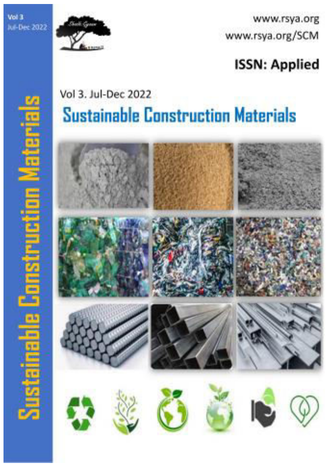

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Sustainable Construction Materials

Vol 2, Issue 2, Jul-Dec 2022
www.rsya.org/scm

Strength Characterization Resulting from the Partial Replacement of Cement with Brick Powder

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Abstract. This research focuses on the examination of the qualities of fresh and hardened M40 grade concrete employing Crushed ROCK Powder (CRP) as fine aggregate instead of the entire amount of sand, with partial substitution of brick powder at 0, 5, 10, 15 20 and 25 percent of the original cement content. These experiments were performed to evaluate the characteristics during 7, 28, 56, and 90 days of curing. The compression strength of bricks aggregate concrete can be increased by lowering the water-cement ratio & applying as needed for workability, according to the experiments performed. The split tensile strength test is the most often used. A 20% substitution of cementitious material raises the compressive, flex, and split-tensile strength of the cement concrete by up to ten percent when compared to the corresponding conventional concrete strength.

Keyword: Concrete, Mechanical Properties, Curing Day's, Brick dust, Compressive strength, Split Tensile strength, Durability Properties.

INTRODUCTION

Cement Concrete is a composite materials of fine & uneven aggregates that is linked along with fluid cement (cement paste) and solidify with time. Compressive strength of clay bricks is two and a half to three times that of concrete bricks. Clay bricks, on the other hand, can endure eight to twelve thousand pounds, whilst concrete can only handle three to four thousand [1]–[4]. Dumping dust and other waste brick particles, flakes, and other materials not only takes up space but also causes environmental issue. By incorporating these waste materials into cement concrete, the problem might be greatly alleviated. To test the qualities of concrete, scientists are substituting several materials for cement. Concrete construction is booming all throughout the world, particularly in poor countries. Carbon dioxide is emitted into the atmosphere as a result According to the Cement Sustainability Initiative report, the production of one tons of cement produces about one tons of CO_2 [5]–[8]. Kamal Uddin looked into the physical & chemical properties of (BDMA) brick dust as a mineral admixture, that were deposited as unwanted materials often referred as waste from Bangladeshi brick and tile companies. Chemical resistance is also good in concrete made with 20% BDMA instead of cement, notably against sulphate attack. Authors looked into using leftover brick powder as a partial replacement for cement in cement mortar manufacture. The mechanical strength of mortar was improved by replacing 10% of the cement with discarded brick. These investigations confirmed that this waste material may be used to make pozzolanic cement. Natural sand, taken from riverbeds, is the most frequently employed fine aggregate in the production of concrete. However, due to the extensive use of nonscientific mining techniques, river sand for appropriate planning has become extremely scarce. The current scenario needs the discovery of replacement supplies for natural sand in the manufacturing of concrete[3], [7], [9]–[11]. The current situation necessitates the identification of substitute resources for river sand in the production of concrete. To reduce the cost of concrete while simultaneously meeting demand. Alternative materials include pond ash, rice husk, sawdust, rock powder, and ceramic debris, all of which are readily available in the local area. Waste plastic & stone dust were used in the concrete by author[12], [13]. The use of these wastes improved properties such as compression strength, split-tensile, and unit weight. Another author reported that brick dust contains pozzolanic properties that can replace cement. Moreover, also came to the conclusion that brick dust has only small influence on strength loss[14]–[17]. As a cement substitute, Khan et al. looked at brick dust and marble powder. The experiments reveal that while utilizing both materials in a specific proportion increases workability, raising brick dust percentage beyond ten percent replacement reduces compressive strength. According to Researcher, using flue ash and brick dust as an additive can reduce up to 20% on cement in concrete while maintaining the same strength. Author found that employing a 0.50 water cement ratio and with the replacement of cement with fifteen percent silica fume and ten percent brick dust resulted in the highest compressive and tensile strength[18]–[21].

