

# Development of Typology Specific Grading Framework to Evaluate Sick Building Syndrome Risk in Educational Building

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**Abstract** - This study aims to develop a grading framework tailored to educational buildings, integrating key environmental and perceptual parameters influencing occupant health and comfort. The research synthesizes existing literature on SBS and IEQ to identify measurable indicators such as indoor air quality, thermal comfort, lighting conditions, and occupant exposure. Based on these parameters, a structured grading system is proposed to categorize buildings according to their potential SBS risk levels. The framework emphasizes architectural evaluation rather than medical diagnosis, offering a systematic approach to assess indoor environmental performance in educational settings.

**Key Words:** Sick Building Syndrome (SBS), Indoor Environmental Quality (IEQ), Educational Buildings, Indoor Air Quality (IAQ), Thermal Comfort, Occupant Perception, Cognitive Performance, Grading Framework, Semi-Quantitative Analysis, Building Performance

## 1. INTRODUCTION

A concern which has become very significant in contemporary architecture type is the dependency on enclosed spaces and mechanically conditioned spaces which plays a major role in developing the Sick Building Syndrome in that space. It has a direct relation on occupant's health and wellbeing as a space suffering from SBS, the occupants may experience nonspecific health issues like eye irritation, headache, fatigue, reduced concentration, etc. These issues are the result of poor indoor environment quality which not only effect on productivity but on the health of the occupants using that space. This makes SBS a critical consideration for evaluating the building performance.

In different building typologies, educational building typology has some unique functions which made it a sensitive context for examining SBS. These building type offer high occupancy, long and sometime extended time exposure, etc which influence the physical and mental health of the occupants. Students in a classroom may loses their focus,

while the staff may suffer mental fatigue and still these types of conditions and relationship between IEQ and occupants is often overlooked or poorly assessed.

Researches available on SBS widely provide the data on IEQ's individual parameters. Also, the standards and systems which serves as evaluating systems for a building focuses on human comfort and sustainability, and fails to address the risk level for SBS specially in an educational environment. This provides an important research gap for a typology specific grading framework which results in providing the risk level for the building under the parameters of IEQ.

## 2. Sick Building Syndrome in Educational Building

A condition in which the users or occupants experience a variety of health symptoms which is directly proportional to the time spent in that indoor environment is known as Sick Building Syndrome or SBS. It includes the headache, dizziness, fatigue, eye and nose irritation, poor concentration, etc. It is a result of multiple conditions collectively causing the effect. Commonly, this happens due to poor indoor air quality, poor ventilation, poor lighting conditions, dense occupancy, thermal discomfort. The causes to SBS are often connected to each other. The main known cause which can be found in almost any building suffering is poor ventilation. It leads in the increasing carbon dioxide level and other pollutants. Building material, furniture, cleaning agents are the common origins of pollutants. Lighting conditions leading to unreasonable glare leads to visual discomfort and causes eye irritation and in some worst case could harm the eyes. Thermal discomfort formed out of poor ventilation which causes headache, dizziness, skin irritation. These factors when combined formed an indoor environment which is not desirable for the occupant's mental and physical health.

In educational building, the analysis for SBS risk plays an important step as the number of user and activities are dense and random. Classrooms, studios, lecture halls can be categorized as longest exposure spaces, where the time spent by user could be several hours without even leaving the space. During this time, the user requires concentration, visual focus and clear mind to learn whatever the activity is happening.

Any deviation in indoor environment can have direct impact on their physical and mental wellbeing, resulting poor productivity and learning experience.

Lack of knowledge and awareness, students suffering from these issues doesn't associate with these symptoms. This results in misinterpreted as general tiredness or lack of interest and SBS remain underreported. Educational buildings are different from other typologies, this offers a limited change in surroundings in according to user's will, which makes it more limited for adaptability in accordance to user, making user more vulnerable to the indoor environment.

These characteristics represent educational building a critical typology to study SBS. The interaction between the IEQ parameters and occupant's response are directly related, which not only affect the comfort but their overall performance and wellbeing. This concludes the need of structured system to evaluate the SBS risk level from a collective approach rather than individual parameters.

