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Research Paper

OPTIMIZATION OF INDUSTRIAL WASTE MATERIAL USED IN CONCRETE UNDER DIFFERENT CURING TEMPERATURES

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Plain concrete subjected to high curing temperature during early hours and days causes rapid precipitation of hydration products. This phenomenon is responsible for the observed early strength development. Furthermore, this fast hydration in the initial stage leads to a more non-uniform distribution of the hydration products. This causes non-homogeneity in the microstructure that significantly reduces the long term strength. In this project work steel industry waste (FES dust) was used as pozzolanic materials. The element composition of these industrial wastes indicates presence of Ca, Si, and Al. So, it contains the cementitious properties. We prepare concrete specimens with 0%, 10%, 20%, 30% and 40% FES dust as replacement of cement. After 24 h of casting all demoulded concrete specimens were exposing to their different temperature for 1-day, 3-days, and 6-days. After that they were transfer to curing tank with water at room temperature. The different curing temperatures were 40^0C and 50^0C. The compressive strength of normal water curing specimens and hot water curing specimens at 7-days and 28-days were comparing. The result obtained suggests that compressive strength of concrete was developed under hot water curing at temperature 40^0C and 50^0C in 1, 3 and 6 days. But the rate of increase in compressive strength is not same for duration.

Keywords: FES dust, Hot water curing, Temperature, Compressive strength

INTRODUCTION

Some of the industrial wastes like fly ash, rice husk ash and blast furnace slag ash are being used in concrete nowadays. Their proportion varies depending of the type of cement. In this project FES dust was used as a partial replacement of cement. FES dust is a waste from steel industry. Normal concrete subjected to high curing temperature during early hours and days causes rapid precipitation of hydration products. This phenomenon is responsible for the observed early strength development. Furthermore, this fast hydration in the initial stage leads to a more non-uniform distribution of the hydration products. This causes nonhomogeneity in the microstructure

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that significantly reduces the long term strength. In this project current trend in concrete technology and practice of replacing cement partially by pozzolanic materials, we get modified materials and it is very important to understand the behavior of these modified materials. In this experimental work FES dust (steel industry waste) were used as pozzolanic materials. The element composition of these industrial wastes indicates presence of Ca, Si and Al. So, it possesses the cementatious properties.

Kim *et al*. (1998) has carried out experimental and analytical research, the strength development for various curing histories was investigated with particular regard to the influences of curing time points with given temperatures. For this purpose, four different points of curing time were considered with an individual interval of 24 h. Test results shows that the concrete subjected to a high temperature at an early age attains higher early-age strength but eventually attains lower later age strength.

Balendran *et al*. (2000) worked on effect of high temperature curing on the compressive strength, tensile splitting strength and flexural strength of concrete made with Hong Kong Pulverized Fuel Ash (PFA). The curing temperatures adopted were 27^{0}C, 34^{0}C, 42^{0}C and 50^{0}C. The experimental results suggests that high temperature cured PFA concrete normally has a greater compressive strength, tensile splitting strength and flexural strength than similarly cured Ordinary Portland Cement (OPC) concrete.

Lo *et al*. (2009) worked on the compressive strength and carbonation of depth of lightweight concrete mixes that contain Pulverized Fuel Ash (PFA) and Silica Fume (SF) as cement replacements. The results indicated that accelerated curing at 60^{0}C at 3 days improved the 28-day compressive strength of the PFA and SF incorporated mixes but resulted in higher carbonation of the mixes compared with that under normal temperature curing.

OBJECTIVES OF STUDY

1. To study effect of curing temperature on compressive strength of concrete (with and without industrial waste material).
2. To determine the compressive strength of normal concrete and replacement of cement (0%, 10%, 20%, 30% and 40% FES dust) by different curing temperatures like 40^{0}C and 50^{0}C for 1, 3 and 6 days.
3. To compare the result normal water curing and hot water curing compressive strength.
4. To develop the model for optimization purpose.

EXPERIMENTAL PROGRAM

Materials

Following are the materials used for the preparation of concrete:

a) Cement; b) Aggregates (Coarse and Fine aggregate); c) Water; d) Superplasticizers; and e) FES dust.

Cement

Ordinary portland cement of 53 grade used. The specific gravity of cement is 3.15.

Aggregate

Coarse Aggregate

The maximum size of aggregate of 20 mm size was used. The specific gravity was found to be 2.96 and fineness modulus of coarse aggregate was 7.49.

