



Fire Risk Estimation of Public-School Buildings in Thailand's Rural Areas

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ABSTRACT

Accidental and intentional fires that can pose a threat to people's lives and destroy buildings. This study aimed to assess fire risk in 41 public school buildings in Ubon Ratchathani University-affiliated schools in rural areas using the risk level estimator found in BS8800. Data were gathered using a questionnaire and a checklist in compliance with Thailand's fire control regulations. Data were analyzed using descriptive statistics including frequency and percentage. The results showed that 90.14% of public-school buildings were at risk of fire. There were no proper and sufficient fire prevention and suppression systems that met Thailand's fire regulations. Only one school successfully completed the fire prevention and suppression plan. However, most schools did not instruct students and staff in basic firefighting. Therefore, concerned agencies should consider reducing fire risk and creating fire safety policies to ensure greater safety when fires do occur, especially in schools.

Keywords: BS8800; Fire risk assessment; Public buildings; Rural areas; Schools

1. Introduction

A fire hazard is anything that creates the potential for a fire to occur or worsen; fires can threaten people's lives, the building's structural integrity, and property. According to the World Fire Statistics Report 2018, No. 23, 2.5 to 4.5 million fires were estimated to have occurred between 1993 and 2016, with

approximately 21,000 to 62,000 fire deaths reported from 57 different countries [1]. Fire hazards have led to the damage or destruction of many rural structures because wood is the primary building material used in rural residential construction [2]. Thailand has frequently had to deal with fires in the past. More than 52,000 fire events occurred between

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1989 and 2015, resulting in 4,532 injuries, 1,740 fatalities, and property damage totaling more than 31 billion baht [3]. Additionally, more than 3,500 fires occurred between 2016 and 2018, more than 60 of which were in schools [4]. The schools that have been burned down include Pitakkiat Wittaya School in Wiang Pa Pao District, Chiang Rai. The dormitory of this all-female primary school caught fire in 2016. This incident led to the deaths of 17 students. Due to the wood construction of the dormitory building and the malfunctioning alarm signaling system, the fire burnt fiercely [3]. In Ubon Ratchathani Province, the Ban Na Du school building had a fire incident as well. The fire started rapidly because the school building, which was two stories and constructed of half-cement and half-wood, was over 30 years old [5]. Ban Don Klang School in That Subdistrict of Warin Chamrap District, experienced a fire in 2016. The damaged building was a two-story half-cement and half-timber school building constructed more than 41 years ago [6]. Ban Nong Bok School in Muang Nongkhainok Subdistrict, Sam Sip District, experienced a fire in 2019. The building that burned down was a half-cement and half-timber school building constructed more than 40 years ago [7]. As these fire incidents demonstrate, most rural school buildings are quite old and were constructed from timber. When a fire breaks out, the damage is more severe if the structure is not constructed from fire-resistant materials.

The school network known as Ubon Ratchathani University-affiliated schools works together to establish academic programs and services for both primary and secondary schools. The schools in this group have, for example, classrooms, computer rooms, nurseries, teacher's rooms, and storage rooms, all of which pose a risk of fire due to ignorance on the part of school personnel who may misuse electrical appliances or store flammable materials or chemicals carelessly. Moreover, without adequate containment and protection, a fire can cause severe damage. In Thailand, there are several laws and

regulations on fire prevention and extinguishing management in buildings, which include Ministerial Regulation No. 33 (B.E. 2535), Standard of Fire Prevention and Suppression System (as amended by Ministerial Regulation No. 42 (B.E. 2537) and No. 50 (B.E. 2540)), and Ministerial Regulation No. 47 (B.E. 2540) issued by virtue of the Building Control Act (B.E. 2522) [8]. These laws and regulations must be followed by those responsible for fire prevention.

However, numerous structures under the control of governmental organizations have been unable to adhere to the fire legislation, especially when it comes to school buildings in rural areas where funding and operating costs are constrained. Additionally, there are few studies on fire assessments in rural schools where buildings have been destroyed. As a consequence, the researchers of this study chose Ubon Ratchathani University-affiliated schools, which are part of the Office of the General of Basic Education Commission and have primary and secondary levels, to assess fire risks by following the risk level estimator contained in BS8800. This research aimed to serve as a guide for improving fire prevention and suppression systems in rural schools to ensure that they are appropriate and more secure.

