

Evaluation for Statistical Analysis of Compressive Strength of Temperature Controlled (TC) Concrete W.R.T. Change in Time as well as Weather Condition

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Abstract: The experiments conducted focuses on research to check the response of concrete during the curing period over the time span and environmental condition change. Curing of concrete is directly related to the performance of structural over the life span of the same. But it becomes very critical when the curing has to be placed over the temperature controlled concrete. The case study of this research is to check, how the concrete the compressive strength change with same type of curing, same amount of curing but change in time and environmental weather condition change. The research is evaluated by Well curb statistical analysis report, which is performed in lab under controlled conditions.

Keywords: Temperature controlled (TC) concrete, Statistical Analysis, Compressive Strength of concrete.

INTRODUCTION

High raise Building, Heavy infrastructures likes, bridges, tunnels etc. required the strong and deep foundations. But when sufficient SBC is not available at the required depth, then the size of foundation increase and the volume of concrete also increased. As increase in volume of concrete

will also increase the heat of hydration of process inside the concrete which can develop internal shrinkage cracks, thermal expansion etc. to avoid these problem, generally temperature controlled (TC) concrete is used. These concrete also required the proper curing to achieve the required strength. Temperature controlled (TC) concrete not only reduce the heat of hydration process but also decrease the shrinkage cracks and thermal expansions. Which not only increase the strength of concrete but also stability and life of structure.

Experimental details:

Material Details: The list and details of material used in the experiment is listed below,

- A. Cement: The Ordinary Portland cement (OPC) of 53 grade witch is completing the standard requirement of IS 269:2015. The physical properties of cement checked as per IS: 4031 (Part-2) -1999 (RA 2009), IS: 4031 (Part-3 to 6)-1988 (RA 2009) and results area listed in Table-1.

Sl. No.	Name of the test	Value	Requirement as per
1	Consistency	29.50%	IS: 12269 - 2013 Not Specified
2	Initial Setting Time	145 min	Shal not be more than 600 Min.
3	Final Setting Time	205 min	Shal not be more than 600 Min.
4	Specific gravity	3.14	
5	Fineness of Cement	302 m ² /Kg	Shal not be less than 225 m ² /Kg
6	Soundness	0.8mm	Shal not be more than 10 mm.
7	Compressive Strength		
	a. 7 Days	47.0 Mpa	Shal not be less than 37 Mpa
	b. 28 Days	62.5 Mpa	Shal not be less than 53 Mpa
8	Density	3.12 g/cc	Not Specified

TABLE: 1 (Physical - Properties of Cement)

The chemical properties of cement checked as per IS: 4032- 1985 (Reaffirmed 2009) and results are listed in Table-2

Sl. No.	Test Conducted	Results (%)	Requirement as per IS:12269-2013
1	Total Loss on Ignition (% by mas)	2.89	Not more than 4%
2	Insoluble Residue (% by mass), max	2.87	Not more than 4%
3	Ratio of % of Lime to % of silica, Alumina and Iron Oxide as per the formula.	0.89	Not greater than 1.02 and not less than 0.80
4	Ratio of % of Alumina to Iron Oxide	1.25	Not less than 0.66
5	Total Sulphur content calculated as sulphuric anhydride (% by mass)	1.50	Not more than 3.5%
6	Magnesia (MgO). (% by mass)	2.01	Not more than 6%
7	Tricalcium aluminate, (% by mass)	6.76	Not specified
8	Chloride (Cl), (% by mass)	0.017	Not more than 0.10%

TABLE: 2 (Chemical - Properties of Cement)

B. Fine aggregates: Crushed Sand has been brought from crusher yard (Uran, Maharashtra), fine aggregate passing through IS sieve, satisfying to grading Zone-II as per the IS: 383-2016 and details are listed in Table-3. The physical properties are listed in Table-4.

Sl. No.	Sieve Size	% Passing	LIMITS AS PER IS 383-2016			
	mm	Crushed Sand	ZONE I	ZONE II	ZONE III	ZONE IV
1	10.000	100.00	100	100	100	100
2	4.500	99.70	90-100	90-100	90-100	95-100
3	2.360	85.00	60-95	75-100	85-100	95-100
4	1.180	52.60	30-70	55-90	75-100	90-100
5	0.600	38.10	15-34	35-59	60-79	80-100
6	0.300	25.60	5-20	8-30	12-40	15-50
7	0.150	19.20	0-10	0-10	0-10	0-15
fineness Modulus		2.80	Note - for crushed stone sands, the permissible limit on 0.150mm sieve is increased to 20%			

TABLE: 3 (Fine Aggregates – Sieve analysis report)

SL. No.	Test Conducted	Result (Crushed Sand)
1	Specific Gravity	2.79
2	Water Absorption (%)	2.41
3	Bulk density (kg/ litre)	
a.	Loose	1.88
b.	Rodded	2.10

TABLE: 4 (Fine Aggregates – Physical Test report)

C. Course aggregates: Mechanically crushed angular granite stone of size 20mm and 10mm has been used, for different size of sieve used as per IS standard, which is maintained with different proportion of coarse aggregate and conforming to IS:383-2016 are listed in Table-5. The physical properties are listed in Table-6.

