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Experimental Investigation on Utilisation of Broken Brick Waste with Silica Fume In Concrete

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ABSTRACT

Brick powder and other waste particles not only occupy land but also create environmental problems. The problem could be reduced to a large extent by using these waste materials in cement concrete. The reason of using brick powder include economical gain. Experimental results indicate that brick powder could be used for partial replacement of cement in concrete. Cement is replaced by waste brick powder in different proportions 5% 10% 15% and 20%. Silica fume is added 10% of concrete. To determine the mechanical properties such as compressive strength, flexural strength, split tensile strength and durability test. The presence of brick powder shows that certain properties of concrete could be improved by using brick in combination with ordinary Portland cement. In this study physical properties of cement, brick powder, fine and coarse aggregate, and silica fume are studied. Specific gravity, sieve analysis, bulk density, bulking of sand, water absorption, moisture content test, fineness of cement, cement consistency, initial and final setting time of cement were tested.

Keywords - Brick dust, Coarse aggregate, Compressive strength, Fine aggregate, Split tensile strength, Flexural strength, Silica Fume

I. INTRODUCTION

Today's world's leading towards advancement, eager for more comfort has led to innovations and revolutions in each and every field of life. But on the other hand it has put some negative impacts on the environment, as natural resources get depleted. As concrete is most commonly used building material across the world and consumes most of the natural resources in the form of coarse and fine aggregates. After studying all these research papers we concluded that if we can use some materials other than basic ingredients of concrete which do not have negative impacts, rather have positive effects on various fresh and hardened properties of concrete, partial replacement of these ingredients of concrete with waste material will largely impact environment and will lead to pollution free and soothing environment.

This waste creates air pollution and land pollution by dumping and also causes water pollution so by using this material in concrete we can save our atmosphere and land. Our ultimate goal is to produce economical and eco-friendly concrete which will possess strength and other desired properties which one achieves by basic concrete ingredients. By using locally available waste like brick powder as partial replacement, it may prove more economical than traditional concrete and dumping of such waste produced by brick industries is also solved. Also construction cost is very high by using conventional materials due to unavailability of natural materials. We have the only option of partially replacing its ingredients by locally available waste materials. Over 3.3 billion tons of cement was consumed globally in 2010 based on survey of world coal association and also cement production also emits CO2 in to the atmosphere which is harmful to the nature. Also for producing 1 kg of cement we require 372 Kilo joules of energy while we require only 19 kilo joules of energy to produce 1 kg of brick powder (surkhi). If we can partially replace the cement with the material with desirable properties then we can save natural material, reduce emission of CO2 in to the atmosphere and save the energy for the coming generations. The industrial waste dumping to the nearest site which spoils the land and atmosphere as well as it also affects aesthetics of urban environment so use of this waste material in concrete is economical as well as environment friendly way to disposal of waste.

This Use of brick powder or surkhi has been used as pozzolana in India for many years. This material is used as a partial replacement of cement to produce mortar or concrete, which results in improved concrete properties which include reduction of permeability and resistance to sulphate attack and alkali-aggregate reaction. It has been used in Europe since ancient times, where powdered brick was mixed with hydrated lime to produce mortars. There are many examples across Europe of Roman buildings bearing the fact that these mortars have been used since long time in past and hence, the fact that these materials are durable is proved. So potential use for ground brick powder is possible, not only for repair of important historic buildings where compatibility of materials is important, but this can also be used for the production of durable and impermeable concrete or mortars. The pozzolanicity of brick powder depends upon the burning or calcining temperature of clay. The most reactive state of clay is when the burning temperature results in loss of hydroxyl and a collapsed and distorted clay structure, the burning temperature to produce this active state is usually in the range of 600-900°C.

