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Study on Concrete Production using Waste Brick and Tiles as a Replacement for Coarse Aggregates

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ABSTRACT

This study focuses on producing concrete by using brick and tile waste as a replacement for coarse aggregates. The main goal of this research is to help reduce the growing problem of construction waste and promote sustainability in the construction industry. The study analyses the physical and mechanical properties of the produced concrete, including water absorption, density, compressive strength, and slump tests. The research uses a 1:2:4 mix ratio, with concrete samples tested after curing periods of 7, 14, and 28 days. The results show that using brick and tile waste as a substitute for coarse aggregates can produce concrete with strength and durability properties comparable to conventional concrete. This study also proves that using construction waste as an innovative material reduces reliance on natural aggregate resources, supporting the "3R" initiatives (Reduce, Reuse, Recycle) in waste management. In terms of application, this study has significant potential for use in TVET institutions, especially for students' technical training. It can help lower the cost of purchasing construction materials, address the issue of waste accumulation in workshops, and give students the opportunity to understand the importance of innovation and sustainability in construction. This study not only contributes to reducing environmental pollution but also offers a more effective alternative for the construction sector, aligning with the needs of sustainable development.

1. Introduction

The construction industry is a key driver of Malaysia's economy, supporting national development through large infrastructure projects by both the government and private sector [1]. This industry includes not only building construction but also repairs, demolition, and maintenance of structures like roads and bridges. Additionally, modern housing construction mainly relies on concrete as the primary material [2]. Concrete is made from a mix of water, cement, and coarse and fine aggregates, with different grades used to determine its strength [3]. Choosing high-quality concrete is essential

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in construction. Studies show that modifying the base materials of concrete and using waste from demolished buildings can create concrete with similar strength to regular concrete. This method also helps reduce construction waste [2]. Construction waste includes materials like wood, stone, sand, tiles, and iron. However, due to a lack of cooperation from consumers and traders, these materials are often not recycled, leading to increased pollution as construction projects grow [2]. This study suggests replacing coarse aggregates in concrete with waste materials, using a 1:2:4 mix ratio for M20 concrete grade. Compressive strength tests will be conducted after 7, 14, and 28 days of curing to evaluate the concrete's strength [3]. This approach can help reduce waste disposal issues, save space in construction sites, lower raw material costs, and minimize environmental pollution [2].

Even though recycled materials have been the subject of numerous studies, there are still certain unanswered questions. Among these are the dearth of comprehensive research on the long-term durability of concrete made from leftover brick and tile, the lack of adequate data regarding the concrete's performance in environments with significant temperature fluctuations, and the lack of cost comparison and efficacy of this material's application in the real construction industry. By assessing the durability, mechanical, and physical performance of concrete made from leftover brick and tile, this study seeks to close this research gap and provide more thorough information to back up its application in the building sector.

1.1 Research Background

The construction industry plays an important role in helping Malaysia develop, but it faces challenges like a shortage of raw materials such as aggregates. This shortage affects project progress, construction costs, and the national economy [4]. The high demand for aggregates causes material prices to rise, which impacts the sustainability of construction projects, including the training for TVET (Technical and Vocational Education and Training) students who need materials like cement, sand, bricks, and tiles [5]. In addition, the construction industry generates a large amount of waste, including concrete, wood, iron, glass, and tiles. These materials are often not recycled and end up in landfills, contributing to environmental pollution and safety risks [6]. Even though different methods have been introduced to address this issue, construction waste management is still not organized and remains a challenge [7]. A survey in Vocational Colleges revealed that students don't have a strong understanding of recycling, and the wastage of materials during training worsens the construction waste problem in the DCA 2012 subject. The high cost of materials and the distance of vocational colleges from city centers also affect the availability of materials, making waste management more critical. This study is testing the use of brick and tile waste as a substitute for coarse aggregates in concrete mixtures. This method could not only reduce pollution and solve the issue of waste disposal but also help reduce the cost of materials needed for practical training. If managed well, this waste can become an opportunity for Vocational Colleges to improve teaching and learning and support sustainable development in Malaysia's construction industry [8].

