SHIHAB JOURNAL OF HUMANITIES
Volume (2), Issue (4) (October, 2026)
ISSN: 3136-2958

مجلة الشهاب للعلوم الإنسانية
المجلد (2) العدد(4) اكتوبر 2026
عدد خاص بالمؤتمر الدولي الأول لسلاسل الامداد والتوريد والإدارة اللوجستية في ليبيا
26-27 أغسطس 2026

An Engineering Evaluation of Built-Environment Safety Standards in Private School Buildings: A Case Study of the International Knowledge School (IKS), Zawiya, Libya

Hameda Grabil [1], Muhammed S. Maddi [2]
[1] The Libyan Academy for Postgraduate Studies. hamedagrabil@gmail.com
[2] Libyan Authority for Scientific Research, Muhammed.maddi2@gmail.com
Received: 29/6/2026 Revised: 05/7/2026 Accepted: 28/7/2026 Publication: 5/10/2026

Abstract
School buildings must provide a safe built environment that protects students, staff, and visitors during normal operation and emergencies. This study presents an engineering evaluation of built-environment safety standards at the International Knowledge School (IKS) in Zawiya, Libya, using a mixed-methods case study approach; site inspections, dimensional measurements, staff interviews, and questionnaires; assessed against the International Building Code (IBC) and NFPA standards. While the building largely complies with international standards, a converted basement theater was found non-compliant on multiple counts: its 70 m² floor area falls 18 m² short of the 88 m² required for its 71 fixed seats; it lacks measurable ventilation; and its 50 m egress travel distance exceeds the 46 m maximum for non-sprinklered occupancies. Additional deficiencies were identified building-wide, including inward-opening exit doors and the absence of fire alarms, smoke detectors, and emergency lighting. The study proposes practical engineering recommendations to improve safety in private educational facilities in Libya**.**
Keywords: school buildings, safety standards, safety applications, healthy environment, students' safety.

1. Introduction

School safety is a fundamental requirement for ensuring a secure learning environment that supports the well-being of students, staff, and visitors. Since students spend a significant portion of their time at school, educational facilities must provide a built environment that minimizes potential hazards and complies with recognized engineering safety standards. This importance is particularly acute in developing-country contexts, where resources for building maintenance and safety compliance are often limited.

In Libya, and particularly in cities like Zawiya, the private education sector has expanded dramatically over the past fifteen years. According to data obtained from the Zawiya District Ministry of Education (personal communication, July 11, 2026), private schools in Zawiya numbered fewer than 10 approximately fifteen years ago, alongside approximately 110 public schools. Today, the landscape has shifted markedly: private schools in Zawiya now number around 150, while public schools have remained relatively stable at approximately 110. This reversal—from a ratio of approximately 1 private school for every 11 public schools to nearly a 1:1 ratio—reflects both the growing demand for private education and the emergence of private schooling as a significant business sector in the region. While some of these private facilities were purpose-built as educational buildings, many others have been converted from residential or commercial buildings without fully considering engineering safety requirements during their adaptation.

The safety performance of a school building depends on several built-environment factors, including structural integrity, fire protection systems, emergency exits, electrical installations, accessibility, and emergency preparedness. Deficiencies in these areas may increase the risk of accidents and reduce the effectiveness of emergency response measures. Despite the importance of these issues, and despite the explosive growth of the private-school sector in Libya, there is limited research evaluating the extent to which private school buildings comply with recognized engineering safety standards.

This study focuses on the International Knowledge School (IKS) in Zawiya as a case study to evaluate the compliance of its built environment and safety systems with recognized engineering safety standards. Specifically, the study addresses the following research questions:

1. To what extent does the IKS Zawiya building comply with recognized engineering safety standards, including structural integrity, fire protection, emergency egress, electrical installations, and accessibility?

2. What are the main gaps between the current condition of the building and these recognized safety standards?

3. What practical structural or architectural modifications could be implemented to close these gaps and improve the overall safety of the school environment?

By answering these questions, the study aims to identify existing safety gaps, assess the level of compliance, and propose practical structural modifications that can minimize risk and enhance the overall safety of the school environment. The findings are expected to provide valuable guidance for school administrators, engineers, and policymakers in improving the safety of private educational facilities and promoting safer learning environments in Libya.

