International Journal of Applied Engineering Research ISSN 0973-4562 Volume 13, Number 7 (2018) pp. 94-99

Strength Characteristics by Partial Replacement of Cement with Brick Powder

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Abstract
The purpose of this research is to study the properties of fresh and hardened states of M40 grade concrete, using Crushed ROCK Powder (CRP) as fine aggregate to full amount of sand with Partial replacement of brick powder at 0%, 5%, 10%, 15% and 20% to existing cement content. This paper investigates quantitatively the strength of concrete mix at different ages. The overall test results revealed that in concrete mixtures, Crushed Rock Powder can be fully substituted as an alternative material for natural sand (fine aggregate) in presence of Brick powder upto 15%. These findings guide the practitioner in selecting fly ash and Crushed Rock Powder contents to meet the strength and workability requirements in a concrete mix. The concurrent use of two byproducts will lead to a range of economic and environmental benefits.

Keywords: Brick Powder, Crushed Rock Powder, Compressive Strength and Split Tensile strength

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Introduction

Concrete is a composite material composed of fine and coarse aggregate bonded together with fluid cement (cement paste) that hardens overtime. Most concretes used are lime-based concretes such as Portland cement concretes or concretes made with other hydraulic cements, such as calcium aluminate cements. However, asphalt concrete, which is frequently used for road surfaces, is also a type of concrete, where the cement material is bitumen, and polymer concretes are sometimes used where the cementing material is a polymer.

When aggregate is mixed together with dry Portland cement and water, the mixture forms fluid slurry that is easily poured and moulded into the shape. The cement reacts chemically with the water and other ingredients to form a hard matrix that binds the materials together into a durable stone like material that has many uses. Often, additives (such as pozzolans or super plasticizers) are included in the mixture to improve the physical properties of wet mix or the finished materials. Most concrete is poured with reinforcing materials (rebar) embedded to provide tensile strength, yielding reinforced concrete.

Concrete plays the key role and a large quantum of concrete is being utilized in every construction practices. They also studied that natural river sand is one of the key ingredients of concrete, is becoming expensive due to excessive cost of transportation from sources & also large scale depletion of sources creates environmental problems & to overcome these problems there is a need of cost effective alternative and innovative materials.

Research Significance

The most widely used fine aggregate for the making of concrete is natural sand, mined from the river beds. However, the availability of river sand for the preparation of concrete is becoming scarce due to the excessive nonscientific methods of mining. Apart from this, issues like lowering of water table, sinking of bridge piers, etc. are becoming common threats. The present scenario demands identification of substitute materials for river sand for making of concrete. The choice of substitute materials for sand in concrete depends on several factors such as their availability, cost, physical properties, chemical properties, chemical ingredients etc. for reducing the cost of concrete and also to meet the demand. Locally available waste materials, such as pond ash, ,r ice husk, sawdust, rock powder and ceramic scrap can be used as alternate materials.

This research work reports the potential of using Brick Dust Waste (BDW) as a partial substitute for Portland Cement (PC) in the development of concrete. BDW is recycled waste materials that are sourced from the demolishing of fired clay brick buildings or the discarded by-product materials from the cutting of fired clay bricks into shape and sizes for the construction of chimneys, and other uses needing the use of fired bricks. This results in the disposal of BDW as an environmental problem of concern.

Experimental Program

Material Properties

Experimental investigation carried out including properties of various materials used and their mix proportions. The details of method of casting of specimens and their testing procedures are explained.

Cement: In the present work, ordinary Portland cement of 53 grade RAMCO cement conforming to 12269:1987 is used. The physical properties of cement obtained on conducting appropriate test as per IS 269/4831 and the requirements as per 4031-1968 are given in Table 1.

Brick powder: Bricks were collected and crushed into fine powder from students. It was sieved from IS 4.75mm sieve. Physical properties of brick powder are given Table 1.0.