### Literature Review and Inferences

- **Indoor Air Quality, Ventilation and Health Symptoms in Schools**

This study aims to analyze the relationship between indoor air quality, ventilation rates, and health symptoms in school environments by reviewing existing data from multiple educational buildings.

#### Key Findings:

- Classrooms frequently exhibit inadequate ventilation rates
- Elevated CO<sub>2</sub> levels due to high occupancy
- Strong correlation between poor IAQ and symptoms like headaches and fatigue

#### Inference:

The study establishes indoor air quality as a primary factor influencing SBS in educational buildings. It supports the inclusion of **ventilation efficiency and CO<sub>2</sub> concentration** as critical parameters in the grading framework.

- **Effects of Classroom Temperature and Ventilation on Student Performance**

This research investigates how variations in classroom temperature and ventilation rates affect students' cognitive performance and task efficiency.

#### Key Findings:

Increased temperature reduces concentration and task accuracy

Improved ventilation enhances performance levels

Environmental conditions directly affect learning outcomes

#### Inference:

Thermal comfort and ventilation are not only comfort parameters but also performance determinants, supporting their inclusion as **core measurable indicators** in SBS risk evaluation.

- **Do Indoor Pollutants and Thermal Conditions Influence Student Performance?**

The study reviews multiple research projects work to evaluate how indoor environmental conditions impact student health, attendance, and academic performance.

#### Key Findings:

Poor IEQ linked to increased absenteeism

Reduced learning efficiency in suboptimal conditions

Strong association between indoor pollutants and SBS symptoms

#### Inference:

This study highlights the need to integrate **health and performance indicators** into SBS evaluation, extending beyond basic comfort assessment.

- **Quantitative Relationships Between Occupant Satisfaction and IEQ**

This study explores how occupant perception relates to measured indoor environmental conditions across various building types.

#### Key Findings:

Occupant satisfaction does not always align with measured parameters

Psychological perception plays a significant role

Discomfort reported even within acceptable standards

#### Inference:

The findings justify incorporating **occupant perception as a qualitative parameter** within the grading framework, making the evaluation more holistic.

- **Indoor Environmental Quality and Student Wellbeing**

This research examines the relationship between indoor environmental conditions and health symptoms among students in school buildings.

**Key Findings:**

Increased reports of fatigue, irritation, and discomfort in poor IEQ

Students often unaware of environmental causes

SBS symptoms commonly underreported

**Inference:**

The study supports integrating **health symptom indicators** with environmental data to better assess SBS risk.

- **Indoor Air Quality Study in Chennai School (India Context)**

This study evaluates indoor air quality conditions in a school located near a high-traffic area, focusing on the impact of outdoor pollution on classroom environments.

**Key Findings:**

Outdoor pollution significantly influences indoor air quality

Elevated CO<sub>2</sub> and pollutant levels observed

Natural ventilation introduces external contaminants

**Inference:**

In the Indian context, SBS is influenced by both indoor and outdoor conditions. This supports including **location and external pollution factors** in the evaluation framework.

- **SBS in Green vs Conventional Buildings (India – Manipal Study, 2020)**

This study compares the prevalence of SBS symptoms in green-certified and conventional buildings to assess the effectiveness of sustainable design practices.

**Key Findings:**

SBS symptoms present in both building types

Lower prevalence in green buildings but not eliminated

Certification does not ensure occupant wellbeing

**Inference:**

The study highlights the gap between design intent and actual performance, reinforcing the need for a **performance-based grading system** rather than reliance on certifications

- **Indoor Air Quality and Respiratory Symptoms in Schools**

This study investigates the impact of indoor air quality on respiratory health in children within school environments.

**Key Findings:**

Poor IAQ linked to increased respiratory issues

Children more sensitive to environmental pollutants

Long exposure increases health risks

**Inference:**

The findings emphasize the importance of **occupant vulnerability**, supporting the need for typology-specific SBS assessment in educational buildings.

**PARAMETER IDENTIFICATION**

By reviewing these studies, we can say that the SBS effects in an environment is a collective and interrelated resultants of the IEQ factors and conditions. These studies repeat the recurring variables that had influence on both the wellbeing and productivity of occupants. These parameters are identified as key components and base for this grading framework.