2. Literature Review

2.1 The Importance of Safety in the School Built Environment

A safe school environment is widely recognized in the literature as a precondition for effective learning, not simply an administrative add-on. Al-Ansary et al. (2023) note that because students spend a substantial share of their day on campus, the physical adequacy of the school environment directly affects both the learning process and student health. School buildings are also treated in the literature as a distinct building typology that demands a higher standard of care than most other occupancies, given the number of occupants, their age, and their limited ability to respond independently to hazards (Saxena & Kamal, 2018). This has led several scholars to argue that safety and security should be considered a core design objective of school architecture, on par with function and aesthetics, rather than a compliance afterthought (Saxena & Kamal, 2018).

Despite this consensus on importance, researchers repeatedly find a gap between recognized standards and what is actually built or maintained on the ground, particularly outside high-

income countries. This review therefore organizes the literature around the main built-environment safety domains identified in prior studies — structural and design safety, fire safety, emergency preparedness, and the specific risks associated with converted or non-purpose-built school buildings — before turning to the regional and Libyan context relevant to the present case study.

2.2 Structural and Architectural Safety Standards in Schools

A significant body of work has translated general building-safety principles into concrete design guidance for school facilities. Saxena and Kamal (2018), drawing on case studies of school buildings in India, proposed a comprehensive set of environmental-behavior design guidelines covering site planning, building form, entrances and exits, corridors, staircases, and building services. Their framework illustrates how architectural decisions; such as corridor width, door-swing direction, staircase enclosure, and lighting placement; have direct, measurable safety consequences, including for evacuation and injury prevention, in addition to their role in reducing opportunities for accidents and campus crime. This line of research treats the physical layout of a school as an active safety system rather than a passive container for activities.

At a broader policy level, the World Bank's review of school-building codes across multiple countries found that most national codes are written primarily for new construction, and that far fewer countries have explicit provisions covering the alteration, retrofit, or change of use of existing buildings — a gap of direct relevance to schools that were not originally designed as educational facilities (World Bank, 2025). The same review found that simplified, easy-to-understand code provisions tend to produce better compliance in smaller-scale buildings, suggesting that complexity of regulation, and not only its content, affects real-world safety outcomes (World Bank, 2025).

2.3 Fire Safety Compliance in Educational Facilities

Fire safety is one of the most extensively studied dimensions of school building safety, largely because of the severity of documented incidents. Case studies from Nigeria and Kenya illustrate the human cost of inadequate fire protection in academic settings, including a 2001 fire at a Kenyan school that killed 58 people (Sholanke et al., 2024). Reviews of fire hazard literature more broadly point out that the level of fire safety achieved in a building depends not only on the stringency of codes but on the degree to which those codes are enforced and complied with in practice — a distinction that matters greatly in developing-country contexts where enforcement capacity is often limited (Kodur et al., 2020).

Fire safety audits of educational buildings elsewhere in the developing world reinforce this compliance gap. A Tanzanian study of fire disaster preparedness in higher-learning institutions found that many buildings in developing-country cities still lack basic firefighting facilities, and concluded that enforcement of building codes remains a persistent challenge even where the codes themselves exist (Kihila, 2017). Similarly, an audit-based study of fire safety compliance across government schools in Pahang, Malaysia found that compliance levels varied considerably between individual school buildings, even within a single, unified regulatory system underscoring that compliance is often building-specific rather than uniformly determined

by national policy (Nadzim & Taib, 2014). A related framework study implemented and tested a generic fire-safety-management framework in a secondary school in the Eastern Province of Saudi Arabia, developing a practical action plan to raise the facility's fire safety level an approach methodologically close to the evaluative case-study design adopted in the present research (Hassanain et al., 2022).

2.4 Emergency Preparedness and Safety Management in Schools

Beyond the physical fabric of the building, the literature emphasizes that safety outcomes depend heavily on institutional preparedness policies, drills, and staff training operating alongside the built environment. The most directly comparable regional study, Al-Ansary et al. (2023), evaluated safety preparedness across seventeen girls' public schools in the Eastern Province of Saudi Arabia using a 58-item checklist covering general safety criteria. Their results showed considerable variation, with compliance ranging between 70% and 90% across the sampled schools, and identified rented, non-purpose-built buildings as a recurring source of safety deficiency: such buildings, not originally designed as schools, consistently lacked certain safety criteria present in purpose-built, government-constructed facilities (Al-Ansary et al., 2023). This finding is especially relevant to the present study, since the IKS case study similarly examines a private school operating within the Libyan built environment, where school buildings frequently originate as residential or commercial structures.