Fine Aggregate

The fine aggregate confirming to IS: 383 used. The sand is obtained from Local River 'Krishna' and conforming to Zone I was used. Grading of sand was done strictly as per IS 383-1970. The specific gravity of sand was found to be 2.66 and fineness Modulus was 2.61.

Water

Clean potable water was used for mixing and curing.

Superplasticizers

Fosroc (Conplast) is used with a proportion of 0.8% with respect to weight of cement was used to achieve the desired workability since addition of FES dust adversely affects the workability of concrete.

FES Dust

The particles are of irregular shapes. The FES dust has particles below 150 μ and 90 μ sizes.

In a free state it absorbs moisture from atmosphere and form lumps, which can be easily broken by hand. It is obtained from Essar steel industry, Hazira, Surat.

Physical Properties

1. It is brownish red in color.
2. It is in powder form.
3. Its bulk density is 1054 kg/m^3.

Table 1: Elements of FES Dust

Composition	Value (%)
T.Fe	44.03
FeO	4.47
M.Fe	0.46
SiO_2	8.22
Al_2O_3	2.87
CaO	9.75
MgO	5.84
MnO	0.52
ZnO	1.12
Pb	Traces
LOI	6.44

Chemical Properties

The mix design of M30 grade concrete was done by IS method of mix design (IS 10262 - 2009) and a proportion (By weight) as given below was adopted in the laboratory.

Water:	Cement:	FA:	CA
158 kg/m^3	377 kg/m^3	793 kg/m^3:	1122 kg/m^3
1:	0.42:	2.1:	2.98

Casting

The concrete is casted in to 150 X 150 X 150 mm cubes size and to find compressive strength. The compaction is achieved by giving 25 manual strokes for each layer by using tamping rod.

Curing

After casting specimens are placed at room temperature for 24 h. Then demoulded and hot water cured at their high temperature like 40ºC and 50ºC for 1, 3 and 6 days After that they are transferred to curing tank with water at room temperature.

Compressive Strength Test

The compressive strength test is conducted on the 100 ton capacity compressive testing machine. Compressive strength test is carried out on the various mixes by keeping all other parameters as constant.

RESULTS AND DISCUSSION

Concrete with five different proportions were prepared to test. The compressive strength of normal water cured specimens and hot water cured specimens at 7-days and 28-days were compared in Table 2 to 6. In this chapter the test results of all the cube specimens are discussed.

7 days compressive strength comparison hot and normal water curing of concrete with and without FES dust as shown in Figure 1. The normal concrete 0% FES dust waste gets maximum compressive strength is 39.68 N/mm^2 by 6-days hot water curing at 50^{o}C increasing 68.56% as compared to normal water curing compressive strength 23.54 N/mm^2 for 7-days. The normal concrete 10% FES dust waste gets maximum compressive strength is 37.71 N/mm^2 by 6-days hot water curing at 40^{o}C increasing 78.38% as compared to normal water curing compressive strength 21.14 N/mm^2 for 7-days. The normal concrete 20% FES dust waste gets maximum compressive strength is 35.53 N/mm^2 by 3-days hot water curing at 50^{o}C increasing 53.74% as compared to normal water curing compressive strength 23.11 N/mm^2 for 7-days. The normal concrete 30% FES dust waste gets maximum compressive strength is 31.17 N/mm^2 by 6-days hot water curing at 50^{o}C increasing 58.87% as compared to normal water curing compressive strength 19.62 N/mm^2 for 7-days. The normal concrete 40% FES dust waste gets maximum compressive

Table 2: Compressive Strength of Normal Concrete (0% FES Dust)

NWC Comp. Stren. N/Mm^2		HWC					Difference Between NWC and HWC (%)	
		Marking	Curing Period	Curing Temp.	Comp. Stren. N/Mm^2			
7-Days	28-Days		Days	^{0}C	7-Days	28-Days	7-Days	28-Days
23.54	41.73	1D40^{0}C	1	40	31.19	43.60	32.49	4.48
		1D50^{0}C	1	50	28.60	34.88	21.52	-16.41
		3D40^{0}C	3	40	37.70	39.24	60.15	-5.97
		3D50^{0}C	3	50	34.11	37.93	24.51	-9.11
		6D40^{0}C	6	40	38.15	42.51	62.06	1.87
		6D50^{0}C	6	50	39.68	39.89	68.56	-4.41

Note: NWC- Normal Water Curing, HWC- Hot Water Curing.

