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Development of Carbon Negative Concrete By Using Ferrock

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ABSTRACT

Concrete is one of the most widely used building materials in Civil engineering works. From this point of view, a great variance of so-called Green concrete concept has been developed over the years. Most often these concepts focuses on partially replacing cement, the concrete constitute responsible for highest CO_2 emotions, by other materials.Ferrock is the brainchild of a PhD student David Stone (yes, that's really his name), who set out to create a viable alternative to cement. One that could be mixed and poured to make a substance with all the strength and versatility of concrete. In reality, Ferrock is actually quite a bit stronger than Portland cement, by far the leading type in use today. This work is carried out by using the ferrock as a binder material in the concrete. For that first, to check how much percentage of ferrock to be add in concrete by use of mortar cubes. After that the test like split tensile strength, compressive strength and flexural strength carried out by using cylinder, cubes and beams respectively.

Keywords: Ferrock, Versatility of concrete, mortar cubes, split tensile test, flexural test, Compressive strength

I. INTRODUCTION

Concrete is one of the most widely used building material in roads, buildings, bridges and other infrastructures. On average, approximately 1 ton of concrete is produced each year for every human being in the world. Because of this global extensive use, it is imperative to evaluate the environmental impact of this material correctly. Nowadays, a material's environmental impact is evaluated with its effect on greenhouse gas emissions and climate change. From this point of view, a great variance of so-called Green concrete concept have been developed over the years. Most often these concepts focuses on partially replacing cement, the concrete constitute responsible for highest CO2 emotions, by other materials. Worldwide, the cement industry alone was estimated to be responsible for 5-7% of all anthropogenic CO2 generated. Since this branch of industry emits no other GHGs, it is held accountable for only about 3% of total GHGs emissions generated by human activities. The challenge of the present century is to make a transition to a new form that can sustain the natural system. This requires a threadbare rethinking on ways and means of providing shelter and infrastructure for the community. Perhaps there is a necessity of making a concerted effort for developing innovative and alternative novel materials for construction. Green concrete is capable for sustainable development is characterized by application of industrial waste to reduce consumption of natural resources and energy and pollution of environment. Use of such waste materials saves 14-20% amount of cement. On the other side of the spectrum, in order to reduce the rate of climate change, a global resolution to an 8% reduction in greenhouse gas emissions by 2010 was set in the Kyoto Protocol in 1997. Developed countries are much aware for its need and a climate change tax was introduced by them. In this connection, UK Government also introduced same kind of tax on 1st April 2001, in order to achieve its target of a 12.5% reduction in greenhouse gas emissions which is the government's domestic goal of a 20% reduction in CO_2 emissions by 2010. Therefore, it is evident that, in order to keep its position as a dominant material in the future, the model of concrete industry needs to be shifted towards "sustainability"

Concrete has long been the go-to material for durable, robust and long-wearing construction. You see it absolutely everywhere – highways, bridges, buildings and sidewalks – and around 4 billion tons of cement are produced every year, having huge implications for our environment. But what if there was something stronger, more flexible, less expensive and carbon-negative to work with, acting as a sponge to literally absorb CO_2? Well, there is: Ferrock. David Stone is the brains behind a new patented concrete technology known as Ferrock, based on iron carbonate and incorporating largely recycled materials to produce (around 95%)! It's showing promising signs as an alternative to concrete and a far greener building material.

II. METHODS AND MATERIAL

Experimental Investigation: This Section presents the experimental program that was undertaken for the development of a green concrete of required strength with consistent properties.

Materials:

General use of hydraulic Portland cement (GU) with density of 3.15 kg/m^3 was used. In addition, Ferrock with density 5.29 kg/m^3 was used as supplementary cementing material. Also two type of coarse aggregated were used, which are 20mm normal size with density 2.74 kg/m^3 and 10mm coarse aggregate of 2.74 kg/m^{3}density. To ensure acceptable workability of concrete, a water reducing adonixture (Fair F10s (RPT)) (FMFF – 2016) was also used.

