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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.

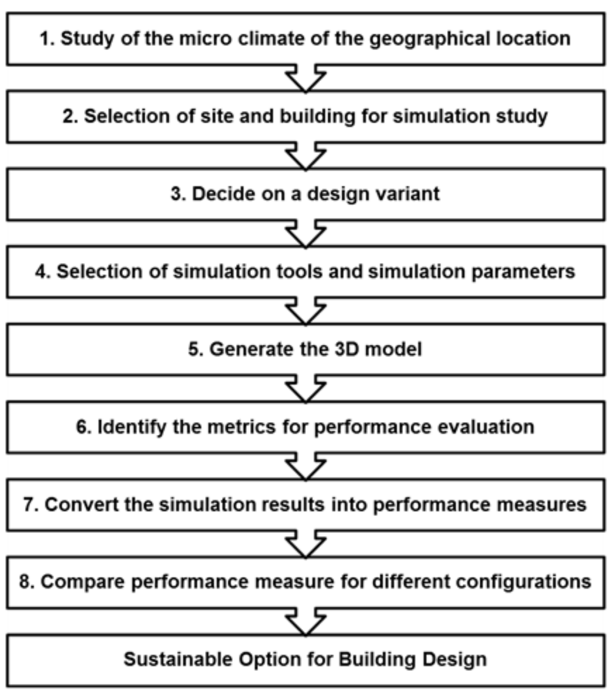


Figure 01: Flow diagram of the decision-making process by simulation study (after Joarder, 2011).

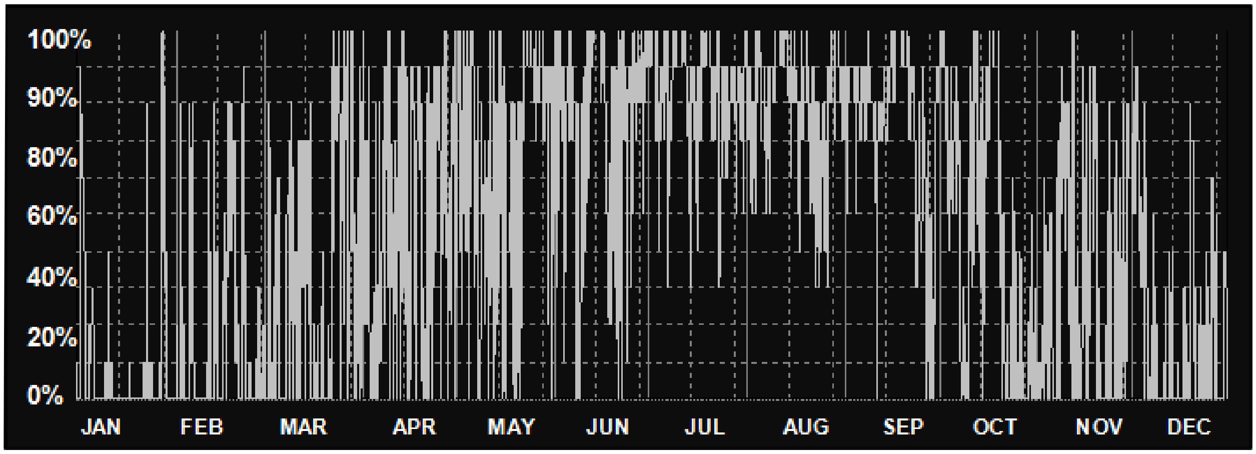


Figure 02: Cloud cover for TRYs, Dhaka (Source: U.S. Department of Energy, 2008).

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.

