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To cite this article: Masril *et al* 2022 *IOP Conf. Ser.: Earth Environ. Sci.* **1022** 012010

Determinant Factors of Safety Impact to the School Buildings in West Sumatera - Indonesia

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Abstract. In visual observations focused on emergency service facilities in several building locations, it was found that several emergency service facilities were not available. In addition, the facility also does not meet the provisions so it is categorized in an unsafe condition. From these conditions, it is necessary to know the safety factor for the comfort and security of the building. This study aims to determine the safety factor and several other factors that affect safety in buildings. It is necessary to determine the critical factors that have a very high influence and, the strategies needed in planning, construction, and operations. This research uses qualitative and quantitative methods with SPSS and Smart PLS tools. A total of 20 questionnaires were given to respondents to get their opinion on the critical factors needed. The purpose of this research is to increase the knowledge base, especially in the field of developing school building safety standards in West Sumatra - Indonesia. The findings of this study are in the form of technical operation & maintenance factors that are influenced by systematic information systems and programs. In addition, safety factors are strongly influenced by building services, external environment, and operational & technical maintenance.

1. Introduction

Building construction is a public service facility that is specially designed with complementary facilities to service potential hazards so that in the event of an emergency all workers, personnel, and, people in the building can be evacuated properly and safely. Emergency conditions are critical conditions when there is a fire or earthquake disaster so that the building is in danger and there is a possibility of building failure that endangers humans, equipment, and materials in the building. Therefore, it is important for workers and all people who are in the building to get information, in case of an emergency to prevent and minimize the loss of life due to the emergency. Based on the results of visual observations at emergency service facilities at the location, it often happens that some emergency service facilities are not available and even do not comply with standard provisions so that they can be categorized as unsafe conditions. The impact of these problems is the quality of service facilities in an emergency condition in sub-standard conditions, the cost has the potential to cause losses due to accidents that require quite a large cost, and delivery facilities that are not fulfilled by the building completeness. In terms of safety, there is a potential for accidents when an emergency occurs and morally there is a moral burden on workers who are responsible for building safety and security [1].

Considerations or concepts of thinking about strategies for building comfort and safety must be carried out since the initial planning and design process so that the problems caused by a building can have a positive impact on the surrounding environment. The Central/Local Government through institutions related to building problems already has various regulations to anticipate building security and safety issues. However, in the process of planning and designing a building, the issue of accuracy and awareness to comply with and accommodate regulations is often not carried out consciously and consistently. Therefore, many cases are found that are concerning in the post-construction period [2].

To achieve the goal of safety evacuation from fire hazards in buildings, which is one of the objectives of fulfilling the Certificate of Building Functionality (BFFC). The BFFC has been mandated by the Law of the Republic of Indonesia Number 28 of 2002 concerning Buildings (Building Law) and must be fulfilled/implemented starting in 2010. However, even though it has been mandated in the Law on Buildings, it is still often encountered fire occurred in buildings and buildings that were already operating were found that did not fully meet the requirements of the BFFC [3].

2. Literature Review

The problems that occur in buildings are not only in structural design and construction implementation but also in operating problems, infrastructure maintenance, and control in building utilization [4]. In addition, the performance of the building can decrease with the increasing age of the building. In general, the cause of the decline in building performance is due to the influence of the environment around the building which can cause damage to the building [5]. During the period of use, the building will experience setbacks due to natural damage, plus problems related to the low quality of building design, repair techniques that do not meet standards, and the level of maintenance to reduce the rate of damage [6].

Based on the implementation of safety measures, all of them must be addressed in several phases of process design. Therefore, according to McDermott's research [7], this case shows that building design and management factors can play an important role in the perspective of building security. In addition, Al-Hamoud and Khan [8] in their research highlight that the effects of hazards that may not be required in building design can be reduced much more easily using a drawing board when compared to that which occurs after actual corrective action. In their identification, they state that the designer will be aware of the requirements of this safety factor starting from the design process when there are very clear and enforced rules.

