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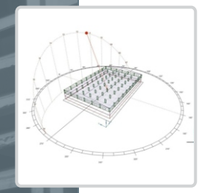
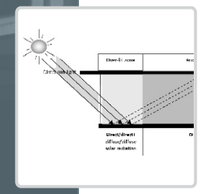
Gender and Houseform

Social Interaction and Housing

Gender and Housing



Daylight Efficiency



Luminous Environment

Bangladesh University of Engineering and Technology, Dhaka

Protibesh
ENVIRONMENT
Journal of the Department of Architecture, BUET

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1.5 Line spacing and leaving 1.2 inch margin space on all sides of the paper.

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Contents

List of Reviewers

Protibesh© BUET
Volume 16, Issue 1, January 2016
pp. 1-2

Editorial

The Dept. of Architecture, BUET, has so far been the only centre of post-graduation in Bangladesh, contributing to, among others, the generation of expertise and knowledge through research. The central role of Protibesh, a DoA-BUET Journal—is arguably concerned with the dissemination of this knowledge. It is time now, to reassess the role of Protibesh, when completed academic research, especially through M.Arch degrees, is higher in number and diversity than ever before. The present multi-disciplinary Editorial Board, since its inception, has taken on board an agenda to create authors, from these budding researchers. The underlying objectives are: DoA-BUET retains the institutional ownership of the possible first publications from the completed research in BUET; by making Protibesh available on the web, it promotes an increase in the number of citations of the publications by local authors that these research articles are based upon; at the same time, it encourages single-authorship among young academics and practitioners, gearing towards their academic/professional advancement, in an era of knowledge-based design and intervention. With the aim of harboring a 'culture of publication' in Architecture, the Editorial Board has tried to ensure the quality of publications through a double-blind peer-review process. Yet the dearth of manuscripts submitted for publication, and the even fewer final acceptances explain the lower-than-expected number of Protibesh issues published.

This last issue, under the present Editorial Board, has five articles covering the streams of Human Settlement and Energy and Environment. We are pleased to note that, three of these are based on completed March dissertations at the DoA-BUET, by their respective authors. The first three articles address housing, amidst thematic issues, public/private sector, and income-group diversities, within the Human Settlement stream. All the articles, in one way or the other, address the social dimensions of housing, with variations in content and methodology, and most importantly, focus on issues previously unaddressed in Bangladesh. During the present ongoing rapid urbanization, a common theme running among them all is on ways in which discrete social groups in Dhaka appropriate indoor and outdoor spaces within buildings and neighbourhoods. The lead article entitled “Segregation in Domestic Spatial Organisation of the Contemporary Middle-Income Group Apartments of Dhaka” explores dwellers' gender-specific organization, and use of domestic spaces through an ongoing transformation of segregation by Space Syntax simulation, and their implications on house form. The following article “Changes in Shared Spaces for Social Interaction: A Socio-Temporal Evaluation of Real Estate Apartments in Dhanmondi R/A, Dhaka” compares the making and changing of social spaces for social interaction, by using Post-Occupancy Evaluation method. It's comparison of cases, in a period of seven years, highlights the necessity of ensuring spaces for social interaction in housing design, when eroding public spaces confine urban dwellers within apartments, while technology expands their social networking in the virtual world. The third article “Women's Negotiation of Domestic Spaces in Slums: The Roles of Physical Environment on Practical Gender Needs in Hajaribagh and Ganaktuli Sweeper's Colony, Dhaka” reveals how women in a specific low-income occupational group, with mixed ethnicities, negotiate their use of indoor/outdoor spaces, through an in-depth ethnography. The revelation of women's negotiation of space for practical gender needs calls for mainstreaming gender issues in low-income housing design and service provision.

The fourth and fifth articles deal with day lighting, in an effort to make buildings more energy efficient, and thus contributing to the sustainability of the built environment. The former entitled “Comparing the Results of Static and Dynamic Daylight Simulations to Support

Architectural Decision-Making in the Context of Dhaka" presents a comparison between two methods of simulating day lighting – static and dynamic. The latter method is argued to be more appropriate for Bangladesh, and has implications for deign decisions for day light design of buildings. The fifth article "A Study of Light Zone in Commercial Buildings: Assessing Energy Efficiency for Shading Devices" shows how the passive architectural features of sunshades affect the nature and extents of the interior luminous environment. Fixed external shading devices from field work are simulated, to suggest selection of shading devices with proper geometrical and material characteristics, for ensuring energy efficiency in offices of tropical areas like Bangladesh.

I, on behalf of the Editorial Board, would like to express our deepest gratitude to all reviewers at home and abroad, who despite their busy schedules, have made the time and effort to review the papers, and to those who have otherwise facilitated the different stages of the review and publication of Protibesh. We earnestly hope that this academic cooperation continues unabated, in the timely publication of future issues Protibesh.

SG

Protibesh© BUET
Volume 16, Issue 1, January 2016
pp. 3-17

Segregation in Domestic Spatial Organisation of the Contemporary Middle-Income Group Apartments of Dhaka

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Abstract: This paper examines 'segregation' in the domestic spatial organisation that has undergone a process of transformation inside contemporary Middle Income Group (MIG) apartments in Dhaka. Questionnaire interview of the female heads from a sample of 50 MIG apartments compliments Space Syntax method analysis. Activity analysis of the family members identify certain spaces as 'gendered' space, used by a gender extensively, and 'shared' spaces used by both genders. Segregation in gendered and shared space is interpreted with the depth and integration values of the spaces found from the justified permeability graph (JPG). Entry penetration and location of the gendered spaces are two important aspects of the spatial organisation to attain segregation in domestic spaces. Symbolic gender aspect segregation, holding a pivotal role in the domestic spatial organization of the urban houses in Dhaka, has gone through a transformation due to the socio-economic changes. Although the role of women has changed in the family due to their participation in the economic activities, women still prefer to preserve segregation from the visitors or outsider's domain. Segregation of gendered spaces is difficult to be maintained in the contemporary compact MIG apartments due to space compaction. It was seen from the study that presence of foyer at the entry creates choice in access and female heads are satisfied with the use of foyer regarding preserving segregation from visitor's area.

Keywords: segregation, gendered space, shared space, middle-income group apartments, Dhaka.

INTRODUCTION

The form of the house is the consequence of a whole range of socio-cultural factors (Rapoport, 1969; Lawrence, 1990). People everywhere produce houses whose spatial organization suits the inhabitants' social life. Social relations and events express themselves through spatial configuration. House form acts as an artefact of culture and reflects the society in relation to a given time. The dwelling reflects ideals and realities about the relationship between women and men within the family and in society. Spatial organisation of the house is a reflection of the life style and the symbolic gender aspects that are the reflection of culture and society (Hanson, 1998; Oliver, 1987).

Hillier (2007, pp.30-31) expresses human societies as a spatial phenomenon. It takes on a definite spatial form in two senses: first, it arranges people in space to understand aggregation and segregation, engendering patterns of movement and encounter between different groupings; and second, it arranges space itself by means of buildings, boundaries, paths so that the physical milieu of the society also takes on a definite pattern. According to Hanson (1998, p.269), houses are more complex phenomena and usually encode a wealth of social and symbolic information which constitute a shared framework of spatial patterns.

Among the symbolic gender aspects 'gendered' and 'shared' spaces are two categories conceptualized with the concentration and segregation of the male and female members of the household. This private-public

territory, as one of the binary codes followed in the organization of domestic space, is governed culturally (Lawrence, 1987). The denotation of 'public' and 'private' implies that some form of spatial pattern accompanied the separation of women and men into different activities. This supported the concept of 'gendered space' originating from a private-public separation model confining women within the private domain of a house in performing the domestic works while secluding from outside public realm (Rendell, 2000, p.103).

The concept of women's sphere was a product of both patriarchy[1] and industrial capitalism (Hayden, 1981, p.296). The inward orientation of the women and the outward orientation of men are reflected in contrast within the house between interior and exterior, dark and light, low and height, back and front, night and day, nature and culture etc. among the anthropological studies so far produced on the use of space, Waterson concludes that the symbolism of gender occupies a prominent place and given the subordinate role of women in many societies. It is, therefore, no surprise to find women persistently relegated to 'inferior' spaces such as back of the house, excluded from the public to private or trapped in a domestic sphere which is intended to be restricted both physically and mentally (Waterson,1990, pp.167-198).

Oliver (1987) finds non-industrial societies to be often separated as women and men within the dwelling. In a typical Purum house, for example, domestic space is divided into right / left, male / female quarters, with higher value attributed to areas and objects associated with right/male and lower value associated with left/female (Lidia,1981, p. 91). The Bedouin tent, the Mongolian nomadic tribe's tent 'ger' provides examples of symbolically differentiated gendered spaces. Each of these single-roomed dwellings is characterized by separate spaces for women and men. The male section contains the possessions of the head of the household and honoured guests: the female section contains cooking utensils and children's possession. The Berber house of the Kabylia, Algeria is simple spaces divided both symbolically and physically into male and female domains.

In the 19th and early 20th century, there was a clear division between front and rear in the English houses. The front room or parlour facing the street was used for receiving the guests and for formal in the family occasions and best furniture was kept there. The kitchen dining was used for eating and performing other household activities like child caring, sewing, resting and other domestic activities. Ozaki's (2003) research initially looks at a link between culture and house plans described in the existing literature on English housing, and provides general ideas on the associations between the two, especially in terms of social status and changing social relations. Consequently, middle-class families developed less formal relationships between husbands and wives, and parents and children, which led to the decline in formality within the household.

Segregation, a symbolic aspect, of male–female domain existed in the life of the family members starting from the early periods of urbanisation in Dhaka. It was expressed in both spatial and behavioural patterns. Female members remained unnoticed from the male and outsiders even in their domestic spaces as their domain was placed at the back or at farther areas from the formal public areas that were the street of the locality. In one of the earliest studies on urban house form in Dhaka by Imamuddin (1982), the binary pairs of front-back, outer-inner, male-female, clean-dirty seem to be present in the organisation of the Bengali houses. He explains this binary concept through a tripartite relationship among formal, family and service part of the consolidated urban house types in the post-colonial period (Imamuddin, 1982, pp. 2.21-2.40). The houses tend to be divided into two separate domains, one section is exclusively used by the inhabitants and the other is reserved for receiving male guests. The front is the street facing side; the public side receives the guests and restricts them to a limited area. This frontal side is maintained and gives an impression of the owner of the house to the outsiders. The male activities were located in this outer zone. Conceptually men are seen as strangers as far as household affairs are concerned. Socio-cultural rules and customs have confined women within the boundaries of the house and they are the back stage performers.

[1] If a society expects males to dominate in all family decision making, it is termed as patriarchy (Schaefer, 2003, pp. 300-311).

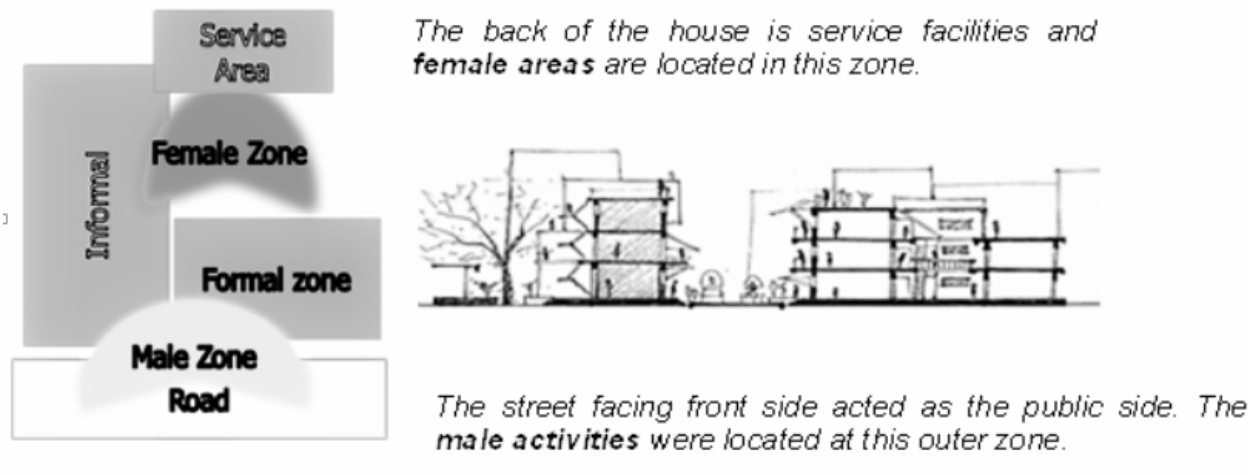


Figure 01: The male and female zones in the Traditional urban houses of Dhaka

METHODOLOGY

This paper focuses on of the women users of the middle-income group with the specific objectives of understanding segregation in the contemporary residential apartments in Dhaka. To address the gender-related symbolic dimension 'segregation' the responses of female heads of the middle-income group, living in apartments in Dhaka, are recorded and quantified to find out their life style and activity pattern in the house. The concept of segregation is addressed with the Justified Permeability Graph analysis [using JASS software] in this research.

Graph[2] theory was first applied to small architectural plans by Levin (1964) in his article, 'use of graphs to decide the optimum layout of the buildings'. Here Levin used access graphs in which the vertices represent rooms and the edges as the connection between rooms. It was March and Steadman 1971 who made a significant contribution to the utilizing mathematical concept of graph theory as an instrument for architectural thinking. Hillier and Hanson took a further step and brought its graph techniques into their spatio-social theory, Space Syntax, to measure and evaluate the property of the built environment. The study of spatial configuration is an approach that reveals the social order embedded in a spatial pattern. Steadman (1983) and Hillier and Hanson (1984) have introduced the analyses of domestic space configuration through architectural morphology.

In Hillier and Hanson's analysis method (Hillier and Hanson, 1988), the morphological characteristics of a plan layout are analysed with the help of graphs called “justified access graphs.” The justified graph represents the permeability of the system. In a justified graph, each space[3] is represented as a circle and doorways and other openings between adjacent spaces and circulation routes are shown by lines linking points. A particular space, which normally is an exterior space, will be selected as a root space and all other spaces will be applied for the depth level from root space. Therefore the level of the root is defined as zero,

[2] A graph is a way of drawing any set of relations between elements; therefore any buildings can be represented by a graph. By incorporating the syntactic structure of each home into one simple diagram a set of otherwise complex spatial relationships can be more easily understood. Spaces within the home have well defined links from one to another and thus the spatial structure can be described by a graph (Hillier and Hanson, 1984).

[3] Bellal (2007) defined a 'space' by the functions rather by physical boundaries. Hence a space has been regarded as a space designated for a particular activity. Areas that are not rectangular in shape such as 'U' or 'L' shape for example, it is used for a single activity has been considered as one space. Rooms with multiple functions for example living and dining area with no demarcation of boundary in between but where different activities happen in designated areas within the same geometrically bounded space has been taken as two spaces.

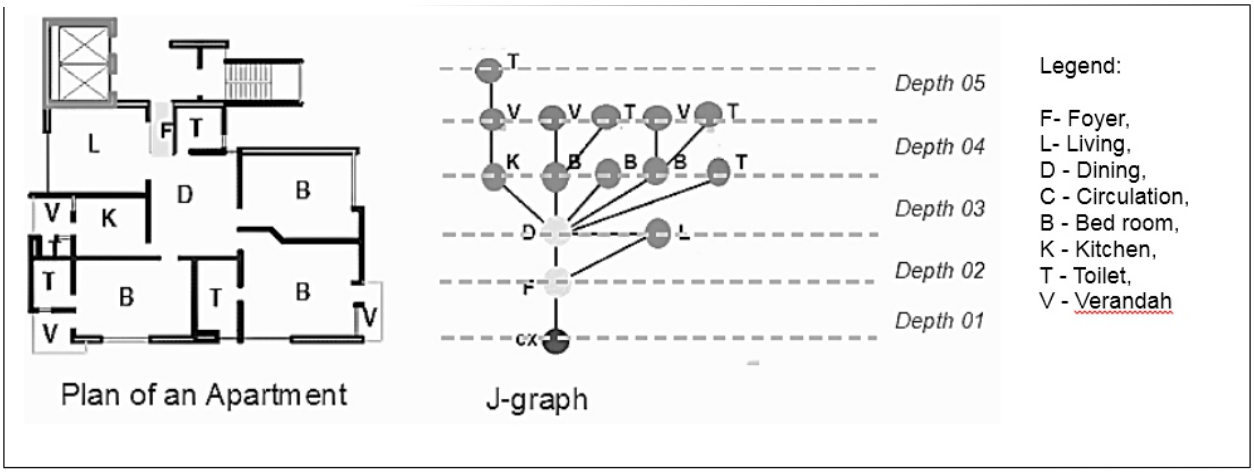


Figure 02: Justified Permeability Graph of an apartment

while the depth level of each space in the diagram corresponds to the steps taken to move from the root to that particular space. Every space in the building is assigned a depth value according to the minimum number of movements that must be taken to get from one space into another space.

Justified Permeability Graph (JPG), which represents the permeability of the system, is used to check the concept of the gendered space by checking integration[4] of spaces and their depth[5] to locate the gendered spaces in the spatial organisation. The relevant analysis shows that spaces are usually connected together in ways that vary the distribution of integration throughout the structure, making some spaces of a house more accessible (public spaces) than others (private spaces). Monteiro (1997) found the more integrated activities as the social ones and the segregated activities as the personal ones. Toker And Toker (2003) concluded that higher integration and lower depth from both the integration core and the entrance space is a reflection of its transformation into a shared space.

In this study Space activity analysis identifies the gendered and shared spaces in the contemporary MIG apartments in Dhaka and integration and depth properties are used for syntactic analysis.

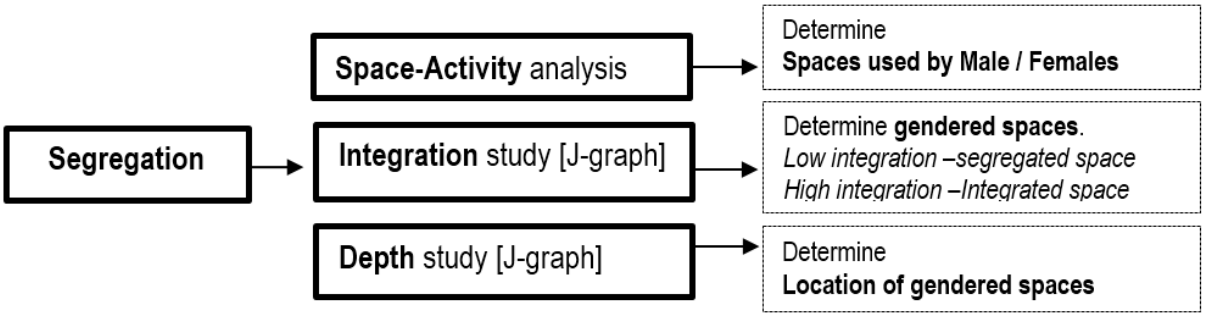


Figure 03: Methodology of Analysing Segregation

[4] Integration of a space expresses the degree to which it is integrated or segregated within a configuration: the more a space is integrated the more it pulls all other spaces in the complex close to it. As remarked by Hanson (1998:32) "Integration has emerged in empirical studies as one of the fundamental ways in which houses convey culture through their configuration".

[5] In these graphs, all spaces of the house are appointed depth values according to a chosen space called "the carrier." The carrier space in the analysis is at the exterior lobby of the studied flats. Depth of space in this study locates the space in the configuration with respect to the exterior.

SPACE - ACTIVITY ANALYSIS

The visitors and inhabitants interactions hold a prime role in the domestic space organisation. The physical division constitutes a social division of two groups: inhabitants as the users of the interior domain, and strangers as the users of the exterior domain. Based on the previous studies on the traditional Bengali houses (Imamuddin,1982; Shabeen,1997; Khan,1999; Islam,2003), it was seen that family activities such as working, eating, sleeping, cooking, etc. are performed in the inner part of the house while formal activities such as socializing, receiving guests, which include participation of the community are performed in the outer part of the house near to the entry. In traditional houses spaces used by male members (outhouse and living) are placed close to the exterior and the spaces those are used by women (kitchen, bed, etc.) are located far from the exterior.

In the contemporary middle-income group apartments, spaces are compactly arranged for bringing the apartment into an affordable range of the middle-income groups. From the study we can categorize the domestic spaces in three groups:

Gendered space	**Shared space**	**Transition space**
Living	Living	Entry
Master bed room	Dining	Circulation
Kitchen	Family living	

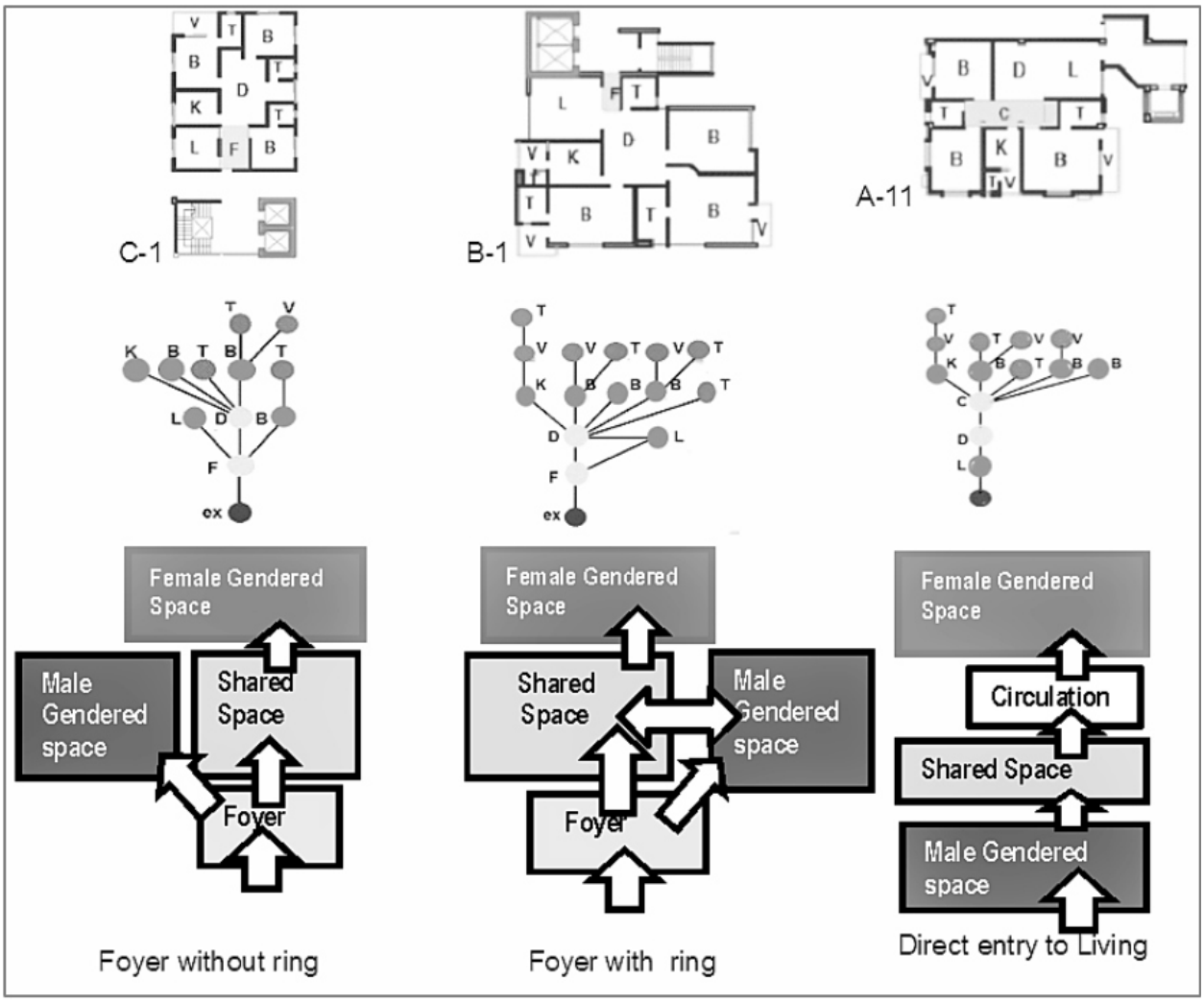
Living space in the contemporary middle-income group apartments is used for receiving and entertaining visitors mainly. Considering this living is symbolically a male gendered space. Unlike the traditional domestic spaces, where outhouse is the guest receiving area, living space in the contemporary middle-income group apartment has a dual character. The study reveals that it is being used by both male and female members of the family nearly equally for other purposes. Considering the activity of the living room it is found as a shared space.

Although master bed room is a shared space but considering female heads' activity and domain, master bed room is restricted for female visitors and in this respect master bed room is symbolically a female gendered space. The kitchen is used for cooking solely and used by the female members of the families. In the study, it was found that cooking is done by the female members. Male participation in cooking is very negligible. Thus the working or service zone kitchen in the contemporary apartment is female gendered space.

Some of the domestic spaces are solely shared spaces which are used by the both male and female members of the family like dining and, family living spaces. The transition spaces for connecting function holding spaces and for movement is used by both genders.

SPATIAL ANALYSIS

In this study, the 'space' is defined by the functions rather by physical boundaries. Hence space has been regarded as a space designated for a particular activity. Areas that are not rectangular in shape such as 'U' or 'L' shape, for example, it is used for a single activity has been considered as one space. Rooms with multiple functions for example living and dining area with no demarcation of the boundary in between but where different activities happen in designated areas within the same geometrically bounded space has been taken as two spaces.



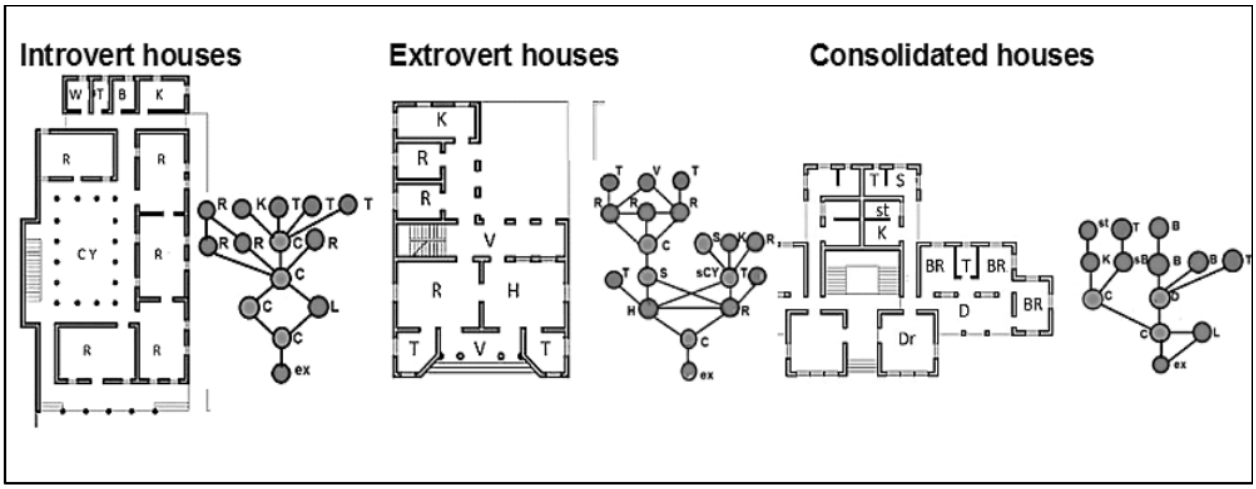
Legend: L-Living, D - Dining, C-Circulation, R - Room, K - Kitchen, T - Toilet, V – Verandah

Figure 04: Ringyness in Foyer (transition), Dining (shared) and Living (gendered)

In the spatial organisation of the MIG apartments of Dhaka, significant numbers of houses (44%) have Tree–like configurations while ringyness appears more predominant as 56% has a ring in their configuration. Ringyness at the entry seems a crucial point as it segregates the visitors and the inhabitants (shown in figure 4).

In the Traditional introvert type plans, entry plays an important role in segregating the user according to gender in the house. Entry is through a verandah and it leads to the outhouse that is used by the male members of the house to interact with the community (guests/Visitors) within the house. The main entry to houses was from the front road to the outer male zone devoted to guest and outsiders. Usually, in urban houses of Dhaka, a secondary entry was for female folks and service which was indirect in nature and led to the inner part of the house without crossing the outer public and male zone.