1.2 Problem Statement

Students at Vocational Colleges in the field of Construction Technology find it difficult to understand and master it in practice due to the shortage of materials and the effects of rising prices of goods. Although the government has provided an allocation to cover the cost of purchasing consumables for students' practical use, it is not sufficient. This results in students lacking skills in doing practical work such as interpreting plans, using hand tools, measuring, and estimating the quantity of materials to be used in the practical interpretation given by lecturers. Therefore, there is a need to develop this initiative in using construction waste materials as a substitute for coarse aggregate in concrete mixing. Finally, this study can also provide great reference value for reforms to the production of concrete that is more environmentally friendly and productive.

1.3 Objective

The research of this study is to:

i. Produce concrete mixtures by replacing coarse aggregates with brick and tile waste.
ii. Identify the physical properties of concrete made from brick and tile waste with regular concrete.
iii. Identify the consistency of concrete made from brick and tile waste with regular concrete.
iv. Identify the comparison of the strength of concrete made from brick and tile waste with regular concrete.

1.4 Research Question

The objectives questions of this study are as follows:

i. How to produce concrete mix by replacing coarse aggregates to brick and tile waste?
ii. What are the physical properties of concrete mixed with brick and tile waste and regular concrete?
iii. What is the difference in the consistency of concrete mixed with brick and tile waste and regular concrete?
iv. What is the comparison of the strength of concrete mixed with brick and tile waste and regular concrete?

1.5 Scope of the Study

This study assesses the mechanical and physical characteristics of concrete that contains discarded brick and tile as coarse aggregates. The study introduced several extra test parameters to get a more thorough analysis in addition to assessing the compressive strength, density, and water absorption rate. To evaluate the concrete's resistance to severe temperature fluctuations and their long-term effects on the structure, additional tests are carried out, such as a freeze-thaw cycle resistance test. Concrete's resistance to acidic or alkaline situations that can be encountered in real-world construction applications is also assessed through chemical resistance testing. To evaluate the structural stability and degradation of concrete's mechanical properties over time, long-term performance tests are also conducted, observing changes over a six-month to one-year period.

A more thorough grasp of the suitability of concrete comprising brick and tile debris in the larger building industry can be obtained by incorporating these further tests into the study. This method also makes it possible to conduct a more thorough evaluation to guarantee that recycled concrete performs on par with regular concrete, which reinforces the case for its application in the contemporary building sector.

1.6 Significance of Study

The importance of this study is to examine whether the materials used can be used in the production of concrete in terms of strength, workability, and durability. This study was conducted to reduce waste generated from the construction sector. This study is also expected to benefit lecturers, students, and vocational colleges.

2. Literature Review

In studies regarding sustainable construction, using recycled materials to make concrete has taken center stage. Utilizing construction waste in the manufacturing of concrete can lessen reliance on natural resources and promote environmentally friendly building methods [1]. Based on [2] study also highlighted the possibility of recycling concrete as a substitute building material, particularly for non-structural uses. Nevertheless, a significant problem in the building sector remains the difficulty of guaranteeing the durability and strength of recycled concrete [3].

In this study, the durability of concrete made from recycled resources is also crucial. Concrete's resistance to humid conditions and drastic temperature variations can be increased by adding additives such rice husk ash [6]. Additionally, concrete that contains waste materials like bricks and tiles absorbs water more quickly than regular concrete, which may have an impact on the concrete's long-term durability [11]. Economically speaking, [7] found that using recycled materials in concrete lowers pollution levels in the environment and helps to lower building material costs.

A specific quantity of cement, coarse aggregate, fine aggregate (sand), and water are combined to create concrete, building material. Strong structural elements like beams, columns, and foundations are created when it is combined and allowed to solidify [9]. Due to its strength and durability, concrete is used extensively. How well a concrete mixture can support large loads depends on its type and quality. Concrete's ability to be readily shaped into various structures is one of its primary benefits [10]. Often used in construction, common concrete is composed of cement, water, and aggregate. It is robust, long-lasting, and accessible. Concrete experiences hydration, a chemical reaction that helps bind the particles together to form a solid, when it is mixed with water [11].

