

Performance Assessment of Sustainable Concrete Using Steel Slag Aggregate and Bentonite-Modified Cementitious Matrix

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Abstract: -

According to the WHO, concrete is the third most consumed material by humans after food and water. Concrete consists of cement, coarse aggregate, fine aggregate and water. In the production of cement, carbon dioxide is released into the environment, which becomes a big problem for environmental protection. Therefore, there is a need to modify the cement with some natural materials with pozzolanic properties. The aggregates, which are extracted from natural rocks and riverbeds, are used mined, it is important to look at alternatives to aggregates in the future. Compressive strength tests, split tensile strength tests after 3, 7 and 28 days were carried out and the flexural strength of the prism was determined, as well as the optimum content of bentonite, with different proportions of bentonite and 60% iron and steel slag replacing the weight of cement and coarse aggregate for a mix of M30 class concrete. It has the problem of disposal as waste and is of ecological interest. Steel slag is an industrial by-product of the steel industry. It is a non-metallic ceramic material formed by the reaction of fluxes such as calcium oxide with the non-metallic inorganic components present in steel scrap. The use of steel slag reduces the need for natural rock as a building material and thus protects our natural rock resources as much as possible. The recovery and recycling of recovered by-products and waste materials have economic and environmental reasons led to a rapid development of slag recycling. This way of using a waste material can solve problems of aggregate shortage at various construction sites and reduce environmental problems associated with aggregate mining. and steel slag, and it was found that there is more room for future research on bentonite dust and steel slag in the future. For our experiment, we need to study the strength of concrete by partially replacing cement with bentonite powder and C. with steel slag. We will try to substitute 0%, 10%, 20% and 30% bentonite powder and 60% steel slag. Tests such as

compressive strength, splitting tensile strength and flexural strength are examined, although these are higher values compared to conventional concrete.

Key Words: Induction furnace slag; Super plasticizer; Compressive strength; Cleavage strength Flexible power, Billing test.

INTRODUCTION: -

Concrete is one of the most frequently used building materials in the world. Thermal conductivity and low flammability, but has very low tensile strength, limited ductility and low crack resistance. In the context of increased awareness of the harmful effects of global warming, green technologies need to be developed for effective resource management. Economics in construction can only be achieved if the building material is thought of down to the smallest detail and there is also a demand for natural aggregates, so the alternative materials must replace concrete as a building material in order to meet future problems. This project attempted to overcome this problem through the limited use of bentonite powder instead of cement and steel slag as a partial substitute for coarse aggregate.

The result of Targan (2002) showed that the setting time of cements was generally accelerated when bentonite replaced part of the cement. of a primary mineral called montmorillonite, which gives it its properties. Metakaolin clay appears to have the greatest overall potential as an alternative pozzolanic material for concrete due to its availability in large quantities and relatively inexpensive price. This way of using a waste material can solve aggregate shortage problems at various construction sites and reduce environmental problems associated with aggregate extraction and waste disposal. Steel slag is an industrial by-product of steel production. Consequently, this project work investigates that M30 grade concrete was poured, varying the percentage replacement of coarse aggregate and cement by steel slag and bentonite powder, respectively.

In that gift paintings, a strive has been made to apply bentonite powder as a supplementary binding cloth for cement. The fundamental goal of this paintings is to examine clean and hardened residences of M-30 grade concrete and urban made with bentonite powder as a partial alternative of cement and metallic slag partial alternative of coarse aggregate.

Objectives: -

Consequently, the main objectives of this investigations are to,

- Determining the degree of strength improvement in concrete obtained after addition of Steel slag and Bentonite powder.
- Compare the properties of conventional concrete mix M30 with the properties of concrete with steel slag and Bentonite partially replacing Coarse aggregate and Cement respectively.
- Find the optimum percentage of bentonite powder that can be replaced for cement.

METHODOLOGY: -

The individual ingredients required for the casing of desired mix were collected and testes were carried for determining their physical properties. The mix proportion for this obtained by using different percentage of Bentonite powder is 0%, 10%, 20%, and 30% and the percentage of steel slag is 60%. The standard mix proportion for a M30 grade conventional concrete mix was obtained as per IS 10262-2009. The mixing in their fresh and hardened states are evaluate.

Physical properties of Steel Slag

Sr. No	Tests	Values
1	Specific gravity	2.97
2	Fineness modulus	5.32
3	Water absorption	0.64%
4	Crushing value	29.00%
5	Impact value	18.50%
6	Abrasion value	28.00%

Chemical Composition of steel slag

Constituent	composition (%)
Aluminium oxide	1-3
Calcium oxide	40-52
Iron oxide	10-14
Magnesium oxide	5-10
Manganese oxide	5-8
Silica	30-35

Physical properties of Bentonite powder

Sr. No.	Tests	Value
1	Specific Gravity	2.41
2	Fineness	3.4
3	Size passing	90-micron sieve
4	Water Absorption	1 %

MIX DESIGN DATA FOR M30 GRADE OF CONCRETE (AS PER IS 10262-2009)