Table 3: Compressive Strength of Concrete with 10% FES Dust

NWC Comp. Stren. N/Mm²		HWC					Difference Between NWC and HWC (%)	
		Marking	Curing Period	Curing Temp.	Comp. Stren. N/Mm²			
7-Days	28-Days		Days	°C	7-Days	28-Days	7-Days	28-Days
21.14	29.43	1D40°C	1	40	37.61	41.86	77.91	42.23
		1D50°C	1	50	31.33	39.68	48.20	34.83
		3D40°C	3	40	37.06	41.53	75.31	41.11
		3D50°C	3	50	34.88	36.62	64.99	24.43
		6D40°C	6	40	37.71	38.58	78.38	31.09
		6D50°C	6	50	31.61	36.62	49.53	24.43

Note: NWC- Normal Water Curing, HWC- Hot Water Curing.

Table 4: Compressive Strength of Concrete with 20% FES Dust

NWC Comp. Stren. N/Mm²		HWC					Difference Between NWC and HWC (%)	
		Marking	Curing Period	Curing Temp.	Comp. Stren. N/Mm²			
7-Days	28-Days		Days	°C	7-Days	28-Days	7-Days	28-Days
23.11	39.24	1D40°C	1	40	27.42	39.60	18.65	0.92
		1D50°C	1	50	32.31	38.59	39.81	1.45
		3D40°C	3	40	33.68	39.57	45.74	0.84
		3D50°C	3	50	35.53	43.38	53.74	10.55
		6D40°C	6	40	32.92	41.42	42.45	5.55
		6D50°C	6	50	33.57	39.68	45.26	1.12

Note: NWC- Normal Water Curing, HWC- Hot Water Curing.

strength is 27.47 N/mm² by 6-days hot water curing at 50°C increasing 46.50% as compared to normal water curing compressive strength 18.75 N/mm² for 7-days.

28 days compressive strength comparison hot and normal water curing of concrete with and without FES dust as shown in Figure 2. The normal concrete 0% FES dust waste gets maximum compressive strength is 43.60 N/mm² by 1-days hot water curing at 40°C increasing 4.48% as compared to normal water curing compressive strength 41.73 N/mm² for 28-days. The normal concrete 10%

Table 5: Compressive Strength of Concrete with 30% FES Dust

NWC Comp. Stren. N/Mm²		HWC					Difference Between NWC and HWC (%)	
		Marking	Curing Period	Curing Temp.	Comp. Stren. N/Mm²			
7-Days	28-Days		Days	⁰C	7-Days	28-Days	7-Days	28-Days
19.62	35.09	1D40⁰C	1	40	23.76	36.20	21.10	3.16
		1D50⁰C	1	50	29.97	39.46	52.75	12.45
		3D40⁰C	3	40	30.96	35.21	57.80	0.31
		3D50⁰C	3	50	30.50	40.11	57.75	14.31
		6D40⁰C	6	40	27.47	35.32	40.01	0.65
		6D50⁰C	6	50	31.17	37.93	58.87	8.09

Note: NWC- Normal Water Curing, HWC- Hot Water Curing.

Table 6: Compressive Strength of Concrete with 40% FES Dust

NWC Comp. Stren. N/Mm²		HWC					Difference Between NWC and HWC (%)	
		Marking	Curing Period	Curing Temp.	Comp. Stren. N/Mm²			
7-Days	28-Days		Days	⁰C	7-Days	28-Days	7-Days	28-Days
18.75	32.26	1D40⁰C	1	40	21.73	33.14	15.89	2.72
		1D50⁰C	1	50	23.65	33.57	26.13	4.06
		3D40⁰C	3	40	22.89	28.01	22.08	-13.17
		3D50⁰C	3	50	26.38	32.48	40.69	0.68
		6D40⁰C	6	40	25.72	28.56	37.17	-11.47
		6D50⁰C	6	50	27.47	30.96	46.50	-4.03

Note: NWC- Normal Water Curing, HWC- Hot Water Curing.