Sl. No.	Sieve Size	% Passing		Limits as per IS-383-2016 (single sized aggregate)	
	mm	20 mm	10 mm	20 mm	10 mm
1	40	100.00	100.00	100.00	100.00
2	20	97.00	100.00	85-100	100.00
3	12.5	32.08	100.00	-	100.00
4	10	7.80	85.75	0-20	85-100
5	4.75	0.40	1.55	0-5	0-20
6	2.36	-	1.27	-	0-5

TABLE: 5 (Course Aggregates – Sieve analysis report)

SL. No.	Test Conducted	Result		Limits as per IS-383-2016
		20 mm	10 mm	
1	Specific Gravity	2.86	2.85	-
2	Water Absorption (%)	1.33	1.44	-
3	Aggregate Impact Value (%) (12.5mm passing through 10 mm retained)	13.2	16.6	Max. 45% non-wearing surface Max. 30% wearing surface
4	Aggregate Crushing Value (%) (12.5mm passing through 10 mm retained)	13.3	16.9	Max. 30% wearing surface
5	Bulk density (kg/ litre)			
a.	Loose	1.56	1.53	-
b.	Rodded	1.69	1.65	-
6	Aggregate Abrasion Value (%)			
a.	Grading (B)	13.3	-	Max. 50% non-wearing surface Max. 30% wearing surface
b.	Grading (C)	-	15.0	
7	Flakiness Index (%)	8.1	12.0	
8	Elongation Index (%)	12.2	17.2	Combined flakiness and elongation index shall not be exceed 40%

TABLE: 6 (Course Aggregates – Physical Test report)

D. Chemical admixtures: Polycarboxylate ether based super-plasticizer condensate as high range water reducing admixture (HRWR) to maintain a satisfactory of workability for different mixes with constant w/b ratio throughout the experimental works. The chemical analysis report is listed in Table-7.

Sl. No.	TEST CONDUCTED	Results	Requirements (as per IS:9103-1999 (RA:2013) Table-2)	Test Method	Conformity
1	Dry Material Content, % by mass	31.27	±5% of declared Value	IS:9103:1999 (RA:2013) Clause.10.1 ANNEX E-1	-
2	Asha Content, % by mass	0.48	±5% of declared Value	IS:9103:1999 (RA:2013) Clause.10.1 ANNEX E-2	-
3	Relative Density at 25°C	1.105	±0.02% of declared Value	IS:9103:1999 (RA:2013) Clause.10.1 ANNEX E-3.1(b)	-
4	Chloride (as Cl). % by mass	0.012	±10% of declared Value	IS:6925-1973 (RA-2008) Clause:5.0	-
5	pH Value at 25°C	6.21	6.0 Minimum	IS:9103:1999 (RA:2013) Clause.10.1 ANNEX E-5	Yes

TABLE: 7 (Admixture – Chemical Analysis/ Test report)

E. Water and Ice: The type of water used for the concrete mix will affect the properties of concrete. So before starting the production of concrete, the physical as well as chemical properties to be check. And when the case arrived for temperature controlled concrete, then become essential to check all factor as per IS code 7861 (Part-1)-1975 to control the temperature of concrete mix. The quantity of ice used for lowering the temperature is calculated as per IS code 7861 (Part-1)- 1975 recommendation and explained below:

Calculation for Ice (to find the quantity of ice to be added in concrete to produce the concrete as per targeted Temperature aggregate): As per IS: 7861 (Part-I) – 1975, the calculation of ice requirement to produce the concrete targeted temperature can be calculated.

As per equation 6.2.b (from IS: 7861 (Part-I) – 1975).

$$T = \frac{S (TaWa + TcWc)}{S (Wa + Wc) +Ww +Wi +Wwa} + \frac{(Ww - Wi) Tw + Wwa Twa - 79.6 Wi}{S (Wa + Wc) +Ww +Wi +Wwa}$$

Where

T = Temperature of freshly mixed concrete (°C);

Ta, Tc, Tw, Twa = Temperature of aggregate, cement, added mixing water, free water on aggregate respectively (°C);

Wa, Wc, Ww, Wwa, Wi = mass of aggregate, cement, added mixing water, free water on aggregate and ice respectively (Kg);

S = Specific heat of cement and aggregate. (As per IS code it can be taken as 0.22)

Situation- 1 (For M50TC Concrete): As per above equation, the ice requirement will be calculated as per calculated data;

T*= 19 °C, Ta= 36 °C, Tc= 45 °C, Tw= 14 °C

Wa= 1880, Wc= 513, Ww=149, Wwa=0**, Wi= to be identified

*T = Targeted Temperature (as the temperature required during placing of concrete is 21 °C)

**Wwa taken as zero, as no water sprinkled over aggregate.

$$19 = \frac{0.22 (36x1880 + 45x513) + (149 - Wi) 14 - 79.6 Wi}{0.22 (1880 + 513) +149 +Wi}$$

$$12833.74 + 19Wi = 19968.3 + 2086 - 14Wi - 79.6Wi$$

$$19Wi + 14Wi + 79.6Wi = 22054.3 - 12833.74$$

$$112.6Wi = 9220.56$$

$$Wi = 81.888 \text{ Kg}$$

Percentage of Ice will be = (81.888/ 149) x 100 = 54.96% of Ice against Water.

