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Experimental Study on Improvement of Compressive Strenght of Concrete Using and Durability of Concrete of Specified Concrete with Adding Waste Spent Fire Brick, Granite and Marble

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ABSTRACT

The advancement of concrete technology can reduce the consumption of natural resources and energy sources and umpteen varieties of concretes (FAC, HVFAC, FRC, HPC, HSC, and others) were researched in several laboratories and brought to the field to suit the specific needs. Marble, granite and Spent Fire Brick industry has grown significantly in the last decades with the privatization trend in the early 1990s, and Accordingly, the amount of mining and processing waste has increased. Stone waste is generally a highly polluting waste due to both its highly alkaline nature, and its manufacturing and processing techniques.

The objective of this paper is to utilize waste marble, granite and Spent Fire Brick waste of different sizes in the manufacturing of concrete bricks, with partial replacement of conventional coarse and fine aggregates with Marble, Granite and Spent Fire Brick waste content up to 25%.and design mix is m40 The produced bricks are tested for physical and properties according to the requirements of the American Standards for Testing Materials (ASTM) and the IDIAN Code. These tests were carried out to evaluate the mechanical properties for 7 ,14and 28 days. .150mmx150mx150mm cubes the test results revealed that the recycled products and Reuse of this kind of waste has advantages economic and environmental, reduction in the number of natural spaces employed as refuse dumps.

Keywords: Granite, Spent Fire Brick and Marble

I. INTRODUCTION

There is an era of industrial explosion. So, it may lead to increasing demand of natural resources. The cost of natural resources is also increased. They have forced to focus on recovery, reuse of natural resources and find other alternatives. Stone waste/Granite has been commonly used as a building material. During the process of cutting, in that original stone waste/Granite mass is lost by 30% in the form of dust. Every year 250-400 tons of stone waste/Granite waste is generated at site. The stone waste/Granite cutting plants are dumping the powder in any nearby pit or vacant spaces, near their unit although notified areas have been marked for dumping.

Solid waste management is a fundamental component to any manufacturing or production enterprise. The natural stone industry is unique in that the majority of its solid waste stream is its raw material, often in unadulterated form. Waste from quarry and fabrication operations can be unsafe and environmentally detrimental. Scrap stone can create an undesirable visual impact as well as dangerous working conditions, if it is not well organized or if piles are allowed to be stacked carelessly. Runoff from the scrap mounds can cause erosion problems, and fines introduced into natural waterways can suffocate local ecosystems. Further, if waste must be disposed of off-site, landfill fees can create additional costs for quarry and fabrication operators.

From the past and present construction industrialization sector it is known that, the growth urbanization increase in consumption on natural material and have led to fast decline in available natural resources. On the other hand high volume of production has generated a considerable amount of waste materials which have adverse impact on the environment. Marble and granite aggregates, which are called as by-products come from the marble and granite stone industries.

As the time is passing, the construction industry is growing rapidly and in the last decade we are seeing relatively huge constructions. With this rapid growth, a concern of its waste management also growing with the same speed every annum.

The brick which are near the fire in the kiln subjected to high heat more than 1000 degree centigrade and ultimately shrink and loose its shape, color becomes reddish and its appearance like reddish to blackish gradient stone. This over burnt brick serves as waste in the construction industry and has to accumulate somewhere in the process of recycling. Concrete is a solid, hard material produced by combining Portland cement, coarse and fine aggregate (sand & stone), water and sometimes admixtures in proper proportions. It is one of the most widely used construction material and has a long history of use. Its constituent ingredients derive from a wide variety of naturally occurring materials that are readily available in the most parts of the world.

Approximately 60 to 80 percent of concrete is made up of aggregates. The cost of concrete and its properties are directly related to the aggregates used. In aggregates, the major portion is of coarse aggregate i.e. stone or gravel which are obtained naturally either from river bed or by crushing rocks mechanically up to the required size.

