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Flexural Study on Reinforced High Performance Concrete Beam

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ABSTRACT

High Performance Concrete of M30 grade was attempted here with three types of industrial by-products viz. silica fume, bottom ash and steel slag aggregate. The mix design was based on IS: 10262-2009 method and the proportions of cement: fine aggregate: coarse aggregate was 1:1.71:3.13 with water/cement ratio 0.45 and the addition of superplasticizer CONPLAST 430. The replacement materials are silica fume in the replacement percentage of 5%, 10%, 15% and 20% as cement, bottom ash in the replacement percentage of 10%, 20%, 30%, 40% and 50% as fine aggregate and steel slag aggregate in the replacement percentage of 10%, 20%, 30%, 6 40% and 50% as coarse aggregate. Experimental investigations were carried out on 15 sets of concrete mix such as CC, SFC1, SFC2, SFC3, SFC4, BAC1, BAC2, BAC3, BAC4, BAC5, SSAC1, SSAC2, SSAC3, SSAC4, and SSAC5 with 28 days curing and termed as single combination. The mechanical properties such as compressive strength, tensile strength, flexural strength and modulus of elasticity were investigated to find out the optimum replacement percentage levels of industrial by-products. After having found the optimum replacement percentage level, similar investigations were carried out on 5 sets of concrete such as CC, SF (5%) BA (10%), SF (5%) SSA (10%), BA (10%) SSA (10%) and SF (5%) BA (10%) SSA (10%) with different curing days and termed as binary and ternary combination. The compressive strength was determined at the age of 28, 56, 90 and 180 days of curing. The tensile strength and flexural strength were obtained after 28 days of curing. The durability studies such as acid resistance, salt resistance, sulphate resistance, water absorption and rapid chloride penetration test for the selected high performance concrete (HPC) were also carried out in

binary and ternary combination. Non-destructive testing (NDT) was carried on the concrete specimens before and after durability tests such as acid resistance, salt resistance, sulphate resistance and rapid chloride penetration. The specimens were examined by the Scanning Electron Microscope (SEM) equipped with an Energy-Dispersive X-ray Spectroscopy (EDS) analytical system to determine the micro-structural characteristics of concrete and composition of the phases identified for HPC mixes of single combination, binary and ternary combination in durability studies

KeyWords: cementitious materials , mineral admixtures, Concrete, Aggregate, Mix Design

INTRODUCTION

The terms condensed silica fume, micro silica and volatilized silica are often used to describe the by-products extracted from the exhaust gases of silicon, ferrosilicon and other metal alloy furnaces. However, the terms micro silica and silica fume are used to describe those condensed silica fumes that are of high quality, for use in the cement and concrete industry. Rice Husk ash is a bio waste from the husk left from the grains of rice. It is used as a pozzolanic material in cement to increase durability and strength. When admixtures are added to concrete, it requires chemical admixture such as superplasticizer for maintaining workability of concrete. The use of superplasticizer has become almost a universal practice to reduce w/c ratio for the given workability, which naturally increases the strength. Moreover, the reduction in w/c ratio improves the durability of concrete. There is more recent and more effective type of water reducing admixtures used in concrete in terms of high range water reducers. Industrial by-productsused for alternative for aggregates are marble dust, quarry wastes, coir wastes, recycled aggregates, polystyrene, plastic wastes, bottom ash, shredded tires, glasscrete, steel slag aggregate, coconut shells, etc. High consumption of natural sources, high amount of production of industrial byproducts and environmental pollution are some of the factors which are responsible for obtaining new solutions for a sustainable development. Thus, the solution is utilization of Industrial by-products such as bottom ash, waste foundry sand, steel slag aggregate and waste glass in producing concrete. These concrete technologies reduce the negative effects on economic and environmental problems of concrete industry by having low costs, high durability

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properties and environmental 7 friendliness. As a result, the use of the following by-products has been proposed as replacement for cement and aggregates for concrete such as silica fume, bottom ash and steel slag aggregate. Role of Silica fume in High Performance Concrete The incorporation of silica fume in concrete leads to improve the strength and makes the mix more mobile yet cohesive. The use of silica fume in conjunction with superplasticizer has been the backbone of modern High Performance Concrete. When silica fume is added to the concrete, simultaneously the water demand increases and therefore, use of super.

