Building safety index for elementary school building in West Sumatera

Masril¹, Deddy Kurniawan¹ and Mohammad Ismail²

¹Postgraduate Student of Civil Engineering Faculty, Universiti Teknologi Malaysia, Skudai, 81310, Johor Bahru, Johor, Malaysia
²School of Civil Engineering, Faculty of Engineering, Universiti Teknologi Malaysia, Skudai, 81310, Johor Bahru, Johor, Malaysia

Email: mril6030@gmail.com

Abstract. Safety and health in building planning must be considered during the building service period. The research objective is the application of Safety Building Index (BSI) in elementary school building planning. The factors of previous research were six factors, and the authors assessed seven, namely architectural factors, building services, the external environment, operational and maintenance, administration and management of building maintenance. The research method was carried out by distributing questionnaires then distributed to construction practitioners such as architects, engineers, surveyors, contractors, consultants and developers. After completing the questionnaire, form to carry out the analysis with the SPSS program. The results of statistical analysis reveal the highest level of influence of each building factor on building planning. The research findings are the influence of each of the factors reviewed and which factors are dominant. The most dominant factors that must be considered by planners in designing elementary school buildings so that the Building Safety index can be applied in elementary schools in West Sumatra Padang.

1. Introduction

The construction sector in Indonesia is growing rapidly in accordance with the progress of the era. Construction work has developed into an increasingly complex job and requires an increasing amount of costs, so that the implementation of building structure design is reviewed based on four sectors namely, residential buildings, non-residential buildings, civil engineering buildings and special trade sector buildings (Amirul Rusyidie bin Rajali).

The development sector involves the construction of non-residential construction consisting of all building construction other than residential. Civil Engineering is related to the construction of public infrastructure such as Building Buildings.

In the implementation of building infrastructure development for public services it seems that elementary schools must be planned in accordance with good standards to ensure that residents can feel safe and comfortable in the planned building.
2. Theoretical study

In the design process, it is very important to implement security measures. Therefore, there is a lot of literature that describes building designs that play an important role in building safety in construction.

According to Suharto (1999), project activities can be interpreted as a temporary activity that takes place in a limited period of time, with the allocation of certain funding sources and intended to carry out tasks whose objectives have been outlined in a firm manner. Many activities and parties involved in implementing construction projects.

In the design process, it is very important to implement security measures. Therefore, a lot of literature shows that building design plays an important role in building safety. Al-Hamoud and Khan [13] highlight that unnecessary hazards in building design can reduce much more easily on the drawing board than in cases after corrective action. They identified that if there were clear rules and were enforced, the designer would be aware of the security requirements in the design process.

It is necessary to study the factors that build safety and health performance that have been identified by previous research. The hierarchical structure of the building’s safety and health factors is to give an initial idea of what previous researchers have discovered are the factors that contribute to building safety and health performance. The safety and health framework must be comprehensive enough to address all relevant safety and health issues. However, it needs to be concise enough to present building safety and health factors systematically.

A literature review is conducted to obtain and establish some knowledge about the topic of learning. The literature review is carried out by collecting all relevant information carried by reading journals, previous theses, articles, especially from newspapers, the internet and books that are in accordance with the topic of study. All references involved were identified in advance to assist in completing this study. The literature review was made to collect relevant information as much as possible facilitating the course of the study and also to improve understanding of the study.

From previous research assessing Building safety index discussed the relevance of these factors in accordance with local design and construction quality, climate, environmental conditions. The research questions consisted of: Building factors, Building Services, External Environment (Amrizul Rusydie bin Rajali).

3. Research Methodology

The research method used in this study uses literature studies and factor analysis in the field of building safety index for elementary school building in West Sumatra, as illustrated in Figure 1 below.

![Figure 1. Research methodology.](image)

Analysis of data collected using Statistics (SPSS) Version 23.0. Basically, to determine the mean and standard deviation of each sub-factor. Ranking analysis is used by ranking key variables. The average value (with 1 - not significant for 5 is very significant) is used to rank the variable factors that contribute to safety and health performance. The main purpose of ranking analysis is to show the differences in the level of significant factors regarding safety and health among variables.
4. Analysis

4.1 Scope of Architecture

In the design of an architectural building plays a very important role. When we review the broader understanding of architecture, it includes designing a comprehensive environment built, starting from the macro level namely urban planning, urban design, and landscape. Architecture refers to the configuration of the layout and disposition of buildings, which are added to provide a greater environment and the best design details. Architectural problems have been long and many are handled by many researchers.

