

# Experimental Investigation on Concrete by Partial Replacement on Cement by Bentonite and Coarse Aggregate by Steel Slag

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**ABSTRACT:** Concrete is the third largest material consumed by human beings after food and water as per WHO. Concrete consists of cement, coarse aggregate, fine aggregate and water. During cement production carbon di oxide released in the environment that is becoming a big issue in pollution control. So there is a need of alter the cement by some natural materials which having pozzolonic properties. Aggregates obtained from natural rocks and river beds, thus degrading important to seek suitable alternatives for aggregates in the future. Tests on compressive strength, split tensile strength at 3, 7, 14 and 28 days conducted and Flexural strength of prism and optimum percentage of Bentonite is find out. Replacing different percentage of Bentonite and 60% of steel slag by weight of cement and coarse aggregate for a mix of M20 grade concrete. Bentonite is a impure clay material Steel slag is an industrial by-product of steel industry. It possesses the problem of disposal as waste and is of environmental concern. The demand for aggregate in construction industry is increasing rapidly and so is the demand for concrete. Thus it is becoming them slowly. This issue of environmental degradation, and need for aggregates demands for the usage of any other alternative source. This paper describes the optimum level of replacement for strength and workability of concrete by.

**KEYWORDS:** Bentonite, Steel Slag, Compressive Strength, Split Tensile Strength, Flexure Strength.

## I. INTRODUCTION

Concrete is one of the most widely used construction material in the world. It can be cast in diverse shapes. Concrete is a composite material formed by the combination of cement, sand, coarse aggregate and water in a particular proportion in such a way that the concrete produced meets the needs as regards its workability, strength, durability and economy. It is found to be versatile and hence gained importance in building materials. The concrete has high compressive strength, stiffness low thermal conductivity and low combustibility, but it has very low resistance tensile strength, limited ductility and little resistance to cracking. In the context of increased awareness regarding the ill effects of global warming, ecofriendly technologies are to be developed for the effective management of resources. The cost effectiveness in construction will be achieved only if we thinking from every corner of construction materials and also there is a demand for natural aggregates. Hence alternative materials must replace the construction material in concrete to meet the future problems. In this project, an attempt has made to overcome this problem by the limited use of Bentonite powder in place of Cement and steel slag as a partial replacement of coarse aggregate.

**II. MATERIALS USED**



FIG (A): STEEL SLAG

FIG (B): BENTONITE

**A. STEEL SLAG**

Steel slag, a by-product of steel making, is produced during the separation of the molten steel from impurities in steel-making furnaces. The slag occurs as a molten liquid melt and is a complex solution of silicates and oxides that solidifies upon cooling.

**B. BENTONITE**

Bentonite is an absorbent aluminium phyllosilicate, impure clay consisting mostly of montmorillonite. Bentonite is available in powder and solution form, which can replace cement up to 40% of cement used in the concrete. Bentonite presents strong colloidal properties and its volume increases several times when coming into contact with water, creating a gelatinous and viscous fluid. The ionic surface of Bentonite has the useful property in making a sticky coating on sandgrains.

**III. MATERIAL PROPERTIES**

**A. CEMENT**

In this project, 53 grade cement is used for the experimental study.

**B. FINE AGGREGATE**

A concrete with better quality can be made with sand consisting of rounded grains rather than angular grains.

**TABLE (1): PROPERTIES OF CEMENT**

PHYSICAL TEST	RESULTS
Specific Gravity	3.15
Fineness of cement	2.85
Initial Setting Time	40 mins
Final setting Time	320 mins
Grade of Cement	OPC – 53

**TABLE (2): PROPERTIES OF FINE AGGREGATE**

PHYSICAL TEST	RESULTS
Specific Gravity	2.6
Bulk Density	1843 Kg/m <sup>3</sup>
Sieve Analysis	Zone II

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**TABLE (3): PROPERTIES OF COARSE AGGREGATE**

PHYSICAL TEST	RESULTS
Specific Gravity	2.6
Bulk Density	1410 Kg/m <sup>3</sup>
Sieve Analysis of CA	20 mm

