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An Experimental Study on Strength of Concrete with Partial Replacement of Fine Aggregate with Recycled Crushed Brick Aggregate and Quarry Dust

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Abstract:*This project is done to reduce the use of Natural aggregates by replacing it with Recycled Crushed Brick Aggregate (RCBA) and Quarry Dust (QD).The reduction in the sources of natural sand and the requirement for reduction in the cost of concrete production has resulted in the increased need to identify substitute material to sand in the production of concrete. Recycled Crushed Brick Aggregate is the by-product of demolished buildings waste and Quarry dust on the other hand is also a waste product in crushing process during quarrying activities. In this paper,, the fine aggregate is replaced with Recycled Crushed Brick Aggregate by 20%, 25%, 30%, 40%, 50% , Quarry Dust by 30%, 40%, 50%, 60%, 70% and the mix of RCBA and QD by 20% with 20%, 30% with 30%, 40% with 40%, 25% with 50% and 50% with 50% for 7 days and 28 days.It is seen from the results that the compressive strength was maximum at 25% for Recycled Crushed Brick Aggregate, 50% for quarry dust and 40% with 40% for combined Recycled Crushed Brick Aggregate and Quarry dust after 28 days of curing. The split tensile strength was maximum at 25% for Recycled Crushed Brick Aggregate, 60% for quarry dust and 50% with 50% for combined Recycled Crushed Brick Aggregate and Quarry dust after 28 days of curing. The flexural strength was maximum at 40% for Recycled Crushed Brick Aggregate, 50% for quarry dust and 50% with 50% for combined Recycled Crushed Brick Aggregate and Quarry dust after 28 days of curing. This project tries to encourage the use of waste materials instead of natural aggregates in the concrete and obtaining the same strength as that of the plain concrete. Hence, conserving the environment and economy.*

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I. Introduction

Bricks are one of the oldest and most traditional construction materials that are trusted by most of the people. Since brick is made of natural materials, which from the viewpoint of ecology, meet modern standards of sustainability. Clay based material is one of the materials that has been widely used in construction materials instead of wood, sand, concrete and other waste materials. This material is a major compound in clay brick, clay tiles and clay roofing tiles due to its wide-ranging properties, high resistance to atmospheric condition, geochemical purity and easy access to its deposits near the earth's surface and low price. Fired clay brick (FCB) can be categorized as one of the demolition wastes as most of the unwanted FCB from buildings or houses renovation are being illegally disposed off in most places. Since they are so common and used in large abundance, they often make up a large percentage of construction waste produced by demolition and re-modelling projects. The utilization of this type of clay based waste materials would replace the natural aggregates in concrete mixture. [1]

Quarry dust is a by-product of the crushing process which is a concentrated material to use as aggregates for concreting purpose, especially as fine aggregates. In quarrying activities, the rock has been crushed into various sizes, during the process the dust generated is called quarry dust and it is formed as waste. So it becomes as a useless material and also results in air pollution. Therefore, quarry dust should be used in construction works, which will reduce the cost of construction and the construction material would be saved and the natural resources can be used properly. Most of the developing countries are under pressure to replace fine aggregate in concrete by an alternate material also to some extent or totally without compromising the quality of concrete. Quarry dust has been used for different activities in the construction industry such as building materials, road development materials, aggregates, bricks and tiles. [2]

1.2 Problem Being Addressed

Concrete is the most important building material used in the construction industry globally. Concrete production has become expensive over the years due to increased demand of construction. This has led to an increase in the rates of the materials used to make concrete i.e. aggregates and cement. Furthermore, production of common granitic aggregates and building stones (rough and machine cut stones) by quarrying is very expensive economically. Quarrying creates an unfriendly environment by leaving land excavated and rocks blasted which can lead to subsidence and in some cases earth tremors due to disturbance of the rock strata.

So keeping in mind the disadvantages of the using natural aggregates, the problem here is to reduce the use of natural aggregates in the construction and to find the alternatives.

