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Laboratory Innovation to Investigate Concrete Paving Blocks Compressive Strength

Riana H. Lumingkewas [1*], Sigit P. Hadiwardoyo [2], Finno A. Hadiwardoyo [3]

[1] *Civil Engineering Study Program, Institut Teknologi Indonesia, Serpong, Tangerang Selatan 15320, Indonesia.*

[2] *Department of Civil Engineering, Universitas Indonesia, Kampus Baru UI, Depok 16424, Indonesia.*

[3] *Masterblock Indonesia, Tangerang Selatan 15318, Indonesia.*

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Abstract

This research aims to evaluate the block method against the cube test method using variations in thickness. Paving blocks can be produced using a hydraulic machine or a simple press, and their performance can be measured based on density and compressive strength tests. The block test method shows that with the same material composition forming the paving block, a paving block with a higher thickness can lead to a lower compressive strength value. In contrast, the cube test method shows different results. The paving blocks used in this study had width and length sizes of 100 and 200 mm, respectively, and had varying heights of 60, 80, and 100 mm. The results reveal that the compressive strength of concrete paving blocks is more precise based on density. Furthermore, the empirical equation and conversion coefficient of the compressive strength of the block test to the cube test have been obtained. This empirical equation is highly recommended for the road pavement industry in controlling the quality of compressive strength, even when using block tests. Further research can help develop a formula for using additive materials in paving blocks.

Keywords: Paving Block; Density; Compressive Strength; Pavement; Infrastructure.

1. Introduction

A road structure consists of several layers, of which the surface layer is essential in producing durable and functional pavement. Various materials for road surfaces can be used, including asphalt concrete, cement concrete, or concrete paving blocks (CPBs) [1–3]. Therefore, carefully selecting road surface covering materials is essential to building effective pavement structures [4, 5]. As a type of surface layer, CPBs have gained widespread popularity and continued to develop as an economical alternative to flexible pavement [6, 7]. CPB products are generally used for road paving on urban sidewalks and in commercial and industrial areas [8, 9]. Furthermore, its ease of installation and versatility make it the primary choice in various construction projects.

As a pavement material, CPB has been proven to have good performance and durability; it is also a low-cost material requiring minimal maintenance requirements and fast construction implementation [10]. Other benefits include a high comfort level, easy replacement, resistance to movement and damage, excellent durability, and attractive surface aesthetics [11]. Other conveniences are fast production and ease of maintenance [12]. These benefits and convenience make CPB a preferred choice for many industry experts. Another advantage is its ability to withstand heavy static traffic loads and its ease of adjustment to suit different layouts [13]. As a result, the CPB industry has continued to develop this construction material with product innovation in increasingly diverse shapes and sizes to meet a wide range of needs [14, 15].

* Corresponding author: riana.herlina@iti.ac.id

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The development of CPB production innovation must include quality improvements, especially in compressive strength performance. Production methods continue to develop from simple manual methods to automatic machines; therefore, material inspection is required to ensure optimal strength [16, 17]. Similar to concrete mixtures in general, the compressive strength of CPB is influenced by water, clay, and aggregate content. Therefore, it is crucial to determine the impact of water content in the mixture and investigate the effects of clay content on the compressive strength of CPB [18, 19]. In its application, aside from the impact of maintenance age on changes in compressive strength, it is necessary to determine the thickness variations and test methods [20–22]. The tests carried out generally use the block test method; the cube test method is rarely employed. Interestingly, differences in CPB thickness variations with the same mixed material composition have shown lower compressive strength values in cube tests compared with the block method test results [23]. Therefore, studying the characteristics of CPB thickness versus compressive strength values based on the cube and block test methods is essential to ensuring reliable and accurate results.

Measuring the performance of CPB in terms of compressive strength and density is an essential parameter for evaluating its quality [24, 25]. The general guidelines for determining CPB compressive strength values follow laboratory testing standards using the cube test method with specific dimensions according to Lin et al. [26]. However, testing with the cube method is more complicated than the block test method. For this reason, small and large industries prefer block tests because the compressive strength test results are more practical, even though using the block test method in CPB requires conversion values.

Several studies have shown that the compressive strength value of CPB only uses the block test method without conversion [27]. The typical reluctance to use the cube test method is because the cube test requires a cutting process from a block sample into a cube sample in the laboratory. Thus, the block test method is inappropriate for testing CPB because there are irregular results from models with different thicknesses. For example, even with the same mixture composition, the smaller the thickness of the block, the greater the compressive strength values produced using samples with a greater thickness. This compressive strength is different from the results of the compressive strength test using the cube test method, where for the same mixture, the compressive strength value remains the same even though the thickness is different. Therefore, to overcome this problem, research is needed to determine the relationship between compressive strength values obtained from block tests and cube tests in the laboratory based on differences in density and thickness [28, 29].

The density value depends not only on the composition of the properties of the forming material but also on the compaction process. There are two ways of compacting process: the compaction method using a hydraulic machine in large factories and the manual method in small factories [30, 31]. A more stable density is obtained using a hydraulic machine compared with the density achieved manually. Therefore, controlling compressive strength values from product density is essential [32], especially in small industries. Several studies have suggested that the analysis of the effects of density on compressive strength must involve cube and block tests [33, 34]. Special attention is needed in small industries that produce unstable compressive strength values, even lower than the compressive strength achieved using machines. Thus, increasing CPB production, especially in small enterprises, requires a guide to compare compressive strength test results between the cube test method and the block test in the laboratory [35].

The present research highlights the need for a comprehensive study of the relationship between density and compressive strength, using different thicknesses as parameters in the cube and block test methods. The following analysis produces a conversion value from the test results of the two methods. In addition, it evaluates the relationship between compressive strength and density ratio of the cube and block tests for different thicknesses. The empirical formula derived can be used to predict the cube test compressive strength value from the block test compressive strength value based on different block thicknesses.

The primary objective of this study is to provide information on a more realistic and practical CPB compressive strength testing method for various thickness conditions. The developed formula facilitates quick identification of CPB's physical characteristics in the laboratory, yielding results that are not only closer to reality but also valuable for small- and large-scale industries in terms of controlling product quality.

2. Materials and Methods

2.1. Cement

The cement employed in all concrete mixtures in this study was Original Portland Cement (OPC) type 1, with a strength level of 42.5 N, as specified by the SNI 15-2049-2004, ASTM C150-2004, and BS EN 197-1 standards. This type of cement has a density of 3280 kg/m^3. OPC type 1 offers several advantages, including quick drying time, strong adhesion, resistance against cracking, and excellent compressive strength. In particular, OPC type 1 cement ensures that the concrete mixtures achieve a reliable and robust final product. Its quick-drying property allows for faster construction processes, while its strong adhesion guarantees secure bonding between aggregates and other materials. Moreover, the reduced tendency for cracking in the mixture enhances the overall durability and longevity of the resulting concrete. Finally, the excellent compressive strength characteristic of OPC type 1 cement ensures it can withstand significant loads and pressures, making it suitable for various structural applications.

