

EXPERIMENTAL EXPLORATION ON CRUSHED BRICKS CONSIDERING PARTIAL ALTERNATE AS COARSE AGGREGATE FOR CONCRETE

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Abstract: Coarse aggregate can be defined as inert granular materials such as gravel, crushed stone and sand. Coarse aggregate is one of the essential ingredients apart from water and cement in concrete production. The only variable considered in this study was the replacement considering (0%, 10%, 20%, and 30%) of natural stone aggregate of brick aggregate by weight. The use of brick aggregate as a partial replacement of stone aggregate in concrete mortar resulted reductions in unit weight and in compressive strength of concrete. Different relations for determination of compressive strength, strength of mix-aggregate concrete have been tentatively proposed. We can use brick aggregate as coarse aggregate wherever load coming chances are less. A total of 12 numbers of concrete specimens were casted with and without crushed bricks. Test results indicated that using crushed bricks reduces the strength of concrete. Also, the percentage of water to cement ratio increases for constant slump when the percentage of crushed bricks increased.

IndexTerms–Coarse aggregate, brick aggregate, Compressive Strength, concrete.

I. INTRODUCTION

Concrete is produced by mixing cement, water, fine and coarse aggregates as main constituents to produce a material that can be moulded into almost any desired shape. The maximum volume of concrete is filled with coarse aggregate. Aggregate inclusion in concrete reduces its drying shrinkage and improves many other properties. Aggregate takes the most amount of the weight of concrete. But it is costly to transport, so local sources are needed to reduce the cost of transport but due to geographical constraint it is not available at all places, therefore it necessitates finding other sources and alternatives from local sources.

Many materials are used as an alternative source for natural coarse aggregate such as recycled low-quality crushed bricks, recycled coarse aggregates, coconut shells, recycled plastic aggregates, well burnt bricks etc. For this work, we had selected bricks as an alternative source for coarse aggregate. This material was chosen because in brick making, a large number of bricks are rejected due to non-conformity and the distorted form of brick produced due to poor temperature control in the kiln. These rejected bricks can also be possible source of coarse aggregate.

Conventionally, the term brick was referred to a unit composed of clay, but it is now used to denote any rectangular units laid in concrete. A brick can be composed of clay, soil, sand and lime or by combination of any these. Bricks are produced in several classes, types and sizes which vary with area and time and are produced in bulk quantities. Two basic kinds of bricks are fired and non-fired bricks. Crushed bricks as aggregates are of particular interest, because their use can considerably reduce the problem of storage of waste and simultaneously helps the preservation of natural aggregate resources. There are however some obstacles for the use of crushed bricks aggregate in concrete; codal limitations on water absorption and impurities and lack of knowledge about the behaviour of concretes made of crushed bricks. The first use of crushed brick with Portland cement was recorded in Germany in 1860 for the manufacturing of concrete products, but the first significant use of crushed brick as aggregates in new concrete has been recorded for reconstruction after the Second World War.

Crushed bricks are extensively used in parts of India and all over Earth for concrete making and the performance of this concrete is found to be quite satisfactory. Recently successful studies on the use of crushed bricks as aggregates in concrete have been reported in some European and American countries as well. However, they are mainly devoted to experiences with crushed bricks as coarse aggregates.

According to general definition, concrete is a composite material so by taking advantage of the situation for the people, this investigation presents the research that is carried out on the concrete when coarse aggregate is partially replaced by brick aggregate.

II. LITERATURE REVIEW

Mohammad Abdur Rashid et al. (2012) [1], did experimental investigation about the effects of replacing natural coarse aggregate by brick aggregate on the properties of concrete. The fresh and hardened properties of concrete obtained replacing stone aggregate as partially or fully by crushed clay bricks. Their study was of volumetric replacement of stone aggregate as brick aggregate. The use of bricks' aggregate as a replacement of stone aggregate resulted in significant decrease in unit weight, compressive strength, and modulus of elasticity of concrete. The reduction in tensile strength of mixed aggregate concrete was found to be less significant up to 50% replacement of stone aggregate by brick aggregate.

Jafar Bolouri Bazaz et al. (2006) [2], studied about the performance of concrete mix produced with crushed bricks as the coarse & fine aggregate. In this experimental, it was discussed about the physical characteristics of crushed clinker bricks, compressive and tensile strength of bricks concrete. The primary test results indicated that the quality of bricks is low in comparison with natural rocks. The strength and durability of concrete is dependent on the porosity, specific gravity, soundness, freezing & thawing resistance, compressive strength. In this project, the properties of concrete were made with three types of crushed brick aggregate in terms of size and material. The first type was, a combination of fine and coarse crushed brick

aggregate; the second type was using coarse crushed brick as coarse aggregate and the third type was using fine crushed brick aggregate as fine aggregate based on ASTM recommendations. From the results, they concluded that, compressive strength of concrete made by replacing crushed bricks is relatively high in comparison with ordinary concrete.