1.3 Solutions to the Problem

- The alternative way of decreasing the use of natural aggregate is by its replacement with any other material which will not be harmful to the environment as well as which will be cheaper than natural aggregate and that material should possess similar properties and characteristics as that of natural aggregate.
- So in our project, we are using Recycled Crushed Brick Aggregate (RCBA) which is a waste product of construction and demolition activities and Quarry Dust (QD) which is a by-product of the quarrying activities. Since RCBA and QD are the waste products, cheaper in price and possess properties similar to that of natural aggregate, this will help in lowering the cost of construction of housing units (low cost housing) for human dwelling.
- Also from environmental point of view, recycling of these wastes would help in the protection of environment i.e. exploitation of normal granitic aggregates through quarrying would be significantly reduced.

II. Material And Methods

2.1 Cement

Ordinary Portland Cement 43 grade confirming to IS: 8112 was used. Different tests are conducted on cement to know the physical properties of cement such as Specific Gravity of Cement, initial setting of Cement and also final setting of cement.

Table-1 Physical properties of 43 grade cement

Sl. No.	Characteristics	Values
1	Specific Gravity	3.12
2	Initial setting time	35 min.
3	Final setting time	6hrs 45 min

2.2 Aggregates

The maximum size of coarse aggregate used in this investigation is 20mm and the specific gravity of CA is 2.76. River Sand is used as a fine aggregate throughout the investigation was zone II and the specific gravity is 2.62.

2.3 Recycled crushed brick aggregates

Recycled Crushed Brick Aggregate are the by-product of demolition waste. They are inert granular materials with most particles passing through a 4.75 mm sieve.Recycled Crushed Brick Aggregate confirming to Zone II with specific gravity 2.35 is used. The testing of Recycled Crushed Brick Aggregate was done as per IS: 383-1970.

Fig. 1 Recycled Crushed Brick Aggregate

2.4 Quarry Dust

Quarry dust is the waste product of quarrying processing.Quarry Dust confirming to Zone II with specific gravity 2.5 is taken. The testing of QD was done as per IS383-1970.

Fig. 2 Quarry Dust

2.5 Mix proportion

Concrete mix design in made as per IS 10262-2009 for M20 grade of Concrete with water/cement ratio 0.46. OPC 43 grade cement was used in the experiment. According to the mix design calculation cement, aggregates and water content was calculated for kg/m^3.

Table 2 Mix proportion for M20 Concrete

Material	Mix proportion	By weight in kg/m^3
Cement	1	447.72
Fine aggregate	1.42	636.34
Coarse aggregate	2.49	1117.88
water	0.44	197

2.6 Specimen preparation

16 mixes were prepared as per IS 516-1959. For compressive strength test cubes of dimension 150x150x150 mm were used. To find split tensile strength cylinders of dimension 150x300mm were used. Prisms of dimension 100x100x500mm were used to find the flexural strength of concrete. All the specimens are tested after 28 days curing.

III. Results

3.1 Slump test results of concrete mix

3.1.1 Slump test results using Recycled Crushed Brick Aggregate

Percentage replacement of fine aggregate by Recycled Crushed Brick Aggregate	Slump value (mm)
0 %	93
20 %	89
25 %	86
30 %	84
40 %	81
50 %	77

3.1.2 Slump test results using Quarry Dust

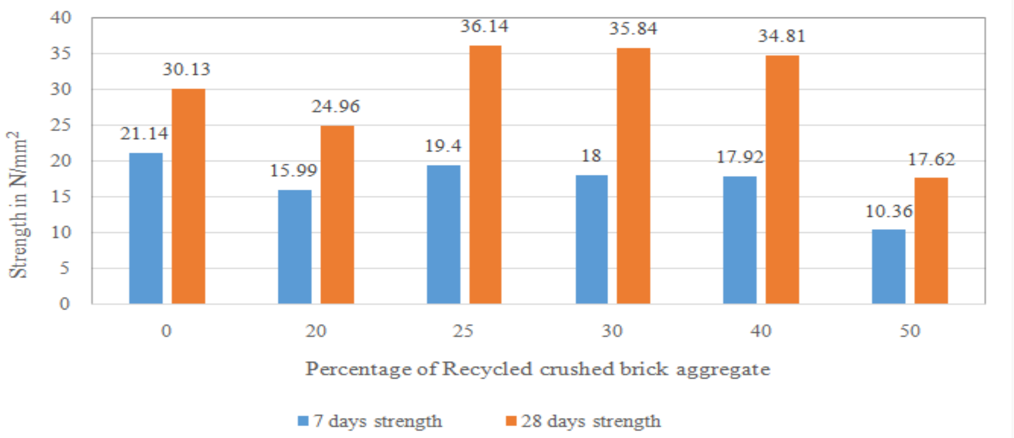
Percentage replacement of fine aggregate by Quarry Dust	Slump value (mm)
30 %	87
40 %	86
50 %	84
60 %	84
70 %	80