Calculation for Ice (to reduce the water temperature from natural temperature): To reduce the existing temperature of water which is 26°C to 14°C, calculate for ice requirement the following equations has performed.

For M50TC Concrete:

To cool 1 g of water by 1°C required = 4.186 Joule to be removed

So (149-81.88)Kg of water by 12°C required= 4.186x12x67.12x1000
 = 3371571.84 Joule to be removed

This energy is then used to melt ice.

Heat of fusion of ice = 333.55 J/g or 0.33355 kJ/g of ice

So to change 3371571.84 joule to change= 3371571.84/ 333.55

= 10108g or 10.11 kg of ice

F. Concrete Mixture proportion and casting of specimens: The mix is designed with the guideline given in IS: 10262:2009 and with the help of ACI-211.1-91. All the details and proportion provided in Table-8. A total of 3 different concrete mixtures were proportioned based on practical requirement of materials. For temperature controlled concrete, Ice is added to water to lower the temperature from its natural temperature level. The concrete mixtures were mixed using 50 litres capacity Pan Mixer (shown in Fig-1) and specimens were casted by using the steel mould of standard cube 150x150x150mm (3 cubes of each mix design). The fresh concrete mixtures in moulds were compacted using table vibrator and the specimens were remoulded after 24 hours after casting and water cured at 27±3°C until the age of testing at 7 and 28 days as shown in figure 2.

Sl. No.	MATERIAL DESCRIPTION	CONCRETE MIX DESIGN (M50 TC CONCRETE)	
1	CEMENT (in Kg)	213	
2	FLY ASH	0	
3	GGBS	300	
4	C. sand	837	
5	AGGREGATE	10mm	522
		20mm	521
6	WATER (in Litre)	149	
7	ADMIXTURE	QTY.	5.64
		PERCENTAGE	1.10%

TABLE: 8 - Mix Proportions (Value for 1 cu-m of Concrete)



Fig-1: Pan Mixer (Experimental Setup for Concrete Mixing)



Fig-2: Experimental Setup for Compressive test

Experimental Test Results and Discussion

A. Content:

Statistical Analysis of cube strength of M50 Temp Controlled concrete - As per clause no 15.4 of IS 456:2000 for individual variation of specimens.

Analysis cube strength of M50 Temp. Controlled concrete for %ge strength achievement at 28th day with respect to 56th day strength.

Acceptance criteria as per agreed specification and IS456 table 11, calculation of Standard Deviation, Mean and chances of failure with graphical representations of the analysis.

B. Executive Summary:

- Total 47 test results are analyzed which are cast during the 1st Jan2015 to 28th Feb 2015.
 - Variation of strengths of specimens is analyzed for max and min variation from average to identify if any specimen is deviating more than 15% form average of three specimens. None of the results are found which are not complying. Hence no test results are discarded.
 - Average achievement of strength at 28th day is 96.0% with respect to 56th day strength.
 - None of the 56 day test results are below characteristic strength i.e. 50 MPa.
 - Established standard deviation for the test results is 2.9.
 - Mean of all the test results is 60.58 MPa against the Targeted Mean Strength 58.3 MPa.
 - Chances of getting low result than 50 MPa is reported as 0.01% compared to the assumed value of 5% (1 low result in 20).
 - No test results are below $f_{ck}-3$ i.e. 47 MPa, hence all the test results are acceptable.
- Observations:

OBSERVATIONS FROM STATISTICAL ANALYSIS

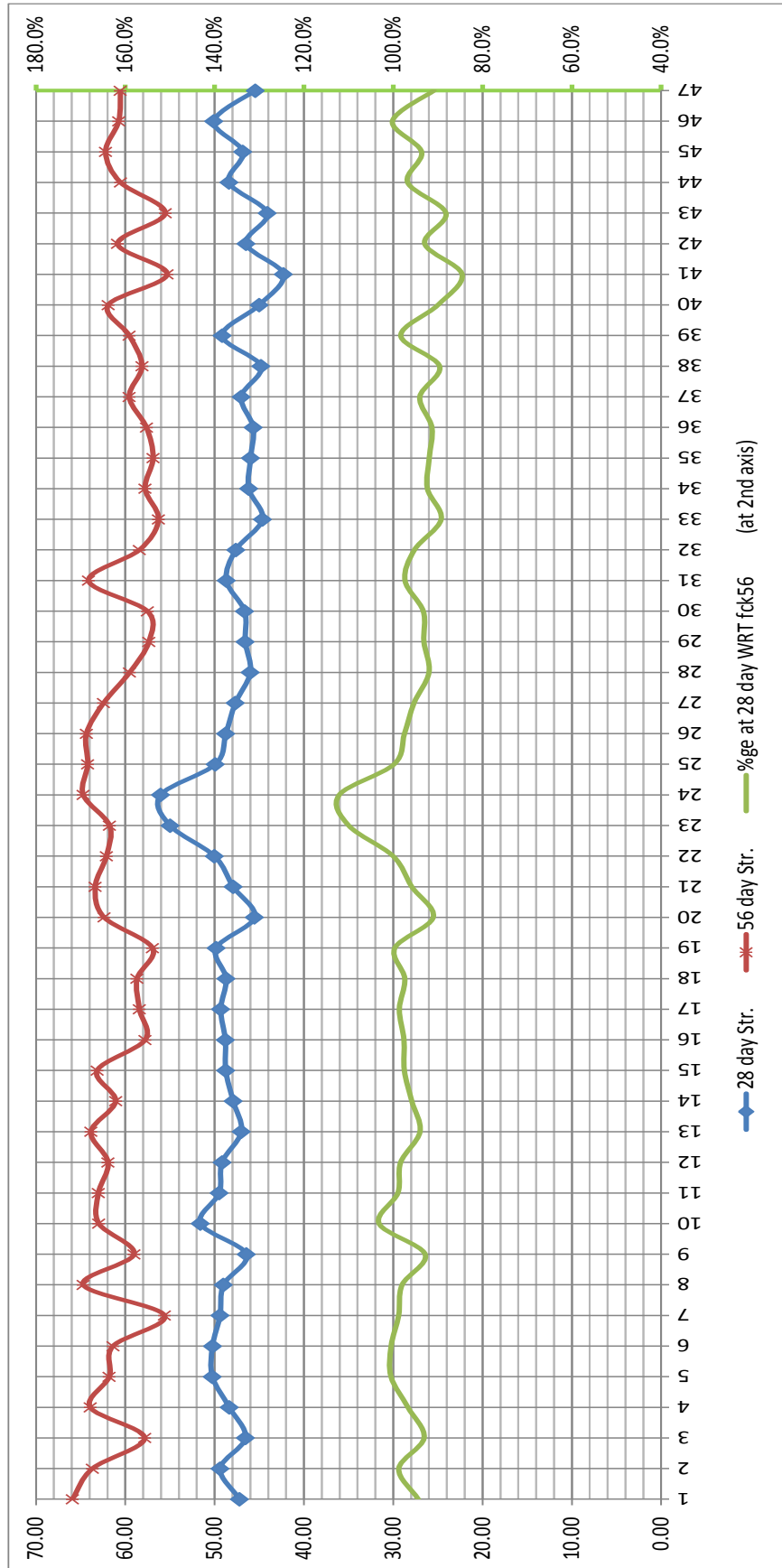
$f_{ck} = 50.0$	Mean= 60.58	Established Std. Dev. = 2.9
<i>Probability of getting less strength than 50 MPa =</i>		0.01%
<i>Calculated Proportion of low results =</i>		1 in 8844
<i>Calculated Value of Statistical Constant (t) =</i>		3.69
<i>Assumed Standard Deviation =</i>		5.0
<i>Accepted Proportion of low results =</i>		1 in 20
<i>Statistical Constant (t) taken for Calculation =</i>		1.65

Analysis for Individual variation (Clause 15.4 of IS 456:2000):