**Indoor Air Quality and Ventilation**

This is most commonly found factor in a building. These literature reviews evident that inadequate ventilation can increase the quantity of pollutants and leads to the increase in carbon dioxide level. Poor ventilation is proportional to poor indoor air quality of the space which causes symptoms like headache, fatigue, concentration failure.

**Thermal Comfort**

In educational building, thermal comfort significantly influences the comfort and productivity of occupants. These literature review shows that change in temperature or humidity or both can cause discomfort, drowsiness, decreasing the efficiency of work. As educational building typology is different from other typologies, the control over the setting is very limited over thermal conditions and high density further leads in increasing the heat gain and affects the thermal balance.

**Lighting Conditions**

Lighting plays an important role in the productivity. Poor lighting conditions like uneven lighting balance, glare, light patches lead to eye strain, effect on visual clarity, poor focus, fatigue. In educational typology where visual command plays important role, inadequate artificial lighting serves a negative impact on occupant's wellbeing.

**Occupant's Density and Exposure**

In educational building, the density is relatively higher than other typologies and the exposure to the environmental effects cannot be unseen. This is directly proportional to the thermal

comfort and indoor air quality as higher the density higher will be the rate of heat gain. It also increases the moisture contains and carbon dioxide levels. In educational buildings, to cover the workload, overtime is a common practice and those extended hours amplify the chances for higher SBS risk to the occupant.

### Perception and Response

Literature reviews say that, even in the acceptable standard conditions of IEQ parameters, user may experience discomfort or symptoms of SBS in that space or building similarly, the scenario can be opposite. The user may not get affected even in high risk prone SBS zones due to one's individual adaptability, perception, psychological response which influences the perception of indoor environmental quality. These factor leads to underestimating the SBS risk and taken as tiredness or lack of interest.

### Learning Performance

Poor IEQ has relation to reduced concentration, slower grasping and learning processing, increased fatigue, and hence it lowers the academic performance. It is important to keep it as parameter of framework as it not only guides the performance and productivity status but also provides the data for the relationship between user's perception and symptoms analysis which could further help in providing the health guidance.

## FRAMEWORK DEVELOPMENT

The development of the grading framework for evaluating Sick Building Syndrome (SBS) risk in educational buildings is based on parameters identified through literature review. Since SBS is influenced by a combination of environmental and occupant-related factors, the framework adopts a **semi-quantitative approach**, integrating observable conditions, indicative data, and occupant perception. This approach enables systematic assessment in real-world scenarios where advanced measurement tools may not be available, while maintaining analytical consistency.

### Identification of Parameters

The framework is structured around six key parameters:

- Indoor Air Quality and Ventilation
- Thermal Comfort
- Lighting Conditions
- Occupant Density and Exposure
- Perception and response
- Impact on Health and Learning Performance

These parameters can collectively represent both the conditions, **objective environmental conditions** and **subjective user responses**. Thus, forming a comprehensive basis for SBS risk evaluation.

## CRITERIA AND SCORING METHODOLOGY

The framework evaluates each parameter using predefined criteria combined with a structured scoring system. Environmental performance is translated into three levels based on observable and assessable conditions, derived from literature-based indicators. This ensures consistency and applicability across different case studies.

Each parameter is scored as follows:

- **Score 3 (Good Condition):** Optimal performance with minimal likelihood of SBS symptoms
- **Score 2 (Moderate Condition):** Acceptable conditions with occasional discomfort
- **Score 1 (Poor Condition):** Suboptimal conditions with high SBS risk

To ensure clarity in application, evaluation bands are defined for each parameter:

### Indoor Air Quality and Ventilation

- **Score 3:** space should meet effective ventilation system, consistent airflow, no odor or stuffiness around. Air exchange should appear adequate as per the density, with openings for continuous air exchange.
- **Score 2:** space have inconsistent ventilation system, occasional stagnation. Air movement may be uneven, mild stuffiness during peak density.
- **Score 1:** no ventilation, noticeable odor, lack of air movement and air exchange.

### Thermal Comfort

- **Score 3:** stable and comfortable temperature and humidity conditions. Heat gain is effectively managed.
- **Score 2:** minor fluctuations causing occasional discomfort. Condition varies from time mainly during peak hours.
- **Score 1:** major fluctuation in temperature and humidity levels causing significant discomfort.