2.2. Aggregates

This study utilized three types of aggregates in the paving block concrete mixture: crushed stone (coarse aggregates), stone ash (medium aggregates), and fine sand (fine aggregates), as shown in Figure 1. All aggregates used in the mixture were free from sludge and were dried thoroughly before use.

Figure 1. Aggregate type: (a) Coarse aggregate, (b) Medium aggregate, (c) Fine sand

Each aggregate material underwent testing and analysis for granular settings by the ASTM C136 standard. As shown in Figure 2, the gradation results of each aggregate were found to be satisfactory. Afterward, the three aggregates were combined, and a comprehensive gradation analysis was conducted, as shown in Figure 3, thus demonstrating the overall satisfactory gradation curve.

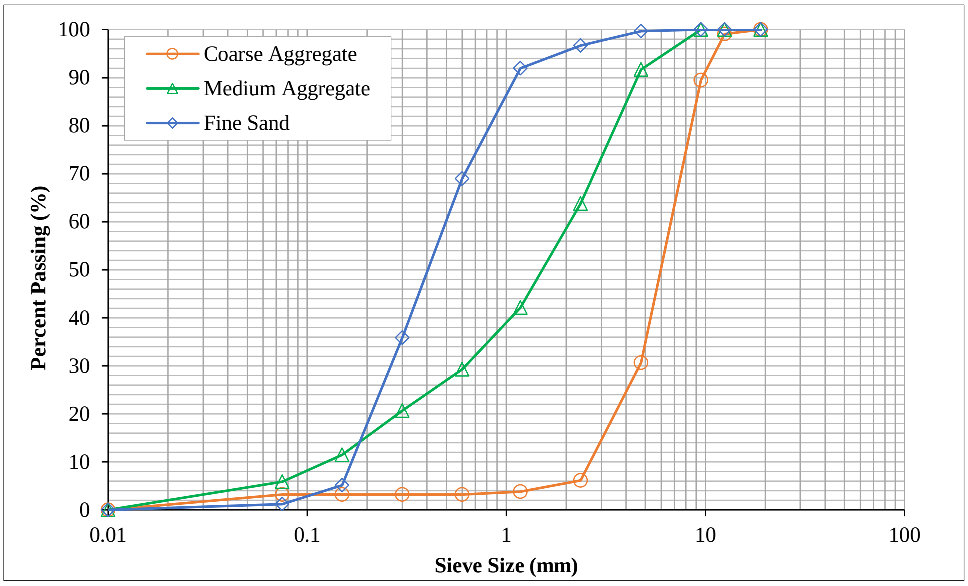


Figure 2. Gradation curve: Sieves of size aggregate

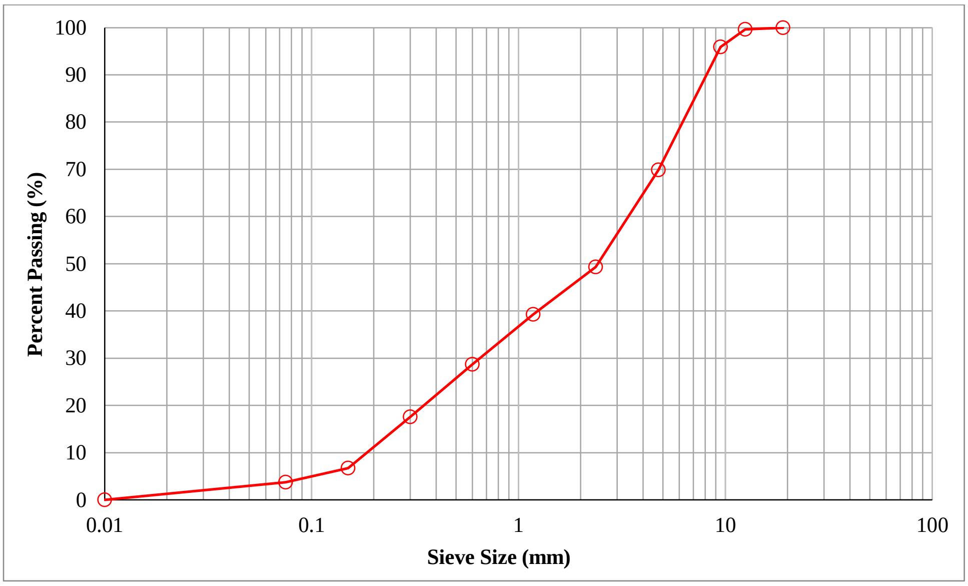


Figure 3. Gradation curve: Blending aggregate

2.3. Water

The binding material between the aggregates in the CPB mixture is cement, where this material is a combination of water and cement. Water and Portland cement composition must be calculated based on the mixing plan. Water used in mixing and curing paving blocks is portable bore water.

2.4. Research Methodology

The research methodology conducted in this study follows a flowchart, as shown in Figure 4. The preparation of concrete paving block forming materials was checked according to material standards. Aggregate testing was done on sieve, absorption, density, and sludge content analysis. Then, carry out the design of the composition of the mixed materials.

