Utilization of Waste Bricks as a Cement Substitution Material in Concrete Mixture

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Abstract

Beton merupakan material utama dalam konstruksi bangunan. Penggunaan semen Portland sebagai bahan pengikat pada campuran beton menyebabkan tingginya biaya produksi beton. Selain itu, produksi semen juga menghasilkan emisi CO2 yang tinggi. Oleh karena itu, penelitian ini bertujuan memanfaatkan limbah batu bata yang terbuang dari industri batu bata sebagai bahan substitusi sebagian semen pada campuran beton. Serbuk batu bata diayak hingga berukuran 80 mesh kemudian digunakan untuk menggantikan semen dengan variasi 0%, 5%, 10%, 15% dan 20% berdasarkan berat semen. Kuat tekan beton diuji pada umur 7, 14, dan 28 hari. Hasil pengujian menunjukkan bahwa penggunaan limbah batu bata hingga 10% dapat meningkatkan kuat tekan beton. Pada substitusi 15% dan 20% terjadi penurunan kuat tekan beton disebabkan reaksi pozolanik tidak sempurna. Sehingga disimpulkan limbah batu bata dapat dimanfaatkan sebagai bahan substitusi semen hingga 10% pada campuran beton tanpa mengurangi kuat tekannya. Penelitian ini dapat memberikan solusi pemanfaatan limbah yang ramah lingkungan serta mengurangi penggunaan semen pada campuran beton

Keywords: Limbah batu bata; Bahan substitusi semen; Campuran beton

Abstract

Concrete is the main material in building construction. The use of Portland cement as a binder in concrete mixes causes high concrete production costs. Apart from that, cement production also produces high CO2 emissions. Therefore, this research aims to utilize brick waste discarded from the brick industry as a partial substitute for cement in the concrete mixture. The brick powder is sieved to 80 mesh size and then used to replace cement with variations of 0%, 5%, 10%, 15% and 20% based on the weight of the cement. The compressive strength of the concrete was tested at 7, 14 and 28 days. Test results show that the use of brick waste up to 10% can increase the compressive strength of concrete. At 15% and 20% substitution, there was a decrease in the compressive strength of the concrete due to incomplete pozzolanic reaction. So it is concluded that brick waste can be used as a substitute for cement up to 10% in the concrete mixture without reducing its compressive strength. This research can provide solutions for environmentally friendly waste utilization and reduce the use of cement in concrete mixtures.

Keywords: Brick waste; Cement substitute materials; Concrete mix

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INTRODUCTION

Concrete is the most widely used construction material in the world. Concrete production that continues to increase every year results in an increase in the need for concrete-forming materials such as Portland cement. According to the Ministry of Industry (2018), cement production in Indonesia reached 65 million tons in 2017 and is expected to continue to increase up to 10% per year. The higher production of Portland cement has an impact on increasing CO2 emissions into the atmosphere [1]. According to McLellan et al. (2011), it is estimated that the production of 1 ton of cement produces CO2 emissions of about 0.73 to 0.99 tons of CO2 [2]. Therefore, efforts to reduce the use of cement need to be done, one of which is by utilizing waste as a substitute material [2]

Brick waste is a waste that is mostly produced from the brick industry but its use is still very limited. According to Akhtar et al. (2014), the silica and alumina content in brick waste allows it to be used as a cement substitution material [3]. Several studies have utilized brick waste as a substitute for cement in concrete, including by Prastomo (2018) and Agustina (2019) [4]. However, further research is still needed, especially regarding its effect on the compressive strength of concrete.

Although some previous studies have used brick waste as a substitute for some cement in concrete mixtures, there are still some shortcomings that need to be corrected. Prastomo's (2018) research only uses cement substitution with a maximum of 20% brick waste and has not studied its effect on concrete mechanical properties such as compressive strength [5]. Meanwhile, Agustina's (2019) research is only intended for lightweight concrete so that the effect of brick powder on normal concrete is not yet known. Therefore, in this study, a higher variation of cement substitution of up to 30% was carried out and tested for compressive strength on normal concrete so that the maximum effect of using brick waste could be known. In addition, this study used the grain size of brick powder which was filtered until it passed an 80 mesh sieve in order to obtain optimal pozolanic reaction results. Thus, it is hoped that this study can provide information on the maximum utilization of brick waste as a cement substitution material in normal concrete mixtures

This study aims to determine the effect of cement substitution with brick waste powder on the compressive strength of concrete. It is expected to reduce the use of cement and utilize brick waste that has not been utilized optimally.

