Bulletin of
CIVIL ENGINEERING
Vol. 3 No. 2, Agustus 2023
Artikel Riset

The Influence of Blasting Waste on Mortar Performance

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DOI: https://doi.org/10.18196/bce.v3i2.17898

Abstrak

Dalam campuran mortar, jumlah pasir yang dibutuhkan kira-kira tiga kali lipat jumlah semen yang digunakan. Oleh karena itu, permintaan pasir alam sangat tinggi karena pesatnya pertumbuhan infrastruktur saat ini. Akibatnya, penambangan pasir yang berlebihan telah menyebabkan erosi sungai yang berlebihan dan bahaya lingkungan. Hal ini menyebabkan perlunya mencari bahan alternatif pengganti pasir. Berkaitan dengan hal tersebut, penelitian ini dilakukan untuk mengetahui kinerja mortar dengan limbah peledakan sebagai material pengganti pasir. Limbah peledakan adalah limbah bahan peledak yang berasal dari area pembuatan kapal atau perawatan di anjungan angkut dan operasi militer. Persentase penggantian limbah peledakan terpilih adalah 0%, 10%, 20%, 30%, 40% dan 50%. Hasil penelitian menunjukkan bahwa persentase limbah peledakan yang dapat digunakan sebagai pengganti pasir mencapai 50%, dengan kuat tekan 21.8Mpa yang hampir dua kali lipat nilai sampel kontrol sebesar 14.2Mpa. Di sisi lain, tingkat penyerapan air untuk sampel 50.0% adalah 9.0%, lebih rendah dari nilai mortar kontrol sebesar 9.2%. Sesuai dengan ASTM C1329, kekuatan tekan mortar yang menggunakan limbah peledakan memenuhi kekuatan yang diijinkan untuk struktur.

Kata-kata kunci: Kinerja mortir; limbah peledakan; kekuatan tekan.

Abstract

In a mortar mixture, the amount of sand needed is about three times the amount of cement used. Therefore, the demand for natural sand is extremely high due to the rapid growth of infrastructure these days. As a result, the over-mining of sand has caused excessive river erosion and environmental hazards. This has led to the need of finding an alternative material to replace sand. In this regard, this study was conducted to investigate the performance of mortar with blasting waste as a replacement material for sand. Blasting waste is explosive waste from shipbuilding areas or maintenance on transport bridges and military operations. The replacement percentages of blasting waste selected were 0%, 10%, 20%, 30%, 40% and 50%. The result showed that the percentage of blasting waste that can be used as a replacement for the sand is up to 50%, with a compressive strength of 21.8Mpa which was almost double the value of the control sample at 14.2Mpa. On the other hand, the water absorption rate for the 50.0% sample was 9.0%, lower than the value of the control mortar at 9.2%. In accordance with the ASTM C1329, the compressive strength of the mortar using blasting waste complied with the allowable strength for structures.

Keywords: Mortar performance; blasting waste; compressive strength.

Article History
Received
15 July 2022

Revised
29 August 2022

Accepted
21 July 2022

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1 INTRODUCTION

Concrete is known as the most used material in the construction industry, and it is also a huge consumer of natural resources (Okolnikova et. al., 2020; Nabil et. al., 2010). Mortar and concrete produced by replacing the cement or aggregate in the traditional concrete mixture or a certain proportion thereof with natural or artificial mineral admixtures are becoming increasingly common (Omar et. al., 2020). With these admixtures, the properties of fresh and hardened mortar are aimed to be improved. Wall and plaster mortars are expected to be as durable and waterproof as bricks (Kan et. al., 2020). Mortar is one of the important materials in construction (Sandhu et. al., 2019). It functions as a binding matrix of structured and unstructured construction. The purpose of mortar is to bind or as an adhesive material for brick bonding work, such as binding bricks or blocks and plastering work on walls (Kaushik and Harshvadan, 2018). In general, for any given brick strength, there is a suitable mortar strength that gives maximum strength to the brickwork (Taufiq and Muttaqin, 2022).

Sustainable development includes various ideas for preventing hazardous actions and increasing the eco-friendly approach in different branches of the industry (Wioletta et. al., 2015; Yashsvi et. al., 2017). One of the solutions is to use industrial waste (Dash et. al., 2016;

Rajendra et. al., 2017; Ridho et. al., 2020). The idea has a double effect. On the one hand, reactive wastes such as fly ash or silica fume can be used to replace Portland cement, therefore contributing to the reduction of overall carbon dioxide emissions. On the other hand, non-reactive wastes can be used to replace the aggregate, improving the properties of mortars or concretes (Borucka et. al., 2018).

Sandblasting is a popular method of cleaning in various branches of industry including shipbuilding, civil engineering, or maintenance. Blasting (or in general abrasive blasting) is a process of removing the layers of dirt, rust, or paint from various surfaces. There are various types of abrasive blasting media used in the industry. Out of the multitude of available materials, sand is one of the most common due to its low cost but the blasting grit after use is considered as a waste product and must be disposed of. Other types of abrasive blasting waste, including steel shots or glass beads, can be reused. The plastic beads have special use in abrasive blasting as they are less damaging and are recommended for more sensitive surfaces (Borucka et. al., 2018). This study tries to determine the influence of blasting waste obtained from a local company on mortar performance.

