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Impact of Courtyard on the Classroom Thermal Environment in the Primary Schools in Dhaka

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Abstract: Primary school buildings in Dhaka are commonly designed with a strong emphasis on classroom functionality, while the influence of architectural elements that affect the indoor thermal environment—such as courtyards—remains insufficiently explored. Consequently, many school buildings do not effectively utilize courtyards as passive design strategies to enhance thermal comfort and natural ventilation within learning spaces. Ensuring a thermally comfortable indoor environment is particularly important for children's health, concentration, and overall well-being, as students spend extended periods inside classrooms during their formative years. This study aims to evaluate the contribution of courtyards to the thermal performance of primary school classrooms and to assess their significance in contemporary school design. The research focuses on comparing the thermal conditions of classrooms located adjacent to courtyards with those in buildings that lack such spatial configurations. A mixed-method research approach was employed. Quantitative data were collected through on-site environmental measurements, using instruments such as thermometers and hygrometers to record indoor temperature and relative humidity levels in selected classrooms. In addition, a qualitative investigation was conducted through questionnaire surveys involving 266 primary school students from four selected schools in Dhaka, aimed at assessing students' perceptions and comfort levels regarding classroom thermal conditions. The findings demonstrate a significant relationship between the presence of courtyards and improved thermal comfort in classrooms. The measurement results indicate relatively lower indoor temperatures and enhanced natural ventilation in courtyard-oriented classrooms. These outcomes were further supported by students' responses, which reflected higher levels of perceived thermal comfort and improved learning conditions. Conversely, classrooms without courtyards were more frequently associated with higher indoor temperatures and less comfortable thermal environments. The study identifies the courtyard as a critical spatial component that contributes to improved thermal performance in school buildings. Incorporating courtyards into primary school design can reduce indoor heat stress and promote healthier and more comfortable learning environments. The findings provide valuable insights for architects and planners and contribute to the ongoing discourse on climate-responsive and child-centered school design in Bangladesh and other regions with similar hot-humid climatic conditions.

Keywords: *Courtyard, Thermal Environment, Thermal Comfort, School Architecture, Student Well-Being.*

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I. INTRODUCTION

Courtyards are semi-enclosed open spaces surrounded by buildings and play a crucial role in improving the thermal environment of classrooms in school buildings. A well-designed courtyard promotes natural ventilation, which facilitates heat dissipation and enhances indoor thermal comfort. Studies have shown that courtyards can significantly reduce indoor temperatures in hot and humid climates by creating shaded areas and encouraging airflow [1]**.** Taleghani et al. also confirmed that courtyards contribute to lowering cooling loads and improving the overall thermal performance of educational buildings [2]**.** Recent studies have further highlighted the importance of courtyard design in regulating microclimatic conditions and enhancing thermal comfort. For example, a study on courtyard microclimates reported that courtyard spaces can remain significantly cooler than surrounding outdoor environments during summer due to shading and reduced solar exposure [3]**.** Similarly, research on courtyard vegetation found that the integration of trees and greenery within courtyards can reduce the mean radiant temperature by 5–7°C**,** thereby improving thermal comfort and reducing heat stress in educational buildings [4]**.** In addition, simulation-based studies demonstrate that well-designed courtyard buildings can significantly reduce cooling loads and improve energy efficiency while maintaining comfortable indoor temperatures in warm and humid climates [5]**.** The topic of

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this research, "Impact of Courtyard on the Classroom Thermal Environment in Primary Schools in Dhaka," was selected to examine the performance of courtyards under the specific microclimatic conditions of Dhaka. Due to limited urban land and high building density, many schools in Dhaka lack adequate open spaces, which negatively affects classroom thermal comfort and ventilation. Since students spend long hours inside classrooms, poor thermal conditions can lead to overheating, discomfort, and reduced concentration. Previous studies indicate that schools with courtyards achieve better indoor thermal conditions by maintaining relatively cooler classroom temperatures and enhancing natural airflow **[**1] [2]**.** Based on a review of several relevant journals and research studies, it is evident that courtyards are an important architectural element for improving the thermal environment of school classrooms. Previous research consistently shows that courtyards help regulate indoor temperature by promoting natural ventilation, reducing heat accumulation, and creating shaded microclimates, particularly in hot and humid climates [1] [2] [3]**.** Therefore, the integration of courtyards in primary school design can be considered a sustainable architectural strategy for improving classroom thermal performance, especially in densely populated urban contexts and warm climatic regions such as Dhaka.