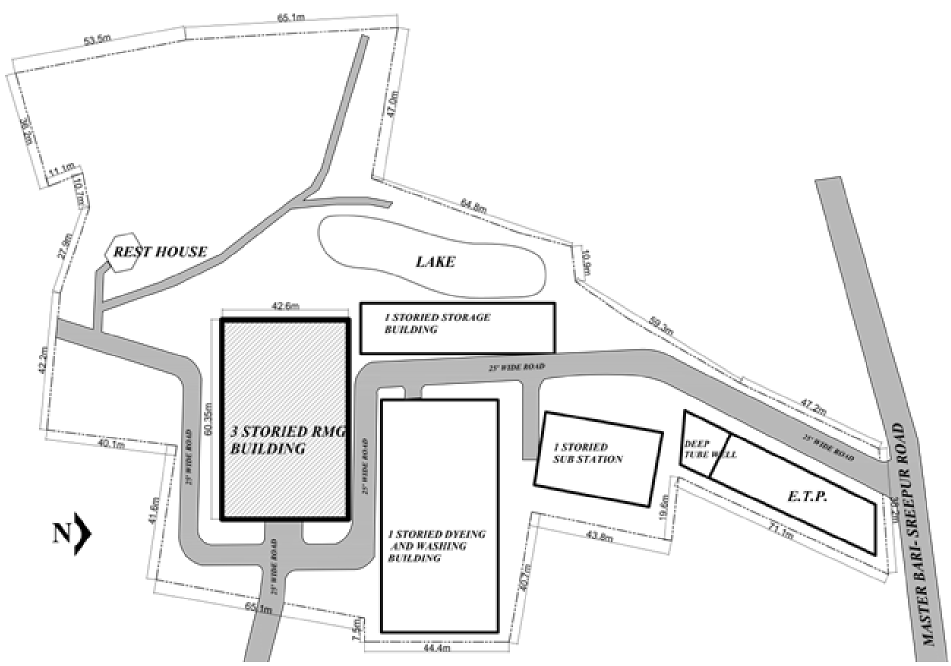


Figure 04: Site and surrounding of the case RMG building at Gazipur, Dhaka.

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).

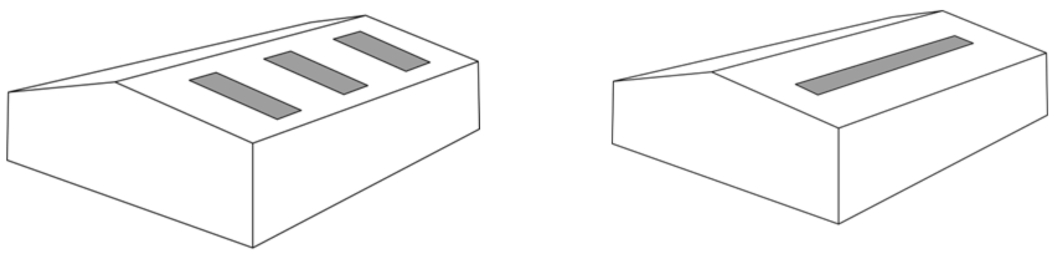


Figure 05: Mid-slope skylights (left) and continuous run – in plane skylights (right) axonometric view (after, NARM, 2009).

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.

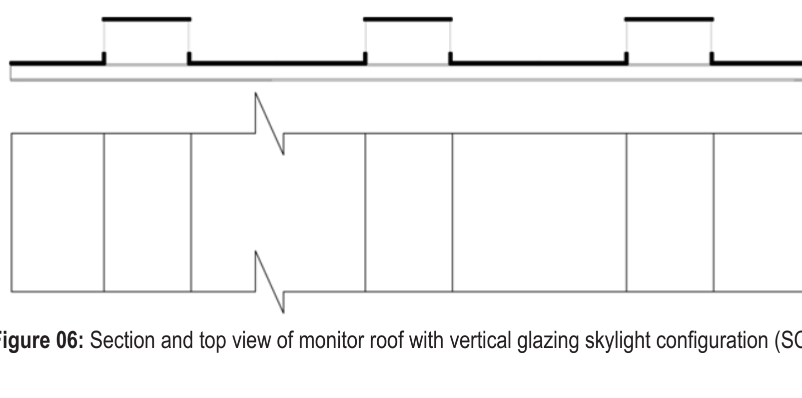


Figure 06: Section and top view of monitor roof with vertical glazing skylight configuration (SC 01)

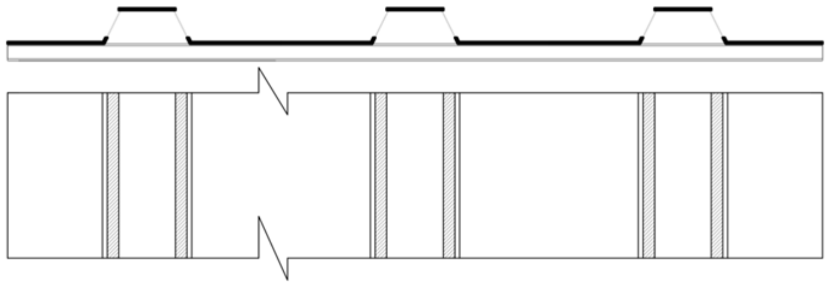


Figure 07: Section and top view of monitor roof with 60° slope glazing skylight configuration (SC 02)

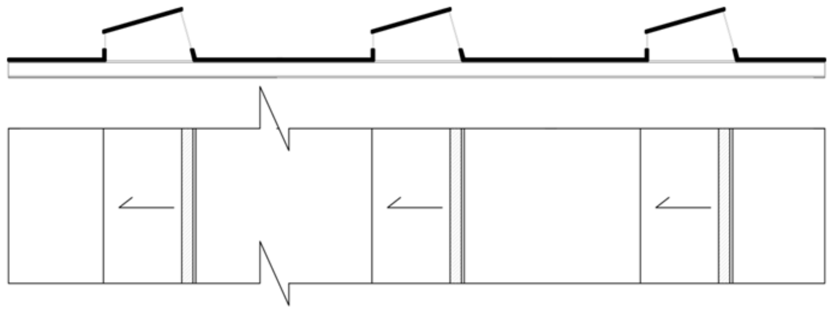


Figure 08: Section and top view of monitor roof with 60° north face glazing configuration (SC 03)