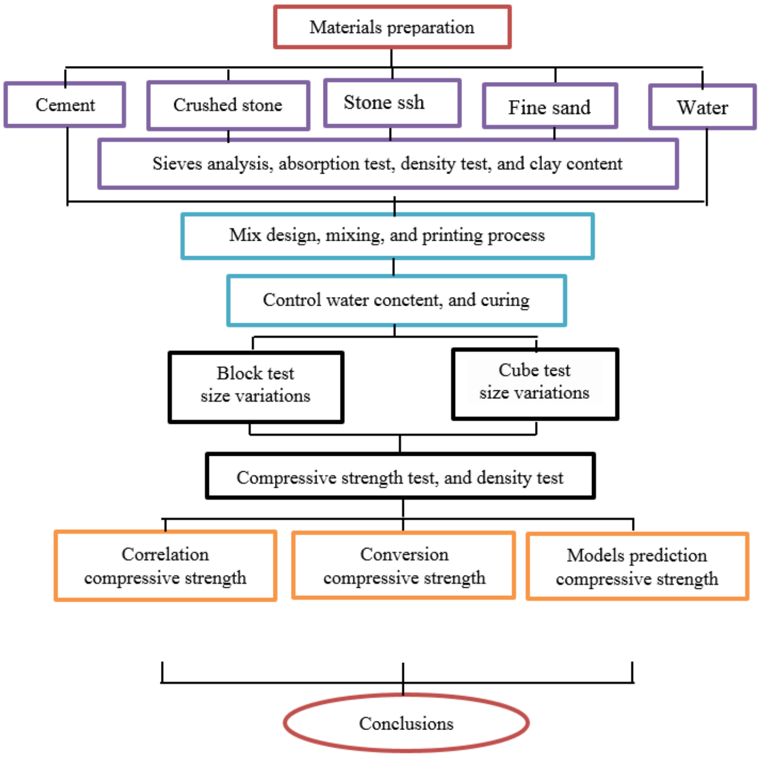


Figure 4. The flowchart of the research methodology

The process of mixing and printing materials used machines. Manufacturing products in large industries use hydraulic machines, as shown in Figure 5. The composition typically used as a mixture position with a ratio between coarse aggregates, sand, and cement is 3:2:1.5, with the percentage of water to cement being 0.5. Printing is done by pressing so that water comes out of the printing. For this reason, water content control is required after printing.

(a) (b)

Figure 5. (a) Hydraulic printing machine; (b) CPB products with the hydraulic machine

The selection of CPB thickness follows the minimum recommended thickness of the ASTM C936 standard. These dimensions are commonly used for street pavements or parking area covers. The size of the height of a rectangle or block corresponds to the needs of the road pavement designation, such as pedestrians, parking lots, or light- or medium-traffic roads. CPB products are usually block-shaped with a size length and width of 200 mm x 100 mm and varying thicknesses of 60, 80, and 100 mm.

Following printing, it is essential to subject the CPB to a curing process to maintain proper humidity and temperature conditions, both in the concrete and on the surface, for a specified period. The material is cured at different treatment ages (7, 14, 21, and 28 days). Environmental factors such as humidity, weather conditions, and temperature in the treatment area can impact the concrete’s strength growth. Thus, it is essential to stabilize the conditions by applying moisture to the material. This treatment involves spraying water twice daily on the products placed on wooden pallets until the specified test age, as shown in Figure 6.

Figure 6. Treatment of concrete paving block products

This practical method is commonly used in factories for its convenience oversoaking. The treatment aims to maintain the optimal conditions for the chemical reaction process between the aggregates and cement, ultimately enhancing the CPB’s compressive strength. The duration and treatment method are crucial in determining compressive strength.

Before conducting the compressive strength test, the block paving products underwent treatment according to the specified age. For the cube test method, the paving block products were cut to transform them into a cube shape. This process involved cutting the block products based on the CPB thickness, as illustrated in Figure 7. The cube test samples were created from the block products, ensuring they possessed the same quantity as the samples. To ensure the accuracy of the data, each batch was produced in five models, allowing for the presentation of average results. This approach guarantees better data accuracy and reliable testing outcomes.

Figure 7. Cutting CPB products into cubes

2.5. Water Content in the Mixture

The water content in the mixture changes from the mixing to the compaction process. This study measured the moisture content in the wet CPB when it came out of the mold. Water content was measured in CPB following the

ASTM C1079 standard. The amount of moisture content in percentage is equal to the total weight of fresh CPB after formation minus the weight of the dry CPB divided by the weight of CPB in the dry state multiplied by one hundred percent.

2.6. Density Test

The dry density of the sample cubes and blocks from the CPB was calculated by dividing the weight by the total volume. The weight of the CPB was measured using digital scales, while that of the sample volume was measured using calipers.

2.7. Compressive Test

Before performing the compression test, the test object was removed from the treatment area. Then, testing was conducted in the age group of treatment. Test samples during the treatment period were used to determine changes in performance improvement, especially in terms of compressive strength. The sample block was weighed, and a compressive strength test was performed. It was necessary to cut the sample cube from the sample block. The shape of the cube was formed based on the thickness of the sample block, and this sample block was cut using a cutting machine with an accuracy of 0.1 mm. The cube-shaped sample passed through drying for 24 hours before a compressive strength test was performed.

The compression test followed the ASTM C109 and SNI 03-0691-1996 procedures by placing the test object on a machine press with a maximum compressive value of 980 KN. The test object was crushed at a compressive speed from the beginning of loading by 1 mm/min. The compressive strength value is in Newton (N), while the surface area is in mm^2; thus, the compressive strength is in N/mm^2. The compressive strength (σ) can be obtained using Equation 1:

$$\sigma = \frac{P}{A} \tag{1}$$

which features the compressive strength σ (MPa), load on failure P (N), and area of pressure A (mm^2).

3. Results and Discussion

In this research, the guidelines for forming CPB mixtures use the Indonesian National Standard, which determines the quality classifications, requirements, sampling, and test methods. This guide ensures that the produced CPB meets the required quality standards. This section explains the influence of the characteristics of each material on the performance of CPB mixtures.

3.1. Analysis of the Water Content in the Mixture

Controlling the performance of the compactor machine is an essential factor in this research because this can affect the quality of the CPB during the compacting process [5]. As stated by previous researchers, the CPB printing process involves determining the density results, in which the attainment of optimal density is influenced by the water content in the mixture [13, 36]. As is known, water plays an essential role as a medium that reacts with cement to form a binder between the aggregate and other materials in the mixture. Specifically, water affects the viscosity of the cement solution, which determines the ease of the mixing process. In this study, the water-to-cement ratio was set at 1:2, equivalent to a water content of 11% of the total mixture during the mixing process

Unlike other cement concrete mixtures, in the process of forming CPB, there is a decrease in water content due to the molding process using a hydraulic machine [6, 15]. As shown in Figure 8, the water content at the end of the machine forming process was reduced by 2% to 4%. The measurement results revealed that the highest compressive strength value was obtained at an optimum water content of 8.76%. Fluctuations in water content in the mixture can result in changes in compressive strength values. Therefore, controlling water content is essential in predicting the compressive strength of CPB.

Observing the water release process while using CPB as a road pavement material is necessary. Initially, water is released due to the compression of the mixture during the manufacturing process. Furthermore, water content can decrease due to water evaporation, thereby causing the formation of voids in the CPB during drying. During the curing process to achieve drying, the loss of moisture released into the atmosphere can further reduce the material's compressive strength. As shown by the results of this study, the water content in the mixture contributed to the formation of voids when the CPB dried after 28 days of treatment. Therefore, the greater the cavity value, the lower the compressive strength. The cavity volume for a given CPB is required to facilitate water drainage from the road surface, especially for specific applications, such as porous pavements [37].