2. Materials and Methods

2.1 Population and sample

Forty-one public school buildings from 10 Ubon Ratchathani University-affiliated schools with primary and secondary education levels were chosen as the sample. All of the school buildings included in this study were designated as public buildings.

2.2 Research tools

1. Checklist. There are 22 items on the checklist for fire suppression and prevention systems in Ubon Ratchathani University-affiliated schools that comply with Ministerial Regulation No. 33 (B.E. 2535), Standard of Fire Prevention and Suppression System (as amended by Ministerial Regulation No. 42

(B.E. 2537) and No. 50 (B.E. 2540)), and Ministerial Regulation No. 47 (B.E. 2540).

2. The questionnaire concerns general school information and information about school emergencies such as fires.

2.3 Research tool quality assessment

The tools' quality was assessed using the following methods: The questionnaire had a number of closed-ended questions. An index of item objective congruence (IOC) between 0.67 and 1.00 was obtained after three experts had verified the content validity.

2.4 Data collections

1. Forty-one public buildings administered by Ubon Ratchathani University-affiliated schools were surveyed. Teachers in charge of the school's safety and building construction, as well as the school's director, were asked to complete questionnaires.

2. Data collected from the questionnaire were utilized to determine the risk level using the BS8800 risk estimator, as shown in Table 1.

3. Risk estimates were interpreted as shown in Table 2.

Table 1. The risk level estimations for public school buildings in Ubon Ratchathani University-affiliated schools.

Likelihood of fire	Consequences of Fire		
	Slight Harm	Moderate Harm	Extreme Harm
Low	Very low risk	Low risk	Moderate risk
Medium	Low risk	Moderate risk	High risk
High	Moderate risk	High risk	Very high risk

Source: British Standard 8800, 2004 [9].

Table 2. Evaluation of risk tolerability

Categories of risk	Evaluation of tolerability
Very low risk	Acceptable
Low risk	
Moderate risk	Risks should be reduced
High risk	
Very high risk	Unacceptable

Source: Nunes (2016) [10].

2.5 Data analysis

The qualitative variables, such as general information and data from the fire prevention and suppression system checklist, the risk levels, and the tolerability of risk, are presented using frequency and percentage.

The quantitative variables are presented using mean, standard deviation, maximum, and minimum.

2.6 Ethical considerations

This study was approved by the Human Research Ethics Committee of Ubon Ratchathani University (code UBU-REC-134/2565).

3. Results and Discussion

3.1 Results

The study found that all the schools affiliated with Ubon Ratchathani University have an average age of 66.00 years (S.D. = 36.36). Most of the public-school buildings were constructed with concrete (70.73%) and half-timber and half cement (26.83%). The schools had manual fire alarms (66.70%), fire extinguishers (90.90%), and fire-prevention and suppression plans in place (90.00%). Additionally, it was discovered that more than half of the students and staff had never received any basic firefighting training (60.00%), the fire protection and suppression equipment was not inspected or maintained (70.00%), the schools did not practice fire evacuation drills (70.00%), and the schools had never experienced a fire (90.00%) (Table 3).

Table 3. General information on Ubon Ratchathani University-affiliated schools ($n = 10$).

General information	Frequency	Percentage
Schools' age (years)		
Mean = 66.00 S.D. = 36.36 Min = 30		
MAX = 100		
Building type (41 buildings)		
Public building	41	100
Construction materials used (41 buildings)		
Cement	29	70.73
Wood	1	2.44

Half timber and half cement	11	26.83
Fire-safety equipment availability (check all that apply)		
Smoke detectors	1	8.30
Manual alarm devices	8	66.70
Voice alarm devices	1	8.30
Lightning protection systems	1	8.30
Electric cutting machines	1	8.30
Fire-extinguishing equipment availability (check all that apply)		
Fire hoses	1	9.10
Fire extinguishers	10	90.90
Existing fire-prevention and suppression plans in accordance with the law (check all that apply)		
All plans in place	1	10.00
Some plans in place	9	90.00
- Inspection plans	2	11.10
- Training plans	3	16.70
- Fire prevention campaign plans	6	33.30
- Fire plans	2	11.10
- Fire evacuation plans	2	11.10
- Relief plans	3	16.70
Have arranged basic firefighting training for staff and students		
Never	6	60.00
Yes	4	40.00
Training recently completed within 1 year	4	40.00
Inspection and maintenance of fire suppression and protection equipment		

No	7	70.00
Yes	3	30.00
Fire evacuation drills		
No	7	70.00
Yes	3	30.00
Experience of school fires		
No	9	90.00
Yes	1	10.00

According to the survey conducted at 41 public buildings of the schools affiliated with Ubon Ratchathani University, the ground level of each school building did not have drawings that prominently displayed where rooms, fire extinguishing equipment, doors, or fire escapes were located. It also found that 97.60% of the schools did not make adequate effort to promptly activate an automatic fire alarm and an automatic fire suppression system that covers every floor of the building. Moreover, 95.10% of them did not install a well-connected lightning protection system made up of poles, lightning rods, conductor cables, and grounding conductors that met the Department of Energy Development and Promotion's standards for electrical safety (Table 4).