The impact of changes in the proportion of brick and tile waste mixtures in concrete on their mechanical qualities has also been the subject of numerous studies. For instance, [3] discovered that adding more brick debris to aggregate mixtures can lower concrete's density and increase porosity, both of which can have an impact on compressive strength. However, according to a study by [11], if waste materials are processed and the water-to-cement ratio is properly controlled, an ideal mixture of brick and tile waste can yield concrete with mechanical qualities that are nearly identical to conventional concrete.

This study will define the important factors that influence the durability and usability of recycled concrete, strengthening the basis for applications in the contemporary construction industry. Previous research has demonstrated the great potential of using brick and tile waste as a substitute for coarse aggregate in sustainable construction. However, additional research is still required to evaluate the long-term durability of these concretes under different environmental conditions.

3. Methodology

Methodology is a research procedure, or systematic steps followed to conduct research or analysis in a study. This process involves various procedures such as data collection, data analysis, and interpretation of study results [16]. In the context of research, study procedures ensure that the study is conducted carefully and structured to achieve the set study objectives. Therefore, according to [17], procedures in a study play a significant role in ensuring the validity and reliability of the study results. By following a systematic and organized procedure, researchers can ensure that the study is conducted carefully and reliably.

The sample size and test variability are also taken into consideration in this study to guarantee the precision and dependability of the outcomes. Enough sample sizes were employed in this investigation for every type of concrete mixture to guarantee that the information gathered accurately reflected the tested material's performance. Every test was run in multiple replicates to get a more consistent average value and lower experimental errors, which improved the studies' validity. Additionally, tests were conducted to determine the effects of different mix ratios of brick and tile debris on the concrete's mechanical and physical characteristics.

To produce concrete by replacing coarse aggregate with brick and tile waste, the equipment used consists of a portable electric cement mixer, scope, spatula, tray, bucket, and wheelbarrow for mixing concrete. Meanwhile, for materials, it consists of cement, brick waste, tile waste, sand, and water. Materials such as brick waste and tile waste will undergo a grinding process using a crusher first and go through a screening process to obtain the desired size.

Table 1
Material Classification

Set (%)	Cement (kg)	Sand (kg)	Brick Waste (kg)	Tile Waste (kg)	w/c (kg)
A (100)	4.59	10.18	-	16.56	0.5
B (25:75)			3.98	12.41	(2.3)
C (50:50)			7.96	8.27	
D (75:25)			11.93	4.15	
E (100)			15.91	-	

Next, the material will be mixed according to the percentage specified with other concrete ingredients starting by mixing the ingredients until a stable mixture is obtained as shown in Table 1. After that, the concrete mixture will be assessed by placing it in a mold (slump cone) to assess the consistency of the concrete and thus control its strength. Next, the concrete will also be poured into 50mm x 50mm cube mold to be used as a specimen for compressive strength testing on day 28. Finally, the results of the tests will be analyzed and used to make a comparison between the percentage of coarse aggregate replacement materials contained in the concrete.

4. Findings and Discussion

This chapter will discuss the findings of the study from the analysis that has been done at the testing and evaluation stage on the replacement of coarse aggregate in concrete mixtures using brick waste and tile waste. Each result taken from all the tests will be analyzed according to the sample or percentage of brick and tile waste used as a substitute for coarse aggregation in concrete mixtures. For the physical test, it is divided into two tests, namely the water absorption test and the density test. For the water absorption test, the results are taken when conducting the experiment on the 28th day. Where it will be dried and re-immersed in water to obtain the dry cube weight and after water absorption for 48 hours while to obtain the density of concrete by taking the mass of concrete divided by the volume of concrete.