Raw data from non corrected tests results						Individual Variation less than 15%		
						As per IS456 / 15.4		
SI No.	Date Of Casting	Specimen 1	Specimen 2	Specimen 3	AVG CS (Mpa)	Max	Min	Compliance
1	05.01.2015	67.51	63.02	67.24	65.93	2.4%	4.4%	YES
2	06.01.2015	61.24	64.22	65.60	63.69	3.0%	3.8%	YES
3	08.01.2015	61.11	54.00	58.40	57.84	5.7%	6.6%	YES
4	10.01.2015	65.47	66.31	60.00	63.93	3.7%	6.1%	YES
5	15.01.2015	58.00	61.56	65.82	61.79	6.5%	6.1%	YES
6	15.01.2015	66.04	63.96	54.13	61.38	7.6%	11.8%	YES
7	15.01.2015	55.51	57.11	54.22	55.61	2.7%	2.5%	YES
8	15.01.2015	65.20	62.71	66.22	64.71	2.3%	3.1%	YES
9	15.01.2015	61.29	55.64	60.13	59.02	3.8%	5.7%	YES
10	15.01.2015	65.20	64.00	59.69	62.96	3.6%	5.2%	YES
11	15.01.2015	61.96	62.40	64.67	63.01	2.6%	1.7%	YES
12	15.01.2015	63.73	56.98	65.07	61.93	5.1%	8.0%	YES
13	16.01.2015	60.67	63.42	67.47	63.85	5.7%	5.0%	YES
14	20.01.2015	58.80	61.47	62.98	61.08	3.1%	3.7%	YES
15	20.01.2015	65.73	61.16	62.58	63.16	4.1%	3.2%	YES
16	21.01.2015	54.49	58.22	60.62	57.78	4.9%	5.7%	YES
17	21.01.2015	57.38	58.71	59.16	58.41	1.3%	1.8%	YES
18	21.01.2015	63.16	54.62	58.27	58.68	7.6%	6.9%	YES
19	21.01.2015	54.89	60.80	55.16	56.95	6.8%	3.6%	YES
20	22.01.2015	60.13	64.00	62.98	62.37	2.6%	3.6%	YES
21	22.01.2015	61.69	62.58	65.82	63.36	3.9%	2.6%	YES
22	24.01.2015	63.87	61.91	60.58	62.12	2.8%	2.5%	YES
23	25.01.2015	63.02	60.62	61.64	61.76	2.0%	1.8%	YES
24	25.01.2015	62.58	68.04	63.51	64.71	5.2%	3.3%	YES
25	27.01.2015	62.04	65.20	65.38	64.21	1.8%	3.4%	YES
26	28.01.2015	65.96	62.89	64.22	64.36	2.5%	2.3%	YES
27	29.01.2015	63.96	65.82	57.51	62.43	5.4%	7.9%	YES
28	05.02.2015	56.22	58.53	63.78	59.51	7.2%	5.5%	YES
29	06.02.2015	56.67	60.49	54.93	57.36	5.4%	4.2%	YES
30	07.02.2015	61.16	57.33	54.09	57.53	6.3%	6.0%	YES
31	10.02.2015	64.49	66.13	61.73	64.12	3.1%	3.7%	YES
32	15.02.2015	57.87	58.84	58.53	58.41	0.7%	0.9%	YES
33	17.02.2015	54.89	54.36	59.60	56.28	5.9%	3.4%	YES
34	17.02.2015	56.53	57.51	59.29	57.78	2.6%	2.2%	YES
35	17.02.2015	56.13	55.42	59.11	56.89	3.9%	2.6%	YES
36	17.02.2015	56.49	56.04	60.36	57.63	4.7%	2.8%	YES
37	17.02.2015	61.16	59.56	57.96	59.56	2.7%	2.7%	YES
38	18.02.2015	59.42	56.67	58.31	58.13	2.2%	2.5%	YES
39	20.02.2015	62.40	56.09	60.18	59.56	4.8%	5.8%	YES
40	23.02.2015	63.29	65.47	56.98	61.91	5.7%	8.0%	YES
41	24.02.2015	55.51	55.02	55.38	55.30	0.4%	0.5%	YES
42	24.02.2015	58.18	61.29	63.11	60.86	3.7%	4.4%	YES
43	25.02.2015	54.98	56.00	55.60	55.53	0.9%	1.0%	YES
44	26.02.2015	63.56	59.07	58.98	60.53	5.0%	2.6%	YES
45	26.02.2015	61.69	63.47	61.47	62.21	2.0%	1.2%	YES
46	26.02.2015	64.31	56.89	61.02	60.74	5.9%	6.3%	YES
47	28.02.2015	60.53	61.73	59.38	60.55	2.0%	1.9%	YES

Analysis of strength achievement % age :

Sl No	Date of Cast	28 day Str.	56 day Str.	%ge at 28 day WRT fck56	%ge at 56 day WRT fck56
1	05.01.2015	47.20	65.93	94.4%	132%
2	06.01.2015	49.38	63.69	98.8%	127%
3	08.01.2015	46.55	57.84	93.1%	116%
4	10.01.2015	48.36	63.93	96.7%	128%
5	15.01.2015	50.25	61.79	100.5%	124%
6	15.01.2015	50.24	61.38	100.5%	123%
7	15.01.2015	49.39	55.61	98.8%	111%
8	15.01.2015	49.01	64.71	98.0%	129%
9	15.01.2015	46.43	59.02	92.9%	118%
10	15.01.2015	51.59	62.96	103.2%	126%
11	15.01.2015	49.48	63.01	99.0%	126%
12	15.01.2015	49.17	61.93	98.3%	124%
13	16.01.2015	47.01	63.85	94.0%	128%
14	20.01.2015	47.93	61.08	95.9%	122%
15	20.01.2015	48.76	63.16	97.5%	126%
16	21.01.2015	48.80	57.78	97.6%	116%
17	21.01.2015	49.32	58.41	98.6%	117%
18	21.01.2015	48.71	58.68	97.4%	117%
19	21.01.2015	49.82	56.95	99.6%	114%
20	22.01.2015	45.53	62.37	91.1%	125%
21	22.01.2015	47.93	63.36	95.9%	127%
22	24.01.2015	50.01	62.12	100.0%	124%
23	25.01.2015	54.99	61.76	110.0%	124%
24	25.01.2015	56.04	64.71	112.1%	129%
25	27.01.2015	49.91	64.21	99.8%	128%
26	28.01.2015	48.74	64.36	97.5%	129%
27	29.01.2015	47.67	62.43	95.3%	125%
28	05.02.2015	46.00	59.51	92.0%	119%
29	06.02.2015	46.56	57.36	93.1%	115%
30	07.02.2015	46.64	57.53	93.3%	115%
31	10.02.2015	48.68	64.12	97.4%	128%
32	15.02.2015	47.63	58.41	95.3%	117%
33	17.02.2015	44.64	56.28	89.3%	113%
34	17.02.2015	46.18	57.78	92.4%	116%
35	17.02.2015	45.97	56.89	91.9%	114%
36	17.02.2015	45.67	57.63	91.3%	115%
37	17.02.2015	47.02	59.56	94.0%	119%
38	18.02.2015	44.81	58.13	89.6%	116%
39	20.02.2015	49.16	59.56	98.3%	119%
40	23.02.2015	44.99	61.91	90.0%	124%
41	24.02.2015	42.30	55.30	84.6%	111%
42	24.02.2015	46.47	60.86	92.9%	122%
43	25.02.2015	44.10	55.53	88.2%	111%
44	26.02.2015	48.39	60.53	96.8%	121%
45	26.02.2015	46.83	62.21	93.7%	124%
46	26.02.2015	50.09	60.74	100.2%	121%
47	28.02.2015	45.44	60.55	90.9%	121%