Table 1 Physical properties of cement

Sl. No	Properties	Obtained values	Requirements as per IS: 12269- 1987
1	Fineness	2.5%	Not more than 10%
2	soundness	1mm	Not more than 10mm
3	Initial setting time	45 min	Not less than 30min
4	Standard consistency	30%	-
5	Specific gravity	3.13	-

Fine aggregate:

M-sand: locally available M-sand is used. Specific gravity, sieve analysis, bulk density and bulking of fine aggregate tests are carried out and the results are presented in Table 2

Coarse aggregate:

Crushed stone of 20mm maximum size have been used as coarse aggregate. It was obtained from nearby quarry.

Water: Clean portable water is used for mixing and curing of concrete.

Admixture: Super plasticizer is used.

Table 2 Physical Properties of Brick powder

Sl. No	Properties	Obtained values	Properties	Obtained values
Brick Powder			**Fine Aggregate**	
1	Specific gravity	2.71	Specific gravity	2.39
2	Water absorption	0.38%	Fineness modulus	2.33
3	Bulk density	1.820cc	Bulk density	1.82 cc
4	Bulking of FA	45%	Bulking of FA	52%

Variable parameters:

a) M-sand: Natural sand is replaced by M-sand in proper proportions.

b) Brick powder: Cement is replaced by Brick powder in four proportions.

The replacements levels were: **0%, 5%, 10%, 15%, 20%.**

Mix Proportions

Concrete with brick powder: M40 grade of concrete is considered. Natural sand is replaced with M-sand. Cement is replaced with brick powder in 4 different percentages namely 5, 10, 15 and 20%. The mix design for concrete with brick powder is carried out as per IS 10262. Details of mix proportion for M40 concrete are given Table 3

Experimental Procedures

Strength Test on Concrete with Brick Powder

The casting and testing of concrete with Brick powder specimens for Compression and Split tension are conducted in accordance with IS 516-1959 (Reaffirmed 1999)

Compression Test

Compression test is carried out on specimen cubical in shape. The cube specimen is of size 150mm. A steel cube Moulds were coated with oil on their inner surface and are placed on plate. The amount of cement, Brick powder, M-sand, And coarse aggregate required for cubes are weighed. The materials are first dry mixed and then mixed with water and calculated amount of superplastizer. The top surface is finished using trowel. After 24 hours concrete cubes are demoulded and the specimens are kept for curing under water.

Table 3: Mix Proportion

Sl no	Mix	Cement Kg/m^3	Brick Powder Kg/m^3	FA Kg/m^3	CA Kg/m^3	Water Kg/m^3	Superplastizer
1	M40 Normal Concrete	315.2	0	694.12	1169.12	157.6	0.7 %
2	M40 5BPNC	299.4	15.76	694.12	1169.12	157.6	0.7 %
3	M40 10BPNC	283.68	31.52	694.12	1169.12	157.6	0.7 %
4	M40 15BPNC	267.92	47.28	694.12	1169.12	157.6	0.7 %
5	M40 20BPNC	252.16	63.04	694.12	1169.12	157.6	0.7 %

Testing of Cube Specimens

At each desired curing periods specimens of normal concrete are taken out of water and dried. The concrete cubes are also taken for the test. The cubes are tested in 200T capacity compression testing machine to get the compressive strength of concrete.

Split Tensile Test

Direct measurement of tensile strength of concrete is difficult. Neither specimens nor testing apparatus have designed which assure uniform distribution of the pull applied to concrete while a number of investigations involving the indirect measurement of tensile strength have made. The widely used test is split tensile strength test.

Casting of Cylinder Specimens for Split Tensile Test

The cylinder Moulds were coated with oil on their inner surfaces and were placed on plate. The amount of materials required to produce required number of cylindrical specimens are weighed. The materials are first dry mixed and then mixed with water and super plasticizer. The top surface is finished using trowel. After 24 hours concrete cylinders are demoulded and the normal concrete specimens are kept for curing under water.

