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INVESTIGATION ON FERROCK BASED MORTAR AN ENVIRONMENT FRIENDLY CONCRETE

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Abstract: Concrete is the most used building material for Construction works, which is responsible for 70% of the industrial carbon dioxide emission. From this perspective, the green concrete concept has evolved and more researches have been done on replacement by green materials. Ferrock is a binder that is a blend of Iron Powder, Flyash, Lime Powder, Metakaolin and Oxalic acid. Oxalic acid acts as a catalyst and on reaction with CO_2 and water produces Iron Carbonates, which is the hardened product. It can enhance the environment by absorbing the atmospheric CO_2 for its hardening process. The current work was carried out by varying the oxalic acid (Catalyst) concentrations among the constituents of the Ferrock mortar mix. From results, it has been found that the optimum molarity of oxalic acid as catalyst was 10 moles and ferrock also absorbs considerable amount of CO_2 from the atmosphere and reduces the amount of CO_2 emitted from the industries.

Keywords: Ferrock, Oxalic acid, Mechanical Properties, CO_2 absorption.

1. Introduction

Concrete is the most utilized structural ingredient in all places. Roughly 1 ton of cement is created every year from each person on the planet. In view of the broad use, it is critical to assess the effects of this material in the environment precisely. These days, a material's ecological effect is assessed with its individual impact on ozone harming gas discharges and environmental change. From this perspective, the Green concrete ide was evolved. Globally, cement production is in charge of 5 to 7 percent of carbon dioxide generated. David Stone is the author of another concreting innovation called Ferrock, in view of iron carbonate and utilizing to a great extent reused materials to deliver around 95%. It's giving promising suggestions as a choice to concrete and a far greener construction material. Being environment friendly, Ferrock uses all the materials from scratch viz., waste metal powder, Limestone, Metakaolin and Flyash. This concreting technology is far greener, stronger and durable compared to its predecessor.

2. Literature Review

V Rajesh M Patel, Hardik J Solanki on "Development of Carbon Negative Concrete by using Ferrock", IJSRSET (2018). In their experiment they partially replaced cement with Ferrock in gradually varying proportions from 20%-30%. Specimens were cast and test for Compression, Tension and Flexure. The test results showed that 25.43% replacement gave optimal performance in compression, 17.51% in tension and 25.11% in flexure.

Alejandro Lanuza Garcia et al on "FERROCK: A life cycle comparison to ordinary portland cement", ISE 576 - Industrial Ecology (April 24 - 2017). This is the only available published journal for proportioning of Ferrock. In this paper, Life Cycle Analysis (LCA) is utilized to look at the natural effects of Ferrock and Ordinary Portland Cement, concentrating explicitly on their commitment to carbon contamination, water usage. This procedure incorporates a top to bottom natural evaluation of Ferrock generation, from the purpose of its materials extraction to all its steps. The outcomes have been contrasted with a past life-cycle investigation of OPC. This examination finds that Ferrock has both the possibility to supplant OPC, and contribute essentially to the advancement of an feasible future.

Balraj More, Pradeep Jadhav, Vicky Jadhav, Giridhar Narule, Shahid Mulani in their research paper "CO_2 Absorbing Concrete Block", IJTEEER (Volume 2, Issue – 7, ISSN 2347 – 4289). In this paper they founded the amount of CO_2 absorbed by the concrete using the Zeolite powder and Zeolite sand as a supplementary material. They found that the Zeolite Concrete absorbs around 1 mole of CO_2 from atmosphere in 50 days.

3. Materials and Properties

Ferrock is used as a binder material. Ferrock is a blend of various materials like Iron Powder, Fly Ash, Limestone, Metakaolin and Oxalic acid. Ferrock has a specific gravity of 5.29 of size 90 microns. Locally available M-Sand (passing through 2.36 mm) with Fineness modulus 4.66 having Specific gravity 2.73 were used based on IS 383 (2002). Potable tap water was used for mixing and curing of concrete.

