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Day Lighting Analysis of colonial Institutional Building Libraries in Pune

Ar. Snehal Amte

MMIED, COA Maharashtra, India

Corresponding Author: Snehal Amte**,** snehal.amte@mmied.edu.in

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ABSTRACT

An integral feature of a sustainable, environmentally friendly approach to architectural design is the use of daylight as part of an integrated and controlled lighting plan because it is assumed to minimize the use of electricity for lighting and saving of energy. The main aim of the report is Analysis of Day Lighting in Colonial Institutional Building Libraries in Pune as all the selected buildings are Institutional Buildings Libraries which are designed and built in the post independent era and even today, they are serving the purpose. This examination of the Analysis looks at the advantages and drawbacks of daylight as light and windows are the most popular way to let in daylight. As Institutional buildings work during day time, so for the library reading area can be incorporated with day lighting. My research findings as per the field readings that were obtained from the case study show that, in overcast conditions (critical) the library achieves the desired LUX level. The study shows that the colonial structures are still fulfilling the day lighting function, but the day lighting function should be incorporated with artificial lighting.

Keywords: Libraries, Daylighting's, Energy, Lightings, windows.

1. INTRODUCTION

"A room is not a room without natural light. Natural light gives the time of day and the mood of the seasons to enter" L.KAHN

One of the most crucial aspects of architecture is natural light since it transforms places and helps conserve energy. Daylighting is used in buildings as a design element to give occupants a more comfortable and productive environment**.**

Daylighting is the process of positioning windows or other openings and reflective surfaces so that during the daytime, natural light serves as an efficient source of interior illumination. Due to the nearly 40% energy savings, it is extremely important in today's sustainable building designs. Designing any sustainable structure now includes daylighting as a key consideration.

Pune is called as the **"OXFORD OF THE EAST"** due to the presence of many educational institutes from pre independence era. As the city is having a strong historical background of educational buildings, many of them are designed as per British Architecture.

2.OBJECTIVES.

The primary objectives of this research proposal are as follows:

- Evaluate the current daylighting conditions in the library building.
- Assess the visual comfort and well-being of occupants in relation to daylight exposure.
- Analyze the energy performance and efficiency of the existing daylighting strategies.
- Identify potential design modifications or operational strategies to enhance daylighting efficiency.
- Study the lighting control systems such as daylighting controls and other artificial lighting control strategies for cost effective design solutions and sustainable developments.

3.LITERATURE REVIEW

The utilization of natural light, or daylighting, has long been regarded as a desirable architectural element and an indication of excellent design. When properly included, daylight fosters a sense of calm reflection and aesthetic comfort while also psychologically connecting the current library user to the pre-technological past. For decades, memorable library rooms have been distinguished by naturally lit books and surfaces that provide glare-free lighting in reading areas.

Beyond these aesthetic and psychological benefits, daylighting design has recently become more significant due to energy limitations and sustainability issues. As a substitute for daylighting, using electricity to light libraries puts a pressure on the state's electricity generation capacity and makes inefficient use of nonrenewable energy sources. Additionally, the expense of lighting a library has grown significantly and will continue to do so in the future. The possibility to significantly lessen these bad effects brought on by an overreliance on electric lighting sources is provided by daylight, which is free.

3.1. THE NEDD FOR DAYLIGHTING IN LIBRARIES.

Due to its many advantages, daylighting is a crucial factor to take into account while designing library buildings. The following are some arguments in favor of daylighting in libraries:

1. Energy Efficiency: Daylighting reduces the reliance on artificial lighting, which can lead to significant energy savings. By maximizing the use of natural light, libraries can minimize electricity consumption and lower their operating costs.
2. Visual Comfort: Natural light creates a pleasant and visually comfortable environment for library users. It helps reduce eye strain, enhances the readability of books and materials, and creates a more inviting and welcoming atmosphere.
3. Health and Well-being: Exposure to natural light has positive effects on human health and well-being. It helps regulate the body's circadian rhythm, improves mood, and increases productivity and concentration. In libraries, where people spend extended periods studying or reading, access to daylight can positively impact users' experience.
4. Connection with the Outdoors: Daylighting allows library users to feel connected to the surrounding environment. The views of the outdoors can provide a sense of tranquility, inspiration, and a break from the enclosed indoor spaces. It also promotes biophilia, our innate connection with nature, which can enhance the overall user experience.
5. Sustainability and Green Building Design: Incorporating daylighting strategies aligns with sustainable design principles. Libraries that prioritize natural light reduce their carbon footprint by minimizing energy consumption, thereby contributing to environmental preservation.
6. Aesthetics and Architectural Integration: Natural light can be used as a design element to enhance the architectural features of a library. Well-designed daylighting solutions can create visually appealing spaces, highlight specific areas, and contribute to the overall aesthetics of the building.
7. Flexibility and Adaptability: Libraries often have diverse functions and activities, including reading areas, study spaces, group discussions, and events. Daylighting provides flexibility, as the intensity and distribution of natural light can be modulated to suit different activities and user preferences.
8. Daylight Harvesting: Daylighting strategies can include efficient methods of capturing and distributing natural light. This can involve the use of light shelves, skylights, clerestory windows, and light-diffusing materials to optimize the penetration of daylight into the interior spaces.

