International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Experimental Analysis of Compressive & Tensile Strength of Concrete Using Crushed Brick Powder as a Partial Replacement of Sand in Concrete

Patel Atharoddin Moizoddin [1], Prof. G.N. Shete [2]

[1]PG student, Department of Civil Engineering, M.S. Bidve Engineering College, Latur
[2]Professor, Department of Civil Engineering, M.S. Bidve Engineering College, Latur

ABSTRACT

The rapid depletion of natural river sand and the growing concern for environmental sustainability have led to the search for alternative fine aggregates in concrete. This study investigates the feasibility of using crushed brick powder as a partial replacement for sand in concrete. Crushed brick powder, a waste product from demolished brick masonry or brick manufacturing industries, offers a promising alternative due to its pozzolanic properties and availability.Concrete mixes were prepared by replacing sand with crushed brick powder at varying percentages (0%, 5%, 10%, and 15%) by weight. The workability, compressive strength, and flexural strength of the mixes were tested at different curing ages to evaluate the mechanical performance. The results showed that up to 0%–10% replacement of sand with crushed brick powder can improve or maintain the strength characteristics of concrete compared to the control mix. However, beyond this percentage, a gradual decrease in strength was observed due to the high porosity and water absorption of brick powder. The study concludes that crushed brick powder can be effectively used as a partial replacement for sand in concrete, promoting the use of construction waste and reducing the dependency on natural river sand. This contributes to sustainable construction practices and waste management in the building industry.

Key Words – Compressive strength **,** Tensile strength , Crushed brick , Sand & Cement.

1. Introduction-

Concrete is a fundamental material in the construction industry, known for its strength, durability, and versatility. It is composed primarily of cement, fine aggregates (such as sand), coarse aggregates, and water. Among these, natural river sand is commonly used as a fine aggregate due to its desirable properties. However, the rapid urbanization and infrastructure development in recent years have led to the over-exploitation of natural sand, causing several environmental and ecological concerns. These include depletion of riverbeds, erosion, disturbance of aquatic ecosystems, and increased cost of sand due to scarcity. In response to these challenges, the construction industry is exploring alternative materials that are sustainable, economical, and capable of performing effectively as fine aggregates. One such material is crushed brick powder, a waste product generated from the crushing of broken or discarded clay bricks, which are abundantly available from demolition waste and brick manufacturing processes. Crushed brick powder possesses pozzolanic properties, meaning it can react with calcium hydroxide in concrete to form additional binding compounds, potentially improving the strength and durability of the concrete. Its angular particle shape also contributes to good bonding within the concrete matrix. Utilizing this material not only reduces The objective of this project is to survey and evaluate existing research on the partial replacement of sand with crushed brick powder in concrete, focusing on its effects on fresh and hardened concrete properties. Parameters such as compressive strength, workability, setting time, flexural strength, water absorption, and long-term durability are considered. The replacement levels typically range between 5% and 15%, depending on the specific application and desired concrete performance

This study compiles and analyzes various research findings to assess the feasibility of using crushed brick powder as a sustainable and cost-effective alternative to sand. It also highlights potential advantages, limitations, and recommendations for future research and practical implementation in construction projects. By adopting such sustainable practices, construction industry can move toward more eco- friendly and resource-efficient building solutions, supporting the global shift toward green construction and circular economy principles.

2 Literature Review

Poon et al. (2002) studied the properties of crushed clay bricks used as fine aggregate in concrete. Their research focused on evaluating the feasibility of using this material as a partial replacement for natural sand. The study revealed that crushed bricks possess a higher water absorption capacity and lower specific gravity compared to natural aggregates, which affects the workability and mix design of concrete. Despite these drawbacks, the concrete maintained adequate compressive strength up to 25% replacement and showed potential for use in lightweight and non-structural concrete applications. The angular texture of crushed bricks also contributed to better bonding within the concrete matrix, although it required mix water adjustments or admixtures to achieve desired workability.