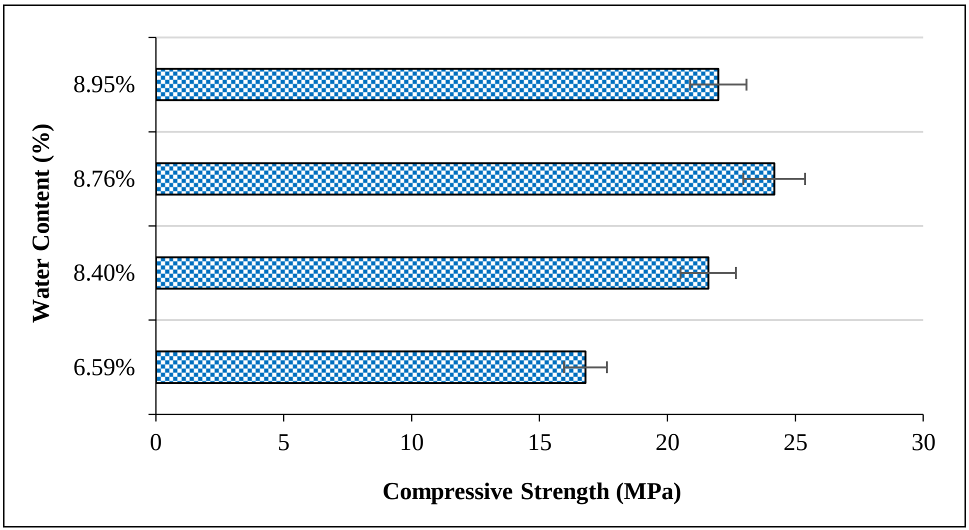


Figure 8. Water content in the mixture and its impact on the CPB's compressive strength

3.2. Effect of Clay Content on the Characteristics of the Mixture

Aggregate material is always covered by clay, which can reduce the performance of the concrete mixture due to its properties. Thus, in this study, maintaining the maximum limit of clay content required in the filler material is very important. In addition, the refined grains in the mixture act as a filler, occupying the voids between the coarse aggregates. A larger filler will increase the amount of cement because cement functions as a binder for other forming materials.

Figure 9 compares the performance of mixtures with controlled variations in clay content in the filler. The results reveal that the compressive strength value increases when controlling clay with a filler component of less than 5% [16]. On the other hand, if the clay content exceeds the maximum allowable limit, it will harm compressive strength. Clay content is found not only in coarse aggregate but also in fine sand. The highest compressive strength value is achieved when the clay or mud content is less than 5%. In several previous studies [18], the filler material's composition and characteristics, especially clay content, are proven to be essential factors that must be carefully controlled to optimize the compressive strength performance of CPB. This control ensures that the filler material meets the specified limits because it will contribute to the overall quality and durability of the CPB examined in this study.

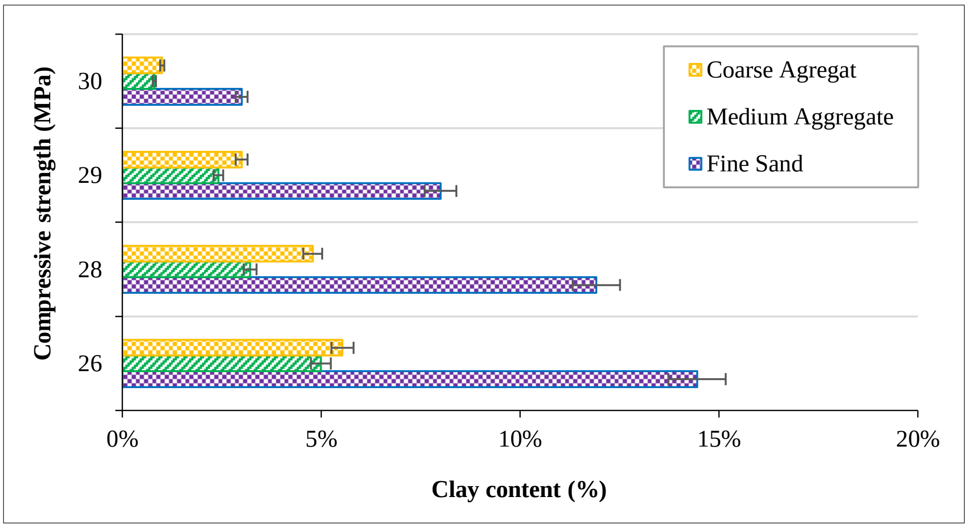


Figure 9. CPB performance with clay content

3.3. Compressive Strength on the Curing of the Test Object

Figure 10 shows the changes in compressive strength observed at ages 7, 14, 21, and 28 days for samples with a thickness of 8 cm. The curing process lasted 28 days to determine changes in compressive strength values [14, 38]. In general, compressive strength values approaching the maximum in CPB take 28 days, and during this period, the compressive strength of CPB increases significantly. At 14 days of treatment, the compressive strength value obtained from cube testing reached 78%, and at 21 days, it further increased to 89%. The compressive strength values continually increased during the treatment period of up to 28 days.

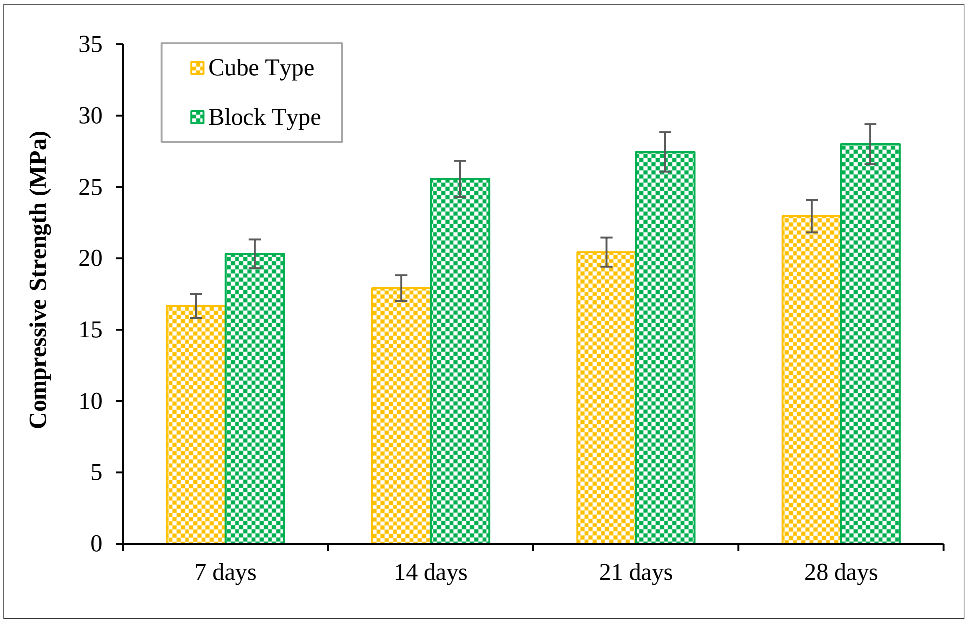
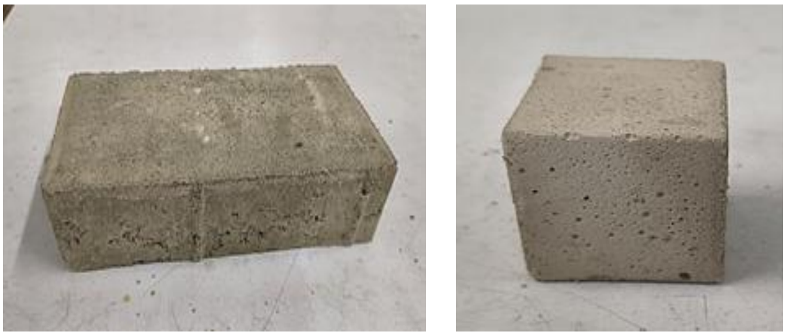