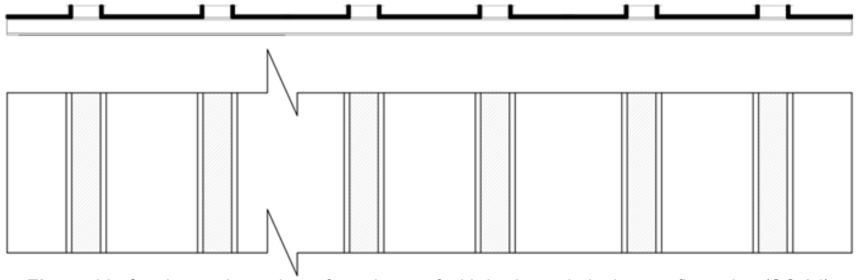


Figure 09: Section and top view of monitor roof with horizontal glazing configuration (SC 04)

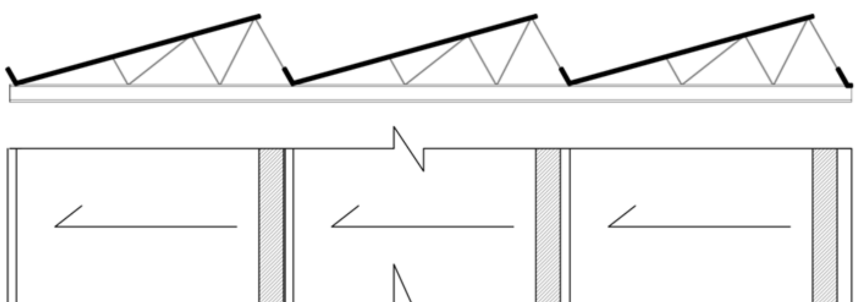


Figure 10: Section and top view of north light skylight configuration (SC 05)

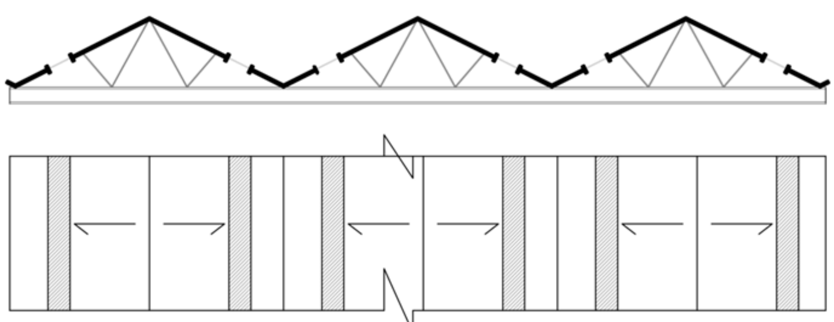


Figure 11: Section and top view of pitched roof with 30° slope skylight configuration (SC 06)

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

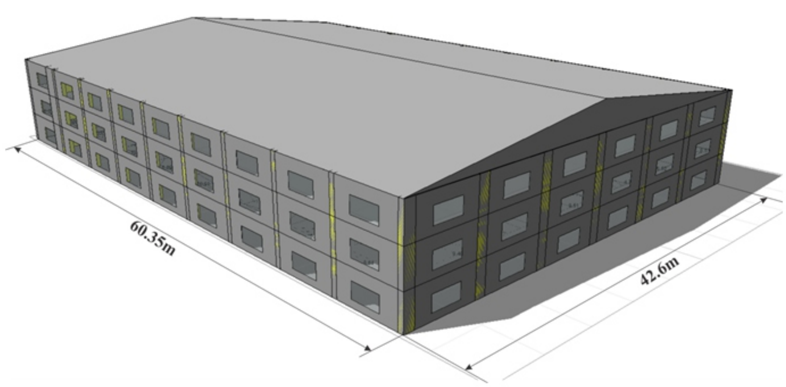


Figure 12: 3-dimensional exterior view of the case RMG building (ECOTECT model).

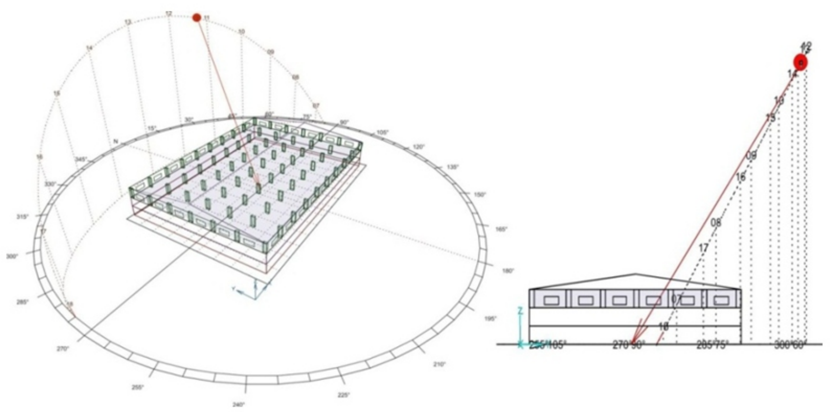


Figure 13: 3-dimentional modeling of the case RMG building with sun path diagram of Dhaka (ECOTECT model).