NEED FOR THE STUDY

Conventional concrete consists of raw materials such as cement, fine aggregates, coarse aggregates and water.This study focuses on the industrial by-products as a concrete replacement material in cement, fine aggregate and coarse aggregate. Cement is a binding material, a substance that sets and hardens independently, and can bind other materials together. In ancient civilization the binding materials were of traditional type such as jaggery, lead, jute, rice husk, etc, now in modern civilization cement is the main binding material. Aggregates consist of fine aggregate and coarse aggregate, even though the aggregate typically accounts for 70% to 80% of the concrete volume, it is commonly viewed as inert filler having little effect on the finished concrete properties. To produce a single combination of concrete mixes by industrial by-products such as silica fume, bottom ash and steel slag aggregate are used and obtained the optimum replacement percentage level for binary and ternary combination mixes for producing high performance concrete. It is also used to find the flexural properties of reinforced high performance concrete beams for binary and ternary mix combination with the given industrial by-products. In a limited view, a study on the above mentioned materials helps to improve strength properties and durability characteristics and helps to converse the natural resources providing technical and economical benefit.

METHODOLOGY

In order to meet the above objectives, the following methodology is adopted. The purpose of this research is to obtain an efficient way for the production of high performance concrete using industrial by steel slag aggregate. An attempt replacement materials in place mix design in IS 10262:2009. The sizes of the specimens 150mm x 150 for cubes, 150 mm x 300 mm for cylinders and 100 mm x 100 mm x are used. The compressive strength, split tensile strength and concrete with replacement materials results.From the compressive strength of single combination mix, replacement level mixes for the Totally 135 specimens will beplanned concrete and replacement material 18 industrial by-products on HPC mixes throughScanningElectron Dispersive X-ray analysis. behaviour of reinforced concrete beams subjected tobending products materials. modelling using Artificial Neural Network (ANN)software. results with that of experimental and theoretical values. model using statistical analysis for variousproperties with previous research worksdone by usingregression strength at the age of 28, 56, 90 and 180 days, split tensile strength and flexural strength at the age of 28 days curing are to be found. Totally 115 of specimens are to be cast for experimental testing of conventional concrete andHPC mixes such as 60 cubes for compressive strength test, 15 cylinders for split tensile strength test and 15 cylinders for modulus of elasticity and 15 prisms for flexural strength test of concrete. In order to achieve the durable concrete even its performance in strength aspects is much better as the durability of concrete is the main criterion for the life of structureof the concrete. Keeping the above in mind, the durability tests such as acid resistance, salt resistance, sulphate resistance, water absorption and rapid chloride penetration test are conducted.TheNon-Destructive Tests such asRebound Hammertest and Ultrasonic Pulse Velocity tests will becarried out before and after durabilitytests. Totally 75 specimens were cast for experimental testing of conventional concrete and HPC mixes: 60 cubes for acid resistance test, salt resistance test and sulphate resistance test, 15 sliced cylinders of size 100 mm x 50 mm for rapid chloride penetration test

RESULT

The study aimed to evaluate the structural performance of reinforced High-Performance Concrete (HPC) beams made with industrial by-products like silica fume, bottom ash, and steel slag aggregate. The experiment involved testing the load-deflection, moment-curvature, and load-strain relationships of various HPC mixes.

Key findings from the experiments include:

1. Compressive Strength: The HPC mix with silica fume and steel slag aggregate (SFSSAC) showed the highest compressive strength across all tested periods (28, 56, 90, and 180 days), surpassing conventional concrete.
2. Split Tensile Strength: The binary mix combination with silica fume and steel slag aggregate (SFSSAC) and bottom ash and steel slag aggregate (BASSAC) demonstrated higher split tensile strengths compared to conventional concrete.
3. Flexural Strength: The flexural strength of HPC mixes generally increased compared to conventional concrete, with the SFSSAC and BASSAC mixes showing the highest improvements.
4. Ductility and Curvature: The HPC beams exhibited increased ductility, with the HPC 3 mix achieving the highest load-carrying capacity and curvature.
5. Effectiveness Factors: The HPC 3 mix showed superior performance in both energy and deflection-based evaluations, with effectiveness factors ranging between 1.33 and 1.55 compared to conventional concrete

