EXPERIMENTAL STUDY OF PARTIAL REPLACEMENT OF CEMENT WITH BRICK POWDER AND FINE AGGREGTAE WITH QUARRY STONE DUST

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Abstract
The increased emphasis on life-cycle cost analysis for building projects necessitates a new focus on the service life and durability of concrete structures. Durability is the ability to withstand weathering, chemical attack, or any other deterioration process. Concrete is a competitive building material due to its great versatility and relative economy in meeting a wide range of needs. Because of the high demand for concrete in construction, carbon dioxide emissions from cement production have increased, as has the scarcity of natural river sand. As a result, there is a push to replace traditional concrete materials. Materials such as brick powder (BP) and quarry dust (QD) are chosen based on cost and durability. This project is concerned with the evaluation of changes in compressive strength in various M40 Grade concrete mixes, including conventional aggregate concrete, concrete with 10% brick powder (BP) replacement, and fine aggregates with varying percentages of 0%, 5%, 10%, 15%, 20%, and 25% Quarry Dust replacement (QD). We can conclude that concretes made from Brick Powder and Quarry Sand Dust has superior strength and durability in harsh environments when compared to conventional concrete.
Keywords: Quarry Dust, brick powder, Durability, Replacement, River sand, M40 Grade concrete

Introduction
To meet the requirements of globalization, in the construction of buildings and other structures concrete plays the major rightful role and a large quantum of concrete is being utilized. The constituent materials of concrete include cement, sand, coarse aggregate and water. For better performance and to meet the requirements additives or sometimes super plasticizers are used. Portland cement clinker production consumes large amounts of energy (850 kcal per kg of clinker) and has a considerable environmental impact. This involves massive quarrying for raw materials (limestone, clay, etc.), as it takes 1.7 tones to produce 1 ton of clinker, as well as the emission of greenhouse and other Gases (NOx, SO2, CO2) into the atmosphere. Around 850 kg of CO2 are emitted per ton of clinker produced. River sand is most commonly used fine aggregate in the production of concrete poses the problem of acute shortage in many areas. Whose continued use has started posing serious problems with respect to its availability, cost and environmental impact.

Construction and Demolition Waste in India
With Quick urbanization the quantum of construction & demolition waste (C&D Waste) is continuously increasing. While it is estimated that the construction industry in India generates about 10-12 million tons of Construction and Demolition (C&D) waste annually, efforts to manage and use this waste is very petite. This has led to Private contractors utilizing unempirical dumping methods there-by putting harsh pressure on scarce urban land as well as dropping life spans of landfills.

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Fig1: Demolished brickwork

Materials

Cement

Cement is a binder, a substance that sets and hardens on drying and also reacts with carbon dioxide in the air dependently, and can bind other materials together. Cements used in construction can be characterized as being either hydraulic or non-hydraulic, depending upon the ability of the cement to be used in the presence of water.

Water

The water used in concrete plays an important part in the mixing, laying, compaction, setting and hardening of concrete. The strength of concrete directly depends on the quantity and quality of water used in the mix.

Aggregates

Aggregates are granular materials such as sand, gravel, or crushed stone that, along with water and cement, are an essential ingredient in concrete. Aggregate was originally viewed as an inert material dispersed through the cement paste largely for economic reasons. In fact, aggregate is truly not inert and its physical, thermal and sometimes also chemical properties influence the performance of concrete. Aggregate is cheaper than cement and it is, therefore, economical to put into the mix as much as the former and as little of the latter as possible. But economy is not the only reason for using aggregate: it confers considerable technical advantages on concrete, which has a higher volume stability and better durability than hydrated cement paste alone. For a good concrete mix, aggregates need to be clean, hard, strong particles free of absorbed chemicals or coatings of clay and other fine materials that could cause the deterioration of concrete.

Brick powder

The sustainable construction concept was introduced due to the growing concern about the future of our planet because construction industry is a huge consumer of natural resources and, simultaneously, waste producer. Concrete industry, in particular, is one of the biggest natural resource consumers as a consequence of being one the most used construction materials.

Fig2: Brick powder

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Quarry Stone dust

It is obtained from the screenings left from the crushed stone. It is a byproduct in Quarry stone crusher plants. Nowadays, this is being used as fine aggregate because of the difficulty in getting natural sand. Special crushers are introduced in India for making fine aggregate from rocks. In the present work QSD from existing crushers which is a byproduct was used. Stone dust is a multipurpose material for yard construction. A compacted layer of stone dust is well suited to a yard or passageway surface. It is also a great choice for the sub-base in laying paving blocks and slabs, and for jointing natural stone, such as slate. As a stone dust surface is extremely compact and waterproof, banking must be taken into consideration during installation. Properties of Stone dust are a by-product of crushing, with a typical grain size of 0 – 3 to 4mm or 0 – 6 to 8mm. Because stone dust contains very fine mineral aggregates (grain size 0mm), it forms a hard, load-bearing surface.