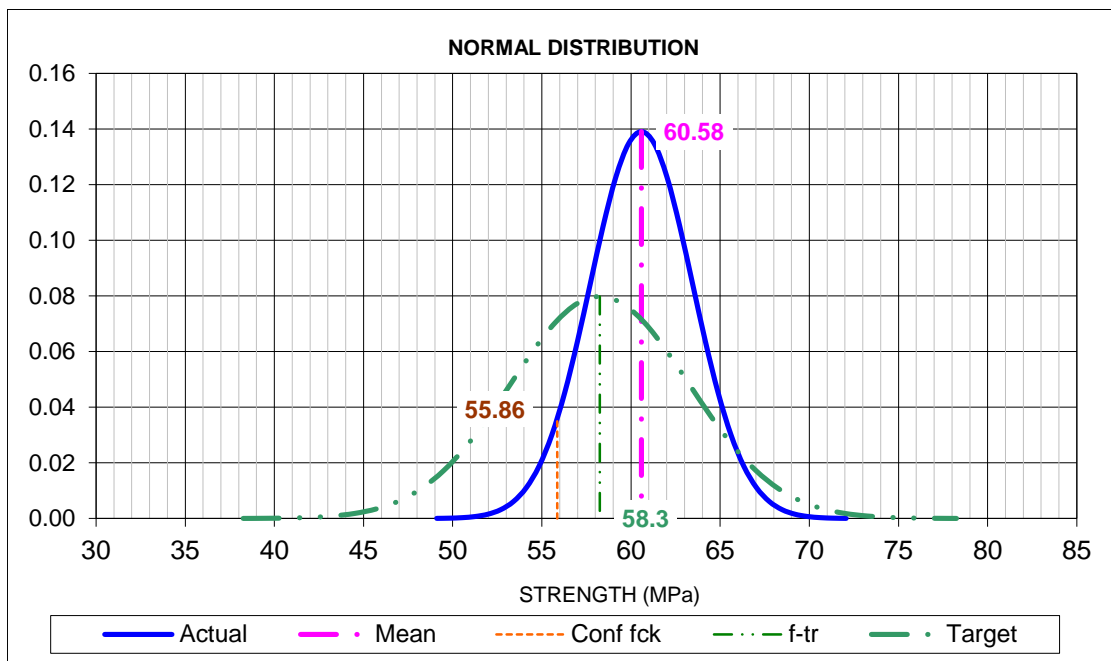
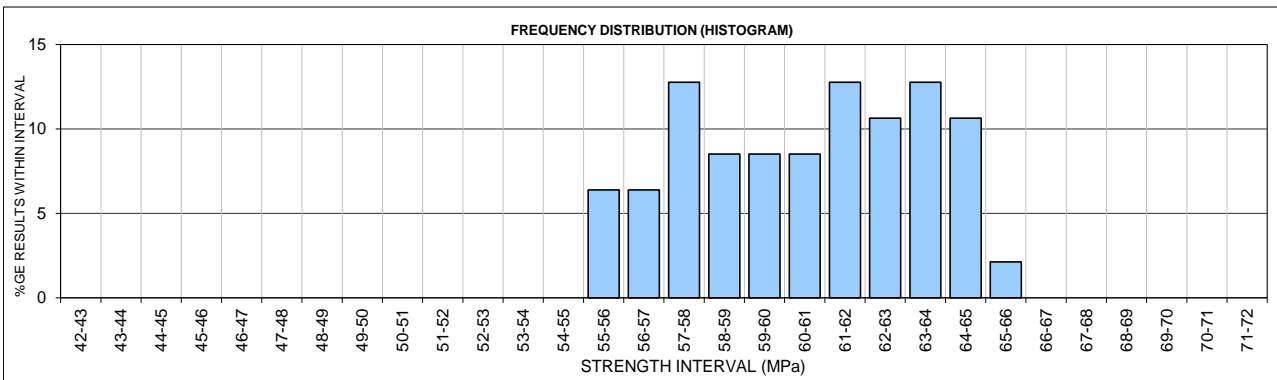
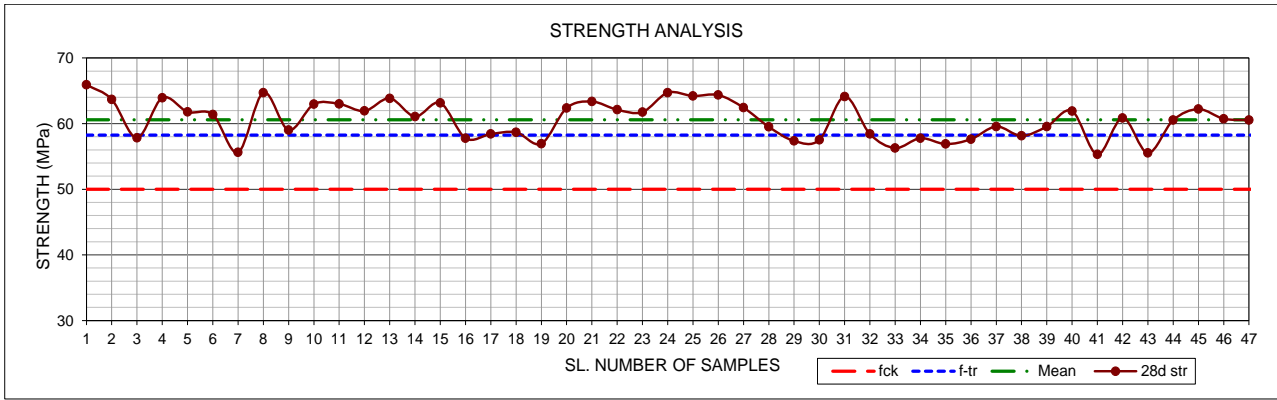
Statistical Analysis:

