OPTIMAL LEARNING SPACES IN HOT AND DRY CLIMATE

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Abstract - *The research, focusing on school buildings, has demonstrated that building features including thermal comfort, lighting, indoor air quality, provision of open spaces impacts the performance of students and teaching staff both physically and psychologically. A high demand for heating energy in winter, overheating in summer and visual discomfort are important issues in school buildings of India. The research includes the detailed examination of the hot and dry climate zone of India and the study of institutional buildings with respect to it. This research will conduct the detailed study of orientation, optimum window-to-wall ratio, space organization, sun shading, and building shape of an institutional building which will help in the considerable results of the research. For the purpose of this study, a typical elementary school in the hot and dry climate of India is selected, modeled, and analyzed.*

Key Words: Optimal learning spaces, Hot and dry climate, daylight, building simulation, Annual performance, illumination, Daylight performance

1. INTRODUCTION

The need to strengthen Government schools in India. This research examines public primary school design as not governed by the needs of a multi-purpose classroom but rather, as the arrangement of integrated learning spaces through responding to the harsh climatic conditions. Climate based design of school buildings can contribute to significant energy savings and improve the students' learning environment. The purpose of this research is to formulate design recommendations for public school buildings in the hot and dry climatic zone of India.

1.1 AIM

This research aims to introduce an optimized school design that meets both inhabitants' comfort needs and better learning environment in a particular environment of hot and dry climate zone of India.

1.2 OBJECTIVES

1. To understand the hot and dry climate condition and its adverse effects on school buildings.
2. An investigation into design principles of reflected daylighting in primary schools in the hot-dry climate of Rajasthan.
3. To deliver the requirements of learning space through standards and case/literature studies.
4. To develop climate responsive design solutions with the purpose of meeting the comfort level in the learning environment.
5. To understand how the existing classroom of hot and dry region performs in terms of daylight.
6. To understand the role of daylight design in terms of the performance of the school building.
7. To understand how different daylight metric helps in recording daylight performance.
8. To analyze the passive design strategies in the hot and dry climatic zone.
9. To analyze the applications of passive design strategies in school buildings situated in the hot/dry climate zone.

1.3 SCOPE AND LIMITATIONS

The research will be controlled on the daylighting parameter of hot and dry climate for the institutional building providing comfort and better educational space.

1. The research will be limited to the public school.
2. The research will include the hot and dry climate zone of India.
3. The study will be limited to the parameter specifically daylight and further analysis on ventilation, form, and materials which will lead to an enhanced design solution.
4. The study will focus on the optimal learning space.

2. HOT AND DRY CLIMATE

2.1 HOT AND DRY AS THE FOCUS OF RESEARCH

The hot and dry climate of India has plenty of sunshine and whilst it can be a great source of energy and natural lighting in buildings, has unfortunately caused overheating and discomfort, particularly in institutional buildings. It is mainly because of poor design and technical implementation. This problem is exacerbated with the implementation of passive design solutions.

Solar radiation is a great source of energy and with a good understanding of how to use such a valuable resource effectively; buildings can be more energy efficient, using daylight more productively and also be better for the well-being of the students. Therefore, based on the above two main reasons, the hot-dry climate zone of India is selected to make more precise research. Having focused on a specific climate zone, it is important to address the climate change and sustainable architecture as they support daylighting from a climatic and environmental point of view.

2.2 RAJKUMARI RATNAVATI GIRL'S SCHOOL

The Jaisalmer sandstone used to construct the Rajkumari Ratnavati Girl's School was hand-carved locally by skilled artisans and utilizing local resources to build infrastructure and installing a solar panel canopy on the roof as a cooling system when temperatures can reach close to 120 degrees helps minimize carbon emissions. The school has an oval-shaped building that connects with the desert environment. The structure also includes sustainable features. 400 females from kindergarten to class X will be able to attend the school section, known as the Gyaan Centre.

