Scientific Modeling for Bridging the Environmental Design and Social Behavior in Hyper Dense Urban Open Space Planning

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Abstract. In Hong Kong, about 46% of the population lives in public housing estates. The density of the estates could be as high as 2,500 persons per hectare and there is an increased pressure for increasing the density. Therefore, open space in the estates contributes significantly for relieving the sense of over-congestion. Preliminary study shows that the usage of these open spaces is as low as 1.36%, and the low usage rate is largely due to inappropriate planning and design, particularly with respect to climate requirements, rather than insufficient area. Researchers thus attempt to overlay the user-behavior with the environment-behavior data to investigate the impact of irresponsible environmental design on the user-behavior. It is also this exercise that provides new thoughts to research of social behavior and activity study for high density urban habitation.

Keywords. Building simulation; post-occupancy evaluation; behavior maps; planning and design for hyper dense habitation environment.

Introduction

Open spaces are omnipresent in Hong Kong public housing estates, and contribute important social functions in the hyper dense habitation environment. With the planning standards for high-density housing estates allowing as many as 2,500 persons per hectare, open space is important for relieving the sense of over-congestion. Consider that about 46% of population lives in public housing estates, the quality of public open space is critical to the quality of life of more than three million people. A post-occupancy evaluation (POE) study (Tsou and Lam 2002) has been conducted by the research team on several housing estates built from 70s to 90s to investigate the usage of these spaces. Preliminary results show that the usage of these open spaces is as low as 1.36%. The low usage rate is largely due to inappropriate planning and design rather than insufficient area. With full exposure to the non-verbal setting of sights, sounds, wind and daylighting in the field survey, researchers particularly identified the low usage rate is closely related to the irresponsible building performance of the environment. The research team then carried out simulations on the building layout with respect to daylighting, airflow and visual sustainability on the studied environment and overlaid with the user-behavior data to further evaluate the impact of the site performances on the user behavior.

The overlaying exercise

For behavioral study, behavior maps, also called “activity mapping” were conducted in selected housing estates to record residents’ responses to the public open space from a third person’s observation (structured observation with standardized recording forms). This comprises multiple site surveys to record human activities and establish a pattern of usage. The data sets of activity mapping include information on the age and gender of users, their location and activities,
and the pedestrian flow during different times of the day on both weekdays and weekends. The data sets indicate residents' physical and psychological interactions with the physical configuration in the open spaces, and these interactions can be translated into a group of physical and socio-cultural variables.

For the environmental design consideration of the open spaces of the selected estates, different simulation models are established to assess the environmental factors concerned by the high density urban habitation: visual sustainability, airflow/natural ventilation, and thermal comfort. The assessments are conducted in two stages: scientific simulation and physical measurement. The on-site physical measurements record the environmental conditions with respect to the observed behavior patterns and locations. Simulation models are setup for simulating the environmental conditions in the open spaces during various time and climatic condition. The simulation domains were extended to take into account the impact of the hyper-dense built environment. Computational fluid dynamics (CFD) technology is applied to investigate the airflow pattern and potentials of passive cooling design. Based on the daylighting simulation technology, solar irradiation model are built to examine the relationship between the radiation gain and residents' activity pattern. To study the visual sustainability of the open space, we use an in-house prototype application based on the geographic information system (GIS) to generate "openness ratio" 3-D graph to investigate the formation of embracing elements of open space, and to establish "visual sensitivity ratio" diagram related to nearby natural landscape.

The overlaying exercise was simply carried out by superimposing the behavior map with the simulation result of the same areas (Figure 1). The composite image graphically represents the relationship between activity patterns and the environmental simulation results. It helps to identify the key factors and correlation between the physical environmental settings and human social behavior in the open spaces. Cross comparison between open spaces in different housing estates reveals the impact of the different environmental conditions on the usage patterns of the residents. The concerned area is composed of two interlocked open spaces. The open spaces are both featured with planters and seating in a square manner. They are differed by only the playground facilities at the upper one in terms of the physical layout. From the above composite image, majority of users were found under the shade. They have activities like reading, chatting and playing chess etc. The minority of users under the sun...
were identified to have activities associated with the playground facilities, the fixed-located amenities. Certainly, human behavior is a dynamic emergence of aspects from a broad spectrum including sociology, psychology, geography, urban planning and landscape architecture etc. One could argue that the recorded behavior as a consequence of impacts other than the environmental behavior. As the study focused on area at a reasonable scale with users of almost homogeneous background, the result is well-justified. More composite images concerning other aspects of the environmental behavior will be illustrated in the presentation.