BRICK POWDER

About 1-5% of waste bricks are generally produced in all brick companies, which add to quantity of waste materials considerably. This varies from 50,000 tons for a large scale company to 100 tons for a small scale company. Recycling of these waste bricks is one of the most challenging problems worldwide with the extraordinary growth of the world population. The waste from these companies is crushed and sold as low grade aggregate at prices varying between Rupees 129 to 430 Rupees per ton. Although this is a much lower cost than cement (4300 Rupees per ton) however there will be added cost of crushing if this is to be used as cement replacement. It is the waste material produced from brick kilns which is of no use adds to the waste to environment, which is to be landfilled. The landfilling of this material degrades the quality of soil and also contaminates the ground water of that area. It is finely ground bricks, orange in color and Sp. gravity 2.52. Particle size of brick powder is about 20 to 60 microns. Calcination temperature of bricks ranges from 900 to 1000 degree Celsius. The SiO2 content in brick powder is about 54.8% and Al2O3 content is about 19.1%.

Fig 1 Brick Powder

II. OBJECTIVES OF THE RESEARCH

- To check the behaviour of concrete incorporated with brick powder as a replacement of cement and optimum use of silica fume.
- To find the optimum quantity of used brick dust aggregate in concrete mixtures for engineering applications.
- To find an effective & inexpensive way of recycling the brick dust.
- To reduce the recycling of such material. This in turn helps in reducing environmental pollution up to a certain level. Developing such construction materials could have both environmental and economic advantages.

III. Literature Survey

Singh and Joshi (2023) in the research paper, hardened properties like compressive strength, split tensile strength test were carried out on Brick kiln dust concrete. The percentage of bricks kiln dust that partially and fully replaced by fine aggregates by weights were 0%, 10%, 20%, 30%, 40% and 50% with M25 Grade. Examinations were led for both Ordinary Concrete and blocks furnace clean Concrete with various rates of BKD.

Results demonstrated that the ideal substitution of reused blocks oven tidy with fine totals was 30%. Up to 30% replacement, it is possible to gain the same strength as conventional concrete. Beyond 30% replacement the strength results following a decreasing trend.

Arif et.al (2022) objective of the research paper was to interrogate the feasibility of using Waste brick powder (WBP) successfully in concrete as a substitute of cement. The replacement levels were kept at 5% and 10%, compared to the reference concrete. The tests consisted of slump, density, compressive, flexural and splitting tensile strengths, Schmidt Hammer, Ultrasonic Pulse Velocity and microscopic analysis.

The results revealed an increase in workability, which is attributed to the particle size and shape of WBP. WBP particles have round edges and smooth surfaces, which lubricate the mix and give a ball bearing effect. The decrease in density is attributed to the lower density of WBP. The increase in compressive, split tensile, and flexural strengths highlighted an indication of the improvement of concrete quality by WBP inclusion: This is attributed to compact structure of the specimens owing to the location of pozzolanic products in concrete voids. Rebound Hammer and Ultrasonic pulse velocity also validated enhancement of the quality of concrete. Scanning Electron Microscopy (SEM) confirmed the formation of primary ettringite and enhanced CSH content in WBP-replaced samples. Energy Dispersive Spectra (EDS) showed highest peaks of Ca and Si (enhanced quantity of CSH) and low peak of Al (Ettringite) in WBP-containing concrete specimens.

IV. MATERIAL AND PROPERTIES

CEMENT

Cement is one of the important binding materials in concrete. Cement is made by heating of limestone (calcium carbonate) with different small quantities of

other material like Silica, iron, etc. it's heating around 1450 °C in a kiln, this process is known as calcination, whereas a molecule of carbon dioxide (CO2) is liberated from the limestone to form calcium oxide (CaO) /quicklime. Then it has blended with the other materials that have been included in the mixer. The cement which is using have the following properties. Commercially available Ordinary Portland Cement of grade 53 was used in this research. The properties (physical) of the cement used were presented in table below.