MATERIALS USED

Brick Dust

Brick dust is produced during the loading and unloading of bricks, as well as at construction sites and brick kilns. Since ancient times, pozzolanic elements like brick dust and other ceramic powders have been utilized in concrete. Because they were uninformed of the qualities of brick dust, they employed it based on their own experiences and experiments in ancient times. Bricks are created from a variety of clays as well as other constituents like sand. The clay is a mixture of 20-30% Alumina, fifty to sixty percent Silica, and various carbonates & oxides. The pozzolanic behaviour of brick is caused by clay. Clay does not have pozzolanic qualities on its own, but when combined with lime in the brick-making process.

Figure 1: Brick dust

Cement

The work was completed with regular Portland cement of 43 grade that met IS 8112 requirements. The fine aggregate employed for the experimentation was clear natural sand with a maximum size of 4.75 mm and grading zone II compliance. Cement is a powdered substance made from calcining lime and clay and combining it with water to produce gravel, mortar or sand, and water to make concrete. The specific gravity of Portland cement varies between 3.12 and 3.9.

Fine Aggregate

In mortars and concrete, sand is utilized as a fine aggregate. Natural sand is frequently dug out from a pit, a lake, or the seabed. River sand is getting more and more scarce. Thus, the artificial sand will overcome the scarcity of the river sand. One of the first tests is to determine the grade of fine aggregate. One of the first tests is to determine the grade of fine aggregate. The material utilized must be free of dust particles in order for the quality of the concrete to be unaffected.

Table 1: Chemical and Physical Properties of OPC

Sr. No	Physical Properties	Findings	Chemical Properties			
			Content	%	Content	%
1.	Normal Consistency	30%				
2.	90 micron sieve Fineness	90	SiO_2	21.38	MgO	2.09
3.	Initial Setting time	37	Fe_2O_3	3.26	SO_3	2.21
4.	Final Setting time	300	Al_2O_3	5.83	LOI	0.65
5.	Specific Gravity	3.20	CaO	65.61		

Table 2: Physical Properties Test Result

Sr. No.	Physical properties	Test Result As per IS Code	
		FA	CA
1.	Compacted Bulk Density	1757	1602
2.	Specific Gravity	2.59	2.67
3.	Fineness Modulus	2.91	7.26
4.	Water Absorption	1.29%	0.63%
5.	Particle Size		

Coarse Aggregate

Quarry rock, boulders, cobbles, and big gravel are crushed to generate crushed aggregate. Recycled concrete has proven to be a reliable source of aggregate in granular sub bases, soil-cement, and fresh concrete. The qualities of freshly mixed and hardened concrete, mixing proportions, and economy are all influenced by aggregate.

Water

The w/c ratio plays an important level role concrete's quality. It's the ratio of water in cement to create a concrete mix. With the increase in water to cement ratio improvement in the workability of concrete but reduces its strength. A lower w/c ratio results in greater strength and durability, but it makes working with the mix using a form more challenging. As a result, it is critical to make the best use of the water in the cement concrete. Plasticizers or super-plasticizers can be used to improve the workability of a product. The amount of water varies based on the materials' absorption ability.

METHODOLOGY

The design concrete mix entails determining the most sensible quantity of concrete elements in order to produce a concrete that is workable in its plastic stage and will harden to attain the desired properties. The design concrete mix comprises finding the most practical quantity of concrete materials to generate a concrete that is workable in its plastic stage and will harden to achieve the desired qualities. The goal of the experiment was to evaluate the qualities of brick powder concrete and to investigate many critical elements like split-tensile strength, flexural strength, and compression strength of brick powder concrete with varying percentages of cement replacement. The control concrete mix design was proposed utilising Indian Standard. M25 was the letter grade. In concrete, replacement levels of cement by powder of brick were 0 percent, 5%, 10%, 20%, and 25%. Table 1 shows the specifics of the blends.

