Chapter 5

Discussion of Results Other than Carbonation

5.1 Introduction

In this chapter compressive strength of OPC and PPC concrete test samples has been analysed. Compressive strength of carbonated and non carbonated samples of OPC and PPC concrete have been compared. Also, compressive strength of OPC and PPC concrete samples with 10, 30, 50 and 70% cement replacement with fly ash, microsilica and GGBS have been tested. The impact of various factors simultaneously affecting both carbonation resistance and compressive strength of concrete have been analyzed, both being the most valuable performance parameters in construction.

5.2 Results of Compressive Strength of Carbonated and Non-carbonated Concrete

Table 5.1: Compressive Strength of Carbonated and Non-Carbonated OPC concrete

Mix	W/C		Compressive Strength (N/mm^2) at 28 Days Curing	
			Non-Carbonated concrete	**Carbonated concrete**
O1	0.5	M-25	33.9	36.9
O2	0.45	M-30	40.1	44.5
O3	0.4	M-35	45.4	50.8

Table 5.2: Compressive Strength of Carbonated and Non-Carbonated PPC concrete

Mix	W/C		Compressive Strength (N/mm^2) at 28 Days Curing	
			Non-Carbonated Concrete	**Carbonated Concrete**
P_1	0.5	M-25	31.8	34.9
P_2	0.45	M-30	36.9	43.2
P_3	0.4	M-35	42.6	49.8

It can be seen from the above Tables that Compressive strength of carbonated concrete is greater than that of non-carbonated concrete. This may be due to the conversion of calcium hydroxide to calcium carbonate which has higher volume and results in reduction of pores in concrete.

5.3 Compressive Strength of Concrete Samples

Experimental results of Compressive Strength of OPC and PPC concrete samples with and without super plasticizer and with replacement of cement with Fly ash, Microsilica and GGBS are tabulated and shown plotted below.

Table 5.3 Compressive Strength of Concrete Samples with Variable Parameters

Test Results for OPC Combinations

Type of Mix	**Compressive Strength (N/mm^2)**		
	W/C 0.5	**W/C 0.45**	**W/C 0.4**
OPC Concrete	33.90	40.10	45.40
OPC Concrete mix with super plasticizer	34.20	40.30	45.20
OPC Concrete mix with 10 % replacement of cement with Fly ash	31.87	38.18	43.13
OPC Concrete mix with 30 % replacement of cement with Fly ash	26.14	30.48	34.05
OPC Concrete mix with 50 % replacement of cement with Fly ash	17.29	20.85	22.70
OPC Concrete mix with 70 % replacement of cement with Fly ash	5.39	5.61	7.72
OPC Concrete mix with 10 % replacement of cement with Micro silica	40.68	48.92	53.57
OPC Concrete mix with 30 % replacement of cement with Micro silica	32.21	37.69	43.58

OPC Concrete mix with 50 % replacement of cement with Micro silica	18.65	20.45	26.79
OPC Concrete mix with 70 % replacement of cement with Micro silica	4.07	4.01	6.36
OPC concrete mix with 10 % replacement of cement with GGBS	37.97	44.51	50.85
OPC concrete mix with 30 % replacement of cement with GGBS	36.61	42.91	49.49
OPC concrete mix with 50 % replacement of cement with GGBS	32.54	37.29	44.49
OPC concrete mix with 70 % replacement of cement with GGBS	16.95	18.05	21.34

Test Results for PPC Combinations

Type of mix	**Compressive Strength (N/mm2)**		
	W/C 0.5	**W/C 0.45**	**W/C 0.4**
PPC Concrete	31.80	36.90	42.60
PPC Concrete mix with super plasticizer	32.10	37.20	42.10
PPC Concrete mix with 10 % replacement of cement with Fly ash	29.89	33.95	40.47
PPC Concrete mix with 30 % replacement of cement with Fly ash	19.08	20.30	27.69
PPC Concrete mix with 50 % replacement of cement with Fly ash	14.95	18.45	17.89
PPC Concrete mix with 70 % replacement of cement with Fly ash	4.13	4.43	5.11
PPC Concrete mix with 10 % replacement of cement with Micro silica	38.80	46.13	52.40

