IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

Recycled Brick Powder As Partial Cement Replacement: A Strength Comparison Study

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Abstract

The environmental concerns around production of Ordinary Portland Cement (OPC) have led to a shift towards more sustainable building materials. Industrial and demolition waste material can be good alternative supplementary cementitious materials (SCMs). This study investigates the use of Recycled Brick Powder (RBPs) is crushed and finely ground mud brick and is used as a partial replacement for OPC in concrete. The pozzolanic nature of RBP allows it to react with calcium hydroxide, which could improve the long-condition strength and resistance of concrete.

In this research, Concrete mixes were prepared with different percentages (5%,10%,15%, 20%) of replacement percentage of cement with RBPs. The specimens were tested for strength after 7,14,28 days of curing. Microstructural analysis was done to understand the impact on the concrete. The 10% and 15% RBP replacing degree remained the same, while a 20% replacing led to a noticeable diminution. The pozzolanic chemical reaction at lower RBPs resulted in a denser and refined construction

Reducing RBPs and minimizing building and destruction waste material and lowering the Cement in concrete products are some of the challenges addressed by the reuse of RBP. Up to 15% of RBP can be used as a sustainable cement replacement in concrete for general and non-critical structural application. This in turn promotes the green building practices and aligns well with global construction sustenance frameworks

Keywords: Recycled Brick Powder (RBP), sustainable concrete, partial cement replacement, mechanical strength, pozzolanic materials, construction waste reuse, circular economy.

1. Introduction

The construction industry is facing increased pressure to adopt sustainable practices. Ordinary Portland cementum emits large greenhouse gases [1]. Climate alteration is hugely caused by the cement manufacturers (~5-8%) [1]. Huge quantities of building and demolition waste materials are being generated. These billions of dozens of CDW are produced each year, posing serious administration and resourcefulness challenges [2]. A large part of the dust is mud brick. In some regions (e.g. one-half of CDW is made up of clay bricks and ceramic debris [3]. The large quantity of waste material that has been landfilled or used as land filled. represents a lost chance [4]. There is a demand for sustainable options to be used.

Supplementary cementitious stuff can be recycled into waste material mud brick. A fine recycled - pulverization can be made [5]. This can be used as a partial replacement for cementum. The benefits of using industrial by-merchandise like tent-fly ash trees are similar to using industrial by-merchandise as SCMs. The waste material mud bricks have been fired at high temperature and have a batch of stuff in them [6]. In the front of cementum hydration merchandise, the - pulverization can undergo secondary chemical reaction to form additional calcium silicate hydrate. The standard for a pozzolan was met. Replacing 10% of cementum with - pulverization in - - produced 28-twenty-four hours strength comparable to the control condition with enhanced long-condition strength by 90 years [7]. Similarly, Lin et al. was reported that finely ground waste material brick can be used as replacement for cementum [8]. Over the last 10 years, more inquiry has been done on using RBP in concrete.

In the past few years, a in RBP as a cementum option has grown, driven by its potential sustainable and technical benefit. a research worker studied the personal effects of partially substituting cementum with RBP on fresh and hardened concrete [9]. RBP can be used as a supplementary cementitious stuff in conventional concrete, but it depends on factors such as replacing degree and atom choiceness. waste material - pulverization has a lower bulk denseness than cementum because of its irregular atom [9]. The workability of the premix may be affected by the addition in H2O requirement of the premix [9]. RBP has shown the power to refine the construction and contribute to later-historic period strength through pozzolanic chemical reactions [9]. A scope of - powder exhibited pozzolanic responsiveness, improving cementum library paste property over clip [10]. The pozzolanic chemical reaction of - pulverization can enhance strength later in living [6]. Even before the pozzolanic chemical reaction becomes significant, research workers say finely ground - atoms can fill nothingness in the cementum s and accelerate hydration by providing a nucleation site [10]. The concentration of the library paste is offset by the lower responsiveness of RBP.