From Figure 5 it is seen that in the Introvert, extrovert and consolidated urban houses of Dhaka choice of movement created with ringyness of the configuration is a characteristic (Gomes, 2014, p.116). From the exterior the entry to the house gives two choices: one for the formal zone and the other for the informal zone which is connected by a circulation space, and the other in the inner part of the house connecting the



Legend: OH-Out House, CY -Court Yard, H-Hall, L-Living, D - Dining, C-Circulation, R - Room, K - Kitchen, T - Toilet, V – Verandah

Figure 05: J Graphs of the Introvert, extrovert and consolidated type urban houses in Dhaka [Source: Gomes, 2014]

courtyard circulation and the individual rooms. With choice in movement at the entry and around the courtyard helps to segregate female members of the house from the male outsiders and visitors. Different spaces in the urban houses of Dhaka follow a characteristic: Shared spaces are highly integrated and gendered spaces are segregated.

The spatial organisation of the traditional Introvert type houses in the context of Dhaka courtyard was a highly integrated space and acted as the shared space. The outhouse which was used as the guest receiving space and used by male members of the family is segregated with lower integration values. The cell-like rooms, used for sleeping and another purpose, were also segregated and mostly used by the female and family members. Kitchen the women's space was gendered and segregated having lower integration. (Gomes and Nilufar, 2012, pp. 362-365).

SEGREGATION IN MIG APARTMENTS

Segregation in gendered and shared space is interpreted with the depth and integration values of the spaces. It was found from the study of the middle-income group families that in contemporary urban apartments the living room is for the outsiders and visitors. Male members of the family interact with visitors in the living room which is located near to the entry of their house. Thus considering the stair lobby as the exterior point, from where the apartment is accessed, depths of different spaces are calculated and from it the percentage of each space according to depth are placed in Table 1 below.

Table 01: Depth of the different spaces in the studied apartments

	depth (1)	depth (2)	depth (3)	depth (4)	depth (5)	depth (6)
Foyer	**44%**					44%
Living	46%	54%				
Circulation		10%	24%			
Dining	32%	68%				
Kitchen		18%	60%	22%		
Family Living		08%	20%	08%		
Master Bed Bed-2 Bed-3		14% 10% 38%	40% 48% 36%	38% 36% 16%	08% 06% 02%	
Toilet (with M bed)			14%	42%	36%	08%
Veranda(with M bed)			14%	42%	36%	08%

Studying the order of depth a pattern is observed in the studied apartments. The living which is considered as the location for visitors in the studied cases is located near to the entry at depth one or depth two. In the studied apartments, 46% entry leads directly to the living. In 54% apartments, living is located at the second depth from the entry. Shared space dining and family living are after the living and in the configuration, it is at the central position. In 32% studied apartments shared spaces are at depth 01 near the entry. The female gendered spaces are located at a deeper location far away from the entry. Kitchen and bedroom are found to be located farther away from the entry in the study at depth 03 and in depth 04. Spaces used individually like toilets are terminal spaces and located at the end of the spatial configuration.

While analysing the depth of the studied apartments the depth of living becomes second in the spatial organisation when transition "Foyer" is used at the entry point. With a choice of access from this point of Foyer, segregation between the visitors and the inhabitants is achieved. Foyer, the transition space, creates ring among the male gendered space shared space and entry giving choice to a person while entering. Survey reveals that the respondents are satisfied with the privacy of the female gendered spaces from the visitor's area in the apartments where foyer is present. Where entry is to the living or dining directly the female heads expressed a desire to have separate entries so that the visitors cannot see the inner part of her house that is used mostly by female members of the house.

INTEGRATION OF SPACES IN THE MIG APARTMENTS

The activity pattern study denotes some spaces as male gendered space for having a concentration of activities of male members of the family and some spaces as female gendered spaces. By converting the RRA (Real Relative Asymmetry) values of different spaces from the J graphs constructed by using JASS software, the integration values of the different spaces are obtained for creating order of integration:

Dining(2.20)> Circulation(1.92)> F.liv(1.41) > Foyer(1.16) > Bed(1.15) > Kitchen(1.11) > Living(1.07)
shared transition shared transition female gendered male gendered

The living is considered as a male gendered space in this study which has a lower value of integration (average value 1.07). The female gendered spaces in the spatial organisation are located farther away from the entry and the integration of the female gendered spaces is lower compared to the shared space's integration values. Kitchen (average value 1.11) and Master Bed room (average value 1.15) have a lower value of integration.

The shared spaces in the spatial organisation are located at the central position of the spatial organisation and Integration of the shared spaces (Dining, Family living) are the highest in a spatial organisation (average value 2.20). The shared space Dining has the highest integration in 76% cases. Transition spaces (foyer and circulation) have high integration values as they are connecting the gendered spaces and shared spaces. Circulation is highly integrated (average value 1.92) in apartments and in some cases have the highest

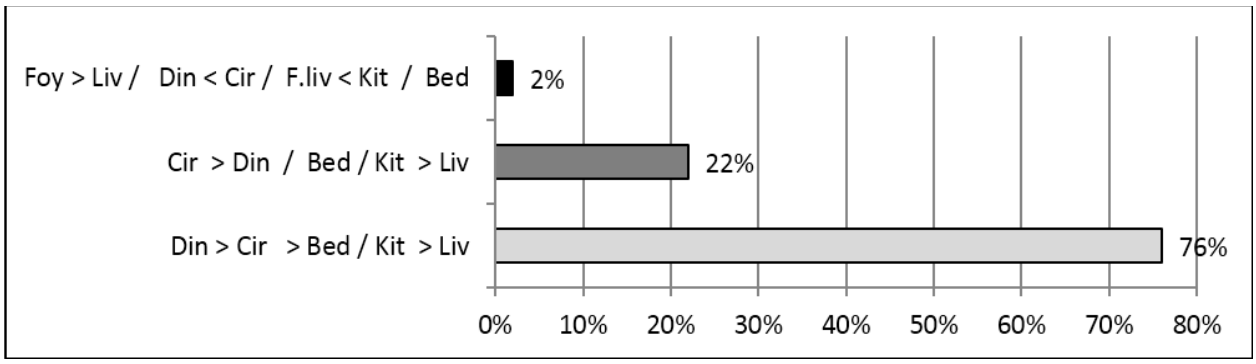


Figure 06: Orders of Integration [Source: Gomes, C. D., 2014]

integration values where circulation is a dominant element in the spatial organisation. Foyer itself is an integrated space (average value 1.16) and has higher integration values than the gendered spaces. The following graph shows different alternative orders of integration that prevail among the samples.

Thus the findings from the spatial analysis of the MID apartments lead to the conclusion that shared spaces (Dining, Family living) and transition space (circulation and foyer) are highly integrated and gendered spaces (Kitchen, Living, and Bedroom) are segregated in their configuration.

TRANSITION SPACES EFFECTING SEGREGATION

Transition space has become an important element as it impacts the affordability of the owners and at the same time it influences upon the symbolic aspects of the domestic space. Three types of spatial organizations are seen in the MIG apartments based on the presence or absence of the transition space: First, Apartments without Transition Space; Second, Apartments with Transition Space-Foyer and Third, Apartments with Transition Space-Circulation.

In apartments where foyer is absent at the entry (Figure 7), one enters directly to the living from the exterior lobby space. 36% apartments of this type are tree-like and rest 64% have ringy type configuration. The configuration of this type is shallow because of the absence of transition spaces. Shared space is observed between the male gendered space and the female gendered spaces. Dining as the shared space in this type configuration is the most integrated space. Gendered spaces living and master bed room have lower integration than the shared spaces. Kitchen, the female gendered space, is the most segregated space in the configuration.
In the apartments where Transition space is absent, the order of Integration follows a pattern:

Dining (3.17)	>	F.Liv (1.43)	>	M.Bed (1.37)	>	Living (1.25)	>	Kitchen (1.19)
		shared		gendered (F)		gendered (M)		gendered (F)

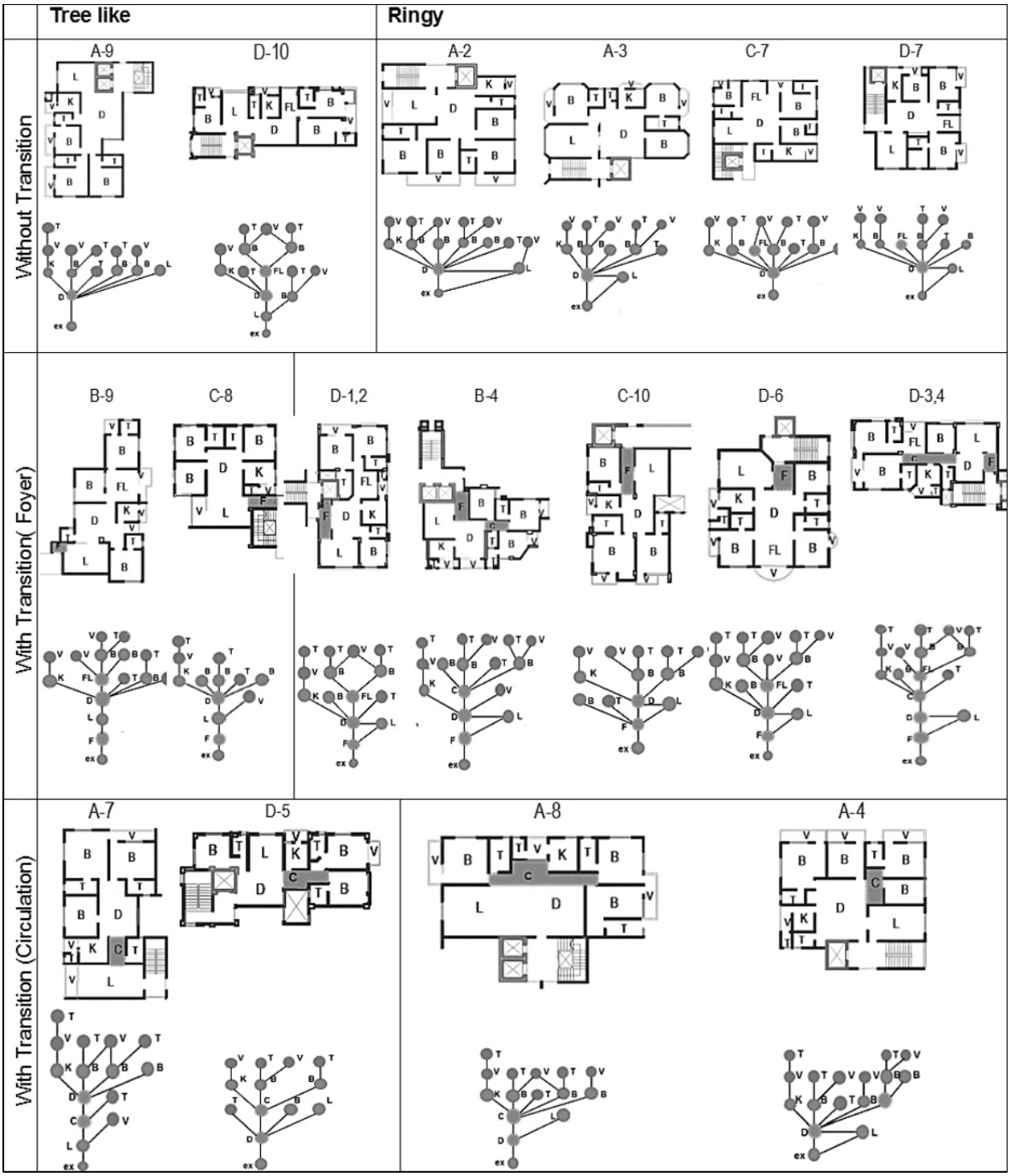
In apartments where foyer is present (Figure 7), it acts as a node to the exterior and living, guest bed room and dining spaces. In 27% cases, foyers do not create ring among the spaces and have tree-like configurations. 73% of the apartments with foyer ring among the living, dining and foyer space creates choice in access. When foyer is present the integration of dining is highest in the configuration. Gendered spaces, living and master bed room, have lower integration than the shared spaces. In the apartments where foyer is present, the order of Integration follows a pattern:

Dining(2.06)	>	Cir (1.67)	>	F.liv(1.44)	>	Foyer (1.15)	>	Kitchen (1.11)	>	Living (1.09)	>	M.Bed (1.07)
Shared		transition		Shared		transition		gendered (F)		gendered (M)		gendered (F)

Circulation acts as insulation between the gendered space and shared space in the apartments where circulation is introduced in the central position, connecting the internal female gendered spaces with the shared spaces. The order of Integration follows a pattern:

Cir (2.00)	>	Dining (1.74)	>	M.Bed (1.15)	>	Kitchen (1.06)	>	Living (0.93)	>	MI (0.88)	>	Toil (0.70)
transition		shared		gendered (F)				gendered (M)				

Comparing the three types of configurations, it can be concluded that when the transition is absent in the apartments, dining acts as the most integrated space in the configuration. The presence of the transition space makes the male gendered space 'living' more segregated in the configuration. While conducting the survey and interview with the respondent's segregation created with entry was becoming emphasized by the respondents.



Legend: F- Foyer, L- Living, D - Dining, C - Circulation, B - Bed room, K - Kitchen, T - Toilet, V – Verandah

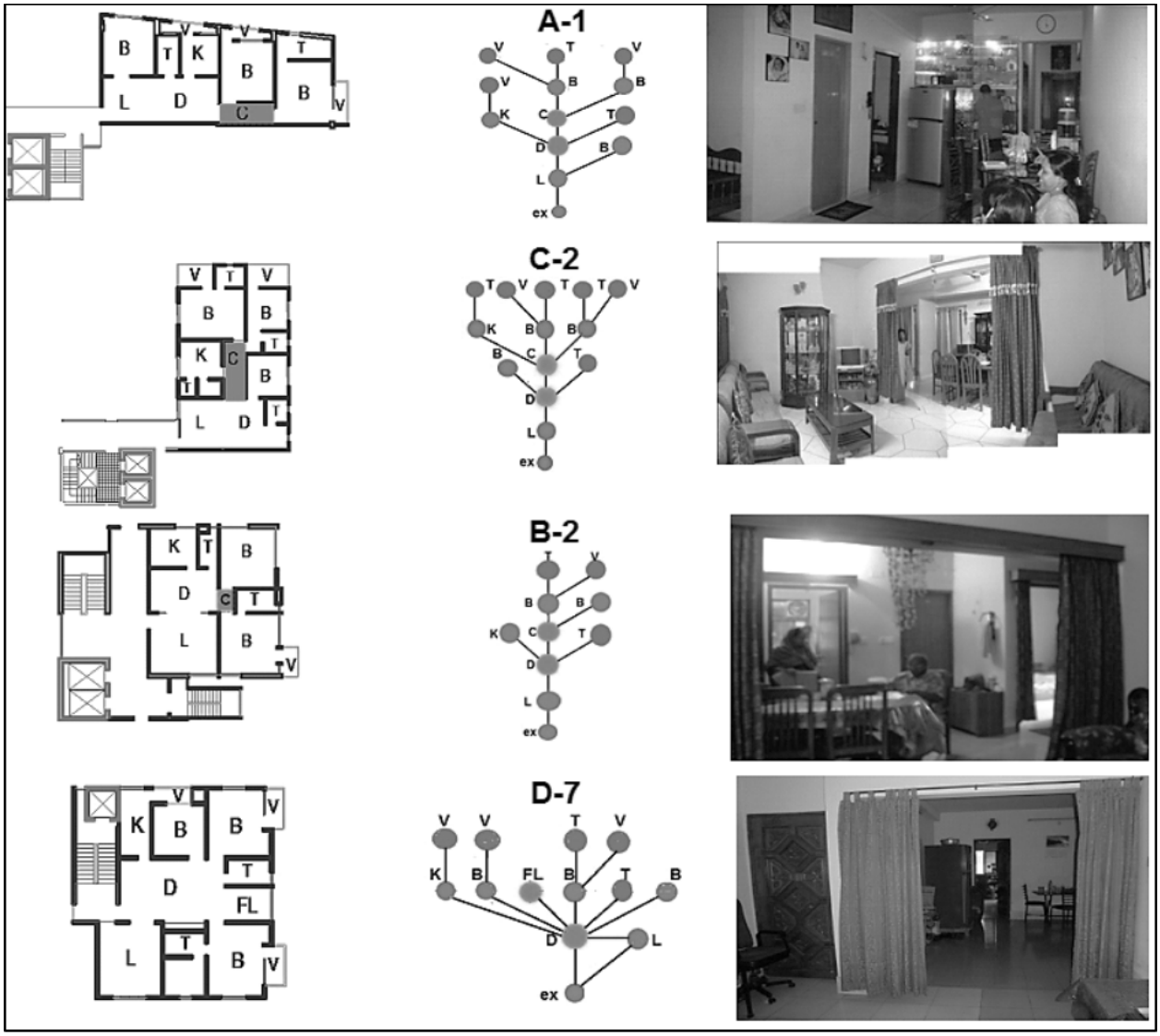
Figure 07: Configuration of the Apartments without Transition Space, with Transition Space Foyer, with Transition Space Circulation [Source: Gomes, 2014]

Mainly two types of entry penetration to the domestic space from the exterior lobby are seen in the middle-income group apartments of Dhaka. These are concerned with the presence of foyer–that is an ante-space distributing access to the domestic space. In the study, 44% samples were with foyer and remaining 56% of

the sample was without foyer, where entry was to the living (28%) or dining (16%) or to both (12%). When foyer is not present the access to the domestic spaces are direct to Living and Dining or two both from the exterior. The presence of foyer creates ring among the spaces and gives choice in access which impacts greatly on the segregation of genders in the domestic space while entering. In some apartments these foyers are present but they do not create the ring and cannot provide choice in access.

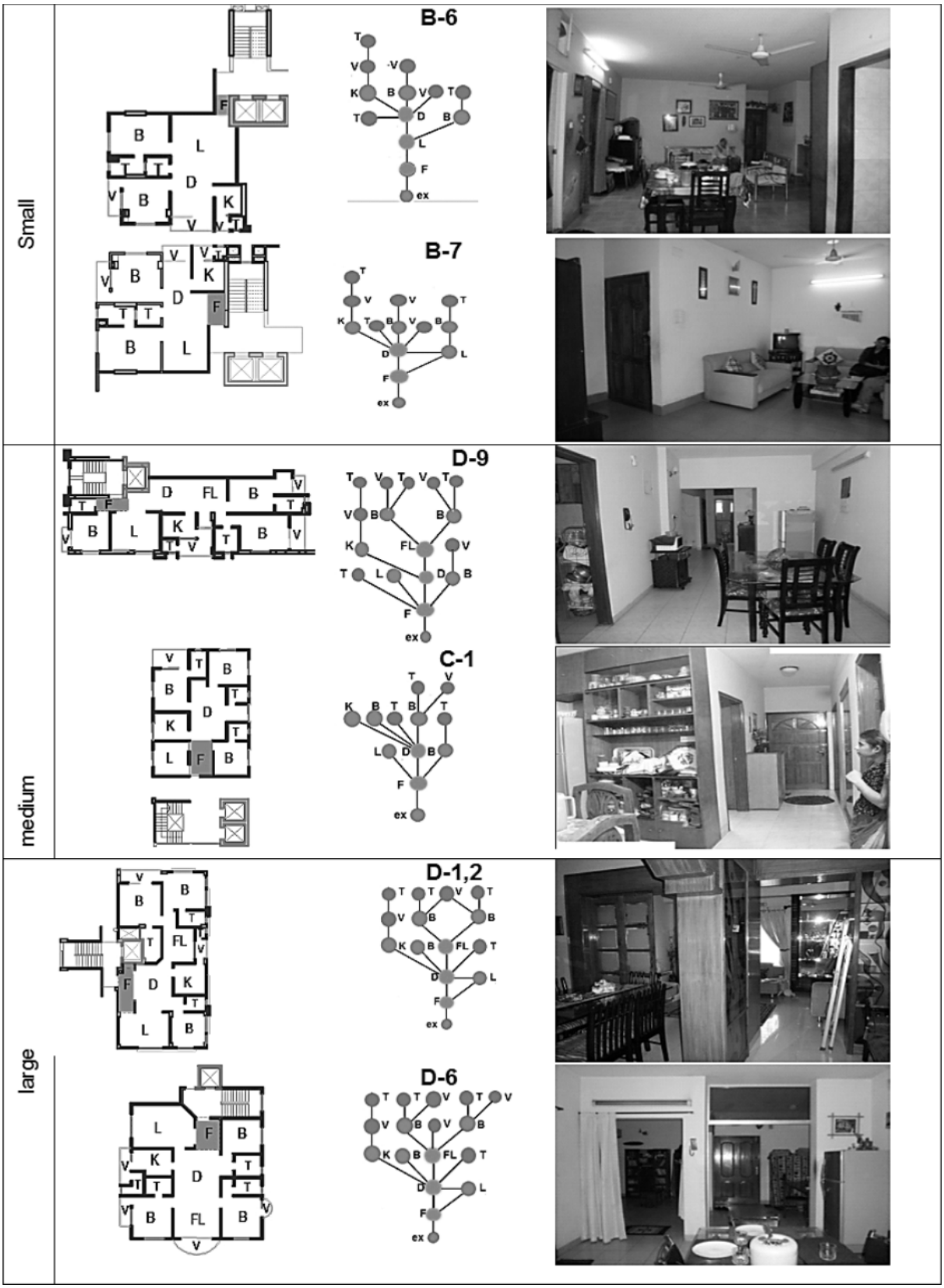
In the contemporary MIG apartments, transition space has become an important element as it impacts upon the symbolic aspects of the domestic space. The presence of the transition in the spatial organisation creates depth and choice of movement with ringyness and helps to segregate male and female gendered spaces. Analysing the depth of the studied apartments it is seen that:

- The male gendered spaces in the MIG apartments are located near the entry. The living which is considered as the location for visitors in the studied cases is located near to the entry at depth one or depth two.
- When a transition “Foyer” is added at the entrance space it creates a choice in access and brings the male gendered space at depth 02.
- The female gendered spaces are located at a deeper location far away from the entry.



Legend: L- Living, D - Dining, C - Circulation, B - Bed room, K - Kitchen, T - Toilet, V - Verandah

Figure 08: Entries directly to the living and dining [source: Gomes, 2014]



Legend: L- Living, D - Dining, C - Circulation, B - Bed room, K - Kitchen, T - Toilet, V - Verandah

Figure 09: Small, Medium and Larger apartments with Foyer [Source: Gomes, C. D., 2014]

Integration values of the different spaces of the studied apartments show that mean integration of different spaces follows a pattern:

- Shared spaces (Dining, Family living) and transition spaces (circulation and foyer) are highly integrated.
- Gendered spaces (Kitchen, Living, and Bedroom) are segregated in their configuration.
- Toilets, verandah those are terminal spaces are the most segregated spaces in the configuration.

Comparing the integration values of the different spaces in three types of configurations considering transition space, it was seen that when the transition is not present in the apartments the spaces in the spatial organisation have higher integration compared to the other two types.

- In the compact apartments where transition (foyer and circulation) is absent living, the male gendered space is less segregated than in the apartments with foyer and circulation. The presence of the transition creates depth and makes the male gendered space 'living' more segregated in the configuration.
- Transition reduces the integration of the shared spaces. Shared space dining acts as the node and the most integrated space in the configuration. It is less integrated into the configurations where circulation is present.
- Kitchen, the female gendered space, is a segregated space in all type of spatial organisation and presence of transition makes it more segregated in the configuration.

STATUS INFLUENCE ON SEGREGATION

Socio-economic status of women, as a social dimension, influences on house plans. Socio-economic changes bring consequent changes in the lifestyle and act as causes for changes in the symbolic dimensions and synchronize with the change in the spatial organisation. The social status of middle-income group women depends largely on their economic status in the urban context of Dhaka. In the case of studied urban houses of Dhaka, a development in the status of women is evident that can be interpreted by the change of educational status and women's participation in the economic activities. The female heads of the MIG families in this study are found to be educated and the majority of them having a higher education above graduate level (Gomes, 2014). This has an influence on the symbolic perception of women regarding segregation.

To check the impact of the status of the female heads regarding segregation responses of the economically active and economically non-active female heads are compared with the spatial findings. Preference of segregation with foyer is found to be relatively high in contemporary middle-income group female heads in Dhaka. From Table 2 it is seen that the respondents, those who have foyer at their entry point, are satisfied with the foyer of their apartment mostly regarding preserving segregation from visitor's area and family area in their house. In apartments where Foyer is not present and entry is to the living or dining directly the female heads expressed a desire to have separate entries so that the visitors cannot see the inner part of her house that is used mostly by female members of the house.

Table 02: Comparative study of the responses regarding segregation with Foyer

	Apartments with Foyer	**Apartments without Foyer**
Economically non-active	Satisfied with the foyer 75% Not Satisfied with the foyer size 25%	Needs Foyer 82%
Economically active	Satisfied with the foyer 50% Not Satisfied with the foyer size 50%	Needs Foyer 82%

In the domestic spatial organization of the MIG apartments kitchen is the most segregated space. A desire was seen in few female heads regarding open type kitchen to have better control from there. This issue needs further elaboration as it tends to generate a different type of domestic spatial organisation in the context of Dhaka.

CONCLUSION

The spatial organisation in the context of Dhaka has gone through a transformation and at present has resulted in a specific apartment type due to land scarcity along with other reasons. The price of the apartment has increased; still, researchers found that the need to live close to the work space and schools of their children are making the middle-income group families inclined towards owning an apartment in Dhaka (Begum, 2010; Zahur, 2007). Flats are made affordable to middle-income group by compromising the size and location of the apartments. Designer and developers are making adjustments with the cultural issues present in the middle-income families while making it compact to provide within the affordable limit to them.

Segregation between male and female members in the domestic space remained with some alterations in the contemporary MIG apartments due to compaction of spaces. Although their socio-economic status is raised from that of the traditional society still they seek for segregation from the male visitors. Due to change in the family composition, the interface between male and female family members has become reduced. But in terms of the visitors-inhabitants interface, this segregation is followed in a subtle way. Spatial organisations of the MIG apartments are becoming compact by reducing the transition spaces to minimize apartment area. Study findings support the fact that existence of the transition spaces at the entry of the house offers segregation of the female inhabitants from the visitors. The transition space –foyer- in the spatial organisation increases the depth and create ring among the male gendered space and shared spaces. Male gendered spaces in the MIG apartments are located near the entry and female gendered spaces are located at deeper depth away from the entry. With respect to segregation aspect foyer acts as a spatial component that creates depth to segregate the gendered spaces in the spatial organisation. This spatial component which is necessary for creating segregation in the Domestic spatial organisation is omitted in the compact apartments for space minimization. Using foyer at the entrance to segregate the visitors is one of the preferred options found in the contemporary apartments that has become effective and desirable from the female head's point of view. The female heads, those who have a foyer in their apartment acting as transition space to give choice in access, are satisfied with respect to segregation. When the apartment is too compact providing a satisfactory foyer is difficult. Yet in some small compact MIG apartment's foyer exist serving the need for segregating the visitors from the inhabitants. There is a demand in the present female users of these apartments regarding this spatial component foyer to maintain segregation in their domestic space. In the densely populated city, Dhaka, the developers are making the MIG apartments compact in order to bring the apartments within affordable range; while doing this they are negotiating with the socio-symbolic demands of the middle income group women. This need of segregation and maintaining privacy in the contemporary apartments should be given more emphasis while designing since it is the reflection of the lifestyle and need of the contemporary women living in the apartments in Dhaka.

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Changes in Shared Spaces for Social Interaction: A Socio-Temporal Evaluation of Real Estate Apartments in Dhanmondi R/A, Dhaka

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Abstract: This paper evaluates the role of shared spaces within contemporary real estate apartments in Dhanmondi Residential Area in Dhaka-based on users' adaptation for social interaction by comparing two assessments separated by seven years. While these apartments provide regular and designed shared spaces for generating social interactions, besides dwelling units, do people change themselves for making changes in their setting—social space—for social interaction? This paper probes this question when affluent communities living in apartments, belonging to a wide-ranging socio-economic background, face a higher degree of hesitation for social interaction than those living in traditional arrangements and resulting to a socially unfit group. The issue of social interaction within apartment community, this paper argues, becomes equally important with other issues of apartment planning and design. The shared spaces of six apartments of Dhanmondi R/A were evaluated through ethnographic study and post-occupancy evaluation (POE) method based on observations made in 2008 and 2015. A socio-temporal evaluation gives evidence to the 'then-now' condition of the apartments and the social and spatial changes taking place in regular and designed shared spaces of the same apartments. The findings from a 'then-now' comparison assert apartments' growing and transforming with the change of its inhabitants and their needs, and are evident in its regular and designed shared spaces for social interaction. In conclusion, the findings support the rationale of evaluating the built environment performance to provide design feedback as it ruminates social and behavioural issues considering the users' standpoint.