II. AIM AND OBJECTIVES

This study aims to analyze the impact of courtyards on the thermal environment of classrooms in primary schools in Dhaka, with particular emphasis on how these architectural features influence indoor temperature and the subsequent effects on students' comfort. The objective of the research is to identify the effect of courtyards on classroom thermal conditions and to understand how improved thermal environments can enhance students' comfort.

III. METHODOLOGY

This study employs a mixed-method research approach through a comparative analysis of selected primary schools in Dhaka. The research aims to evaluate the influence of school courtyards on the thermal environment of classrooms, with particular emphasis on indoor temperature and students' thermal comfort. Quantitative data were collected through on-site environmental measurements using instruments such as thermometers and hygrometers to record indoor temperature and relative humidity levels in selected classrooms. In addition, qualitative data were obtained through questionnaire surveys conducted among students to understand their perceptions and experiences regarding classroom thermal conditions. The selected schools include Bangla Bazar Government Girls High School and Sunbeam School, which have courtyard spaces, and Cosmopolitan Laboratory School and South Point School and College, which do not have courtyards. A comparative analysis was conducted among these schools to examine the impact of courtyards on classroom thermal conditions. By comparing classrooms from these four schools, the study investigates how the presence or absence of courtyards influences indoor temperature and overall thermal comfort. This comparative approach helps to evaluate the role of courtyards in improving the thermal environment of classrooms and enhancing students' comfort.

IV. RESULTS AND DISCUSSIONS

- *Questionnaire Survey on Classroom Thermal Conditions:*

A questionnaire-based survey was conducted to assess the thermal environment of school classrooms using a qualitative approach. Data were collected from a total of 266 students across four selected schools**.** The survey aimed to understand students' perceptions and experiences regarding indoor temperature and overall thermal comfort within their classrooms. The responses were analyzed to compare the thermal conditions in schools with courtyards and without courtyards**.** The findings suggest that students from schools with courtyards generally reported more comfortable classroom thermal conditions. In contrast, students from schools without courtyards often indicated higher indoor temperatures and lower levels of thermal comfort. These results highlight the potential role of courtyards in improving the thermal environment of classrooms and supporting students' comfort.

- *Analysis of Questionnaire Survey: Comparison of Classroom Thermal Comfort Between Schools With and Without Courtyard.*

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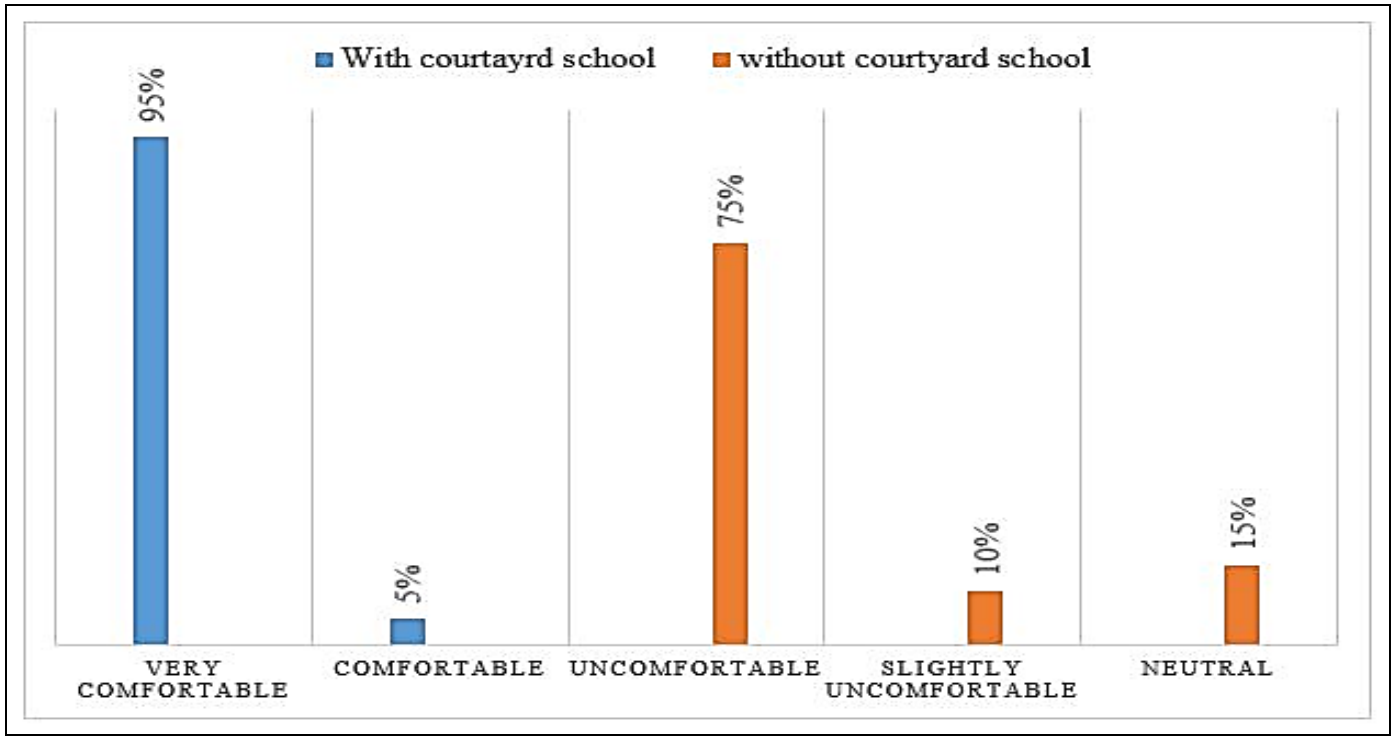