In 1984, Banham emphasized on human needs and environmental problems to be considered as an integral part of architecture, systematically explored the impact of engineering health and comfort on the building design and mind of the architects [23]. Bokalders and Block [24], highlighting the sustainability of development must be made more extensive changes in architecture, construction and spatial planning to reduce the environment, safety and health impacts of buildings. Therefore, the focus of architecture is not only on the aesthetics of aspects, it must be in combination with certain structural solutions or styles and it must be attached to a space where certain activities can take place, be safe, comfortable and efficient.

Al-Hamoud and Khan [13] proposed a systematic security compliance checklist with safety requirements including fire system design, smoke detectors, ladders and handrails, minimum court width, exterior finishes and existing quantities and outgoing access to distances and dimensions. the variables reviewed concern the value of Architecture:
Evacuation Line, Access Point, Structure, Fireproof, Construction, Building Materials, Function Rooms.

4.2 Building Services

Evaluation studies show that the environment in a building is an important factor that affects occupants' safety, health and comfort. Thus, the health and comfort of improvements to manage indoor environmental quality have been emphasized such as thermal comfort, lighting quality, indoor air quality and acoustic quality [11].

Lai [31] states that building service installations include electrical systems, lighting, ventilation and air conditioning, water supply, drainage, fire service installations, gas supply, elevators and escalators. He suggested that installations for the safety, health and comfort of building services must function together with operations and maintenance to ensure that the conditions designed from the installation are properly delivered and maintained in their life cycle.

Further evidence regarding the relationship between overall health and safety and the scale of development has been illustrated by Wong et al [10] in relation to building services. They identified major developments that were carried out better in terms of building services because of the flexibility in adopting better building service designs and adequate funding in building maintenance and management. This leads to the following hypothesis that there is a positive relationship between building services and building safety and health performance. There are 6 variables that are reviewed concerning the value of building services, namely electricity installation, lighting, air ventilation, air conditioning, plumbing & sanitation services, Lift.
4.3 External Environment
Health and safety measures must include protection against additional hazards introduced by the external environment. Environmental hazards refer to all potential threats faced by human society by events originating from, and transmitted through, the environment [32].

They identified the main categories of environmental hazards are natural hazards (floods and landslides), technological hazards (hazardous materials, unsafe public buildings and facilities) and context hazards (environmental degradation and air pollution). In another study, Zainal, Kaur, Ahmad, and Khalili [34] measured the quality of the surrounding environment by air quality and level of peace. They found that the surrounding environment had a significant positive correlation with health status and overall quality of life. Both studies report that the external environment is a strong safety and health factor in building performance. Through this study, it is expected that the importance of the construct can be extended to the context of health and safety performance.

Five perspectives in this framework include emergency services, external hazards, density, location and fresh air quality. Wong et al. [19] proposed a valuation method that identifies a building factor affecting health and safety performance. The BQI valuation method is related to changes in the external environment, consisting of density, adjacent use, air quality, aural quality, visual obstruction, thermal comfort, proximity to special hazards and distance to station fire. Indicators tested on services to the environment consist of: Electricity Installation, External Hazards, Air Quality, Environment, Location, Period of Type.

4.4 Technical operation & maintenance

Isa et al. [24], provides a review of the relationship between good maintenance practices and good literature on conservation practices. Before proposing building guidelines for best maintenance practices, they defined the following criteria 1) clear maintenance policies, 2) program and systematic maintenance priorities, 3) produce accurate building assessments and conditions, 4) the latest information and data integration systems. Further evidence relating to operations and maintenance (O & M).

