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Behaviour of Concrete with Partial Replacement of Natural Coarse Aggregate (NCA) with Iron Slag and Natural Fine Aggregate (NFA) with Quarry Dust

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Abstract— Aggregate materials and ornamental stones which are extracted mainly from quarrying operations are extensively used for all construction applications. The production of these materials generates large quantities of fine by-products as wastes such as quarry dust. Also the handling and disposal of these fine by-products serves severe problems to the environment and disposal of these wastes becomes extremely costly due to the scarcity of disposal land. Therefore, due to the depletion of NCA and NFA deposits, it is necessary to find some alternative materials which have been studied for use as partial replacement in NCA such as iron slag and in NFA such as quarry dust. In this study, NCA and NFA are replaced with iron slag and quarry dust respectively by various percentage replacement by weight. Various properties of concrete are checked out by doing this replacement such as compression strength test and tensile strength test.

Keywords— Iron Slag, Quarry Dust, Natural Fine Aggregate, Natural Coarse Aggregate, Water, Cement.

I. INTRODUCTION

Concrete is a mixture of cement, sand, aggregates, water, etc. which are economically available. Concrete is made up of granular materials. It looks like coarse aggregates embedded in a matrix bound together with binder or cement which fills the space between the particles and glues them together as a whole body. Almost two and half quarter volume of concrete is made of aggregates and one quarter volume of concrete is made of fine sand (NCA). The major source of sand is river beds which have been used extensively and depleted for construction purposes. This depletion may create shortage of sand and can cause a noticeable increase in the price of sand. Hence In the future, to meet the global demand of concrete, we are forced to think of alternative materials which are to be replaced in conventional concrete.

In this project, I have used industrial by product named Iron Slag and Quarry Dust which is by-product of mining industries. I have done partial replacement of Iron Slag with Natural Coarse Aggregate (NCA) and Quarry dust with Natural Fine Aggregate (NFA). By using replacement ratios of Iron Slag and Quarry Dust in conventional concrete, I am trying to retain the same strength as conventional concrete.

In fact, the aggregates represent almost 80% of concrete, thus their replacement with recycled materials can help us to transform traditional concrete into a sustainable material. The use of granulated blast furnace slag (GBFS) aggregates in concrete by replacement of natural aggregates is very great concept because the impact strength of Iron Slag is quite more than natural aggregate.

II. SIGNIFICANCE OF THE WORK

The present work is aimed to study the Behaviour of Concrete in presence of Iron Slag (IS) and Quarry Dust (QD). NCA is replaced by Iron Slag by percentage replacements such as 00%, 10%, 30%, 50%; and NCA is replaced by Quarry dust by percentage replacements such as 00%, 10%, 20%, 30%, 40%, 50% by weight. By the use of IS and QD, the environmental problem of disposal of waste materials can be satisfied and also have the improvement in performance of concrete.

III. MATERIALS

A. Cement

Ordinary Portland Cement (OPC) of Ultra Tech of 53 grade conforming IS: 12269, 1987 was used.

B. Natural Fine Aggregate

Natural Fine Aggregate used in the study was obtained from river sand conforming to zone I of IS: 383, 1987. The size of aggregate is less than 4.75mm.

TABLE I
Physical Properties of Natural Fine Aggregates

Test	Result
Specific Gravity	2.67
Water Content	0.41%
Silt Content	2.1

C. Natural Coarse Aggregate

Machine crushed granite chips conforming to IS: 383, 2016 of maximum size 20mm size of aggregate obtained

from the local quarry was used and the specific gravity of 2.77.

TABLE II
PHYSICAL PROPERTIES OF COARSE AGGREGATES

Test	Natural Coarse Aggregate
Specific Gravity	2.77
Water Absorption	0.26%
Moisture Content	NIL
Abrasion Test	20.56%
Impact Strength	22.66%

D. Water

Normal tap water was used for casting and curing.

E. Iron Slag

Iron Slag was brought from Gautam Casting Ind. Pvt. Ltd. Rajkot, with the specific gravity of 2.69.

TABLE III
PROPERTIES OF IRON SLAG

Test	Result
Specific Gravity	2.69
Impact value	26.73%
Water Absorption	1.71%
Abrasion Test	24.76%

F. Quarry Dust

Quarry Dust was brought nearby Aji Dam quarrying site, Rajkot.

TABLE IV
PROPERTIES OF QUARRY DUST

Test	Result
Specific Gravity	2.58
Water Absorption	1.36%

IV. MIX PROPORTIONING

Design of concrete mix as per the water cement ratio of 0.45 conventional batch of M30 grade was casted and then compared with the percentage replacement of the by-products (IS and QD).