(a) (b)

Fig 1: a) Ferrock and b) Fair Mate

Mixture Proportions :

The mixture proportions for all green concrete batches mixed in this study were derived by using a reference normal mixture provided by Hand mix or machine mix. To mix the green concrete batches, the water-cement ratio was kept constant at 0.50. The Ferrock replaced the Portland cement by weight.

The mixture proportions of different green concrete batches are presented in Table: 1

Table: 1 Proportion of concrete mix.

Mixture	Normal	20 %	23 %	25 %	27 %	30 %
Cement (kg/m^3)	63.50	50.8	48.9	47.62	46.35	44.45
Ferrock (kg/m^3)	-	12.70	14.60	15.88	17.15	19.05
Water (kg/m^3)	30	30	30	30	30	30
Sand (kg/m^3)	142.84	142.84	142.84	142.84	142.84	142.84
20mm course aggregate (kg/m^3)	114.80	114.80	114.80	114.80	114.80	114.80
10mm course aggregate	114.80	114.80	114.80	114.80	114.80	114.80

(kg/m³)						
Add mixture	0.5	0.5	0.5	0.5	0.5	0.5
FCUW (kg/m³)	114.80	114.80	114.80	114.80	114.80	114.80

Fresh concrete properties :

The fresh concrete properties, i.e.slump for each batch are presented in table.2. The results show that the normal mixture had a slump of 80mm. With 30% replacement cement having maximum slump of 95mm. Which is 18.75 % more than normal concrete slump.

Fig.2 Slump Test

Table: 2 Properties of fresh concrete

Property	Normal	20 %	23 %	25 %	27 %	30 %
Slump(mm)	80	75	85	90	85	95

Specimens :

For each concrete batch, six beams, six cubes, six cylinders were cast. A total of 36 beam of 150X150X700mm, 36 cubes 150X150X150 and 36 cylinders of 150mm diameter with 300mm longer as per IS 516 (1959). For each concrete batch to allow the 7, 28 days compressive strength, flexural strength, split tensile strength, flexural strength, split tensile strength for cube, beam and cylinder respectively tests.

Curing :

After removing moulds of cube, beam, cylinder, they poured and directly placed into the curing chamber for 28 days.

Testing Procedure

The compressive strength, flexural strength, split tensile strength were measured according to IS 516(1959). Here the cube was loaded at a rate of 400-850 KN. The beam was loaded at a rate of 4 to 50 KN. The cylinder was loaded 140 to 650 KN.

III. EXPERIMENTAL RESULTS AND DISCUSSION

Compressive strength

The results obtained from hardened concrete compressive strength test for each are presented in fig. 3. The results presented in fig.3. Show that 28 days compressive strength for the normal concrete reached because the mixture proportion used for normal concrete mixture were designed to obtain a concrete 28 days. Strength after only days. This indicates that the mix design as per IS-10262:2009.

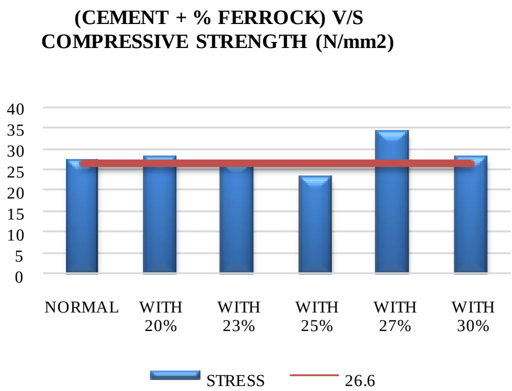

Fig. 3 Results of Compressive Strength

Flexural Strength:

The results obtained from hardened concrete flexural strength test for each batch are presented in fig.4. The concrete flexural strength results obtained for individual and combination cement replacement batches obtained for individual and combination cement replacement batches are analysed separately in this section. This section discusses the flexure strath of concrete by replacing ferrock with cement individually at different level.