MIX ID:	M50 TC						PERIOD OF CASTING:	01-01-2015 to 28-02-2015						Report Date:	07/05/2014			
BINDER	OPC	FA	SLAG	McSi			Total Binder									Charac. Strength (fck) :	50	Mpa
DETAIL:	213		300				513									Assumed Std. Deviation:	5	MPa
													Target Mean Strength (TMS) =	58.3	MPa			

Serial No.	Date of casting	Avg 56 days Strength (MPa) of each set (3 cubes)	Conformity to Table-2 (Test Result >= fck)	Acceptance Test required or not	Individual test				Group Test					Output		
					fck - 3	Conformity (56dy str >= fck - 3)	3 previous non-overlapping consecutive test results to form a group of 4 results			Avg. of Group	A= fck+0.825[std]	B = fck+3	Controlling Value (Max of A & B)		Conformity (Gr.Avg >= Cont. Val.)	Final Acceptance of Low Result
1	05.01.2015	65.93	OK	NO	-	-	-	-	-	-	-	-	-	-	-	-
2	06.01.2015	63.69	OK	NO	-	-	-	-	-	-	-	-	-	-	-	-
3	08.01.2015	57.84	OK	NO	-	-	-	-	-	-	-	-	-	-	-	-
4	10.01.2015	63.93	OK	NO	-	-	-	-	-	-	-	-	-	-	-	-
5	15.01.2015	61.79	OK	NO	-	-	-	-	-	-	-	-	-	-	-	-
6	15.01.2015	61.38	OK	NO	-	-	-	-	-	-	-	-	-	-	-	-
7	15.01.2015	55.61	OK	NO	-	-	-	-	-	-	-	-	-	-	-	-
8	15.01.2015	64.71	OK	NO	-	-	-	-	-	-	-	-	-	-	-	-
9	15.01.2015	59.02	OK	NO	-	-	-	-	-	-	-	-	-	-	-	-
10	15.01.2015	62.96	OK	NO	-	-	-	-	-	-	-	-	-	-	-	-
11	15.01.2015	63.01	OK	NO	-	-	-	-	-	-	-	-	-	-	-	-
12	15.01.2015	61.93	OK	NO	-	-	-	-	-	-	-	-	-	-	-	-
13	16.01.2015	63.85	OK	NO	-	-	-	-	-	-	-	-	-	-	-	-
14	20.01.2015	61.08	OK	NO	-	-	-	-	-	-	-	-	-	-	-	-
15	20.01.2015	63.16	OK	NO	-	-	-	-	-	-	-	-	-	-	-	-
16	21.01.2015	57.78	OK	NO	-	-	-	-	-	-	-	-	-	-	-	-
17	21.01.2015	58.41	OK	NO	-	-	-	-	-	-	-	-	-	-	-	-
18	21.01.2015	58.68	OK	NO	-	-	-	-	-	-	-	-	-	-	-	-
19	21.01.2015	56.95	OK	NO	-	-	-	-	-	-	-	-	-	-	-	-
20	22.01.2015	62.37	OK	NO	-	-	-	-	-	-	-	-	-	-	-	-
21	22.01.2015	63.36	OK	NO	-	-	-	-	-	-	-	-	-	-	-	-
22	24.01.2015	62.12	OK	NO	-	-	-	-	-	-	-	-	-	-	-	-
23	25.01.2015	61.76	OK	NO	-	-	-	-	-	-	-	-	-	-	-	-
24	25.01.2015	64.71	OK	NO	-	-	-	-	-	-	-	-	-	-	-	-
25	27.01.2015	64.21	OK	NO	-	-	-	-	-	-	-	-	-	-	-	-
26	28.01.2015	64.36	OK	NO	-	-	-	-	-	-	-	-	-	-	-	-
27	29.01.2015	62.43	OK	NO	-	-	-	-	-	-	-	-	-	-	-	-
28	05.02.2015	59.51	OK	NO	-	-	-	-	-	-	-	-	-	-	-	-
29	06.02.2015	57.36	OK	NO	-	-	-	-	-	-	-	-	-	-	-	-
30	07.02.2015	57.53	OK	NO	-	-	-	-	-	-	-	-	-	-	-	-
31	10.02.2015	64.12	OK	NO	-	-	-	-	-	-	-	-	-	-	-	-
32	15.02.2015	58.41	OK	NO	-	-	-	-	-	-	-	-	-	-	-	-
33	17.02.2015	56.28	OK	NO	-	-	-	-	-	-	-	-	-	-	-	-
34	17.02.2015	57.78	OK	NO	-	-	-	-	-	-	-	-	-	-	-	-
35	17.02.2015	56.89	OK	NO	-	-	-	-	-	-	-	-	-	-	-	-
36	17.02.2015	57.63	OK	NO	-	-	-	-	-	-	-	-	-	-	-	-
37	17.02.2015	59.56	OK	NO	-	-	-	-	-	-	-	-	-	-	-	-
38	18.02.2015	58.13	OK	NO	-	-	-	-	-	-	-	-	-	-	-	-
39	20.02.2015	59.56	OK	NO	-	-	-	-	-	-	-	-	-	-	-	-
40	23.02.2015	61.91	OK	NO	-	-	-	-	-	-	-	-	-	-	-	-
41	24.02.2015	55.30	OK	NO	-	-	-	-	-	-	-	-	-	-	-	-
42	24.02.2015	60.86	OK	NO	-	-	-	-	-	-	-	-	-	-	-	-
43	25.02.2015	55.53	OK	NO	-	-	-	-	-	-	-	-	-	-	-	-
44	26.02.2015	60.53	OK	NO	-	-	-	-	-	-	-	-	-	-	-	-
45	26.02.2015	62.21	OK	NO	-	-	-	-	-	-	-	-	-	-	-	-
46	26.02.2015	60.74	OK	NO	-	-	-	-	-	-	-	-	-	-	-	-
47	28.02.2015	60.55	OK	NO	-	-	-	-	-	-	-	-	-	-	-	-

