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Analysis of Alternative Substitute Materials for Concrete Production Using Word Cloud

Analisis Alternatif Bahan Pengganti untuk Produksi Beton Menggunakan Word Cloud

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ABSTRACT

Concrete is a construction material whose use continues to increase every year. This need is based on concrete forming materials, especially cement, which has experienced quite a large increase. Word cloud is a system that creates visualizations of words by emphasizing the frequency of occurrence of related words in written discourse. This research uses the text mining method with the help of Word Cloud and Term Document Matrix to analyze 76 articles as a dataset that discuss various concrete substitute materials including husk ash, dry bamboo leaves, construction waste, husk ash, and shells. The use of Word Cloud in the analysis of concrete substitute materials provides a fast and effective visualization of the frequency and relevance of words in the text and helps identify environmentally friendly substitute materials, the most widely used in the industrial world and has concrete compressive strength according to concrete quality standards based on the frequency of word occurrences. key in the dataset.

Keywords: Concrete, Substitute Material, Text Mining, Word Cloud

ABSTRAK

Beton adalah salah satu bahan konstruksi yang penggunaannya terus meningkat setiap tahun. Kebutuhan ini didasarkan pada bahan pembentuk beton, terutama semen, yang telah mengalami peningkatan yang cukup besar. Word cloud merupakan sebuah sistem yang memunculkan visualisasi kata-kata dengan memberikan penekanan pada frekuensi kemunculan kata terkait dalam wacana tertulis. Penelitian ini menggunakan metode text mining dengan bantuan Word Cloud dan Term Document Matrix untuk menganalisis 76 artikel sebagai dataset yang membahas berbagai bahan substitusi beton meliputi abu sekam, daun bambu kering, limbah konstruksi, abu sekam, dan cangkang kerang. Penggunaan Word Cloud dalam analisis bahan substitusi beton memberikan visualisasi yang cepat dan efektif mengenai frekuensi dan relevansi kata-kata dalam teks serta membantu mengidentifikasi bahan substitusi ramah lingkungan, paling banyak digunakan di dunia industri dan memiliki kuat tekan beton sesuai standar mutu beton berdasarkan frekuensi kemunculan kata kunci di dataset.

Kata Kunci: *Beton, Bahan Substitusi, Text Mining, Worl Cloud*

1. INTRODUCTION

According to the SNI 03-2834-1993 standard, concrete is defined as a composite material produced from the mixing of Portland cement or other types of hydraulic cement with fine aggregate, coarse aggregate, and water (Ginting, 2014). This mixture, with or without the

addition of additives, will harden and form a solid mass (Bint Ashraf & Noor, 2011). Aggregates, which generally fill most of the concrete volume, significantly affect the properties of concrete. These materials, usually in the form of natural stone or sand, provide stability and wear resistance to concrete (Nasrulloh & Kurniawan, 2018).

Generally, concrete is made from a mixture of Portland cement or other hydraulic cement, fine aggregate, coarse aggregate, and water, with or without additional limited natural resources, new innovations are needed, one of which is using ceramic waste as coarse aggregate (Rifai, Arnandha, & Rakhmawati, 2019).

Concrete components include water, Portland cement, coarse and fine aggregates, and additives, each of which has different functions or influences. An important property of concrete is its compressive strength. If the compressive strength of concrete is high, other properties of concrete are generally good as well. Factors affecting concrete strength include the concrete components themselves, the water-cement ratio, aggregate gradation, maximum aggregate size, and the concrete production process (mixing, lifting, compaction, and curing) as well as the age of the concrete (Orozco, Avila, Restrepo, & Parody, 2018). The use of concrete material as part of building structures has been widely adopted due to its high compressive strength. Many efforts have been made to improve the compressive strength of concrete, one of which is by adding waste materials to the concrete mix.

Text Mining is the discovery of knowledge in textual databases (Knowledge Discovery in Textual databases or KDT for short (Feldman & Dagan, 1995), also known as the extraction or search of text-based data (Firdaus & Firdaus, 2021a). This includes the interest in newly created knowledge, defined as part of the process of extracting or searching for previously unknown text data, so that it can be understood, has potential, and practical patterns or knowledge from collections of text data or massive corpora (collections of texts that capture the use of language in written or spoken form comprehensively and densely) and unstructured. Processing data in the form of text, often referred to as text mining, can be more effective when management and processing are done using software assistance. Manual data processing, whether filtering data, grouping data, or other types of data processing, will take a long time (Julianto & Lindawati, 2022). Word cloud is a text mining method that displays graphics of word frequency, highlighting words that appear more frequently in the source text (Limbong, Sembiring, & Hartomo, 2022). The larger the word size in the visual, the more common the word is in the document (Alamsyah & Zuhri, 2017).