II. METHODS AND MATERIAL

The different methods utilized in this research include the following:

Background Study:

Literature survey was carried out to review previous studies related to this these

ii) Collection of raw Materials:

All the required materials were collected and delivered to the laboratory. These are; Cement, fine aggregate, coarse aggregate, marble, granite and spent firebrick wastes and admixture.

iii) Material Tests:

Tests were conducted on the raw materials to determine their properties and suitability for the experiment.

iv) Mix Proportioning (Mix Design):

Concrete mix designs were prepared using the Indian standard recommended method.

v) Specimen preparation:

The concrete specimens were prepared in the PITW, Civil Engineering Department Material Testing laboratory. The prepared samples consist of concrete cubes, cylinders.

vi) Testing of Specimens:

Laboratory tests were carried out on the prepared concrete samples. The tests conducted were compressive strength tests.

vii) Data collection:

The data collection was mainly based on the tests conducted on the prepared specimens in the laboratory

viii) Data Analysis and Evaluation:

The test results of the samples were compared with the respective control concrete properties and the results were presented using tables, picture and graphs. Conclusions and recommendations were finally forwarded based on the findings and observations.

Characteristics of Concrete:

Concrete is a composite material composed of coarse granular material (the aggregate or filler) embedded in a hard matrix of material (the cement or binder) that fills the space between the aggregate particles and glues them together. In its simplest form, concrete is a mixture of paste and aggregates. The paste, composed of Portland cement and water, coats the surface of the fine and coarse aggregates.

Constituents of Concrete:

Cement:

Cement is a generic name that can apply to all binders. Portland cement, the basic ingredient of concrete, is a closely controlled chemical combination of calcium, silicon, aluminium, iron and small amounts of other ingredients to which gypsum is added in the final grinding process to regulate the setting time of the concrete. Lime and silica make up about 85% of the mass. Common among the materials used in its manufacture are limestone, shells, and chalk or marl combined with shale, clay, slate or blast furnace slag, silica sand, and iron ore.

Aggregates:

Aggregates generally occupy 70 to 80 % of the volume of concrete and can therefore be expected to have an important influence on its properties. They are granular materials derived for the most part from natural rock and sands. Based on their origin, aggregates can be classified as natural aggregates and non-natural Aggregates.

Natural Aggregates:

Mineral aggregates consist of sand and gravel, stones and crushed stone. Construction aggregates make up more than 80 percent of the total aggregates market, and are used mainly for road base, rip-rap, cement concrete, and asphalt. The sources of mineral aggregates are by directly extracting from the original sources like river basins or by manufacturing them into a desired shape from the parent rock in a crasher mill**.**

Artificial Aggregates:

This category consists of aggregates that are artificial in origin. The reasons for their advent in concrete construction are:

i. Environmental considerations are increasingly affecting the supply of aggregate.
ii. There are strong objections to opening of pits as well as to quarrying.
iii. At the same time, there are problems with the disposal of construction demolition waste and with dumping of domestic waste.

Water:

Water is a key ingredient in the manufacture of concrete. Attention should be given to the quality of water used in concrete. The time-honored rule of thumb for water quality is “If you can drink it, you can make concrete with it.” A large amount of concrete is made using municipal water supplies. However, good quality concrete can be made with water that would not pass normal standards for drinking water.

Mixing water can cause problems by introducing impurities that have a detrimental effect on concrete quality.

Chemical Admixtures:

Admixtures are ingredients other than water, aggregates, hydraulic cement, and fibers that are added to the concrete batch immediately before or during mixing. A proper use of admixtures offers certain beneficial effects to concrete, including improved quality, acceleration or retardation of setting time, enhanced frost and sulphate resistance, control of strength development, improved workability, and enhanced finish ability. It is estimated that 80% of concrete produced in North America these days contains one or more types of admixtures.

The Use of Recycled Materials In Concrete Construction:

The recycled materials in this study consisted of ground granulated blast furnace slag (GGBFS), recycled concrete (crushed hardened concrete) and crushed waste glass. The GGBFS was used as a replacement for the cement. The recycled concrete and waste glass were used to replace the coarse and fine aggregates, respectively. The concrete mixtures designed ranged from a twenty-five percent replacement to one hundred percent replacement with materials.

These mixtures were compared against a standard concrete mixture using cement and virgin aggregates. For comparison purposes, all mixtures were held constant in regards to water to cementitious ratio. The fresh concrete properties examined included slump, air content and unit weight. The hardened properties examined included compressive strength, rate of strength gain, freeze-thaw durability, permeability, and alkali-silica reactivity potential.