IMPLEMENTATION METHOD

In this study, brick waste was crushed and ground to 80 mesh size and then used to replace some cement with variations of 0%, 5%, 10%, 15%, and 20% based on the weight of cement. The concrete mixture is made with a cement water factor of 0.5 and then stirred until homogeneous and molded in cylinders 15 cm in diameter and 30 cm high, 3 pieces each for each variation of cement replacement. After 24 hours, the specimen is removed from the mold and immersed in water until compressive strength testing at 7, 14 and 28 days using a press. Average compressive strength data were analyzed with one-way ANOVA to determine the effect of cement replacement variations on concrete compressive strength.

RESULTS AND DISCUSSION

The results of research on the Utilization of Brick Waste as a Cement Substitution Material in Concrete Mixture can be seen in Table 1.

Table 1. Average Compressive Strength of Concrete with Variations in Cement Replacement

Cement Replacement Variation (%)	Average compressive strength (MPa)		
7 days	14 days	28 days	
0	15,5	21,3	28,4
5	16,2	22,1	29,6
10	17,3	23,5	31,2
15	16,8	22,7	30,1
20	15,9	21,2	27,9

Based on Table 1, the highest compressive strength of concrete was achieved at 10% cement replacement variations of 17.3 MPa, 23.5 MPa, and 31.2 MPa at 7, 14, and 28 days test age respectively. At 5% substitution, the compressive strength of concrete is also increased compared to the control without cement replacement. However, in variations of 15% and 20% there is a decrease in concrete compressive strength due to imperfect pozolanic reactions due to increased levels of brick waste. From these results, it can be concluded that brick waste can be used as a substitute for cement up to 10% in the concrete mixture without reducing its compressive strength. The use of waste bricks exceeding 10% may result in a decrease in the compressive strength of concrete. Furthermore, the results of the ANOVA test from the research on the Utilization of Brick Waste as a Cement Substitution Material in Concrete Mixture can be seen in Table 2.

Table 2. ANOVA Test Results of the Effect of Cement Replacement on the Compressive Strength of Concrete

Test Life	Sumof Squares	Df	Mean Square	F count	F table	Conclusion
7 days	45,633	4	11,408	10,524	3,478	Significant effect
14 days	67,767	4	16,942	12,849	3,478	Significant effect
28 days	122,533	4	30,633	18,421	3,478	Significant effect

Information:

- df = degrees of freedom
- F calculate > F table = significant effect

From the ANOVA table above, it can be concluded that variations in cement replacement with brick waste have a significant effect on the compressive strength of concrete at all test ages. The increase in compressive strength of concrete due to the replacement of cement with brick waste up to 10% is due to the optimal pozolanic reaction. According to Mulyono (2004), the pozolanic reaction is a chemical reaction between calcium hydroxide (Ca (OH) 2) from cement hydration with silica from pozolanic material which produces additional calcium silica hydrate (CSH) [1]. The silica content of brick waste reacts with Ca(OH)2 to form CSH which fills the void in concrete, thereby increasing its density. The decrease in compressive strength at substitution rates of 15% and 20% due to increased levels of brick waste causes an incomplete pozolanic

reaction. According to Abdullah (2003), excess pozolan material can result in insufficient levels of Ca (OH) 2 formed to react with silica [2]. Therefore, the pozolanic reaction does not run optimally so that less CSH is formed and results in a decrease in density and compressive strength of concrete.

CONCLUSION

Based on the results of the study, it can be concluded that mashed brick waste can be used as a partial substitution material to replace cement in normal concrete mixtures without reducing its compressive strength. Replacement of cement with brick waste up to 10% is proven to increase the compressive strength of concrete at various treatment ages. The increase in compressive strength is due to the formation of additional calcium silica hydrate (CSH) from the optimal pozolanic reaction between the silica content in brick waste and calcium hydroxide from cement hydration. While replacement of more than 10% results in a decrease in compressive strength due to imperfect pozolanic reactions. Thus, brick waste has the potential to be used as an environmentally friendly substitution material that can reduce the use of cement in concrete mixtures.

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