Table 4. List of findings from building inspections that did not meet the qualifications required by law ($n = 41$).

ID	Description	Aspects not meeting the qualifications	
		Frequency	Percentage
1	There is a signaling device for the fire escape that can transmit noises or signals for those within the building to hear or fully understand.	29	70.70
2	An automatic alarm system is present.	40	97.60
3	There is a manually operated alarm system present.	30	73.20
4	Fire extinguishers are installed throughout the entire structure. The distance is 20 meters or less, and the height above floor level is 1.5 meters or less.	32	78.00
5	Fire extinguishers are placed in an open space that is both easily seen and accessible.	25	61.00
6	Fire extinguishers are tested at least once every six months.	36	87.80
7	There is an automatic fire extinguishing system that can be activated immediately in the event of a fire and cover every floor of the building.	40	97.60
8	There are at least two fire escape stairs from the top floor or terrace to the ground.	12	29.30
9	There is a fire escape stair that is conveniently positioned so that everybody in the building may access it.	12	29.30
10	Fire escape stairs and terraces have fireproof walls on the side where the stairs pass.	10	24.49
11	The emergency power system illuminates the fire escape so that people can see the exit during a fire.	25	61.00
12	Every floor of the fire exit door has floor indications and fire exit signs on the interior and exterior.	28	68.30
13	There are fire escape signs and floor signs with legible lettering. There is no smaller letter size than 10 cm.	29	70.70
14	Fireproof materials are used to construct fire doors.	26	63.40

15	It is convenient to open the fire door anytime needed.	1	2.40
16	The walls of the fire escape staircase inside the building are non-combustible on all sides.	8	19.50
17	The ground level of each school building has drawings that prominently display where rooms, fire extinguishing equipment, doors, or fire escapes are located.	41	100.00
18	No less than one fire extinguisher is installed on each floor; at least fire extinguisher one per 1,000 square meters; and at least one fire extinguisher per 45 meters of distance.	32	78.00
19	A lightning protection system, which is made up of poles, lightning rods, conductor cables, and grounding conductors, is installed systematically and connected in accordance with the Department of Energy Development and Promotion's standards for electrical safety.	39	95.10

Fire risk estimate on public school building. This study found that Ban Don Klang School had a high level of risk, with 48 out of 70 concerns (68.57%) present. The risk levels at the other schools were both low and very low. This study found 497 concerns, of which 400 were low-risk (80.48%), 49 were very low risk (9.86%), and 48 were high-risk (9.66%) (Table 5). The related issues that raise concerns about the high risk as identified at Ban Don Klang School include a lack of a fire alarm system that can be heard or detected by

those inside the building, not having sufficient fire extinguishers in place to cover the entire building, not having a lightning protection system in place, not having fire doors made of fireproof materials, the emergency power system not providing enough lighting for the fire escape stairs, and the ground level of each school building not having drawings that prominently display where rooms, fire extinguishing equipment, doors, or fire escapes are located.

Table 5. Fire risk levels at public school buildings of Ubon Ratchathani University-affiliated schools.

School names	n (concerns)	Risk Levels (Percentage)				
		Very low	Low	Moderate	High	Very high
Ban Mad Kam Laucha	34	11.76	88.24	0.00	0.00	0.00
Ban Hae Nam Thang	31	6.45	93.55	0.00	0.00	0.00
Chumchon Bansrikhai	36	11.11	88.89	0.00	0.00	0.00
Ban Nong Song Hong	41	14.63	85.37	0.00	0.00	0.00
Bua Wat	19	15.79	84.21	0.00	0.00	0.00
Ban Non Dang	87	9.20	90.80	0.00	0.00	0.00
Ban Pho	56	10.71	89.29	0.00	0.00	0.00
Kham Khwang	62	12.90	87.10	0.00	0.00	0.00
Ban Don Klang	70	0.00	31.43	0.00	68.57	0.00
Ban Kumuang	61	13.11	86.89	0.00	0.00	0.00
Total	497	9.86	80.48	0.00	9.66	0.00

Remark: Concerns refer to issues that are substandard following a checklist survey in each school.