Table 1. Test Results on Cement (IS 12269-1987)

Properties	Results
Type of cement	OPC 43
Fineness	7%
Nominal consistency	29%
Initial setting time	30min

Table 2 Chemical Composition of Cement

Components	CEMENT (%by mass)
Silica (Sio2)	18.89
Alumina (Al2O3)	4.24
Iron oxide (Fe2O3)	3.83
Calcium oxide (CaO)	62.37
Magnesium oxide (MgO	0.99
Sulphur trioxide (SO3)	2.31
Sodium oxide (Na2O)	0.12
Potassium oxide (K2O)	1.14
Titanium oxide (TiO2)	0.3
Manganese (II)oxide (MnO)	0.077
Phosphorus Pentoxide (P2O3)	0.12
Loss on Ignition	1.52

FINE AGGREGATE

The aggregates are passing 4.75 mm Tyler sieve and.075 mm sieve is retained. Fine aggregate (Sand) is a very important civil engineering material. In construction works, sands are used as a fine aggregate material. Fine aggregate (Sand) is a form of silica (quartz) and might be siliceous argillaceous, or

calcareous depends upon the composition. Natural sands are formed from weathering of rocks. The grains of sand may be angular, sharp, or rounded.

Most of the fine aggregate (sand) particles should pass from No.4 to No.16 sieves. But most of the fine aggregate (sand) should not contain very fine particles. The various sizes of sand particles are determined by using 'Sieve Analysis.

As fine aggregate (FA), river sand that was readily available in local area was used for concrete preparation whose physical properties were as presented in the table below. The sand was thoroughly cleaned for removal of any deleterious contents before the testing.

Table 3 Test Results on Fine Aggregate

Properties	Results
Specific gravity	2.8
Fineness modulus	2.7
Moisture content	1.45
Water absorption	15%
Bulking sand	4%

The basic test where conducted and the results are as follows: Specific gravity = 2.65 Water absorption = 1.01.

Table 4 Results of sieve analysis of Fine Aggregate

Sieve Size	Cumulative % Finer	Grading Limits For Zone-II As Per IS 383:1970
4.75 mm	92.6	90-100
2.36 mm	83.2	75-100
1.18 mm	68.5	55-90
600 µ	46.4	35-59
300 µ	5.7	5-30
150µ	0.8	0-10

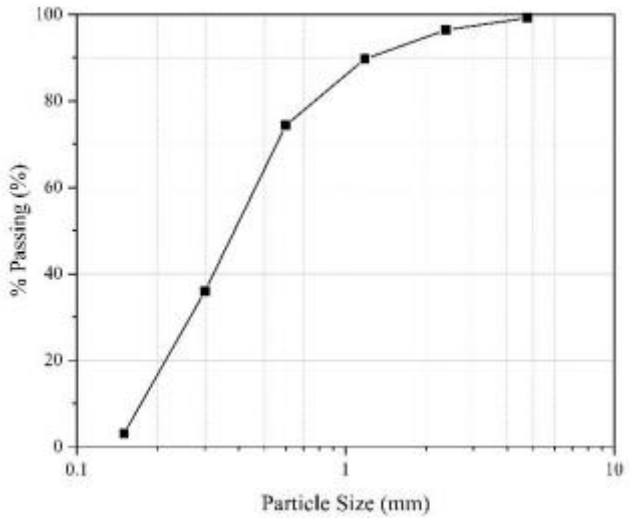


Fig 2 Gradation of Fine Aggregates

COARSE AGGREGATE

It is the important material used for making concrete. Aggregates occupy about72 - 75% of the volume of concrete and they greatly influence the strength of concrete. These are cheaper than cement and admixtures. The aggregate imparts density to concrete. Coarse aggregates are the particles that retain on a 4.75 mm sieve. The surface area of coarse aggregate is less than fine aggregates (Sand). it acts as inert filler material for concrete.

20mm and 10mm single sized crushed stone aggregates from the local quarry were used as coarse aggregates (CA) in the ratio of 65% and 35% to satisfy the gradation limits as per IS:383-2016. The physical properties of the CA were presented in table below.