Characteristics compressive strength	: 30Mpa
Maximum size of aggregate	: 12mm down
Degree of workability	: High
Degree of quality control	: Very good
Type of Exposure (Assumed)	: Mild
Type of aggregate	: Sub-angular aggregate

Test Data for Materials:

Specific gravity of cement	: 3.15
Specific gravity of coarse aggregate	: 2.68
Specific gravity of Fine aggregate	: 2.63
Moisture content of coarse aggregate	: Nil
Grading of the Aggregate	: Zone II
Standard Deviation	: 5
Entrapped air	: 3% of volume of concrete
Water-cement ratio	: 0.40

1. Target Mean strength

$$f_{ck}^* = f_{ck} + t \times S$$

$$\therefore f_{ck}^* = 30 + 1.65 \times 5$$

$$\therefore f_{ck}^* = 38.25 \text{ N/mm}^2$$

2. Selection of W/C Ratio

w/c ratio – 0.40 (From graph)

w/c ratio – 0.55 (For mild exposure)

Final w/c ratio = 0.40 (Lesser of the two mentioned above)

3. Determination of Cement content

$$C = \frac{\text{Water content}}{\text{w/c ratio}}$$

$$\therefore C = \frac{200}{0.40}$$

$$\therefore C = 500 \text{ kg/m}^3$$

4. Determination of Fine Aggregate and Coarse aggregate

$$V = \left[W + \frac{C}{S_c} + \frac{P}{S_p} + \frac{F_a}{S_{fa}} \right] \times \frac{1}{100}$$

$$\therefore 0.97 = \left[200 + \frac{500}{3.15} + \frac{1}{0.4} + \frac{F_a}{2.63} \right] \times \frac{1}{100}$$

$$\therefore F_a = 643.53 \text{ kg/m}^3, \text{ say } 644 \text{ kg/m}^3$$

$$C_a = \left(\frac{1-P}{P} \right) \times F_a \times \frac{S_{cm}}{S_{fa}}$$

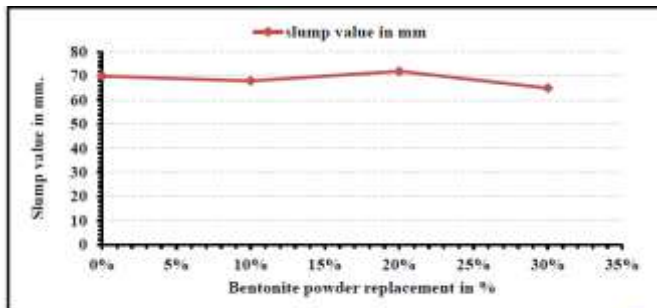
$$\therefore C_a = \left(\frac{1-0.40}{0.40} \right) \times 643.53 \times \frac{2.68}{2.63}$$

$$\therefore C_a = 984.67 \text{ kg/m}^3, \text{ say } 985 \text{ kg/m}^3$$

TEST & RESULT: -

Slump cone test on fresh concrete

Percentage of Replacement	W/C Ratio	Slump Value	Nature of Collapse
Conventional concrete	0.40	70	True
10% Bentonite 60%Steel Slag	0.40	68	True
10% Bentonite 60%Steel Slag	0.40	72	True
10% Bentonite 60%Steel Slag	0.40	65	True



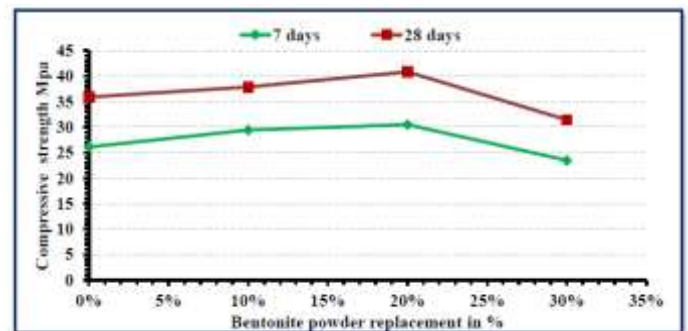
Slump of concrete in mm

Compressive strength of concrete for Different percentage of Bentonite powder and 60% of Steel slag constant for curing days

Sr. No.	Percentage of replacement	Compressive strength in N/mm ²	Average compressive strength in N/mm ²
1	Conventional Concrete	23.98	26.11
		28.92	
		25.44	
2	10% Bentonite 60%Steel slag	31.31	29.44
		29.26	
		27.74	
3	20% Bentonite 60%Steel slag	27.29	30.48
		34.01	
		30.14	
4	30% Bentonite 60%Steel slag	23.95	23.47
		24.94	
		21.53	

Compressive strength of concrete for Different percentage of Bentonite powder and 60% of Steel slag constant for 28 days curing

Sr. no.	Percentage of replacement	Compressive strength in N/mm ²	Average compressive strength in N/mm ²
1	Conventional Concrete	38.46	35.88
		36.03	
		33.12	
2	10% Bentonite 60%Steel slag	38.97	37.86
		38.05	
		36.56	
3	20% Bentonite 60%Steel slag	38.75	40.83
		42.92	
		40.83	
4	30% Bentonite 60%Steel slag	34.46	31.44
		29.48	
		30.38	