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.

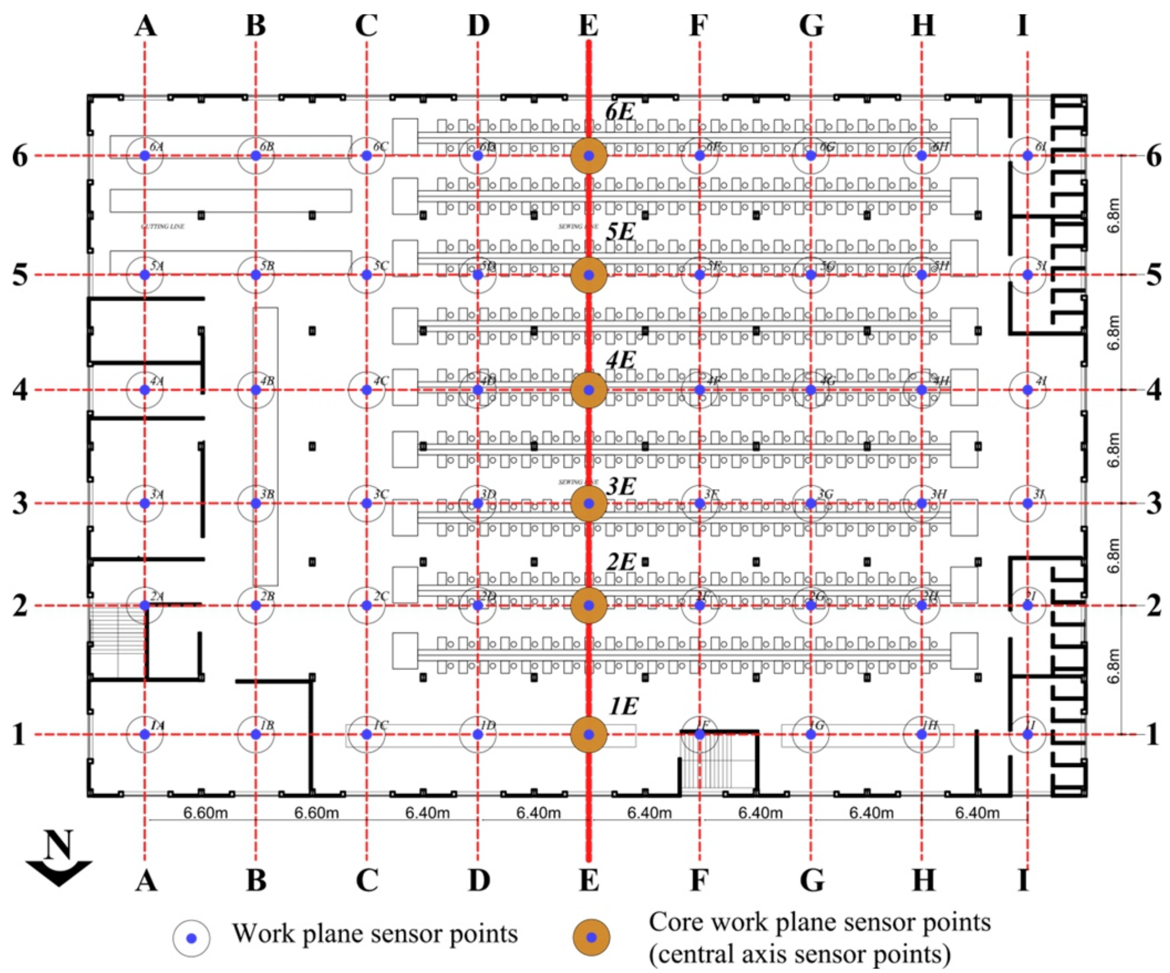


Figure 14: Location of sensors and test points in the case space.

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.