Alternative waste materials that can be added to concrete mixtures include ceramic waste, rice husk ash, dried bamboo leaves, demolished waste, fly ash, and shells. This research uses the Term Document Matrix to display the most frequently written words in articles collected in the dataset, to obtain more detailed and specific data. The use of the Term Document Matrix feature is still closely tied to the use of the Word Cloud feature. These two features complement each other in text mining research. This research resulted in three categories: environmentally friendly concrete substitute materials, the most widely used concrete substitute materials in the industrial world, and concrete substitute materials with high compressive strength.

2. LITERATURE REVIEW

Concrete is a mixture composed of various materials such as gravel, cement, sand, and water, with or without additional admixtures, forming a solid mass (Ismawati & Andaryati, 2024). The DPU Building Research Institute defines concrete as a mixture of hydraulic cement or Portland cement, water, sand, and gravel, with or without additives, forming a solid mass (Setiawan, Yulianto, & Aji, 2017).

High-quality concrete has each aggregate coated with a mortar mix (Arifin & Martomi, 2009). Good concrete quality can be achieved from good mortar or paste quality as well (Pratapa & Fahad, 2014). Good mortar quality means that the space between aggregates is fully filled and there are no voids. Substitute materials are those used to partially or completely replace the components of concrete, such as sand, gravel, and cement (Yulianto, 2013). Similar to the concept of substitute materials, a material can be replaced with a certain percentage of another material that has similar characteristics, both in terms of content and reaction to the concrete mix when stirred (Maulana, 2015). Some substitute materials that can be used include ceramic waste, rice husk ash, dried bamboo leaves, demolished waste, fly ash, and shells.

Text mining is the science of processing to extract information and works using methods and tools to analyze collections of documents. The main methods for text mining are rule-based methods, machine learning, and combined methods. Among them, there is the rule-based method, which also includes the lexicon method. Text mining refers to information retrieval, data mining, machine learning, statistics, and computational linguistics (Firdaus & Firdaus, 2021b).

A word cloud is a tool or application that allows users to generate visually appealing representations of text by highlighting the presence of significant words within the text. By using a word cloud, users can clearly see how often certain words appear in the text, as words that appear more frequently are displayed larger and more prominently in the visualization (Huang, Wang, & Ye, 2019). One popular data visualization technique is Wordcloud. In this visualization, the font size of words correlates with their frequency of occurrence in a set of documents; the more frequently a topic appears, the larger the font size.

3. RESEARCH METHODS

This research can be seen in Figure 1. The first stage is data collection. This research uses 76 articles detailing substitute materials: 13 journals on rice husk ash, 15 journals on dried bamboo leaves, 10 journals on construction waste, 10 journals on fly ash, 15 journals on shells, and 13 journals on ceramic waste.

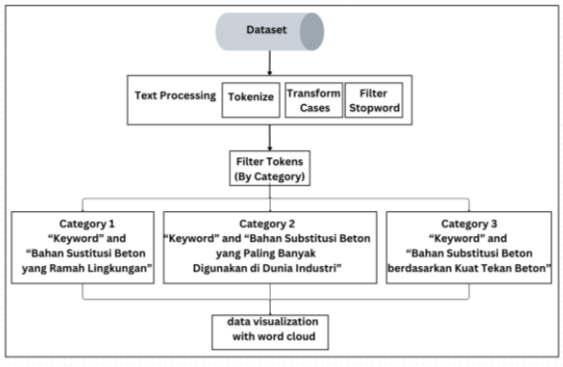

Figure 1. Research Methods

The objectives of text mining can be divided into two: text categorization and text clustering. In categorization, text mining is used as a tool to find categories that match the specified classes, while clustering in text mining functions as a tool to group text data based on similar characteristics, and clustering can be used to label previously unknown classes (Ardiani, Sujaini, & Tursina, 2020). This research uses text categorization because it categorizes substitute materials for concrete production into the required categories.