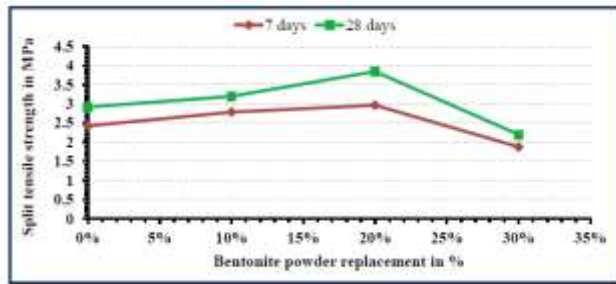
Average Compressive strength in MPa

Split tensile strength of concrete for Different percentage of Bentonite powder and 60% of Steel slag constant for 7 days curing

Sr. no.	Percentage of replacement	Tensile strength in N/mm ²	Average Tensile strength in N/mm ²
1	Conventional Concrete	2.52	2.43
		2.06	
		2.70	
2	10% Bentonite 60%Steel slag	2.80	2.79
		2.62	
		2.95	
3	20% Bentonite 60%Steel slag	3.20	2.97
		3.55	
		2.16	
4	30% Bentonite 60%Steel slag	1.92	1.88
		2.12	
		1.61	

Split tensile strength of concrete for Different percentage of Bentonite powder and 60% Steel slag of constant for 28 days curing

Sr. No.	Percentage of replacement	Tensile strength in N/mm ²	Average Tensile strength in N/mm ²
1	Conventional Concrete	2.82	2.92
		2.91	
		3.05	
2	10% Bentonite 60%Steel slag	3.20	3.20
		3.57	
		2.83	
3	20% Bentonite 60%Steel slag	3.71	3.85
		3.54	
		4.31	
4	30% Bentonite 60%Steel slag	2.22	2.20
		2.56	
		1.82	



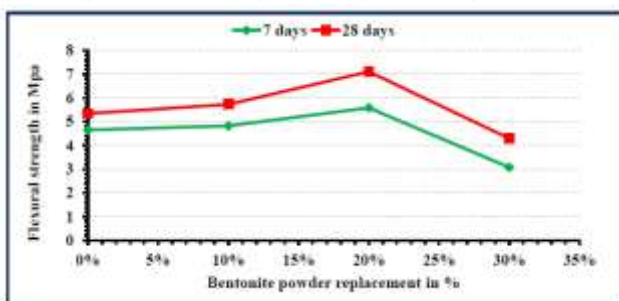
Average Split tensile strength in MPa

Flexural strength of concrete for Different percentage of Bentonite powder and 60% of Steel slag constant for 7 days curing.

Sr. no.	Percentage of replacement	Flexural strength In N/mm ²	Average Flexural strength in N/mm ²
1	Conventional Concrete	4.52	4.65
		5.03	
		4.43	
2	10% Bentonite 60%Steel slag	4.73	4.82
		5.29	
		4.45	
3	20% Bentonite 60%Steel slag	5.73	5.58
		4.74	
		6.28	
4	30% Bentonite 60%Steel slag	3.87	3.07
		3.09	
		2.28	

Flexural Strength of concrete for Different percentage of Bentonite powder and 60% of Steel slag constant for 28 days curing

Sr. no.	Percentage of replacement	Flexural strength In N/mm ²	Average Flexural strength in N/mm ²
1	Conventional Concrete	5.77	5.34
		5.44	
		4.83	
2	10% Bentonite 60%Steel slag	5.55	5.73
		6.01	
		5.64	
3	20% Bentonite 60%Steel slag	6.79	7.11
		8.10	
		6.49	
4	30% Bentonite 60%Steel slag	4.65	4.29
		4.14	
		4.08	



Average Flexural strength in MPa

CONCLUSION: -

Based on the results and observation made in this experimental research study. The following conclusions are drawn.

1. The experimental study proved to be a better method to provide a strong and durable concrete and also solve the problem of steel slag removal.
2. After carrying out all the tests on the specimens, it was observed that up to 20% substitution of cement for bentonite achieves good compressive and splitting tensile strength, while confirming the properties of concrete with the same proportion of bentonite and conventional cement. be inefficient.
3. From this we conclude that the cement can be partially replaced with bentonite without affecting the strength properties.
4. The compressive electricity, break up tensile electricity and flexural electricity of the cubes, cylinders and beams will increase whilst the 10% and 20% of cement is changed through Bentonite and 60% of Coarse mixture is changed through metallic slag. When the 30% changed through Bentonite with 60% of Steel slag, discount in compressive electricity, break up tensile electricity and flexural electricity is observed.
5. An increase in compressive strength of 14.23 and 13.85% is observed when replacing 20% cement with bentonite and 60% coarse aggregate with steel slag after 7 and 28 days, respectively, compared to normal concrete. And resistance decreases by 10.11% and 12.37% when the cement is replaced by 30% bentonite and the coarse aggregate is replaced by 60% steel slag when the aggregate/cement ratio (A/C) is 3.25 and the water/cement ratio (A/C) 0.40.

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