2.5 Risks Associated with Converted and Non-Purpose-Built School Buildings

A recurring theme across the literature is that buildings adapted from other uses into schools pose distinct safety challenges that purpose-built educational facilities do not. Al-Ansary et al. (2023) found that rented buildings not originally designed as schools lacked several recommended safety criteria compared with buildings that were purpose-built. Documentation of school and institutional building retrofits elsewhere similarly shows that converting a building to educational use typically requires additional egress stairs, wider exits, and structural upgrades to meet the occupant-load and life-safety requirements of an educational occupancy category, requirements that a residential or commercial structure was never designed to satisfy, a gap that many national codes do not explicitly address for altered or repurposed buildings (World Bank, 2025).

2.6 The Libyan and Regional Context

Compared with the international literature on school-building safety, research specific to Libya is limited, and almost none focuses on the engineering safety performance of private-school buildings. What literature does exist on Libyan education points to a system under considerable strain: political instability following 2011 has repeatedly damaged educational infrastructure and disrupted school operation (Broken Chalk, n.d.; The National, 2021), while the expansion of private education has occurred partly as a response to pressure on the public system (WENR, 2022). Reporting on the Libyan education sector also notes that many school buildings, public and private alike, face problems of overcrowding and inadequate basic infrastructure (Broken Chalk, n.d.). However, none of the available sources evaluate private-school buildings in Libya against recognized engineering safety standards in the structured way this study proposes, which

is precisely the gap the present research on IKS Zawiya is intended to address.

2.7 Summary and Research Gap

Taken together, the literature establishes three consistent findings. First, school buildings warrant a distinct and elevated safety standard because of their occupancy characteristics, and this standard span structural design, fire protection, and building services (Saxena & Kamal, 2018). Second, actual compliance with these standards is frequently uneven, and the gap between prescribed standards and built reality is especially pronounced in buildings that were converted from other uses and in contexts with weaker code enforcement (Al-Ansary et al., 2023; Kihila, 2017; Nadzim & Taib, 2014; World Bank, 2025). Third, while this compliance gap has been documented in several Middle Eastern and developing-country contexts, it remains largely unstudied in Libya, and almost entirely unstudied with respect to private-school buildings specifically. This study addresses that gap by applying an engineering evaluation framework, informed by the standards and compliance issues identified in the literature above, to a single private-school case study, the International Knowledge School (IKS) in Zawiya.

3. Methodology

3.1 Study Design and Approach

This study employs a mixed-methods case-study approach to evaluate the safety compliance of the International Knowledge School (IKS) building in Zawiya, Libya. The research combines three complementary data-collection techniques: (1) a detailed physical audit using laser measurement and direct comparison with architectural blueprints; (2) semi-structured interviews with school administrative staff; and (3) a questionnaire administered to teaching staff to capture documented safety concerns and incident history. This triangulation of quantitative measurements, qualitative interviews, and survey responses allows both objective assessment of building conditions against standards and subjective reporting of experienced safety hazards.

3.2 Study Site and Building Description

The International Knowledge School (IKS) is a private educational facility located in Zawiya, close to the main eastern city entrance, Libya, serving students from preschool, primary through secondary levels. The main building comprises three occupied stories (ground floor, first floor, and second floor) plus a basement level. The school building was originally designed according to specific educational specifications; however, alterations have been made to the original design, most notably the addition of a theater facility in the basement. The present study evaluates whether the building's current configuration complies with recognized engineering safety standards applicable to educational facilities.