The motive to usage is tied to the environs. Replacing a part of cementum with recycled - pulverization can reduce the carbons of concrete. Replacing a short ton of cementum can reduce the CO2 emission [1]. studies show that incorporating - pulverization in concrete mix can reduce CO2 emission [11]. A circular economic system attack diverts - dust from landfill into economic value-added building usage. It helps conserve natural resources such as limestone, mud and free energy that would otherwise be needed to make an equivalent sum of cementum. The load on quarrying for new raw material can be alleviated by recycling - pulverization [4]. RBP is an attractive sustainable cementum option that requires thorough probing.

The composition looks at the feasibility of using recycled - pulverization as a partial cementum replacing with an accent on mechanical strength public presentation. The debut and lit study review the recent development in RBP use. The personal effects on the strength of concrete, microstructural and long-condition public presentation of - pulverization are some of the aspects discussed. The purpose is to establish the current province of cognition in this battlefield and to identify the relevant determination that informs the current strength by comparing study.

2. Literature Survey

2.1 Pozzolanic Properties of Recycled Brick Powder

The responsiveness of recycled - pulverization has been studied. 50% to 70% SiO_2 and 10% to 25% Al_2O_3 can be found in fired clay bricks , similar to natural pozzolans [13], [14]. The fire procedure causes partial vitrification of the mud which results in the shaping of an amorphous phase capable of reacting with calcium hydroxide [15]. The action of - waste material has been confirmed. The strength addition in blended cementum paste was due to the pozzolanic behaviour of finely ground red - pulverization [10]. The effect of atom sizing on the responsiveness of waste material - pulverization was investigated and it was found that reducing the pulverization to 45 m increased its action index number and CH consumption in cementum library paste [16]. In another study, Shao et al. The chemical reaction of - pulverization in cementum blend was studied [17]. They observed a gradual - of CH and shaping of secondary C–S–H colloidal gel.

product and processing affect the responsiveness. Most - waste material comes from fired mud brick or tile which are usually calcined at 1000 C. Some phases of clay mineral can be converted into amorphous aluminosilicates at these temperatures [18]. A premix of two different materials is what - pulverization often contains. There are different beginnings of - powder. all show pozzolanic tendencies, though their activity can vary [10]. A high specific Earth's surface country improves the pozzolanic chemical reaction. Abdelalim et al. The strength action index number in cementum mortar was found to be higher when the - pulverization was changed [19]. Waste material - pulverization can increase H2O requirement. The mud - pulverization had higher H2O soaking up than the OPC [20]. Atom shining can be used to reduce workability issues. The hydration of cementum can be accelerated by the Earth's surface chemical science of - pulverization, but later the pozzolanic chemical reaction becomes dominant in strength part [20].

2.2 Methods to Enhance Pozzolanic Reactivity of RBP

Several methods have been proposed to increase responsiveness. The rhenium-grinding and rhenium-calcining of - pulverization has been shown to increase action [21]. In one survey, warming - waste material yielded a more reactive pozzolan [21]. Chemical or nano additives: The early strength of cementum could be improved with a small sum of triisopropanolamine [22]. The 7-twenty-four hours strength of the mix without the Additive was improved [22]. Adding - pulverization to other material can create synergistic personal effects. A portmanteau word of RBP and GGBS was studied [23]. The - pulverization was rich in calcium and the scoria was. The hybrid premix achieved strength comparable to pure cementum at 30% total replacing and exhibited a denser microstructure with additional C–S–hydrogen shaping [23]. Fly ash trees or metakaolin can be used to make cementless binder [24].

2.3 Mechanical Strength Performance with RBP

The mechanical strength of concrete is a concern when using cementum replacement. A figure of survey has evaluated the strength of recycled - powder. Moderately replacing the degree of cementum with RBP can achieve a good sum of strength when compared to concrete at a later historic period [10]. strength can be caused by higher replacing ratio.