A concrete mixture composed entirely of recycled materials was developed. This concrete mixture developed substantial strength and durability and is comparable to a normal strength concrete mixture in several aspects. This concrete made from100% recycled materials was a very low permeable concrete with a compressive strength of 4300 psi (29 .6 MPa). A concrete composed of 50% and 75 % recycled materials that achieved strengths of nearly 7000 psi (48 MPa) and 6300 psi (43.4MPa) respectively were also developed.

Recycling Of Waste Marble, Granite And Spent Brick:

Composition of Marble, Granite and Spent Firebrick:

Marble is composed primarily of calcite, dolomite, or perhaps serpentine and other similar minerals. The exact chemical composition of marble will greatly vary depending on the location and the minerals or impurities present in the limestone during re-crystallization. Typically, marble is composed of the following major constituents: 38-42% Lime (CaO), 20-25% Silica (SiO_2), 2-4% Alumina (Al_2O_3), 1.5-2.5% various oxides (NaO and MgO), and 30-32% various carbonates ($MgCO_3$ and others).

Granite is a light-colored plutonic rock found throughout the continental crust, most commonly in mountainous areas. It consists of coarse grains of quartz (10-50%), potassium feldspar, and sodium feldspar. These minerals make up more than 80% of the rock. Other common minerals include mica (muscovite and Biotite) and hornblende (see amphibole). The chemical composition of granite is typically 70-77% silica, 11-13% alumina, 3-5% potassium oxide, 3-5% soda, 1% lime, 2-3% total iron, and less than 1% magnesia and Titania.

Applications of Marble, Granite and Spent fire Brick:

The areas where the utilization of marble, granite and firebrick waste needs to be explored as a substitute for conventional raw materials are as follows.

As a filler material for roads and embankments: As stone dust is an inert material it can be mixed with certain types of soils for the preparation / rising of embankments etc. which will result in the saving of valuable soil. Central Road search Institute (CRRI), New Delhi has carried out preliminary research on the utilization of stone waste dust in road sector. Unconfined Compressive Strength (UCS) have been performed to determine the strength of the mixes with soils and it has been observed that, In silty soil, there is 12 percent increase in UCS with 10% stone waste dust - There is a 20% increase in UCS with 30% stone waste dust - There is no improvement in clayey soil.

For Manufacture of Bricks: Stone waste is used as a fine aggregate in manufacturing bricks by using cement or lime as a binder. Central Brick Research Institute (CRRI), Roorkee has conducted research on this aspect. The results are very encouraging and the physical properties of the bricks produced by this process exceed those of normal bricks. The stone waste slurry-lime bricks were made in laboratory using, slurry, sand and hydrated lime, cured in a steam at normal pressure. It attained strength of 50 – 60 kg / cm^2. (Since this process requires steam curing it may not be economically feasible).

Manufacture of Portland cement:

Cement grade limestone is the main raw material along with clay and other corrective materials for the manufacture of Portland cement. Analysis of stone waste shows that it satisfies the chemical composition requirements of cement grade lime stone to a great extent. As a part replacement of limestone, either stone waste and or a combination of along with limestone and or lime can be used.

Manufacture of Ceramic Tiles: A possibility of utilizing stone waste slurry as a raw material for production of Ceramic Wall tiles needs to be evaluated on a pilot plant level. A leading ceramic producer in the country has undertaken laboratory scale studies on this matter, which were reported to be highly successful.

Manufacture of Thermoset Resin Composites: The Macromolecular Research Centre at Jabalpur has conducted a short term programmed with a view to explore the possibility of converting stone waste slurry into Resin Composites. The preliminary results have demonstrated the technical feasibility of such an option. However, pilot plant level studies need to be conducted.

Manufacture of lime: Limestone is the main raw material for the production of Lime. Limestone can be replaced by stone waste.

Manufacture of Activated Calcium Carbonate:

Limestone or combination of stone waste and stone waste dust (from slurry) can be used on the production of activated or precipitated calcium carbonate.

Hollow Blocks and Wall Tiles: Stone waste slurry waste and other clay products can be used in the production of Hollow prefabricated blocks for buildings if used in the right proportion.

Cost Consideration in Marble,Granite and Spent firebrick:

Marble: India, from a general viewpoint, can offer an enormous potential reserve of materials, such as marble, stone, onyx (onyx marble), travertine, granite, etc., often of excellent quality, that could prevail on the world-wide market. At the present time the quarry mining conditions are in most cases primitive and in an artisanal stage. When mechanization exists, it consists of pneumatic hammers solely, obtaining only about 30-35% block production of the whole material exploited.