As shown in Table 6, the tolerable risks in public school buildings in the event of a fire were at an acceptable level in 9.86% of cases and the risks should be reduced in 90.14% of cases.

Table 6. Tolerability of risk at public school buildings of Ubon Ratchathani University-affiliated schools ($n = 497$ concerns).

Tolerability of risk	Frequency	Percentage
Acceptable	49	9.86
Risk should be reduced	448	90.14

3.2 Discussion

According to this study, the majority of schools have public buildings that are less than 23 meters high. The level of risk that could be tolerated in a Ubon Ratchathani University-Affiliated public-school building was 90.14%, which means relevant agencies should consider taking steps to reduce fire risk and prepare plans to ensure that proper controls are maintained. It was found that more than 30% of the buildings were reported to be constructed of wood which is more prone to fire than buildings made of other materials. These findings are consistent with a 2019 study by Liu et al. that found timber structures to be more likely to collapse during fires [2].

The issues regarding fire prevention and suppression systems in Ubon Ratchathani University-affiliated schools can be classified into six categories: 1) no fire alarm system that can provide a clear signal for everyone inside the building to hear or understand; 2) no portable fire extinguishers sufficiently covering the entire area of the building; 3) no lightning protection system in place; 4) fire escape doors constructed of materials that cannot withstand fire; 5) the emergency power system does not illuminate the fire escape stairway; and 6) no fire escape or door in a clearly visible location on the ground level of the structure and the ground level of each school building does not have any drawings that prominently display where rooms, fire extinguishing equipment, doors, or fire escapes are located. Furthermore, upon visiting the schools, the researchers found that the schools lacked the budget for purchasing equipment and maintaining or replacing broken equipment such as fire alarms, fire extinguishers, lightning protection systems, and emergency power systems. If these emergency tools are not installed, it could have detrimental effects on the building and the lives of students and staff in case of a fire emergency. The findings of this study are in line with Kungsadan's research (2017), which found inadequate monitoring of equipment and fire protection systems and a lack of a

maintenance schedule in school buildings [11]. The findings of this study are also congruent with the findings of Noisuwan et al., (2013) and Akashah et al., (2017), which revealed that the fire protection systems and equipment in the studied buildings were unavailable, insufficient, and poorly maintained [12, 13]. Furthermore, these findings are also in line with a study by Lui et al., (2017), which found that the security exits were blocked, the evacuation's width was reduced, and the evacuation signs were covered in the old shopping stores [14].

It was also discovered that many schools had problems with moving fire extinguishers, which were then not installed back at the original location. Consequently, there were no readily available fire extinguishers. In the event of an emergency, this can result in the initial fire not being put out in time, leading to a more severe fire incident. This is in agreement with a study by Vorakarnchanabun et al. (2021), which found that public buildings like temples almost always have issues, including improper installation of fire extinguishers that are installed in the area of blind corners, construction material blocking access to the fire extinguishers, and no clear signage indicating the location of fire extinguishers [15].

The present study also found that only one school had completed the inspection, training, fire prevention campaign, fire evacuation, and relief plan for preventing and suppressing fires. Most of the schools did not train students and staff on the basics of firefighting (60.00%) and did not conduct fire evacuation exercises (70.00%). As a result, students and staff will not be able to put out a fire and get everyone out of the accident site in an emergency since effective basic firefighting and fire evacuation requires prior skills and knowledge according to research by Wang et al., reporting that the main cause of fires is usually human behavior, which was followed by combustible materials, speed of rescue, and staff assignment [16]. This is also consistent with research indicating that staffs rarely

received training or participated in emergency drills [17, 18]. According to a study by Kodur et al. on fire hazards in buildings (2019), the main causes of fires were found to be inadequate planning or training for fire suppression and evacuation [19]. These findings are in line with Ronchi et al., (2013), who indicated that the training demonstrates how evacuation models can be used to evaluate evacuation plans and safety concerns related to high-rise buildings [20].

4. Conclusion

The public buildings of Ubon Ratchathani University-affiliated schools were found to be at risk of fires, as their fire prevention and suppression systems did not meet the standards required by Thailand's fire protection and suppression laws and regulations. Therefore, relevant agencies such as the Office of the Basic Education Commission and the Bureau of Disaster Prevention and Mitigation should collaborate to reduce fire risk and develop procedures to ensure that fire safety systems are properly implemented.