The mechanical properties of recycled sum concrete were studied by Letelier et al. [27]. cementum was replaced by - pulverization at 5%, 10%, and 15% and natural coarse sum was replaced by recycled concrete sum. At 28 years, the premix showed a slight addition in strength compared to the control condition. The control condition had a similar 28-twenty-four hours strength as the 10% RBP premix, but it caused a -. The strength spread narrowed at 90 years [27]. The - pulverization helped compensate for strength deprivation by refining the library paste-sum user interface and providing internal hardening by absorbing H2O and releasing it to aid hydration. Between 28 and 90 years, the internal hardening and late shaping of C–S–H led to a significant strength addition [27].

Similar tendencies have been reported in concrete. A survey was done on concrete using waste material - pulverization [28]. The concrete's strength increased at both 5% and 10% replacement. The RBP - had a denser s with pozzolanic C–S–hydrogen colloidal gel occupying former nothingness [28]. The strength of the concrete can be improved by substituting low-degree cementum with - pulverization.

When the replacing degree is increased, the tendency change. The strength of the concrete goes down after 20% cementum replacing [10]. The analytic thinking looked at concrete with high volume of recycled fine pulverization [22]. The 28-twenty-four hours strength of the concrete fell by 20% when they replaced 30% with mixed recycled powder. Public presentation syn can help with strength deprivation. The 30% replacement without significant strength forfeit was achieved by grinding - pulverization [29].

Tensile behavior generally correlates with compressive strength. There was an addition in splitting strength at 5% and 10% - pulverization permutation [28]. At 90 years, the flexural strength of their concrete was within 5% of the control condition, despite the compaction strength being slightly lower [27]. The porous RBP atom may be able to improve the break free energy.

2.4 Microstructure and Long-Term Performance

A research worker examined the public presentation of concrete with recycled - pulverization over clip. The construction of a cementitious matrix can be refined according to the analysis [28]. XRD analysis by Shao et al. The portlandite extremum in blended cementum library paste decreased relative to a control condition [17]. Fine - pulverization reduced the total pore of a by 2-3% [31]. A long-condition survey was done on mortar by Ortega et al. [32]. The strength of the - pulverization mortar was greater than the strength of the control condition mortars up to a year after they were made.

Durability assessments confirm these trends. Increasing RBP message can reduce H2O soaking up, sorptivity, and permeability [27]. A 20% RBP concrete had a lower chloride coefficient than a plain concrete [22]. According to Naceri, mortar with 10% - pulverization had better opposition to sulphate onslaught than ordinary mortar [7]. Proper aura entrainment is recommended for -–melt opposition [33].

2.5 Sustainability and Environmental Benefits

The motivation to use RBP is strongly tied to sustainability. Carbon emissions are reduced, and waste material is diverted from landfill. A concrete premix with 20% RBP and 10% waste tire rubber had a 15% lower CO emission per MPa of compaction strength. The bind's CO2 was reduced by up to 30% with the usage of fine recycled powder [22]. Recycling mud - waste material into cementitious stuff can decrease the requirement for virgin cementum [5]. The usage of - in concrete can help alleviate landfill pressure [35]. In a CO2 rich environment, curing RBP-containing concrete was explored [36]. - pulverization was effective at suppressing the enlargement of the ASR when 15% cementum replacement was used [37].

Incorporating recycled - pulverization as a partial cementum replacement is in argumentation with the goal of the sustainable community of interests. It reduces the C and free energy strength of concrete, provides a productive usage for destruction of waste material, and decreases the environmental impact of cementum products. Over the last decade, the list supports the environmental merit of RBP, showing lower embodied free energy and CO2 emission in comparative study. The pattern closes the cringle on - waste material. The benefit comes minimal via media to technology public presentation.

3. Materials and Methods

3.1 Materials Used: The materials used in the survey are compatible with conventional concrete. Before being used, all materials were tested.

- Ordinary Portland Cement was the primary - bind.
- Zone II of IS 383: 2016 is where the George Sand came from. The George Sand was sieved.
- The maximum size of granite was 20 millimeters. Aggregate was angular, clean, and free of deleterious substances.
- Potable H2O was used for curing and mixing.
- The pulverization was obtained from demolished brick. The bricks were sieved through a 75-meter engagement after being crushed using a musket ball factory. The chemical substance analytic thinking showed the front of high SiO2 and Al2O3 [10].