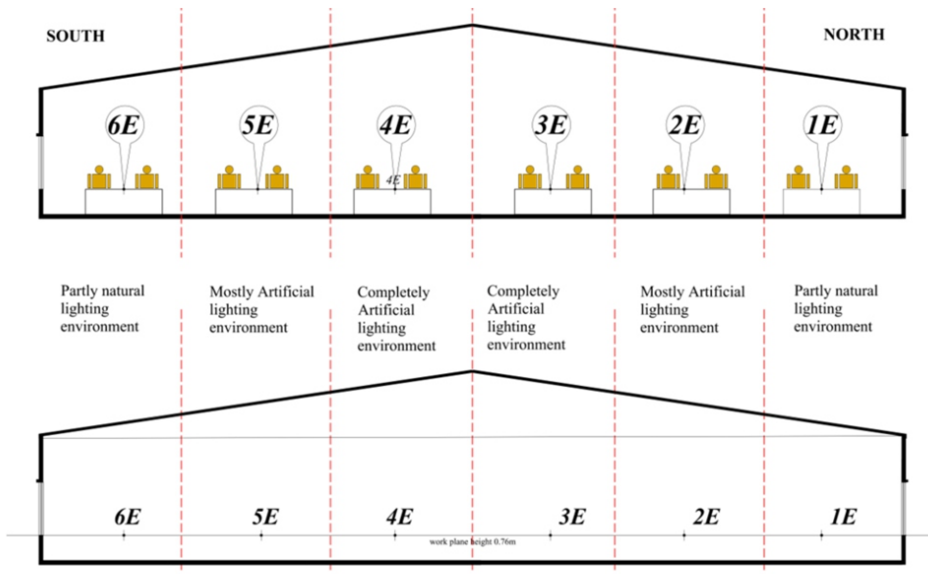


Figure 15: Schematic cross section of the case production space towards EE' axis (central core work plane sensors axis)

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.

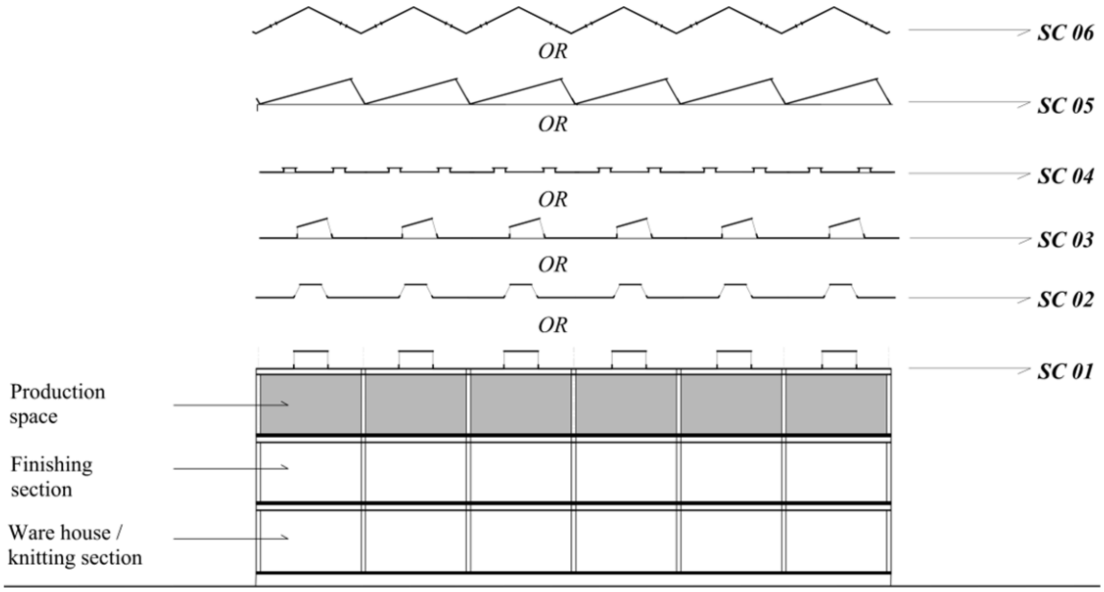


Figure 16: Simulation analysis of six alternative skylight configurations for performance evaluation process.

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.