III. SIGNIFICANCE

Determining the suitability of bricks as alternative coarse aggregate in concrete is very important as these researches can convince people that bricks' waste material can be reused in the construction processes. The analysis of the test is required to identify the results and whether it can be satisfactory meet the basic requirements or not. The results from the test will show that whether bricks can achieve the minimum required compressive strength or even higher. The test to identify compressive strength of brick concrete is vital for improvisation in the partial replacement of coarse aggregate by bricks in concrete.

IV. OBJECTIVE

The main objectives are:

- To determine the suitability of brick as replacement of coarse aggregate in concrete production.
- To investigate the mechanical and physical properties of brick concrete.
- To compare the performance between concrete with brick waste as coarse aggregate and to know its compression strength.

V. MATERIALS USED

5.1 Cement

Cement is a material that has cohesive and adhesive properties that enable binding of rocks into one body. There are unusual cases of cement made at factory for specific purposes and to conform to the specific demands. When the void between the aggregates is minimized, then the need for cement to fill the empty space can be reduced to maintain the workability and the strength of concrete. And so, the optimal mixing ratio of aggregates will produce a concrete with minimal quantity of cement content. The cement used was ordinary Portland cement (OPC) of 43 grades as per IS 8112 (1989)[6].

5.2 Fine Aggregate

Locally available sand from nearby construction site was used. Sand passing through IS 4.75 mm Sieve was used for casting all the cubes' specimens. To make comparison easy, one type of fine aggregate was used throughout the experimental work so as to keep the fine aggregate variable constant.

5.3 Coarse Aggregate

Coarse aggregate can be defined as inert granular materials such as gravels or crushed stone. Coarse aggregate is one of the essential ingredients apart from water and cement in concrete production and so it consists about 60 to 75 percent of total concrete production. Coarse aggregate comes from particles greater than 4.75 mm but in a range between 9.5 mm to 37.5 mm.

5.4 Water

The amount of water present in concrete controls many fresh and hardened properties of concrete. Some of these are workability, compressive strength, permeability, water tightness, durability, weathering, drying shrinkage and chances for cracking.

5.5 Bricks

Only one type of unused fired clay bricks of 23 X 7.5 X 10 cm was used in the experiment. The size was measured before the bricks were crushed down to be used as coarse aggregate. The compressive strength of whole brick was found to be 11.23 N/mm².

5.6 Bricks' Aggregate

Standard bricks were crushed to 40 mm nominal size aggregate. Breaking of brick was done manually with hammer which produced angular aggregates.

VI. METHODOLOGY

6.1 Concrete Mix Design

It is a process of selecting suitable ingredients for the concrete and determining their proportion which would produce economical concrete that satisfies the job requirement. The proportioning of the ingredients of concrete is an important phase of concrete production as it ensures quality and quantity in pursuit of the goal to obtain concrete with desired performance characteristics. The grade of concrete used while performing this experimental investigation was M20 and no chemical admixture was used.

Table 1 Basic Mix Proportions

Cement	Fine Aggregate (FA)	Coarse Aggregate (CA)	Water/Cement Ratio(w/c)
1.000	1.602	2.507	0.450

6.2 Number of concrete specimens casted

Twelve concrete specimens were casted with and without use of crushed bricks:

- Three with 100% natural coarse aggregate and 0% brick aggregate (100NA00BA).
- Three with 90% natural coarse aggregate and 10% brick aggregate (090NA10BA).
- Three with 80% natural coarse aggregate and 20% brick aggregate (080NA20BA).
- Three with 70% natural coarse aggregate and 30% brick aggregate (070NA30BA).

Table 2 Modified Mix Proportions

Description	0% (100NA00BA)	10% (90NA10BA)	20% (80NA20BA)	30% (70NA30BA)
Cement (kg)	1.46	1.46	1.46	1.46
Water (L)	0.66	1.20	1.60	1.80
FA (kg)	2.35	2.35	2.35	2.35
CA (kg)	3.67	3.30	2.94	2.57
Brick aggregate (kg)	0.00	0.37	0.73	1.10

6.3 Compression Test

Compression test is a very familiar testing method that is used to establish the compressive force or crush resistance of a material. This test is used to determine the material behavior under gradual loading conditions. The maximum stress which the specimen can sustain over a period under a constant or progressive load is determined. Compression testing is often done to find break or rupture limit.

VII. OBSERVATIONS, ANALYSIS AND RESULTS

7.1 Observations and Calculations

Table 3 Ultimate Compressive Load

Natural Coarse Aggregate (%)	Specimen 1 (kN)	Specimen 2 (kN)	Specimen 3 (kN)	Average Compressive Load (kN)
100 (100NA00BA)	310.0	325.0	332.0	322.3
90 (090NA10BA)	280.0	295.0	289.0	288.0
80 (080NA20BA)	270.0	273.0	262.0	268.3
70 (070NA30BA)	240.0	248.0	255.0	247.7

Table 4 Compressive Strength

Natural Coarse Aggregate (%)	Specimen 1 (N/mm ²)	Specimen 2 (N/mm ²)	Specimen 3 (N/mm ²)	Average Compressive Strength (N/mm ²)
100 (100NA00BA)	13.78	14.44	14.75	14.32
90 (090NA10BA)	12.44	13.11	12.84	12.79
80 (080NA20BA)	12.00	12.13	11.64	11.92
70 (070NA30BA)	10.67	11.02	11.33	11.01

7.2 Plotting of Graphs

To make analysis easier, graphs were plotted.