3.2. THE PURPOSE OF DAYLIGHTING IN LIBARARY BUILDINGS

The main purpose of daylighting in library buildings is similar to the general purpose of daylighting in any building, with some specific considerations related to the unique functions and user needs of libraries as Libraries are spaces where people engage in reading, studying, and research activities.

Daylighting helps create a well-illuminated environment that supports these tasks. Ample natural light enhances visibility, reduces eye strain, and provides a comfortable reading and study experience for library users. Libraries are spaces where individuals spend extended periods engaged in concentrated mental activities. Natural light improves visual comfort, reduces glare, and creates a soothing and pleasant atmosphere, making it easier for users to focus and concentrate on their work for has the reading and study environments, visual comfort, user well beings as natural light has a positive impact on the well being of library users. Exposure to datlight has been linked to improved mood, increased productivity and enhance mental health, incorporating daylighting is more benefited for energy efficiency and sustainability.

3.3. PHYSICAL CHARECTERISTICS OF DAYLIGHTING

Understanding the physical properties of daylight is the first step in designing for it. It takes some understanding of this energy medium that is entering

the building to control it and modify it for usage in a library.

The sheer amount of daylight needs to be carefully controlled and managed because of how bright sunshine is, in order to prevent issues with glare or heat gain. When using it, the design and implementation of solutions for the daylight problem are of paramount importance.

As was already mentioned, the primary goal of library lighting is to give enough light for a visual task, like reading. This entails adjusting the aperture designs for daylight to reduce solar heat gain while maintaining the footcandle levels necessary for optical clarity.

The second requirement is that the contrast brightness of other objects within the field of view must not be excessive, such that the library user can view the task comfortably and not become visually fatigued over time. In daylight design, glare conditions (i.e., when the brightness ratios of surfaces exceed visual comfort conditions) are avoided through aperture design, exterior sun control components and the placement of adjacent surfaces to balance the nearby surface brightness levels a typical condition that can be observed in libraries with relatively poor daylighting design is that electric light fixtures are turned on during the day to overcome glare conditions created by windows or roof monitors and to balance the brightness distribution in the space.

Another characteristic of daylight is its variability. the amount of daylight and its direction at the window or roof of a building vary during a typical day as the sun moves, and seasonally as the sun's predominant position in the sky changes.

There is additional variation depending on sky conditions. Daylight direction on cloudy days is still variable, though the light is more diffuse than on a clear day. On overcast days, the daylight is uniform, though varying in absolute brightness somewhat from sunrise to sunset. as shown in figure is shown in 3.1

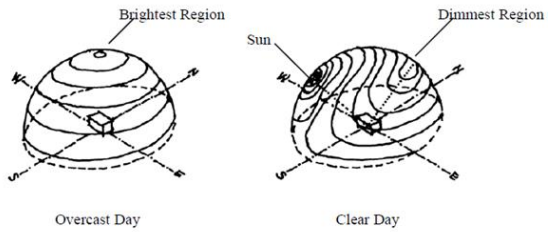

Fig.3.1: sky conditions

In general, people prefer variable light in the form of daylight and the connection it provides to the natural environment. However, it is important in libraries to maintain a relatively constant light level for visual tasks so that short term variability does not become distracting or inadequate. This is accomplished by using electric light fixtures for what they do well, namely, provide a constant level of comfortable light, in coordination with the light available from daylight.