The second stage is Text Processing. The goal of Text Processing is to prepare documents in the form of text that were initially unstructured to become structured (Amin, Sutrisman, & Firdaus, 2017). Text Processing is a sub-process that includes other processes. These processes are as follows:

1. Tokenize, which is the process of separating words, where the word fragments are called tokens or terms (Manning, 2008; Witten, Frank, Hall, Pal, & Data, 2005).

2. Transform Cases, which is the process of automatically converting all letters in the text to lowercase or vice versa (Manning, 2008). In this research, all letters were converted to lowercase;

3. Filter Stopwords, which is the process of removing frequently occurring words that have no impact on word cloud extraction. These include words like time indicators and question words (Rahutomo & Ririd, 2019).

4. Filter Token (By Category), which is the process of deleting words with a certain number of characters using parameters min chars 4 and max chars 25 to limit the number of characters in a word to a minimum of 4 and a maximum of 25 in the text (Harsono, Alkhalifi, & Gata, 2022; Sinsuw & Najoan, 2013). The final stage is Word Cloud Visualization in this research using the Python Programming Language.

4. RESULTS

4.1. Concrete Substitute Materials Based On Environmentally Friendly

In the search for a word cloud for environmentally friendly concrete substitute materials, several alternative keywords have been identified through research that shows ecological benefits and good mechanical performance.

Concrete substitute materials include rice husk ash, fly ash, shellfish shells, and dried bamboo leaves, which stand out in this category. The resulting word cloud is a combination of the "keywords" entered into text mining and "Bahan Sustitusi Beton yang Ramah Lingkungan". The order of writing concrete substitute materials is based on the highest word cloud frequency.

Rice husk ash, produced from the burning of rice husks, is an environmentally friendly material. It can be used as a partial replacement for cement in concrete mixtures, reducing the use of cement, which has a significant impact on carbon emissions (Rigon, Espinosa Modolo, Zortea, Mancio, & Moraes, 2021).

Fly ash is a byproduct of coal combustion and can also be used as a cement substitute in concrete mixtures. It is an environmentally friendly material if sourced sustainably.

Shellfish shells can be used as fine or coarse aggregate in concrete mixtures. Their use not only helps reduce waste but also adds strength to the concrete (Zhu, Chen, Yu, Liu, & Liao, 2024).

"Although not commonly used in concrete production, dried bamboo leaves have the potential to be an environmentally friendly additive. However, further research is needed to understand their effects on the mechanical properties of concrete.

Ceramic waste can be used as aggregate in concrete production. This utilizes waste and reduces the environmental impact of ceramic waste disposal. Construction waste can be well managed and reused as aggregate in concrete mixtures, thereby reducing waste.

Figure 2. Word Cloud of Eco-Friendly Concrete Substitution Materials

Figure 2 represents word cloud by taking the keywords "Ramah Lingkungan" as many as 1206, "Abu Sekam" as many as 1203, "Abu Terbang" as many as 1194, "Cangkang Kerang" as many as 1035, "Daun Bambu Kering" as many as 943, "Limbah Keramik" as many as 884, "Limbah Konstruksi" as many as 614, "Agregat Kasar" as many as 282, "Agregat Halus" as many as 214, "Sekam Padi" as many as 92, "Emisi CO2" as many as 81, "Ekonomis" as many as 78, "Inovasi" as many as 45.

4.2. Concrete Substitute Materials Based on the Most Widely Used in the Industrial World

In the search for a word cloud in this category, it resulted in popular concrete substitute materials in line with the increasing public awareness of sustainability and waste reduction. Some of the substitute materials identified include fly ash, construction waste, and other substitute materials most widely used in the construction industry. The resulting word cloud is a combination of the "keywords" entered into text mining and "Bahan Substitusi Beton yang Paling Banyak Digunakan di Dunia Industri". The order of writing concrete substitute materials is based on the highest word cloud frequency.

Fly ash is the most widely used substitute material in the construction industry. Its use can enhance the durability of concrete, reduce CO2 emissions, and utilize waste from coal-fired power plants (Gaikwad & Sathe, 2025).

Construction waste, such as old concrete and building debris, is often reused as aggregate in new concrete (de Andrade Salgado & de Andrade Silva, 2022). This helps reduce waste and the need for natural disasters.

Rice husk ash is used as a cement substitute in concrete. Its use can increase the compressive strength of concrete and reduce environmental impact (Endale, Taffese, Vo, & Yehualaw, 2022).

Ceramic waste from the ceramics industry can be used as aggregate in concrete. This helps reduce industrial waste and improves the mechanical properties of concrete (Gopinath & Senthamarai, 2012).