Table 5 Test result on coarse aggregate (IS 383-1970)

Properties	Results
Specific gravity	2.7
Fineness modulus	6.14
Moisture content	15%
Water absorption	23%

Table 6 Sieve analysis of Coarse aggregate

Sieve size in mm	Wt. of aggregate retained (gm)	% of total wt retaine	Cumulative % wt. retained	% passing
20	0	0	0	100
16	142.7	4.75	4.75	95.25
12.5	1485	49.5	54.25	45.75
10	1121.1	37.37	91.62	8.38
4.75	251.2	8.37	100	0
Pan	0	0	100	0

Total weight of sample taken = 3000gm

SILICA FUME

Silica fume is also known as micro silica. It is an ultra fine material with spherical particles less than 1 μm. In this project 10% of cement is replaced by silica fume.

Table 7 Test result on silica fume

Properties	Results
Specific gravity	2.25
Bulk density	430Kg/m
Particle size	1μm

BRICK POWDER

Brick powder reduces the weight of the concrete. Increase in construction activities. Brick crushed in coarse powder were used in cement for making concrete. With proper mix design concrete with brick powder will increase the strength. As curing age increases the compressive strength will be increased.

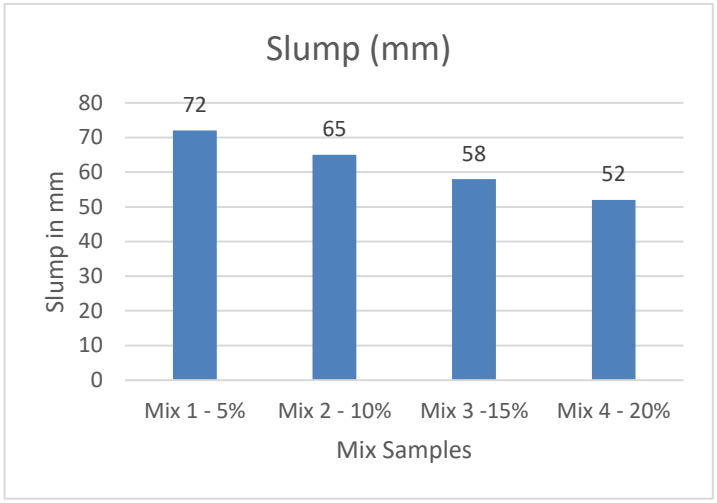
Table 8 Test result on brick powder

Properties	Results
Specific gravity	2.2
Bulk density	520 Kg/m^3

V. RESULTS AND DISCUSSION

The compressive strength, tensile strength, and flexural strength of various concrete mixtures were determined on 150×150 mm cubes, 150×300mm cylinders and 100×100×500 prism respectively.

