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An Experimental Study for Cost Reduction of Concrete

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ABSTRACT

In developing countries where concrete is widely used, the high and steadily increasing cost of concrete has made construction very expensive. This project is experimented to reduce the cost of concrete. Specific gravity tests are carried out for fine and coarse aggregate. The coarse aggregate is replaced with 10%, 20%, and 30% by recycled crushed aggregate. The design mix used to execute this project is M40 grade concrete. This M40 grade concrete is designed as per Indian Standard Code for both the normal concrete and recycled brick waste concrete. The water cement ratio is maintained for this mix design is 0.5. Preliminary tests comprising sieve analysis, specific gravity, consistency, setting time, water absorption test were conducted. The rate of water absorption for the recycled brick waste aggregate was 21.35% as observed. workability and strength test were also carried out on fresh and hardened concrete made from the study material. The strength properties obtained from recycled brick waste concrete is compared with the normal concrete. The compressive strength and split tensile strength results are gradually decreases upto 20% recycled brick waste aggregate by replacement of coarse aggregate. To increase the strength properties by addition of crimped steel fibers at 20% recycled brick waste concrete with 1% and 2% by the volume of concrete. While increasing the percentage of recycled brick waste aggregate and steel fibers, it was observed that the workability of the concrete decreases. After addition of steel fibers the compressive, split tensile and flexure strength results are gradually increases. By using recycled brick waste aggregates, weight of concrete can also be reduced, which can also solve problems related to self-weight of concrete.

I. INTRODUCTION

Concrete is the most widely used man-made construction material. Cement and aggregate, which are the most important constituents used in concreteproduction, are the vital materials needed for the construction industry. Aggregates impart higher volume stability and better durability than hydrated cement paste in concrete and provide around 75 per cent of the body of concrete.The aggregates are usually derived from natural sources.This inevitably has led to acontinuous and increasing demand of natural materials used for their production. Parallel to the needfor the utilization of the natural resources emerges a growing concern for protecting the environmentand a need to preserve natural resources, such as aggregate, by using alternative materials that areeither recycled or discarded as a waste.Over the past several decades, steel fiber reinforced concretehas been used in many applications such as concrete pavements,overlays, patching repair of hydraulic structures, thin shells andprecast products. Nowadays, it is well established that theincorporation of steel fibers improves engineering performanceof structural and non-structural concrete, including better crackresistance, increase in ductility and toughness as well as enhancement in resistance to fatigue and impact.A higher content of fibres during mixing increases the interactionof fibres with aggregates, which in turn causes the effect ofballing and affects negatively the workability of the concrete mixture.The workability and the compaction method affect the movementof fibres during the casting of specimens; a too highworkability allows for a better orientation of the fibres. Specimensize indirectly affects the orientation of fibres since the lattersare forced to align along moulded surfaces.

So far a few numbers of researches on the performance of crushed clay-brick as coarse aggregate in making concrete has been reported in the literature. And the reports show that the use of crushed normal strength brick instead of stone aggregate results a reduction in strength and stiffness of the concrete. However, the use of mixed aggregate (a combination of brick aggregate and stone aggregate) may improve the strength and stiffness of concrete in comparison with those of purely brick aggregate concrete.

II. MATERIAL AND MIX DESIGN

2.1 MATERIALS

In this project materials like cement, river sand, Coarse Aggregates (CA), Brick Aggregates(BA), water and steel fibers are used in this study. The description of each of the material is described in the following sections. The materials used in this study are tested to obtain their properties as per the relevant IS codes.

2.1.1 CEMENT

Ordinary Portland Cement (OPC) is the cement best suited to general concreting purposes. OPC 53 grade confirming with IS12269: 1987 was used in this study. The cement is kept in an airtight container and stored in the humidity controlled room to prevent cement from being exposed to moisture. The physical properties of cement are shown in below.

2.1.2 SAND

Those fractions from 150micron to 4.75mm are termed as fine aggregate. The sand used in this research for preparation of normal concrete is natural river sand conforming to grading zone-lllas per **IS 383:1970** with specific gravity 2.62.

2.1.3 COARSE AGGREGATE (CA)

Crushed granite coarse aggregate conforming to **IS 383:1970** of size between 12.5mm to 20mm having a specific gravity of 2.7 was used. The loose and compacted bulk density values of coarse aggregate were 1483kg/m3 and 1680kg/m3 respectively for different grades of concrete.

2.1.4BRICK AGGREGATE (BA)

Demolished bricks were crushed to 20mm nominal size aggregates as per **IS 383:1970**. The demolished bricks are breaked by using hammer. After breaking the bricks,they are crushed mechanically with jaw crusher and produce flaky and elongated aggregate. Then the brick aggregates are sieved by using IS 12.5mm and 20mm sieves.