Testing of Cylinder Specimens

At each desired curing periods specimens of normal concrete are taken out of water and dried. The concrete specimens are also taken for the test. The cylinders were tested in 200T capacity compression testing machine, applying the load diametrically to get the split tensile strength of concrete.

Figure 1: Process of making brick powder

Results and Discussion

The test proportion of each mix were evaluated and compared with normal concrete. The tests were carried out to determine the effect of brick powder on strength of various mixes of concrete for different percentages of brick powder.

Figure 2: Adding Brick Powder to the concrete

Figure 3: Casted specimens in laboratory

Figure 4: Failure patterns of specimens

Table 4: Compression strength values at 7 days

Sl. No	Type of concrete	Binding material		Fine aggregate content	Coarse Aggregate content	Avg value (N/mm²)
		Cement	Brick powder			
1	NC	100%	0%	100%	100%	26.84
		100%	0%	100%	100%	
		100%	0%	100%	100%	
2	5BPNC	95%	5%	100%	100%	26.62
		95%	5%	100%	100%	
		95%	5%	100%	100%	
		90%	10%	100%	100%	
3	10BPNC	90%	10%	100%	100%	27.21
		90%	10%	100%	100%	
4	15BPNC	85%	15%	100%	100%	20.18
		85%	15%	100%	100%	
		85%	15%	100%	100%	
5	20BPNC	80%	20%	100%	100%	20.51
		80%	20%	100%	100%	
		80%	20%	100%	100%	

Table 5: Compression strength values at 14 days

Sl. No	Type of concrete	Binding material		Fine aggregate content	Coarse Aggregate content	Avg value (N/ mm²)
		Cement	Brick powder			
1	NC	100%	0%	100%	100%	28.58
2	5BPNC	95%	5%	100%	100%	31.18
		95%	5%	100%	100%	
		95%	5%	100%	100%	
		90%	10%	100%	100%	
3	10BPNC	90%	10%	100%	100%	38.03
		90%	10%	100%	100%	
4	15BPNC	85%	15%	100%	100%	24.07
		85%	15%	100%	100%	
		85%	15%	100%	100%	
5	20BPNC	80%	20%	100%	100%	23.29
		80%	20%	100%	100%	
		80%	20%	100%	100%	

Effect of brick Powder on Compressive strength

As per design obtained in according to IS-102 62, mix proportion of various materials (viz cement, Sand, Aggregate and Water) is calculated for M-40 grade of concrete. The cubes were tested in laboratory in accordance to code IS1343-1980. The results of compressive strength of cubes for 7, 14 and 28 days for various mixes are compared and presented in Table 4 to 6. The compressive strength for 5%, 10%, 15% and 20% replacement of cement by brick powder are compared with conventional concrete. It is observed that the compressive strength of the cubes initially increases upto 10% brick powder at 7, 14 and 28 days. When the percentage of brick powder is increased to 15% and 20% retrogression in the strength is observed at all ages i.e. 7, 14, and 28 days. At 7 days the overall increase in the strength is observed to be 1%.

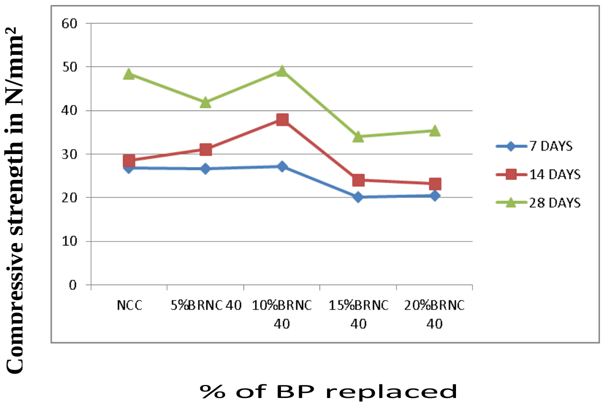

Figure 5: Compressive strength of concrete with0%, 5%, 10%, 15%, and 20% of Brick Powder for a curing period of 7, 14 and 28days