### Lighting Conditions

- **Score 3:** space provide adequate daylight with minimal glare and well distributed lighting.

- **Score 2:** space has functionally acceptable lighting with occasional glare or insufficiency in luminance.
- **Score 1:** poorly managed or no lighting causing visual discomfort and excessive contrast to the space with high glare or no luminance.

### Occupant Density and Exposure

- **Score 3:** efficiently distributed occupancy with adequate space per user, allowing the air flow and exposure duration is managed or scheduled.
- **Score 2:** occasional crowding with less space per user but with manageable exposure and airflow.
- **Score 1:** overcrowded spaces with prolonged exposure and less airflow.

### Perception and Response

- **Score 3:** majority of users report comfort in the space.
- **Score 2:** mixed responses from occupants.
- **Score 1:** majority report discomfort.

### Learning Performance

- **Score 3:** no observable impact on health or performance.
- **Score 2:** occasional fatigue or reduced concentration.
- **Score 1:** frequent discomfort and noticeable decline in performance.

This system allows different IEQ parameters to be analyzed in a structured form helping to clearly identify the performance and potential SBS risk level. By using this scoring methods, the framework enables fair and comparable results while still being easy to apply in real life.

### SBS INDEX CALCULATION

To determine the overall SBS risk, the individual parameter scores are combined into a composite index

$$SBS\ Index = \frac{\{\sum Parameter\ Scores\}}{\{Maximum\ Score\}} \times 100$$

Where:

- Maximum Score = 18 (6 parameters × 3)

This converts the evaluation into a **percentage-based index**, enabling easy interpretation and comparison.

### Interpretation of SBS Risk Levels

Based on the SBS Index, buildings are categorized into the following risk levels:

- **80% – 100% (Low Risk):** Indicates a healthy indoor environment with minimal SBS impact
- **60%– 79% (Moderate Risk):** Reflects acceptable conditions with some environmental concerns
- **Below 60% (High Risk):** Indicates poor indoor conditions with high SBS risk

### APPLICATION AND FLEXIBILITY

The proposed framework is designed to function as a practical assessment tool for educational buildings. It allows the integration of **measured environmental data where available**, while remaining applicable through observational and perception-based inputs. This flexibility ensures usability across diverse contexts, particularly in settings with limited access to advanced monitoring systems.

### CONCLUSION

The study establishes that Sick Building Syndrome (SBS) in educational buildings is a multifaceted issue influenced by the interaction of indoor environmental conditions and occupant-related factors. Through the review of existing literature, it is evident that parameters such as indoor air quality, thermal comfort, lighting conditions, and occupant density significantly impact both health and cognitive performance. In the context of educational environments, where prolonged exposure and high mental engagement are inherent, the implications of these factors become more pronounced.

The primary objective of this research was to develop a typology-specific framework for evaluating SBS risk in educational buildings. This objective has been achieved through the identification of key parameters and the formulation of a semi-quantitative grading system. The proposed framework integrates observable environmental conditions, indicative data, and occupant perception into a structured evaluation model. By introducing a scoring mechanism and SBS Index, the study provides a systematic approach to assess indoor environmental performance without relying on advanced measurement tools.

The framework demonstrates that SBS risk cannot be

attributed to a single parameter but must be understood as a cumulative outcome of multiple factors. This reinforces the need for holistic evaluation methods in architectural assessment. Additionally, the inclusion of perception-based indicators highlights the importance of user experience in understanding indoor environmental quality, bridging the gap between measurable conditions and actual occupant response.

However, the study is limited by its reliance on observational and literature-based data, which may introduce subjectivity in evaluation. The absence of advanced environmental measurements and long-term monitoring restricts the precision of the assessment. Furthermore, the findings are influenced by contextual factors such as climate and building usage patterns, which may vary across different regions.

Future research can expand upon this study by incorporating real-time environmental monitoring, larger sample sizes, and comparative analysis across different building typologies. The framework may also be refined through integration with digital tools or building performance simulations to enhance accuracy and scalability. Despite these limitations, the study contributes a practical and adaptable tool for assessing SBS risk in educational buildings, emphasizing the importance of indoor environmental quality in shaping healthier and more effective learning environments.

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