III. TESTS

3.1 TESTS ON MATERIALS:

3.1.1 SPECIFIC GRAVITY:

- Specific gravity (G) is the ratio of the weight of soil solids at a given temperature to the Weight of an equal volume of distilled water at that temperature, both weights being taken in air.
- Pycnometer, balance, weight box, oven, desiccator, desired distilled water, vaccum source, and thermometer equipment’s are used.
- Pycnometer is a glass jar to which a brass conical cap is screwed with a rubber washer. A 6 mm dia. hole is provided in the brass cap.
- Weigh the clean and dry pycnometer with its cap.
- Fill the pycnometer one-third full with oven dried soil taken directly from desiccator and determine its weight after screwing the cap.
- Add desired distilled water to pycnometer after removing the cap, until the pycnometer is half full and stir it with a glass rod, (to assist in removal of air) and screw the brass cap.
- Add desired distilled water till the pycnometer is full.
- Remove remaining air by shaking after closing the screw top with one finger. Clean the outer surface of pycnometer and then determine its weight.
- Empty the contents of pycnometer and thoroughly wash it.
- Fill the pycnometer with distilled water till the surface of water is flush with the hole in the screw cap. Then weigh the pycnometer.
- Note the temperature of water.

CALCULATION & TABULATION

Weight of Pycnometer = W1

Weight of Pycnometer + oven dried soil = W2

Weight of Pycnometer + oven dried soil+ remaining space completely filled with water without any air = W3

Weight of Pycnometer + full of water = W4

Weight of oven dried soil = W2-WI

Weight of water filling the Pycnometer = W4-W1

Weight of water in Pycnometer over and above the dry soil = W3-W2

Weight of Water having the same volume of dry soil= (W4-W1) - (W3-W2)

specific gravity of soil grains at temperature T°C

= Weight of ovendried soil weigh / Weight of water equal to the volume of ovendriedsoil

= W2 – W / (W4- W1) – (W3 – W2)

G27 * specific gravity of water at 27°C = Gt * Specific gravity of water at room temperature,t

Where G27 & Gt are specific gravity of soil at 27°C and at room temperature,t

Gt = GL (W2 – W1) / (W4 – W1) – (W3 – W2)

Where, GL = specific gravity of liquid at that temperature.

Table 1: Specific gravity of Materials

S.No.	Description	Represent	CA	FA	BA
1.	Weight of pycnometer	W1	520gms	520gms	520gms
2.	Weight of pycnometer + oven dried soil	W2	917gms	930gms	785gms
3.	Weight of pycnometer + Soil + Water	W3	1660gms	1666gms	1560gms
4.	Weight of pycnometer + full of water	W4	1410gms	1410gms	1410gms
5.	Weight of soil	W2-W1	397gms	410gms	265gms
6.	Weight of water filling the pycnometer	W4-W1	890gms	890gms	890gms
7.	Weight of water above soil	W3-W2	743gms	736gms	775gms
8.	Specific gravity	G	2.7	2.6	2.3

3.1.2 WATER ABSORPTION:

- Absorption capacity is a measure of the porosity it is also used as a correlation factor in determination of free moisture by oven-drying method.
- The absorption capacity is determined by finding the weight of surface-dry sample after it has been soaked for 24 hr and again finding the weight after the sample has been dried in an oven. The difference in weight, expressed as a percentage of the dry sample weight, is the absorption capacity.
- Weight balance, container of waterare used.
- 500g of brick aggregates and taken it as W1.
- Then take a container and filled full with distilled water.
- Then the brick aggregates are immersed in water without any air voids.

- After 24hours the brick aggregates are take it on cloth and then weighed. Take it was W2grams.
- The absorption capacity of bricks can be calculate using the formula(W2/W1)*100

Calculation:

W1 =

W2 =

Water absorption = 21.35%

3.2 TESTS ON FRESH CONCRETE:

3.2.1FRESH CONCRETE:

Fresh concrete is that stage of concrete in which concrete can be moulded and it is in plastic state. This is called “GREEN CONCRETE”. Another term used to describe the state of fresh concrete is consistence, which is the ease with which concrete will flow.

Properties of fresh concrete:

Following are the important properties of fresh concrete

1. Setting
2. Workability
3. Bleeding
4. Segregation
5. Hydration
6. Air entrainment

3.2.2WORKBILITY BY SLUMP CONE TEST

Unsupported concrete, when it is FRESH, will flow to the sides and a sinking in height will take place. This vertical settlement is known as SLUMP. Slump is measure indicating the consistency or workability of cement concrete. It gives an idea of water content needed fir concrete to be used for different works. A concrete is said to be workable if it can be easily mixed and easily placed, compacted and finished. A workable concrete should not show any segregation or bleeding. Slum p increases as water-cement ratio increases.

Slump test is the most commonly used method of measuring consistency of concrete which can be employed either in laboratory or in site of work. It is not a suitable method for very wet or very dry concrete. It does not measure all factor contributing to workability, nor it is always representation of the place-ability of concrete.However, it is used conveniently as a control test and given an indication of the uniformly of concrete from batch to batch. Repeated batches of the same mix, brought to the same slump, will have the same water content and w/c ratio, provided the weights of aggregates, cement and admixtures are uniform and aggregate grading is within acceptable limits.

