

# Selection of Repair and Strengthening Methods Structure Powerhouse to Optimize Operational Activities

**Argya Jaganaputra, Bambang E Yuwono,**  
Master Degree Faculty of Civil Engineering and Planning  
Trisakti University, Jakarta, Indonesia  
[argya.jp@gmail.com](mailto:argya.jp@gmail.com), [bambang.endro@trisakti.ac.id](mailto:bambang.endro@trisakti.ac.id)

## Abstract

Powerhouse also called a generator house is a place or space that is used to meet the operational needs of buildings, usually used as an installation space for electricity, water, air conditioning, and others. There are many cases of structural damage caused by human error or natural behavior. Structural damage can occur in the construction process or factors of the building itself or external factors. The shape and level of structural damage can occur from mild to severe. In choosing the method for repairing and strengthening concrete structures, several factors must be considered, namely the capacity of the structure, the environment in which the structure is located, the available equipment, the ability of the implementing staff and the limitations of the owner such as limited workspace, ease of implementation, implementation time and cost. Analytical Hierarchy Process is a support systems method in decision making, with real data and carefully studied can solve various multi-criteria decision-making problems, and can solve the problem of choosing the method of repair and reinforcement of concrete in the powerhouse building. The results of the decision making on the repair of concrete building structures can be decided to choose the alternative application of the Mortar Cement as the main choice with the highest value: 0.3485, as the best choice. Furthermore, to strengthen the concrete building structure, it was decided to choose the highest value: 0.3564, with the alternative application of Self Compacting Concrete as the main choice.

## Keywords

Powerhouse, Strength building, Repair building, Analytical Hierarchy Process, Structural damage

## 1. Introduction

The construction of multi-storey buildings in Indonesia is currently increasing its needs. Multi-storey buildings are commonly used as government buildings as well as public facilities such as offices and hospitals. In addition, the construction of multi-storey buildings in Indonesia can also be used as an investment such as apartments, hotels, malls, and others. The use of multi-storey buildings needs to be supported by the existence of power house buildings (generator houses). Overall the powerhouse has a smaller building size than the main building, the size of the powerhouse space is calculated from whatever utility is in it. For example, space is needed for generator sets, panel rooms, ac chillers, transformers, and sub stations or medium voltage and low voltage panel rooms. In the implementation of the powerhouse building will carry out operational activities, as for the operational understanding according to Sofjan Assauri (2008:12), said that "Operations are activities that regulate and coordinate the use of resources in the form of human resources, resource tools and resources of funds and materials, effectively and efficiently to create and increase the usefulness utility of goods or services".

Powerhouse must be built at a higher level to be safe from the possibility of flooding. In addition, the distance of the powerhouse with the main building is recommended to be closer to saving energy. Powerhouse is the heart of every existing building, because this building supplies power for the operational needs of the building. If there is damage to the power house building or working machines it will result in disruption of operational activities in the building. The losses incurred from such damages are not small, in addition to costs can also interfere with the comfort and safety of building users. There are many cases of structural damage caused by human error or natural behavior. Structural damage can occur in the construction process or the age of the building and damage due to lack of maintenance. The

level of structural damage can occur ranging from minor damage to major damage. In the condition of the building that has been operational is expected to be repaired immediately so that the machines can work optimally. The handling carried out is the repair of the structure and strengthening of the structure of the building. Time constraints are a challenge in repairing and strengthening existing structures, so proper quality control and procedures are needed when the work is done.

## 2. Literature Review

The condition of damage that can be found visually in the building is cracking on the concrete surface. Cracks on the concrete surface can occur because concrete is shrinking, deflection due to live load/dead load, due to earthquakes, high temperature differences at the time of the process of drying, and the result of corrosion. Categories of damage to concrete buildings according to the Department Pekerjaan Umum Dirjen Cipta Karya can be classified as:

### a. Minor Non-Structural Damage

A building is categorized as experiencing nonstructural damage in the event of the following:

- Fine cracks (the width of the gap is smaller than 0.075 cm) on the stucco.
- Plaster flakes fell.
- Covers a limited area.