In addition, for the concrete strength test, several tests need to be conducted such as the slump test, compression test and pirate hammer test conducted at the FKAAB lab to obtain the required data based on the samples made. After the laboratory test is completed, the data is taken and recorded for analysis and discussion purposes. The results are displayed in the form of tables and graphs to facilitate understanding and interpretation. All tests conducted were aimed at seeing the extent of the workability of brick and tile waste as a substitute for coarse aggregate in concrete mixes.

4.1 Water Absorption Test

Water absorption testing of concrete is important to assess the resistance of concrete to water absorption which can affect the strength and durability of concrete (Figure 1). This water absorption testing of concrete is based on Malaysian standards, specifically referring to MS 30: Part 5 - Methods of Testing for Water Absorption of Concrete. The importance of this testing is the resistance to water and moisture, resistance to freezing and thawing as well as the quality and strength of concrete [18]. The calculation of the percentage of water absorption is by finding the difference in wet weight and dry weight. Wet weight is the weight after water immersion, while dry weight is the weight before immersion. Next, divide the difference in weight by dry weight to obtain the absorption ratio and multiply by 100 to convert the value to a percentage.

Water absorption testing is one of the important ways to ensure that the concrete used in construction is suitable and able to last in the long term, especially in challenging environmental conditions. The results of the water absorption testing for each set with the modification of the percentage of brick and tile waste showed that as the percentage of brick in the mix increased, the water absorption rate increased gradually, as recorded for each design. This shows that the water absorption rate of the mixture is directly influenced by the more dominant porous nature of bricks compared to tiles. Therefore, according to [19] in their study, the higher water absorption rate of bricks can be attributed to the natural properties of this material which is less dense and has greater water absorption capacity, compared to tiles which are more compressible and waterproof.

The phenomenon of different water absorption rates based on the percentage of the mixture of bricks and tiles occurs due to differences in the physical properties and density of the materials. According to [20], bricks have a more porous structure, which means there are more air spaces in the material compared to tiles. This property causes bricks to be able to absorb more water because water easily seeps into the air spaces that exist in the brick structure. On the other hand, tiles that have a higher density than bricks and a less porous structure or have less air spaces than bricks cause their water absorption to be lower [21].