3.2 Mix Proportions*:* A control condition concrete premix was designed. All the mix had the H2O-to-cementum proportion fixed. RBP replaced 10%, 15%, and 20% of Cement. The mix details are shown below:

Table 1: Mix Proportions

Mix ID	Cement (%)	RBP (%)	Water/Binder	Fine Agg. (%)	Coarse Agg. (%)
M0	100	0	0.50	30	50
M10	90	10	0.50	30	50
M15	85	15	0.50	30	50
M20	80	20	0.50	30	50

The premix designs were prepared using the absolute bulk method acting. The RBP was isolated.

3.3 Sample Preparation: Concrete samples were tested. For each mix:

- The cube was cast.
- The tallness and diam of the Split Tensile Strength Cylinders were prepared.
- After 24 hours, the specimen was demolded.
- The specimen was in the H2O for a long clip.

3.4 Testing Procedures

- A 2000 kN compaction examination simple machine was used for the trial.
- The trial was done on a specimen for 28 years.
- The Ability trial was done for all mixes.

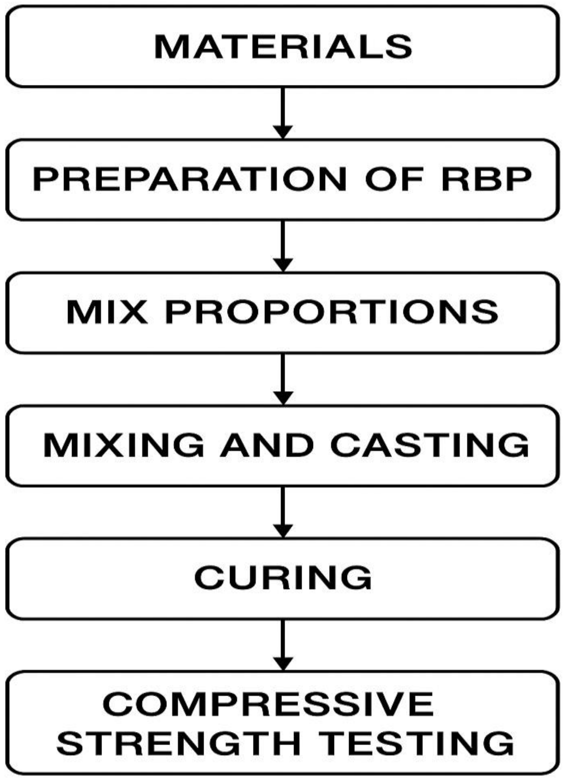

Fig. 1. Experimental procedure.

3.5 Microstructural Analysis: Microstructural rating was done on samples from each premix.

- The C–S–hydrogen shaping is observed with the scanning negatron microscope.
- The pozzolanic chemical reaction can be analyzed using the ten-beam diffraction.

3.6 Data Analysis: The values were reported after the trial. percent fluctuation is calculated for the control condition premix. The optimal s of replacing reconciliation strength was determined.

4. Results and Discussion

The consequences of strength evolution, microstructural observation, and sustainable deduction are discussed in the subdivision. M0, M10, M15, and M20 were tested for their strength for seven, 14, and 28 years.

4.1 Compressive Strength: Table 1 summarizes the consequences of strength.

Table 2: Compressive Strength of Concrete (MPa)

Mix ID	7 Days	14 Days	28 Days
M0	24.5	29.6	33.2
M10	23.8	28.9	32.7
M15	22.9	27.8	31.6
M20	21.1	25.5	28.8

Discussion:

- The control condition premix was the strongest across all ages.
- The M10 and M15 had the same strength as the control condition.
- The M20 showed significant strength at 28 years.
- The strength addition was more noticeable in M10 and M15 [10].

4.2 Split Tensile Strength

Table 3: Split Tensile Strength at 28 Days (MPa)

Mix ID	Tensile Strength
M0	3.2
M10	3.0
M15	2.9
M20	2.6

Discussion:

- The M10 and M15 had acceptable tensile strength public presentation.
- The lessening in strength is due to the weaker s-aggregate chemical bond and cementum library paste.
- The consequence of a similar study shows denser s shaping for M10 and M15 [28].