Fig 1 Students' Responses on Thermal Comfort

Figure 1 presents the results of the questionnaire survey comparing students' thermal comfort in schools with and without courtyards. In schools with courtyards, 95% of students reported their classrooms as very comfortable, while 5% reported them as comfortable. In contrast, in schools without courtyards, 75% of students reported their classrooms as uncomfortable, 10% as slightly uncomfortable, and 15% as neutral. These results indicate that the presence of courtyards has a significant influence on the thermal environment of classrooms. Courtyards can help regulate indoor temperature and create a more comfortable microclimate within the school building. As a result, classrooms with courtyards tend to provide better thermal conditions for students. Overall, the findings highlight the important role of courtyards in improving classroom thermal comfort and creating a more comfortable learning environment for students.

- *Comparison of Students' Perception of Classroom Environmental Comfort and Frequency of Distraction Due to Heat, Stuffy Air, or Poor Lighting in Schools With and Without Courtyards.*

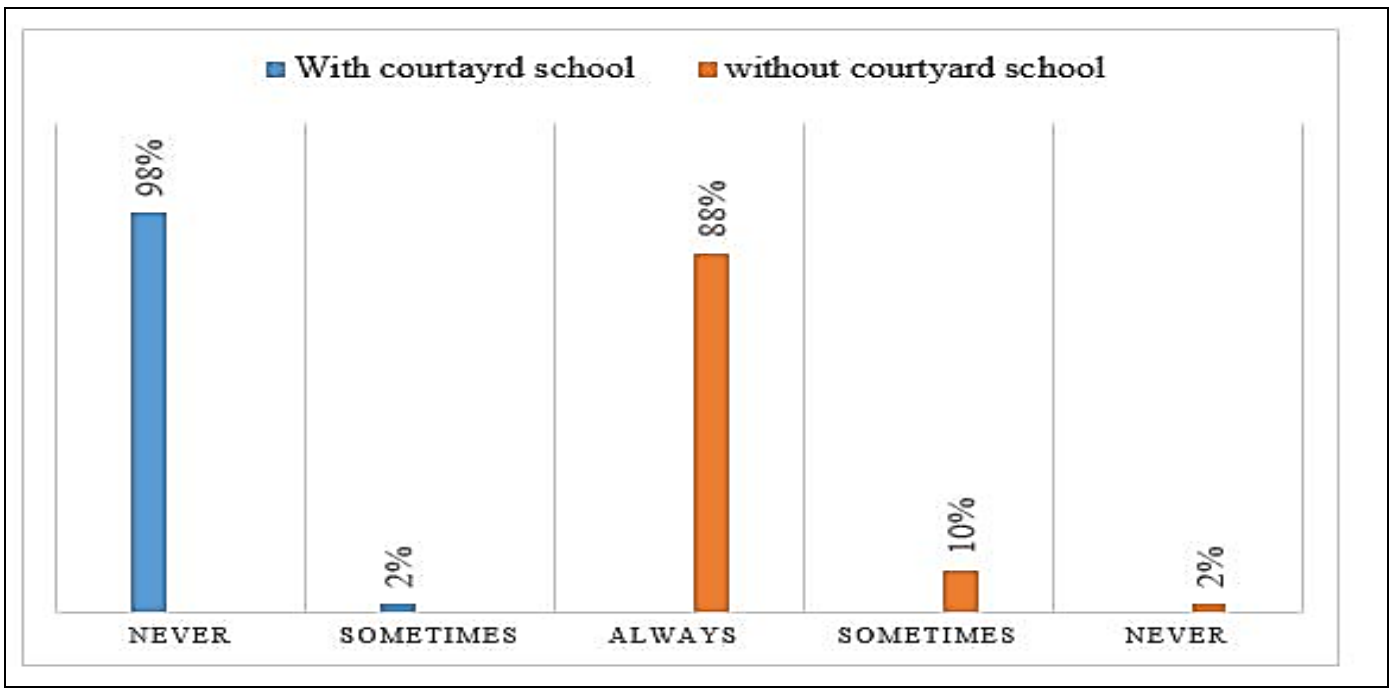

Fig 2 Comparative Analysis of Classroom Thermal Environment and Students' Thermal Comfort.

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The comparative analysis of Figure 2 highlights the influence of courtyards on students' thermal comfort and the frequency of heat-related distractions in classrooms. In schools with courtyards, 98% of students reported that they never feel distracted by heat during lessons, while 2% reported that they sometimes experience such discomfort. This suggests that courtyards help create a more comfortable thermal environment by moderating indoor temperature and improving the overall microclimate of classrooms. In contrast, in schools without courtyards, 88% of students reported that they always feel distracted due to heat, 10% reported sometimes, and 2% reported never experiencing such distraction. The absence of courtyard spaces may contribute to higher indoor temperatures and reduced thermal comfort within classrooms. These findings indicate that the presence of courtyards plays an important role in improving classroom thermal conditions and reducing heat-related discomfort for students. As a result, courtyard design can contribute to creating a more comfortable and supportive learning environment.

- *Data-Based Analysis of Classroom Thermal Environment:*

This section presents a data-based analysis of the thermal environment of classrooms in selected primary schools in Dhaka. The analysis focuses on key environmental factors such as indoor temperature and relative humidity, which directly influence students' thermal comfort in the learning environment. According to historical climatic data, April is the hottest month of the year in Bangladesh [8]. Therefore, April was selected for data collection to represent the peak thermal conditions during the school year. Thermal data were collected at 9:00 AM and 12:00 PM from four schools: Bangla Bazar Government Girls High School and Sunbeam School, which have courtyards, and Cosmopolitan Laboratory School and South Point School and College, which do not have courtyards. Measurements were taken from classrooms, courtyards, and adjacent roads to understand both indoor and surrounding thermal conditions. All classroom measurements were recorded at approximately one meter above the floor level, while measurements in courtyards and nearby roads were taken at ground level. The analysis included both individual assessments of each school and a comparative evaluation between schools with and without courtyards. Previous studies indicate that classroom indoor temperatures between 25°C and 30°C are generally considered comfortable [6], while an indoor relative humidity range of 30% to 60% supports a comfortable and healthy indoor environment [7]. The collected data are presented in tables and graphs for each school, enabling a clear comparison of indoor and outdoor thermal conditions. Overall, the results show that indoor temperature and humidity levels were more stable than outdoor conditions, and classrooms in schools with courtyards demonstrated comparatively improved thermal conditions.