Fig.-1: Rajkumari Ratnavati Girl's School

Source: https://www.archdaily.com/960824/the-rajkumari-ratnavati-girls-school-diana-kellogg-architects/60897ade975ec001650b3bae-the-rajkumari-ratnavati-girls-school-diana-kellogg-architects-photo

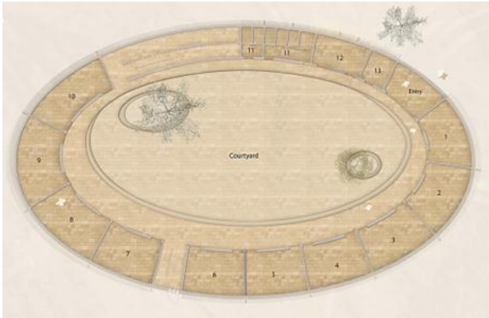

Fig.-2: Plinth Level Plan

Source: https://www.dkarchitects.com/rajkumariratnavatigirlsschool?pgid=kitd4a4f3-c2c1e5cd-14b3-4bf9-9592-5910d2210d80

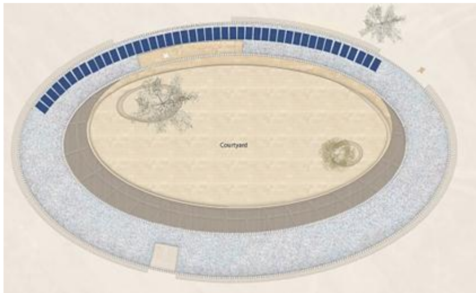

Fig.-3: Roof Plan

Source: https://www.dkarchitects.com/rajkumariratnavatigirlsschool?pgid=kitd4a4f3-d3cb3536-dc54-47c6-a1ab-b4535405cc9b

Legends:

1-10 Classrooms

11 Bathrooms

12 Staff room

13 Office

3. DATA ANALYSIS AND FINDINGS

3.1 SOFTWARE

The use of software-Design Builder:

Daylighting-

The Daylighting module provides Spacial Daylight Autonomy (sDA), Annual Sunlight Hours (ASE), Useful Daylight Illuminance (UDI), Daylight Illuminance, Daylight Factor and Uniformity results for the selected zone.

The findings will be an accurate daylight simulation including transmission of light through exterior and interior windows and reflection from all surfaces.

The daylight factor (DF) is the most used parameter in the characterization and quantification of daylight in buildings.

3.2 THE STUDIED CASE AND ITS SPECIFICATIONS

The representative model of the school built, is located in the hot and dry climate of Jaisalmer. Each classroom has two twenty windows located throughout the wall.

Specifications and details:

1. Parameters considered while doing simulation-
2. Climate- Hot and Dry
3. Location- Salkha, Rajasthan, India (Located in the Thar Desert in the North of India)
4. Area- 9,000 square foot
5. Material- Stone in abundant therefore, yellow sandstone used throughout.
6. Size of window- 600x600 mm
7. Size of jail- 300x150x50 mm
8. Size of brick used- 215x102x65 mm
9. Wall thickness- 300 mm
10. The 'u' value of material- 'sandstone' 03.0-0.002
11. Window to wall ratio/window to wall %- 25
12. Window height- 600 mm
13. Window spacing- 150 mm
14. Sill level- 2100 mm

3. RESULTS

The sun path diagram of the selected case study of Rajkumari Ratnavati Girl's School, Rajasthan are as follows:

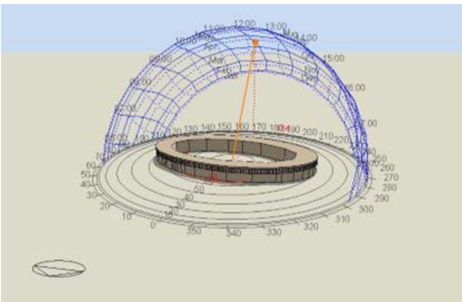

Fig.-4: Sun path diagram of the studied case at 12 p.m.