TABLE V
CALCULATED MIX DESIGN

Concrete Mix Design			
Cement (kg)	Water (litre)	Natural Coarse Aggregate (kg)	Natural Fine Aggregate (kg)
425.78	194.58	1133.85	703.11

V. EXPERIMENTAL WORK

A. *Casting and Curing of Specimens*

Casting of specimens was done by proper batching of materials, preparation of moulds and placing of concrete into moulds. After every 1/3 filling of material into the moulds, tamping rod was used for better compaction and later, vibrator was used. After using vibrator, top surface was properly levelled. Then all moulds are allowed to dry for 24 hours and proper mix were written for identification and kept into curing tank for 7 and 28 days.

B. *Slump Test for the Fresh Concrete*

The slump test was done for the comparison of degree of workability between natural concrete and replaced concrete. By increasing the percentage of IS and QD, the slump value is decreasing, but the value were satisfied the assumption of slump as per mix design. So without any admixtures the workability criteria was satisfied by using by-product.

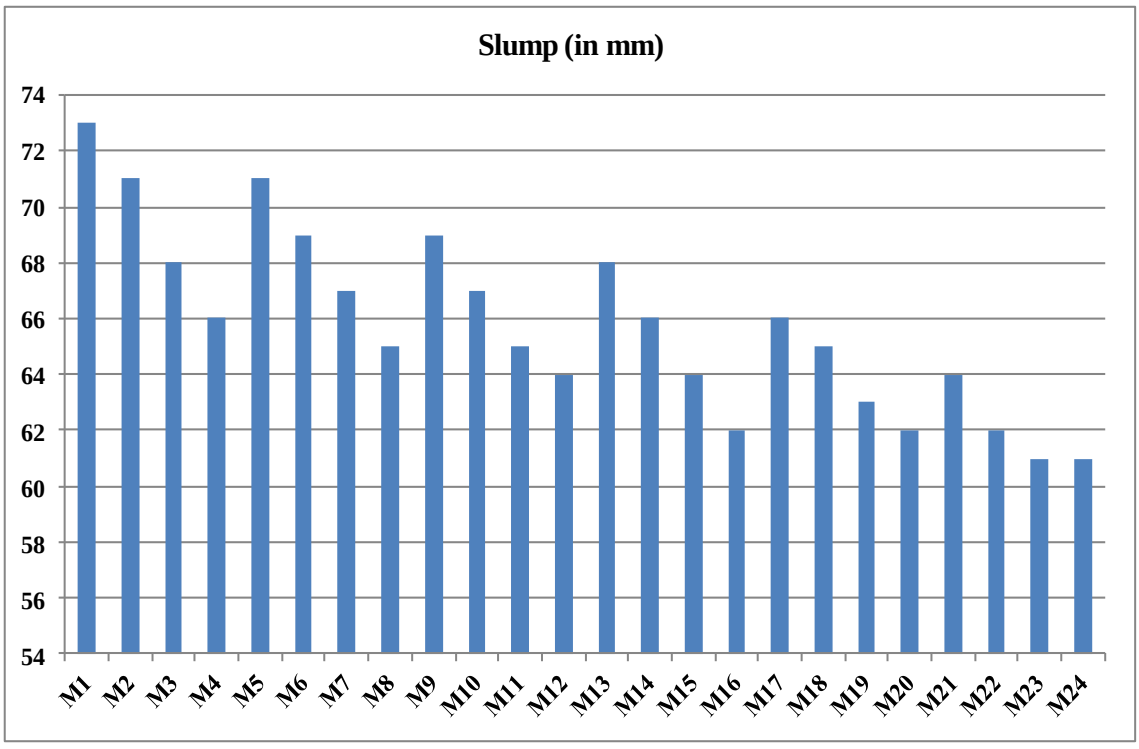
C. Strength Tests

The compressive strength tests were done with the size of specimen 15cmx15cmx15cm.The cubes were tested after curing of 7 days and 28 days from the date of casting. Three cubes were tested for each day and strength of each cube was calculated. The work of casting, curing and testing was done in the proper manner. Cylinder of size 15 cm diameter and 30 cm height were used for split tensile strength. Beams were used of the size 10cmx10cmx50cm for flexural strength test. Beams and cylinders were tested after 28 days of curing.

