Priority of Maintenance of Structural and Architectural Elements Using the Analytical Hierarchy Process (AHP) Method

Fadli Idris[1], Astiah Amir[2], Aris Marisa[3]
Department of Civil Engineering, Faculty of Engineering, Teuku Umar University.
Meulaboh, Indonesia.
Email: astiahamir@utu.ac.id.

A R T I C L E I N F O	A B S T R A C T

The building construction will decrease with an increased service life of the structure. The school building for SMP Negeri 2 Meulaboh West Aceh is one of the school buildings that need attention from the government. Much of the building damage is due to age and improper maintenance methods. This study aimed to determine the maintenance priorities of the structural and architectural elements of the SMP Negeri 2 Meulaboh school building. This study used the descriptive qualitative method. Primary data was collected through surveys, interviews, documentation, and distributing questionnaires, while secondary data was collected from related institutions or agencies. Data analysis was processed using the Analytical Hierarchy Process (AHP) method. The selection of sample respondents is not random/nonrandom sampling but is carried out using purposive sampling. The analysis results of the order of priority for the maintenance of structural elements the priority, namely, the column, the type of damage to the chipped concrete cover gets the highest priority with a priority value of 0.359. While the second priority is for architectural elements, namely ceilings, walls, doors, windows, and floors, the damage to fading ceiling paint gets the lowest priority with a value of 0.016.

I   Introduction

School buildings are educational institutions that are formal and non-formal and are public facilities that have an essential function. As a building and public infrastructure, it is appropriate to pay attention to the reliability and feasibility of the building. Building reliability is necessary to ensure the safety of building users, while building feasibility will guarantee the comfort of building users [1]. School buildings are an essential infrastructure to support the quality of education in Indonesia. However, quite a lot of school buildings have been damaged. Therefore, school buildings need to be taken seriously, especially in terms of maintenance [2].[3],[4] ,[5],[6].

Students can be more productive than if they were studying in an unkempt school building. Maintenance of the building is essential and needs to be carried out. This maintenance will extend the life of the building in terms of aspects of strength, safety, and appearance. The biggest problem facing schools is providing funding for such activities. The funds the government has provided for the maintenance of the building may not be sufficient in its entirety. Therefore a way is needed to choose the most priority to maintain. Some methods can be used, for example, the AHP method, SPSS software, and others. Research that is in line with the selection of priority of building maintenance, both school buildings and other structures, for example, bridges, roads, and others [7], [8],[9],[10],[11],[12].

Maintenance of the building can reach a decent life that has been taken into account, and the reliability and feasibility of the building are still guaranteed for the safety and comfort of users; it is necessary to carry out building maintenance[13]. State Junior High School (SMP) 2 Meulaboh West Aceh Regency, the building in Johan Pahlawan District, West Aceh is a case study of this research; the building is planned to be able to operate during a certain service period. However, during the service period, the structure can experience changes in quality or decreased strength caused by various factors such as building age, natural factors, human factors due to building use, excessive load, fire, or other causes. [14], [15], [16]. Based on preliminary observations, it is indicated that the condition of this school building is poorly maintained. Most of the damage occurs to structural and architectural parts, so research needs to be carried out so that it can be traced to the problems and obstacles. Documentation of the damage can be seen in Figure 1.

Figure 1. Damage elements of the school of SMPN 2 Meulaboh
Source: Personal Data Research Results, 2022

A. Level of Building Damage
According to [17], buildings are classified into 3 (three) levels of damage, namely:
1. Minor damage
Maintenance for minor damage rates, the maximum cost is 35% of the highest unit price of the construction of a new building in force for the same type/class and location.
2. Moderate damage
For maintenance for moderate damage levels, the maximum cost is 45% of the highest unit price of constructing a new building in force for the same type/class and location.

3. Heavy damage

The maximum cost is 65% of the highest unit price for constructing a new building in force for the same type/class and location. The level of building damage is shown in Table 1.