PPC Concrete mix with 30 % replacement of cement with Micro silica	30.53	35.06	42.17
PPC Concrete mix with 50 % replacement of cement with Micro silica	16.22	17.71	21.30
PPC Concrete mix with 70 % replacement of cement with Micro silica	3.82	5.17	6.39
PPC concrete mix with 10 % replacement of cement with GGBS	34.98	40.96	47.71
PPC concrete mix with 30 % replacement of cement with GGBS	22.58	23.99	26.41
PPC concrete mix with 50 % replacement of cement with GGBS	15.90	19.19	21.73
PPC concrete mix with 70 % replacement of cement with GGBS	3.18	4.06	5.11

Test results tabulated above can be represented graphically as follows :

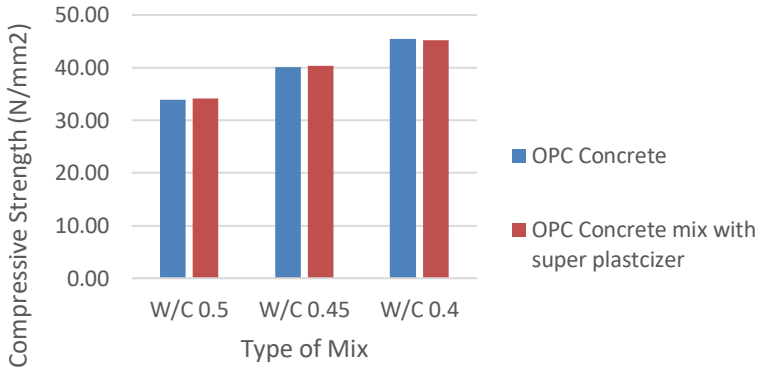

Fig 5.1 Compressive Strength vs. Addition of Superplasticizer for OPC Concrete

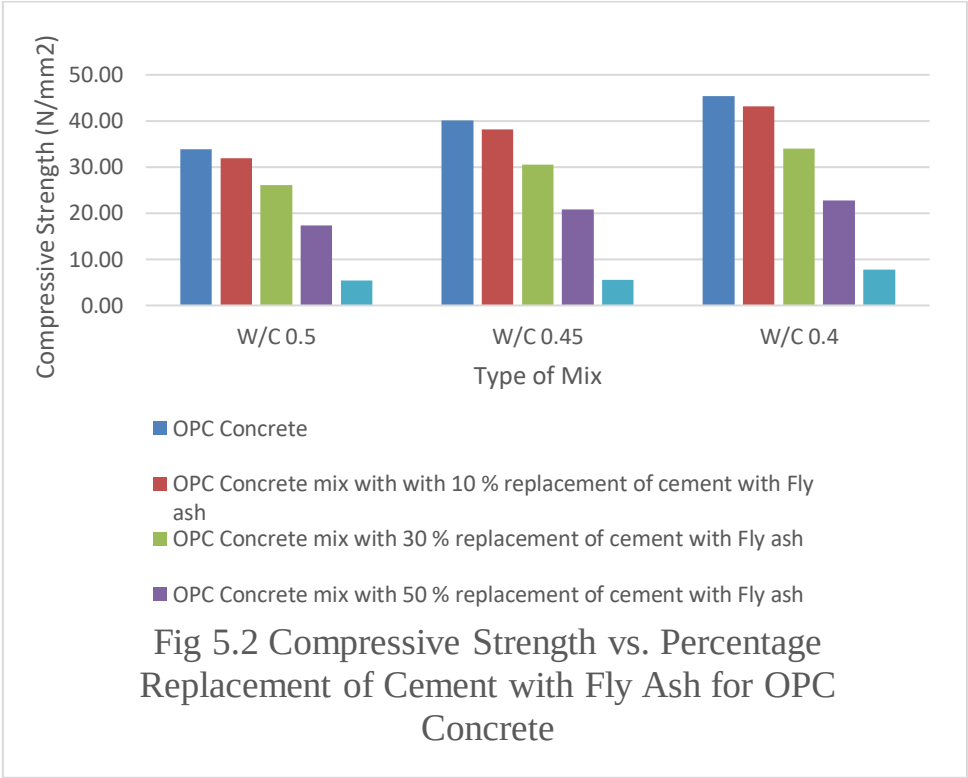

Fig 5.2 Compressive Strength vs. Percentage Replacement of Cement with Fly Ash for OPC Concrete

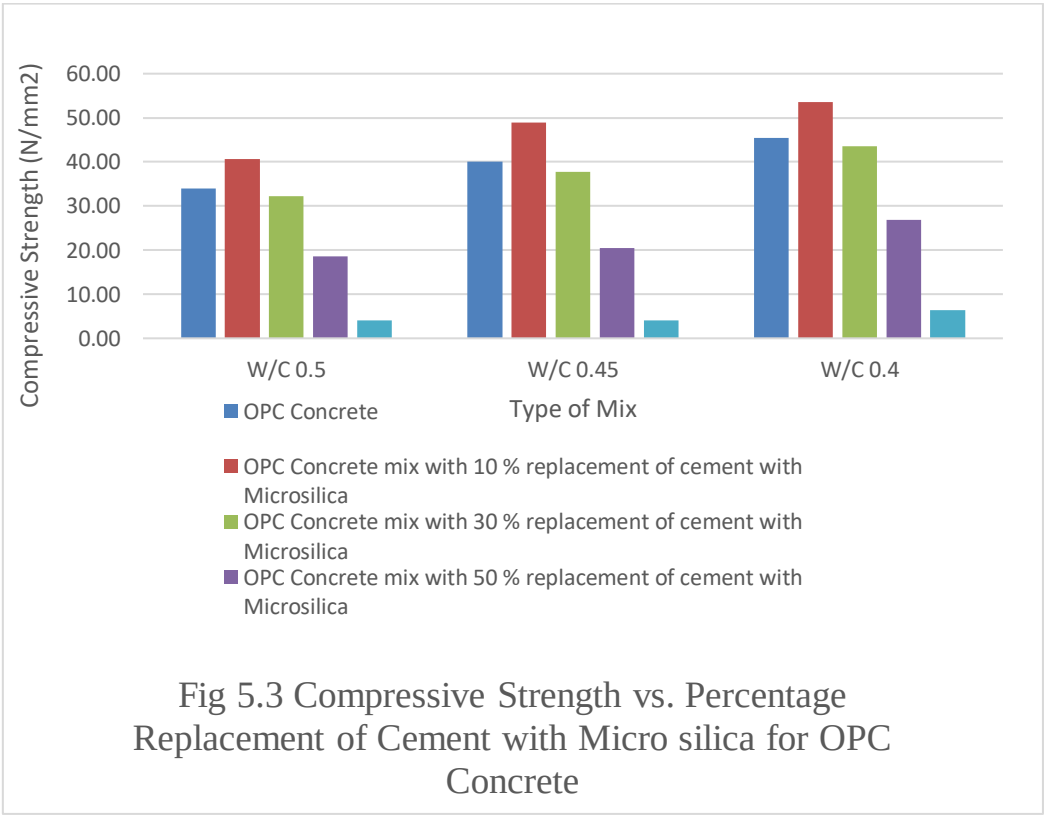

Fig 5.3 Compressive Strength vs. Percentage Replacement of Cement with Micro silica for OPC Concrete