### b. Minor Damage to the Structure

A building is categorized as experiencing minor structural damage in the event of the following:

- Low level cracks (gap width between 0.075 to 0.6 cm) on the wall.
- Some plaster fell.
- Covers the entire area.
- Damaged in the nonstructured area of example; chimney, listplang, etc.
- The strength of the structure to support the load is still sufficient.
- Habitable laik and function.

### c. Moderate Level Structural Damage

Categories of buildings that have structural damage with moderate levels when they occur in the following;

- Large cracks (the width of the hole  $>$  of 0.6 cm) on the wall.
- Cracks in the building area creeping whole and cracking on the walls of load musicians, column, chimney tilted, and collapsed.
- The strength of the structure to support the load is less partial.
- Habitable laik and function.

### d. Damage to Heavy Structure

Categories of buildings that have structural damage with a heavy level when it occurs in the following:

- On the wall the weight support and collapse.
- Building is divided because it fails on the bonding part.
- An estimated 50% of essential components get damage.
- Not habitable and functional.

### e. Total Damage

The category of buildings that have structural damage with the highest level or total damage when it occurs in the following:

- Building collapse ( $>$  65%).
- Almost the entire main part is damaged.
- Not functional.

First identify in priority areas of repair or strengthening of structures, secondly make the creation of hierarchical structures to meet the needs of existing criteria, third the creation of questionnaires for weighting on each criteria and alternatives with the Analytical Hierarchy Process (AHP) method.

Analytical Hierarchy Process or commonly called AHP, is a model in support of decision making designed by Thomas L. Saaty. The goal is to reduce the problem of multiple criteria complex into a hierarchy, according to Saaty (1993), hierarchy is defined as a representative of a complex problem in a multilevel structure which is the first level is the goal, which is accompanied by factors, criteria, sub criteria, and so on down until the last level on the alternative. With hierarchy a complex problem can be broken down into groups that are then organized into a form of hierarchy so that the problem will look more systematic and structured.

### 3. Methods

In conducting a study, choosing the right method is very important, because using the right methods will help researchers to be able to achieve the desired goals. According to Arikunto (2002:136) research methods are the means used by researchers in the collection of data needed in research. According to Sugiyono (2013:224) data collection techniques are the most strategic step in research, because the main purpose of research is to obtain data. The techniques used to collect data in this study are:

a) Questionnaire

According to Arikunto (2006:151) the definition of angket is a written statement used to obtain information from respondents in the sense of reports about personal or things he knows. While according to Sugiyono (2008: 199) questionnaire is a data collection technique that is done by giving a set of questions or written statements to respondents to answer. The questionnaire or angket used in this study is a type of questionnaire or direct questionnaire that is closed because respondents only give a sign on one of the answers that are considered correct.

b) Interview

Interview is a data collection technique conducted through face-to-face and direct Q&A between data collectors and researchers to sources or data sources (Borman & Helmi, 2018).

At this stage, problem identification is carried out, studying the criteria related to alternative decision selection, selection of methods used in repair and retrofitting concrete structures without stopping the operational activities of the powerhouse.

Research on Powerhouse is done to find out the condition of potential damage to every element of the structure of the building. In this study the test will lead more to the structure beam, and there are 1-2 areas of test points on one beam span. Located on the 2nd floor of the building, the beam will be carried out structural repairs and strengthening of the structure. This area in the condition of the room is still operational and under the beam there is engine generator set. Here is the location of the test point,



Figure 1. Testing point on the beam for repair and strengthening of concrete structures

The examination is carried out based on the value generated from the results of filling out questionnaires and interviews with power house building management, consultants and contractors.

There are several stages in data collection in this study. First identify in priority areas of repair or strengthening of structures, secondly make the creation of hierarchical structures to meet the needs of

existing criteria, third the creation of questionnaires for weighting on each criteria and alternatives with the Analytical Hierarchy Process (AHP) method.