B. V. Reddy and A. Gupta (2005) investigated the strength and durability characteristics of concrete in which crushed brick aggregates were used as a partial replacement for fine aggregate (sand). Their experimental results indicated that replacing natural sand with crushed brick aggregate up to 30% had a marginal effect on compressive strength, making it suitable for general construction purposes. The study also noted that the inclusion of crushed bricks improved certain durability aspects, particularly in thermal insulation and resistance to weathering, owing to the brick's porous nature and thermal properties. However, higher replacement levels resulted in reduced mechanical performance, and therefore, an optimal range was recommended for balancing strength, workability, and long-term durability.

N. K. Bansal and A. K. Jain (2009) reported that the incorporation of crushed brick as a partial replacement for fine aggregate in concrete leads to a notable reduction in the density of the resulting mix. This reduction is primarily due lightweight nature of brick particles compared to natural sand. As a result, the concrete becomes more suitable for lightweight construction applications, such as partition walls, non-load-bearing structures, and thermal insulation components. The study suggested that a replacement level of up to 25% could be adopted without significantly compromising compressive strength, while still achieving the benefits of reduced self-weight and improved thermal properties to the porous and.

K. Senthamarai and P. Devadas Manoharan (2011) conducted a comparative study on the performance of ceramic waste and crushed brick as partial replacements for fine aggregate in concrete. Their research focused on evaluating the mechanical properties, workability, and durability of concrete mixes incorporating these alternative materials. The results showed that both ceramic waste and crushed brick aggregates could be used effectively up to 30% replacement without severe reductions in compressive strength. Among the two, crushed brick demonstrated better bonding with cement paste due to its rough surface texture and angular shape, resulting in improved interfacial transition zones (ITZ). However, both materials showed increased water absorption, necessitating adjustments in water content or the use of admixtures to maintain desired workability.

Ibrahim and Skariah (2018) conducted an experimental study to assess the effects of crushed brick powder as a partial replacement for fine aggregate in concrete, with replacement levels of 0%, 10%, 20%, 30%, and 40% by weight. Their investigation focused on key parameters such as compressive strength, workability, and durability. The results revealed that concrete mixes with 10% and 20% replacement showed comparable or slightly improved compressive strength compared to the control mix. Workability decreased with higher replacement percentages due to the higher water

absorption of crushed brick particles. Beyond 30% replacement, a noticeable decline in strength and workability was observed, indicating that 20% replacement provided the optimum balance between performance and sustainability.

Hansen's work laid the groundwork for further investigation into optimizing mix designs to improve the performance of recycled concrete.

3.AIM

A Experimental analysis of concrete strength using Crushed bricks as Partial replacement of Sand.

4.OBJECTIVES

1 Evaluate the mechanical properties of concrete (such as compressive, tensile stremgth) when fine aggregate is partially replaced by CBP at varying percentages.

2 Assess the workability and durability of concrete mixes containing CBP.

3 Determine the optimum percentage of CBP that can be used without significantly compromising concrete quality and performance.

4.Compare performance of concrete made with CBP to

that of conventional concrete (control mix) in terms of strength and sustainability.

5.Explore environmental benefits, such as reducing the dependency on natural sand and promoting the reuse of construction and demolition waste

5.Material Used-

5.1. cement

cement**,** in general, adhesive substances of all kinds, but, in a narrower sense, the binding materials used in building and civil engineering construction. Cements of this kind are finely ground powders that, when mixed with water, set to a hard mass. Setting and hardening result from hydration, which is a chemical combination of the cement compounds with water that yields submicroscopic crystals or a gel-like material with a high surface area. Because of their hydrating properties, constructional cements, which will even set and harden under water, are often called hydraulic cements. The most important of these is portland cement.This article surveys the historical development of cement, its manufacture from raw materials, its composition and properties, and the testing of those properties. The focus is on portland cement, but attention also is given to other types, such as slag-containing cement and highalumina cement. Construction cements share certain chemical constituents and processing techniques with ceramic products such as . brick & tile, abrasives For detailed description of one of the principal applications of cement, see the article building construction.

