A Vision of Daylight Technologies for High-Rise Residential Building in Tropic

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Abstract. Sidelighting is still the primary lighting opening for most buildings in all part of the world. The technology allows only limited penetration of daylight that causes a high energy consumption for artificial lighting. Using a right daylight technology in high-rise residential building could saving more energy and have a good impact on productivity and occupant’s health. This paper discusses the daylighting technologies for high-rise residential buildings in tropical area with literature review method. Some factors such function of systems, location, ability to change and transparency/ the view outside will be the factors that must consider in selecting daylight technologies for high-rise residential building in tropic. The diffuse light-guiding system is a practical daylight technologies for deep floor plan building in tropics. The studies shows that potential daylight technology is diffuse light-guiding system that composed from light shelf, fish sytem and anidolic system. The performance of light shelf influenced by direct sunlight. Its increasing illuminance near window area and causes uneven distribution of illumination in the room. Fish system shows better performance than ordinary blinds, however the result is from integration of fish system and external blinds at low internal illuminance. Application anidolic system in tropical area improving illuminance ratio by factor 3.3, reducing glare by 14%, under overcast sky could transfer daylight upto12.5 m and under intermediate sky up to 20 m. For future work, anidolic system expected to respond sky conditions and direct sunlight for improvement in tropical area.

1. Introduction
The process of designing daylighting in building must consider some factor in building, room, window, and daylighting system [1]. Tropical climate has a different sky conditions with other climates. CIE (International Commission on Illumination) and SNI 03-2396-2001 [2] divide the sky conditions into two types: overcast sky and clear sky, but the tropical climate has a sky condition between overcast and clear skies named cloudy sky [3]. Despite the dominance of the cloudy sky, the outdoor illumination levels in tropical climates reach of 10,000 to over 20,000 lux [3][4].

Sidelighting is still the primary lighting opening for most buildings in all part of the world. The building in the tropic has shading characteristics that became a challenge for designer to improve daylighting and leads to practical challenge of daylighting in tropic which is in deep floor plan buildings [5]. The demand in high-rise residential building is not synergize with the increasing of daylight technologies usage. High rise residential building has the characteristic of laying the
apartment units on the side and circulation in the middle of the building. It leads to limited penetration of daylight, low illumination level in room especially in the rear room and increasing artificial lighting usage that cause increasing in high energy consumption. Using the right daylight technologies could saving more energy [6] and have a good impact on productivity, satisfaction and occupant’s health [7][8][9]

2. Method and material

This paper discusses the daylighting technologies for high-rise residential buildings in tropical area with literature review method. Using daylighting in buildings does not just collect and install building components such as windows or skylights [10]. The application of daylighting is only one part of daylighting strategy. There are some factor that must consider when selecting the right technologies such as:

a. Function of systems
   - Multiple function
   - Single function

b. Location
   - Exterior
   - Window pane
   - Interior
   - Combined systems

c. Ability to change
   - Fixes, no change
   - Fixed, with change
   - Adjustable can be recessed
   - Sun tracking

d. Transparency / The view outside [1]

For this paper, the selecting of daylight technologies will accommodate:

a. The dominance of diffuse light that have high illumination level
b. High-rise residential building type that use sidelighting and have deep floor plan
c. The aim for this daylighting system is to even out the distribution of light in rear room

3. Daylight Systems For High Rise Residential Building In Tropic

In its application, the use of different types of daylight systems can be used simultaneously to achieve the required lighting requirements in space. Advanced Lighting Guidelines [11] calls this the 'advanced daylight system' which is a window and skylight design that regulates and shapes the distribution and level of room’s lighting to meet the glare illumination requirements. The strategy is to
distinguish between a view window and a daylight window. Where a view window should be transparent, at the eye level of the user, leads to landscapes outside the building and minimizes glare. While a daylight window is designed to provide uniform illumination in a room with high visible light transmission and placed high above the wall.

Furthermore, IEA Task 21 [1] and Lopin [12] categorize daylight systems based on the presence and absence of shading devices. Daylighting systems with shading function to provide protection against glare and direct direct or diffuse light. The system is divided into two categories:

a. Systems that reject direct sunlight and using only diffuse skylight and such as: prism and venetian blinds
b. Systems that using direct sunlight, direct it onto the ceiling or above eye level such as louvers and blinds, light shelf, anidolic system

While daylighting system without shading is design to direct the light to areas far from windows or skylight openings. The system is divided into:

a. diffuse light-guiding system such as light shelf, anidolic system, fish system
b. direct light-guiding systems
c. light-scattering or diffusing systems
d. light-transport systems.

Many of this new daylight technologies termed “light redirecting devices”. Its aim to do: first, block or bend direct light that cause glare while allowing diffuse light. Secondly, uniformity in room. So, daylight systems divide to three categories:

a. Mirrored systems to reflect light such as light shelf, reflective louvers
b. Glazing systems to bend light such as glassblock
c. ‘Smart’ system that are dynamic in the sense that they adapt themselves to the conditions of the moment [13].

To obtain the uniform distribution of illumination from diffuse light on the deep floor plan, its requiring daylight technologies without shading device that rely on redirecting or guiding diffuse light. That make diffuse light-guiding system is a practical daylight technologies for deep floor plan building in tropics. Some daylight technologies in IEA Task 21 that fall in a daylight window category are:
3.1. **Light Shelf**

A lightshelf is a daylighting system designed to shade from direct sunlight (DSL) and then reflect light on its top surface [1]. Light shelves improved work plane illuminance by 24% at rear room, however the performance influenced by direct sunlight. Its show better result in overcast sky than under intermediate sky without direct sunlight. But, recent research show that light shelf increase illuminance near window area and causes uneven distribution of illumination in the room. So, designing light shelf must responding to change in sky conditions and direct sunlight. [14][15]

3.2. **Fish System**

The advantage of louvers and blinds is to reduce luminance contrast, however it has weaknesses in daylight utilization [16]. Fish system is fixed horizontal louvers that have precisely aligned triangular section and designed for redirect light especially diffuse light and protect from glare. This system can transmitted light from upper part of the sky to ceiling to protect from glare. Its shows better performance than ordinary blinds, however the result is from integration of fish system and external blinds at low internal illuminance levels [1].
3.3. Anidolic System

Anidolic systems is daylight system with compound parabolic concentrators that transport diffuse daylight from the sky to the rear rooms and consist of three component: collector, duct and distributor [1] [17]. The characteristic angle of the anidolic system, or $\theta$, has an inverse relationship with the peak benefit’s distance from the window façade; the wider the angle then the peak benefits will be closer [13]. This system aims to provide daylight availability and better illumination in rear rooms under overcast conditions [1]. Application anidolic system in tropical area improving illuminance ratio by factor 3.3, reducing glare by 14%, under overcast sky could transfer daylight upto12.5 m and under intermediate sky up to 20 m [18] [19].

Figure 4. An illustration of the effects of anidolic system characteristic angle on the daylight factor profile [13]
4. Conclusions
From the literature, diffuse light-guiding system is a practical daylight technologies for deep floor plan building in tropic. The performance of light shelf influenced by direct sunlight. Its increasing illuminance near window area and causes uneven distribution of illumination in the room. Fish system shows better performance than ordinary blinds, however the result is from integration of fish system and external blinds at low internal illuminance. Application anidolic system in tropical area improving illuminance ratio by factor 3.3, reducing glare by 14%, under overcast sky could transfer daylight upto12.5 m and under intermediate sky up to 20 m. For future work, anidolic system expected to respond sky conditions and direct sunlight for improvement in tropical area.

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