**TABLE (4): TEST ON BENTONITE**

PROPERTIES	VALUE
Fineness	3.4
Specific Gravity	2.41
Size passing	90µm sieve
Water Absorption Ratio	1 %

**TABLE (5): TEST ON STEEL SLAG**

SLAG SOURCE	AGGREGATE IMPACT VALUE (%)	REMARKS
Source 1	42 %	Marginal
Source 2	35.76 %	Acceptable
Source 3	33 %	Acceptable

## IV. TEST ON FRESH CONCRETE

**TABLE (6): SLUMP CONE TEST ON FRESH CONCRETE**

PERCENTAGE OF REPLACEMENT	W/C RATIO	SLUMP VALUE	NATURE OF COLLAPSE
Conventional Concrete	0.5	70	True
10% Bentonite 60% Steel Slag	0.5	68	True
20% Bentonite 60% Steel Slag	0.5	72	True
30% Bentonite 60% Steel Slag	0.5	65	True

## V. MATERIAL PROPORTIONING

**TABLE (7): MIX PROPORTION OF CONCRETE**

PERCENTAGE REPLACEMENT	CEMENT (Kg)	BENTONITE (kg)	FA (kg)	STEEL Slag (kg)	CA (kg)
Conventional Concrete	1.9075	-	1.9075	-	3.8151
10% Bentonite 60% Steel Slag	1.7168	0.1907	1.9075	2.289	1.5261
20% Bentonite 60% Steel Slag	1.5263	0.3815	1.9075	2.289	1.5261
30% Bentonite 60% Steel Slag	1.3353	0.5722	1.335	0.573	3.8151

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## VI. TESTING OF SPECIMENS

### A. COMPRESSION TEST ON CUBES

The test is done on 7<sup>th</sup>, 14<sup>th</sup>, 28<sup>th</sup> day of curing to determine the compressive strength of concrete specimens as per IS: 516 – 1959. The compressive strength of the cube is determined by the following formula and expressed in terms of N/mm<sup>2</sup>.

Compressive strength = Maximum load /area

**TABLE (8): COMPRESSION STRENGTH OF CUBES**

PERCENTAGE OF REPLACEMENT	COMPRESSIVE STRENGTH N/mm <sup>2</sup>		
	At 7 <sup>th</sup> Day	At 14 <sup>th</sup> Day	At 28 <sup>th</sup> Day
Conventional Concrete	12.5	17.2	20.4
10% Bentonite 60% Steel Slag	13.2	19.8	21.8
20% Bentonite 60% Steel Slag	14.7	21.1	23.7
30% Bentonite 60% Steel Slag	12.1	18.9	21

### B. SPLIT TENSILE TEST ON CYLINDERS

The test is done on 7<sup>th</sup>, 14<sup>th</sup>, 28<sup>th</sup> day of curing to determine their split tensile strength. The specimens are placed horizontally between the loading surface of the Compression testing machine and the load is applied till the specimens fails. The ultimate load at the time of the failure is noted down.

Horizontal compressive strength =  $2p / LD$ . Where p, is the compressive load.

L is the length of the cylinder, D is the diameter of the cylinder.

**TABLE (9): SPLIT TENSILE STRENGTH OF CYLINDER**

PERCENTAGE OF REPLACEMENT	TENSILE STRENGTH N/mm <sup>2</sup>		
	7 <sup>th</sup> Day	14 <sup>th</sup> Day	28 <sup>th</sup> Day
Conventional Concrete	2.12	2.68	3.11
10% Bentonite 60% Steel Slag	2.40	2.90	3.46
20% Bentonite 60% Steel Slag	2.68	3.25	3.82
30% Bentonite 60% Steel Slag	1.98	2.47	2.83

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### C. FLEXURAL STRENGTH OF PRISM