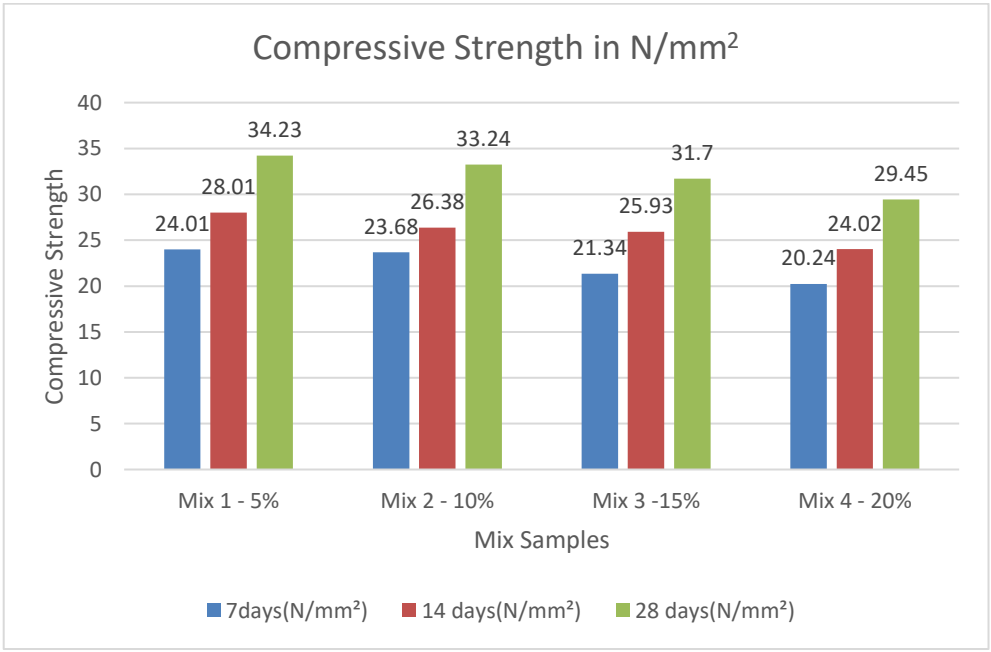
WORKABILITY TEST



GRAPH 1 Workability Test Results

Inference- As the percentage of brick powder increases, the workability decreases in all the samples.

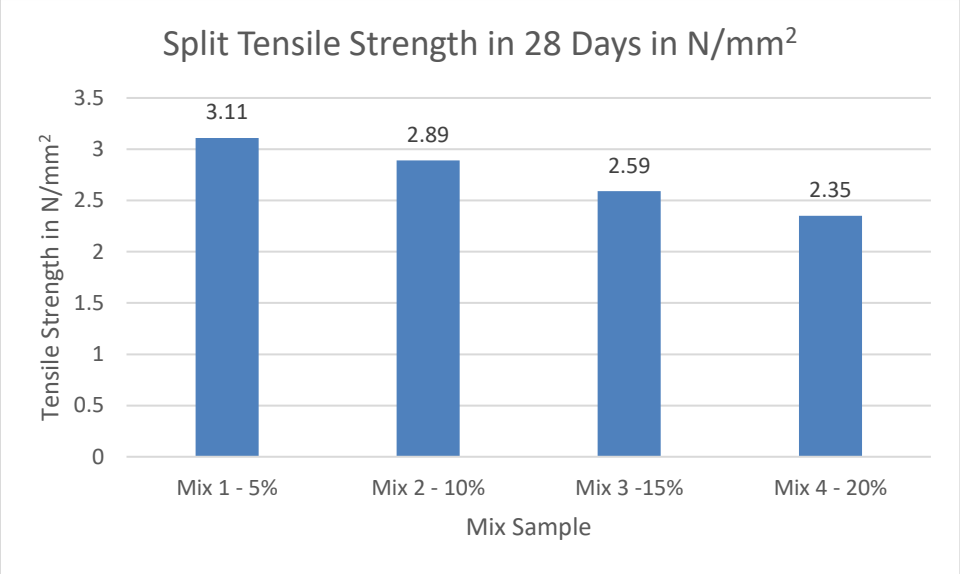
COMPRESSIVE STRENGTH



GRAPH 2: Compressive Strength of the Concrete Mixtures in N/mm2

Inference- The capacity of a material or structure to carry loads on its surface without cracking or deflection is referred to as compressive strength. When a material is compressed, its size appears to shrink, while when it is tensioned, its size elongates. Some materials crack as their compressive strength reaches its maximum, while others deform irreversibly. The most preferable results were visible for the sample M1 with 5% of Brick dust powder with maximum strength achieved as 34.23 N/mm2.