3.1.3 Slump test results using Recycled Crushed Brick Aggregate and Quarry Dust

Percentage replacement of fine aggregate by Recycled Crushed Brick Aggregate + Quarry Dust	Slump value (mm)
20 % + 20 %	84
30 % + 30 %	81
40 % + 40 %	76
25 % + 50 %	73
50 % + 50 %	68

3.2 Compressive strength of Concrete Cubes using Recycled Crushed Brick Aggregate

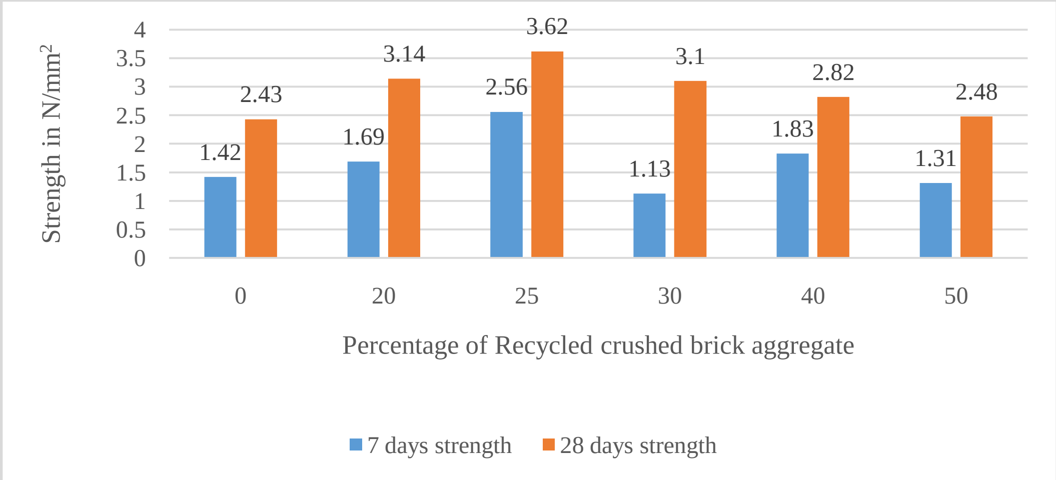
Sl. No.	% of Recycled Crushed Brick Aggregate	Avg. compressive strength at 7 days (N/mm^2)	Avg. compressive strength at 28 days (N/mm^2)
1	0	21.14	30.13
2	20	15.99	24.96
3	25	19.40	36.14
4	30	18.00	35.84
5	40	17.92	34.81
6	50	10.36	17.62



Graph 1 - Compressive strength of RCBA Concrete cubes

3.3 Split tensile strength of Concrete Cylinder using Recycled Crushed Brick Aggregate

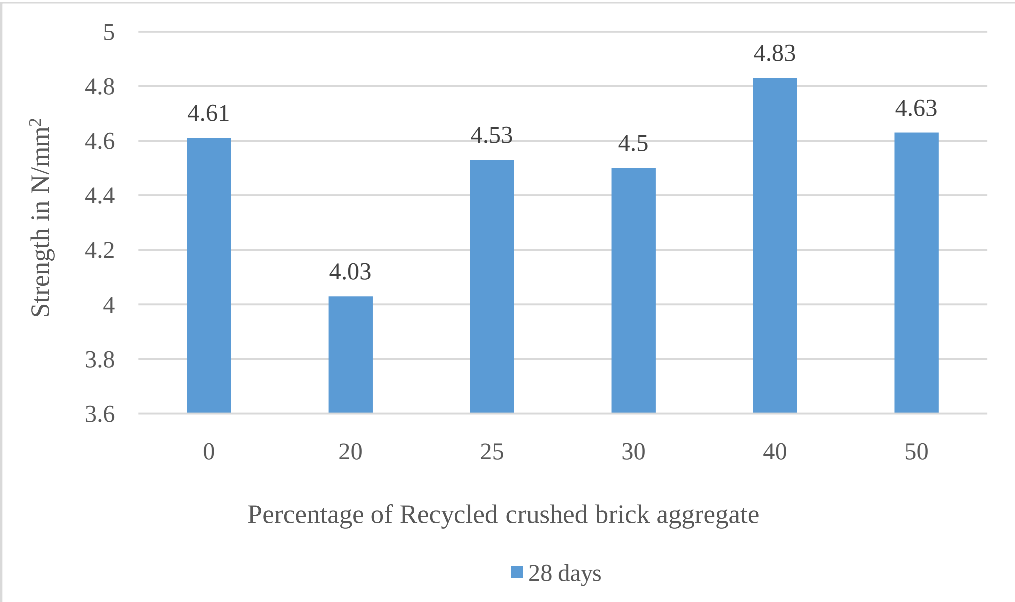
Sl. No.	% of Recycled Crushed Brick Aggregate	Avg. split tensile strength at 7 days (N/mm^2)	Avg. split tensile strength at 28 days (N/mm^2)
1	0	1.42	2.43
2	20	1.69	3.14
3	25	2.56	3.62
4	30	1.13	3.10
5	40	1.83	2.82
6	50	1.31	2.48