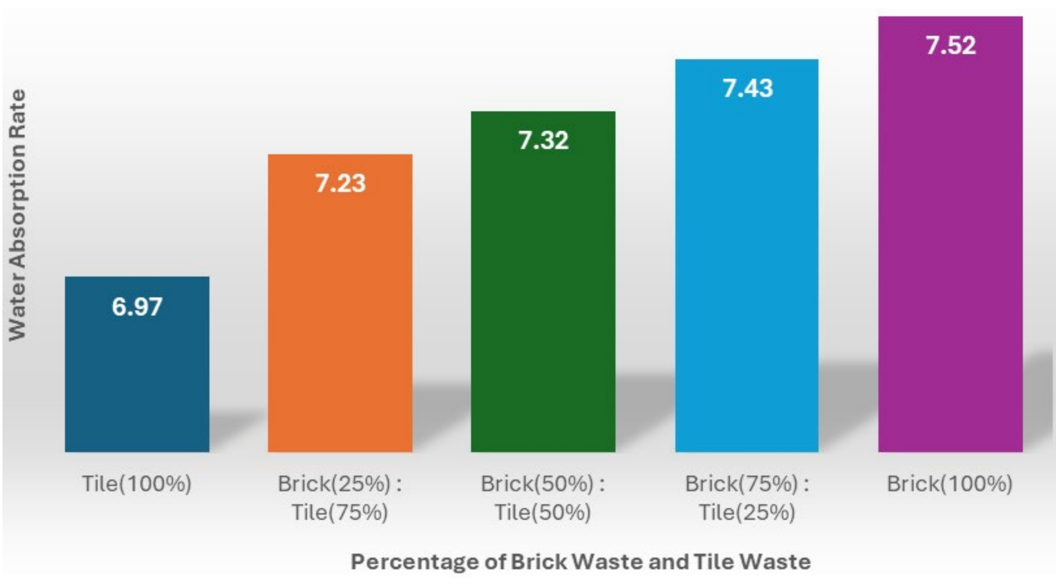

Fig. 1. Percentage of Water Absorption Rate

4.2 Density Test

Density test is a test that measures the density of an object (Table 2). For regular concrete, the density is usually in the range of 2200 kg/m³ to 2500 kg/m³ as stated in the Malaysian standard, namely MS 522: part1-2007 (specification for structural concrete). While for Lightweight Concrete it is in the range of 1600–2000 kg/m³. For concrete, density is usually measured to ensure the quality and strength of building materials. The density of an object can be measured where the mass of the object is divided by the volume used.

Table 2
Density Average

Set	Density Average (kg/m³)
A	2082.47
B	2048.40
C	2023.71
D	1993.58
E	1969.38

The difference in concrete density as stated in the test results is due to the physical properties and density of the aggregate material used, namely tile fragments and brick fragments. Tile fragments have a higher density than brick fragments because the tile structure is more compressed and less porous [21]. This resulted in concrete using 100% tile chips recording the highest density, indicating that it is denser and has better strength. On the other hand, brick chips have a lower density due to their more porous nature [20]. This resulted in concrete with 100% brick chips recording the lowest density compared to the densities of other mix designs. Concrete mixes using a combined percentage of brick and tile recorded densities between these two materials.

The density of concrete increases as the percentage of tile chips in the mix increases because the tiles, which are more compact, increase the total mass per unit volume of concrete. On the other hand, the use of more porous and lighter bricks in the mix reduces the density of concrete. Therefore, this difference in concrete density occurs due to the physical properties of the coarse aggregate material, where tiles provide higher density and strength while bricks provide lower density but may produce lighter concrete. By referring to the standards, the researcher can conclude that the average results for each concrete design show that it does not reach the density of normal concrete, which is in the range of 2200 kg/m³ to 2500 kg/m³. However, the average results for each concrete design can be categorized as lightweight concrete, where the density range is in the range of 1600–2000 kg/m³.

4.3 Slump Test

The result of slump test at Table 3 can be used to measure the workability and workability of all types of concrete. Changes in the material, water content or mixing ratio indicate a change in the slump value. According to [22], the slump test is known as the concrete workability test, where it is carried out to measure the workability of a concrete that has been mixed. The results obtained from the concrete mix test of brick and tile mixtures show differences in workability values and types of slumps based on the percentage of the mixture. The slump test is important because it provides an indication of the workability and consistency of fresh concrete, helping to determine whether the concrete mix meets the desired specifications for proper placement and compaction [23].

Table 3
Slump Test Results

Set	Brick (%)	Tile (%)	Slump Results (mm)	Types of Collapse
A	0	100	142	Shear Collapse
B	25	75	130	Shear Collapse
C	50	50	125	True Collapse
D	75	25	100	True Collapse
E	100	0	75	True Collapse

The classification of concrete slump according to Malaysian standards, refers to MS 26: Part 2 (Methods of Testing Concrete, Method of Sampling Fresh Concrete and Determination of Workability) where for the low slump type there is a standard scale in 0 – 125mm which is suitable for minimum formwork filling. In addition, for the moderate slump type there is a standard scale in the range of 125 – 150mm which is suitable for making columns, beams and walls, while the high slump type has a standard scale of 150 – 255mm which is suitable for making foundations, floor slabs and cylindrical structures.

Based on the observations made by the researcher on the testing of sets A and B, it shows high workability. This is because the tiles, which are usually finer and smoother, produce a mixture that flows more easily. The lack of roughness in the tiles reduces the internal resistance between the particles, making the mixture more easily deformed when tested. But for set B, it contains a small number of bricks, which are usually coarser and porous, adding a little resistance to the flow of the mixture. Both sets produced a type of shear collapse that reflected the characteristics of the mix that were less rigid and more likely to flow due to the smooth surface. A shear collapse occurred due to the lack of water in the concrete mix. Furthermore, the flat shape of the tiles prevented the mixed particles from compacting.