Figure 10. Increasing compressive strength value based on the test object's age

3.4. Crack and Failure Pattern

Block and cube samples that have been cut into a cube shape from concrete paving blocks before the compressive strength test are shown in Figure 11. After compressive strength tests were performed on block and cube samples, the cracking and crushing patterns are shown in Figure 12.



(a) (b)

Figure 11. Sample of concrete paving block products: (a) block; (b) cube

(a) (b)

Figure 12. Failure under compressive strength test of concrete paving block products: (a) block; (b) cube

The pattern of cracking and failure for both the block sample and the cube shows the exact mechanism, namely in the vertical direction of loading. Collapse generally occurs outside of the sample as the result of the collapse of previous researchers [11, 15, 27, 39]. Less strong aggregate and cement bonds can be caused by non-optimal water content. In addition, there are still cavities due to non-solid aggregates.

3.5. Thickness Characteristics of CPB Performance

CPB has various shapes, dimensions, and thicknesses as a covering layer on road pavement structures. The choice of various forms depends on the need to determine the strength of the road structure to withstand traffic loads. In this case, determining the compressive strength value is essential in selecting the appropriate CPB strength for road pavement structures. Compressive strength is typically measured using a pressing machine to apply pressure to the tested material. This study uses two CPB testing methods: the cube and block tests. Even though the provisions for CPB testing are used in the cube test, in reality, quite a few employ CPB compressive strength values using the block test results.

This research demonstrates fundamental differences in the results obtained from testing blocks and cubes for CPB using data featuring different thicknesses, even from mixtures with the same composition and materials. Other researchers have reported similar findings, stating that the difference in compressive strength values is noticeable when comparing different thicknesses [3, 7, 14]. In the current study, the block test produced higher compressive strength values than the cube test for the same material, and such a difference became more pronounced as the thickness of the CPB decreased. Figure 13 shows the variation in compressive strength values between block and cube tests. At a thickness of 10 cm, the difference in compressive strength values was almost the same. However, the difference in block and cube test results became more significant as the thickness of the CPB decreased. Such a difference indicates something that is not normal in the testing process. The Indonesian National Standard recommends using the cube test to validate CPB performance and ensure its suitability as a road pavement structural material.

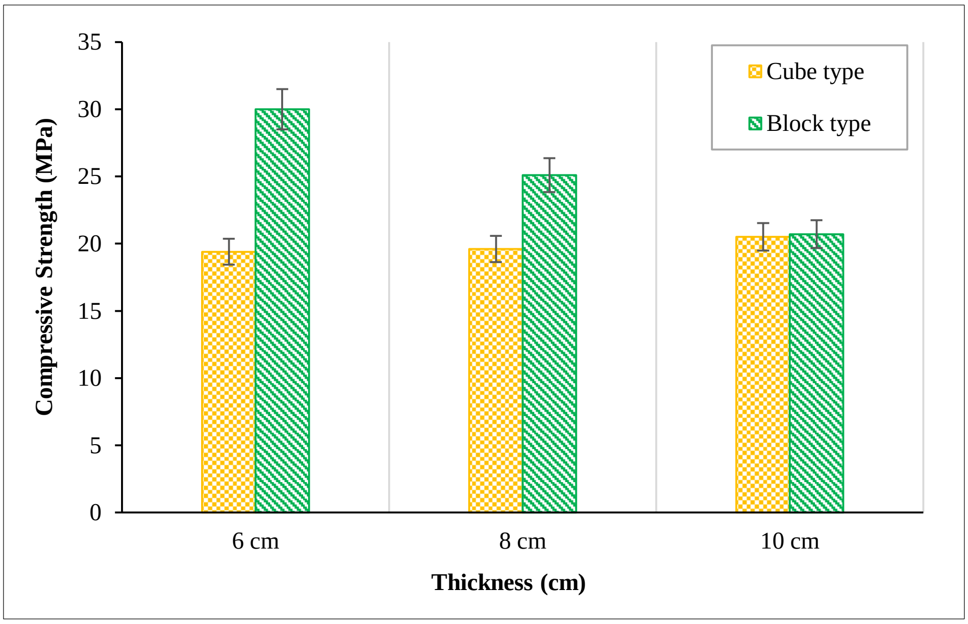


Figure 13. Changes in compressive strength value based on the thickness of CPB

The present research results show that the cube test provides almost the same assessment of the compressive strength of CPB from the same composition and material for different thicknesses. Therefore, the cube test is more accurate and reliable, especially considering thickness variations. This research addresses the conversion of cube and block test results into studies needed to ensure corrections for block test users because such a strategy is considered more practical.

3.6. Effect of Density on Compressive Strength

CPB density is an important characteristic that directly influences its compressive strength value. This density value is obtained by calculating the dry weight of CPB divided by its volume. The dry density of CPB is determined via compaction during the wet-forming process [40–42]. The water content in the mixture affects the ease of compression. Another factor that influences the compressive strength of CPB is its thickness; that is, a thicker CPB requires additional energy during the compaction process.

For the present study, a machine was used to test CPB samples with 6, 8, and 10 cm thicknesses with the same mixture of materials. As shown in Figure 14, CPB measuring 6 cm has a higher compressive strength value in the block test compared with the cube test results. A similar trend can be found in Figure 15 for the eight cm-thick CPB. However, for the ten cm-thick CPB shown in Figure 16, the compressive strength values obtained from the block and cube tests are almost the same. From the three images, it can be seen that for CPB with the same densities, the test results produce compressive strength values that are close to each other based on thickness, as seen in Figure 17.