Fig 3: Quarry dust

Applications of quarry dust

There are many applications of quarry dust. Discussed below are applications in construction, processing, and landscaping and recreational applications: Application of quarry dust in construction in the construction industry, quarry dust is used as an aggregate substitute especially for sand in a concrete mixture. The application of quarry dust can reduce the cost of construction. In the Centre for Housing Planning and Building built a number of low-cost houses using quarry dust. The research done for the cost of construction proved that using quarry dust is cheaper than sand.

Mix Design

Introduction

Mix design can be defined as the process of selecting the suitable ingredients of concrete and determining their relative proportions with the object of producing concrete of certain minimum strength and durability as economically as possible. The first objective is to archive the stipulated minimum strength and durability. The second objective is to make the concrete in the most economical manner. Cost wise all concretes primarily depends on two factors namely cost of the material and cost of material. Since the cost of cement is many times more than cost of other ingredients, attention is mainly directed to the use of as little cement as possible consistent with strength and durability.

Mix Design Calculations

Following are the site considerations used for the mix design for nominal concrete in our experimental work

Concrete Grade : M40
Type of Cement : OPC 53
Type of aggregate : 20mm Sub rounded
Exposure Condition : Severe
Specific Gravity of Cement : 3.15 Specific Gravity of Fine Aggregate : 2.65
Specific Gravity of Coarse Aggregate : 2.74 Zone Provision : Zone II
Workability : 100 mm (slump)

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Step 1: Calculation of Target Mean Strength

$f'_{ck} = f_{ck} + 1.65\ s$

Where s = standard deviation

f_{ck} = Characteristic compressive strength at 28 days

f'_{ck} = Target means compressive strength at 28 days

Standard deviation value for M40 grade concrete = 5.0 N/mm^2 Therefore f'_{ck} = 40 + 1.65 x 5.0

= 48.25 N/mm^2

Step 2: Selection of Water Cement Ratio

From table 2-IS 10262:2009

Maximum Water Content for 20mm aggregates = 186kg

Since Slump >50mm for every slump greater than 25mm 3% should be added Water Content = 186+6% of 186 = 197.16kg

Step 3: Calculation of Water Content

The average nominal size of aggregate taken is 20mm and the water content given in table 8for 20mm aggregate is 186 liters (this is for 50mm slump). (Our assumed slump 100mm we need to revise the water content. For 25mm slump ⟶ increase 3% water)

Water content: 186 + 3% of 186= 197.16 liter

Step 4: Calculation of Cement Content

W/C = 0.45

Cement content = 197.16/0.45 = 438.13kg

(320kg > 438.13kg <450kg: -from table 5 IS 45-2000)

Step 5: Volume of fine aggregates and coarse aggregates

Volume of Coarse aggregate = 0.59 m3 (for W/C of 0.45) Volume of Fine aggregate = 1-Coarse aggregate

= 1-0.59

= 0.32m3

Table 1: Mix Calculations

• Volume of Concrete	= 1 m^3
• Volume of Cement	$= \frac{\text{Mass of cement}}{\text{gravity of cement}} \times \frac{1\ \text{specific}}{1000}$ $= \frac{438.73}{3.15} \times \frac{1}{1000} = 0.14\ m^3$
• Volume of Water	$= \frac{\text{Mass of water}}{\text{of water}} \times \frac{1\ \text{specific gravity}}{1000}$ $= \frac{197.16}{1} \times \frac{1}{1000} = 0.197\ m^3$

• Total Volume of Aggregates	= 1-(0.135+0.191) = 0.674 m^3 (e)
• Mass of Coarse Aggregate	= Volume of all aggregates x volume of CA x specific gravity of CA x 1000 = 0.674 x 0.59 x 2.74 x 1000

	= 1073.02 kg
• Mass of Fine Aggregate	= Volume of all aggregates x volume of FA x specific gravity of FA x 1000 = 0.674 x 0.32 x 2.65 x 1000 = 734.77 kg

Quarry dust

Quarry dust is a result of crushers while doing quarrying activities. Quarry dust was obtained from nearby quarries at the Medchal. The specific gravity of quarry dust we got 2.7. Water: Clean portable water is used for mixing and curing of concrete.

Mix Proportions

M40 grade of concrete is considered. Natural sand is replaced with Quarry-dust with various percentages 0%, 5%, 10%, 15%, 20% & 25% and brick powder by 10%. The mix design for concrete is carried out as per IS 10262. Details of mix proportion for M40 concrete given below.