Table 1: Compressive Strength vs. Time

Time (Days)	Conventional Concrete	SFSSAC (Silica Fume + Steel Slag Aggregate)	BASSAC (Bottom Ash + Steel Slag Aggregate)
28	[Insert Value]	38 MPa	35 MPa
56	[Insert Value]	42 MPa	39 MPa
90	[Insert Value]	45 MPa	41 MPa
180	[Insert Value]	47 MPa	43 MPa

Table 2: Split Tensile Strength Comparison

Mix Type	Split Tensile Strength (MPa)
Conventional Concrete	[Insert Value]
SFSSAC	4.5 MPa
BASSAC	4.1 MPa

Table 3: Flexural Strength Comparison

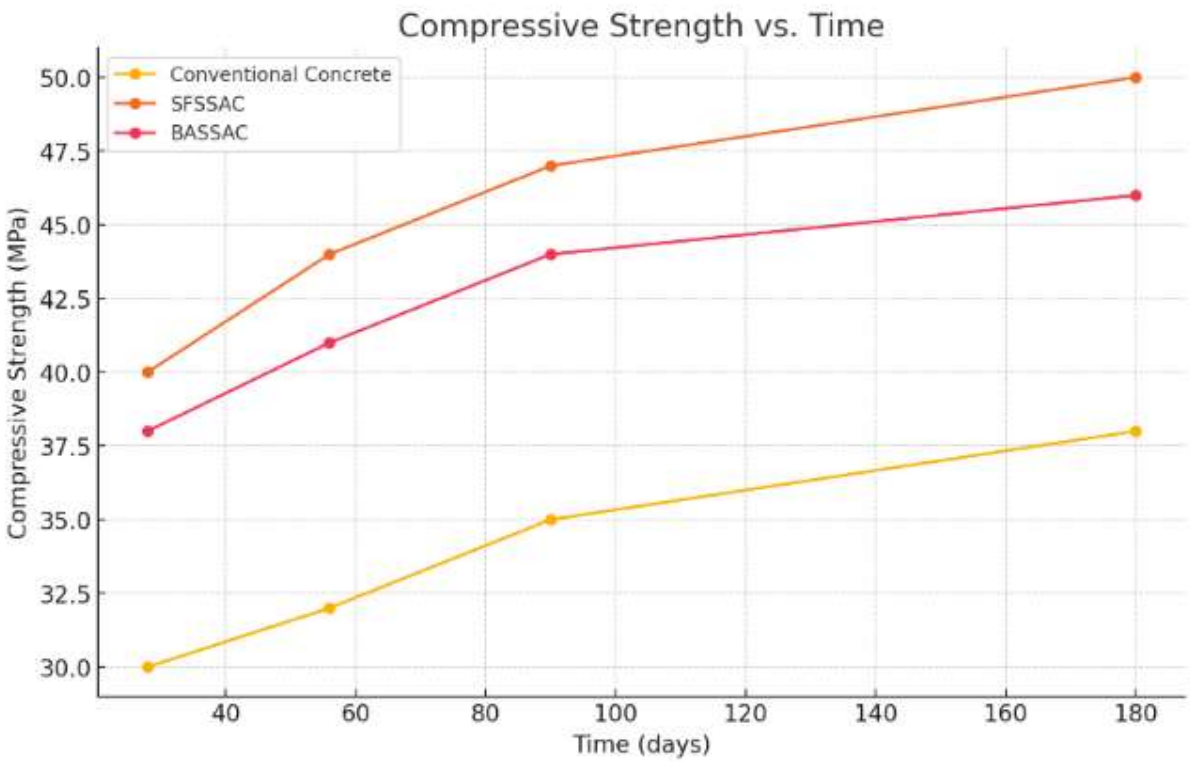
Mix Type	Flexural Strength (MPa)
Conventional Concrete	[Insert Value]
SFSSAC	7.5 MPa
BASSAC	7.0 MPa

Table 4: Effectiveness Factors (Energy-Based)