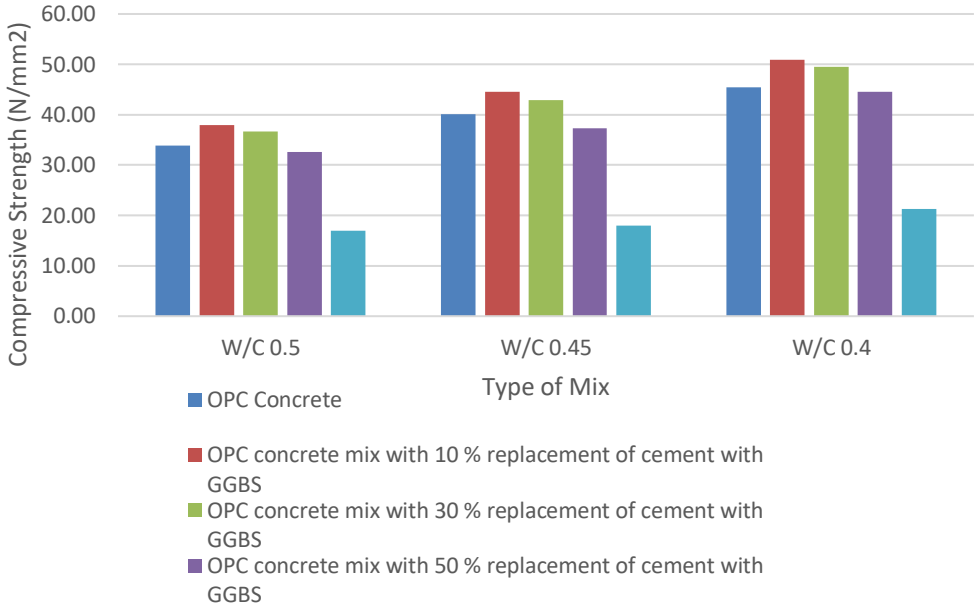

Fig 5.4 Compressive Strength vs. Percentage Replacement of Cement with GGBS for OPC Concrete