Keywords: Social Interaction, Shared Spaces, Real Estate Apartments, Post Occupancy Evaluation

INTRODUCTION

Dhaka, the capital of Bangladesh holds the ninth position in urban agglomerations in the world. The density of urban population of Dhaka has rapidly increased from 4457 per sq-km to 7444 per sq-km (BBS, 2011), and has created a huge demand for housing and physical infrastructure. Furthermore, the shortage of developed urban land and urge for possessing a property in the capital has made Real Estate Apartment (REA) living a popular choice among the affluent urban population. These internally varied modern communities face a higher degree of social disorientation and hesitation to social interaction than the traditional ones, often leading to various social problems and socially unfit groups in the apartments. Henceforth, the issue of social interaction within this apartment housing community along with the spaces for interaction is equally important with other issues of apartment planning (Islam, 2012). Earlier observations suggested that inadequacy or non-existence of community space in these apartment buildings is one of the main reasons for the needs and demands for social interaction of the residents not being fulfilled (ibid). The REAs, besides merely dwelling units, provide two types of shared spaces within the building that are common among the owners: First, the regular shared spaces i.e. lift lobby, staircase, roof, meeting rooms, parking etc. Second, designed shared spaces for social interactions when designers being aware of the problem of lack of social spaces come up with different design solutions in the form of courtyards, swimming pools, multipurpose halls and so on. Social space here refers to the spaces regularly visited, spaces where users spent time on the holidays and spaces that they choose to go out for recreation and eating.

Most of these shared spaces, however, have remained unevaluated in terms of users' adaptation for social interaction in time. Observations of the same shared spaces for social interaction in 2008 and 2015 lead to explore the present condition of the apartments and the social and spatial changes taking place in shared spaces of the same apartments. The shared spaces of six apartments of Dhanmondi Residential Area (R/A) were evaluated through a POE method based on observations made in 2008 (Islam, 2012). The users of these apartments later have had gone through socio-demographic changes: the tenants shifted, children grew up, some service holders retired, and some young adult got married. As shared spaces of the apartments have gone through changes in time, an earlier evaluation of the previously evaluated shared spaces carried out in 2015 searched for tracing changes in the spatial setting with the following objectives: First, searching for the socio-demographic change in a user group in these apartments. Second, searching for the extent of spatial and physical changes taking place between the two survey periods. Third, assessing the nature and extent of changes of shared spaces for social interaction by comparing through a “then-now” evaluation to explain how these changes are affecting dwellers' use of spaces. After setting the objectives in the Introduction, this paper outlines methodology followed by a description of the contextual and theoretical backgrounds. Then it presents the finding coming out of the changing user profile and settings for social interactions between 2008 and 2015. In Conclusion, the findings support the rationale of evaluating the built environment performance to provide design feedback as it ruminates social and behavioural issues considering the users' standpoint.

METHODOLOGY

This paper employs both the ethnographic study for gathering user profile and a POE for evaluating shared spaces for social interactions. The three objectives and their respective data collection methods are outlined below in Figure 01. This paper is a result of two observations obtained from two POE performed in the selected apartments. A similar method that was followed in 2008 was also followed during the POE in 2015, and the key steps involved in the comparison between the two are summed up below in Figure 02.

Review of relevant theories and research on social interaction in apartment buildings in the general field of POE helped to determine the key concepts and develop an understanding of theoretical framework to carry out the field survey and analyze the data. Before going into the detailed survey, a reconnaissance survey was carried out to find out the typologies of apartments present in the area. Six apartments were selected, equally

Objectives	Methods for data collection
To search for the socio-demographic change in a user group in these apartments in relation to the use of spaces.	Case study and Ethnographic study of Selected Families
To search for the extent of spatial and physical changes taking place in the initial survey and	Post Occupancy Evaluation based on selected criteria and indicators.
To assess the shared space through a comparison between the “then-now” evaluations	Comparative analysis between two POEs

Figure 01: Relationship between objectives and method

Figure 02: Steps of the study

located at larger and smaller plots from the survey based on the presence and absence of designed spaces (Islam, 2012). A questionnaire survey was then done to find out the socio-economic data of the residents of these apartments. Based on the questionnaire survey and general discussion and interview, families from these apartments were chosen for in-depth interview for ethnographic study. Families varying in a number of members, age, gender and different profession were chosen so that the variable use of spaces within the building can be traced. In-depth qualitative interviewing means repeated face-to-face encounters between the researcher and informants directed towards understanding informants' perspectives on their lives, experiences or situations as expressed in their own words (Taylor et al, 1984). Life history was taken, where the salient experiences in a person's life and that person's definitions of those experiences were captured. The focus was to identify the social spaces of the residents focusing on the role and use of these spaces in social interaction. The relation of the residents and their neighbourhood is important to understand the situations of the buildings as well as the occupant's sense of spaces for socialization in a bigger scale. Presenting the rich qualitative data is beyond the scope of this paper.

For POE, the regularly shared spaces and designed shared spaces having potential to generate social interactions were identified as shown in Figure 4. Then three evaluation criteria and indicators for each criterion based on which evaluation of each element was done were determined (Islam, 2012). So, every element of the apartment is analyzed in terms of these three criteria based on certain indicators. For every indicator, space is evaluated on a scale of being satisfactory, moderately satisfactory and unsatisfactory. The findings from the three criteria were then summed up to get a compiled result that represents the result for each apartment. For this paper, each element is critically analyzed, but not summed up as a whole (Figure 03).

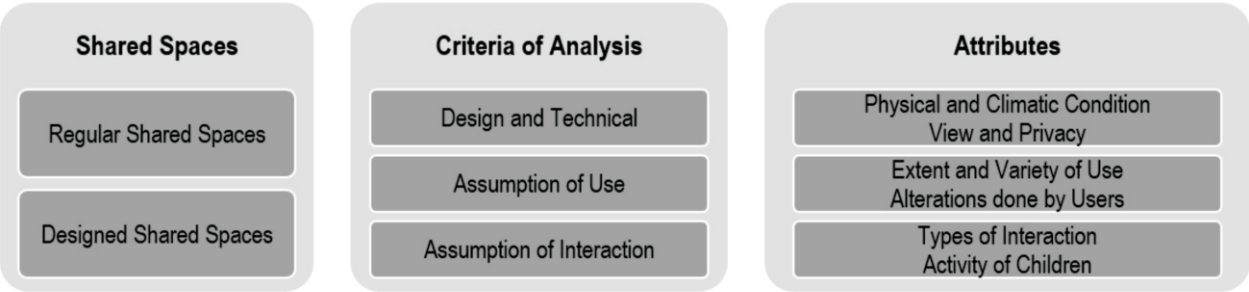

Figure 03: Evaluation Framework: Shared Spaces, Evaluation Criteria and Attributes (Islam, 2012)

CONTEXTUAL AND THEORETICAL BACKGROUND

This section explains the context for considering the role of shared spaces for social interaction by explaining the contextual and theoretical backgrounds for studying the concept of Social Interaction and its significance.

The megacity Dhaka has gone through a rapid growth in the recent decades. The population of Dhaka has grown from 2, 06 million in 1974 to 9,91 million in 2001(BBS, 2001), and is estimated to be 156.69 million in 2015 (Demographia, 2015). Restraint in physical expansion due to city's location within an encircling river system, and lack of urban infrastructure development has restricted its horizontal growth. The phenomenal growth of the city population is dominantly contributing to the dynamic changes in residential areas. The only way to accommodate the rising population appears growing vertically. Thus apartment living in both low-rise walk-ups and high-rises have become a popular choice for the high income and higher middle-income groups of the city dwellers. The formal private developers had introduced the multistory and multi-family apartment building types in the early1980s. Dhaka experienced a boom in apartment development in almost all the planned and unplanned formal residential areas since the late 90s. Although formally the early 1960

developments were not much different from the government quarters and multi-storied single ownership walk-ups, the new idea of multi-ownership and shared facilities like parking area, lobby spaces, lifts, stairs, services etc. with individual unit rights was accepted since the 1980s. The only significant change that has taken place was freeing the ground floor from the unit and providing parking and other services. Though high-rise apartments in Dhaka have a minimum 10 percent of the total floor area dedicated as community spaces as per provision by the 1996 Building Construction Rule, a large number of apartments are exempted from this rule. These are the six story apartments with a smaller number of population living in. These apartments have better options for initiating social interaction among the residents, especially children, elderly people and women, who stays in these building for a longer span of time (Islam 2012). Amidst paucity of local literature, earlier local studies (Ghafur (2005; Ghafur and Siddika, 2014) on the low-income dwellers' social and spatial adaption in multi-story public housing suggest a propensity for social interactions' taking place in shared space. These REA built apartments, therefore, become appropriate cases for studying the shared spaces that generate social interaction

Social interaction is a dynamic, changing sequence of social actions between individuals, modifying their actions and reactions according to the actions by their interaction partner; it occurs in a particular place and duration of time (Giddens, 2006). Social interaction becomes a fundamental concept of society formation (Ian, 1980) as people in a society share a common way of living by interacting on a regular basis as they have acquired a behavioural pattern agreed generally by all. Changes in urban and house forms due to culture, technology, and power initiate changes in social interaction forms- [King, 1980]. Moreover, population size, density, and social heterogeneity of a housing area influence social interactions at the community level (Abu-Ghazzeh and Tawfiq, 1999). Social interaction is enhanced by the presence of three variables: the opportunity for contact; proximity to others; and lastly, appropriate space to interact (Fischer, 1977). This active presence in a given context suggests that the design of a neighbourhood provide both opportunities for and constraints on whom and where the individuals interact. Physical design affects social relations principally through its control over proximity (Festinger et al, 1950). The less the physical distance of the assigned activity and the greater the number of paths leading to it, the more passive contact, the higher the probability of social interaction (Ghazzeh and Tawfiq, 1999). Functional distance affects the space of interaction, proximity to others, the opportunity for contact, and social interaction patterns (Abu-Ghazzeh and Tawfiq, 1999).

The chance of interaction is more in the apartments as they have a smaller number of users and the chance for intimate interaction is high in them. Four forms of social interaction (Figure 04) are distinguished in terms of their relative chances of occurrence (Heatherton and Walcott, 1990). All the above four forms of interaction are expected to be seen in the shared spaces of an apartment; however, no attempt is seen to evaluate regarding social interaction in the local context.

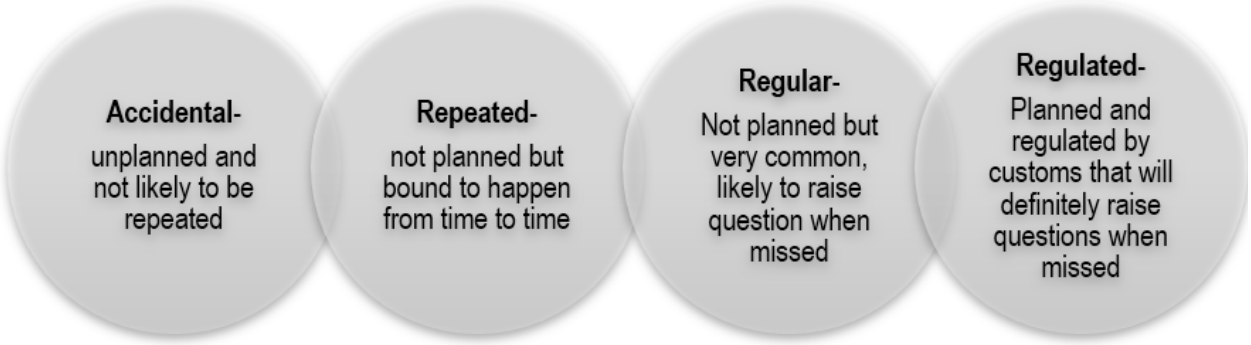

Figure 04: Form of Social Interaction (Heatherton et al, 1990)

The key purpose of residential buildings is to provide their occupants a safe, comfortable, healthy, and secured indoor environment that carries out different activities ranging from family life, leisure to social interactions. Buildings are thus designed based on established standards and specifications by governments, professionals, and experts who have adequate knowledge of users' needs and expectations (Eziyietal, 2013). Studies show that these standards and specifications do not often conform to the changing needs of users leaving them unsatisfied (Kaitilla, 1993; Ukoha and Beamish, 1997; Zeiler and Boxem, 2008; Meir et al, 2009). As Meir et al (2009) rightly observed, whereas designers in other fields expend considerable resources in examining the functioning and user satisfaction with services and products and refining their design accordingly, professionals in building industry appear not to have done well in this area (Eziyietal, 2013). Kim et al. (2005) and Fatoye and Odusami (2009) suggested that one of the ways to improve the performance of buildings is to understand users' needs, expectations, and aspirations through regular performance evaluation. The expectations of building users and the community are diverse and vary among individuals and groups, thus Building Performance Evaluation (BPE) is used to constantly examine the extent to which buildings are effective and efficient in meeting the users' needs and expectations (Liu, 1999; van der Voordt and Maarleveld, 2006; Nawaz and Khalil, 2008). The main categories of approaches to BPE, include: (i) functional suitability of buildings; (ii) quality assessment of buildings; (iii) service ability; (iv) environmental performance; (v) energy consumption and indoor air quality; (vi) user satisfaction; (vii) post-occupancy evaluation (POE) of technical, functional and behavioural aspect of buildings (Khairetal, 2012).

Post-occupancy evaluations (POE), in architecture, are concerned with social and behavioural issues as opposed to aesthetic issues (Wener, 1989). POE focuses on building occupants and their needs and compares actual building performance with human performance needs (Preiser et al, 1988). Main goals of POE are to provide actions to improve life quality of users and to produce a database and generate systematic knowledge on built environment and relations between environment and behaviour (Preiser et al, 1988). The 21st century has seen a new paradigm replacing the hierarchical, command and control, top-down approach, one that is autonomous, self-organizing, ecological, to sustain adaptation and continuous improvement (Preiser, 2007). Issues pertaining to the building delivery cycle and life-cycle – a Meta level approach to building evaluation, were investigated jointly, and an integrative framework for building performance evaluation was developed. In this framework, POE represents only one of six internal review loops, and the framework focuses on the entire life of a building (Figure 05).

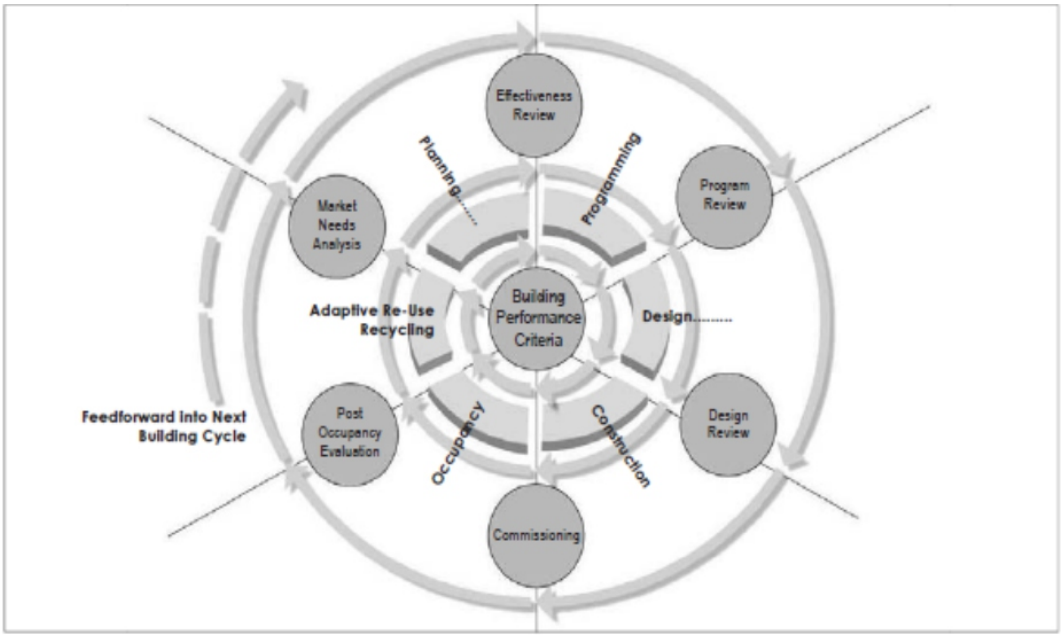

Figure 05: Building Performance Evaluation Process Model (Source: Eziyietal, 2013)

THE CHANGING USER PROFILE AND SETTINGS FOR SOCIAL INTERACTION

As a background to further analysis, this section outlines the profile of the users living in the REAs, of Dhanmondi R/A along with the changes taking place. The socio-economic condition of the users, their social spaces, and type of interaction taking place and their relation with their neighbours and their neighbourhood are discussed next.

Socio-Economic state of the users

The time span of stay in Dhaka of the residents of these apartments varies from twenty years to two generations. The older section of the population though familiarized with the urban life, still struggles to adapt to the busy and self-centered life of the metropolis, whereas, the younger generation are quite habituated with the scenario. Well-established businesspersons or professionals including doctors, engineers, teachers, architects etc. head most of the single families of three to four members. Only 25% of the children being under thirteen years, most of the children are college or university students. Most of these occupants belong to the upper- and upper-middle class strata with about forty percent families where the head is the only earning member and sixty percent families where more than one person is contributing to the household expenses.

The Role of social space in social interaction

The relation of the residents with their neighbourhood is important, as it reflects both the social condition of the buildings and the occupant's sense of spaces for socialization in a bigger scale. The type, occurrence, and extent of the daily activity vary with age group, occupation, distance one travels, and above all individual characteristics. Both the working male and female members spend a large time at the office and after office hours with families. The homemakers, on the other hand, spend most of the time taking care of home. The children under thirteen and teenagers follow the same routine of school, coaching, and games after lunch and homework. The holiday routines vary from family to family reflecting one's family type and the nature of leisure one indulges in. The holiday's routines have extreme opposite examples with cases of spending the whole day at home to members gathering for breakfast beside the lake followed by lunch at one of the member's houses of their morning walk group.

The social network that established by the households over generations, has taken a different form in the apartment context. The apartment dwellers have wider social network mostly with relatives, friends, and fellow dwellers depending on the duration of living, which results in many cluster and fellow groups within the apartment based on age, education, occupation, origin (home district), political identity, religious practices, like-minded etc. Moreover, employment and ownership status play important roles for social networks (Hussain, 2010). The daily household needs of the residents are met from the nearest departmental stores, kitchen markets, and vans. The colourful and well-publicized restaurants are trendy and are hard to find free places on the weekends. Virtual parks are popular among the children. Lack of open spaces for leisure time; force the people to spend most of the time at home.

Changes observed in the user group

Though not a very diverse one, few changes have taken place in the user groups in these apartments. The foremost change that is seen is the children growing up. The buildings, full of chatter, are now quite as most of the children have grownup into teenagers or adults. Many of the professionals have retired, and spend more time in the building premises. This reflects in their attempts in gardening in the roof or common corridors. Many of the tenants have shifted and new tenants have walked in. The variety of the user groups still prevails, and though the previous groups have changed, newer members have taken up the places keeping the overall character homogeneous and identical as before.

SOCIO-TEMPORAL PROFILES OF SHARED SPACES FOR SOCIAL INTERACTION

This section discusses the present condition as observed in 2015, along with a comparison of the previous 2008 findings of the shared spaces and evaluates its role in generating social interaction among the inhabitants. For conducting POE, the shared spaces, both regular and designed, which are thought to be potential in generating social interactions, were identified. Each of the shared spaces was evaluated with the set evaluation criteria along with definite indicators. The obtained findings show the result of each element being satisfactory, moderately satisfactory or unsatisfactory and from this compiled together, the result of each apartment is obtained. The whole process is shown below (Figure 06).

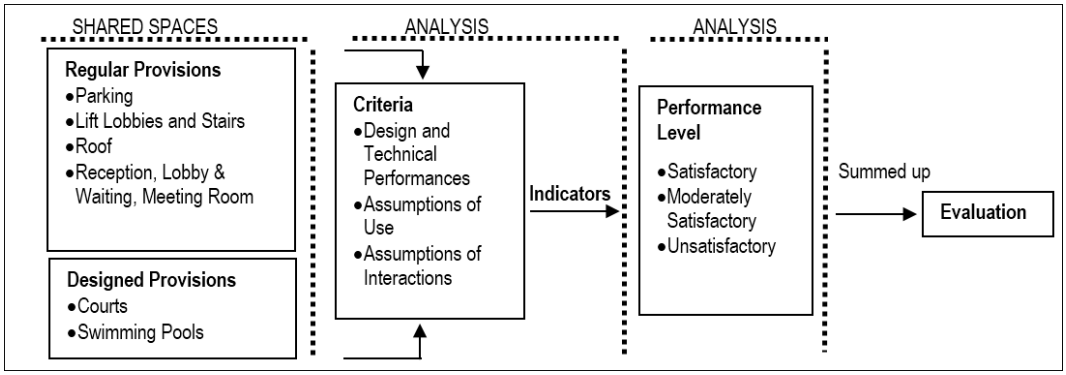

Figure 06: Evaluation Process (Islam, 2012)

Regular Shared Spaces of the buildings

The regularly shared spaces are those, which are present in all the apartments and are thought to be generating social interaction among its users. Parking, lift lobby, stairs, roof, meeting rooms are identified as regularly shared spaces. The evaluation of the spaces will be described along with the changes observed during a recent survey.

Parking

The Parking spaces in these apartment buildings are proved to be satisfactory in terms of design with being well lit and ventilated. Besides car parks, these spaces are facilitated with lift lobby, reception and other utilities in both small and large plots. Parking spaces in the previous survey were sometimes seen to be used for holding programmes like milad or annual get together of residents. In the recent survey, some small changes that are observed are that an attempt of beautifying the spaces by painting the walls or cladding tiles is seen. Erecting a small room to support the drivers is also seen in one of the buildings. Nevertheless, the parking spaces are unsatisfactory when it comes to being generating social interaction, as except for some annual large gathering, residents seldom stop here for any interaction. Only children are sometimes seen playing.

Lift Lobby and Stairs

The lift lobbies of these apartments give a diverse image. Almost all the lobbies of the smaller plots are unsatisfactory in terms of all the criteria as they are tightly designed and serve only as a transaction point from lift to the unit. These lobbies are hardly ever used and only hi-hello or small chitchats takes place while somebody enters or leaves the unit. Personalization through interior design intervention or arranging some plants or potteries is seen in these lobbies. The larger plots, where open space is kept; the lobbies are used for sitting and plantation. The interaction among the residents is more in the lobbies than those that have smaller space. The stairs, which are open, and faces the open spaces are more used than those of the one designed in a tight and closed space.

2008		2015
		
The parking of the larger plots		Tile cladding is being done
		
Parking place on a regular day		Room erected in the corner
		
The parking on a regular day and on a *milad*		Columns painted

Figure 07: Parking Space of the apartments

2008	2015
	
Stairs are rarely used, other than for service	Pots are seen kept for decoration
	
Small lobbies are usually used for circulation	Personalizing the lobby

2008	2015
	
Lobby before interior intervention	Lobby after interior intervention
 	
Plantation is seen in the larger lobbies	Plantations are replaced with services

Figure 08: Lobby of the apartments

Roof

Roof being the only open space, is a possible option to generate gathering all kinds of users, and this reflects in the attempts taken to be seen in both the small and large plots to generate social gathering. Even provision of small meeting rooms and pantry is seen. The roofs are used for the daily activities like drying clothes or foods. Varied use like walking, gardening and gossiping in small scale is seen but not a larger scale. Often the lack of coordination between the residents and building committee results in conflict and the use of roof space is hampered. Only in few apartments, the roof is used for gathering.

The roof is one of the spaces, where major changes are observed. Some roofs are seen unchanged other than a different colour is painted or some plantation is done. The children are seen drawing a badminton court on the roof for playing. On the other hand, some roofs have faced drastic changes. One of the roofs which were barren is now green with a huge number of plants and a swing is seen kept on the roof for the inhabitants to use. Use of floor paving is also seen in one of the roofs. There are even roofs which have lost its liveliness. The roofs are mostly kept closed due to security and restricting unattended teen-agers' use.

Then	Now
  	  
Some roofs that didn't have many changes other than paint, green or drawing a badminton court	

Then	Now
	
Major transformation is seen in form of plantation and tile cladding	
	
Roofs those were lively earlier are now rather is barren and kept locked	

Figure 09: Roof of the apartments

Meeting Rooms

Almost all the apartments provide a meeting room for the inhabitants, to use for monthly or annual meetings. Some of these are just rooms with small openings and some are designed with open spaces and large openings that connect the space with the outside. These meeting rooms are often converted into other functions like prayer space, office, game room etc. Even if not converted the rooms are kept locked and sometimes used by the security guards. Seldom are these rooms used for any social purpose. The uses of these meeting rooms are almost similar in the second evaluation as well.

2008	2015
	
Large meeting rooms used by security guards and converted to prayer room	The same use is observed, as addition to a table tennis table was seen in one of the apartments

2008	2015
	
Meeting rooms in smaller plots are mostly unchanged	

Figure 10: Meeting Rooms of the apartments

Designed Shared Spaces of the Building

Designed spaces are unique in character, and are an additional effort by the architects to make the living space better. In the apartments, these features are seen in form of open court like spaces, swimming pools etc. There is varying use seen of these spaces, depending upon the mentality i.e. differing priorities of the inhabitants of the buildings and the coordination between the building committee. Among the three, in two of the apartments, the central court is extensively used for children playing, evening walk, gathering etc.; whereas, in the other, space acts just like an airshaft devoid of social interactions.

Courts

Central courts are seen in three of the surveyed buildings. In two of them, the courts are placed in the centre and in the other; it is placed in the corner. Two of the courts are green and other has a combination of paving and green. The courts, which are open towards the end, and have an open view seem to be working more than that of the one, which is covered from all the sides. The courts open on one side are used for playing, gathering, even keeping cattle during the eid-ul-azha. Even the lobbies and windows facing these open courts are also used more than that of those, which have no open space. The paved court is used for multipurpose uses starting from children playing, gathering to evening walk of women. Though the courts of all the buildings are satisfactory in the designed criteria they vary in the satisfaction level. Besides the design aspects, the mentality of the users and the coordination between the building community effects in the use of the spaces.

Even during the second survey, the courts are seen to be used as it was seen in the earlier one. The surrounding contexts of two buildings have not changed and thus the courts of those two buildings face internal changes only. The children have grown up and the courts are now mostly used for evening walks. And the building which had the court placed in the corner now has a fifteen storied building as a neighbour and that has affected the scale of the court and the court being shaded does not grow grass anymore. The windows and the lobby places are not used as much it was used earlier because of the privacy reasons.

2008	2015
	
Court used for various purposes	Court losing it's scale and green
	
Multiple uses of the court	

Figure 11: Courts of the apartments

Swimming pool

Swimming Pool is seen in one of the cases in the surveyed buildings. The attempt to provide a pool was very good as it was thought to be generating a gathering and sharing of the users with a common interest. Nevertheless, the pool of the apartment was never even filled with water. Lack of coordination between the users and the conflicts between the inhabitants kept this unused.

The preceding discussions outline the changes observed in the evaluations of the regular and designed shared spaces of the surveyed buildings that have (not) taken place between 2008 and 2015. These observations are summarized below in Figure 13.