CEMENT

5.2 Fine Aggregate

. Fine aggregate should be natural sand or crushed stone sand conforming to IS 383:2016.

It must be clean, hard, durable, and free from clay, silt, salts, organic matter, and other deleterious substances.

Silt content in fine aggregate should not exceed 3% by weight for natural sand (per IS 2386 Part 2).

Particles should be angular or sub-angular, especially in crushed stone sand, to ensure better bonding in concrete.

sand confirms to zone 1 as per Indian Standards. The Specific gravity sand is 2.65. Those fractions from 4.75mm to 150 micron are termed as fine aggregate

FINE AGGREGATE

5.3Coarse Aggregate

Coarse aggregate should be crushed stone, gravel, or a combination of both.

It should be clean, hard, durable, and free from:

Dust , clay lumps & organic impurities

It should be clean, hard, durable, and free from:

Dust , clay lumps & organic impurities

The crushed aggregates used were 20mm nominal maximum size and are tested as per Indian standard sand results are within the permissible limit. The specific gravity of coarse aggregate is 2.68

COARSE AGGREGATE

5.4 Brick powder :

Usually crushed and sieved to match the fineness of natural sand (passing 4.75 mm sieve).

It can be **used as a substitute** for sand or as **a pozzolanic material** (similar to fly ash) in cementitious systems.

Crushed brick powder

#Advantages

1. Sustainable Waste Management

Utilizes construction and demolition waste (broken bricks), reducing landfill burden.

Promotes recycling and reuse of materials in construction.

2. Conservation of Natural Resources

Reduces the demand for natural river sand, which is increasingly scarce due to over-mining.

Helps in conserving riverbeds and ecosystems.

3. Cost-Effectiveness

Crushed brick powder is often cheaper or free if sourced from construction waste.

Reduces material costs, especially in regions with abundant brick debris.

4. Environmental Benefits

Reduces carbon footprint associated with sand mining

and transportation.

Supports green building practices and sustainable construction.

5. Improved Bonding and Strength (at Optimum Levels)

Angular shape and rough surface texture of brick powder can enhance bonding with cement paste.

Can contribute to long-term strength development if fine enough to act as a pozzolan.

6. Better Thermal Insulation

Bricks are inherently insulating materials; crushed brick in concrete can improve thermal resistance, beneficial for buildings in hot climates.

7. Lightweight Concrete

Crushed brick powder is less dense than sand, resulting in slightly lighter concrete, which can reduce dead load.

8. Pozzolanic Activity (if finely ground)

Finer brick powder may contribute to cement hydration by reacting with calcium hydroxide, improving durability and long-term strength.

9. Enhanced Durability (in Some Cases)

Certain studies show improved resistance to chemical attack, especially in sulphate environments, depending

5.5 Water

Free from harmful amounts of oils, acids, alkalis, salts, sugar, organic materials, or other substances that may affect hydration or durability. Water available from the local sources conforming to the requirements of water for concreting and curing as per IS:456-200 on mix and curing.

6.Concrete Mix

The physical properties of blended cement (Portland cement replaced by 0%, 5%, 10% &15% With constant water ratio concrete design mix of grade M30 was prepared and design mix was studied for compressive

Cement (Kg/m^3)	Fine Aggregate (FA) (Kg/m^3)	Coarse Aggregate (Kg/m^3)	Water (Kg/m^3)
1	1.79	2.24	0.42
442.85	796.9	992.59	185.89

7.Test for concrete

7.1Compressive Test

The compressive strength of concrete is determined using a cube or cylinder that is tested in a compression testing machine (CTM). A standard-sized specimen is cast, cured under specific conditions, and then crushed in the CTM after a set period (usually 7 or 28 days). The load at failure is recorded and divided by the cross-sectional area to calculate the compressive strength. The standard IS code for this test is IS 516:1959.