Table 1. Pair comparison assessment scale

Intensity Interests	Definition	Explanation
1	Elements that are equally important compared to other elements (Equal importance)	Both elements contribute equally to the trait.
3	One element is slightly more important than the other element (Moderately more important)	Experience states a small quantity of siding with one element
5	One element is more important than the other (Essential, Strong, more important)	Experience shows strong siding with one element.
7	One element is very clearly more important than the other element (Demonstrated element)	Experience shows strongly favored and dominant in practice.
9	One element is more important than the other (Absolutely more important)	Experience shows that one element is more important

(Author of [18])

B. Analytical Hierarchy Process (AHP)

AHP is an excellent mathematically based procedure and is appropriate for conditions.   The attributes are mathematically quantified in 1 set of paired comparisons. The advantage of AHP over others is due to the hierarchical structure, as a consequence of the selected criteria, to the most detailed sub-criteria.

Consider the validity up to the tolerance limit of inconsistencies of various criteria and alternatives chosen by decision-makers [19]; because it uses human perception input, this model can process qualitative and quantitative data.

C. Building Physical Condition Index (BCI)

After data processing using the Analytical Hierarchy Process (AHP) method, the calculation of the building condition index of the school building of SMP Negeri 2 Meulaboh West Aceh was then carried out. The procedure for the calculation of the index of the condition of the building is carried out by the formula of the equation as follows: Calculate the index of an element condition

$ECI = 100 = sf_{=1} \ y \ (Tj, \ Sj, \ Dif) \ x \ F \ (ti \ d)$

1. Calculate the sub-component condition index
   $SCCI = (ECI_1 x BE_1) + (ECI_2 x BE_2)$
2. Calculate the index of a component's condition
   $CCI = (SCCI_1 x BSK_1) + (SCCI_2 x BSK_2)$
3. Calculating the building condition index
   $BCI = (CCI_1 x CW_1) + (CCI_2 x CW_2)$

D. Weighting Criteria

The weight of each criterion, namely by determining the eigenvalue. Ways to get weight are as follows:

1.   Performs multiplication of elements in a single line and rooted in the rank

2.   Calculating the priority vector or vector agent, the result obtained is the Aigen
3.   A vector is the weight of the element.
4.   Calculating the maximum eigenvalue by multiplying the reciprocal matrix by obtained weight, the result of the summation of the matrix operation is the maximum Eigen value (max).
5.   The consistency index calculation is to find out the consistency of the answer that will affect the validity of the results.
6.   Ratio consistency calculation and comparison matrix are acceptable if the consistency ratio value < 0.1.
7.   In determining the weight of components/elements using this AHP model, the conditions for compiling a comparison matrix can be accepted when the CR value < 0.1.

3   Research Methods

Research methods can obtain information that authors can use as research material[20]. With research methods, researchers can solve problems according to systematic and composed procedures or work steps. In this study, the authors used descriptive research. This research will reveal how to prioritize the maintenance of school buildings for researchers and school residents in the SMP Negeri 2 Meulaboh building. The data used are primary and secondary. Researchers collect and process primary data directly from respondents or measurements in the field. In contrast, secondary data is obtained from an institution or institution in a ready-made form. Primary data collection includes survey data, interviews, documentation, and questionnaires.

Planning for the distribution of questionnaires and assessing the physical condition of the building involved 4 (four) respondents, consisting:

1.   One Engineering expert of PUPR West Aceh
2.   One principal of SMP Negeri 2 Meulaboh West Aceh
3.   One Civil Engineering Expert Lecturer at Teuku Umar University
4.   One Engineering expert of PT. Inochi Consultants

Furthermore, preliminary observations were carried out, and the results obtained the degree of damage to each component. This research was conducted at the SMP Negeri 2 Meulaboh building, Jl. Dr. Sutomo, Suak Indrapuri Village, Johan Pahlawan District, west Aceh Regency. Geographically, Suak Indrapuri Village is located at a position of 4° 08' 01" North Latitude (LU) and 96° 07' 35" East Longitude (BT).

4   Results and Discussions
4.1   Building Damage Data

Based on the results of the identification of damage to the school building of SMP Negeri 2 Meulaboh West Aceh, several components were damaged, both structural and architectural components. There were two building masses for which there was much damage, but the damage identification only reviewed the mass of building 1. According to Law No. 28 of 2002, Building Buildings are classified into 3 (three) levels of damage, namely: Lightly damaged (damage value < 30%), moderately damaged (30% < damage value < 45%), severely damaged (45% < damage value < 65%). Next is to determine the weight of each component; the value of this weight ranges of the element from 10-100% according to the description of the damage to the building; the calculation can be done using the help of the building damage value form. The recapitulation damage can be seen in Table 2.