2008	2015
	
No change is seen in the condition of the pool	

Figure 12: Swimming Pool

Shared Spaces	Spaces	Observations in 2008	Observations in 2015
Regular Provisions	Parking	1. Satisfactory in design. 2. Used for holding programmes and different works. 3. Only children playing.	1. Beautifying the parking level with tiles cladding. 2. Rooms erected for extension and fewer programmes held. 3. Children are not seen playing.
	Lift Lobbies	1. Tightly design in the small plots. Open spaces in the larger plots. 2. Serves only as transaction points in the small plots. Lobbies are used for plantations and sittings are kept. 3. Smaller plots do not have many options for any interaction. Interaction amongst the inhabitants is observed in the lobbies of larger plots.	1. Beautifying the parking level with tiles cladding. 2. Rooms erected for extension and fewer programmes held. 3. Children are not seen playing.
	Stairs	1. Stairs in all the buildings are seen to be designed with light and ventilation. 2. Stairs in the larger plots placed in the open spaces are seen to be used more. 3. No interaction is observed.	1. Beautifying the parking level with tiles cladding. 2. Rooms erected for extension and fewer programmes held. 3. Children are not seen playing.
	Roofs	1. Roofs of smaller plots are less likely to have many options to design. Meeting rooms, gathering places, pantry, toilets, seating places are seen in the larger plots. 2. Daily activities like drying clothes or foods are seen. 3. Morning or evening walk gardening, gossiping, the gathering is seen.	1. Painting the roof and decorating with various measures are observed. 2. Use remains as before other than for one or two buildings where the roofs are kept closed. Plantation, Evening walk in some roofs have increased even more than before in many roofs.
	Reception, Lobby, Meeting Room	1. Designed mostly with regular features. 2. Used for meetings and by the guards. 3. Sometimes indoor games are played by the children	No changes are observed in the second survey
Designed Provisions	Courts	1. Designed well. 2.Used for multipurpose reasons throughout the day. 3. Children playing, morning and evening walk, small gatherings are seen.	1. The court of one of the buildings, face major change due to a building erected in the next plot has changed the open character. 2. Use have seen decreasing. The degree of interaction was seen to be less than the previous survey .
	Swimming Pools	1. Well-designed pool 2. Never used as a pool 3. Children played in the pool	No changes are observed in the second survey

Figure 13: Findings on the Regular and Designed Shared Spaces

People require a certain amount of social interaction to maintain their social and psychological wellbeing and for that contacts with others are required which requires an optimal level of environmental stimulation. While too much stimulation is potentially stressful, so is too little; a delicate balance is therefore required. Frequent face-to-face contacts make neighbors significant sources of everyday assistance regardless of the weakness or strength of their bonds. The 'then-now' comparison of the regular and designed shared spaces for social interaction observed in 2008 and 2015 confirms existing assertion: When residents have accessibility and good orientation, the setting encourages their meeting, greeting, and chatting (Unger & Wandersman, 1982; Wellman, 1979). In the apartment premises, the shared spaces are the ones that have an option of generating the face-to-face contacts and opportunities of social interaction. Though regulated social Interaction might

not take place in these premises, repeated and regular interactions are likely to take place. When people are in the presence of others, even if they do not directly talk to each other, they continuously communicate non-verbally through their postures and facial and physical gestures.

CONCLUSION

A comparison between the two observations, in 2008 and 2015, gives the picture of the changes taking place or not taking place in the apartment premises. As for the socio-demographic changes taking place, the user groups in many of the apartments have changed from children to young adults, young adults to office going professional, and professionals to retired elders. This result is dwindling activities like cycling, playing to increasing activities like gardening on the roof, or open corridors. However, physical changes are not very much observed other than erecting one or two rooms or buildings on the surrounding plots, that impacts on the spatial quality of the buildings. One major observation seen was the need for beautification in the shared spaces. Parking and the roofs are seen to be cladded with tiles, while the lobby spaces are decorated in many ways, from the small intervention of flowerpots to ceiling and wall claddings. Most of the meeting rooms are as before with mostly being used by the security guards. The 'then-now' observations confirm various socio-demographic and physical changes' influencing the character of the buildings in time. The building grows and transforms with the change of its inhabitants and their needs, and are evident in its regular and designed shared spaces for social interaction. The changing spatio-temporal dimensionality of user profiles, needs and shared spaces remain an unavoidable fact as much as a necessity for designing future socially responsive apartment buildings. Future researches, however, have to extend this paper's lack of explanation that the key social variables like age, gender, social background, profession—causes of change—play in shaping dwellers' mentality, conflicts, and negotiations in appropriating shared spaces for social interactions.

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Women's Negotiation of Domestic Spaces in Slums: The Roles of Physical Environment on Practical Gender Needs in Hajaribagh and Ganaktuli Sweeper's Colony, Dhaka.

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Abstract: This article investigates women's nature and extent of negotiation of domestic spaces by understanding the role physical environment in slums play in addressing their practical gender needs. While slum area and population in large cities of developing countries are increasing, women among the urban poor suffer doubly from the denial of their human rights on account of gender inequality as well as due to poverty and hence, often are unable to negotiate their Practical Gender Needs. This paper shows how poor women negotiate domestic space use to fulfill their practical gender needs and implies a far-reaching impact on society and conducts a case study of Ganaktuli and Hajaribagh Sweeper's Colony, manifesting slums in Dhaka. This investigation is based on both quantitative and qualitative data with 20 dwelling samples taken for more detailed study from each site. The research findings revealed that in general, women's inability to negotiate domestic spaces in slums results in failure to address their practical gender needs. This also hinders the growth of a gender-sensitive domestic environment, women being the prime users of such spaces. The roles of domestic space use and organization catering to negotiation toward fulfillment of women's gender needs remain crucial for future interventions in a gender-sensitive low-income housing.

Keywords: Slums, Domestic Space, Women's Negotiation, Practical Gender Needs.

INTRODUCTION

Rapid population growth in Dhaka city results in the failure to address increasing demands for adequate housing, services, and employment scopes. A visible manifestation of this failure is the extent in which the informal sector (slums and squatter settlements) has proliferated. According to an estimate of the mid-1980s, 47 percent of Dhaka's population lived in informal settlements and 64.6 percent worked in the informal sector economy (Amin, 1989 cited in Ghafur, 2006, p.5; New Geography, 2012).

A slum, in general, is characterized by the inadequate provision of basic civic amenities, high residential and population densities and unhealthy living conditions. A critical gap in slum discourse relates to the research focusing on urban poor women. It emphasizes gender issues, in particular concerning how these women negotiate in using domestic spaces to fulfill their practical gender needs and eventually imply a far-reaching impact on society.

Women among the poor suffer doubly from the denial of their human rights – first on account of gender inequality, second out of poverty; these women become the poorest of the poor class. Studies on the proliferation of female-headed households and research into social impacts and gender-specific effects of structural adjustment policies have led to increased attention to the concept of “the feminization of poverty.” The perception is growing around the globe that poverty is becoming increasingly feminized, i.e. an increasing proportion of the world's poor are female (Moghadam, 2005, p.2).

This paper is based on a research that attempts to examine the relationship between domestic spaces, their uses and gender relations in women's negotiation pattern in low-income housing in Dhaka. To investigate these issues, two slum areas of Dhaka, Hajaribagh Slum and Ganaktuli Sweeper's Colony were selected as case studies (Rahman, 2013).

To study the patterned relationships between an organization and use of domestic spaces, three different approaches is suggested: behavioral, spatial and temporal interpretations. Also, analysis of domestic space use is governed by a set of binary oppositions like enclosed-open, front–back, public-private, male-female (Lawrence, 1990, p.73-76). Women's negotiation pattern considers both the immediate and extended domestic realm. Here, the concept of negotiation 4 is explained as a problem-solving process in which two or more people voluntarily discuss their differences and attempt to reach a joint decision on their common concerns (Moore,).

Women who typically play the major role to use and organize domestic spaces are subjected to specific roles to modify their mobility and household activities by existing patriarchal/patrilineal society norms ascribed to them. Conceptualization of gender roles and women's needs is central to analyzing their negotiation pattern.
In most Third World households, especially women in low-income group encompass triple roles. They are Reproductive Role, Productive Role, and Role on Community Managing and Community Politics (Moser, 1993, pp. 29, 34). Men and women play separate roles in society, own varied levels of control over resources, and so often have different needs. The concept of gender needs arises from women's `gender interests which women or men may develop due to their social positioning through gender attributes. Gender interests can be either strategic or practical each being derived in a different way and involving differing implications for women's subjectivity (Molyneux, 1985a, p.232 cited in Moser, 1993, p. 38). But the lack of gender awareness and man-made social norms result in women's inability to negotiate in the low-income housing suppressing their practical gender needs. Research works in the context of Housing and Gender, however, lags behind in Bangladesh. Studies on low-income housing or on gender issues have been done separately, but relevant works incorporating both these issues lack in the context of Dhaka. There lacks an effort to understand the link between the low-income housing of Dhaka and women's negotiation pattern in those areas, in the light of fulfilling their practical gender needs addressing the physical environment in which they reside.

The objective of this paper is to identify the nature and extent of women's negotiation of domestic spaces in relation to practical gender need addressing the physical environment in which they live. This paper first examines the nature and use of domestic spaces; then it presents the major findings on the practical gender needs of women addressing the physical environment. Women's negotiation pattern is explicated next in relation to their gender needs. This paper concludes by noting women's inability to negotiate domestic spaces in slums by limiting their fulfillment of practical gender needs.

METHODOLOGY

This article is based on the findings of a research entitled “Women's Negotiation of Domestic Space: An Investigation into Gender Issues in Low-Income Housing of Dhaka” carried out by the Author in 2008. Case Study is the key feature of the Research Methodology to investigate and collect empirical findings, both quantitative and qualitative.

The Case Studies, Hajaribagh Slum and Ganaktuli Sweeper's Colony have been purposively selected considering their location, type of settlement, as well as to accommodate variations in domestic spaces, socio-cultural diversities, women's employment opportunities etc. The selected site in Hajaribagh includes Ward 58, Company Ghat and Ward 59, Bhagalpur, both at the Western fringe of Dhaka with some low lying land and ditches. Ganaktuli Sweeper's Colony,beside Pilkhana consists of Ward 52 and 58. The surveyed areas are high residential and population density slums for heterogeneous residents. Domestic spaces

include the indoor private domestic space/s of a dwelling, as well as the semi-public extended domestic realm There are rarely any pleasant open spaces. Environmental aspects like natural lighting, ventilation, the interior arrangement as well as the provision of kitchen and utility services (drinking water, bathing and sanitation, electricity, fuel, garbage disposal, drainage and flooding etc.) are inadequate. Safety, security, and privacy are improper. Thus, prevailing domestic spaces and unfavorable environment hinder comfortable living for women and children who mostly use the domestic realm.

A field survey was conducted taking a comparatively smaller sample to generate a pattern acting as a basis for descriptive analysis of the research problem. The stratified sampling method was used in sample unit selection. The population was divided into sub-groups (religious, socio-economic groups, age, household position and space organization pattern etc.) and separate samples were taken within each sub-group. From each site, 20 dwelling samples were taken to study while respondents from those 20 household samples were selected.

Data collection method used Ethnographic approach involving "an intensive study of some given society," but it was modified to house the architectural research focusing this study. Data gathering was limited to aspects of domestic spaces and concentrated on the status and roles of women in the two survey areas, their activities within/outside home, their interaction or negotiation with male and other female members of the domestic realm, negotiation patterns in familial and social life relevant to the physical environment of women. A mixed data-collection process was employed consisting of observational techniques, participation, interviews (usually informal) and secondary information bases such as recorded history, oral traditions, physical artifacts etc. A structured questionnaire was prepared to act more as a guideline and help to study various aspects of the respondents' household demographic data, socio-economic aspect, surrounding physical environment etc. Open-ended spontaneous interviews accompanied by Field Notes also enabled added information on the research problem. Information on dwelling types space use and women's negotiation pattern, all were recorded and analyzed. The analysis of the research was carried out in the following two non-physical and physical levels: first, considering the philosophical and religious aspects, and attitudes of the society; second, studying the formal aspects, the design of space and its use, environmental and climatic aspects.

NATURE OF DOMESTIC SPACE ORGANIZATION AND USE IN THE TWO SURVEYED AREAS

The structure type and profile of main dwelling units have been discussed first to understand the domestic space organization and use in the survey areas. Then, domestic organization and space occupancy pattern have been discussed to comprehend the use pattern.

Structures are mostly semi-permanent (Brick/CI sheet walls, C.I sheet roof) and structurally weak; a few permanent type structures (Brick wall, cement roof) are seen. There are quite a few kutcha structures built in bamboo mat walls and C.I Sheet Roof while straw or polythene is used widely. A few two-storied exist mostly having the ground floor built in brick walls but the upper floors in CI sheet tin or bamboo mats. Pitch roof is the common trend. An average household size of 5.2 people occupies an average indoor domestic floor space of 122.25 sft while the floor area per person is 23.5 sft. One-roomed dwelling units dominate while their ceiling heights vary from 6.5 ft to 8 ft.

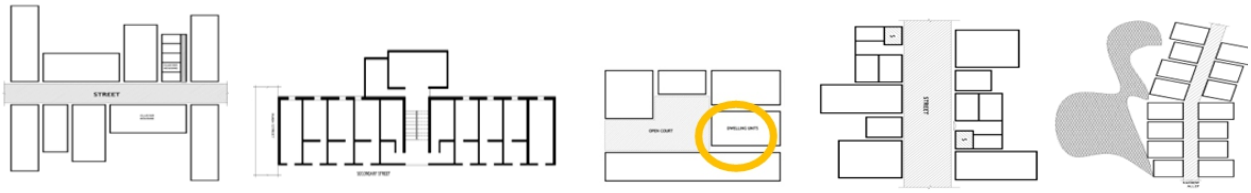
Table 01: Percentage of different types of dwelling units according to number of rooms, Source, author, survey, 2008

Types	Single-roomed dwelling	Two /more roomed dwelling	Dwelling units with single-room and additional space/s	Two or more roomed dwellings with additional space/s
Percentage in Ganaktuli	35	10	40	15
Percentage in Hajaribagh	65	15	20	-

Organization of Domestic Spaces and Dwelling Units

Individual dwelling units are arranged in different patterns in these surveyed areas. These patterns include:

i. Along internal streets in single storied cluster form (Hajaribagh) and four storied buildings (Ganaktuli)
ii. Around an open space
iii. Along the main street with commercial outlets and. one /two storey multi-room structures
iv. Rows of temporary kutcha structures.



(i) Along internal streets (Ganaktuli)

(ii) Along internal streets (Hajaribagh)

(iii) Around open spaces

(iv) Along main street with commercial outlets and one/ two storey structures

(v) Kutcha structure

Figure 01: Pattern of Arrangement of Dwelling Units (Source: author's survey, 2008)

Domestic space includes both the indoor main room and extended domestic realm following hierarchy of space. First, the indoor space of the dwelling unit for the family's private use (Sleeping, storing etc), second, areas of intimate contact like the door step (immediate extended realm) where children play and adults carry out different household and social activities and third, neighborhood covered or open meeting places (water collection area, religious/ community structures etc.).

The single/ multi- room dwelling units are inadequate in terms of occupancy; small floor space results in congestion and overcrowding (varied aged occupants, basic furniture, personal belongings, storage like, food, water, fuel, HBE raw and finished materials, kitchen utensils etc.) which not only limits easy space use and indoor circulation but also makes the space/s hygienically improper. Typically domestic space is a multi-activity, non-segmented single room area indicating user's life-style. For extended families, either space is separated with a physical partition or a separate room is allocated for an adult couple or an elderly member; there is no segmentation age-wise. Service areas (laundry, bathing, toilets) in the extended domestic realm are function-specific and segmented from the main dwelling units. They are sometimes gender-specific but often lack considerable privacy for women. Collective spaces like common circulation corridor, open courtyard etc. are neither gender-specific nor age- segregated loci and are an integral part of the woman's domain being the centre of household activities and leisure time during day time. Cooking, eating, sleeping, child rearing, sewing and gossiping and even home-based income-generating work, all take place in the courtyard. Open spaces existing around temples, shops or schools at times are the venue for women's socialization.

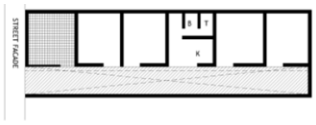
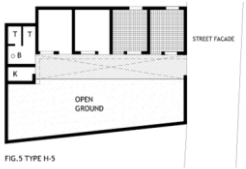
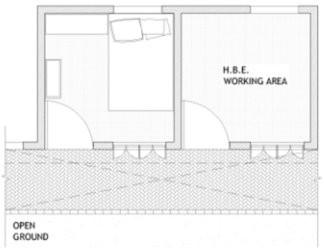
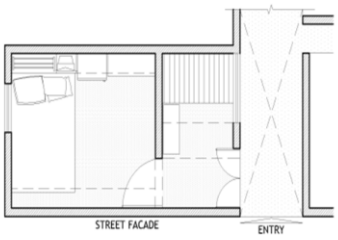
Thus, gender specific and non-gender specific areas, as well as function-restricted and multi-purpose areas, are characteristics of the domestic organization in the surveyed areas.

Space Occupancy Pattern in Domestic Spaces

Space occupancy pattern and use of domestic spaces have been analyzed under three distinct approaches: Behavioral and Spatial interpretation as well as interrelations between them over time. Behavioral pattern of the residents in the surveyed areas reflects their homogeneity in financial status and rural based traditional culture; residents are more social, interact more and socialize in the prevailing common spaces. Spatial

organization regulated by cultural determinants includes factors like personal space, territoriality, privacy/boundary and socialization pattern. Although personal space is absent, space organization is affected by binary oppositions like enclosed-open, front–back, and public-private domain, male-female domain, clean-dirty and symbolic-secular which overlap as houses are mostly one-roomed. Occupants are forced to occupy space within the territory of intimate and personal distance in their rooms. Only when they come out to occupy collective spaces can they operate within the territory of social distance and sometimes in the extended realm within the public distance. Space constraints impose a change of use pattern with time and refer to many meanings at a specific time for a change of use over time, perceiving boundaries between spaces, the creation of ambiguous spaces due to spatial and temporal conditions, the transformation of space use etc. Thus, space occupancy is regulated by behavioral and spatial interpretation while space use is restricted spatially and temporally.

The domestic space organization can be understood from Figure: 2

Cluster and Unit Types	Plans	Images
Single-roomed dwelling unit (usually with circulation corridor and detached common service area)  FIG. 1: TYPE H-1 These single rooms used as multi-purpose space obviously cater to all domestic activities and storage of all kinds of household belongings.	 SINGLE ROOM DWELLING UNIT	
Two or more roomed dwelling unit (with detached common service)  FIG.5 TYPE H-5 Tenants with extended families or using extra room for HBE activities fall in this category.	 	
Dwelling units with single-room and additional space/s (with detached common service)  Fig.3: TYPE H-3 An adjacent space at times is included with single room to be used for cooking, dining, storing, guest/second living room or to sub-let.	 	

Cluster and Unit Types	Plans	Images
Two or more roomed dwelling unit (with attached service area) Extended families usually live in this unit type having two or more living rooms and an adjacent space to be used for cooking, dining, storing or serving as a guest room. Mostly these are individual structures.		

Figure 02: Dwelling types as per number of main living rooms with /without attached spaces and their Uses, Source, author, survey, 2008

Women's Practical Gender Needs Addressing Physical Environment in the Surveyed Areas

Gender need concept arose from women's gender interests which women or men may develop due to their social positioning through gender attributes. Gender interests can be either strategic or practical. The needs women identify in their socially accepted roles are the practical gender needs not challenging the gender divisions of labor or women's subordinate position, but rising out of them. These practical needs are a response to immediately perceived necessity, identified within a specific context and often are concerned with inadequacies in living conditions, such as water provision, health care and employment (Moser 1993, p.40). In this study, the notion of women's Practical Gender Needs is analyzed under the following aspects:

Practical Gender Needs in Housing and Domestic Spaces

Survey reveals that women, as wives or mothers are primary and long time users of domestic space (inside and the extended realm). So, incorporating practical gender needs effectively is vital. Women's practical needs related to domestic space are: adequate indoor space in terms of natural ventilation, light, well arranged necessary furniture with ample circulation space, separate private space or storage for woman's personal use, overall indoor privacy, security, safety and overall cleanliness. These practical genders needs seem inadequate and not fulfilled as analyzed by the quality of physical spaces and factors like personal space, territoriality, privacy, boundary and pattern of socialization. Lack of proper safety and security is also very common. The indicators and their effect on women are discussed below:

Physical Environment – Semi-permanent dwelling units are often inadequate having degraded quality due to ill-maintenance. Some kutcha structures often result in exposure to adverse weather; rain water seeping into rooms through pores on roof/walls etc.

Natural Ventilation and Lighting – The typical one window of a single room mostly is kept closed to maintain indoor privacy and security resulting in inadequate ventilation especially at night. Women use the domestic spaces for a longer period of time and hence are affected health-wise with inadequate ventilation, damp and dark interior.

Comfortable Use of Space and Hygiene – Overcrowding, congestion and damp walls/floors result in presence of rats, insect etc. adding threat to diseases and personal hygiene. The bed is used for sleeping and also for many activities which the women need to manage giving extra labour. Clean spaces for executing religious rites/rituals are difficult to get. At times, cooking activities, washing clothes etc. are done inside hindering normal indoor activities and polluting cleanliness of space.

Privacy – Privacy includes concepts of personal space, territoriality and crowding with the common element of controlling of undesired interpersonal interactions and communication. Privacy is threatened not only by

outsiders or neighboring rooms (both visual and auditory) and also from own household members (for adult women). Here, women do not have any private space of their own. The only open door/window to allow ventilation and natural light threaten privacy for women. Damaged partitions (holed bamboo mat walls covered by newspapers, boards etc.) between two attached rooms do create a visual barrier but fails to create the auditory one; any kind of loud speech or noise disturbs the immediate neighbors.

In the case of joint families living in two spaces of a room, privacy is threatened as members have to pass other's room while going out to use the toilet or for other reasons, especially at night. Thus, adult women feel awkward and embarrassed with such lack of privacy. There is no special arrangement for child-birth which mostly occurs at home. Most often mothers give birth to their babies inside rooms only by placing a mat on the floor and making a temporary, meager partition by a sari or bed sheet; densely placed units, with common walls or often lacking adequate visual/ auditory barriers seems not at all appropriate for child-birth in these single room dwelling units.

Security and Safety – Doors kept open to let light and air in threatens security. Broken electric meter box, exposed wire over wash areas, mud-ovens placed at doorways or inside rooms are threats against safety. Thus, women need to be extra careful as they remain at home mostly.
The quality of Extended Realm – Outdoor Circulation Corridor or open space is used by the neighborhood residents for various activities. Narrow, slippery corridors add threat to accidents and stampede during fire hazard.

Practical Gender Needs in Basic Services

Provision of basic services for livelihood here remains highly inadequate or unsatisfactory. However, sharing kitchens, water collection areas and baths enhance social interaction although at times these inadequate facilities cause quarrels.

Cooking -Typical common kitchens (either semi-permanent or kutcha structures) often do not have adequate openings. Some kutcha structures are comparatively more open. In the absence of a designated kitchen space, women cook with individual mud-stoves outside in open spaces, in front of their rooms or if weather or situation does not permit, then inside the room. The kitchen floors are often wet, slippery and ill-maintained while ventilation or lighting is inadequate. Kitchen space too, at times, is not big enough for several women to work together or place enough burners to fulfill the demand.

Water Collection – Water taps, baths, and toilets are within the cluster territory in Hajaribagh. In Ganaktuli, the common water collection points are away from the dwellings and placed in a public zone. Fetching water from distant water sources early morning, long queue due to a shortage of supply, carrying heavy water pitchers/ pails through wet, slippery pathways create extra loads for women who solely do these.

Washing/Bath/Toilets – Bath spaces and toilets are often at considerable distances from the houses. Sometimes, facilities are not enough and mostly ill-maintained. Privacy for women is threatened in the open common bath spaces. Slippery and dirty floors, exposed wires over the bathing spaces etc. are a threat to the safety of the residents, especially in Ganaktuli.

Child Care – There is no provision of Community Child care. Mothers or elder siblings take care of younger ones in between their domestic chores, HBE activities and other responsibilities.

Practical Gender Needs in Employment

Lack of adequate skills and training is a fundamental problem for formal employment in the surveyed areas. Also, male household heads expect women to remain as home-makers only. But present day economic demand has initiated women's home-based enterprise (HBE) an increasing trend. HBE among women is observed in Hajaribagh. Ganaktuli women earners are mostly employed in the City Corporation or earn by

other means. In Hajaribagh, domestic spaces, common corridors or open spaces are used during daytime for HBE activities. like thonga making, toffee wrapping, food vending, tailoring etc. Gender-biased division of labor promotes women for most of the unpaid work. They cannot invest in their actual needs, priorities or self-development and remains totally financially dependent. Despite their unrecognized experiential knowledge, women tend to reduce their self-confidence and do not agree to participate in household decision-making processes. This is often unfavorable for women as men, who take decisions in planning domestic spaces do not perceive domestic space use as women do. Lack of proper/extra space for HBE activities often creates problems for others. It also hinders effective output since works are abandoned when spaces are occupied by others. Thus, unfavorable housing consumes more work time, reduces work sharing and adds to health and security hazards, all of which reinforces women's subordination in all spheres.
Inadequate multi-use spaces thus play important roles in women's lives not addressing their practical gender needs in the domestic arena. This has resulted in extra time and energy in their requiring as well as created scope to negotiate.

WOMEN'S NATURE AND EXTENT OF NEGOTIATION OF DOMESTIC SPACES

To understand the nature and extent of negotiation of domestic spaces, it is important to understand how activities are distributed over time and space and how the interactions take place between different family members (male –female, female-female or between members of varying age and position). The physical, visual, and audible intersections between customarily self-contained domestic spaces may render negotiable social role of the woman member as a mother, housewife or sometimes as an earning member.

Spatial, Temporal and Social Negotiations in Domestic Spaces

Dynamic and temporal perspectives are important factors to understand negotiation pattern, especially about when and for how long women interact with other household members. Negotiating space for different activities is also important as space constraints force users to use them on a temporal basis. Hence, this discussion is seen on the basis of space use for different activities at different times also taking into consideration social factors of living in a close-knit neighborhood. Women's negotiation of space, in other words, relates to their addressing practical gender needs.

Negotiating the Use of Space for Domestic Activities inside Dwellings

Houses are used by generations; from old to young, mother to daughter, father to son and onwards. With the changes of users' lives and activities, domestic space modifications become necessary too, irrespective of how much change they really can afford to make. Parents with young children in one room negotiate with the circumstances in their limited space constraints. The same parents either rent (in Hajaribagh) an additional space or build one extra room (in Ganaktuli) when their son/s marry and bring the wife in the house. The new bride then negotiates to share available space with her in-laws and often has to accept the minimum facilities that she is provided with. Few areas of negotiation based on activity, interaction pattern and gender needs have been discussed below:

Sleeping – A proper and comfortable bed is required for sound sleep (prerequisite for good health). Most households have a bed (typically chowki) in varying sizes. In the case of larger families, members use the floor for sleeping usually on a 'pati'. Male members are given priority while at times older or woman household head gets the privilege to sleep on beds.But, privacy for sleeping is either meager or totally absent. Even, a young bride most often does not have private space with her husband unless it's time to sleep at night. Thus, some women are able to negotiate and have a better place and privacy for sleeping while others fail to do so.

Eating – There is no formally assigned space for eating. The floor and sometimes the bed is used for eating. Members dine together rarely; most often children and adults eat at different periods of the day while women tend to dine after others have had their meals. This grouping to dining is due to space constraints. So, women

negotiate with space constraints and gendered attitudes in sharing eating time and space.

Storing – Storage of personal belongings, kitchen utensils, fuel or material for HBE is an important space use next to sleeping here. Almost all the walls, space on and under the bed are used for storage. Typically women members need to take the role of managing within inadequate space to accommodate not only persons but also placing or storing objects and also maintain the cleanliness of spaces. At times they negotiate to add furniture to facilitate storage space. Moreover, they often give extra effort to protect /clean the rooms from rain water or drying wet beddings, clothes etc.

Income-based Work – A significant number of female members involved in earning activities go outside the home to work while others work in home-based enterprises. Whatever the situation is, these women have to juggle this labor with their other full-time household responsibilities as husbands seldom help in domestic chores.

Indoor Leisure – Men go out to spend leisure while women mostly remain inside and keep themselves busy with domestic chores not even realizing the need to spend personal time. Small or female children play inside or around the house. Male children often go to the streets to play and fool around while female children are seldom seen to play in the streets. Women here seldom care or rarely have any scope to explore their creative self. They do not negotiate this need and accept their lifestyle. When male members come back home, women interact and negotiate with them to use their limited spaces having little scope to have her own space and privacy. She is the one to sacrifice of having the choice to use her time and space in that limited space. Watching TV is a new trend that women enjoy after a long day's work.

Child-Birth – A woman giving birth to a child has to negotiate with others about how much privacy and space she can afford to get in that meager dwelling before and during her child-birth and afterward during her post-natal period. A pregnant woman cannot even expect to have a special space where she can give birth in a hygienic way.

Guest Entertainment – When any male guests are entertained inside, adult female member, even if tired or sick are expected to leave the room. Negotiations are required often in the case of HBE activities carried out inside; it becomes necessary for the women engaged in HBE to stop and wrap up their activities. The choice is then between incurring a loss of time and income prospect and using the space for some other purpose.