Flexural strength test was carried out on Prisms of size 150 mm × 150 mm × 750 mm at the age of 28 days after curing. The flexural strength is calculated as follows IS: 516 (1959). The flexural strength of the specimen shall be expressed as the modulus of rupture  $f_b$ ,

$$f_b = 3p \times a / bd^2$$

**TABLE (10): FLEXURE STRENGTH OF PRISM**

PERCENTAGE OF REPLACEMENT	FLEXURAL STRENGTH N/mm <sup>2</sup>
Conventional Concrete	3.88
10% Bentonite 60% Steel Slag	4.11
20% Bentonite 60% Steel Slag	4.87
30% Bentonite 60% Steel Slag	4.01

### D. ACID ATTACK TEST

For acid attack test concrete cube of size 150mm x 150mm x 150 mm are prepared for various percentages of Bentonite and Steel Slag addition. The specimens are weighed and immersed in 5% sulphuric acid (H<sub>2</sub>SO<sub>4</sub>) solution for 56 days. After 56 days of immersing in acid solution and tested.

Acid Attack Factors per face is calculated as follows,

- Acid Attack Factor, AAF = ( Loss in mm on eight corners of each of 2 cubes ) / 4
- Acid Attack Factor for Conventional Concrete, AAF = 5/4 = 1.25

Acid Attack Factor for specimen with  
20% Bentonite and 60% Steel Slag,

Acid Attack Factor = 2/6 = 0.33.

**TABLE (11): ACID ATTACK TEST WEIGHT LOSS**

PERCENTAGE OF REPLACEMENT	WEIGHT OF SPECIMEN AFTER IMMERSION (g)	WEIGHT OF SPECIMEN BEFORE IMMERSION (g)	WEIGHT LOSS (g)
CC	7435	7045	390
20% Bentonite and 60% Steel Slag	7312	7089	223

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**TABLE (12): ACID ATTACK TEST STRENGTH LOSS**

PERCENTAGE OF REPLACEMENT	STRENGTH OF SPECIMEN AFTER IMMERSION (g)	STRENGTH OF SPECIMEN BEFORE IMMERSION (g)	STRENGTH LOSS (g)
CC	28.73	23.53	5.2
20% Bentonite and 60% Steel Slag	30.81	26.11	4.7

### E. WATER ABSORPTION TEST

The concrete specimens of 150mm x 150mm x 150mm are casted and they are kept for curing for 56 days, after which they are kept for dry in an oven at a temperature of 110°C for not less than 24 hrs. After removing each specimen from the oven, they are allowed to cool in dry air to a temperature of 20 to 25 °C and determine the weight. Then its first weight is determined and designated as “A”. Then the specimen, after final drying, cooling, and determination of weight, they are kept in water at approximately 21 °C for not less than 48 h and then the specimens are kept for surface drying by removing surface moisture with a towel, and then the mass is determined and designated as “B”.

Absorption after immersion, % = [(B – A) / A] x 100

Where,

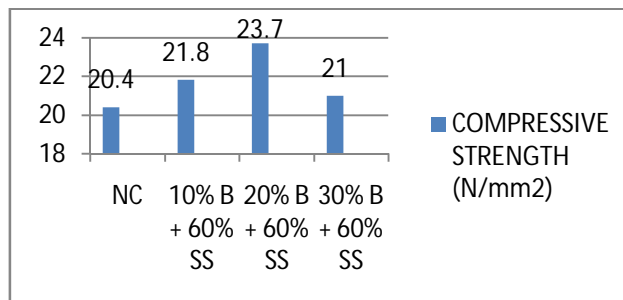
A = weight of oven-dried sample in air, g.

B = weight of surface-dry sample in air after immersion, g.