Table 2.   Recapitulation of element damage

No.	Element Name	Information	Percentage Damage	Condition Beginning	Percentage Condition	Condition Criteria
1	Column	crack	5%	100 %	95%	RR
2	Column	Peeling off concrete	18%	100%	82%	RR
3	Ceiling	Weathered	7%	100 %	93%	RR
4	Ceiling	Color Fading	2%	100 %	98%	RR
5	Wall	Crack	8%	100 %	92%	RR
6	Wall Paint	Peel	2%	100 %	98%	RR
7	Door	Detached	10%	100 %	90%	RR
8	Shutters	Broken	2%	100 %	98%	RR
9	Ceramics	detached	3%	100 %	97%	RR

Source: Personal Data Research Results, 2022

4.2   Weighting of building components

The calculation of weights includes Criteria, elements, and components. They were obtained from the questionnaire with a comparison value filled out by the respondents—calculations using the Analytical Hierarchy Process (AHP) method, processed using Excel. The calculation of the weight of the components of the questionnaire results from the four (4) respondents will then be combined. Look for the average value so that what is taken from the questionnaire results is the respondents' average value. The recap results can be seen in Tables 3 and 4 below.

Table 3.   Recapitulation of combinations of component pairwise comparisons

Respondents	Structural vs. Architectural
PUPR	9
Civil Engineering	7
Principal	9
Consultant	9
Total	28
Mean/Average	5.196

Source: Personal Data Research Results, 2022

Table 4.   Pairwise comparison matrix

Criterion	Structural	Architectural
Structural	1	8.452
Architectural	0.118	1
Total	1.118	9.452

Source: Personal Data Research Results, 2022

Scala's priority in building components is shown in Table 5.

Table 5.   Priority scale of building components

No.	Component	Component Weights (xi)	Component Weights (%)
1.	Structural	0.961	96%
2.	Architectural	0.039	4%

Source: Personal Data Research Results, 2022

4.3   Weighting of building elements

The following is the calculation of building elements obtained from the questionnaire with a comparison value filled out by the respondents. Calculations using the Analytical Hierarchy Process (AHP) method, processed using Excel. To make it easier to combine each element from the results of the questionnaire of the four respondents, each building element is given a symbol/symbol of the alphabet letter from A-Z. Take a look at Table 7 below.

Table 6. Symbol of each element for a matrix of paired combinations

No.	Element	Symbol
1.	Concrete blanket peeling column	A
2.	Cracked column	B
3.	Cracked walls	C
4.	Weathered ceiling	D
5.	Wall Paint peeling off	E
6.	Door Hinges detached	F
7.	Broken Shutters	G
8.	Detached ceramics	H
9.	Ceiling paint fades	I

Source: Personal Data Research Results, 2022

From the results of the questionnaire answers that have been processed using Excel, the highest priority value was obtained at the weight of the concrete blanket peeling column element of 0.359 and the lowest priority value on the weight of the faded ceiling paint element of 0.016 with a consistency ratio (CR) value of 0.00<0.1 in validity the answer from the questionnaire is acceptable.[21]

4.3.1   Building Condition Index Assessment
1.   Element Condition Index (ECI)
2.   Sub-component condition index (SCCI)

$$SCCI = (ECI_{Column} \text{ x} Ew_{Column}) + (IKE_{Column\ basis} \text{ x } EW_{Column\ basis}) \qquad (1)$$
$$= (85 \text{ x} 0.75) + (85 \text{ x } 0.25)$$
$$= 88.75$$

3.   Component condition index (CCI)   (2)

$$CCI_{struktur} = (SCCI_{Column} \text{ x } SCW_{Column})$$
$$= (88.75 \text{x } 0.559)$$
$$= 49.611$$

$$CCI_{arsitektur} = (SCCI_{floor} \text{ x } SCW_{floor}) + (SCCI_{ceiling} \text{ x } SCW_{ceiling}) + (SCCI_{wall} \text{ x } SCW_{wall}) +$$
$$(SCCI_{door} \text{ x } SCW_{door}) + (SCCI_{window} \text{ x } SCW_{window}) \qquad (3)$$
$$= (86.5 \text{x} 0.016) + (95.67 \text{x } 0.110) + (86.5 \text{x } 0.257) + (95 \text{ x } 0.033)$$
$$+ (90 \text{ x } 0.025)$$
$$= 39.523$$

The recapitulation of combinations of comparison of pairs of elements from respondents PUPR service, the Civil engineer, the consultant, and the Principal can be seen in Table 7.