The results of the building inspection produce indicators to establish the method of repair and retrofitting against the determining factors of damage to the building. Indicators set from the basis of the theory are added with the results of observations in the field. At the modeling stage the analytical approach is the Analytical Hierarchy Process (AHP). The hierarchy of decisions to be explained is, criteria and alternatives. Here is an image of the Hierarchy decision selection method of concrete structure repair work.

- a. The purpose or object to be discussed (about the selection of repair methods),
- b. Criteria (cost, application, time, strength and durability, tools),
- c. Alternative method selection is determined by the research maker with references from work warrants in the last three years such alternatives are Cement Mortar, *Epoxy Injection*, and *Sealant Application*.



Figure 2. Examples of hierarchy decision-making improvement of concrete structures

Furthermore, the hierarchy of decisions that will be explained is, criteria and alternatives. Here is an overview of the Hierarchy decision to select the method of strengthening the concrete structure.

- a. Purpose or Object to be discussed (about the selection of retrofitting methods),
- b. Criteria (cost, application, time, strength and durability, tools),
- c. Alternative method selection is determined by the research maker with references from work warrants in the last three years such alternatives are Fibre Reinforced Polymer, Self Compacting Concrete, and Steel Application.

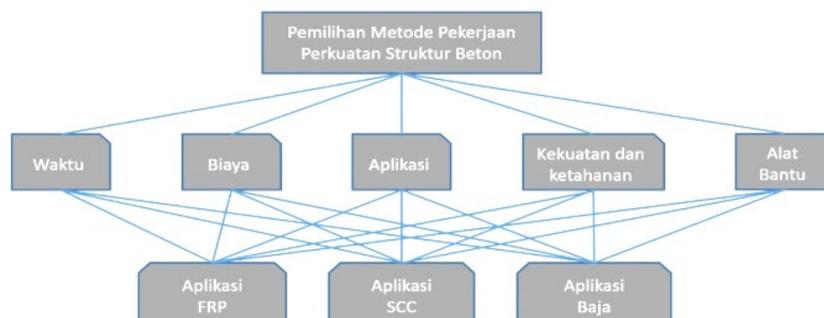


Figure 3. Examples of hierarchy decision-making strengthening concrete structures

#### 4. Data Collection

Analytical Hierarchy Process (AHP) is the stage of method to get decisions that will get reasonable decision results. A reasonable or rational decision is described as the best decision of the various goals desired by the decision maker. Important factors in decision making include alternatives and criteria that lead to the expected goals and based on the source of existing data. As the previous explanation of the first stage in the selection of concrete repair and retrofitting methods include:

- 1) Determining some alternative criteria for the selection of concrete repair methods as a comparison are as follows:
  - a. Criterion 1: Time  
Time on this criterion is one of the important factors in decision making.
  - b. Criterion 2: Cost  
The cost on these criteria has an influence on the type of work, work time, and job application. The cost of work can be determined on any job planning depending on the level of difficulty or material needs of the materials used.
  - c. Criterion 3: Application  
Every application of work done will affect the material used.
  - d. Criterion 4: Durability and Strength  
Durability and strength in the materials used are the main things that are expected in repair or retrofitting work, either in concrete buildings or steel buildings.
  - e. Criterion 5: Tools  
Job applications on the ground require work aids, for example; scaffolding to reach the intended work area, and casting work required pumps, vibrators, and mixers to help with the work to be done.
- 2) Next determining the subcriteria on the improvement of concrete structures as a comparison is as follows:
  - a. Subcriteria 1:  
Application of Mortar Cement  
According to Rahmadi and Arjoeni, mortar is defined as a mixture of materials consisting of fine aggregates (sand) adhesive materials (clay, lime, Portland cement) and water with a certain composition.
  - b. Subcriteria 2:  
Epoxy injection application  
This material is generally made on the basis of epoxy resin and includes resin for injection, castable mortar and a paste that can be applied byhand. Epoxy mortar consists of resin hardener and filler consisting of fine sand, while epoxy concrete consists of resin, hardener, fine sand and small size coarse aggregates.
  - c. Subcriteria 3: Sealant Application  
There are two types of *elastomeric* sealants that are commonly used: hot-applied, which is usually a mixture of bituminous material with compatible rubber and warmed, cold applied sealant like this consists of a mixture with plastomer material, with amixture is adhesive.
- 3) Then determine the subcriteria on the strengthening of concrete structures as a comparison is as follows:
  - a. Subcriteria 1:  
FRP (Fibre Reinforced Polymer)  
The working method of Fiber Reinforced Polymer is like adding a steel plate, essentially strengthening the tensile structure. FRP is widely used to increase the strength of the structure using *carbon*, aramid, and *glass* materials. FRP commonly used is in the form of plate / composite and fabric /wrap. With this shape makes it more efficient and effective on bending of the bending in the beam or on the plate and on the concrete wall. For wrap models to be more efficient and effective at the shear strength in the beam as well as the addition of axial load capacity and slide in the column.
  - b. Subcriteria 2:  
SCC (Self Compacting Concrete)  
In other words, SCC is a new concrete that is elastic and can easily flow to fill all the gaps of the mold, because this concrete has properties that can solidify by itself, without the help of a concrete vibrator device. Good SCC concrete has a cohesive content, is not blocking, homogenous, not

segregation and does not bleed. The use of SCC concrete for repair materials can add to the quality of concrete repair because it can avoid human error due to manual compaction. In the process of poor casting can result in reduced concrete resistance.

c. Subcriteria 3:  
 Steel Structure

Steel is an alloy metal with iron as the base element and carbon as its main alloy element. The carbon content in steel ranges from 0.2% to 2.1% in weight according to its level. The function of carbon in steel is as a hardening element by preventing dislocation from shifting on the crystal lattice lattice of iron atoms. Other commonly added alloying elements besides carbon are manganese, chrome (chromium), vanadium, and tungsten (Tarkono et al., 2012).

From this data is weighting of each criterion both the improvement of concrete structure and the strengthening of concrete structures in accordance with its importance which is in accordance with the provisions of the Analytical Hierarchy Process (AHP) method as follows:

1) Comparison of the improvement and strengthening of concrete over time

The time criteria selected with the amount of the value, on the table listed five numbers Analytical Hierarchy Process (AHP) value (5) has a fast time on the job application, on the contrary the value (1) has a long time in the work process as in the following table:

Table 1. Comparison of Time

Time	Weight	Information
< 3 hours	5	Fast
3-4 hours	4	Rather Quickly
4-5 hours	3	Enough
5-6 hours	2	A Little Long
6 > hours	1	Old

2) Comparison of concrete trim and retrofitting against cost

The cost criteria are selected by the amount of value, on the table listed five numbers Analytical Hierarchy Process (AHP) value (5) has a low cost on job applications, conversely the value (1) has a high cost on the work process as in the following table:

Table 2. Cost Comparison

Cost	Weight	Information
< 2 million Rupiah	5	Cheap
2-4 million Rupiah	4	It's a bit cheap
4-6 million Rupiah	3	Enough
6-7 million Rupiah	2	Rather Expensive
7 > Million Rupiah	1	Expensive

3) Comparison of concrete repairs to job applications

The criteria for job applications are selected by the amount of value, on the table listed five numbers Analytical Hierarchy Process (AHP) value (5) has a very easy application on the job application, on the contrary the value (1) has a very difficult application in the work process as in the following table:

Table 3. Application Comparison

Application	Weight	Information
Very Easy	5	Good
Easy	4	Rather Good
Keep	3	Enough
Difficult	2	A Little Bad
Very Difficult	1	Bad