Negotiating the Use of Space for Domestic Activities inside Dwellings

Use of extended domestic realm for commonly shared spaces (kitchen, wash/bath area) incurs social negotiation. Women sharing such common areas interact and negotiate with other household women or neighboring women, like who will use the spaces or when. Some areas of negotiation regarding sharing extended realm for service activities are as follows:

Cooking – Women (mostly in Hajaribagh) negotiate with neighboring women to use the common kitchen (with multiple-burners, each for the individual tenant). This solves the problem of cooking schedule but often is difficult for several people using the small cooking space. Working women, wake up at dawn, cook for her family, do other household chores before going out to work. In the case of small cooking space, often an attached space or even the dwelling room is used for cooking. Thus, a woman negotiates and shares the inconveniences of sharing a small kitchen.

Bathing and Sanitation – Women share and negotiate use of common bathing space and toilets with both the male and female neighbors. Separate baths and toilets of the clusters are a better option in terms of privacy. But some common bathing spaces not having adequate visual barrier are vulnerable in terms of privacy, safety, health, hygiene and comfort since women of all ages share those with males. Women have an added responsibility to clean these bathing/toilet spaces. Thus, they are unable to negotiate and provide for themselves a good bathing/ toilet space.

Water Collection – A woman starts her life very early in the morning to stand in the queue for collecting water. In Ganaktuli most women have to walk down some hundred feet to collect water (supplied twice a day) or use the toilet. In Hajaribagh although water supply has no definite time but there is a shortage of supply. Thus negotiation with neighboring women takes place and often becomes an extra suffering.

Negotiating Space Use for Home–based Activities:

The survey findings show that HBE is the main income source (Hajaribagh) for most of the earning women. At times male members give a hand to HBE activities when free and at home. For HBE activities, women use the main living room, adjacent spaces, common spaces (circulation corridor, courtyard etc).The raw materials and finished products are kept inside the room creating over-crowding of belongings. In cases, where enterprises operate indoors, the rooms naturally are not being used exclusively for HBE; often, they are forced to stop HBE activities inside rooms to give space to guests or sick family members requiring rest. Some women even continue their HBE activities at night, sacrificing their leisure time. Thus they negotiate with time, space and other household members to carry on income-based works.

There is also a significant gender division in the HBE run by men and those run by women. Like, small-scale tailoring, making things, wrapping toffees, preparation of food items (Pickles, roasted nuts, pan cakes etc.) are mostly done by women. Men mostly earn from block-printing, shoe making, tailoring shop, small-scale general stores etc.

Regarding negotiation, as most of these enterprises involve household women, their manual labor not associating with any kind of unhygienic outcome, noisy activities or forming dirt, hence there are no objections from anyone. However, residents/neighbors get disturbed when HBE activities occupy the only circulation corridor. Also, flies gather around the exposed toffees /other food items to create an unhealthy situation. Despite all inconveniences, household members encourage HBE while landlords or neighbors are tolerant towards HBE workers unless the activities are too disturbing or hazardous as they accept HBE one of the ways to improve their financial struggle. Women involved in HBE activities negotiate socially too; Young mothers at times negotiate with older women of the family (mother /mother-in-law) or others to take care of their babies / young children while they work. Elderly women, young girls or girl- child also extend support in HBE activities sometimes. Thus, women of different age group use the same space for HBE, interact more and share things together creating a better bondage between them.

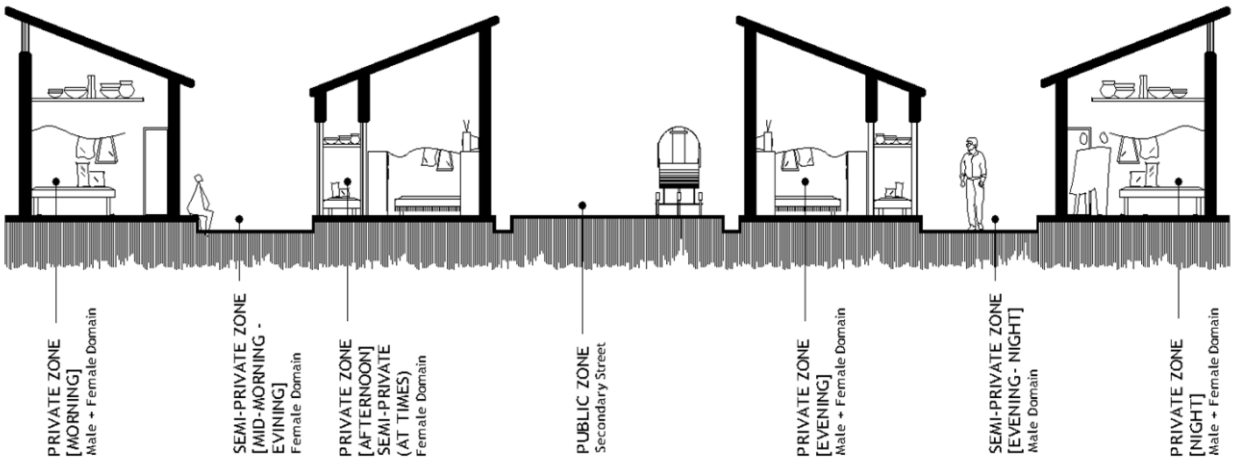


Figure 03: Relationship between domains considering spatial-temporal interpretation

Negotiating Temporal Use of Space – Domestic space, both indoor and extended is used differently at different times for varied purposes; these require temporal negotiation between the space users. In Hajaribagh, average male members spend about 10-12 hours outside the home, few women members working outside (very rare) do not stay out more than 6 to 8 hours a day. Most women involved with HBE activities work in between their home chores. Usually, during early mornings, then mid-mornings and the evenings, women take turns to work in kitchens. Those involved with HBE use their time in between cooking hours to do the HBE activities. Men involved in HBE activities use the whole day (about 10-12 hours) with meal breaks and at times work beyond normal working hours. In Ganaktuli, male and female household members working for the City Corporation usually have work shifts. They stay out of home for 4 to 8 hours per day depending on duties. Some male has extra income from private clients while women usually stay at home after formal work to do their domestic chores. During weekends, men are usually seen in and around the house, passing leisure time while women continue giving time to household matters. At times, guests are entertained inside the only room making it difficult for the adult women to work and move around. The common semi-public domestic realm which is used for regular domestic chores and circulation is sometimes used for a social gathering (wedding ceremony, religious rituals etc.); negotiation takes place with neighbors taking part in these programs.

Negotiation and Gender Needs

Gender roles and negotiation pattern often is related to an individual's economic independence. Survey reveals that some women members play a significant role in earning an additional income for the family. Being either the household head or joint-decision maker with the male counterpart, women have crossed the traditional boundaries of gender roles and try to fulfill their gender needs to an extent. Although decisions to improve living conditions often depend on the family's main bread-winner, but most often aspirations are from women home-makers who motivate and negotiate with their male counterparts to do so.

Survey findings reveal that day-to-day routine activities with the almost constant interactions give structure and form a similar pattern except for a major change in life. The typical nuclear family consisting of parents and children, at few instances has a temporary guest (mother-in-law, siblings etc.) The extended families usually include the comparatively elderly household head with a spouse, son, and daughter-in-law, other children etc. Thus, inside a house, interaction pattern or negotiation revolves around these people and depends on the extent of their relationship and household position. Women's gender needs and negotiation pattern changes with the phases of life cycle. Thus, a girl child, an unmarried girl, a new bride, a new mother, a mid-aged woman, a mother-in-law or an old woman (dependent/independent) will perform in a different set of activities and will have a difference in their negotiation pattern. In the surveyed areas, women face a double or even triple burden of productive and reproductive work putting in longer hours than men. Women maintaining cooking, cleaning and child care occupy the private and semi-private domains of domestic spaces, while men dominate the public arena. Both men and women use the common spaces around their houses periodically according to regular routine chores, occasional needs or during festivals/occasions like Eid, Puja, marriage etc. integrating their spaces to carry out certain goals and use them as a group. Negotiations thus, between women and men are often dynamic mainly depending on the understanding level. At times, negotiation also happens when a male considers the woman counterpart eligible to think, decide or act with intelligence. Although, the survey findings revealed a few instances where women household heads were capable of taking decisions but mostly the typical role of the woman are not negotiable.

CONCLUSION

The objective of this research is to identify women's negotiation of domestic spaces investigating the roles of the physical environment on their Practical Gender Needs. Findings reveal that women's Practical Gender Needs in the surveyed areas regarding the physical quality of dwelling units, surrounding environment and

services are met inadequately. Unplanned, haphazard growth of densely placed dwelling units with the pressure of increasing residents results in a lack of climatic comfort, hygiene, privacy, safety, and security as well as basic service facilities. Lack of designated HBE space or less time and scope for self or skill development has resulted in inadequate fulfillment of women's gender needs in employment. Due to lack of education, financial position and aspirations to enhance individual creativity, skill and identity, women most often are not motivated to explore individual desires. They accept their non-fulfillment of gender needs and desires as mere fate. Thus, women's habitual routines performed mostly in the domestic realm often do not comply with the fulfillment of their gender needs or residential satisfaction and remains nonnegotiable.

Appropriate domestic space organization takes a central role in the negotiation of women's social relations. Women's negotiation of domestic spaces relates to activities distributed over time and space as well as interactions between family members. Gender ascribed roles of man and woman result in their different needs and aspirations. So, negotiation is needed to fulfill their interests, be it for similar objective or for individual goals. Since low-income household women typically have to adjust, interact and negotiate in a multi-purpose single space, hence these are zoned spatially and temporally.

In general, housewives abide by the desires of male household head regarding use or improvement of their domestic spaces. Women's practical gender needs are not met adequately in housings designed for males. Women also are not aware of their individual needs and accept all they lack as mere fate. This unawareness and lack of negotiation result in long-term dissatisfaction or frustration. In the extended domestic realm, women interact on the community level with other men and women. For women, shared areas become a convenient social space where they can share things, talk and laugh even while working. However, women often face privacy, security and safety problems which prove that they still fail to negotiate with the male owners to ensure a certain level of basic gender needs in these semi-public spaces. Earning women often gain an importance and can share in decision making (depends on the attitude of the male counterpart). Women empowerment in the domestic level thus incurs better negotiation. Thus, with similar group orientation having more or less the same origin, characteristics and socio-economic background there is a presence of collective social interaction and negotiation among the neighbors, their kin and old friends in the surveyed areas; but due to lack of awareness of gender equality concept, issues regarding gender needs still need to be addressed and improved.

Improvement of the physical environment both in the domestic realm and basic service areas, progressive interior arrangement, structural adjustments and improvements in the household equipment are possible as a consequence of the ability to negotiate with the decision makers (family members or owners). These issues and observations can be further analyzed and researched for effective outcomes to be implemented in practice and initiate spaces and environment where women may be able to negotiate and fulfill practical gender needs in a better way.

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Comparing the Results of Static and Dynamic Daylight Simulations to Support Architectural Decision-Making in the Context of Dhaka

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Abstract: The evaluation processes of indoor daylighting by computer simulation are at crossroads between static and dynamic methods. Now-a-days, both the methods are used, yet static method is more widely practiced and perceived by architects, designers and researchers in Bangladesh due to its simplicity. Static method concentrates generally on daylight factor (DF) approach. Under DF approach, overcast sky is usually considered as reference sky and by definition; DF is unable to account for the contribution of direct sunlight. In reality, the sun's position and sky conditions change rapidly; DF is unable to predict the dynamic variations in interior illuminance. Therefore, an alternative concept of dynamic simulation has been developed that can calculate indoor lighting levels considering the annual variances of the outdoor available natural light simultaneously with time. A common argument for the DF approach is that, as the reference overcast sky is the worst sky condition, any other sky will lead to better daylight in the space and additional lighting information obtained from a more detail analysis based on a series of sky models under dynamic simulation often not change the design decisions significantly to justify their inclusion in the early design phase. Using two simulation methods, this paper compares the significance of static and dynamic simulations by demonstrating a case of decision-making among six skylight configurations available for the industrial roof in Bangladesh. ECOTECT is used for static simulation and as the modelling interface to launch DAYSIM - a program used for dynamic simulation. The results show, as the dynamic method considers the contribution of the sun to the overall illumination of the building, it can indicate potentiality of glare resulting from direct sun and/or skylight, therefore can explain a situation in more detail and accurately, compared to a static method. This paper also presents a general methodology for decision making regarding daylight design elements with both static and dynamic daylight methods.

Keywords: Daylight simulation; Static and dynamic methods; Skylight configuration; Decision-making processes; RMG building.

INTRODUCTION

A daylight simulation is a computer-based calculation to predict the indoor illumination either under selected sky conditions (static simulation) or under a series of sky models available for the whole year (dynamic simulation) (Reinhart, 2010). Static simulation provides one resultant data for each sensor point, based on one single sky model; and dynamic simulation can provide more than 8760 (365 x 24) hours resultant data for each sensor point, considering all possible types of sky models for a particular climatic context. For the evaluation of a sustainable daylighting concept, a suitable simulation method is required, which can accurately estimate the amount of daylight entering a building; and can evaluate the visual performance and energy efficiency provided by daylighting.

Based on Daylight Factor (DF) approach, most of the static simulations consider overcast skies without any direct component from the sun, defined by International Commission on Illumination (CIE), as the reference sky for calculation of illumination inside a building. A common argument for the DF approach is that, as the

reference overcast sky is the worst sky condition, any other sky will lead to better daylight in the space (Reinhart et al., 2006). It has been reported that, design decisions based on CIE overcast sky performs rationally for many locations, such as Dhaka (Joarder et al., 2015; 2009a; 2009b, 2007), Hong Kong (Li et al., 2003; 2001), and Southern England (Enarun and Littlefair, 1995). Dynamic simulation processes, calculates the performance considering the impact of local climate and generates indoor annual illuminance profile at points of interest in a building that change with time, sky conditions and shading device settings, in contrast to static modelling. It is also argued that, additional lighting information obtained from a more detail analysis based on a series of sky models under dynamic simulation method often not change the design decisions significantly to justify their inclusion in the early design phase (Leslie et al., 2012). Using two simulation programs, this paper compares the results of static and dynamic simulation to demonstrate the benefit of using dynamic simulation as opposed to a static simulation.

This paper consists of two major parts. The first part presents an example application method of the static and dynamic simulation by creating the virtual environment based on the survey of a true site readymade garments (RMG) building located in Dhaka and evaluates the performance of six alternative options for skylight configurations available in Bangladesh for the RMG roof design. The second part demonstrates a case of decision-making based on the comparison of static and dynamic simulation results.

APPLICATION OF STATIC AND DYNAMIC SIMULATION METHOD FOR DAYLIGHTING

This section reports a case application of the static and dynamic simulation methods to make the decision about the configuration of skylights to maximise daylight potential at work plane height of a RMG factory building with actual building surroundings located at Gazipur, Dhaka. To carry out a daylighting analysis of a building, the designer (or a daylighting consultant) should go through a decision tree comparable to the one described in Figure 1. The eight steps listed in the decision tree for skylight configurations are discussed in more detail below.

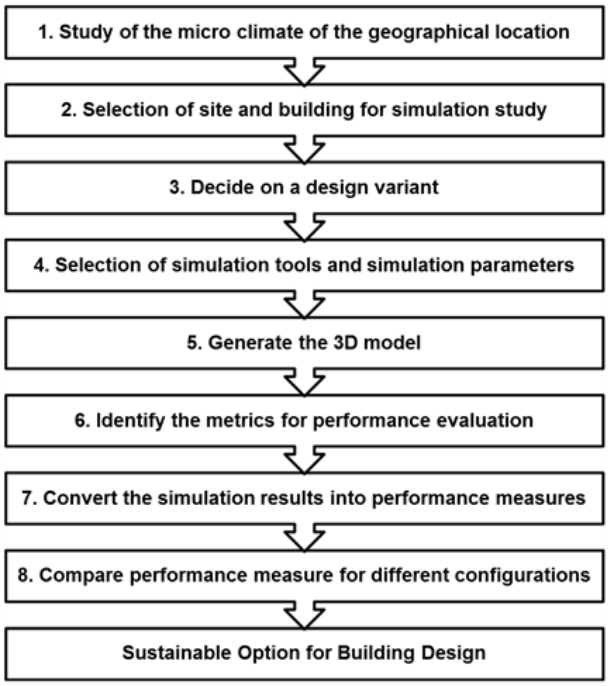


Figure 01: Flow diagram of the decision-making process by simulation study (after Joarder, 2011).

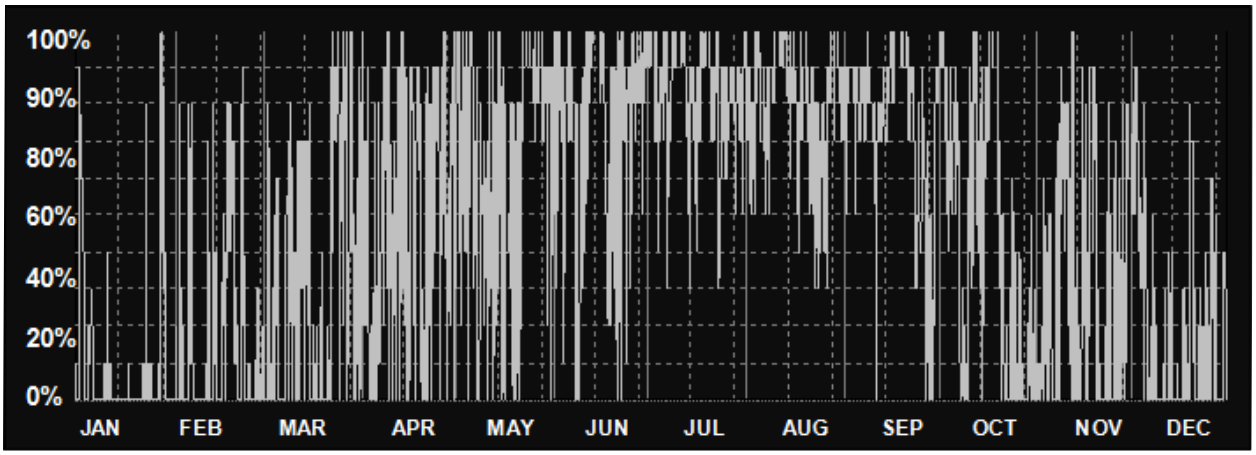


Figure 02: Cloud cover for TRYs, Dhaka (Source: U.S. Department of Energy, 2008).

Study of the micro climate of the geographical location

The geographical location of the building for simulation analysis is Dhaka. The climate of Dhaka is tropical and has three distinct seasons – the hot dry (March-May), the hot humid (June-November) and the cool dry season (December-February) (Ahmed, 1994). During summer (hot dry) the sky can be both clear (with the sun) as well as overcast. During the hot-humid period, which includes the monsoons, the sky remains considerably overcast, most of the time. It is only during the winter (cool dry) that the sky remains mostly clear. Figure 2 shows sky condition of Dhaka with respect to cloud cover for test reference years (TRYs).

Under static simulation, it is the overcast sky, with steep luminance gradation towards zenith and azimuthal uniformity (CIE, 2004) that presents the more critical situation, and hence, when faced with both sky types, design for daylight should satisfy good lighting criteria under overcast sky conditions (Evans, 1980). When the calculations of a static simulation study of this paper follow the DF concept, which is considered valid (the ratio remains constant) only under overcast sky conditions, there was no contribution from direct sunlight (Koenigsberger et al., 1997). However, from Figure 2 it is apparent that cloud cover for TRYs of Dhaka varies significantly, therefore decisions based on DF concept are not expected to be a measure of practical daylighting design.

Under dynamic simulation, sky and solar division schemes distinguish between contributions from various luminous sources, as following: 145 diffuse sky segments; 145 indirect solar positions; 2305 direct solar positions; one diffuse ground segment (Bourgeois et al., 2008); and more than 3650 (365 x 10 hours per day) hours daytime illuminance. Recent studies on daylight simulations have shown that annual dynamic daylight methods can be used to accurately calculate time series of illuminance and luminance in buildings (Reinhart et al., 2006) based on all possible sky types for a particular location.

Selection of site and building for simulation study

The criteria for site and building selection to determine the case RMG production space were based on the following factors.

a) The RMG factory should have to be located within Dhaka region (e.g, Dhaka, Savar, Gazipur, and Narayanganj).

b) The RMG building should be designed as a RMG (e.g. not converted or located in mixed used building) and built in accordance with the Building Construction Regulations of the concerned authority.

c) RMG building should have to be regular in shape and minimum complexity of design for effective daylight simulation.

d) The building should have to be east-west elongated building.

e) Minimum width of the building has to be more than 20m, which will be difficult to be illuminated by vertical façade windows only.

f) Case production floor should have to be on the top floor of the RMG building.

g) The production line layout should have to be in an east-west direction.

h) The scale and volume of the building should be convenient to handle within the time limit of this

Based on a pilot study (Iqbal, 2015), the three storied steel structured Apex Knit Composite Ltd. RMG building was selected for simulation study (Figure 3), as it satisfies all the selection criteria. The building is rectangular in shape with typical floor plans (east–west elongated) and repetitive exterior elevation on each side. This building has a vast opportunity of daylight exposure through roof and facades.

Figure 03: Exterior view of the case RMG building at Gazipur, Dhaka.

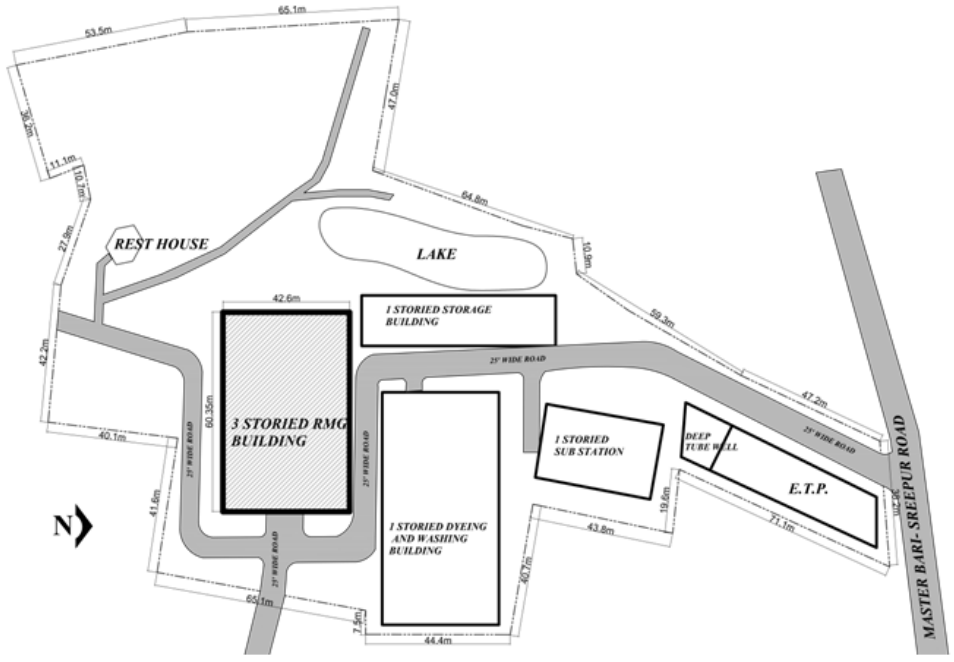


Figure 04: Site and surrounding of the case RMG building at Gazipur, Dhaka.

The selected building has a 6m wide road at the front, some service buildings at its north, an open field in the south, a small water treatment pond and open field on the west side (Figure 4). Both static and dynamic simulations consider the actual surroundings found during the physical survey. In Table 1, field surveyed data of the case RMG building is shown.

Table 01: Field surveyed data of the case RMG building.

Characteristics / Parameters	Specification
Production floor dimension	60.35m x 42.75m
Total floor area	2576m^2
Window size (each)	5m^2 (2750mm x 1830mm)
Number of windows	30 nos.
Sill height	0.85m
Window lintel level	2.6m
Window to floor area ratio	0.06%
Effective window position	North and south directions
External shading	No external shading
Partition height	2.8m
Average work plane height of sewing	0.76m
Ceiling height	4.5m

Decide on a design variant

Daylight simulation for this study was done to find out an effective skylight configuration for RMG industrial roof to increase useful daylight at production spaces in the context of Dhaka. As industries are maintaining a production line, for uniform illumination, mid-slope and continuous run – in plane type skylights are more effective for production areas (NARM, 2009).

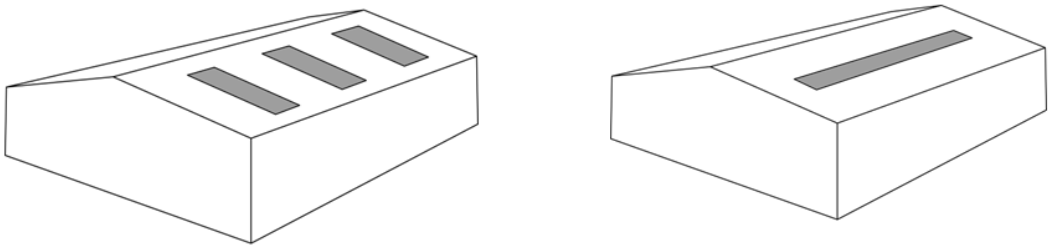


Figure 05: Mid-slope skylights (left) and continuous run – in plane skylights (right) axonometric view (after, NARM, 2009).

Among the different kinds of continuous run skylight configurations, only a few are suitable for Bangladesh. Ahmed (1992) identified six typical skylighting configurations for industrial roofs under the climatic context of Bangladesh, consisting of four roof monitor type skylight configurations, and two slope or pitch roof skylight configurations. Figures 6 to 11 show schematic sections and top views of Ahmed's (1992) recommended six typical skylighting configurations with their code names (SC 01- SC 06) assigned in this research for comparison.