There are two groups of safety factors described in the literature which are used as research references as follows in table 1:

Table 1. Safety factors

No.	Design factors	Author's	Management factors	Author's
1.	**Architectural Scope** - Building design - Spatial planning - Structural - Space	Bluyssen, P.M [9]; Bokalders & Block [10]; Al-Hamoud & Khan [8];	**Operation and technical maintenance** - Policies - Systematic program - Assessment - Information System	Isa et.al., [18]; Ashraf et.al, [19]; Akasah et.al., [20]
2.	**Building Services** - Plumbing System - Electrical System - Fire Protection - Emergency Lighting	Green et.al., [11]; Hacker [12]; Keall et.al., [13]; Wong et.al., [14};	**Administration and management approach** - Competent Workers - Registered Engineers - Specialist Contractors	Bottani et.al., [21]; Akasah et.al., [20] Ashraf et.al, {19];
3.	**External Environment** - Noise Level - Air Pollution - Traffic Level	Smith & Pelley [15]; Hamsa et.al., [16]; Zainal et.al., [17];		

Regarding the perspective of the architectural section, it will be seen systematically that explores the impact of health engineering and the aspect of comfort on the design of a building and architectural thoughts [9]. Meanwhile, Bokalders and Block [10] have highlighted the sustainability of the building, which must take a broader change in the perspective of architecture, construction, and spatial planning. All of this is done to reduce the impact on the environment, safety, and health of the building. Therefore, in terms of focusing on architecture not only on the aesthetic aspect but also must be combined with certain structural solutions or styles and this must include all spaces where certain activities can take place safely, comfortably, and efficiently.

All variables that serve as the basis for the architectural category consist of various types such as escape facilities, access facilities, and fire-resistant constructions based on the objectives of an effective architectural process according to Al-Hamoud and Khan [8]. Next, a systematic safety compliance checklist is defined as proposed as safety requirements, including the design of the fire suppression system, smoke detectors, ladders, handrails, minimum field width, outer layer, and some exit and entry access distances and dimensions [22].

A study conducted by Green et.al., [11] proved that physical changes to conditions such as plumbing such as heating, cooling, and building safety, will contribute to mental health dysfunctions such as depression, feeling worried, feeling sad, feeling helpless, and feeling helpless. feel emotional. Therefore, changing conditions have a significant impact on the safety, health, education, and behavior of the population [12]. Another study stated safety is important and this step is to avoid the potential for electric shock and fires that start with cable tampering. There are many such cases due to safety concerns that must be considered [13]. Further evidence of the relationship between overall health and safety and the scale of development has been illustrated by Wong et al., [14], who are more concerned with building services. They also identified some major developments for the better in terms of building services, due to flexibility in adopting better building service designs and adequate funding for building maintenance and management concepts.

Measures for safety and health should include protection against all additional hazards introduced by the external environment. Hazards to the environment will refer to all potential threats faced by society/humans against events originating from/and transmitted through the environment [15]. Meanwhile, many researchers identified the main categories of environmental hazards as natural hazards (floods and landslides), technological hazards (hazardous materials, unsafe public buildings, and facilities), and contextual hazards (environmental degradation and air pollution). Among them are Hamsa et.al., [16] highlighting some of the shortcomings of environmental housing in the Taman Melati residential area in Kuala Lumpur. This study addresses physical environmental parameters such as noise levels, air pollution, and traffic levels and volumes. Meanwhile, Zainal et.al., [17] in their research measured the quality of the surrounding environment by air quality and the level of peace.

Based on the research of Kristiana et.al., [23] that the management of building maintenance and maintenance is a very important problem and must be considered. This is because it relates to the comfort and safety of everyone who uses or is in the building, and also affects the design age of the building so that it reaches the planned age. Sometimes, maintenance management problems for a building tend to be less attention because their effects are not felt directly.