Graph 2 - Avg. Split tensile strength of RCBA Concrete Cylinder

3.4 Flexural strength of Concrete Prisms using Recycled Crushed Brick Aggregate

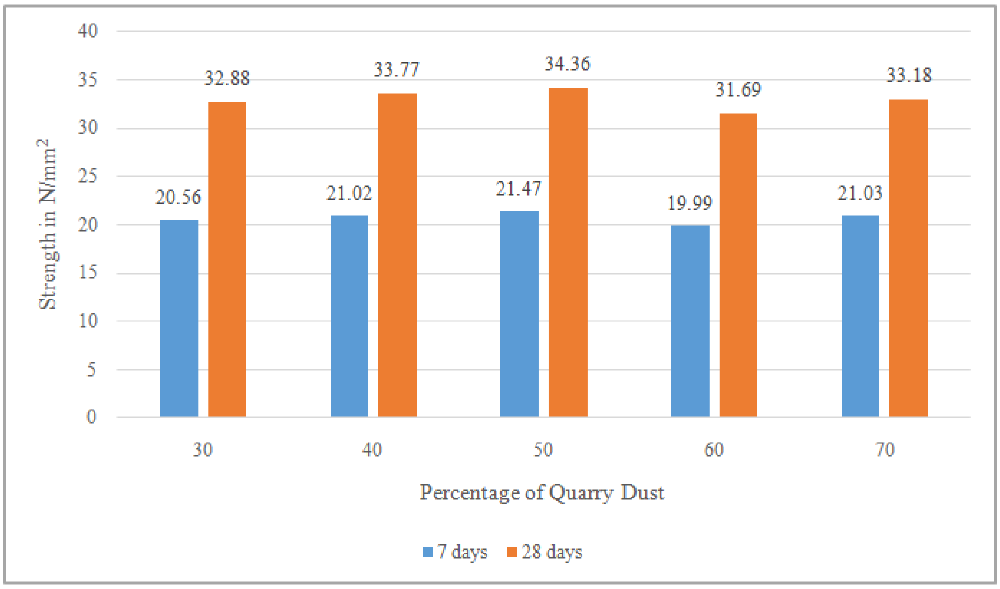
Sl. No.	% of Recycled Crushed Brick Aggregate	Avg. Flexural strength at 28 days (N/mm^2)
1	0	4.61
2	20	4.03
3	25	4.53
4	30	4.50
5	40	4.83
6	50	4.63