Further safety factors in building use include aging of building structures, hidden hazards brought into use of buildings by design and construction, the impact of new construction on existing surrounding security risks carried by peripheral buildings, decoration and building transformation [23]. In addition, due to historical changes and economic development, few users made destructive decorations and transformed buildings. This behavior causes some buildings to appear cracked, tilted and collapsed structures [5]. In this case, the regional department playing building management has an important role to strengthen building security management [26]. Operational and maintenance of this building Indicators tested on operations and maintenance consist of: Building peripherals, building information, building, structural and Fire Compartment integrity.

4.5 Administration – Management Approaches

Many authors agree that the assessment of structural conditions as major security factor to improve the health, safety and sustainability of building [5,6,12,14,23,25]. Furthermore, the major security factors in use of buildings includes ageing of building structure, hidden dangers brought in use of buildings by design and construction, new constructions impact on surrounding existing buildings, security risks brought by the building peripherals, decoration and transformation of buildings [23]. Moreover, because of historical changes and development of economy, few users made destructive decoration and transformation of buildings. These behaviors lead few buildings appeared structure crack, tilt and collapse [5]. In this regard, regional department of building management play
an important role to strengthen the security management of buildings [26]. This factor consists of 6 variables, namely: Emergency Plan alteration of Building, Documentation dan Evolution Safety Education. Security management, Occupant safety Management Cleanliness/ Hygiene.

4.6 Building maintenance

In this study the authors added the Building Mechanism factor from the previous researchers studied for 5 factors, in building maintenance reviewed 4 variables reviewed consisted of: architectural maintenance, structural treatments, mechanical electrical care, spatial planning.

Building Maintenance is an activity to repair and or replace parts of building components, building materials or building infrastructure and facilities that are still curative maintenance. Permenpu no 24/ PRT / M / 2008

According to Lee Low son George C. Yuen (1999) maintenance of said building as a combination of technical and administrative actions, which is meant to maintain and restore the functions of buildings as before. The success of a building is seen from the ability of the building to exist in the expected conditions which are influenced by several requirements, among others.

1. Functional requirements

Functional requirements are defined as requirements based on building functions. Each building has general requirements from specific building functions. Each building has general and special requirements that must meet. The general requirement is that the building must be able to protect its use from the outside environment. While the requirements specifically depend on the type and function of the building in this case the educational building.

2. Performance requirements

Each building has very specific performance requirements. The requirements for campus and school buildings are very different from the requirements of office buildings. The performance of the building includes many aspects, starting from the physical performance outside the building, to the mechanical and electrical elements. Building maintenance actions are strongly influenced by demands for performance related to building functions. but often there is a difference in standard performance according to the owner according to the user.

3. Requirements according to the Act.

Requirements according to the law are requirements that cannot be ignored, because they involve regulations and legality. These requirements include building height requirements and others.

4. User Requirements.

User requirements are based on safety and comfort. User comfort is a measure of the success of a building. Usually buildings that have user requirements are buildings and rental buildings and public buildings

The scope of building maintenance according to the minister of public works regulation No. 24 / PRT / M / 2008, the scope of building maintenance includes several components, namely:

a. Architectural Care

Nursing Architecture includes are:

1. Maintain the exit as a means of salvation for building users.
2. Maintain elements in the space and equipment and look outside the building so that it remains neat and clean.
3. Providing systems and maintenance facilities in the form of fixed equipment and work aids.

Carry out the right way to maintain architectural and decorative ornaments by officers who are competent in their fields.
b Structural Maintenance

Nursing Structure includes are:

1. Maintaining structural elements and protective elements of building structures from the effects of weather corrosion and loading outside the limits of structural capabilities, as well as other pollution.
2. Conduct periodic maintenance as part of preventive maintenance.
3. Maintain the building so that it is functioned in accordance with the planned use and prevents any changes or additions to the function of activities that cause an increase in the burden of working on buildings, beyond the planned load limits.
4. Carry out proper maintenance and structure improvements by officers who are competent in their fields.

c. Mechanical / Electrical (Air Management, sanitation, Plumbing and transportation, lighting, telephone, communication and alarm)

Mechanical Maintenance (Air Conditioning, Sanitation, Plumbing and transportation, lighting, telephone, communication and alarm) includes are:

1. Maintain and carry out periodic inspection of the air system, so that the air quality in the room continues to meet the technical and health requirements that are indicated include maintenance of the main equipment and air ducts.
2. Maintain and carry out periodic inspections of water distribution systems which include the provision of clean water, sewage installation systems, hydrant systems, sprinklers and septic tanks and waste treatment units.
3. Maintain and carry out periodic inspection of the transportation system in the building in the form of lifts, escalators, stairs and other vertical transportation equipment.
4. Conduct periodic checks and maintain on backup power generation equipment.
5. Conduct periodic checks and maintain electrical installation systems both for electricity supply and for lighting the room.
6. Conduct periodic checks and maintain a network of sound and communication installation and data.

d. Set the Outer Space

Outer Spatial Care includes:

1. Maintain the condition and surface of the land and / or outside yard and building.
2. Maintaining landscape elements outside and inside buildings, such as vegetation, landscape furniture, sewerage, gates and gates, outdoor lighting, and post / guard post.
3. Maintain cleanliness outside buildings, yards and the environment.
4. Conducting proper garden maintenance procedures by officers who have expertise / and compel
Figure 2. Building Safety Index Framework
5. Results

Table 1: Descriptive Analysis for architecture approach

| Variable                     | Mean    | St d. Deviation | Rank |
|------------------------------|---------|-----------------|------|
| Means Of Escape              | 4.5557  | 0.53005         | 1    |
| Means of Access              | 4.4984  | 0.50765         | 5    |
| Structural and Finishes Integrity | 4.5235  | 0.52071         | 2    |
| Fire Resistant Construction  | 4.4873  | 0.49940         | 6    |
| Building Material            | 4.4992  | 0.50986         | 4    |
| Space Functionality          | 4.5102  | 0.51978         | 3    |
| AVERAGE                      | 4.5124  | 0.51458         |      |

Table 1 shows the mean scores and standard deviations for each of the sub-factors in the architectural approach. In the analysis, Means of Escape shows as the highest value the average number is 4.5557 and the standard deviation is 0.53005. The average architectural approach is 4.5124 and the average deviation is 0.51458.

The Means of Escape average is categorized as the most influential factor in the architecture of the Approach because of people's reactions when a fire breaks out. People tend to follow the routes they are most familiar with when fires occur.

Survey respondents believe that in an emergency situation they should walk away from the fire and find a safe place, therefore in the planning of elementary school buildings need to be well designed the mean of escape when a fire occurs.

Table 2: Descriptive Analysis for building service approach

| Variable                        | Mean    | St d. Deviation | Rank |
|---------------------------------|---------|-----------------|------|
| Electricity Installation        | 4.5832  | 0.46812         | 2    |
| Emergency Lighting              | 4.5103  | 0.75611         | 4    |
| Ventilation and Air Conditioning| 4.5002  | 0.53471         | 5    |
| Plumbing & Sanitary Services    | 4.4920  | 0.78540         | 6    |
| Fire Services Installation      | 4.6801  | 0.43861         | 1    |
| Lifts                           | 4.5230  | 0.77563         | 3    |
| AVERAGE                         | 4.5481  | 0.62643         |      |

In table 2, Fire Services Installation shows the highest number, 4.6801 and 0.43861 standard deviation. And the average value of Analysis for building service is 4.5481 and the average deviation is 0.62643.

So in planning the construction of elementary schools the planners must design the building is expected to pay attention to the width of the stairs and the hands of the stairs, fire extinguisher system, as well as access to the building exit.

Table 3: Descriptive Analysis for external environment approach

| Variable                        | Mean    | St d. Deviation | Rank |
|---------------------------------|---------|-----------------|------|
| Emergency Services              | 4.0382  | 0.81023         | 2    |
| External Hazard                 | 3.9789  | 0.73241         | 3    |
| Air Quality & Peaceful          | 3.8982  | 0.74532         | 4    |
| Location                        | 4.1058  | 0.71031         | 1    |
| AVERAGE                         | 4.0053  | 0.74957         |      |
In Table 3 Analysis for the external environment approach. That the building sub-section far from danger shows the highest average score of 4.1058 and the standard deviation of 0.71031 and the average value of the external environment is 4.0053 and the standard deviation of the average - arat 0.62643. In planning the location of elementary school buildings, it is very important to pay attention to the location of the building to be built.