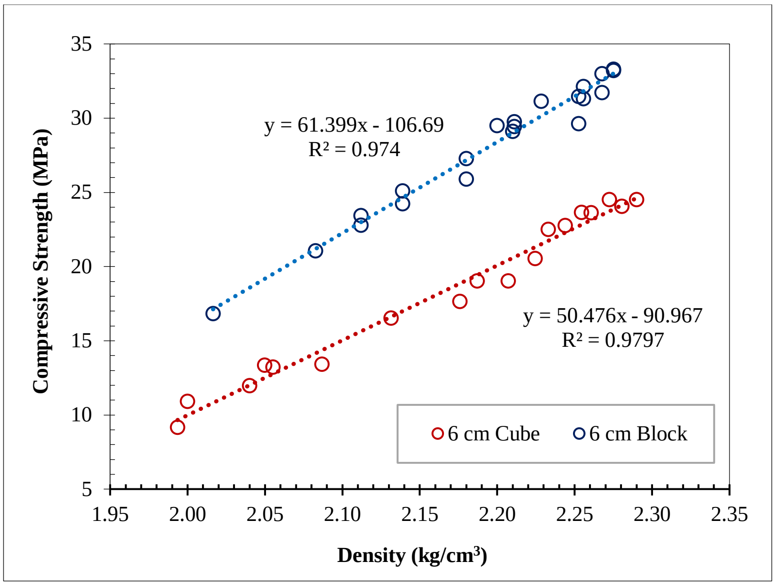


Figure 14. Density-compressive strength relationship cube and block with a thickness of 6 cm

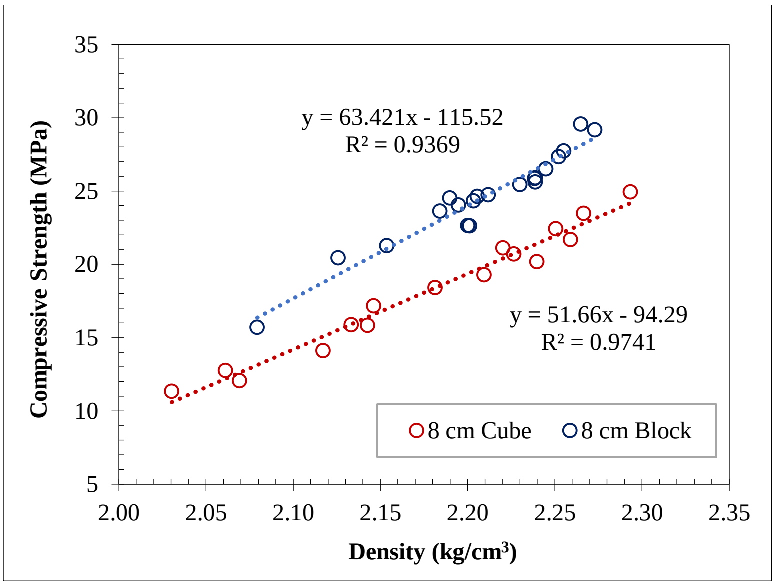


Figure 15. Density-compressive strength relationship cube and block with a thickness of 8 cm

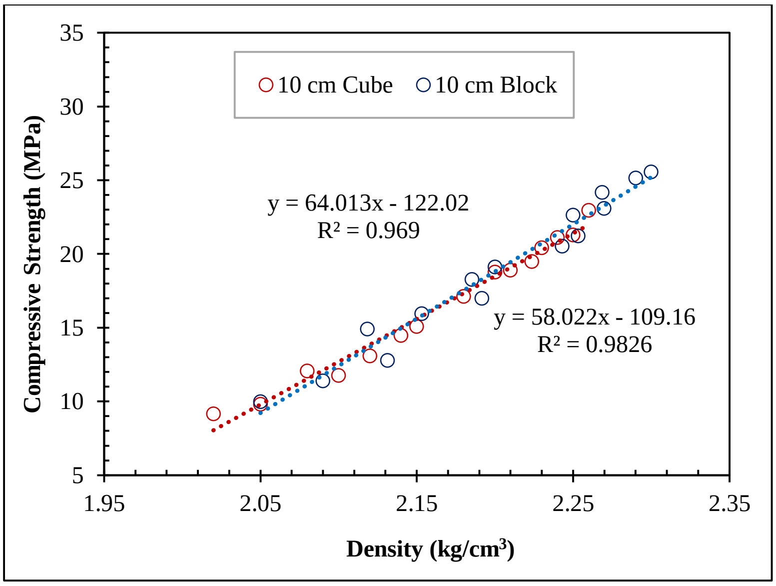


Figure 16. Density-compressive strength relationship cube and block with a thickness of 10 cm

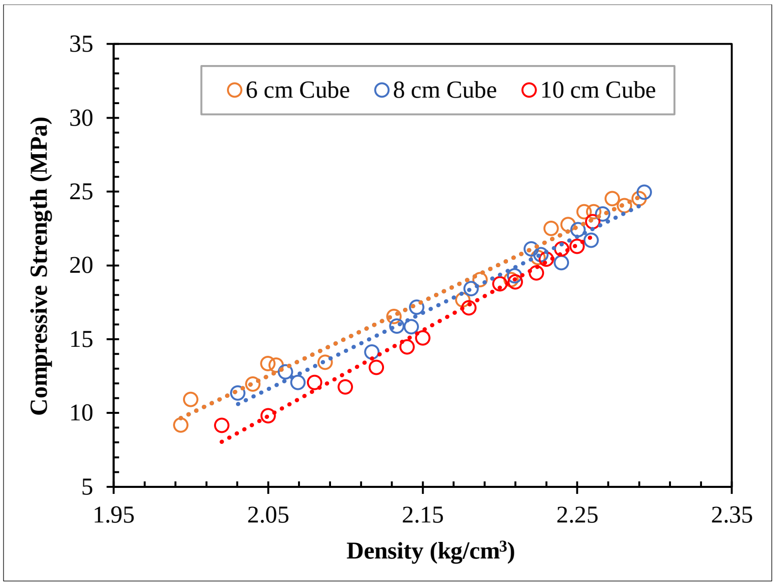


Figure 17. Density-compressive strength relationship with the cube test

At the same time, the test results for blocks of the same density produce different compressive strength values with varying thicknesses, as shown in Figure 18. Observations indicate the importance of using appropriate test methods, especially thickness factors when evaluating CPB compressive strength to ensure accurate and reliable results.