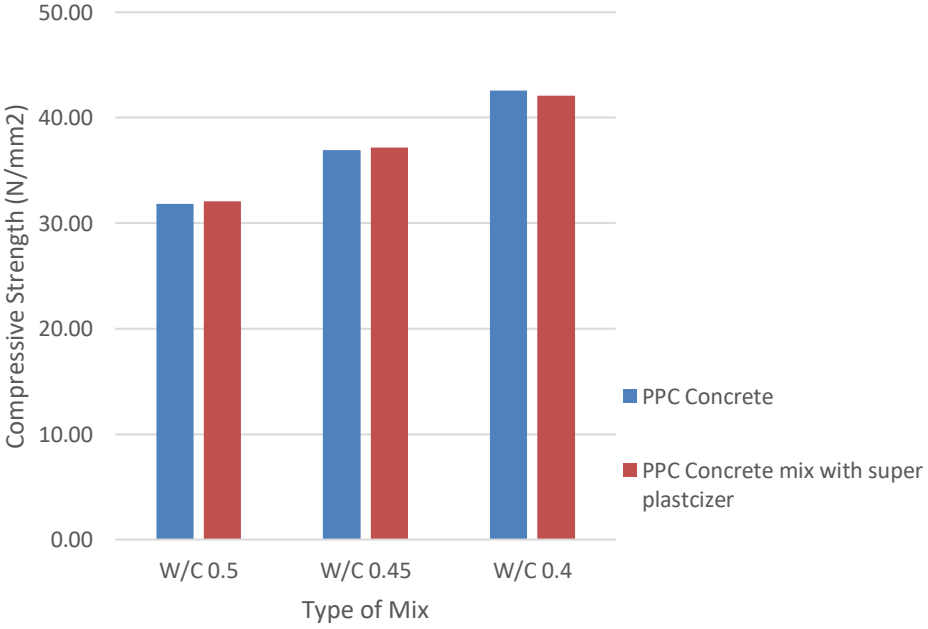

Fig 5.5 Compressive Strength vs. Addition of Superplasticizer for PPC concrete

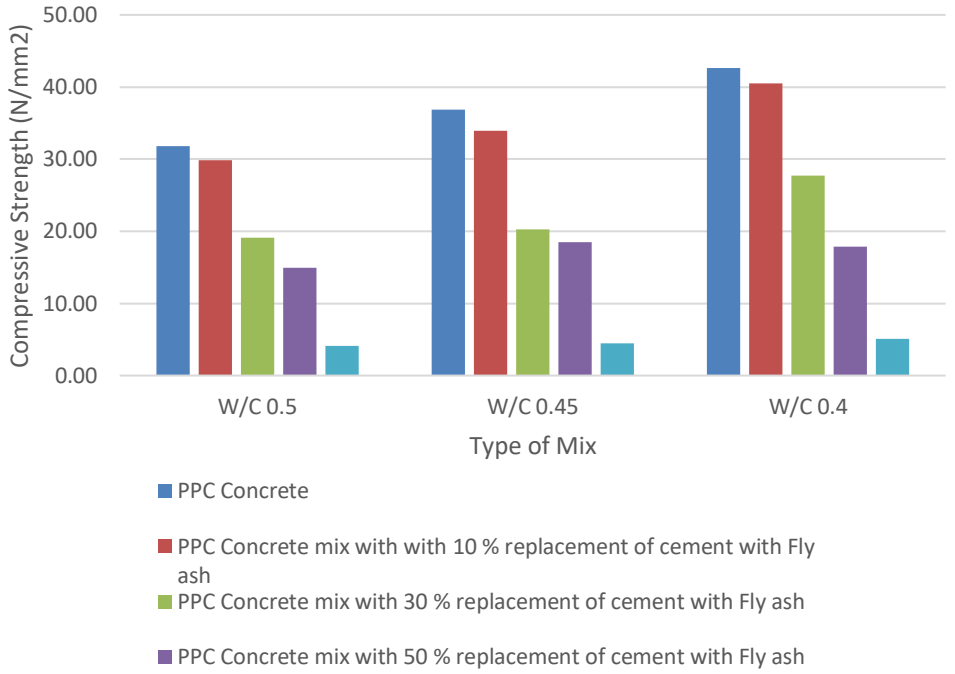

Fig 5.6 Compressive Strength vs. Percentage Replacement of Cement with Fly Ash for PPC Concrete

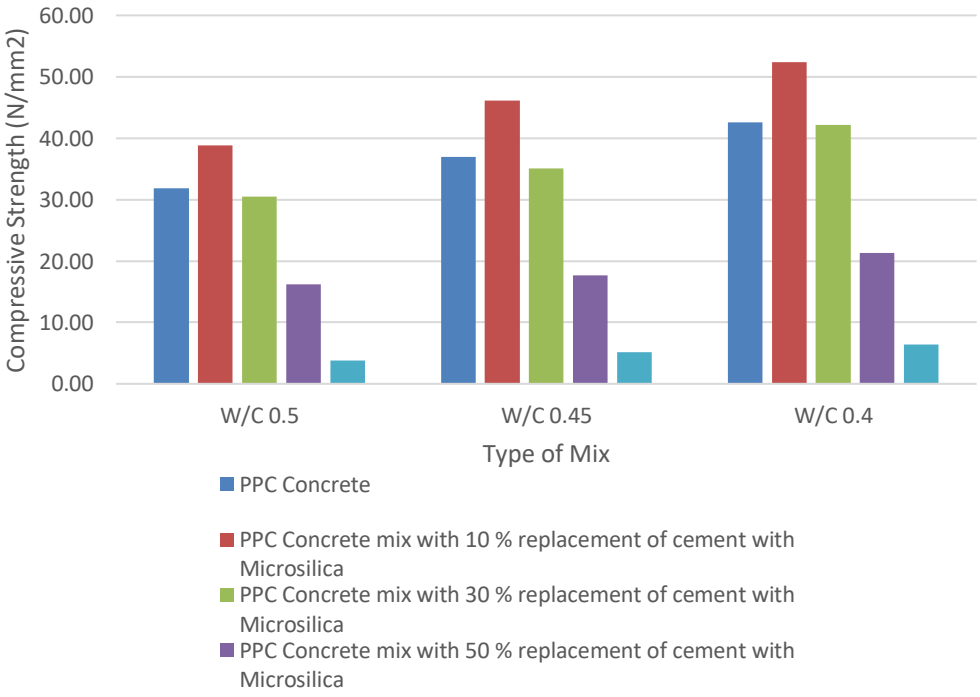

Fig 5.7 Compressive Strength vs. Percentage replacement of cement with Micro silica for PPC concrete