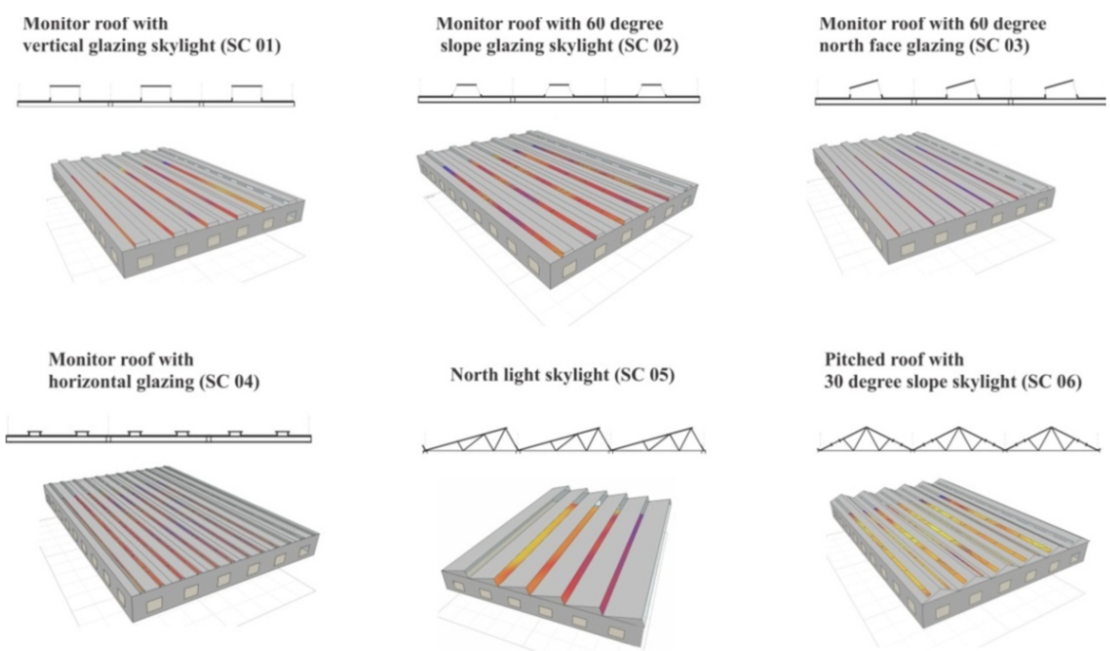


Figure 02: ECOTECT modeling of the case building by replacing existing roof with available skylight configurations suitable for Bangladeshi

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.

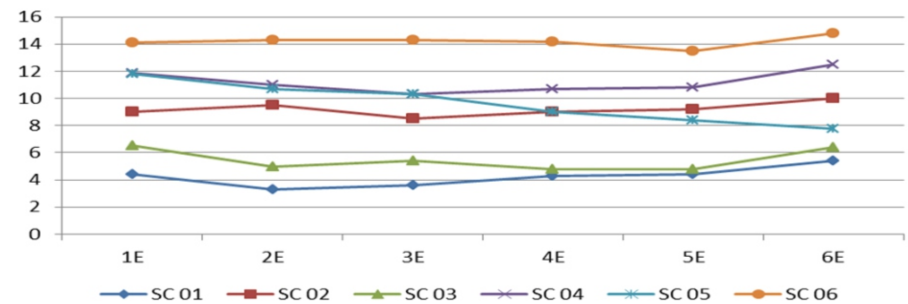
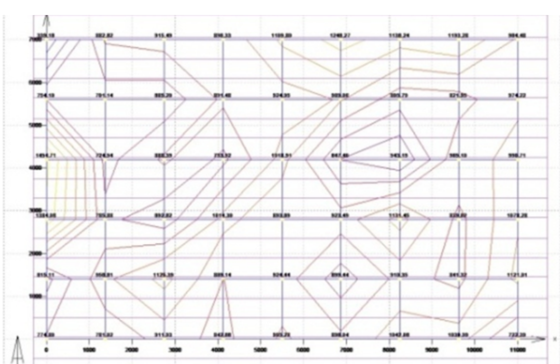


Figure 18: DF performance analysis for available skylight configuration of Bangladesh RMG factories.

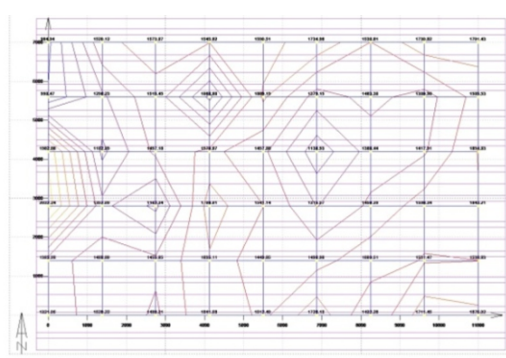
Table 6, shows the complete static daylight simulation results. SC 06 showed high illumination condition and SC 01 showed less illumination level than required level on the work plane height. Considering the average illumination level of the sensor points and its minimum and maximum illumination level 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