Note:-Minimum 30 Test Results are essential to establish Standard Deviation.

Graphical Representation of Analysis:



CONCLUSION:

After analyzing the test result of M50 Temp. Controlled Concrete, cast during Jan 2017 to Feb 2017 (47 Nos.), the compressive strength is changing due to change in weather condition through the months. Which confirm that the compressive strength will effect from the environmental condition while other conditions were controlled.

After analyzing the test results of M50 Temp. Controlled Concrete, cast during Jan 2017 to Feb 2017 (47 nos), it has been found that the concrete conforms to the requirements of the table 2 of IS 456-2000.

Not a single specimen is beyond the deviation limit of 15% from average of three specimens. All the test results are complying with the requirements of Clause 15.4 of IS 456:2000.

Mean of the test results is 60.58 MPa against the Targeted Mean Strength 58.3 MPa. Chances of getting low result than 50 MPa is reported as 0.01% compared to the assumed value of 5% (1 low result in 20).

Established Standard Deviation 2.9 MPa is well below the estimated Standard Deviation 5 MPa (as per IS 456-2000), which implies an excellent control over the quality of the concrete.

The concrete conforms to the requirements of the agreed criteria for acceptance and Table 11 of IS 456-

2000. Not a single test result is below $f_{ck}-3$ i.e. 47 MPa. All the test results are above $f_{ck}+3$ i.e. 53 MPa.

REFERENCES

- [1] IS: 269:2015, Ordinary Portland cement – Specification.
- [2] IS: 4031 (Part-2) -1999 (RA 2009), Methods of Physical Tests for Hydraulic Cement. Part-2 Determination of fineness by Blaine Air Permeability Method.
- [3] IS: 4031 (Part-3 to 6)-1988 (RA 2009), Methods of Physical Tests for Hydraulic Cement. Part-3 Determination of Soundness, Part-4 Determination of consistency of standard cement paste, Part-5 Determination of initial and final setting times, Part-6 Determination of compressive strength of hydraulic cement other than masonry cement.
- [4] IS: 4032- 1985 (Reaffirmed 2009), Method of chemical analysis of hydraulic cement.
- [5] IS: 383-2016, Specification for coarse and fine aggregate from natural sources for concrete.
- [6] IS: 9103-1999 (RA: 2013), Concrete Admixture – Specification.
- [7] IS: 456: 2000 (Reaffirmed 2005), Plain and Reinforced concrete – Code of Practice (Fourth Revision) (Tenth Reprint April 2007 – including amendments 1 and 2)
- [8] IS: 7861 (Part-1)-1975, Code of Practice for Extreme Weather Concreting, Part-I recommended for Hot Weather Concreting.
- [9] IS: 10262:2009, Concrete Mix Proportioning – Guideline (First Revision).
- [10] ACI-211.1-91, standard practice for selecting proportion for normal, heavyweight and mass concrete (ACI-211.1-91) reapproved 1997.