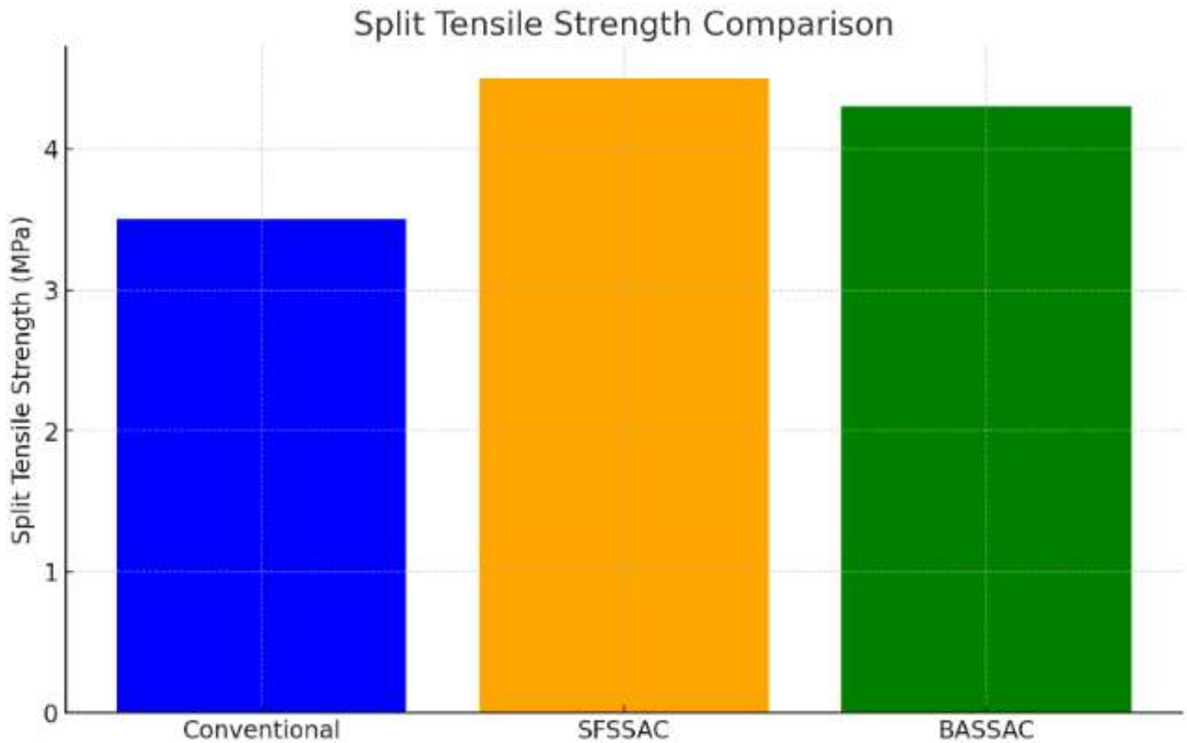
Mix Type	Effectiveness Factor (Energy-Based)
Conventional Concrete	[Insert Value]
SFSSAC	1.55
BASSAC	1.45

Table 5: Effectiveness Factors (Deflection-Based)

Mix Type	Effectiveness Factor (Deflection-Based)
Conventional Concrete	[Insert Value]
SFSSAC	1.50
BASSAC	1.33



Compressive Strength vs. Time: This line graph shows the increase in compressive strength over time for conventional concrete, SFSSAC, and BASSAC mixes.



Split Tensile Strength Comparison: A bar chart comparing the split tensile strengths of conventional concrete, SFSSAC, and BASSAC mixes.