4) Comparison of Concrete repairs to strength & durability

The strength criteria and selected by the amount of the value, on the table listed five numbers Analytical Hierarchy Process (AHP) value (5) has a long strength and durability > 2 years after the application of the job, conversely the value (1) has a short strength and resistance < 1/2 Year After the work process as in the following table:

Table 4. Comparison of Strength and Durability

Strength & Durability	Weight	Information
>2 Years	5	Good
2 years	4	Rather Good
1 Year	3	Enough
1/2 Year	2	A Little Bad
< 1/2 years	1	Bad

5) Comparison of Concrete Repair with Work Aids

The criteria of the tool are selected by the amount of value, on the table listed five numbers Analytical Hierarchy Process (AHP) value (5) has a level of need for aids that are very important in job applications, whereas value (1) has a level of need for unnecessary aids in the work process as in the following table:

Table5. Comparison of Tools

Tools	Weight	Information
Very important	5	Good
Important	4	Rather Good
Keep	3	Enough
No Need	2	Somewhat Less
Very Unnecessary	1	Less

Matrix Comparison

The system supporting the decision of choosing concrete repair and retrofitting methods is determined by existing criteria, then the flow thereafter there is a paired comparison matrix that explains the relative contribution of each component with several other criteria. Determine the weight of criteria based on

these criteria is determined by the user or selector where the weighting value of the scale 1 to 9 according to the interests of the voter, is listed on the following table:

Table 6. Paired Comparison Assessment Scale

Activity intensity	description
1	both elements are equally important
3	one element is slightly more important than the other
5	one element is more important than the other
7	one element is clearly more absolutely important than the other elements
9	one element is absolutely important than the other elements
2,4,6,8	Values between two adjacent considerations

## 5. Results and Discussion

The criteria for the selection of concrete repair and retrofitting methods with the following description and table:

a	The first criterion	K1	Time
b	The second criterion	K2	Cost
c	The third criterion	K3	Application
d	Fourth criterion	K4	Durability and strength
e	Fifth criterion	K5	Tools

Table 7. Pair comparison criteria

<i>Criterion</i>	<i>K1</i>	<i>K2</i>	<i>K3</i>	<i>K4</i>	<i>K5</i>	<i>Eigen value</i>	<i>Weight priority</i>
<b>K1</b>	1.000	0.200	0.200	0.200	0.200	0.275	0.038
<b>K2</b>	5.000	1.000	0.200	0.200	0.200	0.525	0.073
<b>K3</b>	5.000	5.000	1.000	5.000	0.333	2.108	0.293
<b>K4</b>	5.000	5.000	0.200	1.000	0.200	1.000	0.139
<b>K5</b>	5.000	5.000	3.000	5.000	1.000	3.271	0.455
<b>TOTAL</b>	21.000	16.200	4.600	11.400	1.933	7.181	1.000

Table 8. Criterion Value

<i>Criterion</i>	<i>K1</i>	<i>K2</i>	<i>K3</i>	<i>K4</i>	<i>K5</i>	<i>Number of Rows</i>
<b>K1</b>	0.0476	0.0123	0.0435	0.0175	0.1035	0.2244
<b>K2</b>	0.2381	0.0617	0.0435	0.0175	0.1035	0.4643
<b>K3</b>	0.2381	0.3086	0.2174	0.4386	0.1724	1.3751
<b>K4</b>	0.2381	0.3086	0.0435	0.0877	0.1035	0.7814
<b>K5</b>	0.2381	0.3086	0.6522	0.4386	0.5173	2.1548

On table 7, describing the value of 1,000 in column **K1** of row K1 describes the same priority value between **K1** and K1. Furthermore, the value of 5,000 in column **K3** and row K1 explains that K1 is more priority than K3. The value on row **K1** is summed up to get a value of 21. Next, calculations are carried out to get eigen value and priority weights.

**Matrix Value Criteria**

The value 0.0476 in column K1 row **K1** Table 8, derived from the numbers in the K1 time row column in Table 7 divided (/) the number of time columns Table 7, The column value of the number of rows in Table 8 is obtained from the sum of each row. For the first line is the sum result of  $0.0476 + 0.0123 + 0.0435 + 0.0175 + 0.1035 = 0.2244$ .