RESULT AND DISCUSSION

Slump test

The workability of the above mixtures was determined using the ASTM C 143 slump test. A 12-inch slump cone with an 8-inch top opening diameter and a 4-inch bottom opening diameter, as well as a base plate, was employed. With the increase of 25 blows in each layer, the cone was filled with cement concrete in 3 layers. Three trials were made for each blend, and the results were recorded When the amount of brick dust in cement concrete samples is increased, the slump values tend to rise. This rise in slump value could be due to spherical brick dust particles that lubricate the mix & give it a ball bearing effect. Because brick dust absorbs more water after 15 percent substitution of cement, the slump value decreases shown in fig 2.

Table 3: Concrete Mix Design

Sr. No.	Mixture ID	Replacement Proportion	Brick dust	Cement	Fine Aggregate	Coarse Aggregate	Water
1.	MBD_0	0%	-	400	749	1206	191
2.	MBD_5	5%	20	380	749	1206	191
3.	MBD_{10}	10%	40	360	749	1206	191
4.	MBD_{15}	15%	60	340	749	1206	191
5.	MBD_{20}	20%	80	320	749	1206	191
6.	MBD_{25}	25%	100	300	749	1206	191

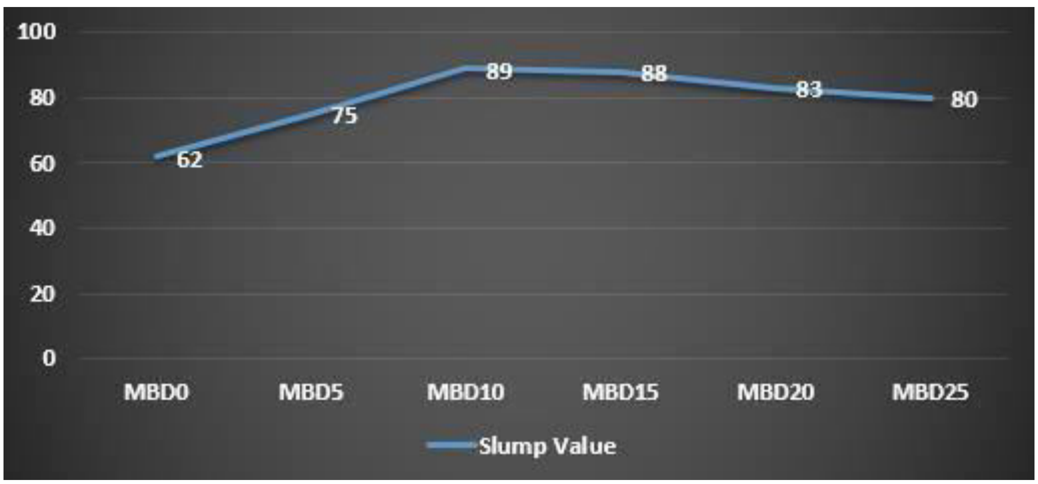

Figure 2: Slump Test result

Compressive Strength

For M-25 concrete grade, mix proportions of different components (viz. Cement, Sand, Aggregate, and Water) are determined based on design obtained in line with code IS-10262. The cubes were tested in a lab according to IS 1343- 1980 code. Figure compares and presents the compressive strength of cubes after 28, 56, and 90 days for various mixtures. The compressive strength of brick powder-replaced cement (M3, and M4 Mix) was compared to conventional concrete at 10%, 15%, 20%, and 25% (M2, M3 and M4 Mix) (M1 mix). Figure 6 shows that at all ages, compressive strength increases as brick dust content increases. When more than 15% of the cement is replaced with brick dust, the strength of the structure suffers. At 15% replacement, the maximum strength value was recorded. Because brick kiln dust is a natural pozzolan, it creates more C-S-H gel, resulting in increased strength. Second, the finer particles of brick kiln dust form a compact mass that fills the pores of concrete, resulting in increased strength compared to the control sample shown in fig 3.