For cube test most of the works cubical moulds of size 15 cm x 15cm x 15 cm are commonly used. These specimens are tested by compression testing machine after 7 days curing and 28 days curing. Load is applied gradually at the rate of 140 kg/cm2 per minute till The specimen fails. Load at failure divided by area of specimen gives the compressive strength of concrete.

To accurately test the compressive strength of concrete, standardized specimens are required. The shape and size of these specimens affect the result, as different geometries distribute stress differently during testing. In India, cubes are widely used, whereas cylinders are more common in countries like the USA. The choice depends on national standards and testing.

 # Calculations

Compressive Strength= P/A

7.2Tensile Strength Test

The tensile strength of concrete is one of the basic and important properties which greatly affect the extent and size of cracking in structures. Moreover, the concrete is very weak in tension due to its brittle nature. Hence. It is not expected to resist the direct tension. So, concrete develops cracks when tensile forces exceed its tensile strength. Therefore, it is necessary to determine the tensile strength of concrete to determine the load at which the concrete members may crack. Furthermore, splitting tensile strength test on concrete cylinder is a method to determine the tensile strength of concrete.

The procedure based on the ASTM C496 (Standard Test Method of Cylindrical Concrete Specimen) is similar to other codes like **I**S 5816 1999.

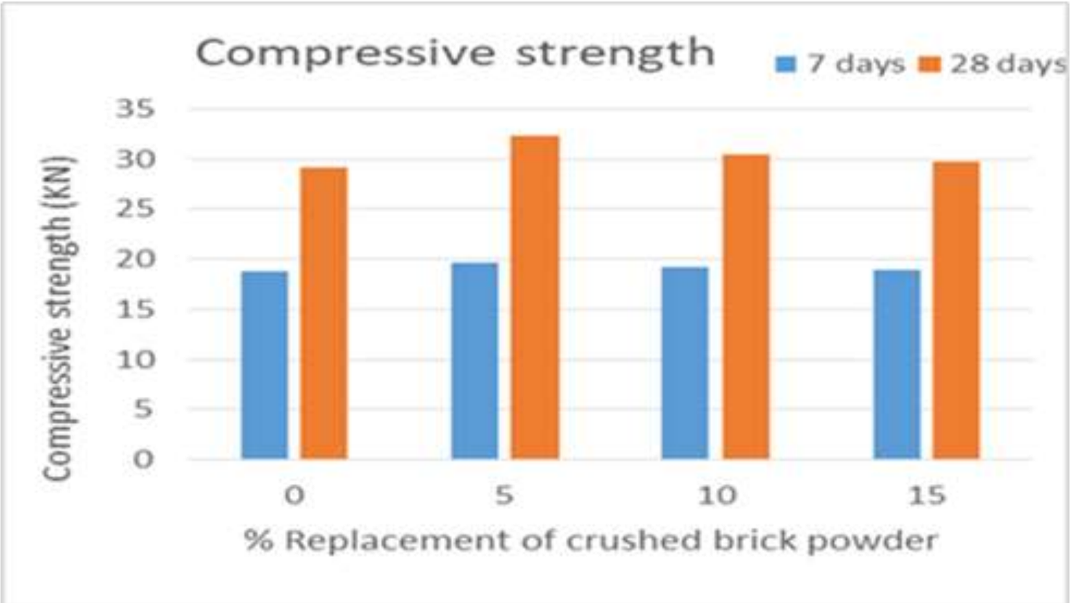
#Calculations

Tensile Strength = 0.642P/A

8. Result Analysis

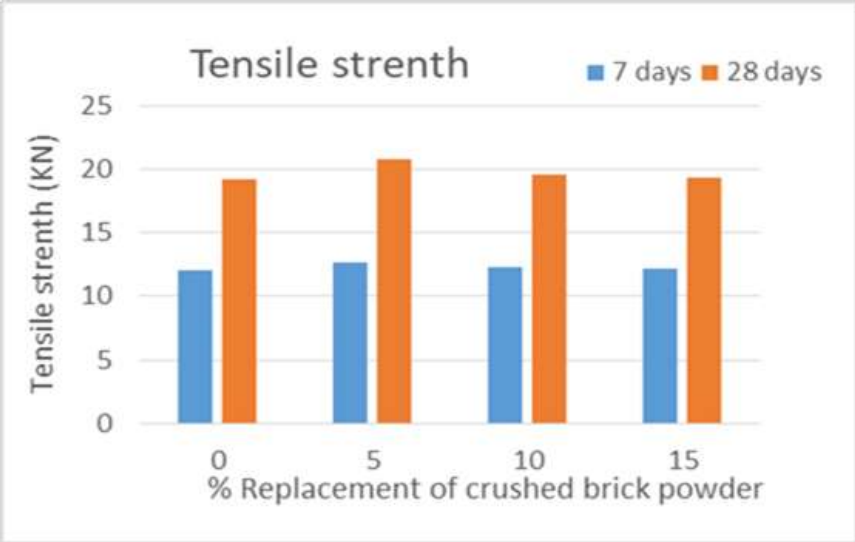
8.1. Compressive Strength

%Replacement (Crushed bricks powder)	7days Comp. Strength (N/mm2)	28days Comp. Strength (N/mm2)
0	18.79	29.22
5	19.61	32.30
10	19.20	30.51
15	18.89	29.72



8.2 Tensile Strength

%Replacement (Crushed brick powder)	7days Tensile strength (N/mm2)	28days Tensile strength (N/mm2)
0	12.06	19.79
5	12.59	20.73
10	12.24	19.58
15	12.12	19.31



9.Conclusion

The following conclusion may be drawn from the experiment carried out