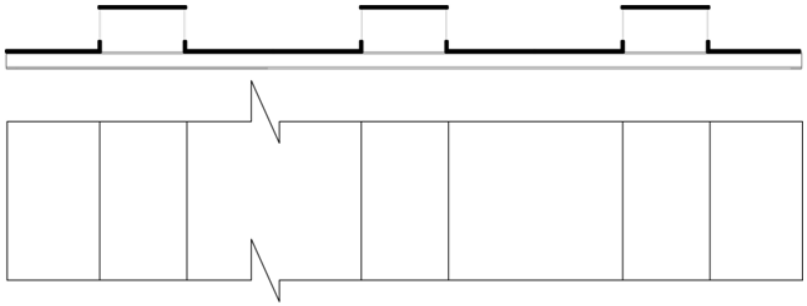


Figure 06: Section and top view of monitor roof with vertical glazing skylight configuration (SC 01)

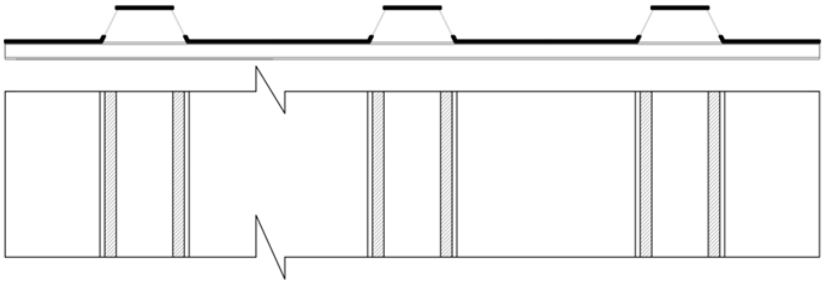


Figure 07: Section and top view of monitor roof with 60° slope glazing skylight configuration (SC 02)

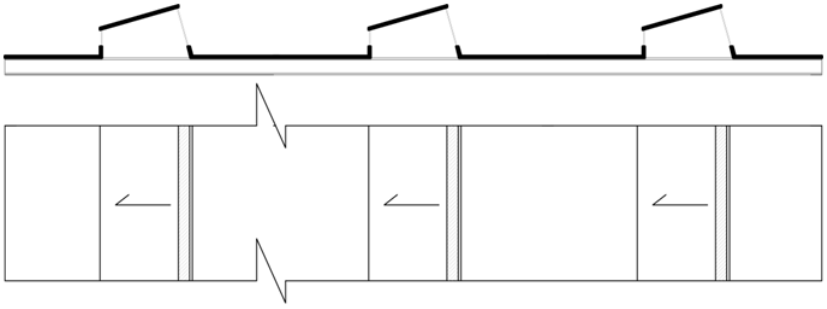


Figure 08: Section and top view of monitor roof with 60° north face glazing configuration (SC 03)

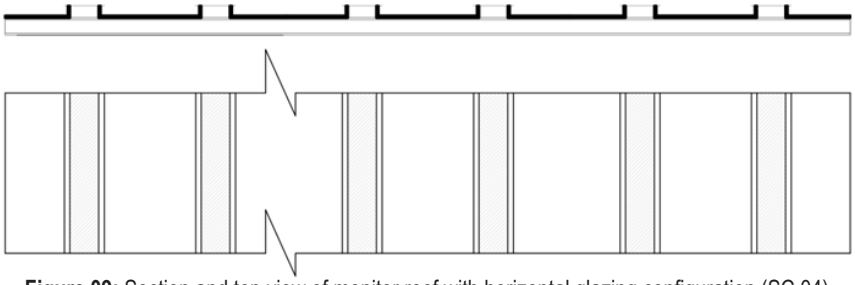


Figure 09: Section and top view of monitor roof with horizontal glazing configuration (SC 04)

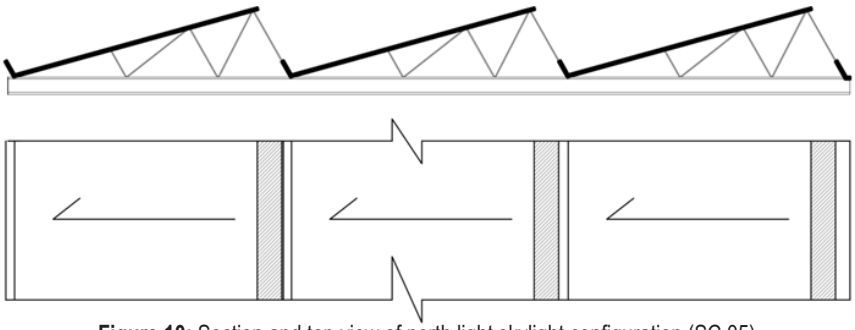


Figure 10: Section and top view of north light skylight configuration (SC 05)

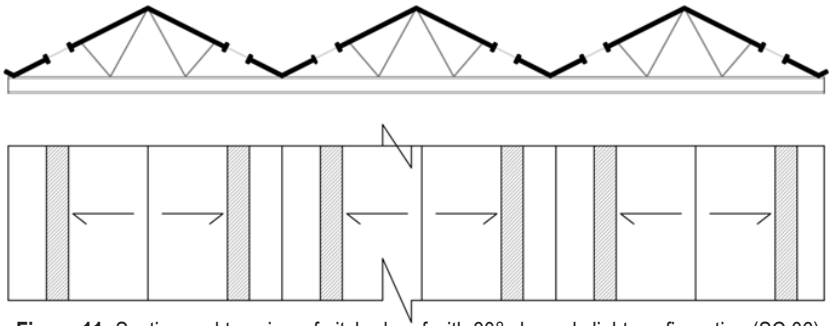


Figure 11: Section and top view of pitched roof with 30° slope skylight configuration (SC 06)

Selection of simulation tools and simulation parameters

In this research, ECOTECT is used for static simulation and as the modelling interface to launch DAYSIM program, a dynamic climate-based daylight simulation method. Both the programs are used to investigate and analyse the impacts of the six above skylight configurations on indoor daylighting. DAYSIM uses RADIANCE (backward) raytracer combined with a daylight coefficient (DC) approach (Tregenza and Waters, 1983) considering Perez all weather sky luminance model (Perez, 1993). Both RADIANCE and DAYSIM have been validated comprehensively and successfully for daylighting analysis (Reinhart, and Walkenhorst, 2001). Table 2 summarizes the non-default RADIANCE simulation parameters for the simulation analysis recommended by Reinhart (2010) for complex geometry.

Table 02: Utilized RADIANCE simulation parameters in DAYSIM (Reinhart, 2010).

Ambient bounces	Ambient division	Ambient sampling	Ambient accuracy	Ambient resolution	Specular threshold	Direct sampling
5	1000	20	.01	300	0	0

Generate the 3D model

Top floor (2nd floor) of the three-story Apex-Knit Composite ready-made garment was selected as the case space for the simulation study. The production lines (sewing and cutting line) of the 2nd floor were elongated towards east–west with equal repetitive column grid spacing. There was a 7.50m high void space above the ceiling. In the production space, 18 windows were located towards N-S direction and 12 windows were located towards E-W direction (Figure 12). The simulation model (Figure 13) was created with furniture arrangements using the same window size, sill height, lintel height, work plane height and material reflectances, found during field survey as mentioned in Table 1 and Table 3.

Table 03: Material properties of the production space found in field investigation (Iqbal, 2015).

Building element	Material description	Material properties
Ceiling	Metal insulated with aluminum fuel paper	80% diffuse reflectance
Walls	Brick with plaster either side	70% diffuse reflectance
Floor	Net cement finishing	40% diffuse reflectance
Window	Single glazed low-e aluminum frame	90% visual transmittance
Furniture	Plywood	60% diffuse reflectance
Mullions	Aluminum	50% diffuse reflectance
External ground	Grass	25% diffuse reflectance

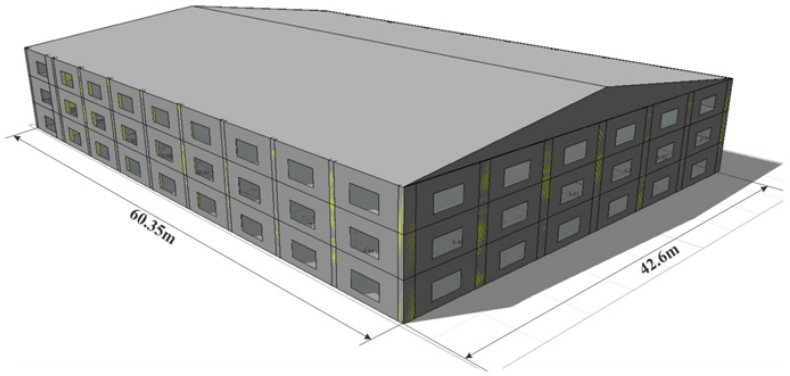


Figure 12: 3-dimensional exterior view of the case RMG building (ECOTECT model).

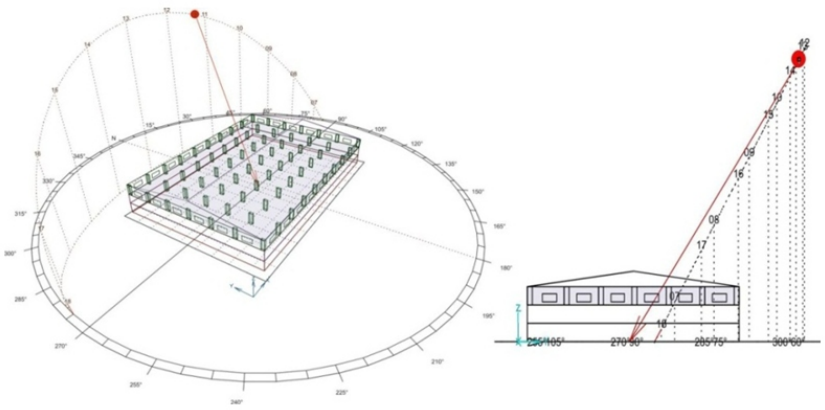


Figure 13: 3-dimentional modeling of the case RMG building with sun path diagram of Dhaka (ECOTECT model).

The entire production floor was divided into grids, with reference to the structural grids, for simulation purposes. Through the centre points of each window, nine axes in XX' direction and five axes in YY' direction are intersected into 54 points. Sensors were placed in the 54 intersection points, at work plane height (0.76m from floor level, representing the average work plane height of sewing). Each intersection point of the grid was coded according to the number/letter system shown in Figure 14 and represented in Table 4.

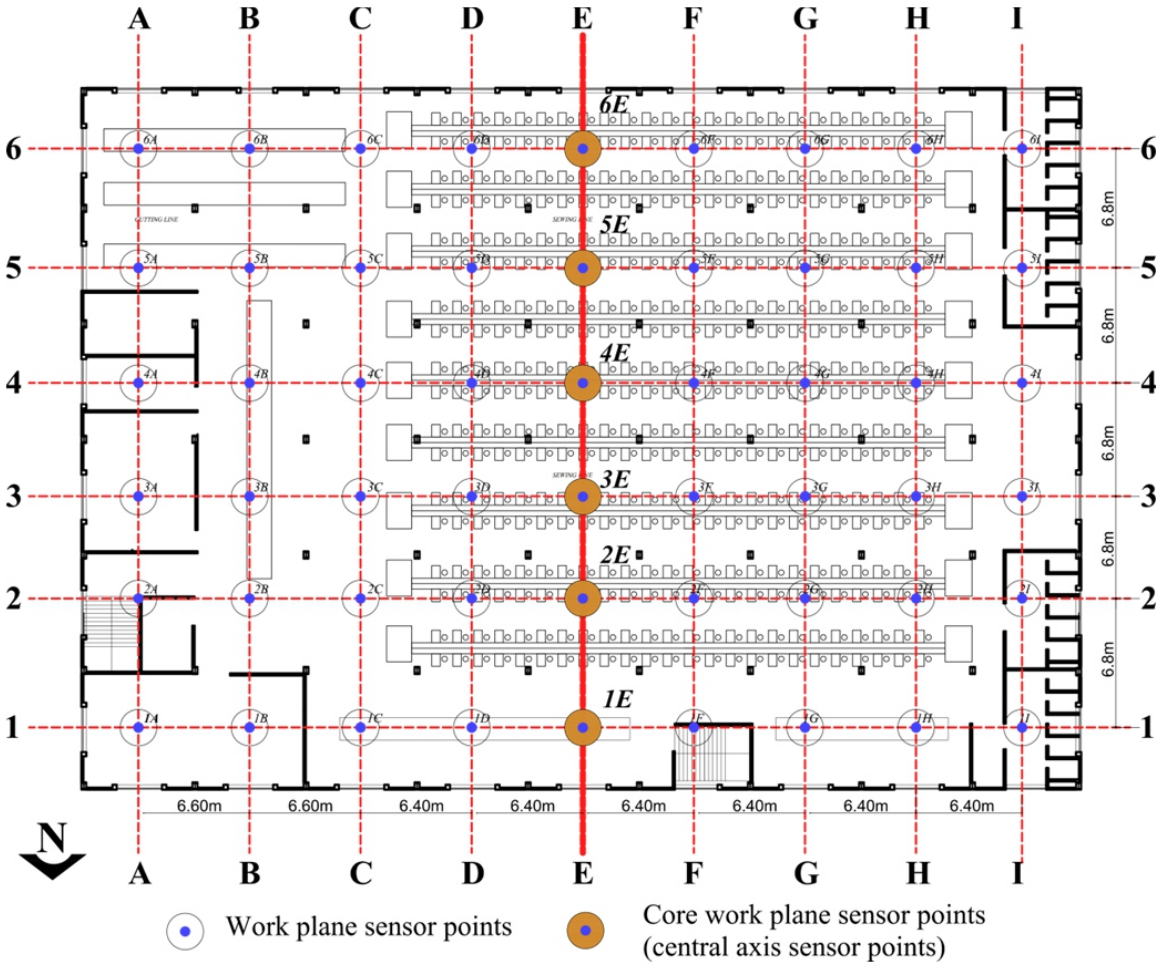


Figure 14: Location of sensors and test points in the case space.

Table 04: Codes with intersection points (54 nos.) for the simulation study.

	A	B	C	D	E	F	G	H	I
1	1A	1B	1C	1D	1E	1F	1G	1H	1I
2	2A	2B	2C	2D	2E	2F	2G	2H	2I
3	3A	3B	3C	3D	3E	3F	3G	3H	3I
4	4A	4B	4C	4D	4E	4F	4G	4H	4I
5	5A	5B	5C	5D	5E	5F	5G	5H	5I
6	6A	6B	6C	6D	6E	6F	6G	6H	6I
Core sensor points :1E, 2E, 3E , 4E, 5E, 6E									

One additional axis EE' was created across the plan to show the fluctuation of the daylight levels from the south window façade towards the opposite north window facade (Figure 15). These six points on the EE' axis (1E, 2E, 3E, 4E, 5E and 6E) were considered as core sensor points. The calculations considered both DF and DC concepts. The static and dynamic daylight simulation parameters are shown in Table 5.

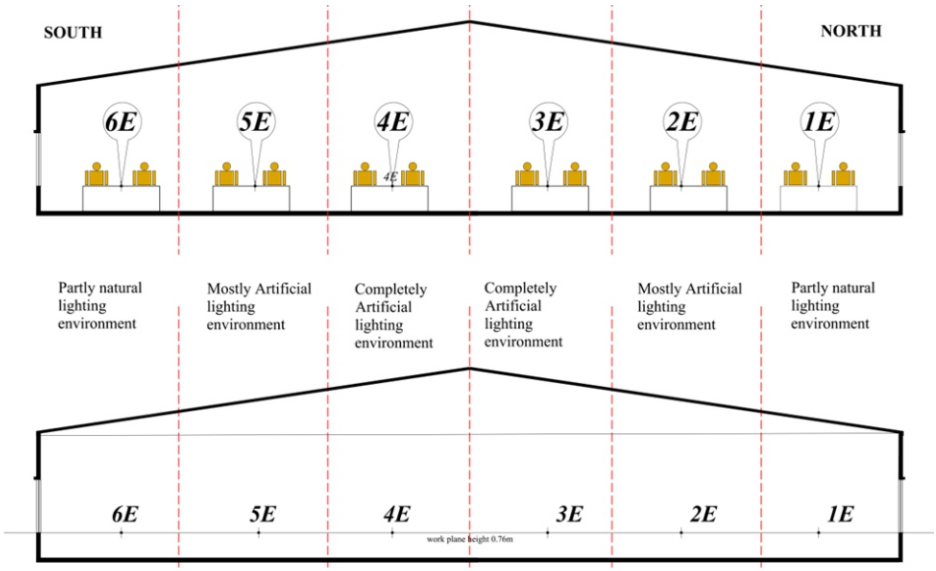


Figure 15: Schematic cross section of the case production space towards EE' axis (central core work plane sensors axis)

Table 01: Field surveyed data of the case RMG building.

Parameters	**Specification**
Location	Within greater Dhaka region, Bangladesh
Longitude	90.25°N
Latitude	23.95°E
Time zone	+6 GMT
Time	For static simulation: 12:30 PM (Joarder, 2007) For dynamic metrics: 8:00 AM to 6:00 PM
Date	For static simulation: 1st April 2014 (Joarder, 2007) For dynamic metrics: whole year For static simulation: overcast sky

Parameters	Specification
Sky model	For dynamic metrics: whole year For static simulation: overcast sky Static sky illumination level: 16500 lux (Khan, 2005). For dynamic simulation: Perez sky model (Perez, 1993)
Unit of dimension	SI, metric (m, cm, mm) Photometric dimension: SI (lux, cd/m2)
Daylight properties of window glaze portion	Transmission: 90% Pollution factor: 0.70 Framing factor: 0.90 Maintenance factor: 0.85

Identify the metrics for performance evaluation

Computer simulation was used to benchmark a skylight configuration for Bangladesh RMG industries against a pool of available skylight configuration types. At first, 3D case model roof was replaced by six available skylight types of Bangladesh (Figure 16). Outdoor and indoor conditions and other physical parameters were kept constant as found during the field survey. Simulation parameters (e.g. intensity, timing, and duration) were kept same as illustrated in Table 5. Skylights' glaze to floor area ratios were considered as 20% (NARM, 2009). Following two types of simulation was done for comparison.

- **Static simulation:** considers one sky model (overcast), done by ECOTECT (considering DF approach) provides one illumination data for each of the 54 intersecting grid points.
- **Dynamic simulation:** considers all sky models and seasonal variation of solar position throughout a year, done by DAYSIM considering DC approach. Calculation of hourly illumination was done for the whole year at the 54 intersecting grid points. Each point provides 8760 (365 x 24) illumination data, considering 24 hours of the day.

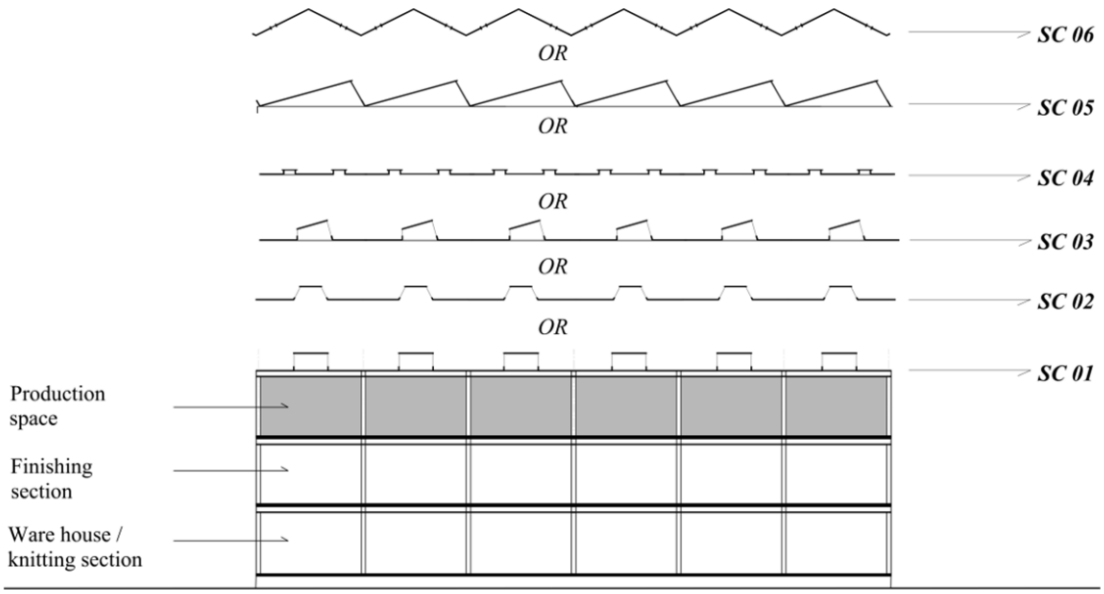


Figure 16: Simulation analysis of six alternative skylight configurations for performance evaluation process.

The findings of the computer simulations were evaluated based on the following static and dynamic performance metrics done to get a complete picture for comparison.

Static metrics

a) Daylight Factor (DF): In DF concept, the horizontal internal daylight illuminance Ei (lux) is considered proportional to the outdoor horizontal illuminance Eo (lux), under the overcast sky (Moon and Spencer, 1942). Mathematically, DF can be expressed as following: DF=Ei/Eo x 100% . DF at six core work plane sensors was compared in this research.

b) Daylight level: Average, minimum and maximum indoor illumination of 54 sensor points on the work-plane height, under overcast sky condition, were compared.

Dynamic metrics

a) Daylight Autonomy (DA): the percentage of the occupied times of the year when the minimum illuminance requirement at the sensor is met by daylight alone (Reinhart, 2006). For this simulation analysis, the minimum illuminance requirement at work plane height was set as 800 lux (Hossain and Ahmed, 2013).

b) Maximum Daylight Autonomy (DA_{max}): the percentage of the occupied hours when the daylight level is 10 times higher than design illumination represents the likely appearance of glare (Rogers et al., 2006). As the design illuminance is 800 lux, DA_{max} corresponds to 8000 lux.

c) Useful Daylight Illuminance (UDI): The aims of UDI are to determine when daylight levels are 'useful' for the user and when they are not. Based on occupant preferences in daylit spaces, UDI results in three metrics, i.e. the percentages of the occupied times of the year when daylight is useful (100- 2000lux), too dark (<100 lux), or too bright (> 2000 lux) (Nabil and Mardaljevic, 2006), were determined.

The goal of the dynamic simulation analysis is to provide minimum 800 lux daylight illumination at each sensor point at work plane height, for the duration of 10 hours in a day from 8:00 AM to 6:00 PM. The upper limit of work plane illumination was fixed at 2000 lux. The same annual illuminance profiles were used in DAYSIM calculations based on US Department of Energy weather files (2008) for Dhaka. The simulation time step was one hour. DF, DA, and UDI were calculated on the six core work plane sensors and Da_{max} calculations were based on the illumination of 54 intersecting grid points that extended across the whole production area.

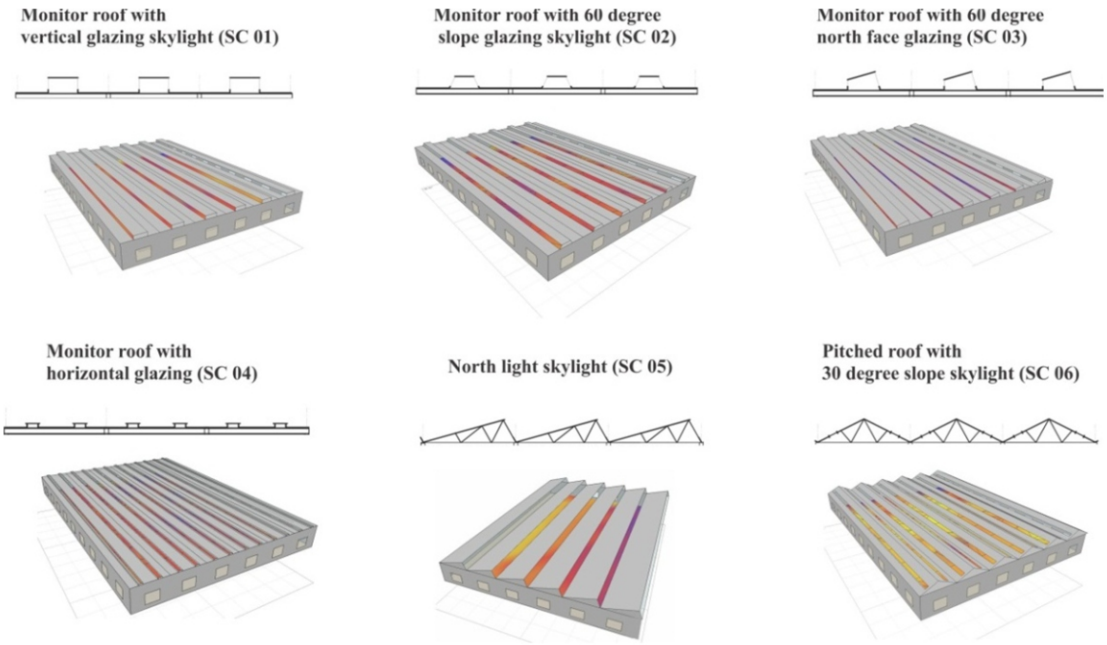


Figure 02: ECOTECT modeling of the case building by replacing existing roof with available skylight configurations suitable for Bangladeshi

Convert the simulation results into performance measures

Once static and dynamic daylight performance metrics are calculated for multiple sensor points in a space, the result can be presented through graphical representations such as contour plots and false colour maps. Such graphical presentations convey valuable information by themselves because they present how daylight is distributed throughout a space (Figure 19). Yet, for a rating system, it is often more desirable to come up with single metric for a space.

Static daylight simulation results

Static daylight simulations are done by considering single sky condition (overcast) on a fixed time of a year. In this study, simulation results were taken on the 54 sensor points on the work plane. Figure 18 shows DF performance analysis for available skylight configuration of Bangladesh RMG factories. Based on DF levels, the performance of SC 06 was the highest and that of SC 01 was the lowest.

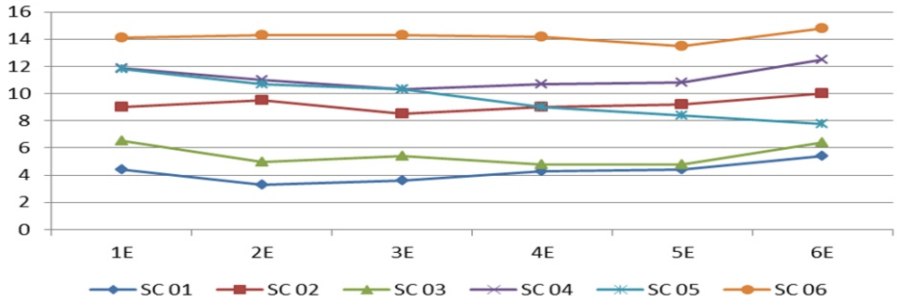
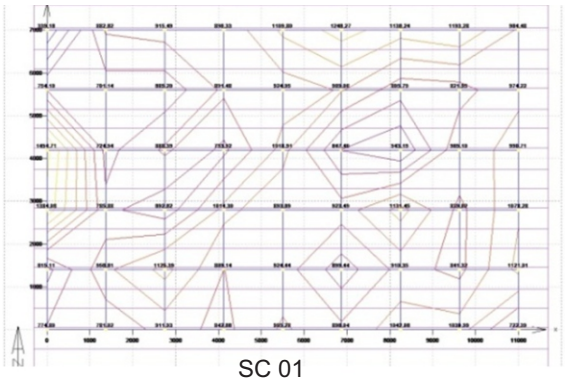


Figure 18: DF performance analysis for available skylight configuration of Bangladesh RMG factories.

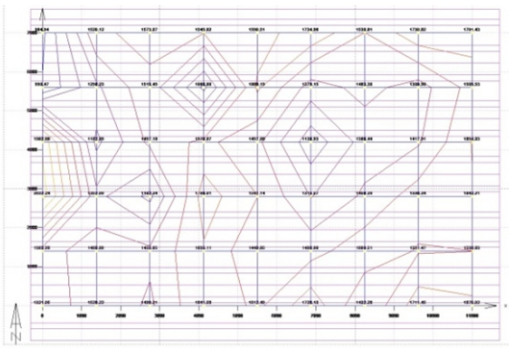
Table 6, shows the complete static daylight simulation results. SC 06 showed high illumination condition and SC 01 showed less illumination level than required level on the work plane height. Considering the average illumination level of the sensor points and its minimum and maximum illumination level values, SC 02, SC 04 and SC 05 performed better than the other three skylight configurations. Based on static metric, SC 06 scored highest followed by SC 04, SC 02, SC 05, SC 03, and SC 01.

Table 06: Static daylight simulation result of six available skylight configurations suitable for Bangladeshi factories.

Illumination level	SC 01	SC 02	SC 03	SC 04	SC 05	SC 06
DF	3.3-5.4	8.5-10	4.8-6.5	10.3-12.5	7.8-11.8	13.5-14.8
Average illumination	907	1482	1178	1497	1427	2141
Min. illumination	339	892	690	984	750	1420
Max. illumination	1454	2195	2017	2232	2074	2388
Place	**6th**	**3rd**	**5th**	**2nd**	**4th**	**1st**



SC 01



SC 03

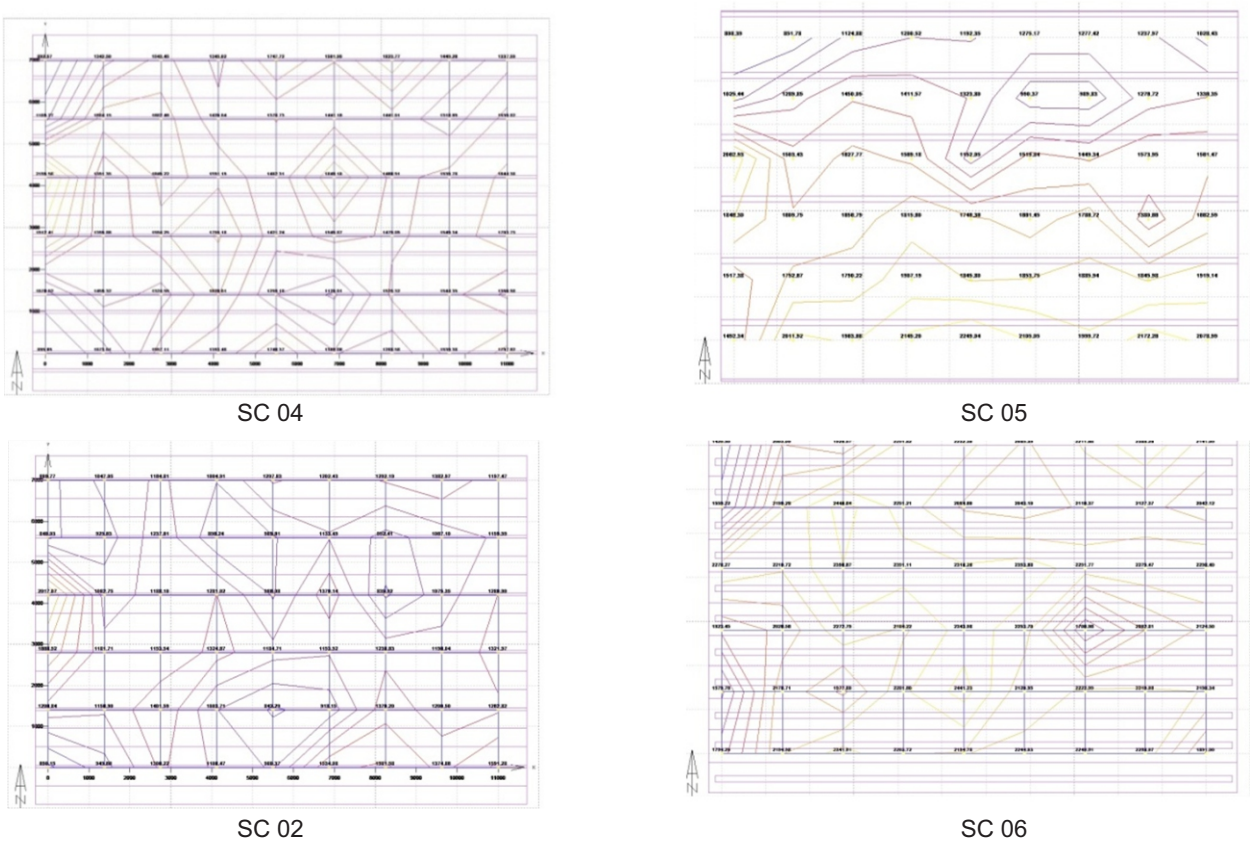


Figure 19: Static daylight simulation result on the sensor points.