The form of the openings can actually help to control variability in roof apertures by dispersing incident light through repeated reflections off matte white surfaces, making the light from above appear directionless. The variability is an unchangeable characteristic for wall apertures (mainly windows), therefore electric light fixtures should be adjusted utilizing daylight responsive control systems to offer constant levels of light for visual tasks close to windows.

3.4. DAYLIGHTING DESIGN IN LIBRARY

A library's entire lighting plan includes daylighting design. To provide an integrated approach to all lighting design considerations controlled to maximize daylight use and visual comfort for library patrons the professional lighting designer must collaborate closely with the building architect and heating/cooling engineer. Libraries give lighting design additional thought and consideration.

The Illuminating Engineering Society (IES) is an independent organization of professionals that sets light level guidelines which serve as the recognized standards for light in building spaces. The following table provides the illumination levels recommended for library spaces.

TABLE.1 IES Recommended Light Levels for Libraries (footcandles)

Space	Minimum FC Level[a]	Average FC Level[b]
Active (occupied) Book Stacks	See footnote *c*	See footnote *c*
Inactive Book Stacks	5	7.5
Book Repair and Binding	20	30
Cataloging	20	30
Circulation Desk and Reference Desk	20	30
Computer Areas	20	30
Audiovisual Areas	20	30
Audio Listening Areas	20	30
Reading (newsprint, magazines, keyboard)	20	30
Reading (fine detail items, small print)	50	75

[a] For younger people, minimum accuracy requirements and background contrast.
[b] For average age persons, task accuracy and background contrast.
[c] For book stacks, use vertical footcandle levels. See the discussion below.

3.5 Daylight Apertures: Roof

The majority of small and medium-sized libraries have one or two levels with generally spacious, open floor plans. The open layout and aim to prevent more remote, unserviceable regions like building wings or lengthy extensions are dictated by service and monitoring requirements. Special reading rooms are an exception, however usually these areas include a service point available throughout open hours.

The design implication of these typical planning characteristics of libraries is to work with the roof component of the building envelope to provide the controlled use of the sun and daylight to offset much of the normally high internal lighting load. There are a variety of methods of introducing diffuse, low-glare daylight from the roof level, including skylights and roof monitors.

Skylights can be successful daylighting roof apertures provided the direct sun is prevented from coming within view by washing down walls or striking floor or table surfaces. In addition, because of the heat

content of direct sunlight, the skylights should be relatively small in area and should be accompanied by large adjacent diffusing surfaces. A simple configuration of a skylight roof aperture that works well to meet these conditions is shown in Figure 3.

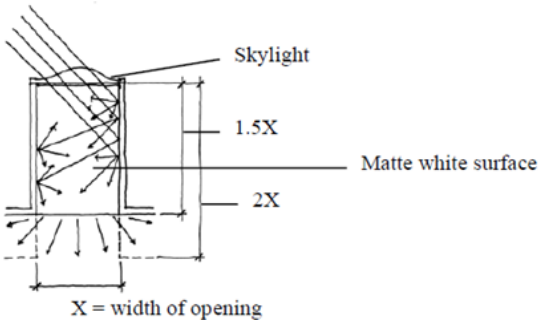

Fig.3.A skylight with deep adjacent diffusing surface is a simple technique of protecting from direct sunlight while providing non-directional, comfortable light to the space.

3.6.Daylight Apertures: Wall

The perimeter spaces of the library can be effectively daylighted for approximately twenty feet from the exterior wall by using windows and *clerestories* (high windows). Generally, the taller or higher the window, the deeper will be the daylight penetration into the space.

Clear glass is preferred for daylighting, but this in turn requires carefully designed exterior sun control devices to provide adequate shading. Although internally mounted shades and blinds reduce the high intensity and heat content of direct sunlight, the most effective sun control device is the exterior sunshade. An internal shade, even a light-colored fabric or blind, reduces solar heat gain by about one-third to one-half of the incident solar energy. An exterior shade will create a reduction of 80% of the incident solar energy.

The light shelf is a device located at the bottom of a clerestory that captures direct sunlight by reflecting it off the top of a plane that extends into the space, either a mirrored or diffuse surface. If the plane of the light shelf screens the clerestory window from direct view, there will be no direct glare and the low angle sunlight will be reflected from light shelf and ceiling, and will reach the task level deep in the space as diffuse light. The light shelf can be used on the south-facing walls as well, and the light shelf can be extended to the exterior to form a horizontal sunshade for the lower window.