Shellfish shells are used as fine aggregate in concrete. Their use can reduce the need for natural aggregates and improve the mechanical properties of concrete (Elliott Richardson & Fuller, 2013). The use of dried bamboo leaves in concrete is still in the research stage and has not yet been widely adopted in the construction industry (Gopinath & Senthamarai, 2012).

Figure 3. Word Cloud of the Most Widely Used Concrete Substitution Materials in the Industrial Sector

Figure 3 represents word cloud by taking the keywords "Dunia Industri" as many as 1173, “Abu Terbang” as many as 1085, “Limbah Konstruksi” as many as 991, “Abu Sekam” as many as 983, “Limbah Keramik” as many as 851, “Cangkang Kerang” as many as 748, “Daun Bambu Kering” as many as 510, “Agregat Kasar” as many as 278, “Agregat Halus” as many as 278, “Batubara” as many as 75.

4.3. Concrete Substitute Materials Based on Compressive Strength

In the search for a word cloud in this category, it involves keywords for selecting substitute materials for concrete that meet compressive strength testing standards, which are crucial for ensuring the quality and performance of structures. Some of the substitute materials identified that meet these standards include fly ash, construction waste, rice husk ash, and other substitute materials that can meet concrete compressive strength quality standards. The resulting word cloud is a combination of the “keywords” entered into text mining and “Bahan Substitusi Beton berdasarkan Kuat Tekan Beton”. The order of writing concrete substitute materials is based on the highest word cloud frequency.

Fly ash has extensive compressive strength testing standards and has been widely used in various construction projects. Its use can enhance the durability and strength of concrete, as well as reduce CO2 emissions (Gaikwad & Sathe, 2025).

Construction waste, such as old concrete and building debris, is often reused as aggregate in new concrete (de Andrade Salgado & de Andrade Silva, 2022; Rustiawandi & Safitri, 2025). The use of construction waste has been tested and meets reliable quality standards. Rice husk ash has also been tested for various concrete compressive strength classes. Research shows that rice husk ash can increase the compressive strength of concrete and reduce environmental impact (Endale et al., 2022).

Ceramic waste from the ceramics industry has been tested as aggregate in concrete and meets good quality standards. Its use helps reduce industrial waste and improves the mechanical properties of concrete (Roig-Flores et al., 2023). Shellfish shells have been tested as fine aggregate in concrete, although quality standards for higher grades may still be limited (Elliott Richardson & Fuller, 2013). The use of dried bamboo leaves in concrete is still in the research stage and has not been widely tested for various compressive strength classes (A A Umoh & Ujene, 2014; Akaninyene A Umoh & Odesola, 2015).

Figure 4. Word Cloud of Concrete Substitution Materials Based on Concrete Compressive Strength

Figure 4 represents word cloud by taking the keywords "Kuat Tekan" as many as 1673, “Abu Terbang” as many as 1181, “Limbah Konstruksi” as many as 1033, “Abu Sekam” as many as 995, “Limbah Keramik” as many as 884, “Cangkang Kerang” as many as 795, “Daun Bambu Kering” as many as 610, “K100” as many as 321, “K300” as many as 311, “Agregat Kasar” as many as 281, “K500” as many as 279, “Agregat Halus” as many as 238, “Kualitas” as many as 114.

5. CONCLUSION

This research shows that various wastes such as rice husk ash, fly ash, shellfish shells, dried bamboo leaves, and ceramic waste can be used as substitute materials in concrete production. The use of these substitute materials not only helps reduce waste but also improves the mechanical

properties of concrete and reduces CO2 emissions. The word cloud method is effective in displaying word frequency and helps in text analysis to identify the most commonly used substitute materials.

This research resulted in three categories: environmentally friendly concrete substitute materials, the most widely used concrete substitute materials in the industrial world, and concrete substitute materials with high compressive strength. In the category of Environmentally Friendly Substitute Materials, rice husk ash, fly ash, shellfish shells, and dried bamboo leaves are some environmentally friendly materials that can enhance concrete performance. In the category of concrete substitute materials for industrial use, fly ash and construction waste are the most widely used substitute materials in the construction industry due to their durability and CO2 emission reduction. In the category of compressive strength, fly ash and construction waste have been proven to meet concrete compressive strength standards, making them a good choice for various concrete quality classes.

For future research, it is advisable to use a different dataset by including International Journals, so that the creation of the word cloud can be more comprehensive

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