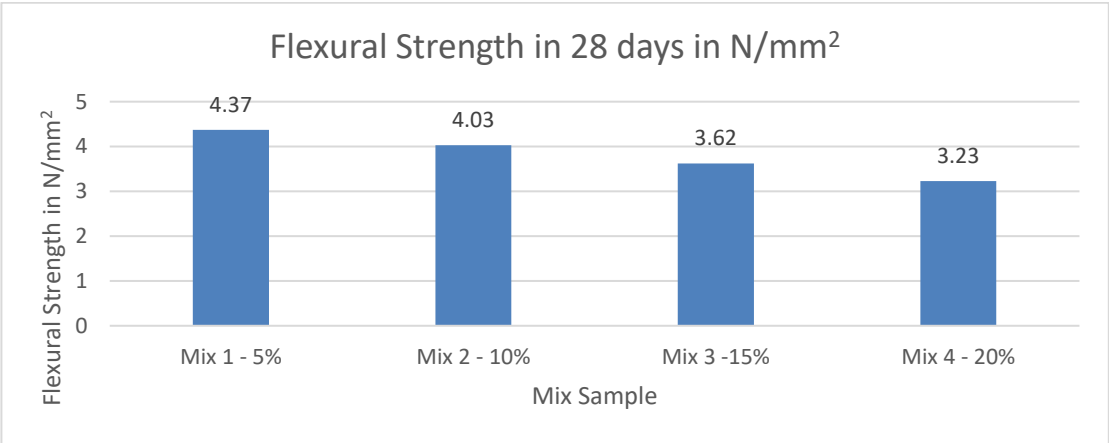
SPLIT TENSILE STRENGTH



GRAPH 3 Split tensile strength of the concrete in N/mm2

Inference- Splitting tensile testing is a standard method used to evaluate the tensile strength of concrete. Splitting tensile testing helps determine the ability of concrete to resist cracking and splitting forces. Split Tensile strength has decreased from 10% to 30% replacement of cement with brick powder and the split tensile strength is less than the conventional concrete.

FLEXURAL STRENGTH



GRPH 5 Flexural strength of the concrete

Inference- The flexural strength of concrete is one measure of the tensile strength of unreinforced concrete. It refers to the ability of the concrete beam or slab that is being tested to resist bending. Flexural strength has decreased from 10% to 30% replacement of cement by brick powder.

VI. CONCLUSION AND FUTURE SCOPE

-> From the literature survey, it is observed that the concrete with brick powder gives better strength and workability. It was observed that the material properties such as cement, coarse aggregate, and fine aggregate satisfied as per the codal provision.

-> In the present study, an attempt is made to replace the cement with industrial waste like brick powder. The use of waste materials like brick powder and silica fume in construction industry reduces the cost, pollution and the problems related to the disposal of waste material. The strength characteristics has developed more when compared with brick powder due to presence of high percentage of alumina and silica content with less percentage of calcium content in the material properties.

-> The replacement of cement by brick dust appears to increase the strength of concrete. Under acid attack, performance of cement concrete cube specimen prepared with 5% 10% 15% and 20% cement replaced by brick powder.

-> As the percentage of broken bricks increases, the workability decreases in all the samples.

-> The capacity of a material or structure to carry loads on its surface without cracking or deflection is referred to as compressive strength. When a material is compressed, its size appears to shrink, while when it is tensioned, its size elongates. Some materials crack as their compressive strength reaches its maximum, while others deform irreversibly. The most preferable results were visible for the sample M1 with 5% of Brick dust powder with maximum strength achieved as 34.23 N/mm2.

-> Splitting tensile testing is a standard method used to evaluate the tensile strength of concrete. Splitting tensile testing helps determine the ability of concrete to resist cracking and splitting forces. Split Tensile strength has decreased from 10% to 30% replacement of cement by brick powder and the split tensile strength is less than the conventional concrete.

-> The flexural strength of concrete is one measure of the tensile strength of unreinforced concrete. It refers to the ability of the concrete beam or slab that is being tested to resist bending. Flexural strength has decreased from 10% to 30% replacement of cement by brick powder.

-> Acid attack is the dissolution and leaching of acid-susceptible constituents, mainly calcium hydroxide, from the cement paste of hardened concrete. This action results in an increase in capillary porosity, loss of cohesiveness and eventually loss of strength. Similar results equivalent to conventional concrete mix were visible for sample M4 with 20% brick dust powder with least loss of weight by 3.0%.

VII. FUTURE SCOPE

1. In this study we are utilizing broken brick waste whereas in future one can add any other industrial waste in concrete.
2. In this study we are considering M-30 grade of concrete whereas in future any higher design mix can be consider for experiment.
3. In this study general testing method is adopted whereas in future F.E.M analysis using Ansys can be done to predict the mode and linearity od various samples.

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