**Consistency Ratio Calculation.**

Table 9. Consistency Ratio

Priority Weights	Number of Rows	Eigen Maks
0.0384	0.2244	5.8410
0.0731	0.4643	6.3475
0.2936	1.3751	4.6840
0.1392	0.7814	5.6116
0.4556	2.1548	4.7295
	Total:	27.2135

It is necessary to ensure that the consistency ratio (CR) value is less = 0.1. if the CR value is greater than 0.1, the comparison matrix is immediately updated. From Table 9 obtained, the total result of the max eigen calculation = 27.2135.

$N$  (Number of criteria) = 5  
 $\lambda_{maks}$  (sum/n) =  $27.2135/5 = 5.4427$   
 $CI$  ( $\lambda_{maks} - n$ )/ $(n - 1)$  =  $(5.4427 - 5)/5 = 0.1107$   
 $CR = CI/IR = 0.1107/1.12 = 0.0988$   
 $CR < 0.1$  accepted.

Perform Sub-criteria calculations with others of all criteria, in this calculation there are 5 criteria. These sub-criteria are Good, quite good, sufficient, somewhat less, and less. As explained at the beginning of the sub criteria is divided into two alternatives, namely, concrete building structure repair work, and concrete building structure retrofitting work. The results of the data obtained are processed with the following calculations.

a) Sub criteria Work on Repair of Concrete Building Structure.

1) Improvements with Cement Mortar Application.

The work of repairing concrete structures by making a matrix of comparison criteria of voter perception by performing mortar cement application is as follows:

Table 10. Overall Criteria with Cement Mortar Application

Criterion	Priority Weights
Time	0.3333
Cost	0.3871
Application	0.3630
Durability and strength	0.3515
Tools	0.3333

2) Repair with Epoxy Injection Application.

The work of repairing concrete structures by making a matrix of comparison of voter perception criteria by performing epoxy injection applications is as follows:

Table 11. Overall Criteria with Epoxy Injection Application.

<b>Criterion</b>	<b>Priority Weights</b>
Time	0.2698
Cost	0.2366
Application	0.2963
Durability and strength	0.3758
Tools	0.3533

3) Improvements with Sealant Application.

The work of improvement of concrete structures by making a matrix of comparison of voter perception criteria by performing sealant applications is as follows:

Table 12. Overall Criteria with Sealant Application

<b>Criterion</b>	<b>Priority Weights</b>
Time	0.3968
Cost	0.3763
Application	0.3407
Durability and strength	0.2727
Tools	0.3133

b) Subcriteria Work Strengthening Concrete Building Structure.

1) Strengthening With Fibre Reinforced Polymer (FRP) Applications.

The work of strengthening concrete structures by making a matrix of comparison of voter perception criteria by performing FRP applications is as follows:

Table 13. Overall Criteria with FRP Strengthening Application

<b>Criterion</b>	<b>Priority Weights</b>
Time	0.3548
Cost	0.3780
Application	0.3462
Durability and strength	0.3298
Tools	0.3091

2) Strengthened With (SCC) Application Self Compacting Concrete.

The work of strengthening concrete structures by creating a matrix of comparison of voter perception criteria by performing SCC applications is as follows:

Table 14. Overall Criteria with SCC Strengthening Application

<b>Criterion</b>	<b>Priority Weights</b>
Time	0.3978
Cost	0.4512
Application	0.4038
Durability and strength	0.3298
Tools	0.3152

- 3) Strengthen with the application of steel structures.  
 The work of strengthening concrete structures by making a matrix of comparison of voter perception criteria by performing the application of steel structures is as follows:

Table 15. Overall Criteria with Application of Steel Structures

Criterion	Priority Weights
Time	0.2473
Cost	0.1707
Application	0.2500
Durability and strength	0.3404
Tools	0.3758