Graph 3 - Flexural strength of RCBA Concrete prisms

3.5 Compressive strength of Concrete Cubes using Quarry Dust

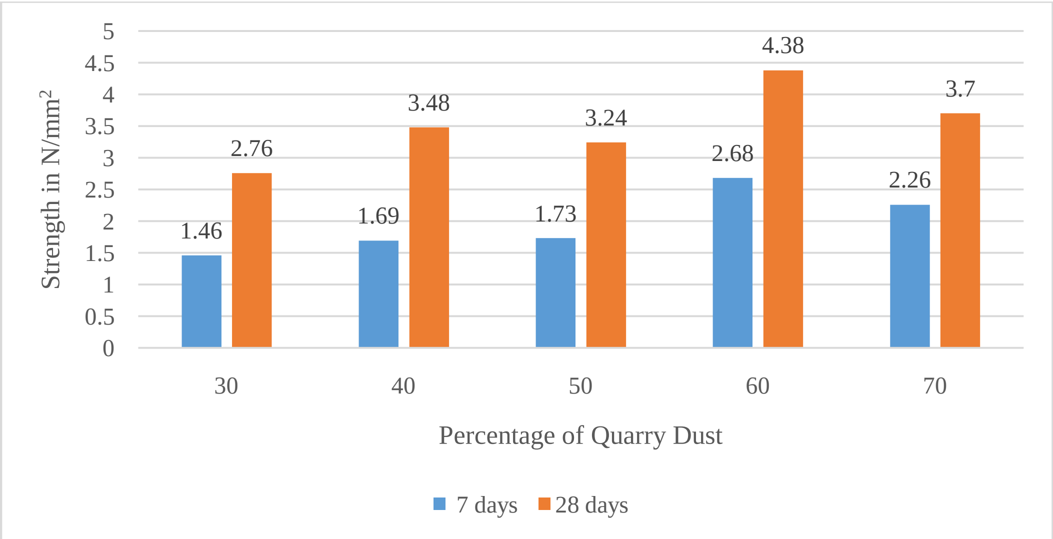
Sl. No.	% of Quarry Dust	Avg. compressive strength at 7 days (N/mm^2)	Avg. compressive strength at 28 days (N/mm^2)
1	30	20.56	32.88
2	40	21.02	33.77
3	50	21.47	34.36
4	60	19.99	31.69
5	70	21.03	33.18



Graph 4 - Compressive strength of QD Concrete cubes

3.6 Split tensile strength of Concrete Cylinder using Quarry Dust

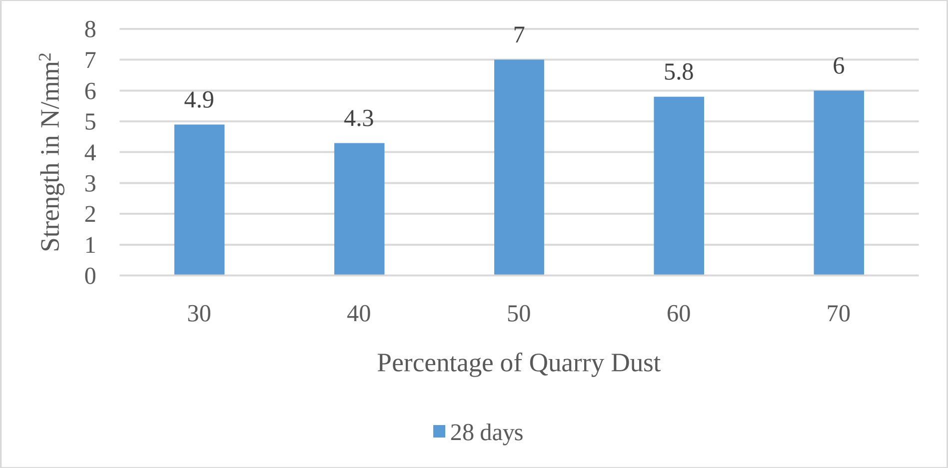
Sl. No.	% of Quarry Dust	Avg. split tensile strength at 7 days (N/mm^2)	Avg. split tensile strength at 28 days (N/mm^2)
1	30	1.46	2.76
2	40	1.69	3.48
3	50	1.73	3.24
4	60	2.68	4.38
5	70	2.26	3.70