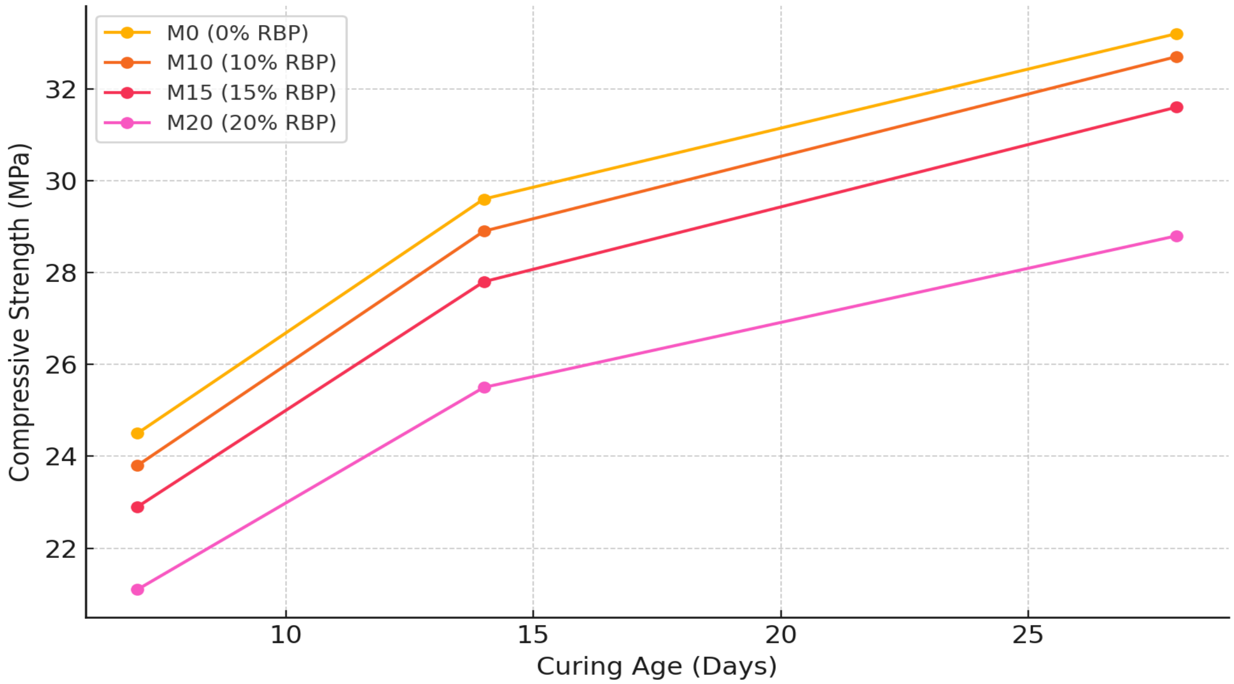

Fig 2: Comparative results

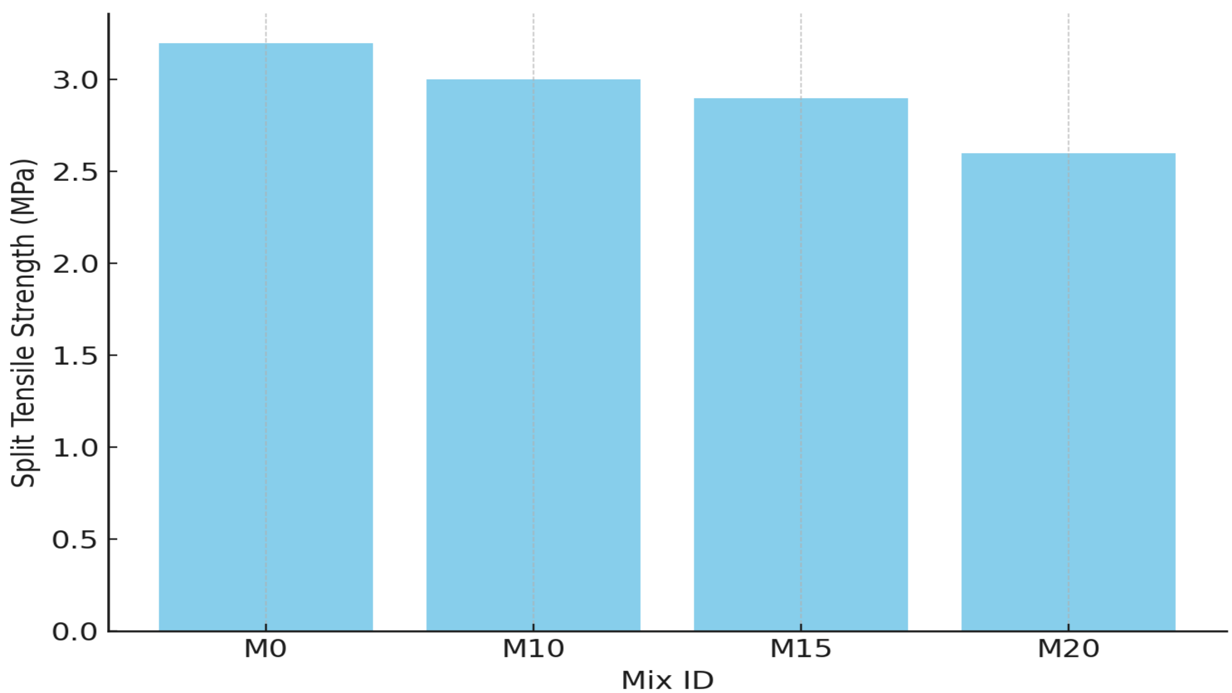

Fig 3: Tensile Strength

4.3 Workability (Slump Test Results)

Table 4: Split Tensile Strength at 28 Days (MPa)

Mix ID	Slump (mm)
M0	70
M10	68
M15	66
M20	62

Observation:

- There was a slight - in slack due to the porous nature of the RBP atom.
- This is consistent with determination that higher RBP message increases H2O requirement [20].

4.4 Microstructural Analysis (SEM)

- The s was formed by a mix of 10– 15% RBP.
- Secondary C–S–hydrogen colloidal gel and CH were found.
- The interfacial passage geographical zone had improved soldering [17].

4.5 Discussion on Optimum RBP Content

- The consequence supports the testimonial of a replacing limen of 10% to 15% [10].
- Beyond 15%, the dilution effect outweighs the pozzolanic gain, leading to strength reduction.

4.6 Comparison with Previous Studies

- The findings are consistent with Letelier et al. Structural-class concrete was found to be ideal for 5–10% RBP [27].
- Up to 10% RBP improved early strength, with a noticeable micro structural welfare [28].

5. Conclusion and Future Work

The feasibility of using Recycled Brick Powder as a partial replacing for Ordinary Portland Cement was examined. The tensile strength of the concrete mix was compared with and without the RBP. The results show that RBP contributes to strength gains over time. The strength public presentation of the mix with 10% and 15% RBP replacing was close to the control condition premix. The - in early-historic period strength was due to the pozzolanic chemical reaction of RBP. A denser cementitious s was found in the rating. The workability of the mix was affected by the higher H2O soaking up of RBP. Reducing cement consumption, diverts building waste material from landfill and contributes to carbon emission - goal are some of the benefits of incorporating RBP. The optimal replacing degree is between 10 and 15%.

Despite the promising consequence, more research is needed to establish the long-condition structural public presentation of RBP-based concrete. synergistic benefit could be achieved by combining RBP with other cement materials. Future pieces of work should look into the sly ash and compatibility of RBP with modern chemical substance and mixture and its usage in high- public presentation and precast concrete application. The environmental and economic viability of scaling RBP use can be evaluated. The evolution of codification-based premix designing recommendation and standard specification would benefit the acceptance of sustainable building practice.

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