For the Technical-Operation & Maintenance issue by Isa et.al., [18], they have provided an overview of the relationship between good maintenance practices and the good conservation practice literature. Previously they proposed guidelines for best maintenance practices for a building, and they established the following criteria: 1) a clear maintenance policy, 2) systematic maintenance programs and priorities, 3) produce accurate building conditions and assessments, and 4) information systems and data integration updated. In addition, they identify damages that could arise due to negligence of law for which they are responsible and perform their obligations. To ensure compliance with the relevant measures, maintenance work must be referred by competent persons as well as competent workers, competent inspectors, registered specialist engineers, and registered specialist contractors in their respective fields [19].

In various opinions, many authors agree that the assessment of structural conditions is an absolute requirement in determining the main safety factors that will increase the health, safety, and sustainability factors of buildings according to Akasah et.al., [20]; Keall, et.al., [14]; Lai and Yik, [24]; Haijian and Longxiang [25]. Currently, the application of safety management systems has become popular to address the challenges of occupational safety and health continuously and improve control over the factors affecting health and safety [21].

3. Research Methodology

The process of collecting and processing data carried out for this study consisted of two types of approaches that could be used in statistical analysis, namely a quantitative approach with the help of SPSS and a qualitative approach using a questionnaire [26-28]. The two types of approaches used are slightly different from other methods and techniques used, such as objectives, concepts, research approaches, data collection methods, data analysis, and sampling [28-29]. In the initial step of this research, all references related to safety factors were collected and included their implementation in various buildings as mentioned by various researchers reviewed previously. The reviews carried out are not only limited to articles published in peer-reviewed journals and papers published by well-known publishers, but also include theses, dissertations, and books.

The referral search date is between 2000 and 2020 just to cover a wide range and at the same time to reveal new findings. Furthermore, in the second stage, factors or aspects related to safety factors and their implementation were collected which were then distributed in the form of questionnaires to respondents using the purposive sampling method. The selected respondents are those who have experience of being involved in building work activities in various schools in West Sumatra, Indonesia. The questionnaire provided consists of some general information and respondents' background and is followed by data on the importance of school building safety factors identified through the literature as shown in the Relationship Model (Figure 1).