Graph 5 - Split tensile strength of Quarry dust Concrete cylinder

1.7 Flexural strength of Concrete Prisms using Quarry Dust

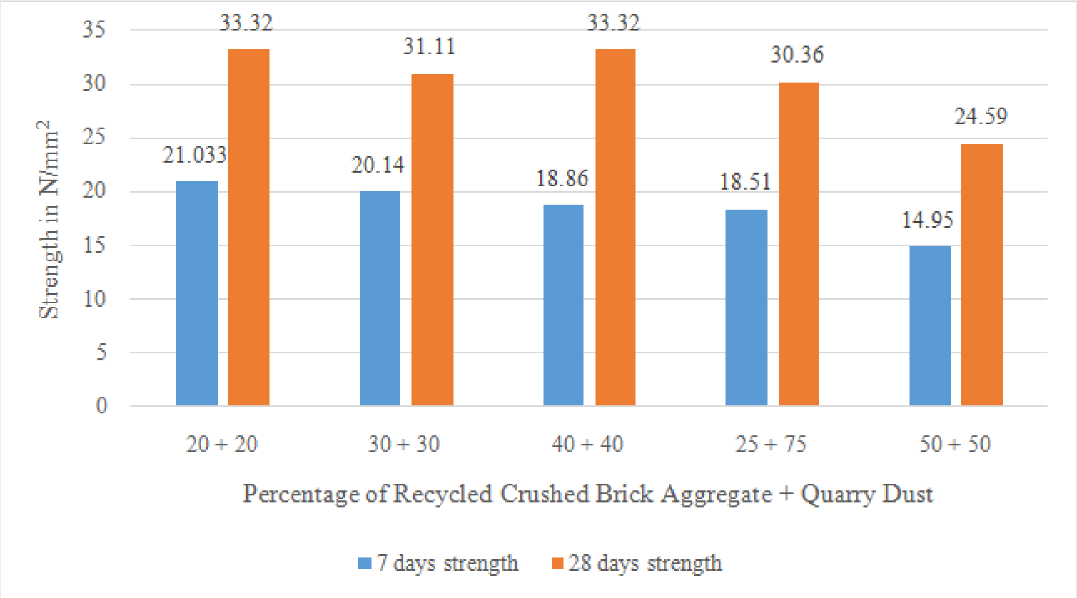
Sl. No.	% of Quarry Dust	Avg. Flexural strength at 28 days (N/mm^2)
1	30	4.9
2	40	4.3
3	50	7.0
4	60	5.8
5	70	6.0



Graph 6 - Flexural strength of QD Concrete prisms

1.8 Compressive strength of Concrete Cubes using Recycled Crushed Brick Aggregate and Quarry Dust

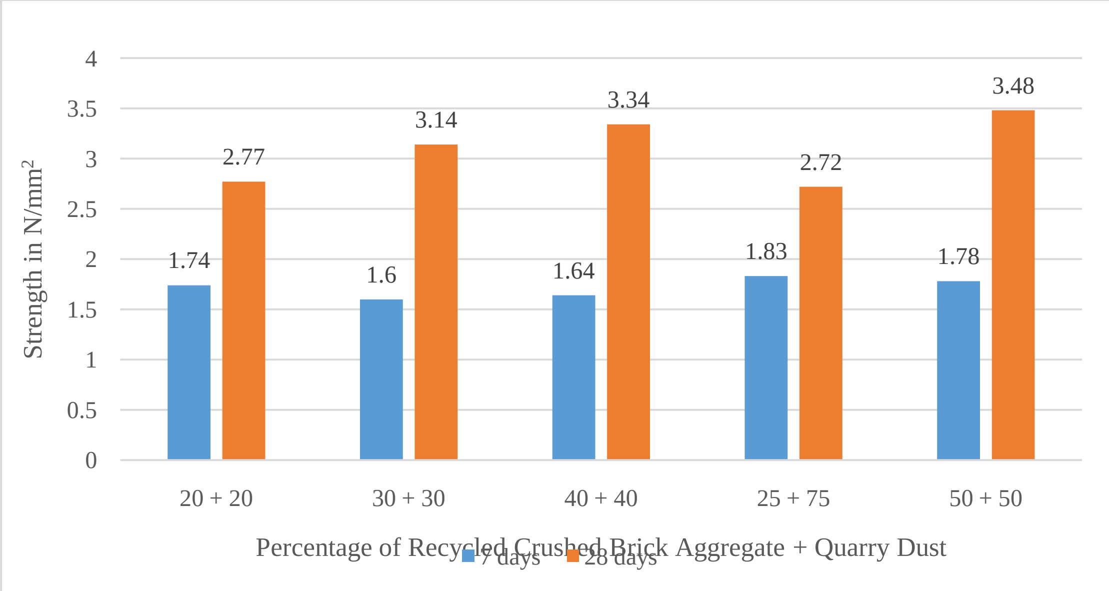
Sl. No.	% of RCBA + % of QD	Avg. compressivestrength at 7 days (N/mm^2)	Avg. compressivestrength at 28 days (N/mm^2)
1	20 + 20	21.03	33.32
2	30 + 30	20.14	31.11
3	40 + 40	18.86	33.32
4	25 + 50	18.51	30.36
5	50 + 50	14.95	24.59