TABLE VI
CALCULATED MIX DESIGN RESULT

Sr. No.	NCA	NFA	IS	QD	Fresh Properties	Hardened Properties			
						Compressive Strength		*Split Tensile Strength*	*Flexural Strength*
					Slump (mm)	*7 days (N/mm²)*	*28 days (N/mm²)*	*28 days (N/mm²)*	*28 days (N/mm²)*
M_1	100%	100%	0%	0%	73	26.1	38.67	3.05	4.13
M_2	90%	100%	10%	0%	71	26.94	39.21	3.09	4.14
M_3	70%	100%	30%	0%	68	28.48	39.87	3.17	4.27
M_4	50%	100%	50%	0%	66	26.87	37.84	2.86	4.11
M_5	100%	90%	0%	10%	71	26.31	39.07	3.09	4.14
M_6	90%	90%	10%	10%	69	27.53	36.76	3.1	4.15
M_7	70%	90%	30%	10%	67	29.17	38.58	3.22	4.31
M_8	50%	90%	50%	10%	65	25.26	35.78	2.89	4.13
M_9	100%	80%	0%	20%	69	26.68	39.93	3.11	4.15
M_{10}	90%	80%	10%	20%	67	27.79	39.29	3.12	4.19
M_{11}	70%	80%	30%	20%	65	29.47	40.13	3.22	4.32
M_{12}	50%	80%	50%	20%	64	26.56	37.56	2.81	4.07
M_{13}	100%	70%	0%	30%	68	27.18	39.93	3.14	4.23
M_{14}	90%	70%	10%	30%	66	28.21	40.78	3.18	4.27
M_{15}	70%	70%	30%	30%	64	29.94	40.59	3.23	4.29
M_{16}	50%	70%	50%	30%	62	27.42	38.04	2.91	4.11
M_{17}	100%	60%	0%	40%	66	27.85	40.17	3.28	4.33
M_{18}	90%	60%	10%	40%	65	29.31	41.31	3.32	4.38
M_{19}	70%	60%	30%	40%	63	31.51	42.65	3.45	4.45
M_{20}	50%	60%	50%	40%	62	29.12	39.22	2.98	4.19
M_{21}	100%	50%	0%	50%	64	26.15	38.96	2.98	4.13
M_{22}	90%	50%	10%	50%	62	26.87	38.9	3.07	4.17
M_{23}	70%	50%	30%	50%	61	29.83	38.75	3.08	4.22
M_{24}	50%	50%	50%	50%	61	26.98	37.18	2.89	3.97