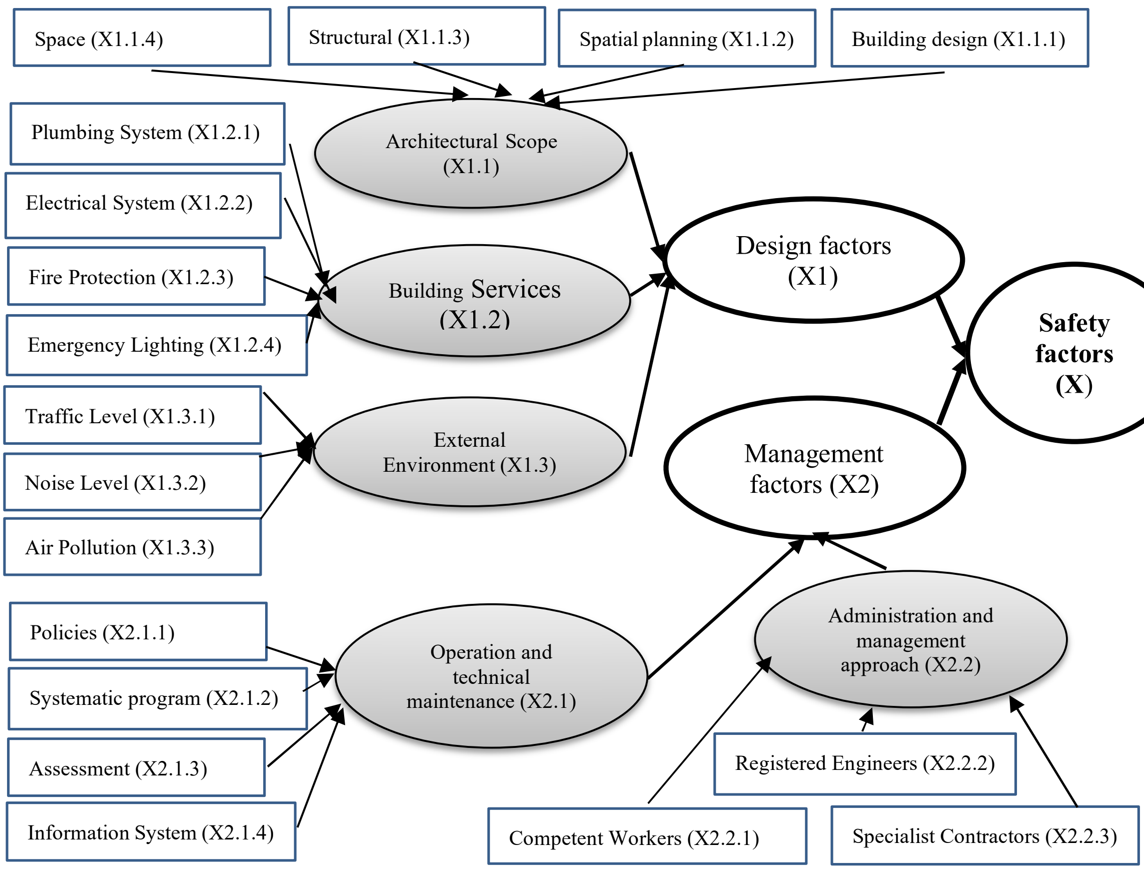

Figure 1. Relationship Model between Safety Factors, Design Factors and Maintenance Factors *(self processed from literature)*

4. Data Collection and Analysis

Questionnaire files were sent to all respondents, where they are several school building stakeholders in West Sumatra (Building Owners, Building Consultants, and Building Contractors) from various job positions who have worked > 20 years in School Buildings. The selection of respondents using the purposive sampling method, where the number taken exceeds 1 (n+1) of the number of questionnaire questions circulated to them. Several answers (18+2) have been received from a total of 20 answers. Measurements were made using a Likert Scale consisting of five points to measure the importance of the Safety Factor for the safety of school buildings. All data received were analyzed using the Statistical Package for Social Sciences (SPSS). The calculated reliability value is found to be above 0.70 (Cronbach's Alpha), while the validity value must exceed the "r" value in the reference table. From all these results, the highest factor value will be the determining factor for the Safety Factor for School Buildings in the West Sumatra region, Indonesia.

Data processing using SPSS version 24.0 according to Supriyadi [29], the testing techniques that are often used to test validity are Pearson Bivariate Correlation (Pearson Moment Product) and Item-Total Correlation Correction. In this study using Corrected item-total with the results for the amount of data (n) = 18 obtained r-table = 0.4555 (r-table for Pearson's Product Moment) with a significance level of 0.05. The results of SPSS data analysis can be seen in table 2.

Table 2. Corrected Item-Total Correlation Results

Item-Total Statistics				
	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
X1.1.1	90.0000	146.632	.119	.948
X1.1.2	90.3500	143.818	.214	.949
X1.2.1	90.6000	140.253	.416	.946

According to Table 2 of the Corrected item-total Correlation value, it seems the calculated R-value (Pearson Correlation) is smaller than r table 0.4555, namely X1.1.1 (Building Design), X1.1.2 (Spatial Planning), and X1.2.1 (Plumbing System). The reliability test method must use the Cronbach's Alpha method whose value is > 0.7 which is used to determine the reliability and is indicated by Cronbach's Alpha all factors > 0.700.

For the next step, data processing is carried out using Structural Equation Modelling (SEM) with Smart PLS version 3 tools, to be able to see the relationship between safety factors and all groups of factors suspected to be the cause of building safety as shown in figure 2.

Observing from Figure 2, it can be seen that the six safety factors got a loading factor value of < 0.700 such as X1.1.1, X1.1.2, X1.2.1, X11.2.4, X1.3.1, and X2.1.1. Due to this, all factors were removed from the data analysis model. Next, the data calculation process is carried out again using the Smart PLS application for the second time. Next, the data calculation process is carried out again using the Smart PLS application for the second time.