2 RESEARCH METHOD

The demand for natural sand due to the rapid growth of infrastructure causes the reduction of natural sand and increases the rate of sand day by day (Kaushik and Harshvadan, 2018). Mortar is a masonry product which is matrix of concrete. It consists of binder and fine aggregate and moreover, it is an essential associate in any reinforced structural construction. The strength of mortar is a special concern to the engineer because mortar is responsible to give protection in the outer part of the structure as well as at a brick joint in masonry wall system (Imrose et. al., 2014). This study involved the production of mortar mixture according to a set of standard ratios. The raw materials used to produce mortar in this study were cement, blasting waste, sand, aggregate and water. The blasting waste used as sand replacement in the mortar mixture in this study was obtained from Bredero Shaw (Malaysia) Sdn. Bhd. The replacement percentage were 0%, 10%, 20%, 30%, 40% and 50%. The total number of mortar samples that were produced was 30 units, with 5 units for each ratio. The variations observed during the study involved changes that occurred in the values of weight, strength and water infiltration rate.

The method used in this study was an experimental method to obtain the optimum mortar mixture. Studies were conducted on the variation of the percentage of blasting waste as sand replacement in the mortar mixture. The first step to producing mortar in this study was to dry the sand and blasting waste. Then, the sand and blasting waste retained between the 4.75mm and 10mm sieves are separated to be used as a mixture. Next, the cement, sand and blasting waste material were weighed according to the design of the mixture, while the cement-water ratios were determined based on the mixtures. The formwork box was smeared with oil to make it easier for the mortar to be removed after drying. The mortar mixtures were poured into the formwork box and dried for 24 hours according to the ratio of the mixture as shown in Table 1.

Table 1. Mixture ratio design.

Blasting Waste (%)	0	10	20	30	40	50
Cement (Portland)	1	1	1	1	1	1
Sand	3	2.7	2.4	2.1	1.8	1.5
Water	0.6	0.6	0.6	0.6	0.6	0.6
Blasting Waste	0	0.3	0.6	0.9	1.2	1.5

After reaching 28 days as specified in the ASTM C109, 3 samples of mortar from each ratio were tested using a compression tester machine. Then, the strength of the mortar was calculated using the formula:

$$f_m = \frac{P}{A} \quad (1)$$

where,
f_m is the strength (Mpa);
P is the maximum load (kN); and
A is the pressure surface area (m^2).

Then, the remaining samples were tested for water infiltration rate at an immersion age of 24 hours, 7 days, 14 days and 28 days.

3 RESULTS AND DISCUSSIONS

The results of the studies conducted on the variation of the percentage of blasting waste in the mortar mixture had shown diverse performances in the samples. Figure 1 illustrates the weight increase directly proportional to the increase in the percentage of blasting waste. The density of mortar containing blasting waste is greater than that of the control sample for a variety of reasons. To begin with, the irregular shape of blasting waste particles improves particle packing and interlocking within the mortar mix. This improved packing minimises the existence of voids or air spaces, resulting in a more densely packed material and, as a result, a greater density. Furthermore, the smaller particle size distribution of the blasting waste might improve packing efficiency, increasing the total density of the mortar.

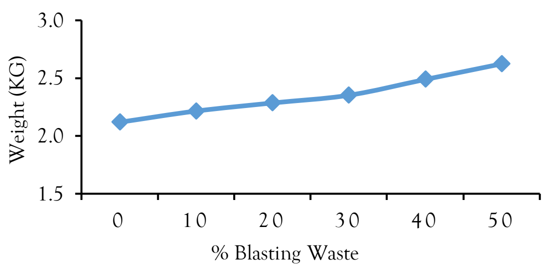

Figure 1. Weight against the percentage of blasting waste.

Finally, the observed weight increase in the sample with 50% blasting waste replacement, which recorded the heaviest average weight of 2.6 kg compared to the control sample's 2.1 kg average weight, demonstrates how a higher proportion of dense blasting waste in the mix raises the overall weight and, as a result, the density of the mortar.

In conclusion, the improved particle packing, finer particle size distribution, and increased material weight all contribute to the mortar with blasting waste replacement being heavier and denser than the control sample.

The results of the compression test conducted on various mortar samples using different percentages of blasting waste as sand replacement on the 28th day shown in Figure 2 revealed an interesting trend in compressive strength. It was observed that the strength of the mortar samples increased proportionally up to 50% after blasting waste replacement.

However, the compressive strength did not rise considerably and remained somewhat unstable in the 10% to 40% blasting waste range. Several causes can explain this phenomenon. Firstly, differences in particle packing and gradation within the mortar mix at various replacement percentages may have impacted strength development Cai (2017). The size and form of blasting waste particles might have also influenced the compressive strength response.