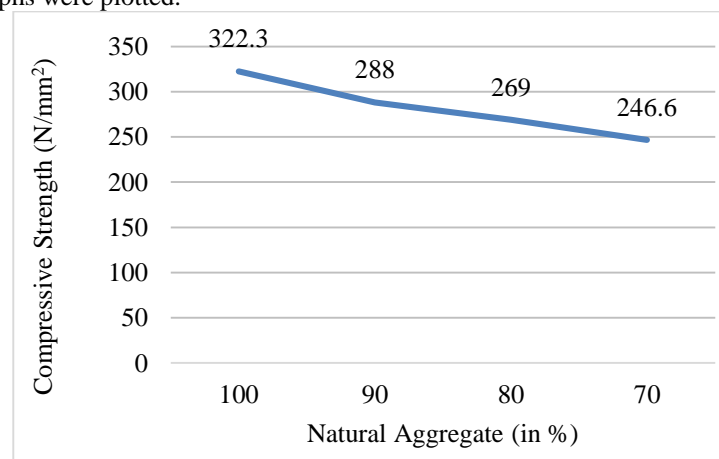


Figure 1 Ultimate Compressive Load vs. Natural Aggregate

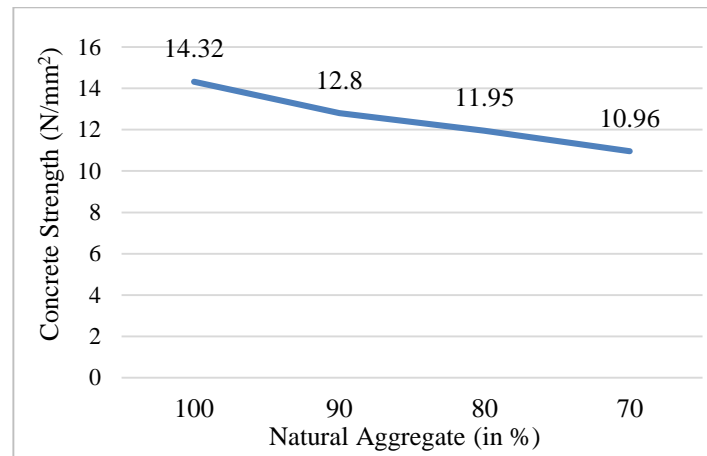


Figure 2 Concrete Strength vs. Natural Aggregate

7.3 Analysis

- From table 2, it can be observed that as percentage of bricks' aggregate added to concrete mix proportions increases, the water content required increases as bricks absorb water from concrete mortar.
- From table 3, it can be noted that as percentage of bricks' aggregate added to concrete mix proportions rises, the compressive strength reduces.
- Figure 1 shows the test results obtained with and without crushed bricks as coarse aggregate in concrete. The results reported are average of 3 specimens after curing time of 7 days.
- From the above figure 1, it is clear that using of crushed bricks in concrete reduces its compressive strength. The reduction in strength may be attributed to three reasons:
 - a. The crushed bricks failed to develop proper / adequate bond with concrete and cement matrix.
 - b. Because of high porosity of the surfaces of the crushed bricks, the mixture needs more water to get the required slump value.
 - c. The crushed bricks made the mixture unworkable because of roughness of the surfaces of crushed bricks aggregates affecting the compaction distribution upon the concrete layers.
- Figure 2 shows the calculated results of concrete strength of natural aggregate in concrete mortar. It can be noted from graph that as content of stone aggregate decreases, and as subsequently content of bricks' aggregate increases in concrete mortar – the concrete strength decreases.
- For 100% stone aggregate content in concrete mortar, the strength is 14.32 N/mm² whereas for 90% stone aggregate it is 12.80 N/mm². As per IS 456(2000), the strength should be 13 N/mm². So, the required strength can be achieved between 100% and 90% stone aggregate content.
- This reduction maybe possible because of artificially made aggregate addition in concrete mortar and this may decrease bond formation between bricks and different concrete materials.
- Moreover, it may be possible because of more water requirement in concrete mortar as bricks as aggregate absorbs more water from concrete mix.

VI. CONCLUSIONS

- This study has found that crushed bricks can be used satisfactory partly as coarse aggregate for making concrete of acceptable strength characteristics.
- It has observed that there is a raise in w/c ratio in concrete while using crushed bricks as coarse aggregates, as bricks absorb a significant amount of water from concrete.
- The concrete strength after 7 days curing is decreasing with increasing bricks' aggregate in concrete mortar.
- The required concrete strength of 13 N/mm² can be achieved between 0% to 10% bricks' aggregate in concrete mortar. Adding beyond this limit reduces the target strength.

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