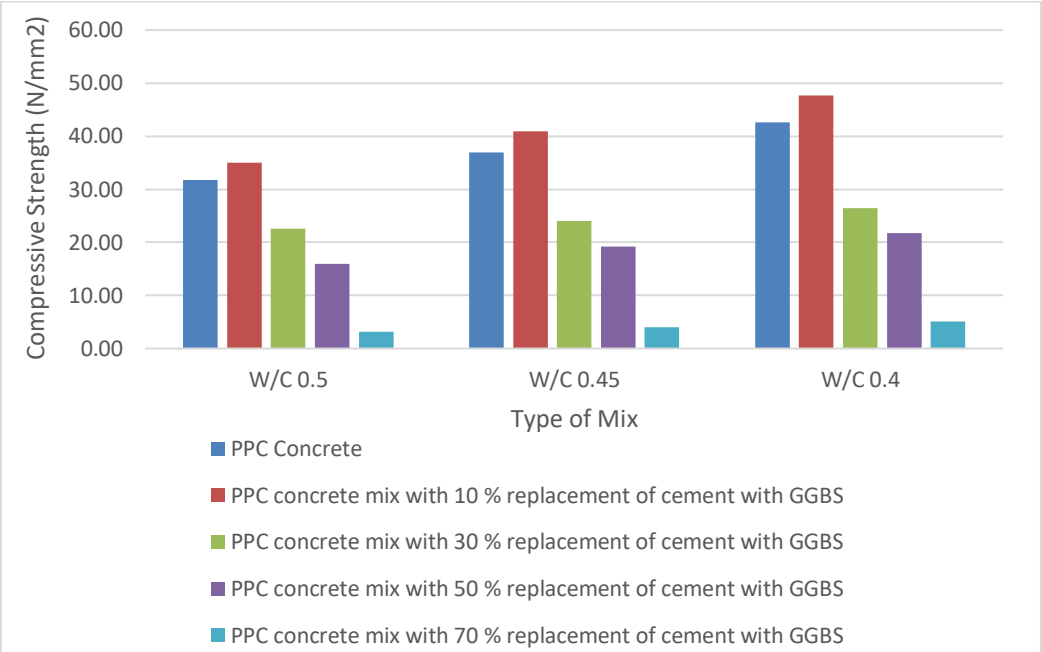

Fig 5.8 Compressive Strength vs. Percentage Replacement of Cement with GGBS for OPC Concrete

The following observations can be made from the above test results:

i. The addition of super plasticizer does not have any major impact on compressive strength for both OPC and PPC concrete however; it helps in reducing cement consumption.

ii. Compressive strength is found to decrease upon addition of fly ash as cement replacement.10, 30, 50 and 70% fly ash replacements have decreased the compressive strength of control mix with OPC concrete by 5, 24, 51 and 85% respectively.10, 30, 50 and 70% fly ash replacements have decreased the compressive strength of control mix with PPC concrete by 6, 40, 55 and 88% respectively.

iii. The addition of micro-silica as cement replacement to concrete has shown an increase up to10% replacement and then significant decrease. For a micro silica replacement of 10,30, 50 and 70% in OPC concrete, the compressive

strength increased by 20%, and then decreased by 6, 45 and 88% respectively. For a micro-silica replacement of 10, 30, 50 and 70% in PPC concrete, the compressive strength increased by 24%, and then decreased by 5,50 and 85% respectively.

iv. The addition of blast furnace slag as cement replacement to concrete has initially shown an increase till 30 % and then significant decrease. For a slag replacement of 10, 30, 50 and 70% in OPC concrete the compressive strength increased by 12% and 8 % and then decreased by 5% and 55% respectively. For a slag replacement of 10, 30, 50 and 70% in PPC concrete the compressive strength increased by 11% and then decreased by and 35, 50 and 90% respectively.