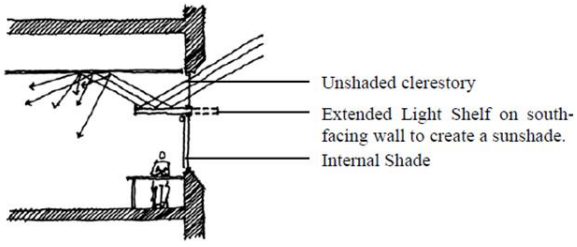

Fig.4.Diagram of the “Light Shelf” concept

3.5. Daylight Controls and Integration with Electric Lighting

In order to control the inherent variability of daylight, which can be unwelcome in certain types of library spaces, and to provide adequate light when adequate daylight is not available, effective daylighting design requires the seamless integration of daylight design features with electric lighting.

This integration is made possible by wiring the electric lighting fixtures separately close to the daylight apertures and utilizing the light control system to decrease the use of electric lighting fixtures in these locations when they are not necessary or are only partially required.

Electric lights near windows can be dimmed with separate control without impacting spaces outside the daylighting zone. Bi-level switching enables individual bulb control so that some of the lamps are turned on or off in response to the amount of daylight present in electric light fixtures, which often have more than one lamp.

The bi-level switching can be done manually, where a staff person or a patron responds to available daylight by turning lamp arrays off or on at the switch. It would be more appropriate for libraries to use a photocell sensor, however, and continuous dimming, so that optimum savings are realized through automatic control and the highly responsive control is executed seamlessly in response to daylight availability.

4.RESEARCH METHODOLOGY

The research is based on quantitative survey approach to compare the efficiency of daylighting in the library buildings.

4.1 SAMPLE

The sample consist of

1.COEP, Pune Library.

2. Wadia College Library.

3. SP College Library were used as sample Case Study.

4.1.1.SAMPLE DESCRIPTION

The all the above colleges are colonial structures and almost completed more than 100 years.

4.1.2. COEP TECHNOLOGY UNIVERSITY, PUNE

College of Engineering, Pune is an autonomous engineering college with an affiliation to Savitribai Phule Pune University in Pune, Maharashtra, India. Established in 1854, it is one of the oldest engineering colleges in Asia, after IIT Roorkee. The college's study model was referred to, in the early 1950s, as the "Poona Model".

The college doesn't appear to have a distinct architectural style, like the majority of Raj-era construction.

In the oldest sections of the institution, there are subtle Victorian influences, such as arched windows and tiled canopies, but the main tower of the administration building clearly shows an indigenous influence.

The jagged edges of the edifice are adorned with gargoyles.

Fig 6. Gothic Influences

4.1.3. NOWROSJEE WADIYA COLLEGE, PUNE

Nowrosjee Wadia College is a college affiliated with the University of Pune. This college was founded in 1932 and now has 6 other sister institutes.

It was founded in 1932 with just 250 students. By year 1982, the student strength was about 3000.In the year 2003 the student strength reached 6000. The College was initially affiliated to the University of Bombay but switched affiliation to the University of Pune in 1949.

The Nowrosjee Wadia College, currently in its 80th year was established on July 21, 1932 within six months of the establishment of the Modern Education Society on February 15, 1932. True to Its credo 'For the Spread of Light', the college pioneered efforts to open the portals of higher education to the residents of eastern parts of Pune and pursued them tirelessly through the last eighty resplendent years. Over the years, it has become the first choice to acquire an all-round quality education for many promising young men and women all over the country and abroad.

While Pune was known ever since the advent of the British rule as a prominent center of education, the eastern parts of the city were virtually devoid of any educational facilities.

The matter of providing facilities for higher education in the eastern parts of Pune would have remained a distant dream had it not been for a group of prominent citizens in these parts and of devoted academicians in the city who clearly brought out to the public the need for a college in this part of the city.