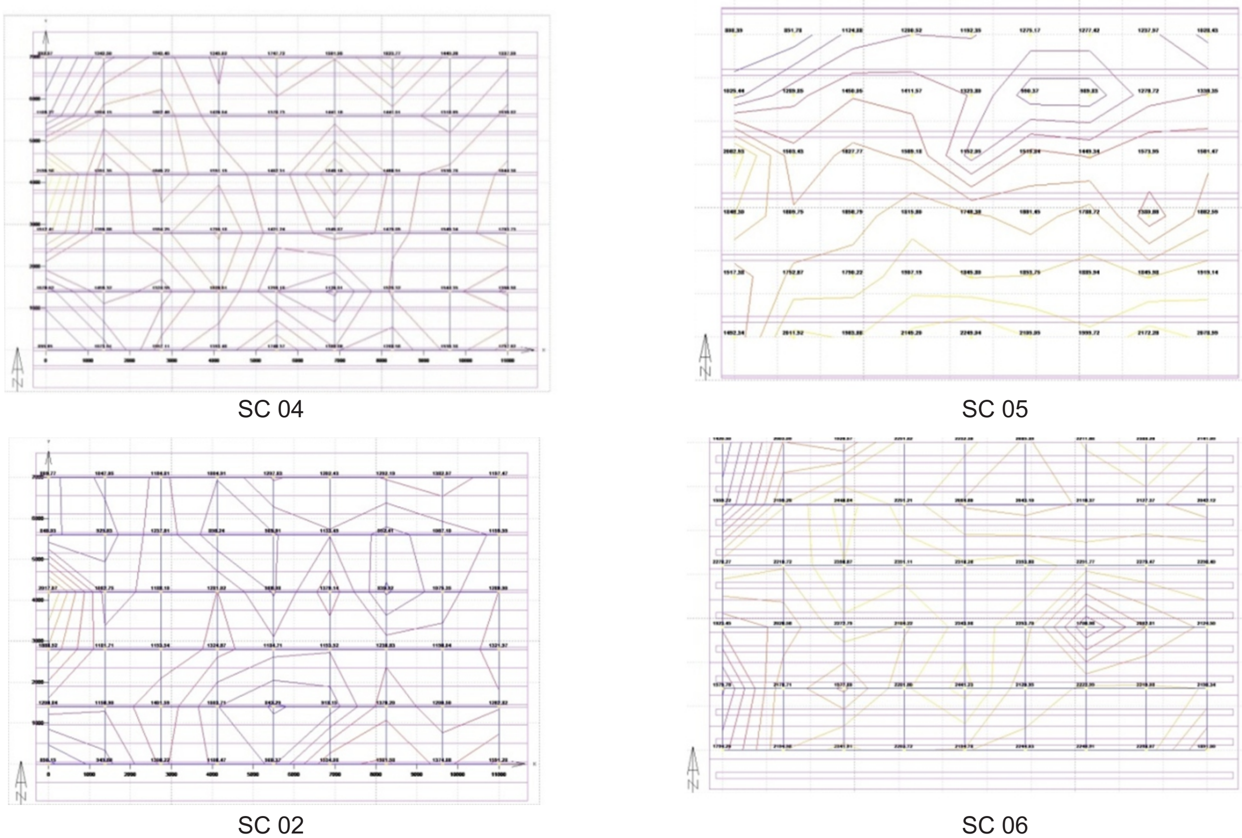


Figure 19: Static daylight simulation result on the sensor points.

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.

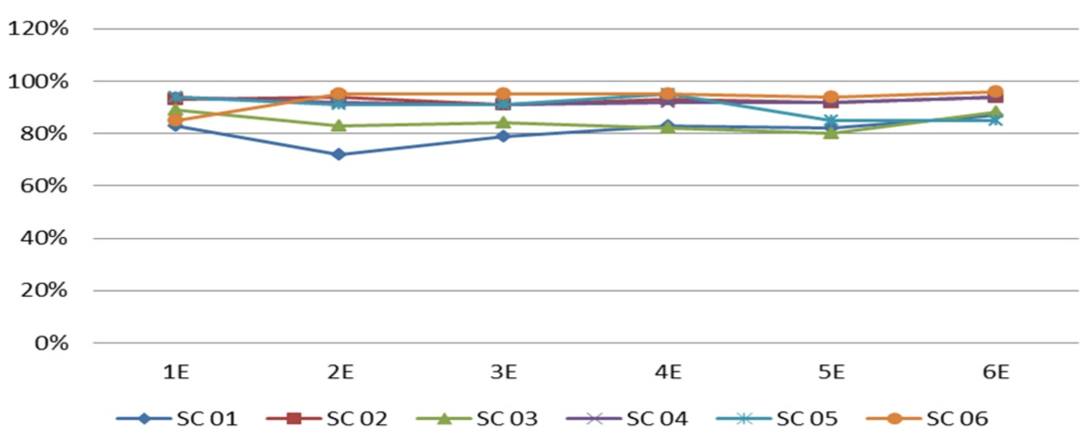


Figure 20: DA performance analysis for available skylight configuration of Bangladeshi RMG factories.

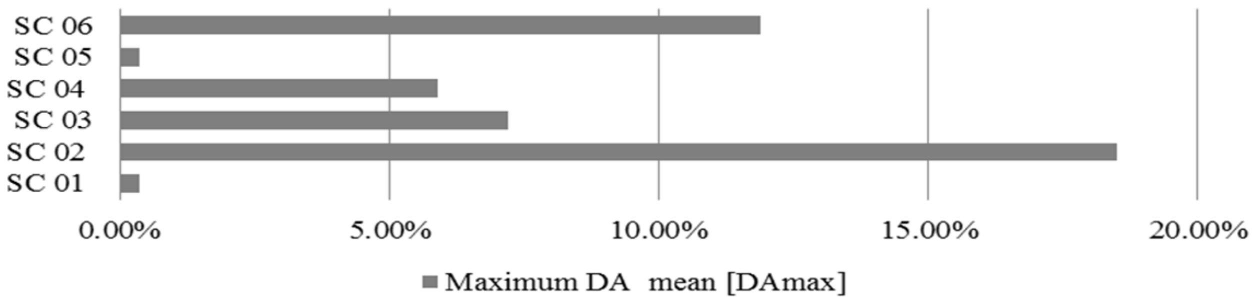


Figure 21: Mean DA_{max} metric performance analysis for available skylight configuration of Bangladeshi RMG factories.