The results of data processing using the Algorithm Test menu, there are three component factors that have a Loading Factor < 0.70 such as X1.1 = 0.384, X1.2 = -0.090, X1.3 = 0.241 and X2.2 = -0,221. Because the four component factors get a Loading Factor value > 0.70, then the four component factors are removed from the factor analysis process and further factor processing is carried out (Figure 3).

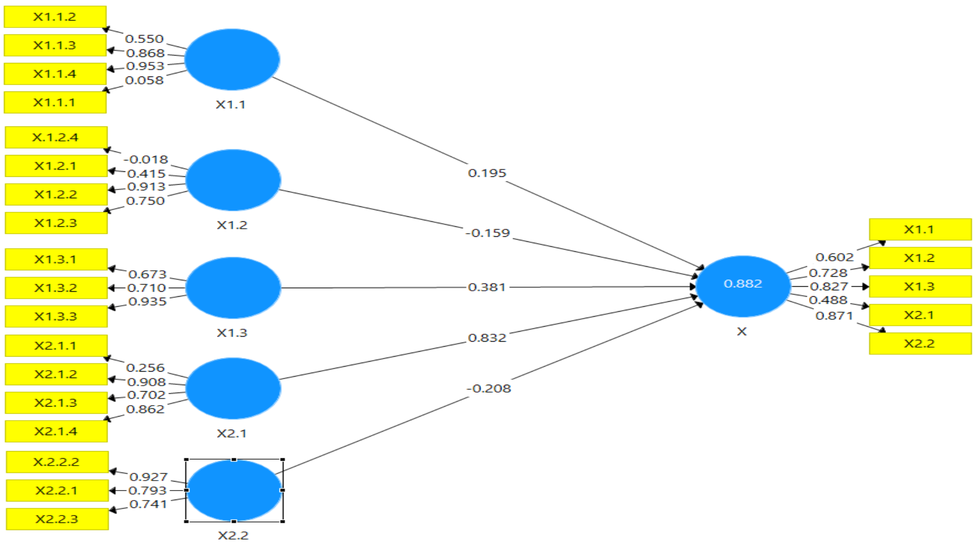

Figure 2. Result Model between Safety Factors and its component factors

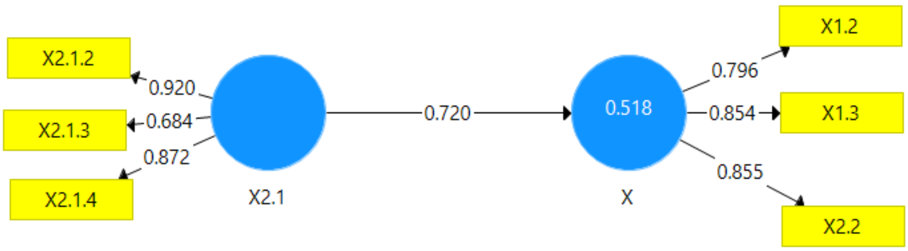

Figure 3. Result Model between Competitiveness and Productivity (re-calculating)

Referring to the results of data processing in figure 3, those with a Loading Factor > 0.70 are 2.1.2 (Systematic Program) = 0.920, X2.1.3 (Assessment) = 0.684 and X2.1.4 (Information System) = 0.872. In the last processing, an assessment is given for the X2.1.3 factor (Assessment) which has a loading factor value of < 0.700 which is 0.684. This is still allowed according to Chin [30] and can be continued for hypothesis testing using the Bootstrapping menu with Smart PLS. Then proceed with processing with the Bootstrapping process to see the hypothetical relationship between the two components of X and Y factors as shown in figure 4 and table 3 below.

