

A Decision Support System for Determining Optimal Concrete Quality Using the Simple Additive Weighting (SAW) Algorithm (Case Study: UISU Concrete Laboratory)

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A B S T R A C T

This study aims to design a decision support system to determine the best concrete quality using the Simple Additive Weighting (SAW) algorithm. Concrete is the primary material in construction, possessing various mechanical properties and characteristics that define its quality. At the Concrete Laboratory of Universitas Islam Sumatera Utara (UISU), the determination of concrete quality is still conducted manually, relying on subjective experience, which can lead to inconsistencies in assessment. Therefore, developing a system based on the SAW algorithm is necessary to enhance efficiency and objectivity in selecting the best concrete. The research process begins with data collection on concrete samples, covering parameters such as compressive strength, water volume, setting time, cement content, and aggregate quantity. Each criterion is assigned a weight based on its importance, followed by normalization to align scale values. The SAW algorithm is then applied to calculate the final preference values for each concrete sample, ultimately generating a recommendation for selecting the highest-quality concrete. The study results show that Concrete C achieves the highest final score (0.94706), followed by Concrete A (0.88328) and Concrete B (0.76292). The study concludes that the SAW algorithm effectively enhances objectivity and accuracy in determining the best concrete quality.

INTRODUCTION

Concrete is one of the most widely used construction materials in various development projects, both on small and large scales. The quality of concrete significantly determines the durability, strength, and safety of the structures being built. Therefore, determining the optimal concrete mix quality is a crucial aspect in the construction industry.

At the Concrete Laboratory of Universitas Islam Sumatera Utara (UISU), various tests are conducted to assess concrete quality based on several parameters such as compressive strength, workability, density, and durability. However, in practice, the selection of the best concrete mix quality is often performed manually or based on subjective experience. This approach may lead to inconsistencies in quality determination and suboptimal use of laboratory test data.

To address this issue, a Decision Support System (DSS) is needed to assist in determining the best concrete mix quality in an objective and systematic manner. The Simple Additive Weighting (SAW) algorithm is chosen as the method for this system due to its capability to perform weighted calculations for each predefined criterion. SAW enables the evaluation of concrete mix alternatives based on normalized values, resulting in more accurate and structured rankings.

With the implementation of this system, the process of determining the best concrete mix quality at the UISU Concrete Laboratory is expected to be more efficient, objective, and transparent.

In addition, this system can assist researchers, academics, and practitioners in making more accurate decisions based on the available data.

METHOD

System

A system is an arrangement that describes a series of interconnected components working together toward a common goal in a balanced, harmonious, and coordinated manner, operating continuously within a planned timeframe [1].

A system is a group of components and elements combined into a unified whole to achieve a specific goal. The term "system" originates from the Latin *systema* and the Greek *sustēma*, referring to a unit consisting of interconnected components or elements that facilitate the flow of information, materials, or energy to accomplish a particular objective. This term is often used to describe a set of interacting entities, for which a mathematical model can often be constructed [2].

Concrete

Concrete is formed from a mixture of fine aggregate, coarse aggregate, cement, and water in specific proportions. The compressive strength of concrete is influenced by the types of materials used in its composition. One significant factor is the gradation of the aggregate. The particle size distribution can affect the quality of the concrete. A uniform gradation, where the aggregate particles are of similar size, differs in density compared to a continuous gradation with varying particle sizes. Concrete is a mixture of Portland cement or other hydraulic cement, fine aggregate, coarse aggregate, and water, with or without admixtures, forming a solid mass. The properties of concrete are generally influenced by the quality of the materials, the method of processing, and the curing process. The characteristics of the cement affect the quality and setting speed of the concrete. The gradation of fine aggregate impacts workability, while the gradation of coarse aggregate affects the concrete's strength. Both the quality and quantity of the materials influence the hardening process and the overall strength of the concrete [3].

Algorithm

According to [4], an algorithm is an effort involving a sequence of operations arranged logically and systematically to solve a problem in order to produce a specific output. An algorithm is a sequence of ordered steps that are systematically recorded to solve a particular problem. Meanwhile, a programming algorithm refers to a series of structured steps arranged sequentially to address problems encountered in computer programming. In basic programming, an algorithm can be considered the first and most essential stage that must be prepared before creating a program [5]. Problems that can be solved by writing computer programs for PCs are typically those defined through numerical estimation. A key priority in writing computer programs lies in developing a fundamental idea of how to solve programming-related problems. Sometimes, a problem that appears simple on paper can be quite difficult to translate into programming logic. The concept of algorithms was first introduced in the book *Al-Jabr Waal Muqabla*, written by the Muslim scholar Abu Ja'far Muhammad Ibn Musa Al-Khawarizmi in 825 AD [6].