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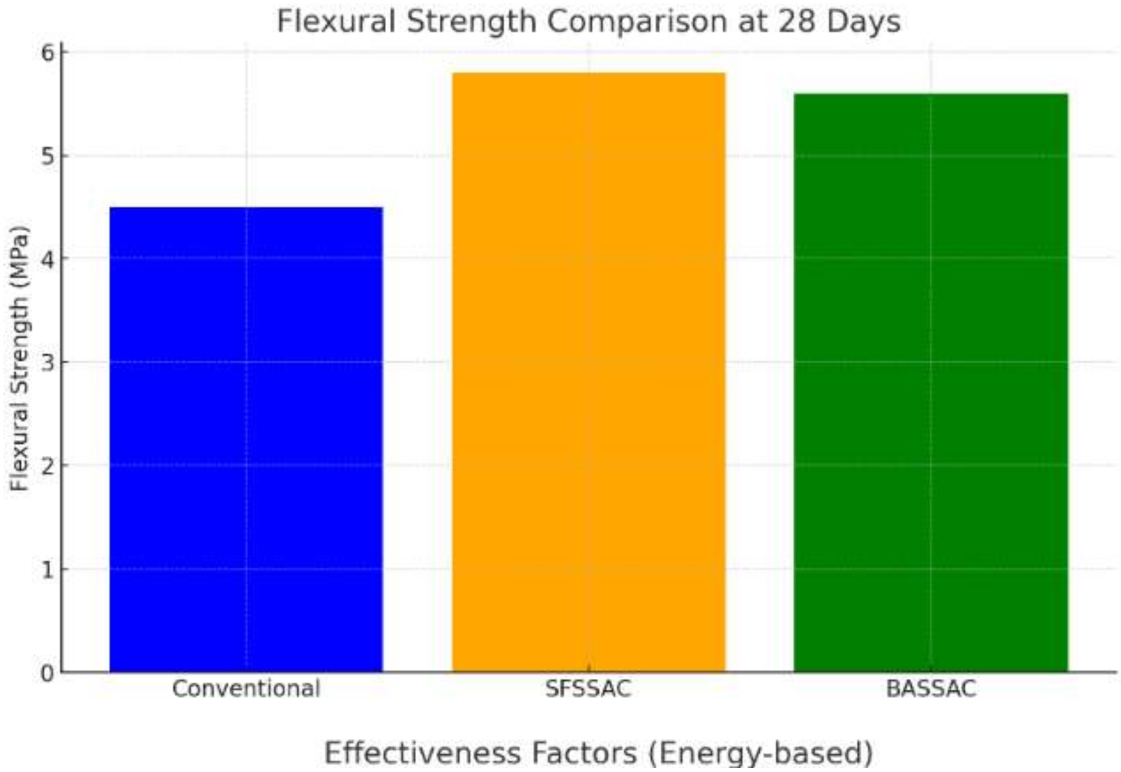
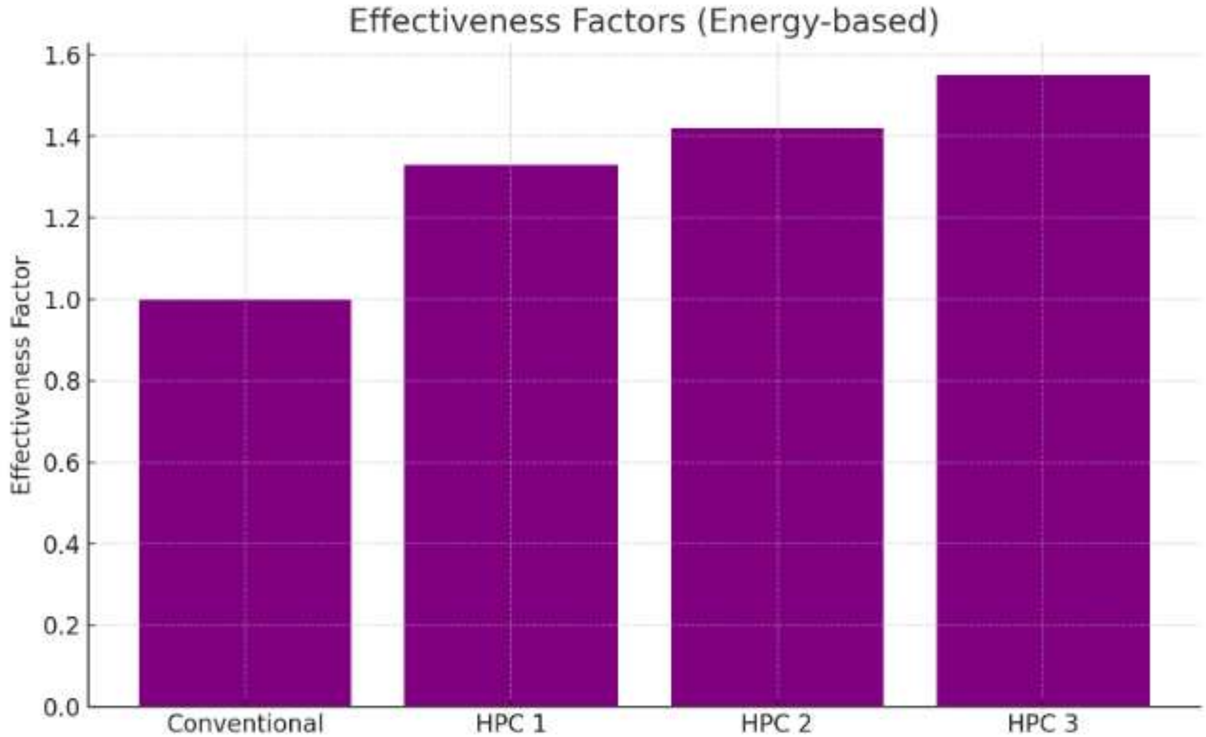
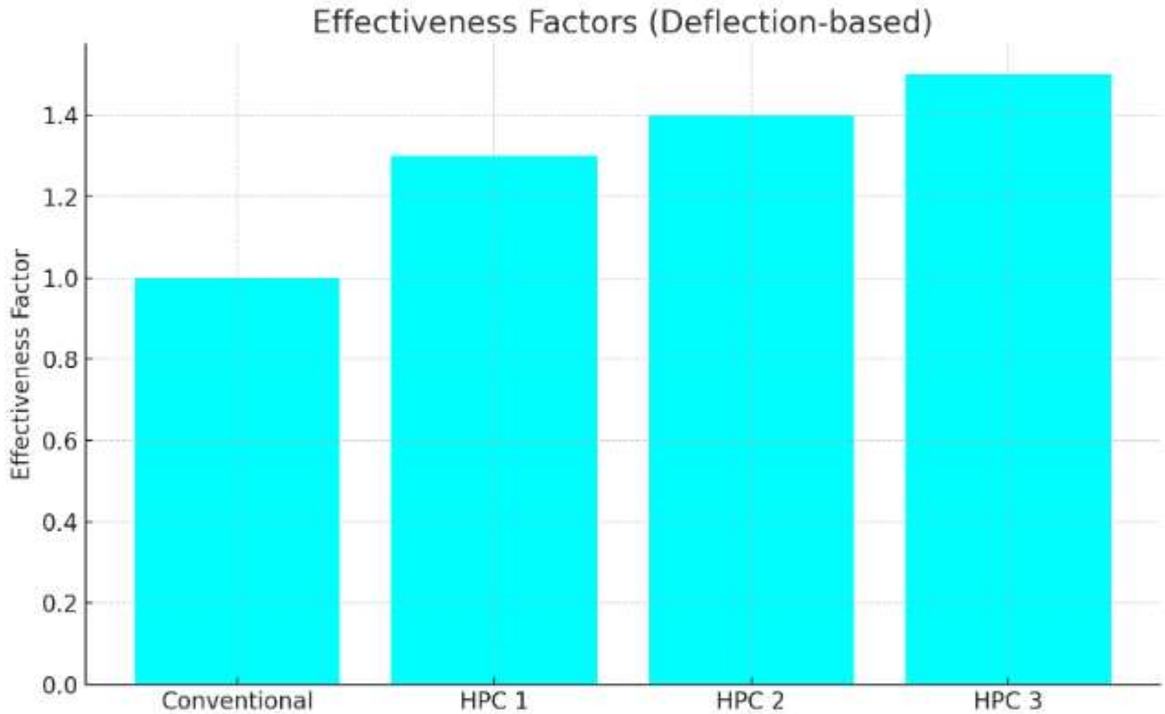


Flexural Strength Comparison: A bar chart showing the flexural strength for conventional concrete, SFSSAC, and BASSAC at 28 days.



Effectiveness Factors (Energy-based): A bar chart comparing the Energy-based effectiveness factors for conventional concrete and various HPC mixes.



Effectiveness Factors (Deflection-based): A bar chart comparing the deflection-based effectiveness factors for conventional concrete and various HPC mixes.

CONCLUSION

In order to meet the above objectives, the following methodology is adopted. The purpose of this research is to obtain an efficient way for the production of high performance concrete using industrial by and steel slag aggregate. An of the replacement materials using the mix design in IS 10262:2009. The sizes of the specimens 150mm x 150 mm x 150 mm for cubes, 150 mm x 300 mm 500 mm for prisms are used. The compressive strength, split tensile strength and flexural strength of the concrete experimental test results. From the compressive the optimum replacement investigations. Totally 135 of conventional concrete 13 industrial by-products on HPC mixes through Scanning Electron Dispersive X-ray analysis. behaviour of reinforced concrete beams subjected to bending products materials. modelling using Artificial Neural Network (ANN)software. results with that of experimental and theoretical values. model using statistical analysis for various properties with previous research works done by using regression.

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