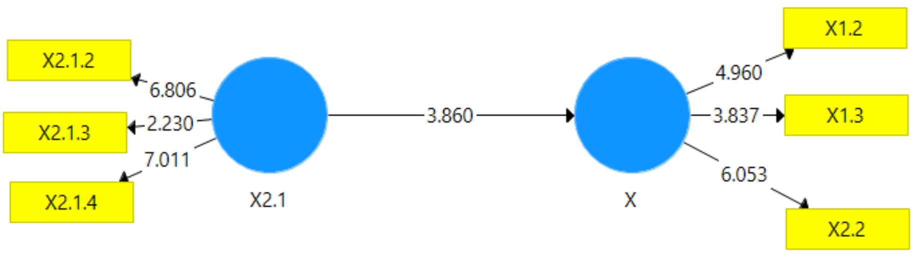

Figure 4. Result Model between Competitiveness and Productivity (Hypothetical)

Table 3. Path Coefficient by Bootstrapping

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	t-Statistics (|O/STDEV|)	p-Values
X1.2 ← X	0.796	0.781	0.016	4.960	**0.000**
X1.3 ← X	0.854	0.806	0.223	3.837	**0.000**
X2.1.2 ← X2.1	0.920	0.912	0.135	6.802	**0.000**
X2.1.3 ← X2.1	0.684	0.626	0.307	2.230	**0.260**
X2.1.4 ← X2.1	0.872	0.859	0.124	7.011	**0.000**
X2.2 ← X	0.855	0.843	0.141	6.053	**0.000**

In the process of obtaining the hypothesis, it must refer to the confidence level used, which is 95% or the limit of inaccuracy is (α) = 5% = 0.05, and the t-table value is 1.96. For the assessment limits in figure 4 and Table 3, an explanation of the results of the hypothesis can be made as follows:

1. X.1.2← X : means that Safety Factor is strongly influenced by Building Services with t-statistic value = 4.960 > 1.96 and p-value = 0.000 < 0.05.
2. X1.3←X : means that Safety Factor is strongly influenced by External Environment with t-statistic value = 3.837 > 1.96 and p-value = 0.000 < 0.05.
3. X2.1.2←X2.1 : means that Operation and technical maintenance is strongly influenced by Systematic Programs factor with t-statistic value = 6.802 > 1.96 and p-value = 0.000 < 0.05.
4. X2.1.3←X2.1 : means that Operation and technical maintenance is not influenced by Assessment with t-statistic value = 2.230 > 1.96 but p-value = 0.260 > 0.05.
5. X2.1.4←X2.1 : means that Operation and technical maintenance is strongly influenced by Information System with t-statistic value = 7.011 > 1.96 and p-value = 0.000 < 0.05.
6. X2.2←X: means that Safety Factors is strongly influenced by Operation and technical maintenance with t-statistic value = 6.053 > 1.96 and p-value = 0.000 < 0.05.

5. Discussion and Result

From the six hypotheses above, it can be explained that Building Services (X1.2), External Environment (X1.3), and Operation & technical maintenance (X2.2) are quite influential on the Safety Factors (X) of School Building in West Sumatera, Indonesia. The results of the factor analysis show that Operation & technical maintenance (X2.2) is influenced by Systematic Programs (X2.1.2) and Information Systems (X2.1.4).

Judging from the results of the hypothesis above that the Safety Factor is largely determined by the Operation and Technical Maintenance of each School Building. This is because the safety level of the building will be reduced due to errors/omissions that occur during the operation and maintenance of the building itself. There have been many examples of the collapse of school buildings and other buildings due to improper maintenance of buildings. This finding is also supported by previous research which states that the Technical-Operation & Maintenance Issues by Isa et.al., [20] have provided an overview of the relationship between good maintenance practices and good conservation practice literature.

6. Conclusion

From the results of the discussion of the hypothesis above, it can be concluded in general that the Safety Factor in School Buildings is strongly influenced by Operation and Technical Maintenance. In addition, when viewed from the aspect of Operation and Technical Maintenance itself, the factors that greatly influence it are Systematic Programs and Information Systems which are created and implemented periodically. However, two other factors also affect the Safety Factor, namely Building Services and External Environment factors.

In continuing this research, more in-depth analysis steps are needed to find out other factors that affect safety in more detail. In addition, all of these factors can also be further developed to obtain more detailed sub-factors. In addition, it can also be investigated for other buildings besides school buildings.

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