Table 6: Compression strength values at 28 days

Sl. No	Type of concrete	Binding material Cement		Fine aggregate content Brick Powder	Coarse Aggregate content	Avg value (N/mm^2)
1	NC	100%	0%	100%	100%	48.4
2	5BPNC	95%	5%	100%	100%	41.85
		95%	5%	100%	100%	
		95%	5%	100%	100%	
		90%	10%	100%	100%	49.18
3	10BPNC	90%	10%	100%	100%	
		90%	10%	100%	100%	
4	15BPNC	85%	15%	100%	100%	33.99
		85%	15%	100%	100%	
		85%	15%	100%	100%	
5	20BPNC	80%	20%	100%	100%	35.33
		80%	20%	100%	100%	
		80%	20%	100%	100%	

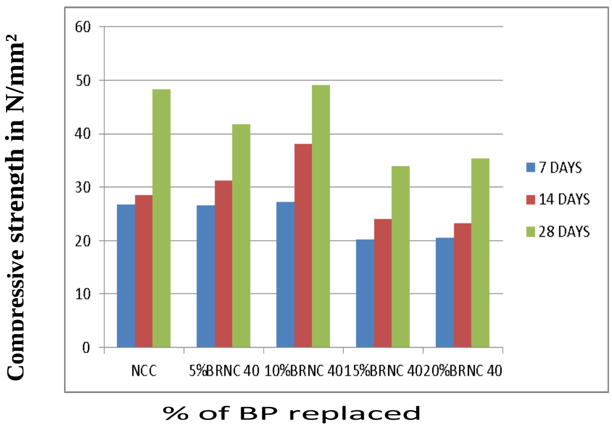

Figure 6: Compressive strength of concrete with0%, 5%, 10%, 15%, and 20% of Brick Powder for a curing period of 7, 14 and 28days.

At 14 days the overall increase in the strength is observed to be 8% in. At 28 days the overall increase in the strength is observed to be 1% in comparison to normal convention concrete. At 15% and 20% the retrogression in the strength cured at ambient temperature is observed, this is may be due to absorption of mixing water by brick powder. At 10% replacement of cement by brick powder the percentage increase in value of 14% was noted down in 14 days strength compared with 7 days and whereas percentage increase in value of 37.44% was noted down when 14 days strength compared with 28 days strength.

Split Tensile Strength

The test results of split tensile strength og M40 grade concrete 5, 10, 15 and 20% replacement of cement , in which natural sand is replaced with M-sand and for different curing period (7, 14 and 28 days) are given below

Table 7: Split tensile strength values at 7 days:

Sl. No	Type of concrete	Binding material Cement	 Brick powder	Fine Aggregate content	Coarse Aggregate content	Avg value (N/mm^2)
1	NC	100%	0	100%	100%	1.92
2	5BPNC	95%	5%	100%	100%	1.76
3	10BPNC	90%	10%	100%	100%	2.33
4	15BPNC	85%	15%	100%	100%	2.4
5	20BPNC	80%	20%	100%	100%	2.07

Table 8: Split tensile strength values at 14 days

Sl. No	Type of concrete	Binding material Cement	 Brick powder	Fine Aggregate content	Coarse Aggregate content cement	Avg value (N/mm^2)
1	NC	100%	0	100%	100%	2.08
2	5BPNC	95%	5%	100%	95%	2.12
3	10BPNC	90%	10%	100%	90%	2.36
4	15BPNC	85%	15%	100%	85%	1.76
5	20BPNC	80%	20%	100%	80%	1.92

Table 9: Split tensile strength values at 28 days:

Sl. No	Type of concrete	Binding material Cement	 Brick powder	Fine Aggregate content	Coarse Aggregate content cement	Avg value (N/mm^2)
1	NCC	100%	0	100%	100%	2.07
2	5BPNC	95%	5%	100%	95%	2.83
3	10BPNC	90%	10%	100%	90%	3.11
4	15BPNC	85%	15%	100%	85%	2.19
5	20BPNC	80%	20%	100%	100%	2.04