The International Knowledge School (IKS)

3.3 Data Collection Methods

3.3.1 Physical Audit and Dimensional Verification

A detailed physical audit of the school building was conducted across all occupied floors (ground, first, and second) to systematically document and verify building dimensions and safety-related features. The audit used the following procedure:

- Equipment: Laser measure and printed architectural plans (blueprints) of the school building, along with AutoCAD digital versions of the same plans.
- Dimensions checked: All classrooms, doors, windows, ceiling heights, hallway widths, and staircase dimensions were measured in situ and compared against the architectural plans to verify compliance with design intent and to identify any discrepancies or unauthorized modifications.
- Safety features documented: Floor materials, type and placement of security doors, presence and positioning of security cameras in classrooms and common areas, emergency lighting, and condition of exit pathways were systematically recorded for each floor.
- Scope: Ground floor, first floor, and second floor were fully audited. The basement level was also inspected, where a newly constructed theater space was identified.
- Key findings from audit: The theater facility added in the basement was found to have a significantly long access route to the single (or primary) emergency exit door, creating a potential egress bottleneck in case of fire or emergency evacuation. Additionally, four emergency exit doors on the campus were observed to open inward (into the building) rather than outward (to the exterior), which violates standard egress safety practice and impedes rapid evacuation.

3.3.2 Semi-Structured Interviews

Semi-structured interviews were conducted with four school administrators/supervisors to gather qualitative information about school operations, current safety practices, past incidents, and perceived safety priorities.

- Participants: School Principal (1) and Supervisors (3)
- Interview format: Oral, in-person discussions guided by a prepared list of open-ended questions regarding building safety, emergency preparedness procedures, staff training, documented incidents, and awareness of any known safety deficiencies.
- Topics covered: Emergency evacuation procedures, staff and student safety training, incident history, maintenance practices, security measures, and administrator perception of the school's main safety vulnerabilities.

3.3.3 Staff Questionnaire

A questionnaire was distributed to teaching staff to document their observations of safety issues, injuries, and hazards experienced within the school environment during normal operations.

- Participants: Teaching staff (38 of 51 teachers completed the questionnaire, representing a 74% response rate).
- Questionnaire content: Questions addressing:
  - Observed safety hazards (structural, electrical, fire-related, access/egress, environmental)
  - Documented or reported injuries or near-misses among students or staff
  - Incidents or accidents that have occurred in specific areas of the building
  - Awareness of emergency procedures
  - Perceived gaps in safety equipment or building features
  - Any other safety concerns specific to their classroom or area of responsibility
  - Data collection: Questionnaires were administered on-school site, with anonymity assured to encourage candid reporting.

3.4 Comparison Against Safety Standards

All audit findings, dimensional measurements, and observations were compared against recognized engineering safety standards for school buildings. The standards applied include:

The compliance assessment was based on the International Building Code (IBC, 2021), NFPA 101: Life Safety Code (National Fire Protection Association [NFPA], 2024), NFPA 10: Standard for Portable Fire Extinguishers (NFPA, 2022), and NFPA 72: National Fire Alarm and Signaling Code (NFPA, 2025), in addition to applicable Libyan safety requirements, covering egress, fire safety, electrical safety, accessibility, and emergency preparedness applicable to educational occupancies (such as provisions for exit door direction, emergency lighting, hallway widths, staircase specifications, and accessibility features).

The comparison identified instances of compliance and, more importantly, documented gaps and deficiencies where the current condition of the IKS building does not meet these standards.

3.5 Data Analysis:

Quantitative audit data:
Measurements from the physical audit were tabulated and compared against the design blueprints and against standard specifications (e.g., minimum hallway width, maximum exit-door travel

distance, required door width for egress). Discrepancies and non-conformances were recorded and categorized by safety domain (fire safety, egress, structural, electrical, accessibility).

Qualitative data (interviews and questionnaires):
Interview notes and open-ended questionnaire responses were reviewed thematically to identify recurring safety concerns, patterns of incidents, and gaps in safety awareness or practice. Responses were organized by location within the building and by type of hazard reported (e.g., fire-safety concerns vs. structural hazards).

Integration:
The physical measurements, interview findings, and questionnaire responses were synthesized to create a comprehensive assessment of the building's safety status relative to recognized standards, highlighting where objective measurements (e.g., exit-door travel distance) align with or contradict subjective reports from occupants (e.g., teacher concerns about evacuation time).

3.6 Scope and Limitations:

This study is limited to a single school building and does not compare IKS to other private schools in Zawiya or Libya. The audit documents the building's condition at the time of measurement (May 24, 2026 – June 3, 2026) and does not assess historical changes or long-term trends. The questionnaire responses reflect the experiences and perceptions of the staff who completed it and may not represent the entire teaching population or student experience. No formal safety incidents or injury data from the school's official records were incorporated into this analysis.