Fig. 1 Slump Test Result



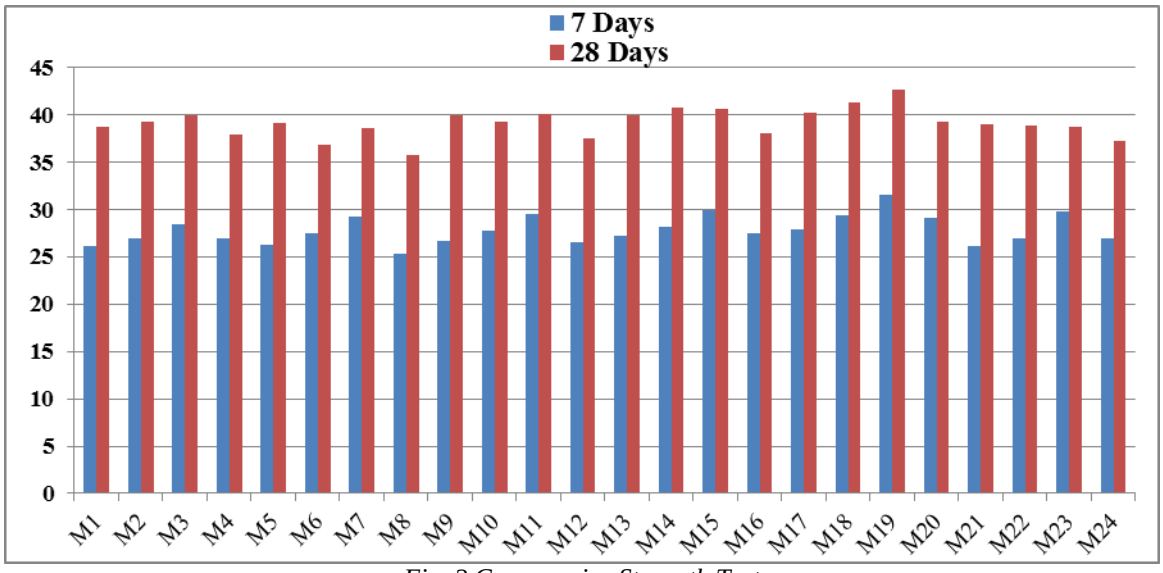


Fig. 2 Compressive Strength Test

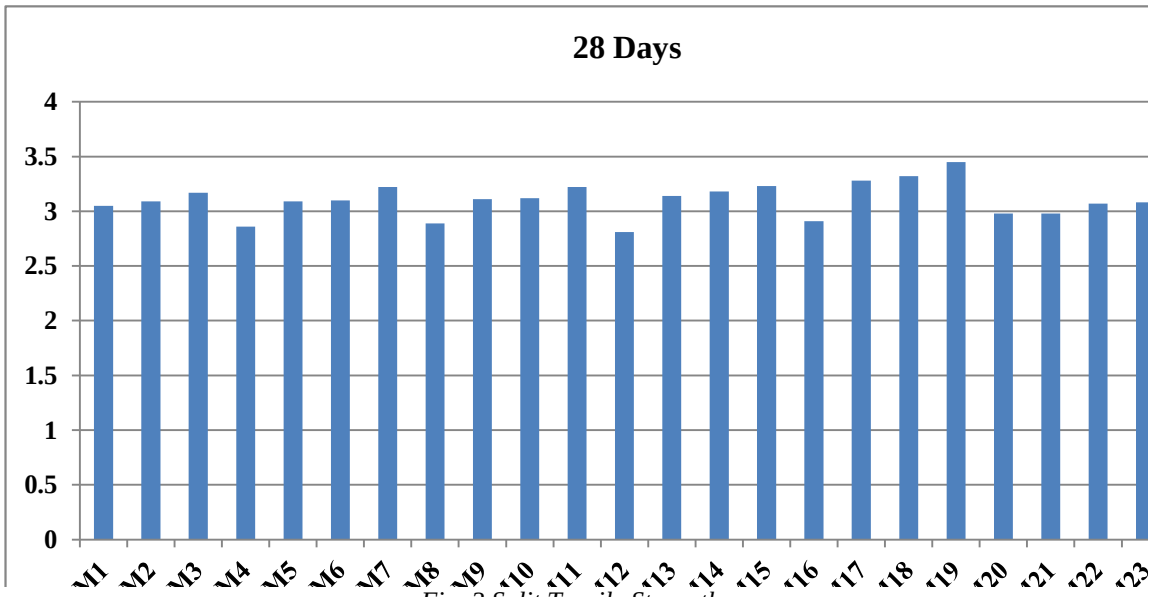


Fig. 3 Split Tensile Strength

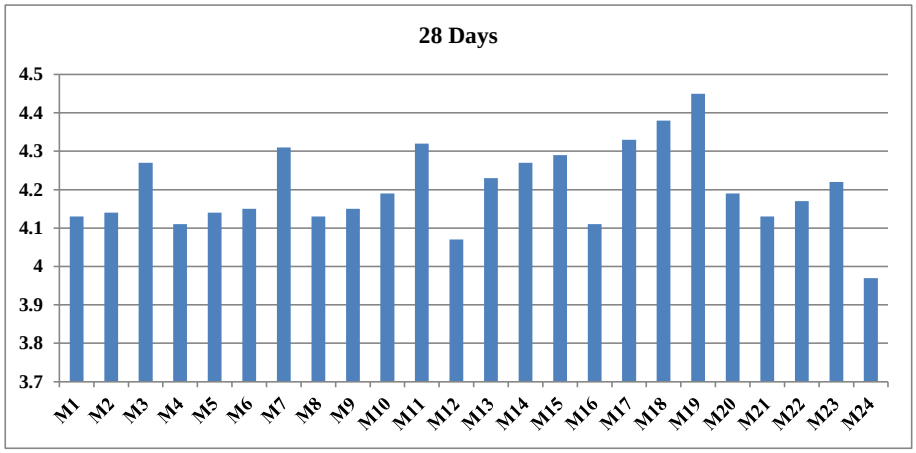


Fig. 4 Flexural Strength Test

VI. CONCLUSIONS

The various experiments have been performed with the comparative study of Iron Slag (IS) with Natural coarse Aggregate (NCA) and Quarry Dust (QD) with Natural Fine Aggregate (NFA). In this study, it was tried to use maximum proportion of by-products without decrease in strength. The IS were used in the replacement of 00%, 10%, 30% and 50% with NCA. Quarry Dust used with the replacement of 00%, 10%, and 20%, 30%, 40% and 50% with NFA. Whole experiment was done for water cement ratio of 0.45. From various experiments and results, the following conclusions were made:

- By replacing 40% of Quarry Dust and 30% Iron Slag, there is an increment in Compressive Strength by 10-11% after 28 days in comparison with normal concrete.
- In Split tensile, there is an increment in strength by 7-8% after 28 days in comparison with normal concrete (M_{19} = 40% QD and 30% IS)
- In Flexural Strength, there is an increment in strength by 13-14% in M_{19} after 28 days with comparison to normal concrete.
- By replacing only IS to NCA by 30%, there is an increment in Compressive Strength by 3.10%, Split Tensile Strength by 3.93% and Flexural Strength by 3.39%.
- By replacing only QD to NFA by 40% there is an increment in Compressive Strength by 3.39%, Split Tensile Strength by 7.54% and Flexural Strength by 4.84%.
- By increasing various percentage replacement of iron slag and quarry dust in concrete, the workability of concrete decreases, but workability criteria is satisfied.
- By the use of such additive materials, the overall cost of concrete can also decrease.
- Use of IS and QD can protect natural resources and decrease the pollution in some manner.

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