Next, for sets C, D and E, a more significant reduction in workability was observed. The presence of higher bricks caused more complex particle interactions and increased friction, reducing the ability of the mix to flow easily. This decrease clearly reflected the dominant influence of bricks, where the roughness and absorption properties of bricks absorbed more water than the mixes of sets A and B which contained more tiles. The type of collapse produced by these three sets was a true collapse, which is collapse that had reached the degree of workability of a concrete mix.

In conclusion, according to [24], the results of this decrease were influenced by the composition of the material, where tiles increased workability through their smooth and non-absorbent properties, while bricks reduced workability through their rough and porous properties. Understanding this effect is important for optimizing concrete mixes to suit the needs of a particular construction project. Referring to the MS 26: Part 2 (Methods of Testing Concrete, Method of Sampling Fresh Concrete and Determination of Workability) standard, good concrete slump is the true slump, with slump values adjusted based on application for most common concrete works, i.e. in the range of 25 mm to 125 mm being considered adequate, as long as it meets the mix design and project specifications.

4.4 Compressive Strength Test

Based on Figure 2, the results of compression tests on samples for days 7 and 28, there was a significant difference in the compressive strength of concrete. The findings showed that the higher the percentage of brick waste used as a replacement in the concrete mix, the lower the compressive strength value. This is because the density and strength between gravel and the replacement material are not the same. Referring to the Malaysian standard (MS EN 12620: Specification for

Aggregates for Concrete) gravel has a higher density than bricks and tiles. This makes gravel stronger to produce more efficient concrete and can be used for the construction of structures that can bear loads.

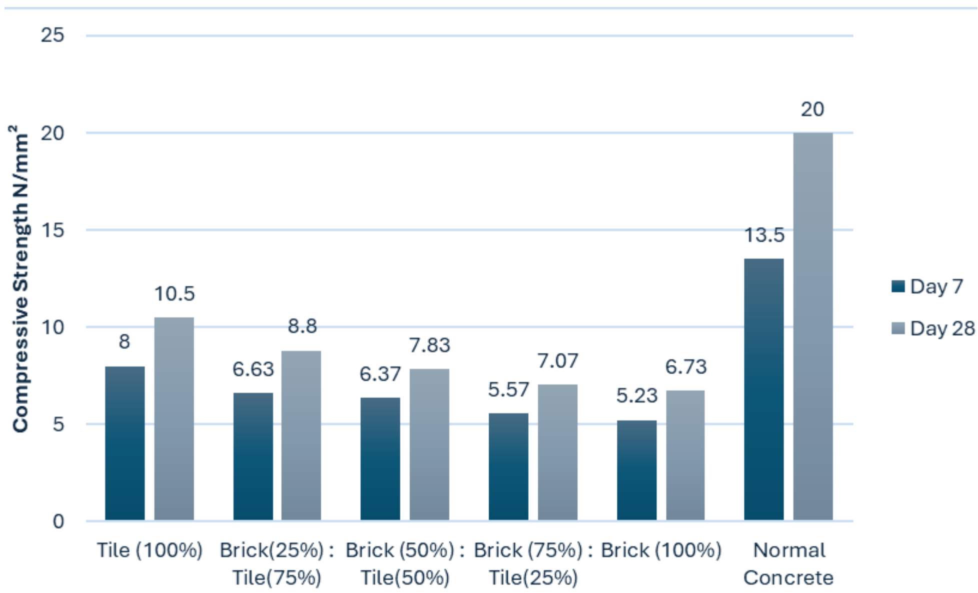

Fig. 2. Compressive Strength Test Result

Next, the researcher found that the decrease in strength for all sets of concrete designs is affected by the water-cement ratio in the mix. Although the water-cement ratio used is the same as regular concrete, which is w/c 0.5, this water-cement ratio is not suitable for use in the design of the replacement mix for brick and tile waste. This is because, due to the nature or composition of the materials used. According to [25] bricks are made from clay that is molded and fired to produce a structure that contains small pores (micropores) and allows water to be absorbed into the brick around 10 –20% of its weight. Meanwhile, tiles, especially those based on ceramic or porcelain, are produced through high compression and firing at very high temperatures, producing a denser material with fewer pores and having an almost waterproof surface, reducing water absorption to less than 0.5% [26]. Therefore, the design of replacing brick and tile waste requires a higher water-cement ratio than the water-cement ratio used in regular concrete mixes.