FIG.7.Nowrosjee Wadia College, Pune

4.1.4. S.P. COLLEGE, PUNE

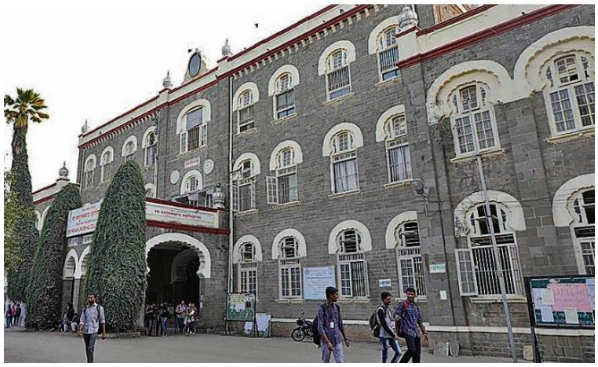

Fig.8.A Maratha style Architecture

In Pune, Maharashtra, India, Sir Parashuraam College (S.P. College) is an autonomous college (as of 2019). New Poona College was founded in 1916[1] by the British Governor Lord Willingdon. As a gesture of appreciation to the then-ruler of Jamkhandi State, who gave Rs. 2 lakhs in honor of his father, Parashuraam Patwardhan, the college was renamed Sir Parashurambhau College. Shikshan Prasarak Mandali, a Maharashtra-based private education association, oversees the college. S. P. College encourages students to develop their skills and offers a platform for cultural activities**.**

One of Pune's oldest colleges, it has a strong intellectual legacy.

4.1.5. Instrumentation

The LUX METER was used for measuring the day light. First of all, the seating layout of the library was drawn and according to the window height, the relevant measurements were taken at a particular distance.

4.2. Data Collections

The study uses libraries from particular sample colleges. They are given the tools necessary to gauge the amount of daylight in the specific 3 library samples. The library's seating arrangement was first sketched, and the pertinent measurements were made at a specific distance based on the window height. Time to highlight that attempts were made to adjust the daylighting in the morning, afternoon, and evening. Only three library buildings were chosen for the daylighting investigation, and the study's scope was restricted to the city of Pune. It lasted for twenty days, from the 27th of December to the 15th of January.

5. DATA ANALYSIS AND INTERPRETATION

The data was collected from the libraries and analyzed by statistical terms. The standards requires as per the recommendations of ECBC for Library designs was also used to analyses and compare the differences in daylighting's. The average were counted of the data taken from the libraries to evaluate the effectiveness of the daylighting's analysis. The sanderds

recommendations for library buildings for daylighting is in below figures as per ECBC.

20.6	Libraries			
20.6.1	Lending library			
20.6.1.1	General	200-300-500	1	
20.6.1.2	Counters	300-500-750	1	Localized lighting may be appropriate
20.6.1.3	Bookshelves	100-150-200	2	The service illuminance should be provided on the vertical face at the bottom of the bookstack
20.6.1.4	Reading rooms	200-300-500	1	
20.6.1.5	Reading tables	200-300-500	1	Localized lighting may be appropriate
20.6.2	Catalogues			
20.6.2.1	Card	100-150-200	2	
20.6.2.2	Microfiche/Visual display units	100-150-200	2	
20.6.3	Reference libraries			
20.6.3.1	General	200-300-500	1	
20.6.3.2	Counters	300-500-750	1	Localized lighting may be appropriate
20.6.3.3	Bookshelves	100-150-200	2	The service illuminance should be provided on a vertical surface at the foot of the bookshelves
20.6.3.4	Study tables, carrels	300-500-750	1	
20.6.3.5	Map room	200-300-500	1	
20.6.4	Display and exhibition areas			
20.6.4.1	Exhibits insensitive to light	200-300-500	—	
20.6.4.2	Exhibit sensitive to light, for example, pictures, prints, rare books in archives	50 to 150	—	
20.6.5	Library workrooms			
20.6.5.1	Book repair and binding	300-500-750	2	
20.6.5.2	Catalogue and sorting	300-500-750	2	
20.6.5.3	Remote book stores	100-150-200	3	

Fig.8. ECBC recommended LUX level for Library design.

5.1. COEP TECHNOLOGY UNIVERSITY, PUNE.

Findings and summery of sample 1

1. The building is facing North as well as the Reading area which gives diffused light throughout the day.
2. The library main reading area is having glass façade on North and East side which provides enough daylight for reading purpose.
3. The stack and reading desk arrangement is perpendicular to the window so it avoids the shadow of the person on the stack.
4. The clear glass wall of North and East side window gives diffused light to the reading area.
5. The internal finishes are quite light colored which acts as a reflected component.
6. The field measurement in the stacking and reading area are the levels for the overcast sky condition which gives an idea that reading area is getting quite low LUX level in critical condition but it suffice with desired LUX level.
7. The stack area should be arranged very densely, need some proper interior arrangement.
8. The Mezzanine floor is totally dependent on the artificial light as there is no window and which acts as a book stacking area is very densely arranged and very dark.