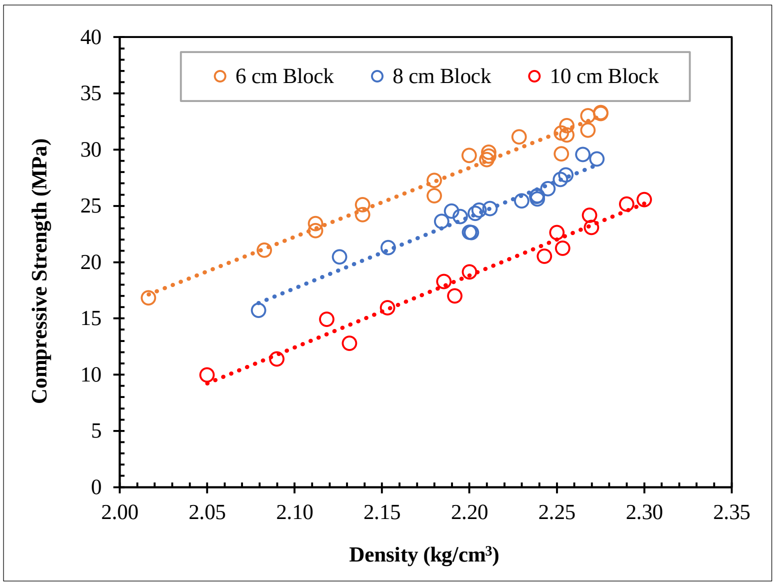


Figure 18. Density-compressive strength relationship with the block test

Along with the increasing demand for CPB as a road pavement material, the need for CPB production in small industries is also increasing [43]. However, small enterprises face many problems, mainly because they use block tests to determine compressive strength. Finding a practical solution that converts block test results into equivalent cube test results at the same density level is essential to overcome this problem. In particular, small industries can predict the compressive strength value of their CPB products by determining conversion factors that can be used as product quality controls. Finding practical solutions for this conversion will improve quality control processes in small industries and enable them to meet industry standards while ensuring the consistent performance of their CPB products. This practical solution will contribute to developing and growing small industries involved in CPB production, enabling them to play a more significant role in meeting the increasing demand for CPB as a road pavement material.

3.7. Density-compressive Strength Correlation

This study conducted several tests using the block and cube test methods on CPB mixed materials to establish the correlation between their results. The compressive strength test results obtained from the cube test method for various CPB thicknesses showed a strong correlation (Figure 19). The high R^2 value of 0.9495 indicates a robust relationship between the compressive strength and density values. This correlation is linear and can be expressed by Equation 2:

$$\sigma\ (cube) = a \times \gamma + b \tag{2}$$

where the coefficients "a" and "b" are influenced by the material composition and the compaction factor during the CPB formation process. The specific aggregate composition and cement content also contribute to the variability of compressive strength values [24, 25]. Consequently, coefficients "a" and "b" depending on the mixture's design and the characteristics of the materials used during CPB formation.

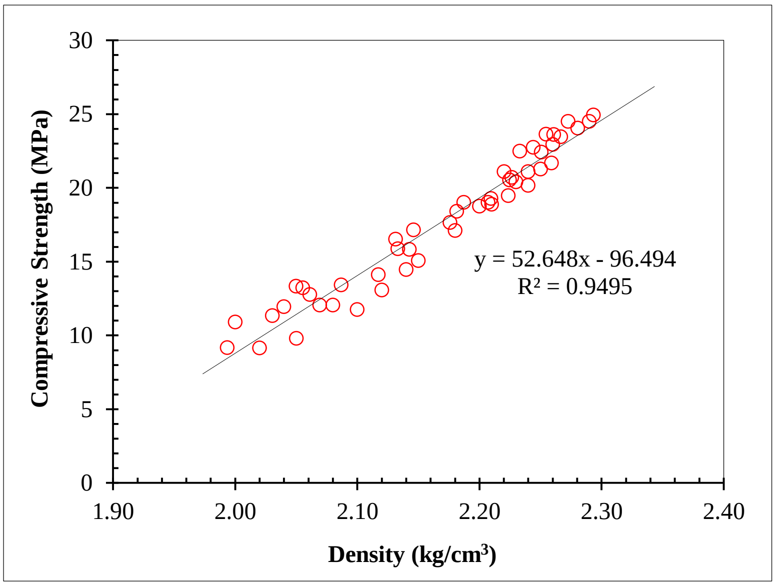


Figure 19. Compressive strength-density relationship of CPB with different thicknesses

3.8. Conversion of Compressive Strength

The density of the CPB mixture significantly influences its compressive strength characteristics [22]. In contrast, the composition and materials used in the mix, such as aggregate and cement, directly impact the density value [44].. As previously described, there are noticeable differences in the compression test results between the block and cube test methods. The block test method shows that, even when the sample has the same composition and mixed material, the thickness of the specimen still affects the compressive strength value. Surprisingly, CPB samples produced through the block test with thinner thicknesses exhibit higher compressive strength values. In contrast, sample thickness does not affect the compressive strength value in the cube test method.

Based on the laboratory data obtained from the block and cube tests, we can calculate the ratio of the compressive strength value of the cube test to that of the block test. By varying the densities in the block and cube tests, we obtained data to create a graph illustrating the relationship between the block and cube test ratios. Figure 20 depicts this relationship between density values and the ratio of cube test to block test results, considering variations in sample thickness.

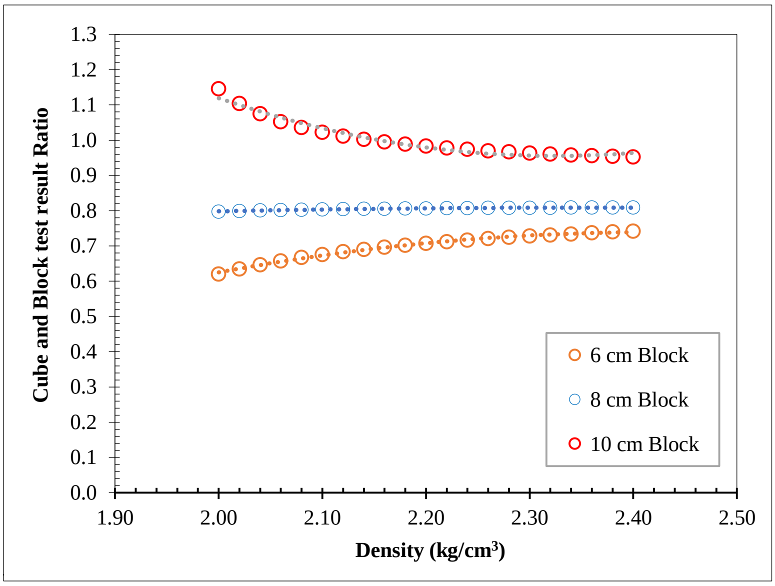


Figure 20. Influence of sample thickness on the density and the ratio of the cube and block test results

3.9. Model Prediction Compressive Strength

A guideline can be made to predict the conversion value from the block test to the cube test results based on several tests using the block and cube tests on a CPB production with the same aggregate composition and characteristics. This method can reduce the time and cost of testing cubes, which require accuracy in the cutting process to obtain cube test samples, thus requiring additional test costs.