Table 1 Comparison of Temperature Data Collected from Four Selected Schools

Temperature Readings of the Four Selected Schools				
Time	**Class 1**	**Class 3**	**Courtyard**	**Road**
Bangla Bazar Govt. Girls High School				
9.00 am	25.2	24.4	23.0	29.8
12.00pm	29.7	28.2	27.4	30.2
Sunbeam School				
9.00 am	25.9	25.8	19.13	29.8
12.00pm	27.7	26.2	19.00	29.0
Cosmopolitan Laboratory School				
9.00 am	30.1	28.3	Not Available	30.9
12.00pm	32.1	30.0	Not Available	33.3
South Point School And College				
9.00 am	30.1	28.3	Not Available	30.9
12.00pm	30.9	32.0	Not Available	32.4

The analysis of the data presented in Table 1 shows a noticeable difference in classroom temperature between schools with courtyards and those without courtyards. In the two schools that have courtyards, the classroom temperature generally remains between 25–28 °C, which falls within the comfortable thermal range for students. On the other hand, in the two schools that do not have courtyards, the classroom temperature is comparatively higher, ranging between 30–33 °C, which exceeds the comfortable range.

These findings indicate that the presence of a courtyard plays an important role in controlling indoor classroom temperature. Courtyards help improve natural ventilation and passive cooling, which keeps the classroom temperature within a comfortable range for students. In contrast, classrooms in schools without courtyards tend to experience higher temperatures, which may reduce students' comfort and negatively affect the environment. The following images show the four schools analyzed in this study.

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Fig 3 Bangla Bazar School, with courtyard, 2019

Fig 4 Sunbeam School, with courtyard, 2019

Fig 5 South Point School, without courtyard, 2019

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Fig 6 Cosmopolitan Laboratory School, without courtyard, 2019