Appendix A: Engineering Safety Compliance Assessment Checklist:

This checklist was developed for the engineering evaluation of the International Knowledge School (IKS), Zawiya. Each item was carefully assessed through site inspection, measurements, photographs, and document review. Compliance is evaluated against the International Building Code (IBC), and the National Fire Alarm and Signaling Code; NFPA 101, NFPA 10, NFPA 72.
Compliance Rating.

C = Compliant, PC = Partially Compliant, NC = Non-Compliant.

Category	Assessment Item	Reference Standard	Requirement / Benchmark	Measurement / Observation	Compliance (C/PC/NC)
Site	**Category**	IBC	Fire/emergency vehicles should have unobstructed access to the building.	U-shaped route entrance with 5.5m wide.	C
Site	Assembly point	NFPA 101	Clearly identified, safe location away from the building and emergency vehicle routes.	25m from the school building Front and back school yard.	C
Structure	Visible cracks	IBC	No major structural cracks, excessive settlement, or signs of structural distress.	No cracks are visible.	C
Egress	Number of exits	IBC/NFPA 101	Minimum of two remote exits where occupant load requires.	4 main entry doors used for exit; each 2 m wide with 2 panels.	C
Egress	Exit door width	IBC	Minimum clear width: 813 mm (32 in).	1000 mm each door panel entry, and 850mm classroom doors width	C
Egress	Exit door swing	IBC/NFPA 101	Doors serving large occupant loads should swing in the direction of egress travel.	The 4 main entrance/ exit doors open inside	NC
Egress	Corridor width	IBC	Minimum corridor width: 1.83 m (72 in) for educational occupancies.	A 3.0 m wide corridor has classrooms on one side.	C
Egress	Stair width	IBC	Minimum clear stair width: 1.12 m (44 in), unless code exceptions apply.	the width is standardized at 1.40 m for all three stairs.	C
Egress	Handrails	IBC	Handrails provided on required stairs, continuous and securely fixed.	All stairs have installed handrails.	C
Egress	Exit signs	NFPA 101	Illuminated exit signs installed and clearly visible at each exit.	All signs are in place.	C
Egress	Emergency lighting	NFPA 101	Emergency lighting provided along exit routes and at exits.	Not available.	NC
Fire	Fire extinguishers	NFPA 10	Extinguishers provided, accessible, inspected, and not obstructed.	2 extinguishers on each floor, and one in each lab.	C
Fire	Fire alarm	NFPA 72	Operational fire alarm system with manual activation points where required.	Not available.	NC
Fire	Smoke detectors	NFPA 72	Smoke detection installed where required and functional.	Not available.	NC
Electrical	Exposed wiring	IBC/NEC	No exposed or damaged electrical wiring.	All electrical plugs are covered.	C
Electrical	Panels	IBC/NEC	Electrical panels labelled, accessible, with required working clearance.	The control room is managing all electrical panels and the monitoring system.	C
Accessibility	Entrance ramp	IBC	Ramp slope not steeper than 1:12; handrails where required.	8% slope with 1.15 m width.	C
Accessibility	Door accessibility	IBC	Accessible route and doorway clear width at least 813 mm (32 in).	3.8m clear zone buffer for each main door.	C
Indoor	Lighting	IBC	Adequate illumination for safe movement and learning; no failed fixtures in critical areas.	2 to 3 windows, each 1.4 m by 2.0 m, per classroom.	C
Indoor	Ventilation	IBC	Classrooms adequately ventilated in accordance with applicable building requirements.	Naturally ventilated classrooms with direct airflow.	C
Emergency	Evacuation plan	NFPA 101	Evacuation maps displayed in prominent locations.	Are mounted on walls opposite to the main doors.	C
Emergency	Fire drill records	NFPA 101	Regular fire drills documented by the school.	Once each school year	C



Part of the safety training



natural light and ventilated classrooms

Discussion

The findings of this study indicate that the school building, taken as a whole, largely satisfies international life-safety and building code standards in terms of structural layout, general means of egress, and occupancy provisions. However, a significant exception was identified in the basement level, where a space originally designed to be an extra 4 classrooms has been converted into a theater/assembly space. This conversion was carried out without corresponding upgrades to meet the life-safety requirements associated with assembly occupancies, and the analysis reveals three interrelated deficiencies: insufficient floor area relative to occupant load, inadequate ventilation, and an excessive egress travel distance.