Discussion

Considering Hong Kong’s hyper-dense habitation pattern and subtropical climate, the two primary phenomena need to be examined in the open space planning and design are urban comfort issues of the residential built environment and the social behavior of the residents. The built environment interacts with ambient physical conditions, especially with respect to visual sustainability, natural ventilation, thermal comfort, and acoustics. It also relates to the administrative and social attributes of the settlement. Establishing the relationship between the built environments and the social behavioral patterns of the users will enable the building professionals to improve the planning and design of open spaces located in housing estates. However, most previous studies of local open spaces are either from a sociological perspective or administratively focused on abstract budgetary metrics such as average area and green space per capita. Much of the understanding of our public housing has been through surveys of housing satisfaction and other factors concerning the provisions of accommodation. Only limited studies concerning both the built environment and social behavior in these spaces have been carried out.

POE has been defined as “the examination of the effectiveness of designed environments for human users” (Zimring and Reizenstein 1980). It has long been used by researchers and authorities for assessing the built environment. Yet, the majority use has been focused on giving a voice to the nonpaying user, researching theoretical questions and affecting decision making, which limits its contribution to the development of theory and of uneven usefulness to those faced with decisions about designed environments (Bechtel and Marans 1987). It is very common that POE is carried out by social surveys like questionnaire and interviews rather than time budget and simulations.

Simulation, which is not widely known or frequently used in the social sciences, requires much technical support and intensive domain knowledge to contribute to meaningful results. The development in recent decades tends to support design process for three purposes: analysis of the environment, design generation and presentation and public communication. The address towards response from human beings is addressed mainly on the area of reflex. An example is virtual environments for training use. Though much effort has been made on artificial intelligence, human reaction towards the built environment remains a researchable issue, particularly when the complicated social factors are to be included.

The methodology and outcomes of the research project establish the relationship between environmental design and social behavior, with respect to the use, social significance, and meaning of public open space to the local community. By relating the scientific assessment and sociological observations of a physical environment, we examine the configuration of open spaces in public housing estates to support the physical, social, and cultural living activities of the
residents. The research team also tends to:

a. Establish a methodology on integrating environmental simulation as part of the social behavior and activity study for high density urban habitation research. Although the research team could generate large amount of information from different simulation skills and behavioral study, it is important to establish an effective methodology to draw the relationship between two separated knowledge domains.

b. Develop expertise in simulation modeling techniques for cross-examination of different environmental factors simultaneously. For example, the openness ratio generated from the GIS system for assessing visual sustainability also contains important information correlated to the permeability of urban wind, which is a crucial factor to be considered for the thermal comfort.

c. Bridge the research of environmental simulation and social behavior in the practice of designing and planning of open space in high density urban context. It is not a common practice for practitioners to simultaneously consider both environmental and behavioral aspect according to a performance based approach. Former experience and heuristic knowledge have been used as the main base for carrying out the practice. It will be an interesting debate on how the methodology and techniques developed in this research to be used as the base to conduct performance based approach on the open space design.

Conclusion

With the increasing concern of social context and human comfort in the planning and design of housing estates, research that ties the environment and human behavior are gaining particular strategic values within environmental design because it joins context to behavior. Many of the professionals have been focused on either the context or the behavior, rather than the relationship which fundamentally drives the whole social setting. It would then be beneficial that the methodology could be developed in advance to individual studies. By developing the bridge between the environmental design and social behavior for the hyper dense urban environment, we attempt to examine the methodological requirements for the overlaying exercise. For example, the impact of social factors on the nature of activities and the balance between social and environmental factors on the justification of the human behaviors. With the procession of the project, many of these methodological requirements would be fine-tuned. It is expected that the methodology could be extended to studies like determination of criteria of environmentally responsive design.

Further Works

Collaborating with Prof. Baruch GIVONI of UCLA, the study will be extended to detailed assessment of physical comfortability in public urban open space. Meanwhile, the POE study data has been given to the research student of Prof. Yehuda KALAY of UC Berkeley and further study will be conducted to simulate the human behavior in the open space with respect to the social and physical environment.
References