Dynamic daylight simulation results

Figures 20 to 23 show comparison of the different skylight performances with respect to different dynamic metrics. According to the DA, SC 06 was found superior to the other skylight configurations. However, SC 06 performed considerably poorer than the other skylight configurations considering the metrics DAmax and UDI. SC 05 and SC 01 scored good value range of DA and both of them were found superior in DAmax and UDI metrics. Table 7 presents summary results of dynamic simulation for available skylight configurations of Bangladeshi RMG factories.

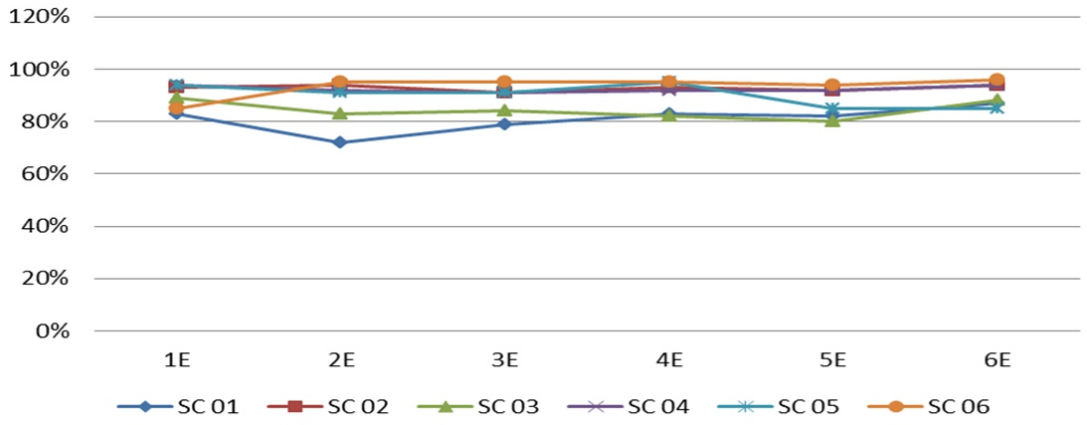


Figure 20: DA performance analysis for available skylight configuration of Bangladeshi RMG factories.

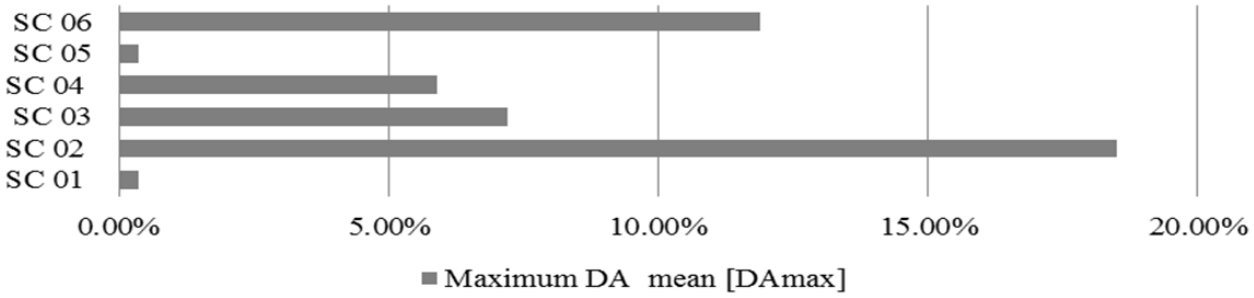


Figure 21: Mean DA_{max} metric performance analysis for available skylight configuration of Bangladeshi RMG factories.

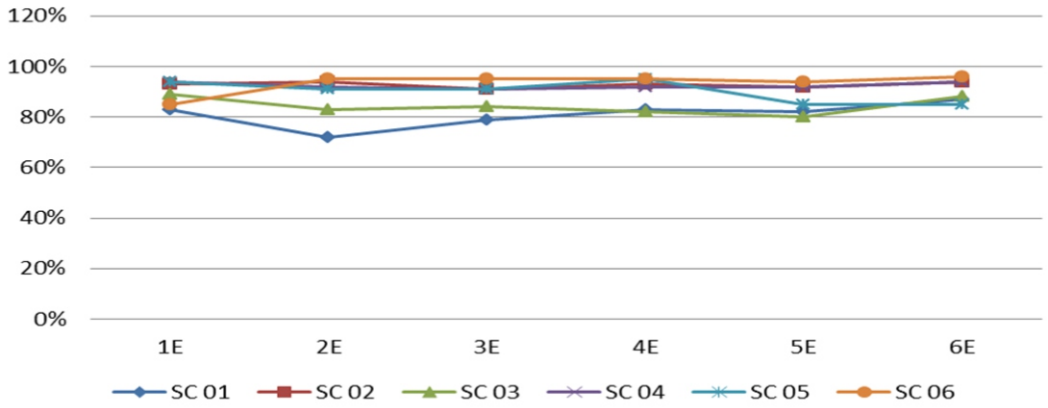


Figure 22: UDI 100-2000 metric performance analysis for available skylight configuration of Bangladeshi RMG factories.

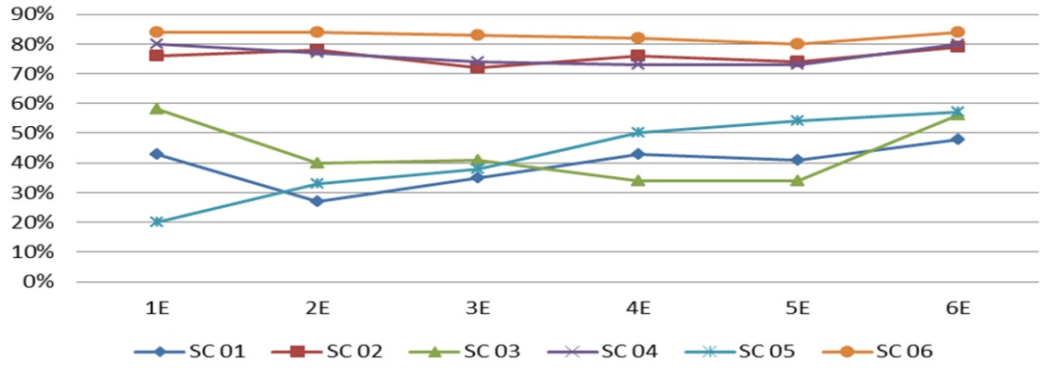


Figure 23: UDI>2000 metric performance analysis for available skylight configuration of Bangladeshi RMG factories.

Table 07: Summary results of dynamic simulation for available skylight configurations.

Code	SC 01	SC 02	SC 03	SC 04	SC 05	SC 06
DA	72%-87%	91%-94%	80%-89%	91%-94%	85%-94%	94%-96%
DA_{max}	0%-10% (mean 0.37%)	15%-30% (mean 18.5%)	5%-17% (mean 7.2%)	0%-24% (mean 5.9%)	0%-9% (mean 0.35%)	1%-27% (mean 11.88%)
$UDI_{<100}$	1%-2%	1%	1%	1%	1%	1%
$UDI_{100-2000}$	51%-71%	20%-27%	40%-65%	19%-26%	41%-80%	15%-19%
$UDI_{>2000}$	35%-48%	72%-79%	34%-58%	73%-80%	20%-57%	82%-84%

Rating between the available skylight configurations based on dynamic simulation results is easier to interpret, except for the value of $UDI_{<100}$, which was mostly identical for all the studied skylight configurations. Table 8 shows the rating of the six available skylight configurations according to the different metrics. When a metric led to the different rating for the EE' axis, the mean result and the minimum to maximums range for the core work plane sensors are compared. The ratings are shown in points that vary between '5' (highest) to '0' (lowest) in Table 8 (Reinhart et al., 2006). The rating was done considering the range values of core sensor points for DA, $UDI_{100\text{-}2000}$, and $UDI_{>2000}$ and mean value of DA_{max} of the 54 sensor points, for each skylight configuration.

Table 08: Ranking between available skylight configurations of Bangladesh RMG factories.

Types	SC 01 Point	SC 02 Point	SC 03 Point	SC 04 Point	SC 05 Point	SC 06 Point
DA	0	4	1	3	2	5
DA_{max}	4	0	2	3	5	1
$UDI_{100\text{-}2000}$	5	2	3	1	2	0
$UDI_{>2000}$	4	2	3	1	5	0
Total Point	**13**	**8**	**9**	**8**	**16**	**6**
Place	**2nd**	**4th**	**3rd**	**5th**	**1st**	**6th**

After summing the rating points achieved by the available skylight configurations, SC 05 was found as superior to all the other skylight configuration types with 16 points (Table 8). On the other hand, SC 06 was found as the lowest with only 6 points, as most of the metrics indicate over daylit condition in the interior of RMG production building for SC 06. SC 01 was also found as one of the most feasible skylight configuration roof types for Bangladesh RMG factories. Performance metrics rated the north light skylight configuration (SC 05) as the most feasible skylight configuration for Bangladesh RMG factory buildings (Figure 24), and further analysis shows 21o slope angle with one segment (length of sloped surface 6.25m with 2.2m rise) performs better compared to other studied configurations of the same skylight type (SC 05) (Joarder and Nahid, 2015).

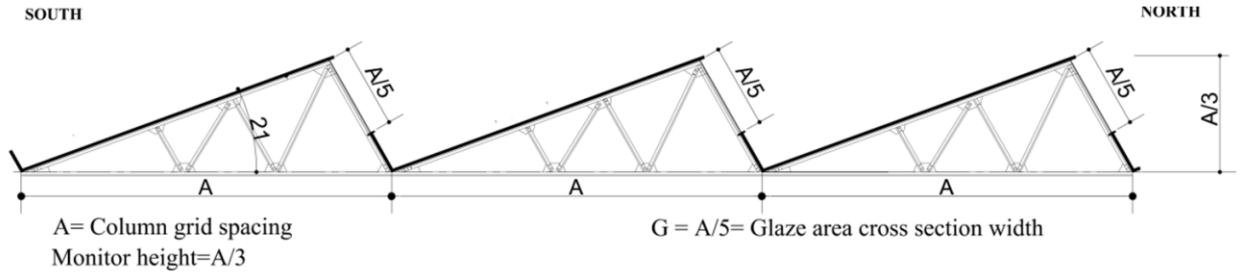


Figure 24: Schematic cross section of a best parametric configuration of north light skylight configuration (SC 05).

COMPARE PERFORMANCE MEASURE FOR DIFFERENT CONFIGURATIONS

Sustainable and low-energy green buildings require a detailed performance evaluation, at the preliminary design stage. Table 9 compares the ranking of studied skylight configurations, based on the results of the static and dynamic simulations. A DF optimized decision, based on static simulation follows “the more the better” approach, and as a result SC 06 becomes the most favourable option. But the dynamic metrics rating puts SC 06 as the least favourable option, because dynamic metrics consider the contribution of the sun to the overall illumination of the building, and can explain a situation in more details and with greater accuracy

indicating of potential glare resulting from direct sun and/or skylight. Dynamic performance metrics ranks SC 05 as the most feasible skylight configuration for Bangladesh RMG factory buildings, while static metrics put SC 05 as the 4th choice. As, DF for a building is not responsive to the orientation (Reinhart et al., 2006), static metrics fails to appreciate the north light skylight configuration (SC 05) where glare-free natural lights coming towards the north is only allowed.

Table 09: Comparing the ranking of skylight configurations based on static and dynamic daylight simulation.

Results	SC 01	SC 02	SC 03	SC 04	SC 05	SC 06
Static simulation	6th	3rd	5th	2nd	4th	1st
Dynamic simulation	2nd	4th	3rd	5th	1st	6th

Static simulation with DF approach has gained favour owing to its simplicity. As DF method is limited to overcast sky conditions, DF is not expected to be a measure of practical daylighting design. Daylight illuminances inside a room, in fact, are not proportional to the external illuminance, and the ratio of indoor to outdoor illuminance can vary greatly. DF is unable to predict the dynamic variations in interior illuminance as the sun's position and sky conditions change. DF is also insensitive to location. Compared to static metrics, the key advantage of dynamic daylight performance metrics is that it considers the quantity and character of daily and seasonal variations of daylight for a given building site, together with irregular meteorological events (Reinhart, 2006).

CONCLUSION

Daylighting is often cited as one of the key components of sustainable building design. Rating systems and energy codes encourage analysis of daylighting performance precisely for sustainable building design. It is apparent that to support decision-making processes in selecting the most suitable skylight configuration for Bangladesh RMG factories, in preliminary design level, suggestions based on static and dynamic simulations vary greatly, often conflicting (opposite to) each other.

Evaluation of the design at a single point in time even with actual sky condition under static simulation simplifies the analysis but fails to adequately represent year round performance. The changing nature of seasonal pattern of daylight quantity and quality demands an evaluation period of a full year to completely comprehend the naturally occurring variations represented in the climate of a particular location. Dynamic simulation processes, in this context, calculates the performance metrics considering the impact of local climate, and generates indoor annual illuminance profile at points of interest in a building, that change with time, sky conditions, and shading device settings, in contrast to static modelling, which concentrates generally on the DF concept.

The conflict between the use of static and dynamic simulation is subject to ease of use and accuracy. An obvious disadvantage of the dynamic daylight simulation is its complexity and increased simulation time to produce a larger number of results. Advances in simulation software and powerful computers have reduced the time for illuminance calculations with dynamic methods, and it is possible that the purely DF approach will become obsolete with time. It is expected that the methodology presented in this paper will help designers to comprehend the benefits of using dynamic climate-based daylight simulation in sustainable building design and green building rating system in Bangladesh.

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A Study of Light Zone in Commercial Buildings: Assessing Energy Efficiency for Shading Devices

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Abstract: This paper addresses the daylighting compromises of the passive architectural feature of sunshades, owing to the subdivision of varying illumination level of light zones into the interior luminous environment. In light zones, under and over-lit zones may cause visual and thermal discomfort, in addition to consequent energy consumption. However, using daylight, dependency on artificial lighting sources can be minimized, resulting in energy efficient sustainable buildings. This paper presents a simulation study of assessing the luminous performance of most commonly used shading devices, for recent tall office buildings of Dhaka. It emphasizes in the context of the most vulnerable—south, east and west orientation for this location—during the overheated period of summer. Six selected fixed external shading devices, from a field survey, have been evaluated, based on the light zone distribution. The simulation results indicate that both the geometrical, as well as the material characteristics of shading devices, can have a noteworthy influence on the desired luminous performance. The results also clearly illustrate the necessity of selecting proper shading devices to modify the dimensional relations of the light zone and enhance energy efficiency in offices of similar tropical areas.

Keywords: Light zone, energy efficiency, shading device, commercial buildings.

INTRODUCTION

Artificial lighting at present shapes 30% of global energy consumption in office buildings (Brotas and Rusovan, 2013). Being no exception, artificial light in the offices of Dhaka is the main contributor to the visual environment, even though there is an abundance of daylight and the working hours in offices utilize much of the daylight hours. However, electric lighting energy use can be reduced by 25-50% with advanced light sources, design strategies and controls, and by 75% with the addition of daylighting (Joarder et.al., 2009, p.218). In cities like Dhaka, beset by load-shedding and electricity interruption, inmates of buildings regularly need to depend solely on daylighting, as a prime consideration for adequate visual performance (Joarder, 2009, p.6). Therefore, daylight is being encouraged in office/commercial buildings all around the world, as well as in Dhaka. The recent trend is seen to be a high rise, deep plan, open layout offices, with extensive use of curtain glass envelopes, using large apertures (Rahman and Ahmed 2008, 15). Though hardly any attention is paid to the interdependence between achieved daylight illumination level in the interior and envelope design.

Generally, daylight inclusion into large interiors creates two types of luminous areas or light zones within a space for a specific task: a daylight zone of abundant daylight and a dark or under-lit zone, requiring artificial light (Trisha and Ahmed, 2016). In the Tropics, unwanted heat may enter with direct sun light in over-lit areas, causing thermal discomfort. Too much or unguided daylight may cause visually uncomfortable glare-prone over-lit zone (Mayhoub 2012). Therefore, the improper and unconsidered addition of daylight may cause harm, rather than any targeted benefit (Joarder, Price and Mourshed 2010).

Shading provision is argued to be considered as an integral part of fenestration system design for office buildings in order to balance daylighting comfort requirements of light zone, versus the need to reduce

energy consumption (Ahmed, 2014, p.139). According to the U.S. Department of Housing and Urban Development (1999), stopping the sun's heat, before it penetrates windows by external shading devices is up to seven times more effective, than using interior blinds or curtain. Another study accentuates the design significance of static solar protection for office buildings (Hans, 2006, p.16). However, the extent of shading devices hasn't yet been investigated (RAJUK 2008) for the Dhaka context.

In a recent study, luminous-thermal conflicts of tall air-conditioned office buildings of Dhaka, with fenestrations, using the most common external fixed shading devices for south orientation have been evaluated (Trisha and Ahmed, 2016). This research paper is based only on the comparative luminous performances of those shading devices for the south, east and west orientations by using 'Ecotect' (version 5.50) computer simulation program with ray trace based software 'Radiance'. The aim of the study was to identify the efficiency of shading devices with respect to lighting.

LIGHT ZONE AND ITS DISTRIBUTION

Conceptually, light-zone(s) are areas, fields or zones of light. The daylight in a space can be regarded as a composition of light-zones ((Merete 2007). In this paper, the light zone has been regarded analytically, as spatial groupings of the lighting variables (intensity, direction, distribution and color), which are significant to space. In any space, a light zone may consist of both direct sun light and diffuse light or only diffuse light. Variation in their illumination level creates over-lit, accepted and under-lit zone (Figure 1)

METHODOLOGY

Quantitative determination of average luminous variables was used, to evaluate the energy efficiency of shading devices in this research. The adopted methodology of this study is as followed (Figure 2):

Energy efficiency assessment criteria

According to the International Energy Agency (IEA, 2000, p.3-5), the luminance ratio set ideally within the visual field include the following: Central field (5): background (2): environment (1). However, whenever this ratio exceeds 10:3:1, the visual problem of glare occurs, due to over-lit zone. The minimum standard illumination level for general office is considered to be 300lux (CIBSE, 2002) (BNBC, 1993, p.8.7).Therefore, on the basis of the distribution of the illumination level (Joarder et al., 2009, p.920-927) in deep plan open office spaces, the luminous energy efficiency of shading devices can be evaluated, under the fulfillment of the four luminous/lighting criteria of Table 1.

Table 01: luminous variables for energy efficiency assessment

Area of daylight zone: acceptable illumination level	Area of over-lit zone	Area of under-lit zone	Maximum depth-accepted illumination level/daylight zone
≤900-≥300lux	≥900lux	≤300lux	≤300lux

Maximizing area of accepted daylight zone is the prime criteria for good quality for daylighting (BNBC, 1993, p.8.3). Both glare-prone over-lit and under-lit or artificial light zone, are considered under efficient, in daylit buildings, for office tasks, and should be minimized, compared to the acceptable area of daylight zone. However, the over-lit zone is given preference compared to the under-lit zone as it requires no energy consumption for artificial lighting. Moreover, it may be converted into usable area merely by changing the direction of seating in the interior layout (Jakubiec and Reinhart, 2012, p.149-170).

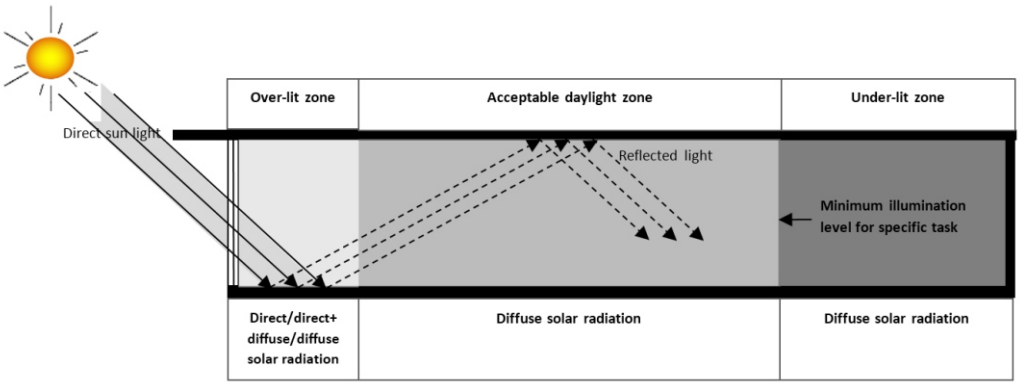


Figure 01: Distribution of light zones in section

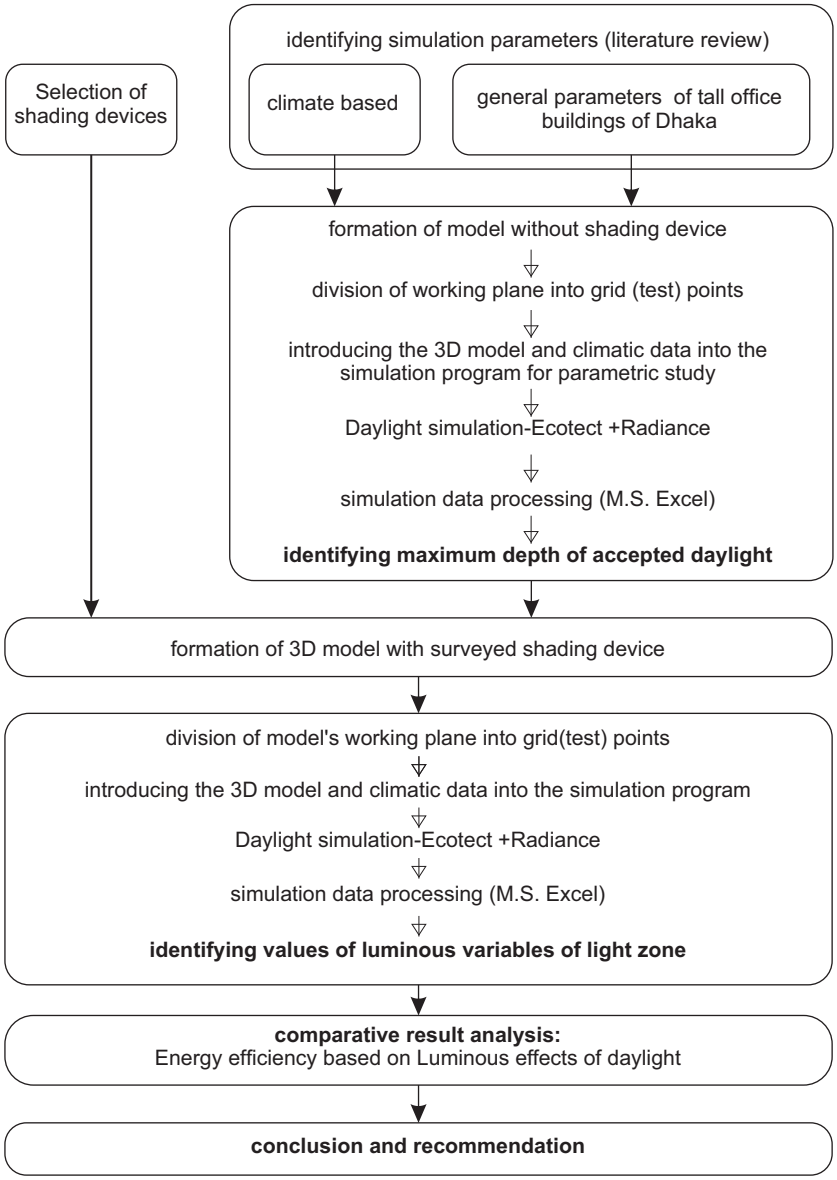
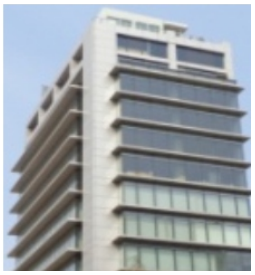
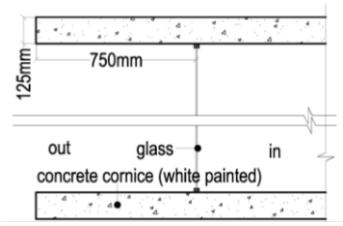
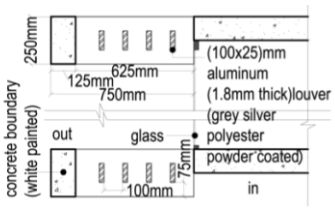
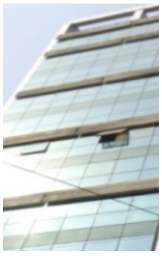
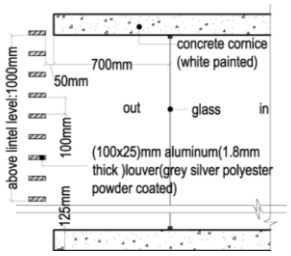
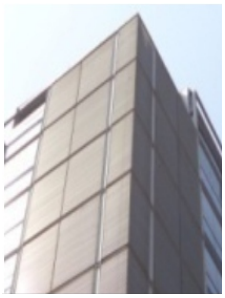
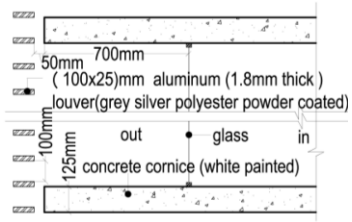


Figure 02: Flow diagram of simulation process

Field survey and selection of shading devices

For the simulation models, parameters of shading devices were derived from a field survey of tall office buildings of Dhaka. As there is no defined aspect of tallness (CTBUH, 2014, p.1-5), buildings above six stories were regarded as tall buildings, considering walk up limit and fire escape provision (RAJUK, 2008, p.33). After a pilot survey, involving 106 buildings, six were finally selected, based on the most commonly found parameters of shading devices (Figure 3).