EQUIPMENTS: Slump cone, tray for mixing concrete, trowel, tamping rod, steel rule,measuring jar, weighing platform machine, spatula. The apparatus for conducting the slump test essentially consists of metallic mould in the form of a frustum of a cone having the dimensions as under:

Bottom diameter = 20cm

Top diameter = 10 cm

Height = 30 cm

The thickness of the metallic sheet for the mould should not be thinner than 1.6mm. For tamping the concrete, a steely tamping rod 16mm diameter; 0.6m long with bullet end is used.

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3.3 IDENTIFICATION OF SPECIMENS:

Immediately after making the specimen they should be marked clearly. This can be done by writing the details of the specimens with nail on a concrete top surface in fresh mix state.

3.4 DEMOULDING:

Test specimen should be demoulded between 16 to 24hours after they have been made. If after this period of time the concrete has not achieved sufficient strength to enable demoulding without damage the specimens then the demoulding should be delayed for a further 24hours. When removing the concrete specimens from the mould, take the mould apart completely. Take care not to damage the specimens because, if any cracking is caused, the strength may reduce.

3.5 CURING OF SPECIMEN:

Curing is the process of preventing the loss of moisture from the concrete and maintaining a satisfactory temperature regime. More elaborately, curing is defined as the process of maintaining satisfactory moisture content and a favourable temperature in concrete during the period immediately following placement, so that hydration of cement may continue until the desired properties are developed to sufficient degree to meet the requirement at service.

After casting, the moulded specimens are stored in the laboratory free from vibration, in moist air (at 90% relative humidity) and at a room temperature for 24 hours from the time at addition of water to the dry ingredients. After this period, the specimens are removed from the moulds, immediately submerged in clean fresh water tank. The water in which specimens are submerged, are renewed every seven days and maintain at temperature of 27°C ± 2°C. The specimens are cured for 7 and 28 days in the present work.

3.6TESTS ON HARDENED CONCRETE

3.6.1 Preparation of test specimens

After applying oil to the moulds, as per the design mix concrete was prepared. After studying flow properties, concrete was poured into the moulds without compaction. After keeping 24 hours at room temperature, the specimens are removed from the moulds and immediately submerged in clean, fresh water for curing. The specimens are cured for 28 days and then tested.

IV. TEST RESULTS

4.1 Compression Test Results: (in Mpa)

Table 2: Compression values for replaced aggregate mix

	B00	**B10**	**B20**	**B30**
7days	30.66	30.21	29.77	23.66
28days	48.88	41.104	36.0	30.88

By the replacement of bricks aggregates the strength will be reduced. So, for the strength improvement steel fibers are added to the concrete mix and the compression results are given in Table 3.

Table 3: Compression values for addition of fibers

	B20	**B21**	**B22**
7days	29.77	31.21	35.22
28days	36.0	38.44	41.11

4.2 Flexural Test Results: (in Mpa)

Table 4: Flexural values for replaced aggregate mix

	B00	**B10**	**B20**	**B30**
28days	5.15	5.13	5.02	3.324

Table 5: Flexural values for addition of fibers

	B20	**B21**	**B22**
28days	5.02	5.12	5.23

4.3 Split Test Results: (in Mpa)

Table 6: Split values for replaced aggregate mix

	B00	**B10**	**B20**	**B30**
28days	3.16	3.11	2.99	2.77

Table 7: Split values for addition of fibers

	B20	**B21**	**B22**
28days	2.99	3.15	3.25

VI. CONCLUSIONS

- As percentage of brick waste increases the compressive strength decreases gradually upto 20% brick waste beyond that compressive strength decreases drastically.
- A 26.3% reduction in compressive strength of concrete is observed due to the use of 20%brick aggregate instead of stone aggregate for the strength range of concrete studied.
- The reduction in split tensile strength of mixed aggregate concrete is found to be less significant up to 20% replacement of stone aggregate by brick aggregate.
- By increasing the percentage of brick aggregate, the flexure strength was gradually decreases upto B_{20} mix and then suddenly decreases.
- The rate of water absorption of crushed brick aggregate was found to be 21.35%
- There is a marginal increase in split tensile strength as %of fibers increased in the mix up to 2% with an addition of steel fibers at B_{20} mix
- Modulus of rupture decreases with increase in fiber percentage upto 2% with an addition of steel fibers at B_{20} mix
- In addition of steel fibers at B_{20} mix, the compressive strength increases with an increase of fibers of 1%, 2% at B_{20} mix.
- In this study solves environmental threats caused by waste clay bricks, introduction of an alternative source to aggregates in concrete that leads to conservation of natural aggregates.
- The workability of the mixed aggregate concrete is lower than that of normal concrete.

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