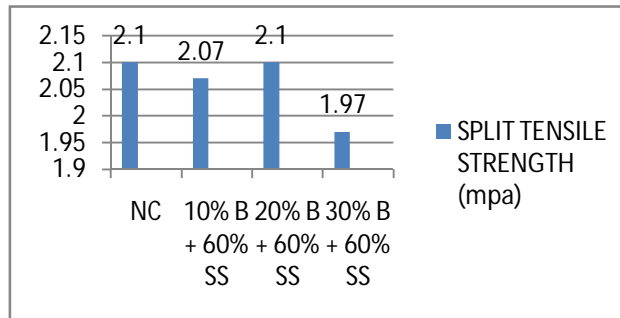
- Weight of oven-dried conventional concrete specimen, A = 6605 g
- Weight of specimen after immersion in water, B = 7130 g
- Absorption after immersion, %  
= [(7130 – 6605) / 6605] x 100  
= 7.94%
- weight of oven-dried specimen with 20% Bentonite and 60% Steel Slag, A = 6452 g
- weight of specimen after immersion in water, B = 6790 g
- Absorption after immersion, %  
= [(6790 – 6452) / 6452] x 100  
= 5.23%

### VII. RESULTS AND DISCUSSIONS

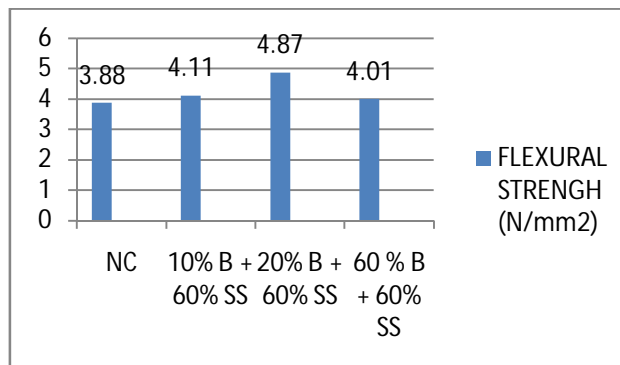
The results and discussions about the various tests are as follows,



**FIG (C): 28 DAYS COMPRESSIVE STRENGTH OF CUBES**



**FIG (D): TENSILE STRENGTH OF CYLINDERS**



**FIG (E): FLEXURAL STRENGTH OF PRISMS**

From the results obtained from the various tests, the following conclusions were made,

- After conducting all the tests on the specimen, it has been observed that upto 20% replacement of cement with bentonite proved to be good in Compression, as well as in Tension, whereas the concrete properties with equal proportion of Bentonite and conventional cement confirmed to be inefficient.
- The experimental study has proved to be better method in providing strong and durable concrete. It also gives solution to disposal problem of steel slag.
- From this we conclude that Cement can be replaced by bentonite partially without affecting strength characteristics.
- The compressive strength and split tensile strength of the cubes and cylinders increases when the 10% and 20% of cement is replaced by BENTONITE and 60% of Coarse aggregate is replaced by Steel slag. When the 30% of cement is replaced by Bentonite with 60% of Steel Slag, slight reduction in the compressive strength and split tensile strength is observed.
- 16.8% increment in the compressive strength is found at 20% replacement of cement by Bentonite and 60% of Coarse aggregate by Steel Slag at 28 days when compared to normal concrete. And the strength decreases by 13.7% when the cement is replaced by 30% of Bentonite and Coarse aggregate is replaced by 60% of Steel slag.
- 7.2% increment in the flexural strength is found at 20% replacement of cement by Bentonite and 60% of Coarse aggregate by Steel slag at 28 days when compared to normal concrete and the strength decreases by 5.24% when the cement is replaced by 30% of Bentonite and Coarse aggregate is replaced by 60% of Steel slag.
- From the results obtained in water absorption test, the specimen with 20% Bentonite and 60% Steel slag shows 34.13% lesser water absorption when compared with the conventional concrete.

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- From the results obtained in acid attack test, the specimen with 20% Bentonite and 60% Steel slag shows 29.11% lesser weight loss when compared with the conventional concrete.
- From the results obtained in acid attack test, the specimen with 20% Bentonite and 60% Steel slag shows 26.17% lesser strength loss when compared with the conventional concrete.
- From the results obtained in acid attack test, the specimen with 20% Bentonite and 60% Steel slag shows 35% lesser Acid Attack Factor (AAF) when compared with the conventional concrete.

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