Selected building	Section of the case shading	Simulation parameters of shading device
		cornice depth:750mm,thickness:125mm Material: White paint on concrete reflectance:0.55, U value:1.8w/m^{2}k
Nuruzzaman Biswas Tower, Gulshan	**Horizontal concrete cornice (ID:H01)**	
		cornice depth:750mm, Boundary depth:625mm, thickness:250mm, louver:100mmx25mm, spacing:100mm,thickness:1.8mm Material: White paint on concrete boundary, reflectance:0.55, U value:1.8w/m^{2}k. grey silver polyester powder coated aluminum louvers, reflectance:0.796, U value:1.7w/m^{2}k
I-Center, Dhanmondi	**Horizontal aluminum louvers with concrete boundary (ID:H02)**	
		cornice depth:700mm,thickness:125mm, offset from overhang:50mm , overhang depth:1000mm, louver:100mmx25mm, spacing:100mm,thickness:1.8mm Material: White paint on concrete boundary, reflectance:0.55, U value:1.8w/m^{2}k. grey silver polyester powder coated aluminum louvers, reflectance:0.796, U value:1.7w/m^{2}k
The Alliance Building, Baridhara	**Horizontal aluminum louvers in overhang (ID:H03)**	
		cornice depth:700mm,thickness:125mm, offset from screen:50mm, louver:100mmx25mm, spacing:100mm, thickness:1.8mm , Material: White paint on concrete boundary, reflectance:0.55, U value:1.8w/m^{2}k. grey silver polyester powder coated aluminum louvers, reflectance:0.796, U value:1.7w/m^{2}k
Uday Tower, Gulshan	**Horizontal aluminum louvers in vertical plane (ID:H04)**	

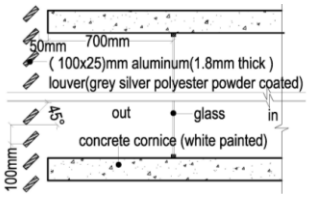
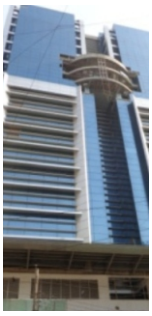
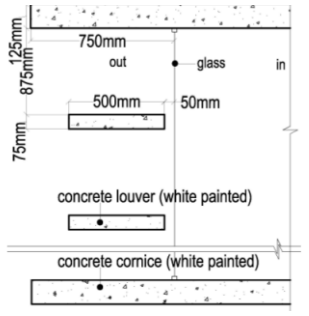
Selected building	Section of the case shading	Simulation parameters of shading device
		cornice depth:700mm,thickness:125mm, offset from screen:50mm louver:100mmx25mm,spacing:100mm, angle:45°,thickness:1.8mm, Material: White paint on concrete boundary, reflectance:0.55, U value:1.8w/m^{2}k. grey silver polyester powder coated aluminum louvers, reflectance:0.796, U value:1.7w/m^{2}k
Mika-Cornerstone, Uttara	**Horizontal angled aluminum louvers in vertical plane (ID:H05)**	
		cornice depth:750mm,thickness:125mm louver depth:500mm, thickness:75mm offset from glass:50mm,spacing:875mm Material: White paint on concrete reflectance:0.55, U value:1.8w/m^{2}k
NCC-Bank, Head office, Motijheel	**Horizontal concrete louvers (ID:H06)**	

Figure 03: Case shading devices from field survey, 2016.

Simulation parameters

The office period between 9.00-17.00 hrs. of 15 April and 'sunny with sun' sky condition was chosen for simulation, characterizing extreme climatic features (U.S. dept. of Energy) of the hottest month of the year, for the study region of Dhaka. The general parameters of the tall office building of Dhaka i.e. typical column grid, clear height, working plane height for simulation models, selected from the literature review (Rahman, A. and Ahmed, K.S., 2008, p.15), are followed in Table 2. Material parameters (Table 2) were used from default material specification, considered by the chosen software.

The depth of the simulation model was derived from the maximum depth reached, of accepted illumination level of 300 lux, for a 'model without shading'. Using daylight thumb rule, i.e. daylight penetrates about 2.5 times the head height of the aperture into the room from a window (Robbins, 1986, p.64), parametric daylight

Table 02: General parameter of tall office building of Dhaka.

Model dimension		
Model Width	6000mm	typical column grid
Floor height	3000mm	typical clear height
Aperture Width	5750mm	the whole span between two columns up to full floor height
Aperture head height	2875mm	
Working plane height	760mm	ergonomics standard

Material specification	
Ceiling	white painted on 12.5mm plaster, 150mm RCC (reflectance:0.7, U value:2.05w/m^{2}k)
Wall	150mm brick work with 18.5mm plaster (reflectance:0.5, U value:2.602w/m^{2}k)
Floor	200mm thick concrete slab plus tiles finishes (reflectance:0.3, U value:2.9w/m^{2}k)
Glazing	Single glazed clear with aluminum frame for maximum visual transmittance with thermal gain. (reflectance:0.89, U-value:6w/m^{2}k)

simulation studies for South, East and West orientations were carried out by considering the severity of direct sun light. The results revealed that 300 lux reaches its maximum depth after 15.00 hours in the West orientation, and at 9.00hours in the East (Figure. 4). With aperture/window heights of 2875 mm, the maximum depth 2.5x2xaperture head height, 13750 mm, was considered the depth of the simulation model.

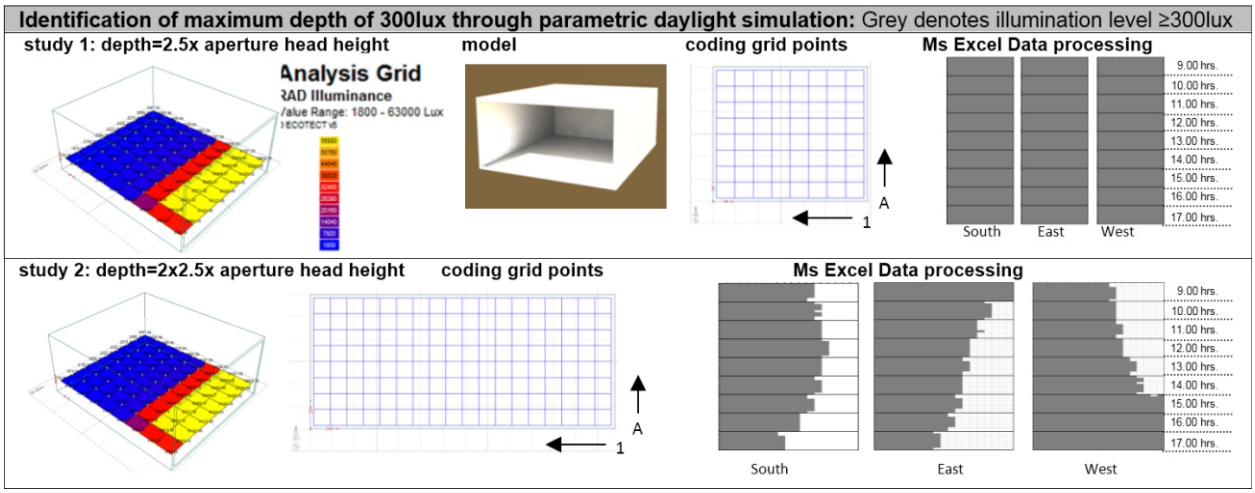
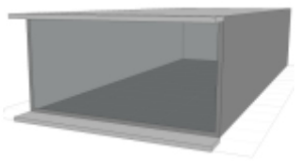
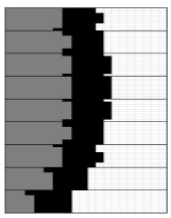
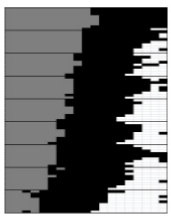
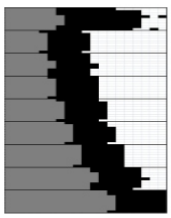
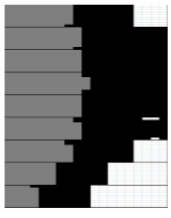
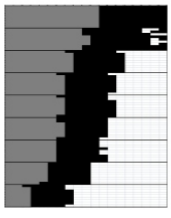
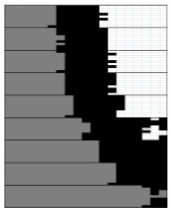


Figure 04: Depth of simulation model.

Generation of simulation model and daylight simulation results

The simulation models with selected shading devices were generated, using the shading device parameters from Figure 3, general parameters of tall office building from Table 2 and the identified depth

Simulation models	Simulation result-south	Simulation result-east	Simulation result-west
			
			

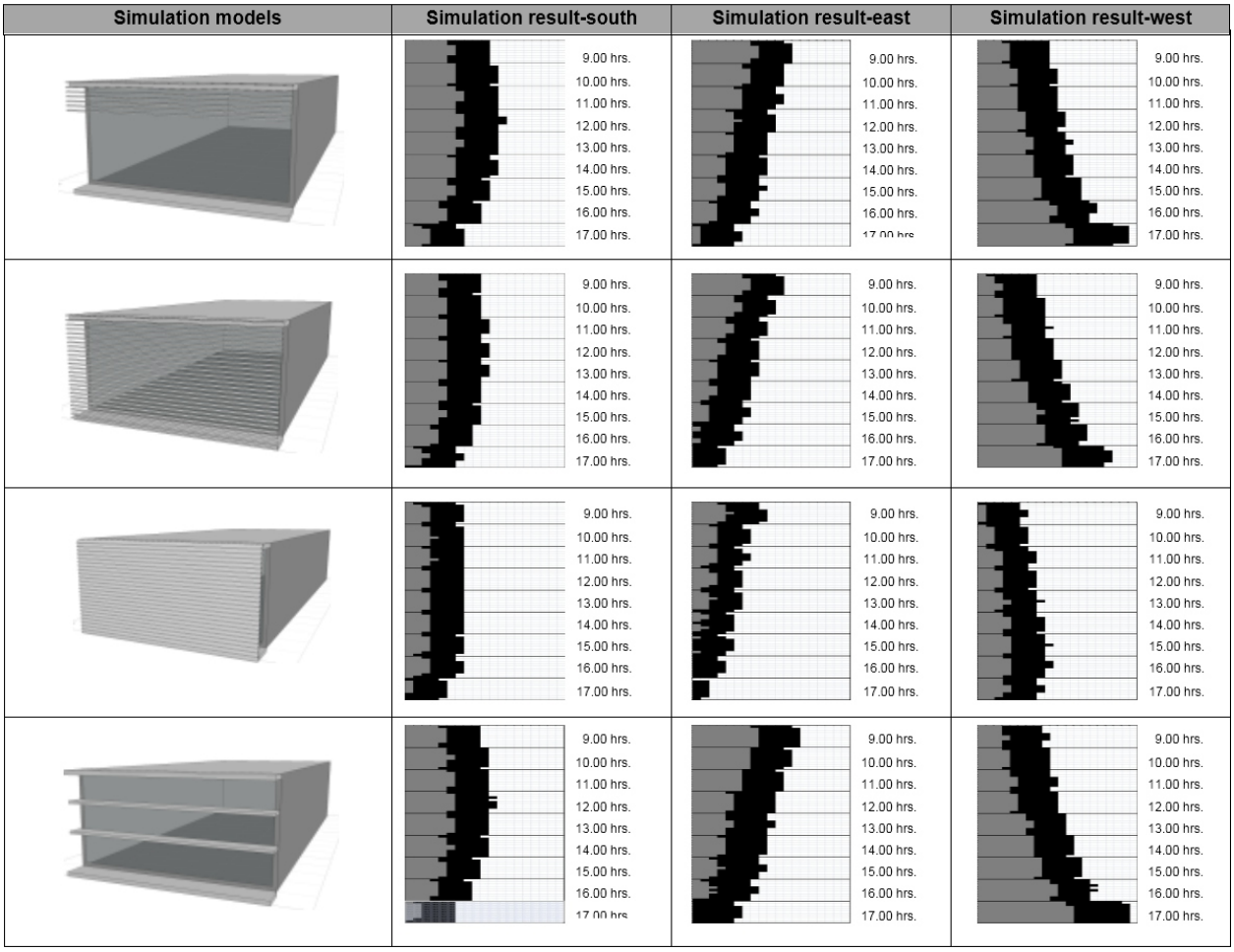


Figure 05: Daylight simulation results for south, east and west orientation.

from Figure 4. In daylight simulation results for the south, the east and west orientation of Figure 5 gray, black, and white denotes over-lit, accepted daylight and under-lit zone accordingly. The simulation process was carried out considering all other variables constant, except shading devices, using the grid points code similar to that of the parametric study 2 in Figure 4.

RESULT ANALYSIS AND DISCUSSION

The comparative evaluation of the simulation results of the shading devices for the south, east and west orientation are as followed:

South Orientation

The average of daylight simulation results of south oriented shading devices (Figure.6) shows that, in general, a total of over and under-lit zones, constitute greater area, than accepted daylight zone, for all the tested models. Values of the Maximum depth of acceptable daylight zone as well as overlit zone, for the south orientation, generally characterize the direct relationship with the accepted daylight zone. Although, the relation between underlit and accepted daylight zone, is inverse. These three variables for H06, only yields opposite relationship, with the accepted daylight zone, when compared to that of the values of H04. For all the tested models, the values are also not directly or inversely proportional, to that of the accepted daylight zone.

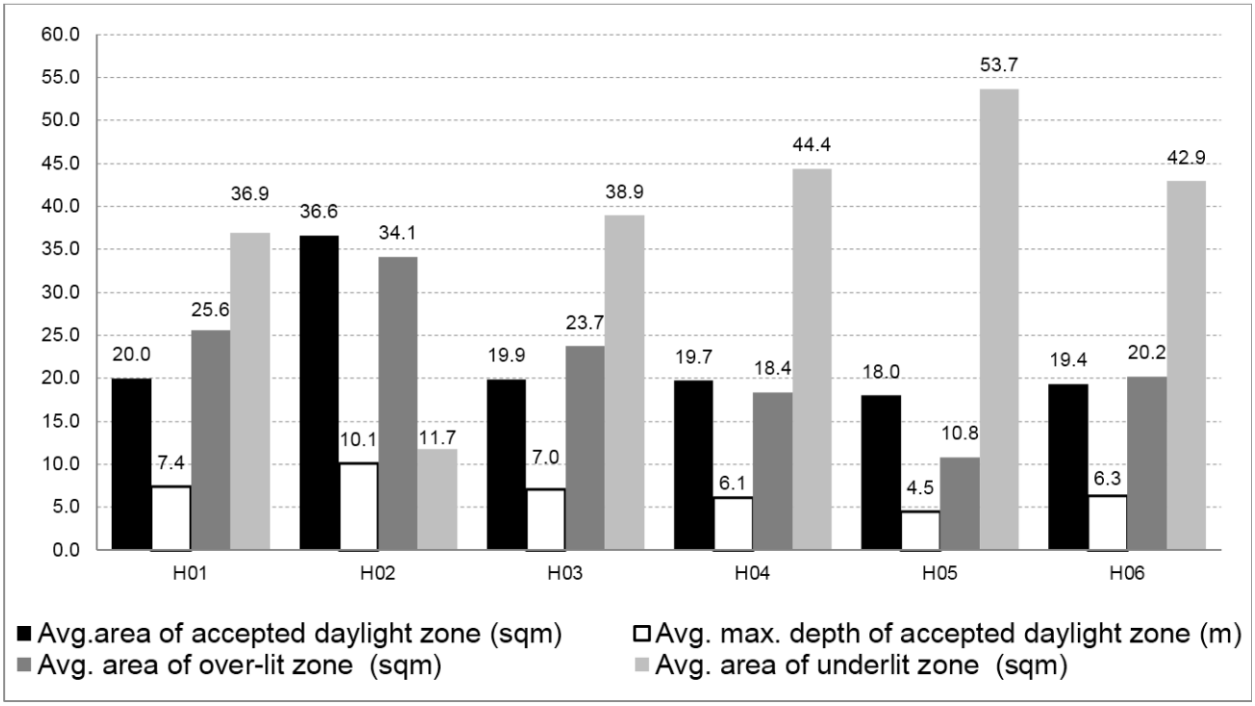


Figure 06: Comparison of different light zones from average of daylight simulation results in the south.

Among the shading devices tested, only H02 yields smaller under-lit or artificial light zone compared to its over-lit glare area. The over-lit area for H02 as well as for H04 and H05 are smaller than that of their accepted daylight zone. However, the area of the under-lit zone, for H04 and H05 is much greater, compared to the rest of the tested shading devices. H05 also presents the worst case scenario, characterizing the least values under other considered criteria. On the other hand, H02 yields a much smaller under-lit zone. It is even smaller than its accepted daylight zone. Moreover, the area of accepted daylight zone, over-lit zone and maximum depth of accepted daylight zone, for H02 has the highest value. H01 shows the second highest value, for these three criteria, though the values are markedly smaller than that of H02. H01 also occupies the second lowest area of the under-lit zone, though it is much greater compared to H02. Over-lit area for H01 is also greater than its accepted daylight zone. With the lesser performance, H03 and H06 yield similar comparative results among their variables, as do H04 and H05. H04 and H06 yields very close results. H04 fulfills the prime criteria of greater accepted daylight zone. However, its performance is not as good as H06, considering the other three criteria. Considering the above discussion on light zones distribution, the identified selection order of the south oriented shading devices for energy efficiency is specified in Table 3.

Table 03: Shading device selection order in the south.

Selection order	1	2	3	4	5	6
Shading device	H02	H01	H03	H06	H04	H05

East Orientation

The average of daylight simulation results of east oriented shading devices (Figure 7) shows that all the tested models constitute a greater area of the total over and under-lit zones than accepted daylight zone. With the accepted daylight zone, values of rest of the three considered variables, characterize relationships, as mostly found in the southern orientation. Only values of H03 yields opposite relationship between overlit and accepted daylight zone, when compared to that of H06.

Among the shading devices tested, only H01 and H02 yield smaller under-lit or artificial light zone, compared to than that of their respective over-lit glare area and accepted daylight zone. However, the area of the under-lit zone for H02 is very close to its accepted daylight zone. Only H02 occupies a greater area of the over-lit zone than accepted daylight area, among all tested devices in the eastern orientation. Its area of the over-lit zone is smaller but very close to that of the highest value for H01. Under-lit zone for H01 is much higher than that of H02. Under the rest of the criteria, the performance of H02 is also not as good as H01. On the other hand, H01 yields the least area of the under-lit zone, among all tested shading devices. Moreover, it occupies the highest value, for the area of accepted daylight zone and its maximum depth. With lesser performance accordingly, H06, H03, H04 and H05 yield similar comparative results, among their variables. Only H03 depicts the almost equivalent area of over-lit and accepted daylight zone, among these shading devices. H05 presents the worst case scenario, characterizing the highest area of the under-lit zone and the least values under rest of the criteria.

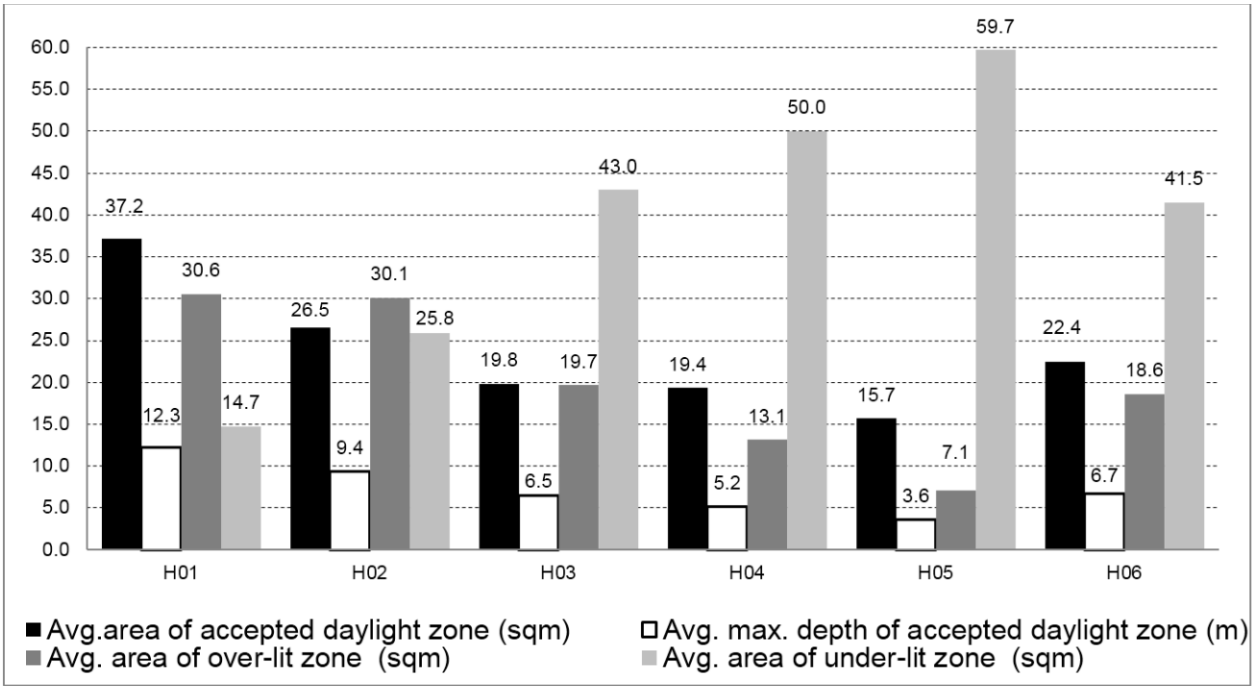


Figure 07: Comparison of different light zones from average of daylight simulation results in the east .

Considering the above discussion on light zones distribution, the identified selection order of the east oriented shading devices for energy efficiency is specified in Table 4.

Table 04: Shading device selection order in the east.

Selection order	1	2	3	4	5	6
Shading device	H01	H02	H06	H03	H04	H05

West Orientation

The average of daylight simulation results of west oriented shading devices (Figure 8) shows that similar to the results of south and east orientations, all the tested models constitute a greater area of the total over and under-lit zones, than accepted daylight zone. With the accepted daylight zone, values of rest of the three considered variables, characterize similar relationship, to that of the results mostly found in the last two considered orientation. Opposite relationship with very close values is found when compared between H03 and H06.

Among the shading devices tested, H01 and H02 yield similar comparative results among their variables, as do H03, H04 and H06. Only H01 and H02 yield smaller under-lit or artificial light zone, compared to their respective over-lit, as well as accepted daylight zone. H01 depicts smaller over-lit glare-prone area than that of the highest value of H02. But for H01, the area of accepted daylight zone is almost equivalent to its under-lit zone. The performance of H01 is also not as good as H02, under rest of the criteria. On the other hand, H02 presents the highest area of accepted daylight zone and its maximum depth, among all shading devices. It also has the least area of the under-lit zone. With the lesser performance, H03 and H06 yield almost equal area of accepted daylight zone. Over-lit area of H03 is greater, compared to that of H06. However, H03 characterizes the greater maximum depth of accepted daylight zone, with the less under-lit area. H04 shows, lower performance than H06, under all the criteria. H05 presents the worst case scenario in the west. It characterizes the highest area of the under-lit zone and the least values under rest of the criteria. The only noticeable preferred result about H05 is, its least over-lit area, among all tested models in the western orientation. Even it comprises the much lower over-lit area than its accepted daylight zone.

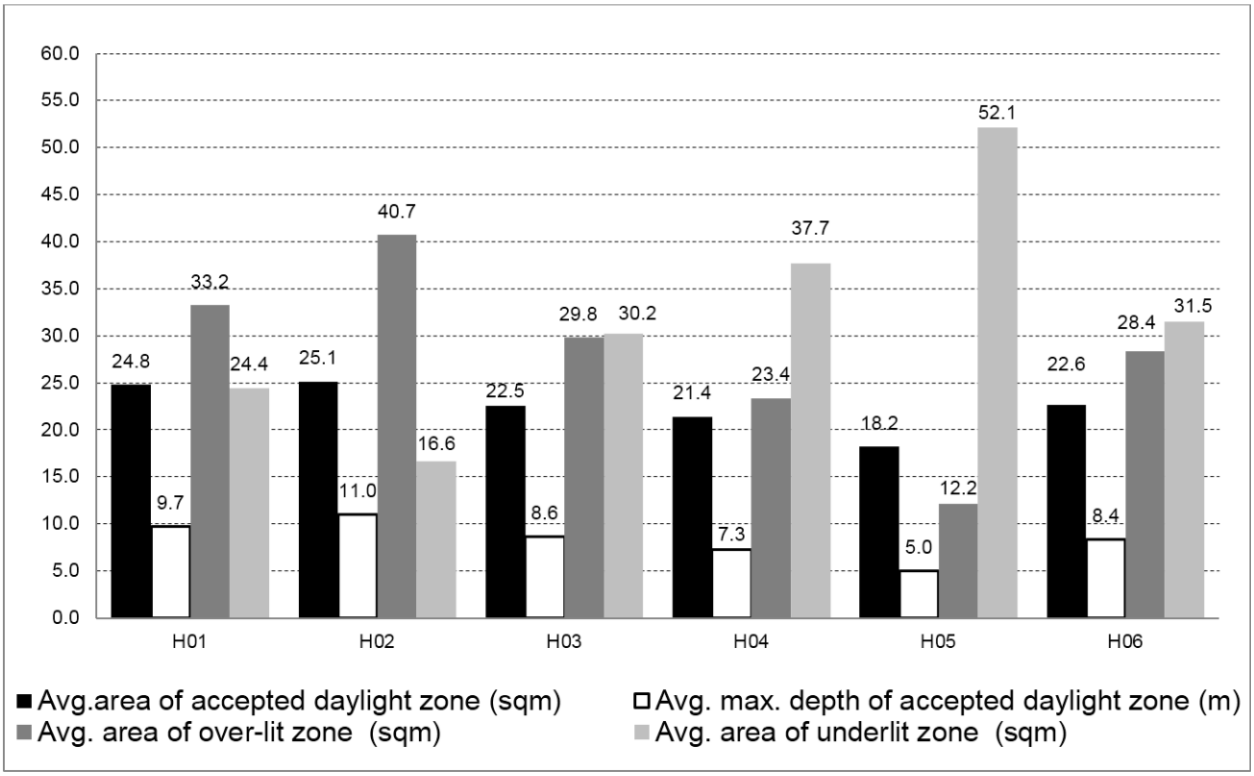


Figure 08: Comparison of different light zones from average of daylight simulation results in the west.

Considering the above discussion on light zones distribution, the identified selection order of the east oriented shading devices for energy efficiency is specified in Table 5.

Table 05: Shading device selection order in the west.

Selection order	1	2	3	4	5	6
Shading device	H02	H01	H03	H06	H04	H05

CONCLUSIONS AND RECOMMENDATIONS

In this paper, luminous performance evaluation of shading devices (Figure 3), reveals that their proper selection, in controlling the distribution of light zone, can advance energy efficiency, in commercial office buildings of tropical cities significantly. Moreover, proper physical characteristics of shading devices can be significant in minimizing artificial light zone as well as, maximizing glare-free acceptable daylight zone. The summary of the findings, from results, discussion and analysis of Table 3,4 and 5, are given below:

- Under-lit or artificial light zone of the unusable area needs to be reduced, through the reduction of depth in space. For south orientation, it should be limited from 1.57 to 3.51 times of the aperture head height. That is 2.40 times of the aperture head height on average. For east orientation, the depth limit should be between 1.25 to 4.27 times of the aperture head height, which is about 2.55 times, on average. The recommended limit for west orientation is between 1.74 to 3.83 or approximately 2.90 times of the aperture head height. (space depth limit for the considered three orientations are calculated from Figure 5, counting the grid distance from Figure 4)

- Over-lit zone should be converted into usable daylight area, particularly in the western orientation. It must be taken into account that, glare reduction should not adversely minimize accepted daylight area and its maximum depth, increasing under-lit zone.

- Aluminum louvered arrangements in concrete cornice are more suitable than solid ones, for south and west orientation. Its geometric and material combination is good for east orientation, as well. Controlling markedly high over-lit zone may further increase its efficiency.

- The arrangement of horizontal aluminum louvers in a horizontal plane should be preferred, to that in the vertical plane.

- Horizontal concrete louvers containing a multiple numbers of cornices are not as energy efficient as a single concrete cornice. But increased number of cornice helps to minimize over-lit glare-prone area.

- Aluminum louvered screens <1800angle is less beneficial than those of 1800, though, both are preferable for daylighting in shallow plan open spaces. Moreover, aluminum louvered screens <1800angle is the most suitable shading device, to eliminate glare-prone over-lit area.

- The addition of 1800 horizontal aluminum louvers, with bare concrete cornice, in vertical planes, helps to control over-lit zone. But, for luminous energy efficiency, the bare concrete cornice is more preferable, to those louvered ones.

- Increasing number of horizontal aluminum louvers covering vertical plane helps to decrease over-lit zone. However, its adverse effect on daylight zone of accepted illumination level and under-lit zone needs to be taken into account, to increase energy efficiency.

This research assesses the luminous energy efficiency of the fixed external commonly used shading devices of tall office buildings of Dhaka, facing South, East and West orientations only. It also gives guidelines to increase their efficiency. Thermal effects of daylight for these shading devices also needs to be explored, with parametric design, to ensure their optimized energy consumption and comfort in total, all the year round.

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Dhaka", submitted to the Department of Architecture, Bangladesh University of Engineering and Technology (BUET), on 20 December 2016.

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