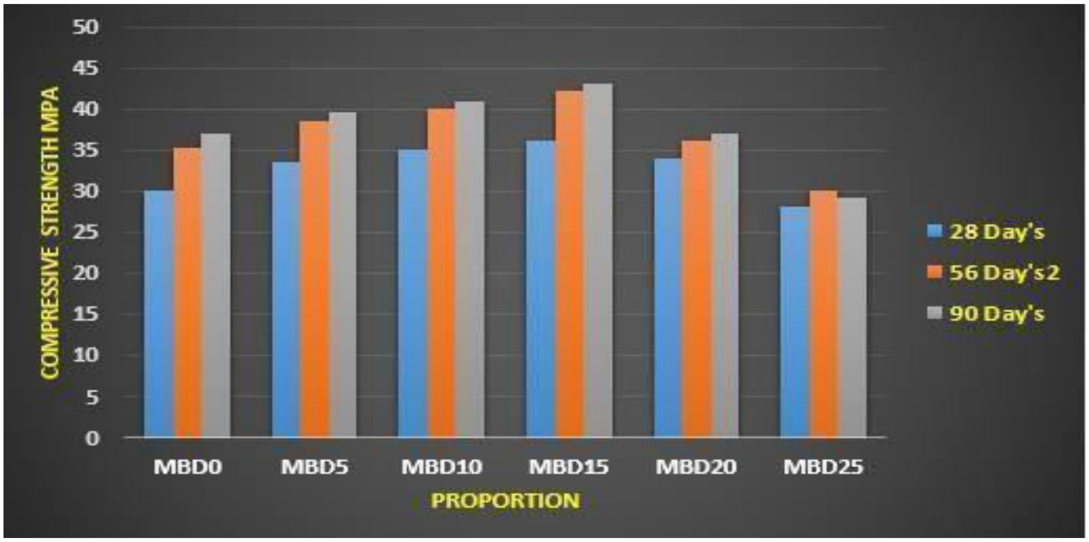

Figure 3: The result of Compressive Strength Test

Split Tensile Strength

In compliance with IS 5816:1998, the cylinders were tested in the laboratory. Figure compares and presents the findings of split tensile strength for various blends at 28, 56, & 90 days. The split tensile strength of concrete with5%, 10%, 15%, 20%, and 25 percent (MBD_5, MBD_{10}, MBD_{15}, MBD_{20} and MBD_{25} Mix) cement substitution was compared to normal concrete (MBD_0 mix). As illustrated in figure 7, split tensile has a similar strength gain pattern that increases up to fifteen percent replacement of cement & then begins to drop. It's possible that the rise is due to finer brick dust particles contributing to a more compact matrix shown in fig 4.