FES dust waste gets maximum compressive strength is 41.86 N/mm² by 1-days hot water curing at 40°C increasing 42.23% as compared to normal water curing compressive strength 29.43 N/mm² for 28-days. The normal concrete 20% FES gets maximum compressive strength is 43.38 N/mm² by 3-days hot water curing at 50°C increasing 10.55% as compared to normal water curing compressive strength 39.24 N/mm² for 28-days. The normal concrete 30% FES dust waste gets maximum compressive strength is 40.11 N/mm² by 3-days hot water curing at 50°C increasing 14.31% as compared to

Figure 1: 7 Days Compressive Strength of Various Percentage FES Dust

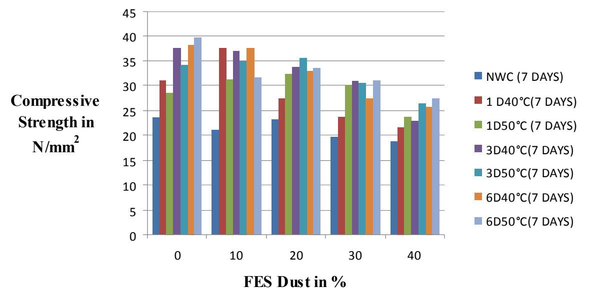
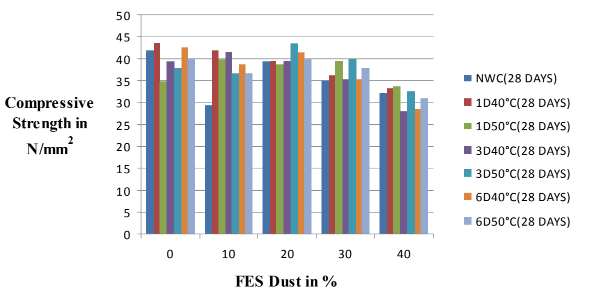


Figure 2: 28 Days Compressive Strength of Various Percentage FES Dust



normal water curing compressive strength 35.09 N/mm^2 for 28-days. The normal concrete 40% FES dust waste gets maximum compressive strength is 33.57 N/mm^2 by 1-days hot water curing at 50°C increasing 4.06% as compared to normal water curing compressive strength 32.26 N/mm^2 for 28-day.

CONCLUSION

The conclusions drawn from the results obtained in this study are as follows:

1. Compressive strength in hot water curing concrete is greater than the normal water curing concrete.
2. 7 days compressive strength of hot water curing concrete 45% to 80% increased as compared to normal water curing concrete.
3. 28 days compressive strength of hot water curing concrete 4% to 15% increased as compared to normal water curing concrete.
4. Compressive strength of concrete was developed under hot water curing at temperature 40°C and 50°C in 1, 3 and 6 days. But the rate of increase in compressive strength is not same for duration.
5. Good concrete compressive strength was developed using 30% FES dust and optimum hot water curing period was found 3 days at 50°C.
6. The temperature activates hydration process as the same manner like chemical reaction.
7. It was also noted from the results that the hot water curing positively help to improve the early 7 days strength of waste based concrete. This early strength development will help to handle the precast concrete components containing the waste during their early period.
8. The overall conclusion can be made from this experimental work that the concrete containing waste from steel industry improves the strength development with hot water curing. But the curing cycle and the temperature level should be selected carefully by the table given in this report.

REFERENCES

1. Balendran R V and Martin-Buades W H (2000), "The Influence of High Temperature Curing on the Compressive, Tensile and Flexural Strength of Pulverized Fuel Ash Concrete", *Building and Environment*, Vol. 35, pp. 415-423.
2. Elkhadiri I, Palacios M and Puertas F

(2009), "Effect of Curing Temperature on Cement Hydration", *Construction Sciences*, Vol. 53, No. 2, pp. 65-75.

3. Ezziane K, Bougara A, Kadri A, Khelaf H and Kadri E (2007), "Compressive Strength of Mortar Containing Natural Pozzolan Under Various Curing Temperature", *Cement & Concrete Composites*, Vol. 29, pp. 587-593.

4. Kim J K, Moon Y H and Eo S H (1998), "Compressive Strength Development of Concrete with Different Curing Time and Temperature", *Cement and Concrete Research*, Vol. 28, No. 12, pp. 1761-1773.

5. Lo T Y, Nadeem A, Tang W C P and Yu P C (2009), "The Effect of High Temperature Curing on the Strength and Carbonation of Pozzolanic Structural Lightweight Concretes", *Construction and Building Materials*, Vol. 23, pp. 1306-1310.