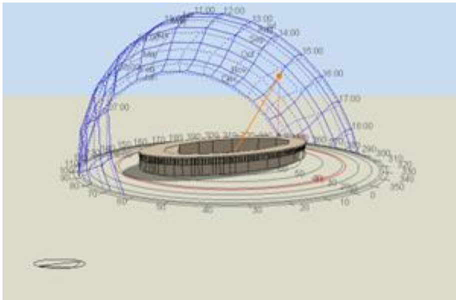

Fig.-5: Sun path diagram of the studied case at 3 p.m.

Generated high quality image to illustrate daylight availability and glare within the block:

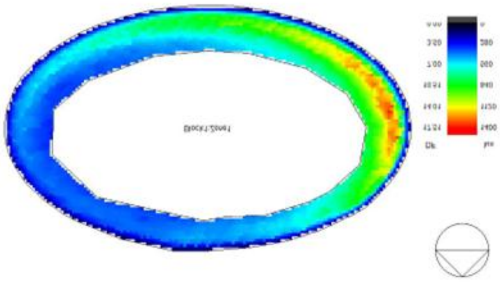

Fig.-6: Daylight illuminance at 9 a.m.

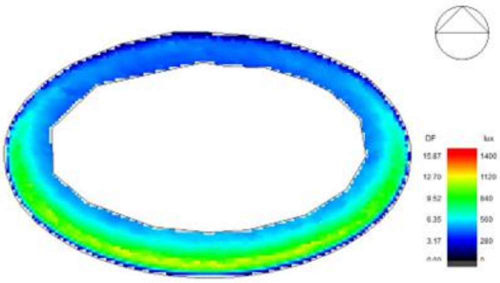

Fig.-7: Daylight illuminance at 12 p.m.

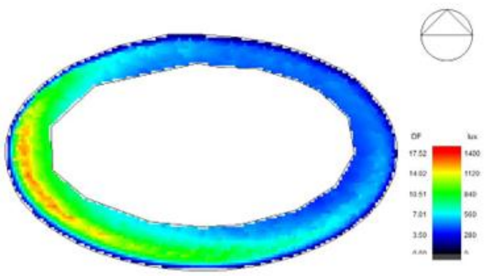

Fig.-8: Daylight illuminance at 3 p.m.

Result analysis for base case:

Daylight Factor (DF) Analysis: 80% of all illuminance sensors have a daylight factor of 2 or higher.

Daylight Autonomy (DA) Analysis: DA requirements (500 lux or more) are met over the total area for 87% of total annual analysis hours.

Useful Daylight Index (UDI) Analysis: The Useful Daylight Index is UDI<2000=less than 60%

4. DESIGN RECOMMENDATIONS

Good daylighting depends on:

1. Amount of daylight available
2. External obstructions and reflectance
3. Internal reflectance of room finishes
4. Proportion of window opening
5. Location of window opening
6. Depth of plan

5. CONCLUSIONS

This research has emphasized the importance of day lighting design on the overall quality of schools. Having reviewed the standards and development of day lighting in schools, it has explored different aspects of daylight influencing schools such as student health and performance as well as energy performance of the building. It has finally delivered some guidelines and principles of day lighting in schools which is useful for school designers.

The hot and dry climate of India is examined and institutional buildings are studied in terms of daylight parameter and for the result one specific newly constructed school in the hot and dry region of India is selected and daylight illuminance is calculated and proved to be the ideal design for an optimal learning space in the desert area of hot and dry region for further design strategies and requirements for such optimal learning space design.

The primary goal of the study was to get an idea about how the typical school plan in Jaisalmer, Rajasthan perform in terms of daylight.

Following are the main conclusions of the study:

Considering the case studied, the metrics worked in the following manner:

-daylight factor (df) analysis: classroom space achieved daylight factor of 2 for 75% of the space.

-daylight autonomy (da) analysis da requirements (300 lux or more) are met over the total area for at least 75 % of total annual analysis hours are fulfilled.

-useful daylight index (udi) analysis: the amount of daylight (500 lux or more) penetrating inside the classroom is lower (less than 60%) in the case that leads to glare free condition, thus visual and thermal comfort is maintained hence, optimal learning space is selected and identified.

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