Granite: Granite purchased here in the Bay Area and installed in a San Carlos home was so radioactive that the homeowners had it removed to protect their health. Scientists pointed out those granite countertops have a substantial environmental footprint. Granite quarries are open pit mines, often thousands of miles from the final destination of the product.

Spent Firebrick : Substitute for firebricks can be old red clay solid bricks. In ovens these alternative red clay bricks will heat up, retain heat, cook, bake, roast, re-fire, absorb conduct store and hold the heat from wood fire and perform the same way as proper refractory firebricks do. If you cannot locate fire bricks where you are or for any reason obtain them, Red Clay Bricks will perform much the same way in wood fire temperature levels and can be used instead.

The replacement bricks must be of this type, old solids. Clay body is the same on the brick's inside as it is on the outside. Break or cut one of the bricks you find in half to see what's in the middle. New products are made out of cheap clay bodies whilst only on the outside a decorative clay slip is applied and then the bricks are fired in kiln – you couldn't use bricks like that.

Mix Design : The process of selecting suitable ingredients of concrete and determining their relative amounts with the objective of producing a concrete of the required, strength, durability, and workability as economically as possible, is termed the concrete mix design. The proportioning of ingredient of concrete is governed by the required performance of concrete in 2 states, namely the plastic and the hardened states. If the plastic concrete is not workable, it cannot be properly placed and compacted. The property of workability, therefore, becomes of vital importance.

Mix Design procedure:

The mix design procedure is recommended in the IS code is as given below.

Procedure:

1. Determine the mean target strength ft. from the specified characteristic compressive strength at 28-day and the level of quality control.

$$\mathbf{f_t = f_{ck} + 1.65\ S}$$

Where S is the standard deviation obtained from the Table of approximate contents given after the design mix.

2. Obtain the water cement ratio for the desired mean target using the empirical relationship between compressive strength and water cement ratio so chosen is checked against the limiting water cement ratio. The water cement ratio so chosen is checked against the limiting water cement ratio for the requirements of durability given in table and adopts the lower of the two values.

3. Estimate the amount of entrapped air for maximum nominal size of the aggregate from the table.

4. Select the water content, for the required workability and maximum size of aggregates (for aggregates in saturated surface dry condition) from table.

5. Determine the percentage of fine aggregate in total aggregate by absolute volume from table for the concrete using crushed coarse aggregate.

6. Adjust the values of water content and percentage of sand as provided in the table for any difference in workability, water cement ratio, grading of fine aggregate and for rounded aggregate the values are given in table.

7. Calculate the cement content from the water-cement ratio and the final water content as arrived after adjustment. Check the cement against the minimum cement content from the requirements of the durability, and greater of the two values is adopted.

8. From the quantities of water and cement per unit volume of concrete and the percentage of sand already determined in steps 6 and 7 above, calculate the content of coarse and fine aggregates per unit volume of concrete from the following relations:

$$V = \left[W + \frac{C}{S_c} + \frac{1}{p}\frac{f_a}{S_{fa}}\right] \times \frac{1}{1000}$$

$$V = \left[W + \frac{C}{S_c} + \frac{1}{1-p}\frac{C_a}{S_{ca}}\right] \times \frac{1}{1000}$$

Where V = absolute volume of concrete= gross volume ($1m^3$) minus the volume of entrapped air

Sc = specific gravity of cement

W = Mass of water per cubic meter of concrete, kg

C = mass of cement per cubic meter of concrete, kg

p = ratio of fine aggregate to total aggregate by absolute volume

fa, Ca = total masses of fine and coarse aggregates, per cubic meter of concrete, respectively, kg, and

S_{fa}, S_{ca} = specific gravities of saturated surface dry fine and coarse aggregates, respective

9. Determine the concrete mix proportions for the first trial mix.

10. Prepare the concrete using the calculated proportions and cast three cubes of 150 mm size and test them wet after 28-days moist curing and check for the strength.