Mixed design proportions for Brick & Quarry dust Concrete

In this research work 15 Standard cubic specimens of size 150mm were casted for the compressive strength of concrete and it was kept under curing for 7, 14 days & 28 days of age. Total cubes for compressive strength were tested.

BP-QD	0%-0%	10%- 0%	10%- 5%	10%- 10%	10%- 15%	10%- 20%	10%- 25%
Cement (Kgs)	16.2545	14.6291	14.6291	14.6291	14.6291	14.6291	14.6291
Brick powder(kg)	0	1.6254	1.6254	1.6254	1.6254	1.6254	1.6254
water (lit)	4.94505	4.94505	4.94505	4.94505	4.94505	4.94505	4.94505
Fine aggregate (Kgs)	22.3251	22.3251	21.2089	2.09259	18.9764	17.86	16.7438
Quarry dust (kg)	0	0	1.1162	2.23251	3.3487	4.46502	5.58127
Coarse aggregate (Kgs)	43.9408	43.9408	43.9408	43.9408	43.9408	43.9408	43.9408

Table 2: Quantities of materials in cement concrete

Material	**Quantity** (kg/m^3)
Cement (grade 53)	438.73
Water	191.58
Fine aggregate	734.57
Coarse aggregate	1073.52
Water: cement	0.45

The final mix proportions are:

Cement: fine aggregate: coarse aggregate: water = 1: 1.67: 2.44: 1.67

Materials and Methodology

Materials Experimental work 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.

Materials used:

• Ordinary Portland cement (53Grade),

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- Brick powder
- Quarry dust
- Fine & Coarse Aggregates
- Water

Fineness of Cement

Observation: Total Weight of cement Sample =100 gm

Weight of cement Retained on 90micron Sieve =6 gm

Fineness Modulus of cement= $weight\ of\ cement\ retaineed\ on\ 90 microns\ sieve/$ total weight of cement sample taken = 6 /100 ∗ 100 = 6%

Specific Gravity of Cement

$$\text{Specific Gravity} = \frac{(w2-w1)}{(w2-w1)-(w3-w4)\times 0.79}$$

Where,

w1 = weight of empty pycnometer bottle = 48gms w2 = weight of pycnometer +Cement = 92gms w3 = weight of pycnometer +Cement +kerosene = 160gms w4 = weight of pycnometer + kerosene = 124gms

$$\text{Specific Gravity} = \frac{(92-48)}{(92-48)-(160-124)\times 0.79}$$

Result: Specific gravity of Cement is =2.827

Standard Consistency of Cement Paste:

Table 3: Observations for Standard Consistency of Cement

S.No	Weight of cement (gm)	Percentage by water of dry Cement (%)	Amount of water added (ml)	Penetration (mm)
1	400	25	100	30
2	400	27	108	25
3	400	29	116	14
4	400	31	124	10
5	400	33	132	6

Result1: The Standard consistency of a given sample of cement is= 33%

Initial and Final Setting Time of Cement

Observations:

1. Weight of given sample of cement is =400gms
2. The normal consistency of a given sample of cement is =33%
3. Weight of water required for preparation of mould =0.85*0.33*400 = 112.2ml

Result: Initial setting time of cement pate is =36min

Final setting time of cement paste is=440min

Results and Discussions

Table 4: Workability Test-Slump Test

Brick dust (%)	% Of Quarry dust	Slump value (cm)
0	0	22
10	0	21
10	5	20

10	10	19
10	15	19
10	20	15
10	25	14

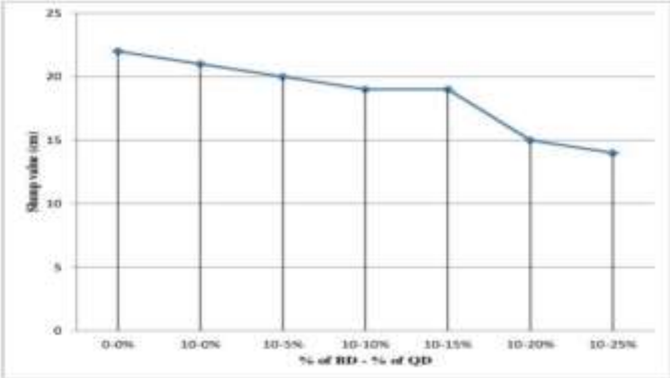

Fig4 : Slump value of concrete

Table 5: Workability Test -

S. No	BD (%)	QD (%)	compaction factor (%)
1	0	0	0.89
2	10	0	0.88
3	10	5	0.86
4	10	10	0.85
5	10	15	0.85
6	10	20	0.84
7	10	25	0.83