Table 7.   Recapitulation of combinations of comparison of pairs of elements

Respondents	PUPR	Principal	Civil Engineer	Consultant	Total	Average
A VS B	9	9	1	9	28	7
A VS C	8	7	1	7	23	5.75
A VS D	8	9	4	9	30	7.5
A VS E	9	7	3	7	26	6.5
A VS F	9	9	3	9	30	7.5
A VS G	9	8	5	8	30	7.5
A VS H	9	7	3	7	26	6.5
A VS I	9	9	5	9	32	8
B VS C	9	8	1	8	26	6.5
B VS D	8	7	4	7	26	6.5
B VS E	8	8	1	8	25	6.25
B VS F	8	9	1	9	27	6.75
B VS G	8	7	1	7	23	5.75
B VS H	8	8	1	8	25	6.25
B VS I	8	6	1	8	23	5.75
C VS D	9	8	3	8	28	7
C VS E	9	9	3	9	30	7.5
C VS F	7	7	7	7	28	7
C VS G	4	5	7	5	21	5.25
C VS H	4	3	7	3	17	4.25
C VS I	6	5	3	5	19	4.75
D VS E	7	7	3	7	24	6
D VS F	7	7	6	7	27	6.75
D VS G	7	6	3	6	22	5.5
D VS H	7	6	6	6	25	6.25
D VS I	7	6	5	6	24	6
E VS F	9	9	3	9	30	7.5
E VS G	6	6	1	6	19	4.75
E VS H	6	5	1	5	17	4.25
E VS I	9	8	6	8	31	7.75
F VS G	7	7	7	7	28	7
F VS H	5	5	5	5	20	5
F VS I	5	4	3	4	16	4
G VS H	5	3	7	3	18	4.5
G VS I	7	7	3	7	24	6
H VS I	7	6	3	6	22	5.5

Source: Personal Data Research Results, 2022

The Priority scale of building elements, ECI Junior High School Buildings, and IKSK Junior High School Buildings Result analysis value as shown in Tables 8,9,10.

Table 8.   Priority scale of building elements

No.	Elemen	xi
1	Columns chipped concrete covers	0.359
2	Cracked column	0.200
3	Cracked wall	0.156
4	Weathered ceiling	0.101
5	Wall paint is peeling	0.067
6	Door hinge loose	0.043
7	The shutters are broken	0.033
8	Ceramic off	0.025
9	Ceiling paint faded	0.016
10	Total	1.000

Source: Personal Data Research Results, 2022

Table 9.   ECI Junior High School Buildings

No.	Elemen	Damage type	Damage Percentage (%)	Deductible value	Correction Factor	ECI 100-(DV x CF
1	Column	Cracked	5	25	0.4	85
		Peeled off	18	25	0.6	
		Slimy	0	0	0	
		Leave	0	0	0	
2	Ceiling	Slimy	0	0	0	95
		Out of date	7	25	0.2	
		Color fades	2	25	0.2	
		Broken	0	0	0	
3	Ceramik	Leave	3	25	0.4	90
		Weathered/Cracked	0	0	0	
4	Wall	Cracked	8	25	0.2	85
		Peeled off	0	25	0.6	
		Color fades	2	25	0.2	
5	Door	Missed out	10	25	0.2	95
		Out of date	0	0	0	
		Broken	2	25	0.4	
9	Window	Out of date	0	0	0	90
		Missed out	0	0	0	

Source: Personal Data Research Results, 2022

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Table 10.   IKSK Junior High School Buildings