Table 4 Descriptive Analysis for Administration – management Approaches

| Variable                                      | Mean  | St d. Deviation | Rank |
|-----------------------------------------------|-------|-----------------|------|
| Emergency plant alteration of building        | 4.7864| 0.74435         | 2    |
| Documentation dan Avolition                   | 4.8791| 0.77343         | 1    |
| Safety education                              | 4.4532| 0.74201         | 3    |
| Occupant safety management                    | 4.4402| 0.78213         | 4    |
| Cleanliness / Hygiene                         | 4.4330| 0.75623         | 5    |
| AVERAGE                                       | 4.5984| 0.75963         |      |

In table 4 Administration - management Approaches, that the Documentation and evaluation sub-section shows the highest average score of 4.8791 and a standard deviation of 0.77343. And the average value of Administration-management Approaches is 4.5984 and the standard deviation is 0.75963. So, after the construction of the school building is complete all planning documents must be in the school.

Table 5 Descriptive Analysis for building maintenance Approaches

| Variable                                      | Mean  | St d. Deviation | Rank |
|-----------------------------------------------|-------|-----------------|------|
| Architectural Care                            | 4.7801| 0.78456         | 2    |
| Building Structure maintenance                | 4.8934| 0.75561         | 1    |
| Mechanical / electrical maintenance           | 4.6853| 0.68945         | 3    |
| Outer space maintenance                       | 4.6678| 0.75432         | 4    |
| AVERAGE                                       | 4.7567| 0.74599         |      |

In table 5 of building maintenance, the Building Structure maintenance sub-section shows the highest average score of 4.8934 and the standard deviation of 0.75561. And the average value of building maintenance is 4.7567 and the standard deviation is 0.74599. In the implementation of maintenance of buildings that have been built. building maintenance is very important so that the planned construction service period can be achieved.

The conceptual model in this study was built based on the theory of Building Safety Index based on previous relevant research literature that has been described in the literature study. In this study, the theory of building Safety Index will be developed which says that the behavior of the building Safety Index has 5 factors from previous research, namely 1) architecture 2) Building Services 3) External environmental 4) technical-Operations & Maintenance 5) Administration Management Approaches and added 1 factor from this research is building maintenance. This theory was developed with variables and indicators of index safety building as forming in construction. This is because previous research only discussed five factors. However, various literatures prove that building mechanism is very important to be included in one factor about the concept of the Building safety index for planning
elementary school buildings in Indonesia. Future research will carry out testing in Indonesia exactly in Elementary Schools in West Sumatra.

6. Discussion

With a large Mean Value, it shows that the factor greatly influences the planned operation of elementary school buildings.

7. Conclusion

The aim of this study is to develop a Building Safety Index (BSI) framework for buildings in Indonesia, especially Elementary Schools in West Sumatra. In the implementation of this study, the method used was using a questionnaire and analyzed using the Statistical Package for Social Sciences (SPSS). The purpose of this study was to study the factors related to building design and its contribution to safety index building and to identify the level of influence of factors.

After the data is analyzed. The first objective is fulfilled by identifying important factors through a review of the literature on current safety and health practices from journals, articles, and theses. The literature review identified 29 variables that contributed to the performance of the safety and health of the buildings of the Elementary School in West Indonesia in Indonesia. Of 29 Variables, supported by 6 Factors, namely Architecture, Building Services and External Environment, Technical-Operations & Maintenance, Administration Management Approaches, Building Maintenance. From the 6 Factors, Architecture is supported by 6 variables, Building Services supported by 6 Variables, External Environmental Support 4 variables, technical operation & maintenance supported by 5 variables, 5 management administration approaches, building mechanisms supported by 4 variables. By analyzing the results of the questionnaire, the second objective is to identify the level of influence of contributing factors. In addition, after analyzing all the results, it was found that the highest level of influence contributing to the performance of safety and health of building design is the architectural approach. The results of this study are transient but can provide some initial insight into developing a performance framework that will encourage better assessment practices. This data will be useful for developing quantitative evaluation of Building Safety methodologies.

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