Compacting Factor

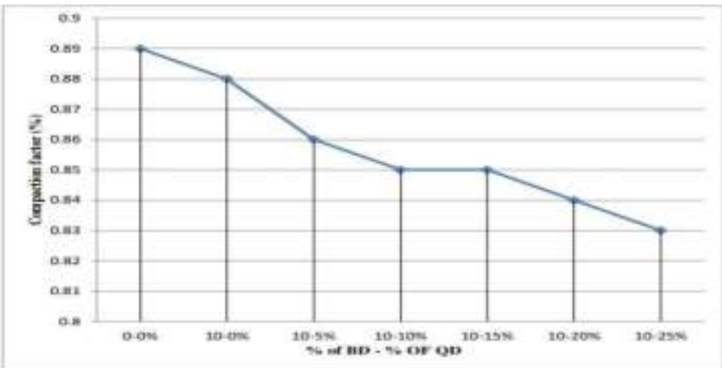

Fig 5 : Compacting factor for concrete

Table 6 : Compressive Strength Test

BD (%)	QD (%)	7days (N/mm^2)	14days (N/mm^2)	28days (N/mm^2)
0	0	26.5	28.7	48.1
10	0	27.3	38.2	49.06
10	5	28.2	40.52	50.12
10	10	30.82	43.65	53.21
10	15	25.41	37.31	51.32
10	20	23.15	33.19	48.23
10	25	20.64	29	46.29

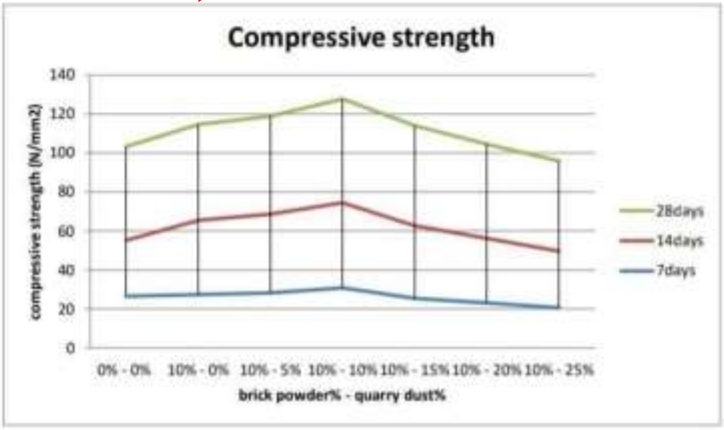

Fig 6 : Compressive strength of concrete

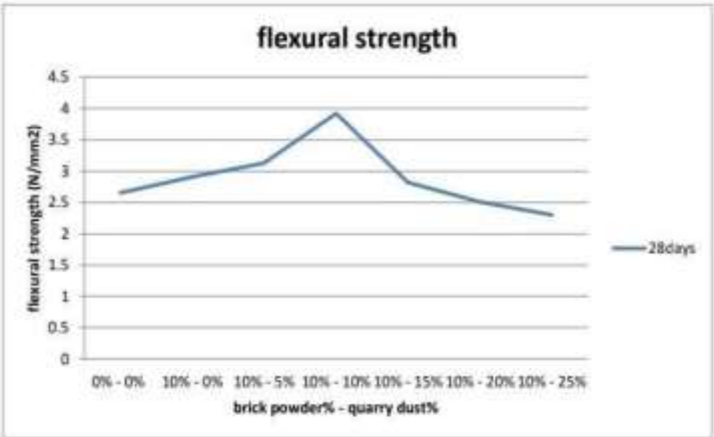

Fig 7: Flexural Strength Test

Conclusions

The current study's results and discussion show that recycled brick powder concrete has good strength under fire exposure. Because recycled brick is readily available and its use reduces environmental impact, it is advantageous to use the brick in concrete. This chapter presents the conclusions drawn from the results and discussions.

- The concrete can be successfully replaced with 10% brick powder and a portion of its weight in Quarry dust.
- The strength decreases as the percentage replacement increases after the BD (10%)-QD (10%) mix proportion (hence the current study is limited to BD (10%)-QD (10%) of replacement).
- The weight loss and residual strength of the brick powder & quarry dust concrete are more than observed more than that of normal aggregate concrete.
- There is a significant decrease in % compressive strength after BD (10%)-QD (10%) mix proportion curing at 7, 14, and 28 days.
- The % flexural strength 28 days after BD (10%)-QD (10%) mix proportion decreases significantly.
- For all types of mixes considered, an increase in strength up to a certain level is always seen for both 7, 14-, and 28-day curing o They also reduce construction costs when compared to conventional aggregate.

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