No.	Elemen	Jenis kerusakan	Prosentase Kerusakan (%)	ECI	BE		SCCI
1	Column	Cracked	5		0.25		88.75
		Peeled off	18	85	0.75		
		Slimy	0		0		
		Leave	0		0		
2	Ceiling	Slimy	0		0		95.67
		Out of date	7	95	0.866		
		Color fades	2		0.134		
		Broken	0		0		
3	Ceramik	Leave	3		1		90
		Weathered/Cracked	0	90	0		
4	Wall	Cracked	8			0.9	86.5
		Peeled off	0		0		
		Color fades	2	85		0.1	
5	Door	Missed out	10		1		95
		Out of date	0	95	0		
		Broken	2		1		
9	Window	Out of date	0	90	0		90
		Missed out	0		0		

Source: Personal Data Research Results, 2022

4. Building condition index (BCI)
In accordance with the weight of each component and its grouping, the Building Condition Index (IKB) can be calculated as follows:
BCI = (CCI $_{struktur}$ x CW $_{struktur}$) + (CCI $_{arsitektur}$ x CW $_{arsitetur}$)   (4)
= (49.611 x 0.961) + (39.523x 0.039)
= 49.218

5. Component condition index (CCI)
CCI struktur   = (SCCI Column x SCW Column) = (88.75x 0.559) = 49.611   (5)
CCI arsitektur = (SCCI floor x SCW floor) + (SCCI ceiling x SCW ceiling) + (SCCI wall x SCWwall) + (SCCI door x SCWdoor) + (SCCI window x SCWwindow) (6)
= (86.5x 0.016) + (95.67x 0.110) + (86.5x 0.257) + (95 x 0.033) +
(90 x 0.025)
= 39.523

6. Building condition index (BCI)
In accordance with the weight of each component and its grouping, the Building Condition Index (IKB) can be calculated as follows:
BCI = (CCI struktur x CWstruktu) + (CCI arsitektur x CW arsitektur)   (7)
= (49.611 x 0.961) + (39.523x 0.039)
= 49.218

Based analysis Building condition index (BCI), and the Component condition index (CCI), the building condition index results are presented in Table 11.

Table 11. Building condition index results

Building Name	Component condition index (CCI)		Building condition index (BCI)	Condition Criteria
	CCI Struktur	CCI Arsitektur		
SMP 2	49.611	39.523	49.218	Moderate Damage

Source: Personal Data Research Results, 2022

5 Conclusion and Suggestion
5.1 Conclusion
Based on the analysis and discussion, several conclusions can be drawn as follows: Based on the calculation results using the AHP Method, the damaged components are structural and architectural, including broken, loose, weathered/cracked, and fading colors. The structural component gets the highest priority, which is 0.922, while the architectural component gets the lowest priority, which is 0.078. The highest priority in care and maintenance for elements lies in the column with a value of 0.359, and the lowest priority lies in the ceiling paint with a value of 0.016.

5.2 Suggestion
From the results of the questionnaire answers that have been processed using Excel, the highest priority value was obtained at the weight of the concrete blanket peeling column element of 0.359 and the lowest priority value on the weight of the faded ceiling paint element of 0.016 with a consistency ratio (CR) value of 0.00<0.1 in validity the answer from the questionnaire is acceptable.

The recapitulation of combinations of comparison of pairs of elements from respondents PUPR Department, the Civil engineer, the consultant, and the Principal can be seen in Table 7.

1. The re1.In determining the priority scale for the maintenance of the school building of SMP Negeri 2 Meulaboh, local governments should consider the AHP method and the Physical Condition Index other than based on the Special Allocation Fund (DAK) Technical Guidelines for Education. The consideration is that the AHP method can combine various aspects and criteria carried out by weighting based on the level of importance so that the results of the priority order of handling the resulting building are more representative.
2. It is necessary to have a competent technical team in their fields and as a companion in planning, supervision, and implementation during construction. For example, the engineering team from the PU in the field of Spatial and Building Planning (DRR).
3. The need to inspect building damage with more accurate tools (hammer test, ultrasonic-frequency speed) "(hammer test, ultrasonic-frequency speed)."
4. It is necessary to develop a network software application program between each school and the education office so that schools get more attention to the damage that occurs and the process of assessing the condition of buildings is carried out more quickly.

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