4. Mix Proportions

Mix Proportions were arrived using "FERROCK: A life cycle comparison to ordinary Portland cement, ISE 576 - Industrial Ecology (April 24 - 2017)". In this investigation the concentrations of oxalic acid was varied (4 moles, 6 moles, 8 moles, 10 moles and 12 moles) among the constituents of ferrock. The ratio of ferrock mortar used was 1:3 with water solids ratio 0.3. The mix proportion are displayed in table 1 & 2.

Table 1. Mix Proportions of Ferrock

Materials	Proportions (% by weight)
Iron Powder	60
Fly Ash	20
Lime stone	10
Metakaolin	8
Oxalic acid	2

Table 2. Mix Proportions

Mix	Ferrock (Kg/m³)	Fine Aggregate (Kg/m³)	Oxalic Acid (Catalyst)	
			Moles	Kg/m³
M1	390	1170	4	42.12
M2	390	1170	6	63.18
M3	390	1170	8	84.24
M4	390	1170	10	105.3
M5	390	1170	12	126.3

5. Casting of Specimen

The Cubes were casted for determining the Compressive strength and carbon dioxide absorption of ferrock. The moulds of size 50 mm x 50 mm x 50 mm were used. The specimens were cleaned and applied with oil before casting. After the casting is done the casted blocks are removed from the moulds after 24 hours from the time of mixing and immersed in curing tank.

6. Results and Discussions

6.1. Mechanical Properties

The Ferrock blocks were tested for Compression at 7 & 28 days respectively. The mechanical properties were tested as per IS: 516 (1970). The results were tabulated in table 3 below for various mixes. From the results we can conclude that the compression strength is found that the strength of Ferrock is twice as that of normal conventional concrete.

Table 3. Test Results of Hardened Concrete

Mix	Compressive Strength (MPa)	
	7 Days	28 Days
M1 – 4 MOLES	32.17	45.03
M2 – 6 MOLES	33.68	48.12
M3 – 8 MOLES	34.6	50.21
M4 – 10 MOLES	36.37	53.14
M5 – 12 MOLES	36.15	52.26

Fig 1. Pictorial Representation of Compression Strength values

Fig 2. Compressive Strength Setup

6.2. Carbonation Depth test

This test was conducted by taking out the blocks from curing after 28 days and kept in atmosphere to dry. Then the blocks were sliced into pieces and phenolphthalein is applied on outer and inner surfaces of blocks. The absence of pink colour indicates the carbonated part and the presence of pink colour indicates the non - carbonated part in the blocks.

Fig 3.a. Carbonation depth of conventional concrete

Fig 3.b. Carbonation depth of Ferrock Blocks

The conventional concrete block shows pink c olour indications in the centre part which indicates non-carbonated part. The Ferrock blocks have no traces of pink indication which implies that the Ferrock has absorbed carbon dioxide for its hardening process and it is fully carbonated. The carbonation depths are displayed in Fig 3.a. & 3.b.

7. Conclusions

The following conclusions were made by the above test results on Ferrock based cement mortar,

1. From the experimental results, the optimum molarity (i.e.,grams/litre) of oxalic acid (catalyst) is found to be 10 moles for the best behavior in compression.
2. It is also found that the strength of Ferrock concrete is twice that of ordinary conventional concrete.
3. From the carbonation depth test, it is evident that the ferrock blocks absorbs considerable amount of CO_2 from the atmosphere and it is fully carbonated, as well as it also reduces the amount of CO_2 emitted from the construction industry which is currently 70%.
4. Ferrock, being Environmental friendly and all the raw materials used are from scratch, is an efficient concreting technology both in terms of strength and environmental efficiency.

7.1. Advantages

- The rate of emission of CO2 due to cement production in the industry is reduced.
- As CO_2 is used during the hardening process it helps reduce one of the most dangerous of greenhouse gases.
- As the experimental investigation concludes, it is evident that the strength of ferrock is twice that of conventional concrete.
- The incremental addition of oxalic acid increases the production of iron carbonate which respectively reflects in increased strength.

8. References

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