11. Prepare trial mixes with suitable adjustments till the final mix proportions are arrived at.

Mix Proportions:

The design mix used in **M40** grade concrete with W/C ratio **0.45.**

The mix design proportion is (**1:1.65:2.92)**

M-40Mix Designs as per IS: 10262-2009

	M-40 CONCRETE MIX DESIGN	
	As per IS: 10262-2009	
A-1	**Stipulations for Proportioning**	
1	**Grade Designation**	**M40**
2	Type of Cement	OPC 43 grade confirming to IS-12269-1987
3	Maximum Nominal Aggregate Size	20 mm,10 mm
4	Minimum Cement Content (MORT&H 1700-3 A)	$400Kg/m^3$
5	Maximum Water Cement Ratio (MORT&H 1700-3 A)	0.45
6	Workability (MORT&H 1700-4)	25-75 mm (Slump)
7	Exposure Condition	Normal
8	Degree of Supervision	Good
9	Type of Aggregate	Crushed Angular Aggregate
10	Maximum Cement Content (MORT&H Cl. 1703.2)	$540 kg/m^3$
11	Chemical Admixture Type	Super-plasticizer Confirming to IS-9103
A-2	**Selection of Water Cement Ratio**	
1	Maximum Water Cement Ratio (MORT&H 1700-3 A)	0.5
2	Adopted Water Cement Ratio	0.40
A-3	**Calculation of Cement Content**	
1	Water Cement Ratio	0.40
2	Cement Content (300/0.5)	$4000 kg/m^3$
A-4	**Proportion of Volume of Coarse Aggregate & Fine Aggregate Content**	
1	Vol. of C.A. as per table of IS 10262	62.00%
2	Adopted Vol. of Coarse Aggregate	62.00%
3	Adopted Vol. of Fine Aggregate (1-0.62)	38.00%

M40 Concrete Mix Design

SLUMP CONE TEST:

1. Slump value for 10mm aggregate – 36mm.
2. Slump value for 20mm aggregate – 32mm.
3. Slump value for 10mm aggregate with spent fire brick – 28mm.
4. Slump value for 20mm aggregate with spent fire brick waste – 26mm.
5. Slump value for 10mm aggregate with marble waste – 38mm.
6. Slump value for 20mm aggregate with marble waste – 34mm.
7. Slump value for 10mm aggregate with granite waste – 32mm.
8. Slump value for 10mm aggregate with granite waste – 32mm

Specific Gravity Of Course Aggregates (10mm):

1. Empty weight of Pycnometer, W_1=0.658 Kg
2. Weight of Pycnometer + Sample, W_2=1.436 Kg
3. Weight of Pycnometer + Sample + Water, W_3=2.051 Kg
4. Weight of Pycnometer + Water, W_4=1.522 Kg

Specific Gravity of Coarse Aggregates

$$= \frac{(W2-W1)}{[(W2-W1)-(W3-W4)]}$$

=(1.436-0.658)/[(1.436-0.658)-(2.051-1.522)]
=3.124

Specific Gravity Of Course Aggregates (20mm):

1. Empty weight of Pycnometer, W_1=0.658 Kg
2. Weight of Pycnometer + Sample, W_2=1.437 Kg
3. Weight of Pycnometer + Sample + Water, W_3=2.043 Kg
4. Weight of Pycnometer + Water, W_4=1.522 Kg

Specific Gravity of Coarse Aggregates

$$= \frac{(W2-W1)}{[(W2-W1)-(W3-W4)]}$$

= (1.437-0.658)/[(1.437-0.658)-(2.043-1.522)] =3.0

III. RESULTS AND DISCUSSION

Compressive Strength Test:

The compressive strengths of concrete specimens were determined after 7, 14 and 28 days of standard curing. For Marble, Granite and Spent fire brick concrete, the results show that the addition of these aggregates resulted in a significant increase in concrete compressive strength compared with normal concrete mix. This increment increased with increasing percentage of Marble, Granite and Spent fire brick aggregate.

The reason for the compressive strength increment could be attributed both to an increase of quantity of the solid load carrying material and to the adhesion at the boundaries of the Marble, Granite and Spent fire brick aggregate.