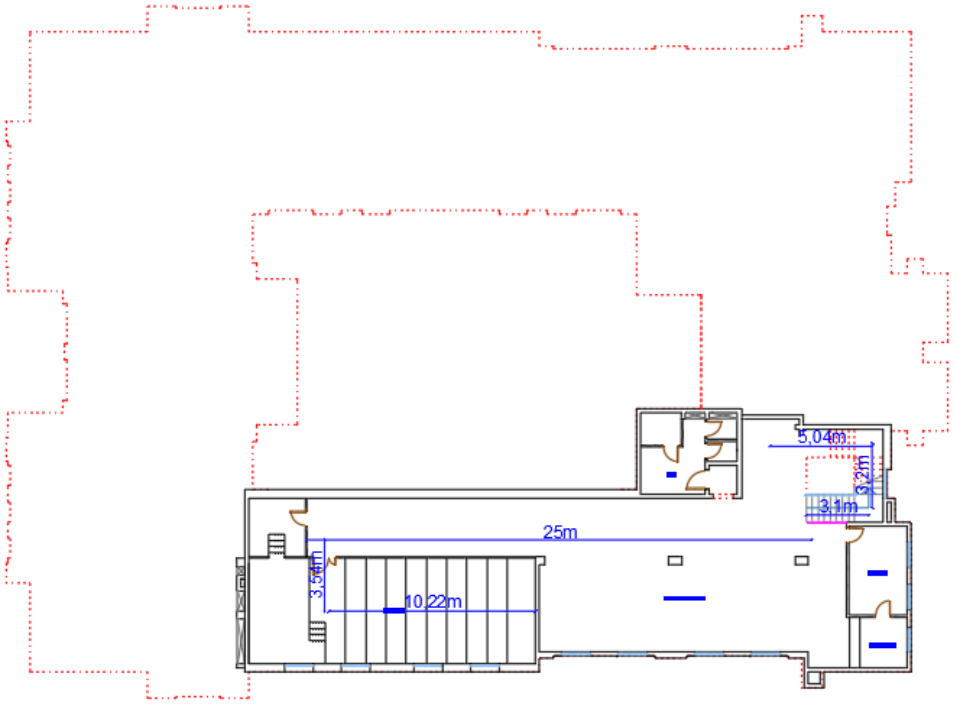
Occupant Load and Floor Area

The converted theater measures 5 m × 14 m, giving a floor area of approximately 70 m², within which 71 fixed chairs have been installed. Based on the minimum net floor area per person required for assembly seating under international standards, a space accommodating 71 occupants should provide no less than 88 m². The existing room therefore falls short of the required area by roughly 18 m², representing a deficit of approximately 20%. This shortfall translates directly into overcrowding: seats, aisles, and row spacing are compressed beyond recommended tolerances, which in turn narrows the effective width of internal circulation paths. In an emergency, this reduction in usable space would slow occupant movement toward the exit

door, increase the likelihood of congestion and falls, and undermine the assumptions on which safe evacuation timing is normally based.



The original basement plan.



As - Built basement plan.

Ventilation Deficiency

The absence of adequate airflow within the theater compounds the risks associated with overcrowding. Assembly spaces of this type are expected to maintain a minimum rate of air exchange both for occupant comfort and, more critically, for smoke and heat management in the event of a fire. Without mechanical or natural ventilation providing measurable airflow, smoke generated by a fire originating in or near the theater would be expected to accumulate rapidly within the enclosed basement volume, reducing visibility and breathable air along the evacuation path more quickly than in a properly ventilated space. Given that the room is below grade, this hazard is intensified, since smoke and heat cannot passively vent upward and out of the building as they might in an above-grade space with limited exterior openings.

Egress Travel Distance

The most significant finding concerns the length of the evacuation path from the theater to a point of safety outside the building. Measuring from the rear row of seating — the worst-case starting point for an occupant — the distance to the theater's exit door is approximately 11 m. From that door, occupants must then travel roughly 25 m along a corridor to reach the first step of the U-shaped stairwell connecting the basement to the ground floor. An additional 12 m (plus a further 2 m allowance for the final approach) is then required to pass through the stairwell and reach the building's exterior exit. Summing these segments yields a total egress travel distance of approximately 50 m.