In addition, another factor that affects the compressive strength of all sets not reaching the strength of regular concrete for days 7 and 28 from the researcher's observations is the form of brick and tile waste used as a substitute for coarse aggregate in the mix. Based on the BS 882: Specification for Aggregates from Natural Sources for Concrete standard, angular aggregates or coarse aggregates tend to provide better adhesion with cement paste, which increases the strength of concrete. According to [27], the surface of tiles is usually smooth and less rough, reducing the ability to adhere to cement paste, causing a weak bond between aggregate and cement, thus reducing the strength of concrete. Meanwhile, for bricks, although they have the same shape as gravel after grinding, the more fragile and non-uniform structure of bricks also makes it difficult to form a strong bond with cement paste, causing a weak bond between aggregate and cement, which will negatively affect the strength and stability of concrete [28].

The difference in the strength of the replacement mix between the percentage of tile waste and brick waste occurs because denser materials such as tiles can produce concrete with a stronger bond between coarse aggregate and cement matrix, which is important to withstand compressive loads. The cement hydration process also plays a major role, where the compressive strength of concrete increases from day 7 to day 28 as the chemical reaction between water and cement continues to occur, forming hydration products that strengthen the concrete structure.

Summary Referring to standards such as BS EN 206 and ASTM C39, the compressive strength of concrete accepted for structural applications is usually at least 20 N/mm² at day 28. In this context, only ordinary concrete reaches the standard compressive strength, while concrete with 100% tiles comes close, but is still suitable for light structural applications. The lack of strength in a mixture with a higher percentage of bricks indicates that it does not meet the standard requirements for heavy structural applications. Therefore, to ensure that the concrete meets the required standards, the selection of high-quality and less porous coarse aggregates such as tiles is important.

4.5 Rebound Hammer Test

Table 4 of the rebound hammer test shows a relationship between the rebound number and the compressive strength of concrete. The lower rebound number as in Set E (11.33) reflects the weak level of concrete surface strength and the ability of the concrete to bounce the test hammer with less force. On the other hand, Set A with the highest rebound number (17.67) shows a harder and denser concrete surface, contributing to a higher compressive strength of 21 N/mm².

Table 4
Rebound Hammer Concrete Strength Test

Set	Average Number of Reflections	Concrete Strength (N/mm²)
A	17.67	21
B	16.11	19
C	14.78	18
D	12.56	17
E	11.33	16

This difference occurs because the rebound number is closely related to the density and structural integrity of the concrete. According to [29] the rebound obtained from the test reflects the hardness of the concrete surface, which is influenced by factors such as concrete composition, curing conditions, and age of the concrete. In this context, the researcher found that concrete designs with a high percentage of brick waste with a low rebound number contain a more porous or less compact concrete structure, resulting in a reduced number of rebounds in the rebound hammer reading. On the other hand, concrete designs that have a higher percentage of tiles with a higher number of reflections indicate more compact and less porous concrete, resulting in an increase in the number of reflections in the rebound hammer reading.

Among other factors that affect the reflection results is the condition of the surface to be tested. The concrete surface to be tested must be in a dry and not wet condition. This is because, according to [30], a wet surface gives a lower reading because it absorbs more pressure produced by the rebound hammer and the occurrence of errors on the reading of the reflection value. In addition, to obtain a certain reflection value when testing concrete samples, make sure the rebound hammer is in a 90° angle position and tested on a flat surface and carried out 9 readings. This procedure must be in accordance with the standard (BS, 1881: part 2020: a86) to ensure that the average value of the 9 readings produced does not occur and affect the test results. Next, check the impression made on the surface after the impact, and if the impact crushes or penetrates the air voids near the surface, disregard the reading and take another reading.