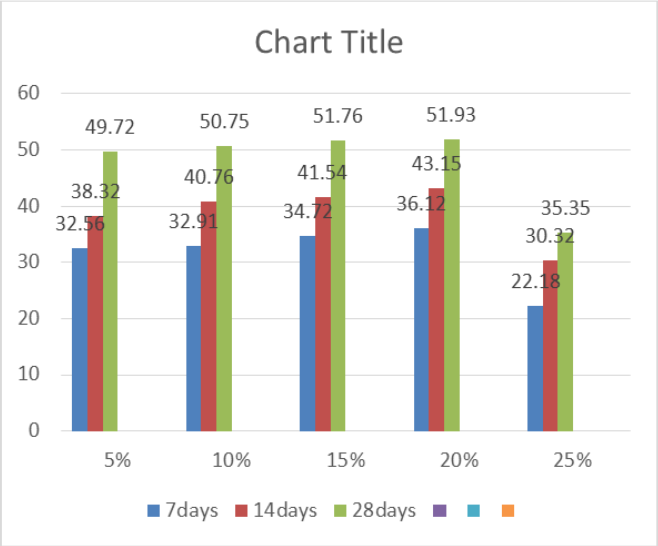
Therefore, Marble, Granite and Spent fire brick aggregates tend to behave like hard inclusions or less voids in the concrete, resulting in an increase in compressive strength. It is well known that the presence of voids in concrete greatly reduces its strength. The existence of 5% of voids can lower strength by as much as 30% and even 2% voids can result in a drop of strength of more than 10%.

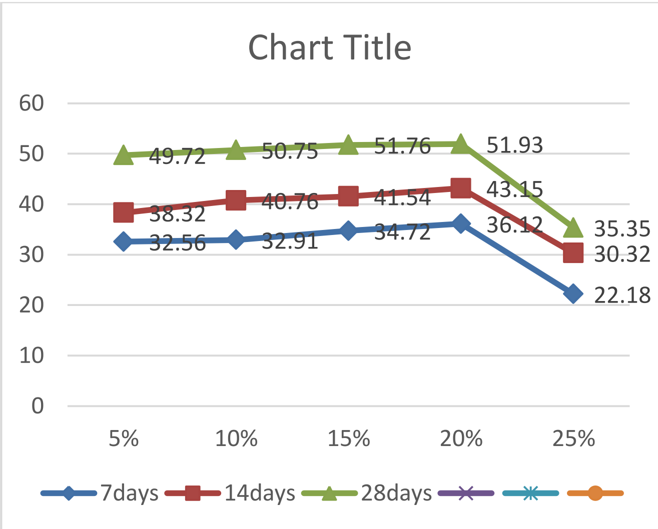
Therefore the breaking point cracks were formed around Marble, Granite and Spent fire brick aggregates and cement paste in Marble, Granite and Spent fire brick concrete. Although the compressive strength values have considerably increased with the addition of waste Marble, Granite and Spent fire brick.

Analysis of Compressive Strength (Mpa)

Grade of concrete	**M40**	**M40**	**M40**	**M40**	**M40**
%of spent fire brick	**5%**	**10%**	**15%**	**20%**	**25%**
7days kn/m²	32.56	38.91	34.72	36.12	22.18
14days kn/m²	38.32	40.76	41.54	43.15	30.32
28days kn/m²	49.72	50.75	51.76	51.93	35.35

Analysis of Spent Fire Brick(20mm)





IV. CONCLUSION

Based on limited experimental investigation concerning the compressive and split tensile strength of concrete, the following observations are made regarding the resistance of partially replaced fine and coarse aggregates.

1. Marble and granite waste cement bricks yield similar mechanical, in terms of compressive strength, and physical, in terms of density and absorption, properties. There is a positive effect of granite waste on cement brick samples that reach its optimum at 20% granite waste incorporation.
2. The SFB is a locally available, low cost, and inert industrial solid waste whose disposal is a matter of concern likes construction waste. On an overall, the CSFB can be comparable to the natural river sand.
3. From the obtained results we observe that the maximum strength is achieved by 25% of CSFB replacement in concrete. The 30th% of CSFB replacement in concrete indicates there is no strength gaining after increasing the proportion.
4. The accelerated hydration, endued by heating, compensated the detrimental effect of volumetric changes associated with temperature variation.
5. The compressive strength of partial replacement of CSFB aggregate concrete is marginally higher than that of the river sand aggregate concrete at age of 7 days, 14 days, and 28 days, respectively. The split tensile strength of partial replacement of CSFB aggregate concrete is higher than that of the river sand aggregate at all ages.

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