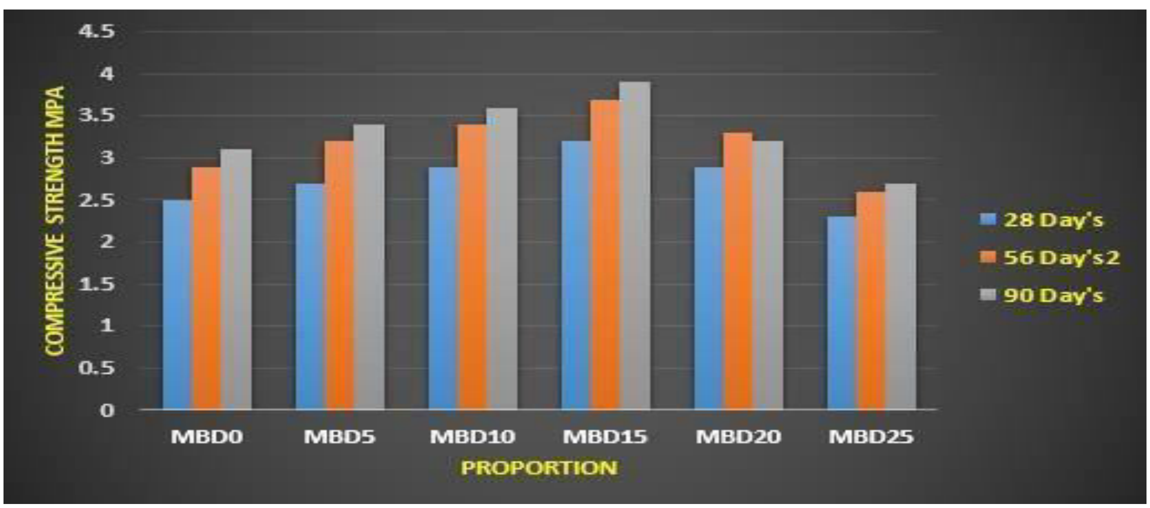

Figure 4: The test of Split Tensile Strength Result

Flexural Strength

In compliance with IS 516:1959, the beam prisms were tested in the laboratory. Figure 5 compares and displays the flexural strength data for various combinations after 28, 56, and 90 days. The flexural strength of brick powder- replacedcement (MBD5, MBD10, MBD15, MBD20 and MBD25) was compared to that of traditional concrete at 10%, 20%, & 30% (MBD5, MBD10, MBD15, MBD20 and MBD25) (MBD0 mix).

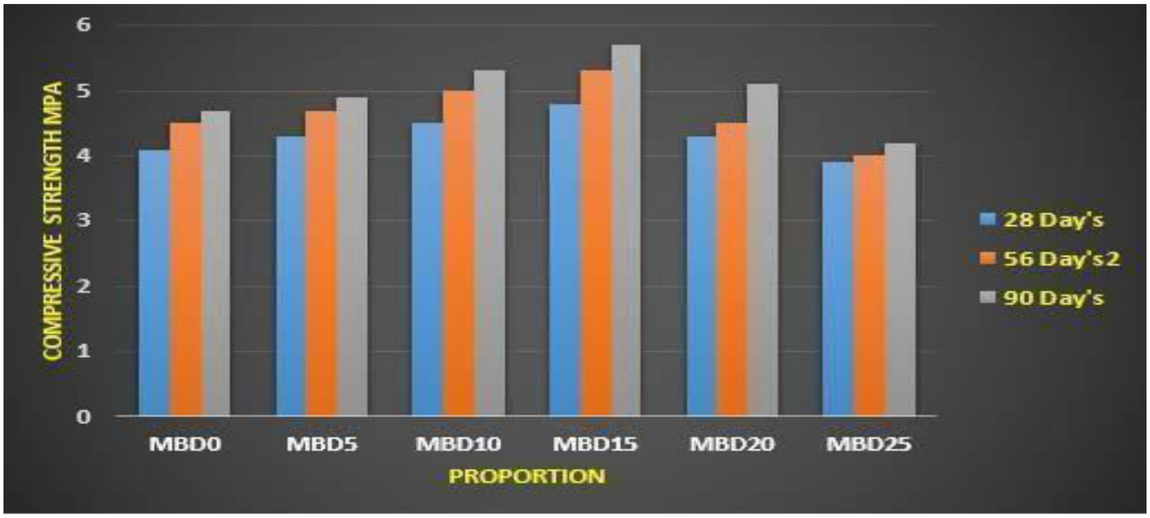

Figure 5: The results of Flexural Strength

Water Absorption Test

The water to cement proportion determines the quality and durability of concrete. The water weight with respect to the cement weight in a mixture of cement is called the w/c ratio. The concrete's workability was observed to be better with the increase in water–cement ratio, but the strength of cement concrete is reduced lower w/c ratio increases strength and durability, but it makes working with a form more difficult. As a result, the most efficient use of water in concrete is critical. Plasticizers or super-plasticizers can be used to improve the workability of a product. The amount of water depends on the materials' ability to absorb it.

CONCLUSION

Based on the experimental investigation and the exploration of the GCM in cement concrete some major conclusions are mentioned below:

Because brick powder has a higher specific gravity than concrete's basic materials, it aids in boosting the density of the cement concrete, resulting in fewer pores & a more compact cement concrete. The presented concrete is environmentally friendly since it consumes demolished brick waste, preventing it from accumulating. This process can save up to a third of the overall cost of cement in the traditional method. As the complexity of the mix design grows, so does the cost savings percentage. Even though the surface area grows with the percentage of brick powder added, the W/C ratio has remained constant. This assisted in the reduction of undesirable concrete bleeding and segregation. When compared to the respective traditional concrete strength, compression, flexural, & split tensile strength rises up to 10%, with a 20% replacement of cementitious material. Because concrete hardens quickly, shuttering can be removed sooner, saving money on secondary overhead. We can make a higher-strength concrete mix with less cement, lowering the primary overhead cost per m3 of concrete in the process.

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