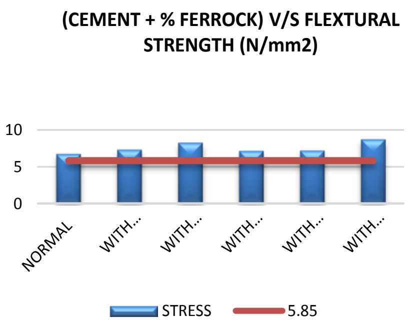

Fig. 4 Results of Flexural Strength

Splitting Tensile Strength :

The results obtained for splitting tensile strength of hardened concrete for each batch are presented in fig. 5.

Fig.5. presents the variations of the results of the splitting tensile strength concrete made with cement replaced by Ferrock at different levels , 0,20%,23%,25%,27%,30% the maximum.splitting tensile strength of 9.19 MPa was achieved at 25% Ferrock replacement level, which was 39.24% increase in strength compared to that of the normal specimen. The tensile strength decreased to 8043 MPa at 30% ferrock replacement level, which was also higher than than that of the normal concrete specimen. Fig4.

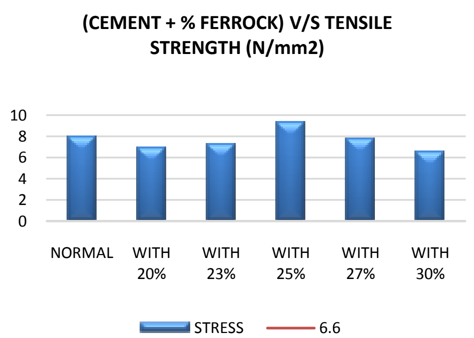

Fig. 5 Results of Tensile Strength

IV. RESULTS AND DISCUSSION

Table: 3 Results of Compressive strength

Type of concrete	Compressive strength of average of 3 cubes (after 7 days)	Compressive strength of average of 3 cubes (after 28 days)
	N/mm²	N/mm²
Normal M_{20}	17.89	27.11
With 20% ferrock	21.56	27.81
With 23% ferrock	19.55	26.68
With 25% ferrock	20.53	27.98
With 27% ferrock	20.58	34.06
With 30% ferrock	20.56	27.98

Table: 4 Results of Flexural strength

Type of concrete	Flexural strength of average of 3 beams (after 7 days)	Flexural strength of average of 3 beams (after 28 days)
	N/mm²	N/mm²
Normal M_{20}	3.40	6.65
With 20% ferrock	3.74	7.33
With 23% ferrock	3.76	8.24
With 25% ferrock	3.83	7.13
With 27% ferrock	3.75	7.18
With 30% ferrock	3.27	8.32

Table: 5 Results of Split Tensile strength

Type of concrete	Split Tensile strength of average of 3 cylinders (after 7 days)	Split Tensile of average of 3 cylinders (after 28 days)
	N/mm^2	N/mm^2
Normal M_{20}	1.90	7.82
With 20% ferrock	2.05	6.74
With 23% ferrock	2.10	7.19
With 25% ferrock	2.05	9.19
With 27% ferrock	2.10	7.74
With 30% ferrock	1.98	6.43

V. CONCLUSION

This study presents the fresh and hardened mechanical properties of green concrete made from Ferrock. Throughout this project, one control mixture batch (NA only) and seven separate green concrete batches were mixed and tested, producing a large number of samples.

From the experimental results, the conclusions described in the following can be drawn

- The Slump Value of Ferrock replaced concrete is as per the requirement of the mix design
- The Compressive strength of Ferrock Concrete is found to be 25.63% more than the Normal Mix.
- The Flexural Strength of Ferrock Concrete is found out to be 25.11% more than the Normal Mix.
- The Split Tensile Strength of Ferrock Concrete is found out to be 17.51% more than the Normal Mix.

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