Graph 7 - Compressive strength of RCBA with QD Concrete cubes

1.9 Split tensile strength of Concrete Cylinder using Recycled Crushed Brick Aggregate and Quarry Dust

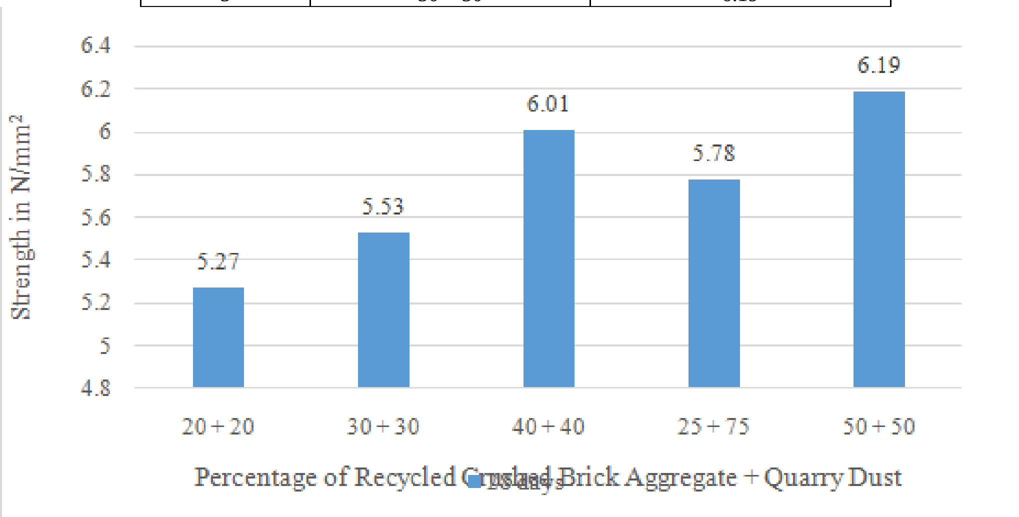
Sl. No.	% of RCBA + % of QD	Avg. split tensile strength at 7 days (N/mm^2)	Avg. split tensile strength at 28 days (N/mm^2)
1	20 + 20	1.74	2.77
2	30 + 30	1.60	3.14
3	40 + 40	1.64	3.34
4	25 + 50	1.83	2.72
5	50 + 50	1.78	3.48



Graph 8 - Split tensile strength of RCBA and QD Concrete cylinder

1.10 Flexural strength of Concrete Prisms using Recycled Crushed Brick Aggregate and Quarry Dust

Sl. No.	% of RCBA + % of QD	Avg. Flexural strength at 28 days (N/mm^2)
1	20 + 20	5.27
2	30 + 30	5.53
3	40 + 40	6.01
4	25 + 50	5.78
5	50 + 50	6.19



Graph 9 - Flexural strength of RCBA and QD Concrete prisms

IV. Conclusions

- Usage of Recycled Crushed Brick Aggregate from 25 % to 40% replacement of natural aggregate will give the same compressive, tensile and flexural strength as that of the plain concrete.
- Recycled Crushed Brick Aggregate reduces workability and increase water demand to maintain the same workability of concrete.
- Replacement of natural aggregate by Quarry Dust up to 70% shows the increase in the compressive, tensile and flexural strength of concrete.
- Quarry Dust concrete also absorbs more water than plain concrete and feels difficulty in mixing.
- The concrete with Recycled Crushed Brick Aggregate and Quarry Dust mix showed desired results up to 75% replacement of the fine aggregate in all the three parameters.

- As per the results, it is showed that concrete can be made by replacing up to 75 % of natural aggregate with Recycled Crushed Brick Aggregate and Quarry Dust.
- This is profitable in terms of economy as Recycled Crushed Brick Aggregate and Quarry Dust are waste products and are much cheaper than the natural aggregate.
- It is better to use this aggregates than exploiting the river beds for natural aggregate. So, it is beneficial even in environmental view point

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