5.2. S.P. COLLEGE, PUNE

Findings and summery of sample 2

1. The one face of the building is oriented towards the North which gives diffused light throughout the day.
2. The building is isolated so the day light penetration is not blocked due to the nearby structure.
3. The stack arrangement is very dense and the stack racks are arranged parallel to the windows which block the light coming inside the space.
4. The Mezzanine floor is totally dependent on the artificial light as there is no window and which acts as a book stacking area is very densely arranged and very dark.
5. The building is very old so the reflection of the wall and ceiling are not contributing to the building interiors.
6. The greater depth of the reading area of top floor i.e. second floor boy's reading area need some top lighting, though, it is incorporated with artificial lighting need some interiors and proper design of reading desk.
7. The field measurement of the stacking and reading area are the levels for the overcast sky condition which gives an idea that there is a drastic difference in the LUX level near window and the interior due to ageing of structure, improper arrangement of the stacks and reading areas.

5.3. NOWROSJEE WADIA COLLEGE, PUNE

Summery and findings of sample 3

1. The above field measurement gives a clear idea that the age of the structure matters in the quality and quantity of the day light in the interior.
2. The area near the window gives quite higher readings which are due to the absence of shading device at the intermediate level so that it gives clear Sun penetration and glare problem.
3. The day lighting level after three meter from the window reduces drastically due to aging of building material and the low reflectance of the ceiling etc.
4. The interior arrangement also needs to be changed to improve the light level inside the library mainly in the stacking area.
5. The Mezzanine floor is totally dependent on the artificial light as there is no window and which acts as a book stacking area is very densely arranged and very dark.

5.4. TESTING OF HYPOTHESIS

Data on daylighting for three samples were analyzed by applaying independent sample T-test to check the significance of the defferences between daylighting of three kinds of Library buildings.

The Null and Alternative hypotheses are stated as under.

HO: There is no significance difference between the daylighting lux levels near a windows with respects to a sky conditions.
HO: there is a significance difference between daylighting and incorporated internal lighting conditions when it's a overcast outside the buildings with respects to walls facings. Level of significance is 5%

5.6.TEST RESULTS:

As compared to a standard Lux levels recommended by ECBC the buildings have different statistical data and the libraries should in corporate with energy saving fixtures, dimmers and sensors lightings.

5.7. ANALYSIS OF THE T-TEST

As the P-value of the test=0.00<0.005 (assuming level of significance) which indicates that the null hypothesis is rejected. It can be concluded that there is a significance differences in the daylighting of the three samples.

6. CONCLUSIONS

1. As they were built in the post-independence era, the structures were not created using day lighting tactics, but the main reading area of library structures still meets the acceptable LUX level that is sometimes needed for reading
2. Because of intensive urbanisation, the sky cover factor and sunlight penetration are both impacted.
3. The glare is a concern because the structure is outdated and there are no shading mechanisms.
4. Improper arrangement of reading desk and stacking has affected the day lighting so proper arrangement of furniture can be suggested.
5. At the mezzanine level there is no window so it is totally dependent on artificial lighting. The area is very dark and densely arranged.
6. The cleaning factor of the glazing is basically neglected so the light does not enter effectively with the spaces.
7. The field measurement of the stacking and reading area are the levels for the overcast sky condition which gives an idea that there is a drastic difference in the LUX level near window and the interior due to ageing of structure, improper arrangement of the stacks and reading areas.
8. The energy saving measures like energy efficient lighting is also needed in the area where daylighting is not available.
9. There should be a suggestion of change in Interior for better daylighting condition.
10. The reflectance off white painted wall and ceiling promotes the light inter reflection. It should be incorporated.
11. Daylighting control and integration with electrical lighting.
12. Smooth integration of daylight design features with electric lighting to control variability of daylight.
    Wiring/Switching the electric lights separately to allow light to be turned On or Off in response to the amount of daylight available.
13. Dimming type lights preferred both fluorescent lamps and some type of halogen lamps can be continuously.
14. Appropriate for some modern design used in libraries to use a photo cell sensor for optimum saving and automatic control.
15. Replace many interior walls with glass to maximize day light with consideration of thermal comfort.
16. Naturally lit reading room with automatic light fixture dimming

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