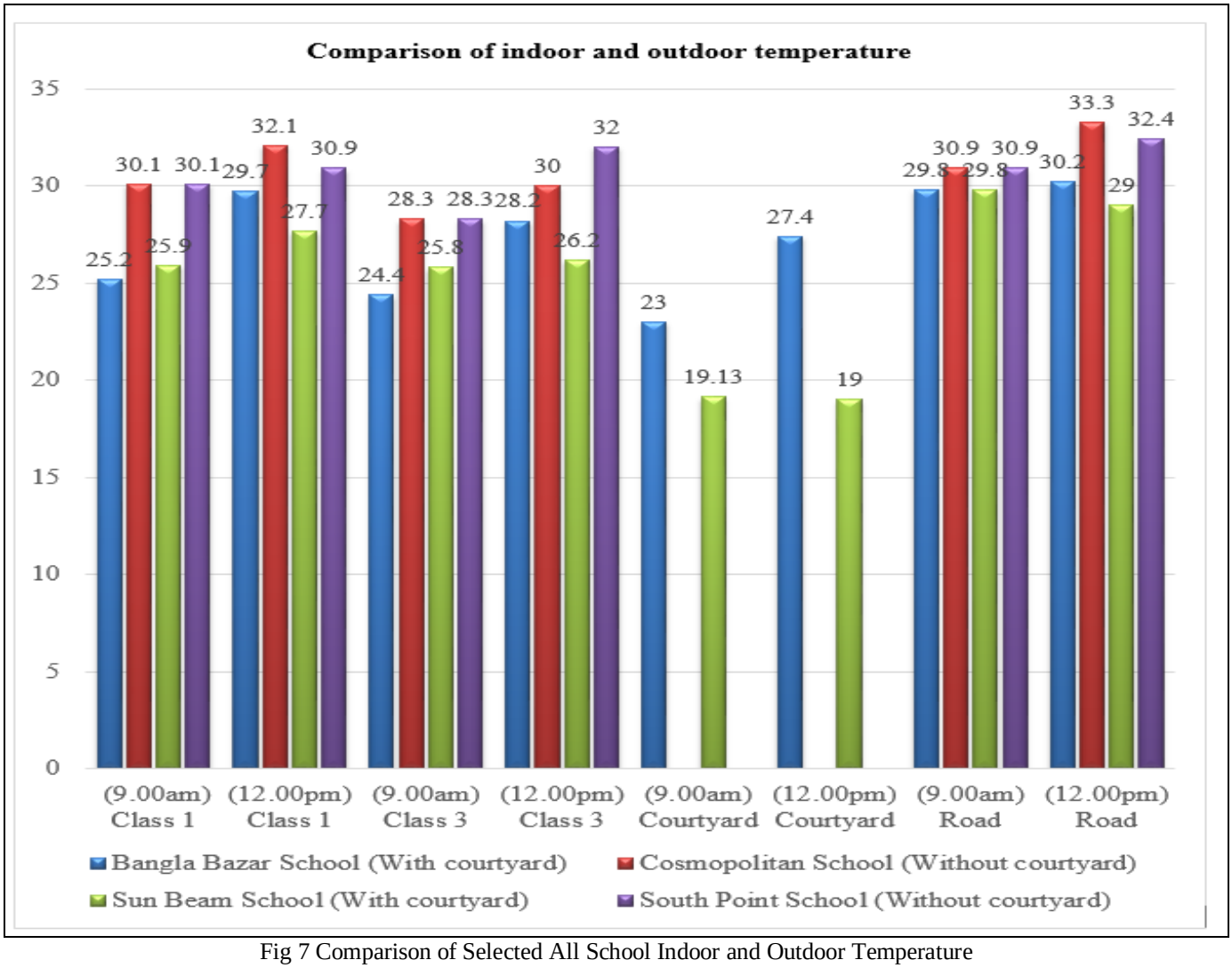

Fig 7 Comparison of Selected All School Indoor and Outdoor Temperature

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The comparison of indoor and outdoor temperatures among the selected schools is presented in Bar Chart 1. The results show clear differences between schools with courtyards and those without. In schools with courtyards, namely Bangla Bazar Government Girls High School and Sunbeam School, classroom temperatures were comparatively lower than those in schools without courtyards.

At 9:00 AM, the temperature in Class 1 was 25.2°C in Bangla Bazar School and 25.9°C in Sunbeam School, while the temperature in Cosmopolitan Laboratory School and South Point School was 30.1°C. This indicates a temperature difference of approximately 4–5°C between schools with courtyards and those without. Similarly, in Class 3, temperatures in schools with courtyards ranged from 24.4°C to 25.8°C, whereas in schools without courtyards the temperature was 28.3°C, showing a difference of about 2.5–4°C.

At 12:00 PM, the temperature in Class 1 classrooms with courtyards ranged from 27.7°C to 29.7°C, while in schools without courtyards it ranged from 30.9°C to 32.1°C, indicating a difference of approximately 2–4°C. In Class 3, classrooms with courtyards recorded temperatures between 26.2°C and 28.2°C, whereas schools without courtyards recorded 30°C to 32°C, which shows a difference of around 2–5°C.

The surrounding road temperatures were also relatively high, ranging from 29.8°C to 30.9°C at 9:00 AM and 29°C to 33.3°C at 12:00 PM, which were close to the indoor temperatures of schools without courtyards. In contrast, courtyard temperatures were significantly lower, recorded at 23°C and 27.4°C in Bangla Bazar School and 19.13°C and 19°C in Sunbeam School.

Overall, the findings indicate that classrooms in schools with courtyards were approximately 2°C to 5°C cooler than those in schools without courtyards. This temperature difference demonstrates that the presence of courtyards helps reduce heat accumulation and improves the thermal comfort of classroom environments.

