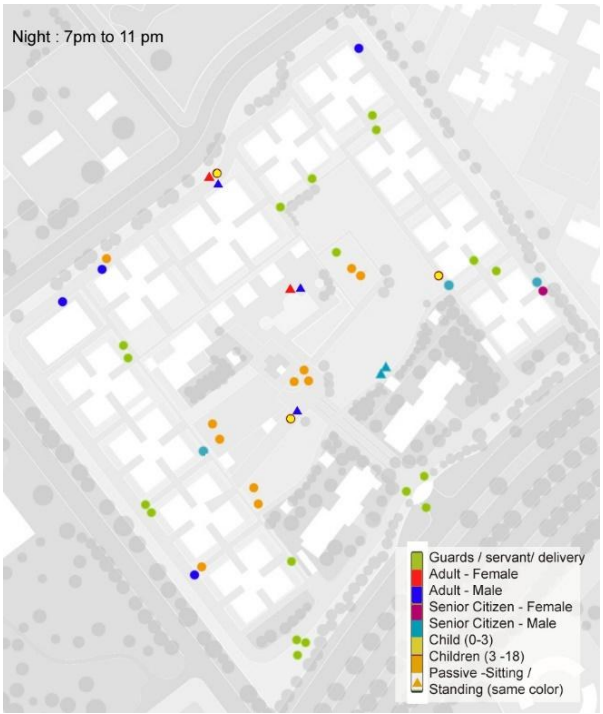


Figure 12: Activity Mapping: Night

Results

The data obtained for the selected parameters - surface material properties, enclosure, orientation, user profile and corresponding

activities were analysed to see the overlaps. This guided to understand a possible interrelation between the aspects of comfort, activity and accessibility (Table 3).

Table 3: Summation of selected parameters to identify possible co-relation

Space	Location	Material	Enclosure	Aspect	Orientation (Shade hours)				Human Activity & User Group (hours)			
	Map	Surface	Section	H/W	6_9	9_16	16-19	19_23	6_9	9_16	16_19	19_23
Park		Grass Lawn and pathway with grit paving & Kota bands		0.28					d	c	a/b /c/d	c
Plaza		Black Polished Granite stone and Kota Stone with Sandstone		0.28					e	e	b	b/c
Pathway & Parking		Exposed Grit paving with kota bands and grass pavers (to deliniate parking)		13 to 4					d/c	c	c	c/d
Parking & Vehicular Road		Interlocking pavers with grass pavers (to deliniate parking)		13 to 4					d	c	b/c	c
Transition Space		Exposed Grit paving with kota bands and Kota Stone transitional plaza		15 to 10					c	c	c	c
			Age group		0 to 3	3 to 18	18 to 60	60 +	Nil			
			Age Category		a	b	c	d	e			
			Amount of Shade		High	Med	low	Very low	Nil			
			Activity Intensity		High	Med	low	Very low	Nil			
			Legend (Color)									

Conclusion

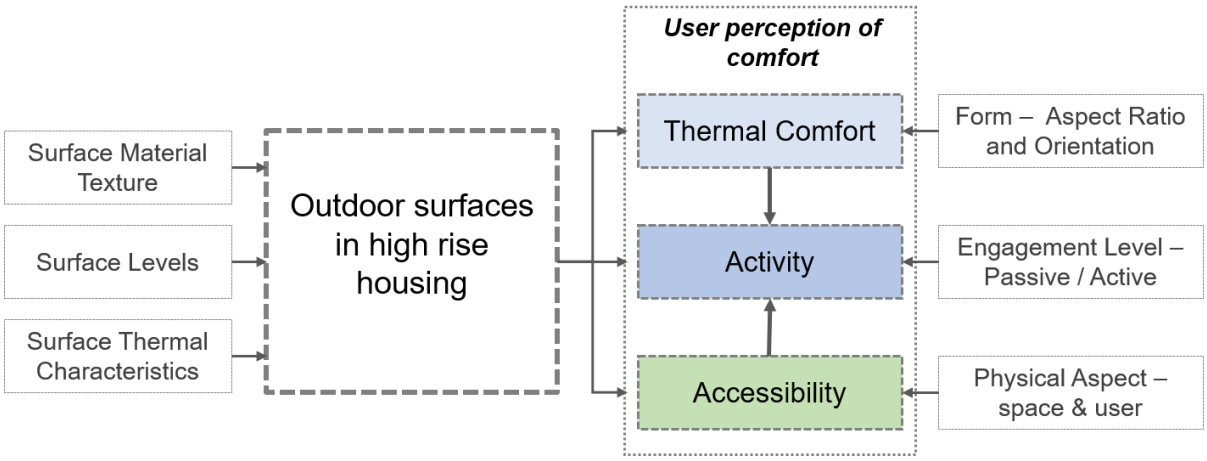


Figure 13: Proposed Relation between Thermal Comfort, Activity and Accessibility

The outdoor surfaces in high-rise housing were found to be crucial in user perception of comfort in outdoor spaces. The activity mapping gave a clear picture on user and activity distribution across spaces in selected group housing society. The key takeaways from the study include –

- ***The activities with greater physical engagement e.g. running, playing, cycling and brisk walking were done in hard paved spaces only (vehicular path & granite paved axis and plaza).***
- ***The senior citizen have strongest preferences. They move and recreate in a fixed pattern everyday – the activity, the speed of walk, the route for walking and bench for sitting etc.***
- ***The adult women were identified in groups and in locations with a greater degree of enclosure***
- ***Opposed to the above, children prefer less enclosure, and spaces with levels. The plaza and stepped court was always occupied by young children only. The children also prefer to regularly change their activities and prefer to explore new materials, locations, textures and spaces.***

- ***The thermal comfort plays greater importance for middle aged and senior citizen in order to select the spaces – for example the amount of sunlight, wind, views all help them build the choice of space.***
- ***The residential space selected was quite accessible for all, yet the continuous pathways of grit along the periphery of park were specifically preferred by people with special needs i.e. pregnant ladies, people with pram/ wheelchair and senior citizens. These were the spaces where lesser number of children were running and cycling, and vehicular movement was restricted. Hence, these were considered to be 'safe' for slow walkers.***

It could be further concluded that there is strong ability of adaptation into play in selection of spaces for everyday outdoor activities. People naturally tend to develop preferences based on their physical abilities, activity level and thermal comfort.

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