Decision Support System

According to [7], a decision support system is an information system used to assist in decision-making by providing structured, relevant, and appropriate information tailored to the needs of the decision-making process.

Structured decisions are repetitive, routine, and well-understood. Therefore, they can be delegated to lower-level employees within an organization. Based on the explanation above, the author concludes that the implementation of a decision support system is intended to enhance the decision-maker's ability by providing better decision alternatives, thereby assisting in determining an appropriate decision [8,9].

Simple Additive Weighting (SAW)

The advantage of the Simple Additive Weighting (SAW) method compared to other decision-making system methods lies in its ability to provide more accurate assessments, as it is based on the criterion values and the required weight of importance. The SAW method can also select the best alternative from a number of available options by performing a ranking process, in which the total weighted scores of all criteria are summed after determining the weight for each criterion [10,11]. The Simple Additive Weighting (SAW) method is one of the multi-criteria decision-making techniques used to determine the best alternative based on a set of predefined criteria. This method evaluates each alternative by applying attributes and weights for each criterion to obtain a final score that serves as the basis for selection. The SAW

method is also commonly referred to as the weighted sum method [12]. The fundamental concept of the SAW method is to calculate the total weighted score of each alternative according to its performance across all criteria [13]. The computation process involves normalizing the decision matrix (X) into a comparable scale so that all alternatives can be evaluated objectively [14].

Flowchart

A flowchart is a graphical representation of the steps and sequence of procedures in a program. A system flowchart illustrates the sequence of processes within a system by showing the input and output devices, as well as the types of media used for storage during data processing. On the other hand, a program flowchart is a diagram using specific symbols that describes a detailed sequence of processes and illustrates the relationship between one process (instruction) and another within a program [15].

RESULTS AND DISCUSSION

The initial stage in implementing the Simple Additive Weighting (SAW) algorithm is to input the concrete data whose quality will be determined. In this chapter, the author will input three concrete data entries to be used for the calculation. The following are the concrete data entered by the author:

Table 1. Concrete Data Samples

Sample Name	Compressive Strength	Water Content	Curing Time	Cement Content	Aggregate Content
Beton A	44	125	20	360	1200
Beton B	35	200	14	320	1100
Beton C	45	170	10	370	1250

After entering the concrete data whose quality is to be determined, the next step is to assign weights to each of the existing criteria. As shown in Table 3.1, there are five criteria data entered; therefore, the weights for each criterion are as follows:

Table 2. Criteria Weight Table

Criteria	Weight
Compressive Strength	0,3
Water Content	0,2
Curing Time	0,2
Cement Content	0,15
Aggregate Content	0,15

After determining the appropriate weights for each criterion, the next step is to identify the criteria based on benefit and cost types. A benefit criterion is one where a higher value indicates a better outcome (this criterion is to be maximized). In contrast, a cost criterion is one where a lower value indicates a better outcome (this criterion is to be minimized).

The next step is to calculate the normalization of each criterion. In this stage, the normalization process is carried out differently based on whether the criterion is classified as a benefit or a cost. For benefit criteria, the sample data for each criterion is divided by the maximum value of that criterion. For cost criteria, the minimum value of the criterion is divided by the sample data. This calculation is performed using the concrete sample data that has already been entered.

After completing the normalization calculations for each criterion across all sample data, the next step is to calculate the final score. The following are the final scores based on the SAW (Simple Additive Weighting) calculations:

Table 3. Final Result Table of SAW Calculation

Sample Name	Result
Beton C	0,94706
Beton A	0,88328
Beton B	0,76292

Based on the calculation of the three sample data entered in this chapter, as shown in Table 3, the best concrete quality among the three samples is Concrete C with a final score of 0.94706, followed by Concrete A in second place with a score of 0.88328, and Concrete B in last place with the lowest quality score of 0.76292.

CONCLUSION

The decision support system based on the Simple Additive Weighting (SAW) method has been successfully implemented in this study to objectively and systematically determine the best concrete quality. The SAW algorithm is capable of evaluating concrete quality based on five main criteria: compressive strength, water content, curing time, cement content, and aggregate content, resulting in a more accurate ranking compared to subjective methods. Based on the research conducted at the UISU Concrete Laboratory, Concrete C achieved the highest final score of 0.94706, followed by Concrete A with a score of 0.88328, and Concrete B with a score of 0.76292, indicating that Concrete C has the best quality among the tested samples.

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