According to standards such as BS EN 12504-2, the rebound hammer test is used as a method of non-destructive assessment of the strength of concrete. Although a low rebound indicates poor compressive strength of concrete, this finding also suggests that concrete is suitable for lightweight structures such as lean concrete that do not require high compressive strength. Therefore, the results of this test illustrate the suitability of concrete for certain uses, where higher rebound numbers and compressive strengths are required for heavy-duty structures, while concrete with a low rebound number is sufficient for light-duty applications.

4.6 Overall Concrete Test Data

Based on Table 5 (test data), it has been proven that using only brick and tile waste as a replacement for coarse aggregate in concrete is not suitable. The main goal of this research was to achieve the objectives stated by analyzing the results of various laboratory tests, including water absorption, density, slump test, compressive strength, and rebound hammer tests. Several conclusions can be drawn from this study.

Table 5
Overall Concrete Test Data

Set	Water Absorption (%)	Average Density (kg/m³)	Slump test (mm)	Compressive Strength (N/mm²)		Rebound hammer	
				7th day	28th day	Rebound Number	Strength (N/mm²)
A	6.97	2082.47	142	8.0	10.5	17.67	21
B	7.23	2048.40	130	6.63	8.8	16.11	19
C	7.32	2023.71	125	6.37	7.83	14.78	18
D	7.43	1993.58	100	5.57	7.07	12.56	17
E	7.52	1969.38	75	5.23	6.73	11.33	16
NC	3 - 5	2200 - 2500	25 - 125	13.5	20	30 >	35

The use of a 0.5 water-cement ratio in concrete containing brick and tile waste affects the consistency of the concrete mix. Water absorption is related to the slump test because both measure the water content and consistency of the concrete. Concrete containing 25%, 50%, 75%, and 100% brick waste showed higher consistency than concrete with 100% tile waste. According to BS 1881: Part 122 standards, water absorption should not exceed 5%. The high-water absorption rate of brick waste requires more water to maintain the proper consistency.

From the compressive strength and rebound hammer tests, it was found that the strength of the samples did not reach the level of normal concrete on days 7 and 28. This was influenced by factors such as material density, shape, composition, and condition. As the percentage of brick waste increased, the strength of concrete decreased compared to concrete with 100% tile waste. This suggests that brick waste does not contribute to increasing concrete strength to match normal concrete standards.

Overall, the samples showed variations in water absorption, density, consistency, and compressive strength depending on the percentage of brick and tile waste used. Although the concrete mix with brick and tile waste did not achieve the compressive strength of normal concrete, it can still be used for lightweight structural applications. Tile waste performed better in terms of density, compressive strength, and durability compared to brick waste. Therefore, using tile waste in concrete can improve its physical properties and strength, making it suitable for certain construction applications that require higher durability. In conclusion, concrete made with brick and tile waste cannot match the strength and consistency of normal concrete.

5. Conclusion

To guarantee that the findings of this study can be used more broadly, an implementation framework that incorporates TVET training has been proposed. This framework allows students to receive specialised training on the effective recycling of building materials and utilise construction waste as hands-on training materials. In addition, case studies of educational institutions that have effectively used recycled materials into their curricula are examined, as is the efficiency of this strategy in lowering building material costs. Issues like material stability and processing techniques are also examined and resolved with the use of suitable technical strategies.

According to this study, there is a chance to save construction waste and material costs by using leftover brick and tile as an alternative coarse aggregate. But there are certain drawbacks that must be addressed, like its reduced compressive strength in comparison to regular concrete. To assess the endurance of this concrete in actual use and optimise the mix ratio, more research is required. Research on material treatment techniques that use additional processing technologies to enhance concrete performance, field tests on the use of this concrete in real construction projects, and combinations with additives like fibre or industrial waste ash to increase concrete's strength and durability are all possible future directions.

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