This section compares each criterion by multiplying the priority weight value of the voter's perception by weight priority of each alternative improvement and strengthening with the following table:

- a. Sub criteria Of Concrete Building Structure Repair Work

Table 16. Overall Criteria for Improvement of Concrete Building Structure

Criterion	Mortar Cement	Epoxy injection	Sealant
Time	0.3333	0.2698	0.3968
Cost	0.3871	0.2366	0.3763
Application	0.3630	0.2963	0.3407
Durability and strength	0.3515	0.3758	0.2727
Tools	0.3333	0.3533	0.3133

Table 17. Overall Priority Weight Criteria

Criterion	Priority Weights
K1	0.0384
K2	0.0731
K3	0.2936
K4	0.1392
K5	0.4556

The value of the overall priority is calculated from the multiplication between a priority weight criteria column with the criteria column of improvement of the structure of the attached concrete building as follows: For the criteria for improvement of concrete building structures using the application of Cement Mortar = (time weight X weight K1 Priority weight) + (cost weight X weight K2 Priority) + (application weight X weight K3 Priority) + (durability weight and strength X weight K4 Priority weight) + (auxiliary weight X weight K5 Priority). So, for the application of mortarmen:  $(0.3333 \times 0.0384) + (0.3871 \times 0.0731) + (0.3630 \times 0.2936) + (0.3515 \times 0.1392) + (0.3333 \times 0.4556) = 0.3485$ . Calculations on the repair of concrete building structures with epoxy injection and sealant applications using the same calculations, then the results are:

Table18. Overall Alternative Criteria for Concrete Structure Repair

Alternative	Overall Priorities
Application of Cement mortar	0.3485
Epoxy injection application	0.3280
Sealant Application	0.3235

Therefore, the results of analytical hierarchy process (AHP) analysis approach modeling on buildings resulted in one decision to establish concrete structure retrofitting methods against alternatives to Mortar Cement Applications, Epoxy Injection Applications, and Sealant Applications. It is then advisable to choose concrete repair with alternative Cement Mortar Application as the main choice with the highest value is 0.3485 as the best option by using AHP calculations.

b. Subkriteria Work Strengthening Concrete Building Structure

Table19. Overall Criteria for Strengthening Concrete Building Structure

Criterion	FRP	SCC	STEEL
Time	0.3548	0.3978	0.2473
Cost	0.3780	0.4512	0.1707
Application	0.3462	0.4038	0.2500
Durability and strength	0.3298	0.3298	0.3404
Tools	0.3091	0.3152	0.3758

Table 20. Overall Priority Weight Criteria

Criterion	Priority Weights
K1	0.0384
K2	0.0731
K3	0.2936
K4	0.1392
K5	0.4556

The value of the overall priority is calculated from the multiplication between the priority weight criteria column and the criteria column for retrofitting the concrete building structure. Calculations on the strengthening of concrete building structures with FRP applications, SCC and Steel applications using the same calculations then the results are:

Table 21. Overall Voter Perception Criteria

Alternative	Overall Priorities
FRP	0.3297
SCC	0.3564
STEEL	0.3140

The results of analytical hierarchy process (AHP) analysis approach on buildings resulted in one decision to establish the method of retrofitting concrete structures against alternative FRP applications, SCC applications, and steel applications. It is recommended to choose retrofitting concrete building structures with alternative applications of Self Compacting Concrete is the best choice with a high value of: 0.3564, the best selection.

## 6. Conclusion

Analytical Hierarchy Process methods can help solve complex problems through systematic or scientific settlement processes, the information obtained by analysis (AHP) is precise and correct. Then the results of the decision on the improvement of concrete building structures can be decided to choose an alternative application of Cement Mortar as the main choice with the highest value is: 0.3485, as the best option. Furthermore, for retrofitting concrete building structures decided to choose with the highest value is: 0.3564, with alternative applications of Self Compacting Concrete as the main choice.

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