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References

- [1] International Association of Fire and Rescue Services. CTIF report-world fire statistics [Internet]. [cited December 20, 2022]. Available from: https://www.ctif.org/sites/default/files/2018-06/CTIF_Report23_World_Fire_Statistics_2018_vs_2_0.pdf.
- [2] Liu Y, Liu W, Luan J, Tian Y. Research Progresses and Needs on Fire Safety of Rural Building in Southern Region of China. *Earth Environ Sci* 2019;371:032083.
- [3] Department of Disaster Prevention and Mitigation. Workshop report on Fire safety for all, 2016. Department of Disaster Prevention and Mitigation. Ministry of Interior. Thailand; 2016.
- [4] Department of Disaster Prevention and Mitigation. Fire Statistics. [Internet]. [cited December 15, 2022]. Available from: http://direct.disaster.go.th/cmsdetail.directing-7.191/35277/menu_4469/4095.1/
- [5] Katevong N. School fire report 2015. Ban Na Du school, Na Di Subdistrict, Na Yia District, Ubon Ratchayhani Province. 2015.
- [6] Phonhan S. School fire report 2016. Ban Don Klang School, That Subdistrict, Warin Chamrap District, Ubon Ratchayhani Province. 2016.
- [7] Chaisena S. School fire report 2019. Ban Nong Bok School, Nongkhainok Subdistrict, Muang Sam Sip District, Ubon Ratchayhani Province. 2019.
- [8] Department of Public Works and Town & Country Planning. Ministerial Regulation, issued by virtue of the Building Control Act, B.E. 2522 [Internet]. [cited December 20, 2022]. Available from: http://oldoffice.dpt.go.th/legal/images/pdf/legal_11.pdf
- [9] British Standard Institution. BS 8800: Guide to Occupational Health and Safety Management Systems. Health and Safety Commission; 2004.
- [10] Nunes FO. Application of a Configurable Model for Risk Assessment in the Work Sites. *J Saf Sci Technol* 2016; 6(4): 99-125.
- [11] Kungsadan K. Building fire safety assessment a case study of 2 storey building 36 meter high Sukhumvit soi Thonglor 20. Proceeding 14th National Academic Conference, Kasetsart University Kamphaeng Saen Campus. 2017.

- [12] Noisuwan Y, Chandarasorn V. Risk assessment on High-rise building in Khon Kaen Municipality, Mueang District, Khonkaen Province. *Var* 2013; 3(1): 29-44.
- [13] Akashah FW, Baaki TK, Lee SP. Fire Risk Assessment of Low Cost High Rise Residential Buildings in Kuala Lumpur: A Case Study. *J Des Built Environ* 2017; 124-39.
- [14] Liu F, Zhao S, Weng M, Liu Y. Fire risk assessment for large-scale commercial buildings based on structure entropy weight method. *Saf Sci* 2017; 94: 26-40.
- [15] Vorakarnchanabun N, Kongchot W, Pangwattanakul P, Vachirasakchai T. Building fire safety assessment a case study of 14 floors academic building. An independent study, Master of Science in Facility Management, Faculty of Architecture Sripatum University [Internet]. [cited December 20, 2022]. Available from: <http://dspace.spu.ac.th/handle/123456789/3085>
- [16] Wang Y, Ni X, Wang J, Hu Z, Lu K. A Comprehensive Investigation on the Fire Hazards and Environmental Risks in a Commercial Complex Based on Fault Tree Analysis and the Analytic Hierarchy Process. *Int J Environ Res Public Health* 2020; 17:7347.
- [17] Zou Q, Zhang T, Liu W. A fire risk assessment method based on the combination of quantified safety checklist and structure entropy weight for shopping malls. *J Risk Reliab* 2021; 1-17.
- [18] Omar M, Mahmoud A, Aziz SBA. Fire Safety Index for High-Rise Buildings in the Emirate of Sharjah, UAE. *Fire* 2023; 6:51.
- [19] Kodur V, Kumar P. Fire hazard in buildings: review, assessment and strategies for improving fire safety. *PSU Res Rev* 2019; 4(1): 1-23.
- [20] Ronchi E, Nilsson D. Fire evacuation in high-rise buildings: a review of human behaviour and modelling research. *Fire Sci Rev* 2013; 2:7.