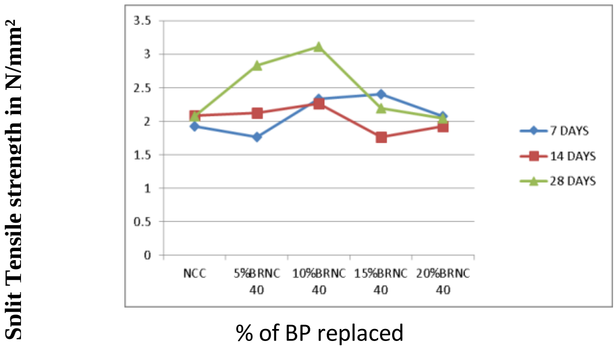

Figure 7: Split tensile strength of concrete with 0%, 5%, 10%, 15%, 20% of Brick Powder for a curing period of 7, 14, anc ys

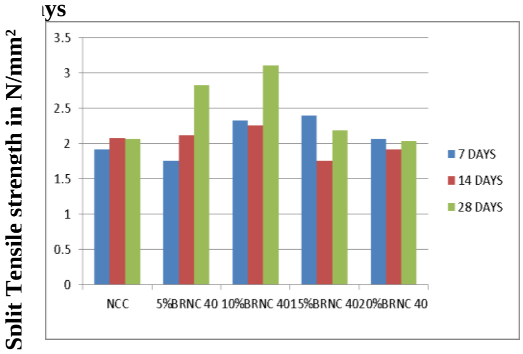

Figure 8: Split tensile strength of concrete with 0%, 5%, 10%, 15%, 20% of Brick Powder for a curing period of 7, 14, and 28 days period of 7, 14, and 28 days

Effect of brick Powder on Split Tensile Strength

As per design obtained in according to IS-10262, mix proportion of various materials (viz cement, Sand, Aggregate and Water) is calculated for M-40 grade of concrete. The cylindrical specimens were tested in laboratory in accordance to code IS1343-1980. The results of Split Tensile strength of cylindrical specimen for 7, 14 and 28 days for various mixes are compared and presented in Table 7 to 9. The Split Tensile strength for 5%, 10%, 15% and 20% replacement of cement by brick powder are compared with conventional concrete. It is observed that the Split Tensile strength of the cylindrical specimen initially increases upto 10% brick powder at 7, 14 and 28 days. When the percentage of brick powder is increased to 15% and 20% retrogression in the strength is observed at all ages i.e. 7, 14 and 28 days. At 7 days the overall increase in the strength is observed to be 20% At 14 days the overall increase in the strength is observed to be 8%, At 28 days the overall increase in the strength is observed to be 50% in comparison to normal convention concrete. At 15% and 20% the retrogression in the strength cured at ambient temperature is observed, this is may be due to absorption of mixing water by brick powder. At 10% replacement of cement by brick powder the percentage increase in value of 1.4% was noted down in 14 days strength compared with 7 days and whereas percentage increase in value of 20% was noted down when 14 days strength compared with 28 days strength.

Conclusions

- The specific gravity of brick powder being higher than the raw materials concrete, it helps in increasing the density of concrete which results in less pores and high compact concrete.
- This is and eco-friendly concrete as it subsides the stagnation of demolished brick waste by consuming it.
- As much as of the total cost of cement in conventional method can be saved by this procedure. Cost saving percentage increases with increase in richness of mix design.
- The W/C ratio has being kept constant even as the surface area is increasing with increase in percentage of brick powder. This helped in reducing the unwanted bleeding and segregation in concrete.
- The compressive and split tensile strength increases up to 10%, 20% replacement of cementitious material compared to the respective conventional concrete strength.
- We can achieve more strength concrete mix with lesser quantity of cement, which indirectly reduces the primary overhead cost per m^3 of concrete.

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