This figure exceeds the 46 m maximum exit access travel distance permitted for occupancies without an automatic fire sprinkler system, as established under international life-safety codes. The 4 m excess may appear modest in isolation, but travel distance limits are not arbitrary margins — they are calculated to correspond to the maximum time occupants can safely remain exposed to untenable conditions (heat, smoke, and reduced visibility) before reaching safety, under the assumption that no automatic suppression system is present to slow fire and smoke development. Because the basement theater lacks such a system, the 46 m threshold applies in its most conservative form, and the measured 50 m path represents a direct, quantifiable violation rather than a marginal or borderline condition.

Synthesis

Individually, each of the three deficiencies identified reduced; floor area, poor ventilation, and excessive travel distance; would be cause for corrective action. Considered together, however, they interact in ways that compound the overall risk. An occupant load compressed into insufficient area will move more slowly at the point of origin; a lack of ventilation means that any delay allows smoke and heat to accumulate more rapidly in the space occupants must first cross; and the resulting evacuation path already exceeds the maximum distance considered safe even under ideal conditions. In effect, occupants of the basement theater face a longer path to safety, a slower start to that path due to crowding, and a more hazardous atmosphere while traversing it a combination that meaningfully elevates the risk to life safety in the event of a fire.

These results suggest that while the school building's original design reflects sound compliance with international standards, the informal or unregulated conversion of the basement space into an assembly occupancy introduced life-safety risks that were not present in the building's original configuration. This highlights a broader concern relevant beyond this single case study: retrofitting or repurposing existing spaces; particularly below-grade rooms; for higher-occupancy uses such as theaters or auditoriums requires a full life-safety review, not merely a structural or aesthetic one, since occupancy classification changes carry code obligations (occupant load

calculations, ventilation, and egress distance among them) that are easy to overlook when the modification is treated as a simple interior renovation.

Recommendations arising from this discussion (which may be developed further in a subsequent section) would reasonably include: relocating or reducing the seating count to meet the 88 m² minimum, installing mechanical ventilation with measurable air exchange, and either shortening the egress path; for example, by introducing a secondary exit closer to the theater; or installing an automatic fire sprinkler system, which would relax the applicable maximum travel distance and bring the space back within compliance.

Recommendations

Based on the deficiencies identified in the basement theater; insufficient floor area, inadequate ventilation, and excessive egress travel distance; the following recommendations are proposed to bring the space into compliance with international life-safety standards. These are organized from most urgent/immediate to longer-term structural solutions.

1. Reduce Occupant Load or Increase Floor Area

Since the theater's current area (70 m²) falls short of the 88 m² required for 71 occupants, the most immediate and lowest-cost corrective measure is to reduce the number of seats to match the available area, rather than undertaking structural expansion.

Recalculate the maximum permissible occupant load based on the existing 70 m² and remove the excess chairs accordingly.

2. Improve Ventilation and Smoke Management

The absence of measurable airflow in the theater should be addressed as a priority, given the compounding risk it poses during a fire event in a below-grade space.

Install a mechanical ventilation system (supply and exhaust) sized to meet the minimum air-change-per-hour rate required for assembly occupancies.

Incorporate a dedicated smoke extraction/venting system, or integrate smoke control into the mechanical ventilation design, to actively remove smoke from the space during an emergency rather than relying on passive dispersal.

Ensure ventilation ductwork and controls are tied into the building's fire alarm system, so that smoke extraction activates automatically upon detection.

Conduct periodic testing and maintenance of the ventilation system to ensure it remains functional over time.

3. Shorten the Egress Travel Distance

The measured 50 m travel distance exceeds the 46 m maximum allowed for occupancies without an automatic fire sprinkler system. Two independent strategies can resolve this — either alone would bring the space into compliance, though pursuing both provides a stronger safety margin.

a) Install an Automatic Fire Sprinkler System

Adding a sprinkler system to the basement (or the building as a whole) would qualify the space for the extended travel distance allowance typically granted under international codes for sprinklered occupancies, effectively resolving the current violation without altering the physical layout.

b) Introduce a Secondary/Direct Exit

Where sprinkler system the space is not immediately feasible, a secondary exit should be considered; for example, a direct stairwell or emergency door leading from the theater (or the corridor immediately outside it) straight to an exterior grade-level exit, bypassing the long 25 m corridor route to the main U-shaped stairwell. This would:

Shorten the primary travel distance significantly. ·

- Provide a redundant means of escape in case the main stairwell becomes blocked or filled with smoke.
- Align with the general life-safety principle of providing at least two remote means of egress for assembly occupancies.