It may be mentioned that carbonation depths have been tested across concrete samples with wide variation of replacement percentages of cement with FA, micro silica and GGBS as well as that of fine aggregate with FA and GGBS in order to experimentally determine the trend of carbonation resistance with increase and decrease of various replacement constituents. Also, compressive strengths of only few samples have been tested only to analyze the broad impact of such mix proportions on strength.

The above results with respect to the impact of various mix proportions on both carbonation resistance as well as compressive strength of concrete can be analyzed simultaneously to design optimum mix proportions of various constituents of concrete to enhance its durability with respect to carbonation without adversely affecting its strength

5.4 Conclusions

The test results can be concluded as follows:

Type of Mix	Carbonation Resistance w.r.t. Normal OPC Concrete	*Compressive Strength w.r.t.* Normal OPC Concrete	Remarks
OPC Concrete	Standard	Standard	
OPC Concrete, with Super plasticizer	Increases	No major change, however, cement consumption reduced	Carbonation resistance increases and cement consumption reduced
OPC Concrete with 10 % Fly Ash Replacement	Increases	Decreases	
OPC Concrete with 30 % Fly Ash Replacement	Decreases	Decreases	
OPC Concrete with 50 % Fly Ash Replacement	Decreases	Decreases	
OPC Concrete with 70 % Fly Ash Replacement	Decreases	Decreases	
OPC Concrete with 10 % Micro silica Replacement	Increases	Increases	Both carbonation resistance and strength increases
OPC Concrete with 30 % Micro silica Replacement	Decreases	Decreases	
OPC Concrete with 50 % Micro silica Replacement	Decreases	Decreases	
OPC Concrete with 70 % Micro silica Replacement	Decreases	Decreases	
OPC concrete with 10 % GGBS Replacement	Increases	Increases	Both carbonation resistance and strength increases

OPC concrete with 30% GGBS Replacement	Increases	Increases	Both carbonation resistance and strength increases
OPC concrete with 50% GGBS Replacement	Decreases	Decreases	
OPC concrete with 70% GGBS Replacement	Decreases	Decreases	
OPC concrete with 10-70% Fine Aggregate Replacement with FA	Increases	-	
OPC concrete with 10 - 70 % Fine Aggregate Replacement with GGBS	Increases	-	
PPC concrete	Standard	Standard	
PPC concrete with super plasticizer	Increases	No major change, however, cement consumption reduced	Carbonation resistance increases and cement consumption reduced
PPC Concrete with 10 % Fly Ash Replacement	Increases	Decreases	
PPC Concrete with 30 % Fly Ash Replacement	Decreases	Decreases	
PPC Concrete with 50 % Fly Ash Replacement	Decreases	Decreases	
PPC Concrete with 70 % Fly Ash Replacement	Decreases	Decreases	
PPC Concrete with 10 % Microsilica Replacement	Increases	Increases	Both carbonation resistance and strength increases
PPC Concrete with 30 % Microsilica Replacement	Decreases	Decreases	
PPC Concrete with 50 % Microsilica Replacement	Decreases	Decreases	

PPC Concrete with 70 % Microsilica Replacement	Decreases	Decreases	
PPC Concrete with 10 % GGBS Replacement	Increases	Increases	Both carbonation resistance and strength increases
PPC Concrete with 30 % GGBS Replacement	Increases	Decreases	
PPC Concrete with 50 % GGBS Replacement	Decreases	Decreases	
PPC Concrete with 70 % GGBS Replacement	Decreases	Decreases	
PPC concrete with 10 -70 % Fine Aggregate Replacement with FA	Increases	-	
PPC concrete with 10 - 70 % Fine Aggregate Replacement with GGBS	Increases	-	