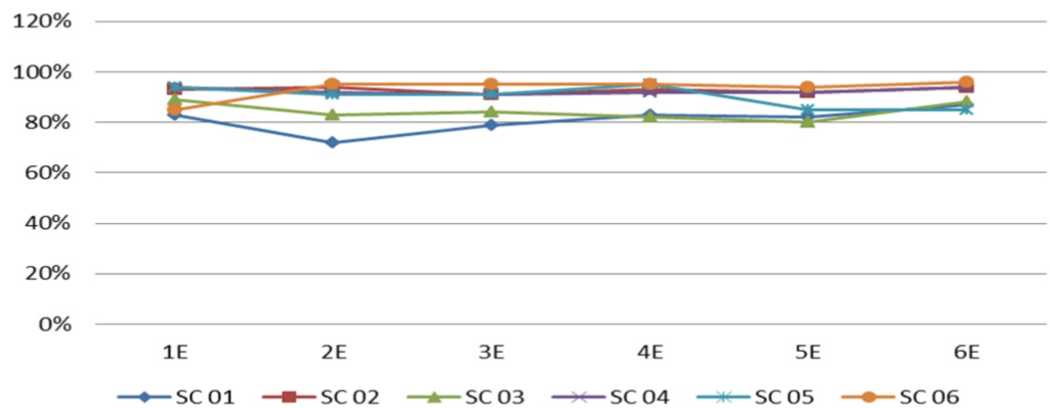


Figure 22: UDI 100-2000 metric performance analysis for available skylight configuration of Bangladeshi RMG factories.

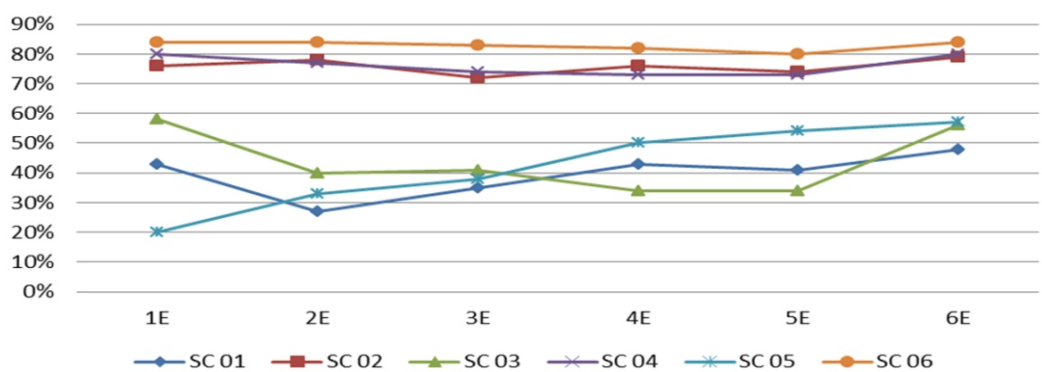


Figure 23: UDI>2000 metric performance analysis for available skylight configuration of Bangladeshi RMG factories.

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).

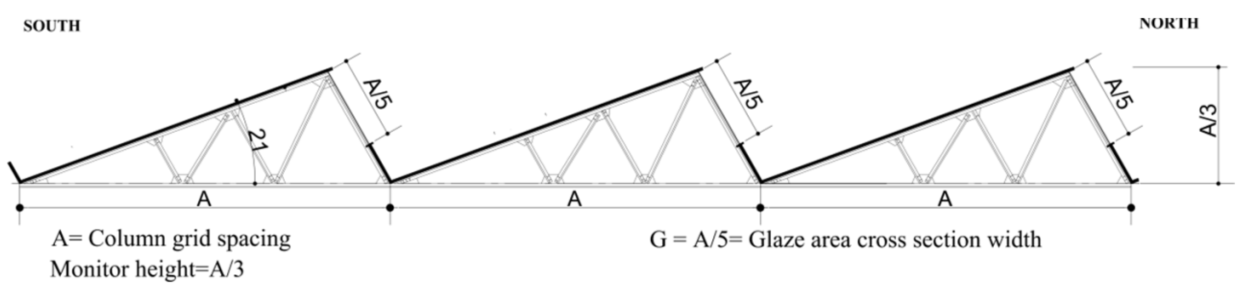


Figure 24: Schematic cross section of a best parametric configuration of north light skylight configuration (SC 05).

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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