V. CONCLUSION

The study focused on selected schools in Dhaka: Bangla Bazar Government Girls' High School and Sunbeam School, both of which include courtyards, and Cosmopolitan Laboratory School and South Point School and College, which do not have courtyards. The findings reveal a clear difference in classroom thermal conditions between schools with and without courtyards. In schools with courtyards, indoor temperatures were observed to remain comparatively lower and closer to the thermal comfort range. In contrast, schools without courtyards showed relatively higher indoor temperatures during the measurement period.

Classrooms in schools with courtyards were found to maintain cooler indoor temperatures compared to those in schools without courtyards. Courtyard spaces also recorded lower temperatures than the surrounding road environments, indicating their role in reducing heat accumulation within the school compound. As a result, classrooms in courtyard schools provide a more comfortable thermal environment for students.

In contrast, classrooms in Cosmopolitan Laboratory School and South Point School and College, which lack courtyards, showed indoor temperatures that were closer to the surrounding outdoor conditions. This suggests that the absence of courtyard spaces may contribute to greater heat buildup within the school buildings, resulting in less comfortable classroom environments.

In conclusion, the analysis demonstrates that courtyards play an important role in improving classroom thermal conditions by helping to reduce indoor temperatures. Therefore, incorporating courtyards can be considered an effective architectural strategy for enhancing thermal comfort and creating more comfortable learning environments in school buildings in Dhaka.

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