The compressive strength ratio-to-density relationship represented in Figure 20 is obtained using the polynomial function approach, as shown in Equation 3:

$$\beta = c \times \gamma^2 + d \times \gamma + e \tag{3}$$

where β is the predicted compressive strength ratio of the cube and block tests, (γ) is the density value, and c, d, and e are coefficients. The coefficient values for each thickness differ based on the mixture used in this study, as shown in Table 1.

Table 1. Coefficient of density variable

Thickness (cm)	Coefficient c	Coefficient d	Coefficient e	R2 value
6	-0.6500	3.1442	-3.0632	0.9965
8	-0.0755	0.3834	0.3834	0.9812
10	1.5556	-7.2327	9.3625	0.9677

Equation 4 provides a formula to predict the compressive strength of the cube test results by multiplying the ratio of the cube test to the block test with the compressive strength results from the block test:

$$\sigma\ (cube) = \beta \times \sigma\ (block) \tag{4}$$

The coefficient values shown in Table 1 facilitate the efficient and accurate estimation of the compressive strength of CPB, considering different density values and thicknesses based on the data obtained from the block test method. The R^2 values demonstrate the goodness of fit for each thickness coefficient obtained in this study.

Prediction results can be obtained using Equations 3 and 4 by comparing the compressive strength of block and cube test objects from laboratory test results for validation of the formulation obtained by comparing the predictive-compressive strength values of the calculation with the compressive strength values produced from laboratory tests. The results of the comparison between the predicted compressive strength values and the compressive strength values resulting from laboratory tests are shown in Figure 21. The results of the cube test laboratory in this study compared with the predicted outcomes based on the model shown in Equation 4. The estimated compressive strength of the cube test appeared to be in close conformity with the value of R^2 = 0.8974. However, it can help predict the compressive strength value close to the actual value.

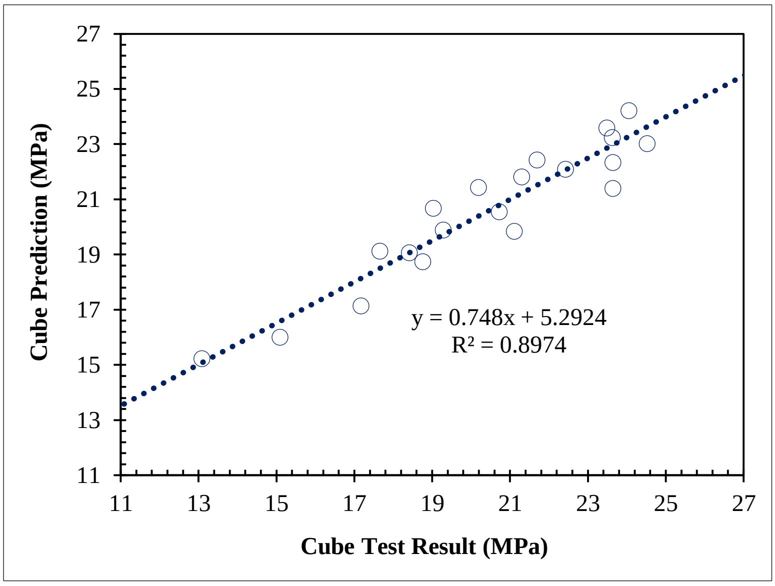


Figure 21. Compressive strength of cube test and prediction

By conducting laboratory research using the cube test and block test results on the same material characteristics, we can obtain a conversion value from the block test to the cube test results. This correlation graph can be constructed from the block and cube test results for the same CPB mixture composition and material characteristics, even with different sizes. Thus, the block test results with the same density and material can predict the cube test's compressive strength value with varying thicknesses and dimensions. Equation 4 can help predict the compressive strength value from the block test results converted to the cube test. This practical method can help CPB manufacturers express compressive strength values closer to the cube test results. Furthermore, this solution can avoid block test confusion from the influence of thickness dimensions.

In small industries, the testing process to determine CPB characteristics is generally more practical using block test objects. However, this value does not represent the actual value of compressive strength. Using correlation graphs of compressive strength and density for certain CPB mixtures can help predict compressive strength values. In particular, the test method with block samples is more practical than the cube test because the cube test process must cut precise pieces from the block shape into the cube.

4. Conclusions

This research evaluated the characteristics of CPB using the cube test and block test methods on one mixture composition. The conclusions are as follows:

- Density, water content in the mixture, clay content, thickness, and the CPB formation process all affect the compressive strength value.
- Tests using cube test objects show consistency in density values with compressive strength values. Thus, the cube test method aligns more with CPB test standards. Furthermore, based on the cube test, the correlation of density with compressive strength produces a linear equation for different thicknesses.
- A correlation formula can be formed to predict the value of the cube compressive strength test from each product's CPB block compressive strength test in the following process. This is achieved by using the cube test and block test results at the same density and thicknesses of 6, 8, and 10 cm from the same mixture composition. Thus, this formula can be used as a practical and efficient approach.
- This empirical formula simplifies the testing process, benefiting the user by obtaining predicted compressive strength values without additional cube testing. Thus, it is expected that the application of this formula will improve the quality control process and demonstrate the optimal performance of CPB as an ideal road pavement material.
- Further studies are needed to examine the ratio of the compressive strength of the cube and block tests by including additives in the aggregate and cement composition. Doing so can help us derive a formula for predicting the compressive strength values of the cube test from the block test in a more varied mixture.

5. Declarations

5.1. Author Contributions

Conceptualization, R.H. and S.P.; methodology, R.H.; software, F.A.; validation, R.H., S.P., and F.A.; formal analysis, S.P.; investigation, S.P.; resources, F.A.; data curation, F.A.; writing—original draft preparation, R.H.; writing—review and editing, R.H.; visualization, F.A.; supervision, S.P.; project administration, R.H.; funding acquisition, R.H. All authors have read and agreed to the published version of the manuscript.

5.2. Data Availability Statement

The data presented in this study are available on request from the corresponding author.

5.3. Funding

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5.5. Conflicts of Interest

The authors declare no conflict of interest.

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