1.The compressive strength of M30 concrete for 7 days at 0%,5%,10%,15% is 18.79KN/m2, 19.61KN/m2,

19.20KN/m2, 18.89KN/m2 respectively

2.The compressive strength of M30 concrete for 28 days at 0%,5%,10%,15% is 29.22KN/m2, 32.30KN/m2, 30.51KN/m2, 29.72 KN/m2 respectively

3.The Tensile Strength of M30 concrete for 7 days at 0%,5%,10%,15% is 12.06KN/m2, 12.59KN/m2,

12.24KN/m2, 12.12KN/m2 respectively

4.The Tensile Strength of M30 concrete for 28 days at 0%,5%,10%,15% is 19.19 KN/m2, 20.73 KN/m2,

19.58 KN/m2, 19.31 KN/m2 respectively

5.Workability of concrete decreases slightly with an increase in crushed brick content due to the angular shape and higher water absorption of brick particles. However, with appropriate adjustments to the water-cement ratio or use of plasticizers, workable mixes can still be achieved.

6.Concrete mixes with up to 0%–10% replacement of sand by crushed brick showed comparable compressive strength to conventional concrete. Beyond 10%, a slight reduction in strength was observed, likely due to the porous nature of the crushed bricks.

7.Crushed brick can enhance microstructure due to better interlocking and pozzolanic activity of fine particles, but excessive replacement may lead to higher porosity and moisture absorption.

8.The use of crushed bricks as a partial sand replacement promotes recycling of construction and demolition waste, reduces environmental degradation from sand mining, and contributes to sustainable construction practices.

10.Reference

1)Concrete Technology- M.S. Shetty

2)"Properties of Concrete" - A.M. Neville

3)"IS 383:2016 – Specification for Coarse and Fine Aggregates"

4)"IS 456:2000 – Code of Practice for Plain and Reinforced Concrete"

5) P. Kumar Mehta – Concrete: Microstructure, Properties, and Materials

6) B. V. Reddy and A. Gupta (2005) investigated the strength and durability characteristics of concrete in which crushed brick aggregates were used as a partial replacement for fine aggregate (sand).

7) K. Senthamarai and P. Devadas Manoharan (2011) conducted a comparative study on the performance of ceramic waste and crushed brick as partial replacements for fine aggregate in concrete.