Furthermore, chemical interactions between blasting waste and cementitious components in the mortar may have influenced the overall strength behaviour (Borucka-Lipska et al., 2019). Additionally, larger blasting waste percentages may have generated excessive voids or increased porosity in the mortar, reducing its strength. Moreover, admixtures or partial cement replacement, as well as curing circumstances, may have contributed to the observed variances in compressive strength.

As shown in Figure 3, it was found that the water infiltration rate increased for the 10% blasting waste sample but decreased for the samples with higher blasting waste in general. The lowest absorption value occurred at 50% blasting waste, which was 9.0% on the 28th day, while the highest absorption value of 10.2% occurred at 10% blasting waste. The absorption rate was taken on the 28th day because the mortar was considered to have undergone a complete hydration process and at the same time had reduced the existing moisture rate in it.

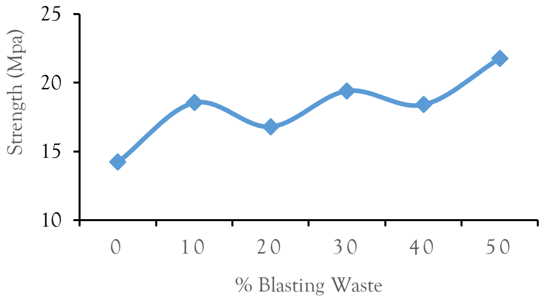

Figure 2. Strength of mortar against the percentage of blasting waste.

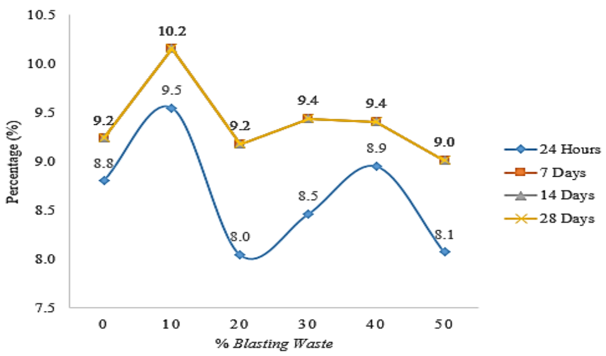

Figure 3. Water absorption rate against the percentage of blasting waste.

The process of drying the mortar in the oven also caused excess water in the mortar to be hydrated and high-water loss to occur. This condition allowed it to absorb more water during the test. It was found that the water absorption rate was closely related to the compressive strength, whereby the stronger the compressive strength, the lesser the water absorption rate.

The optimum content of blasting waste as sand replacement is determined by the maximum value of compressive strength. Based on the findings of the study, the highest compressive strength occurred on the sample with 50% blasting waste as sand replacement. The compressive strength of 21.8Mpa was almost double compared to the compressive strength of the control sample at 14.2Mpa. Moreover, this value was also over the range of the 28th-day compressive strength of the ASTM C1329, which is a minimum of 6.2Mpa and a maximum of 20.0Mpa. Furthermore, the water absorption rate for the sample with 50% blasting waste as sand replacement was 9.0% on the 28th day, lower than the water absorption value of the control sample at 9.2%.

These findings indicate that 50% blasting waste as sand replacement is the optimal value. The performances of strength and water absorption of the sample with 50% blasting waste were better than that of the control sample. This also indicates that blasting waste has great potential in mortar mixture.

The use of blasting waste as sand replacement in mortar mixture influences the mortar performance in terms of compressive strength and water infiltration rate. From this study, the optimum content of blasting waste as sand replacement in mortar mixture was found to be 50%. A comparison with the study of Claudio et al. (2010), who had studied the influence of water absorption on the performance of mortars made with fine manufactured aggregates, is shown in Table 4.

Table 4. Comparison with the findings by Claudio et al. (2010).

Optimum Material Mixture	Compression Strength (Mpa)	Water Absorption Rate (%)
50% Blasting Waste (from this study)	21.8	9
1:1: 4.8F6.92 (Claudio et al., 2010)	2.75	9.84 – 16.18
1:1: 2.4F6.92 (Claudio et al., 2010)	2.8	
1:1: 1.2F6.92 (Claudio et al., 2010)	2.2	

Table 4 shows that 50% blasting waste can provide better performance than the mortar mixture produced in the study by Claudio et al. (2010) of using fine manufactured aggregates.

4 CONCLUSIONS

In conclusion, this study showed that 50% blasting waste can provide better performance than the control mortar mixture. It is hereby proposed that, in future studies, the effects of the use of blasting waste on other engineering parameters, such as workability, density and flexibility, as well as modulus of elasticity based on British or ASTM standards, should be investigated to explore the potential of blasting waste in building construction works.

5 ACKNOWLEDGEMENT

The authors would like to thank Ms Jane Jayanthi, HSE Manager of Bredero Shaw (Malaysia) Sdn. Bhd., Kuantan, Pahang, for giving us the opportunities to study the potential use of blasting waste as sand replacement in mortar mixtures. Without her support, this study would never have been possible.

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