4. Interim Measures (Until Structural Changes Are Implemented)

While permanent corrective works are planned and executed, the following interim measures are recommended to reduce risk:

- Temporarily cap the theater's occupancy at a level consistent with the current 70 m² area until either the area is increased or the chair count is reduced.
- Install portable or temporary ventilation/extraction fans to improve airflow until a permanent mechanical system is installed.
- Clearly mark and illuminate the egress path with photoluminescent or battery-backed exit signage along the full 25 m corridor and stairwell, given the extended travel distance.
- Conduct regular fire drills specific to the basement theater to familiarize staff and students with the extended evacuation route and identify potential bottlenecks in practice.

5. Policy Recommendation

More broadly, this case illustrates the need for a formal life-safety review process whenever an existing space within a school (or similar occupancy) is repurposed for a different use. It is recommended that the school administration, and Libyan Ministry of Education/ Private Education Administration, require that any future space conversions, particularly changes to assembly use or below-grade spaces, be reviewed against occupant load, ventilation, and egress requirements before renovation work begins, rather than after the space is already in

6. References

1. Al-Ansary, N. F., El-Sharkawy, M. F., & Alsulaiman, S. A. (2023). Safety preparedness in Arab public schools. *Heliyon, 9*(9), Article e19635. https://doi.org/10.1016/j.heliyon.2023.e19635
2. Broken Chalk. (n.d.). *Educational challenges in Libya*. Retrieved July 11, 2026, from https://brokenchalk.org/educational-challenges-in-libya/
3. Hassanain, M. A., Aljuhani, M., Hamida, M. B., & Salaheldin, M. H. (2022). A framework for fire safety management in school facilities. International Journal of Built Environment and Sustainability, 9(2), 1–12. https://doi.org/10.11113/ijbes.v9.n2.901
4. International Code Council. (2021). International Building Code (IBC). ICC.
5. Kihila, J. M. (2017). Fire disaster preparedness and situational analysis in higher learning institutions of Tanzania. Jàmbá: Journal of Disaster Risk Studies, 9(1), Article 311. https://doi.org/10.4102/jamba.v9i1.311
6. Kodur, V., Kumar, P., & Rafi, M. M. (2020). Fire hazard in buildings: Review, assessment and strategies for improving fire safety. PSU Research Review, 4(1), 1–23. https://doi.org/10.1108/PRR-12-2018-0033
7. Nadzim, N., & Taib, M. (2014). Appraisal of fire safety management systems at educational buildings. SHS Web of Conferences, 11, Article 01005. https://doi.org/10.1051/shsconf/20141101005
8. National Fire Protection Association. (2022). NFPA 10: Standard for Portable Fire Extinguishers. NFPA.

9. National Fire Protection Association. (2024). NFPA 101: Life Safety Code. NFPA.
10. National Fire Protection Association. (2025). NFPA 72: National Fire Alarm and Signaling Code. NFPA.
11. Saxena, R., & Kamal, M. A. (2018). The impact of built environment on crime prevention and safety in schools: An environmental-behaviour design guidelines approach. *American Journal of Civil Engineering and Architecture, 6*(6), 260–270. https://doi.org/10.12691/ajcea-6-6-5
12. Sholanke, A. B., Ekhaese, E. N., & Ekundayo, P. A. (2024). Users' knowledge of fire safety measures in educational environment: A case study of a college building in Nigeria. International Journal of Safety and Security Engineering, 14(1), 135–143. https://doi.org/10.18280/ijsse.140113
13. The National. (2021, August 5). *In Libya, the education system suffers more than most*. https://www.thenationalnews.com/opinion/in-libya-the-education-system-suffers-more-than-most-1.211393
14. WENR (World Education News + Reviews). (2022, October 19). *Education in Libya*. https://wenr.wes.org/2004/07/wenr-julyaugust-2004-education-in-libya
15. World Bank. (2025, June 13). *Building safer and more resilient schools in a changing climate*.https://www.worldbank.org/en/topic/disasterriskmanagement/publication/stronger-building-codes-for-a-safer-more-resilient-future