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Effect of Change in Mixing Time of Mixer on Wet Density, Dry Density, Workability and Compressive Strength of M-20 Grade Concrete

Dr. M. B.Varma[1]
[1]Assosiate Professor,
Applied Mechanics Department
Government College of Engineering,
Aurangabad, Maharashtra, India

***Abstract*— on actual construction site at the time of concrete production, mixing time of concrete mixer is kept as 2 minutes. This study was carried out on concrete properties by changing its mixing time. Ten concrete samples were prepared and tested with mixing time of mixture 1 minute, 2 minutes, and 3 minutes up to 10 minutes. Concrete of M-20 grade was prepared as per IS 456-2000. Using Nominal mix (guide lines of IS 456-2000) concrete was manufactured. Wet and dry density, workability and compressive strength were recorded for ten concrete mixes. Results obtained were presented in this paper.**

Keywords*— Mixing Time, Compressive Strength, Density Of Concrete

INTRODUCTION

The compressive strength ,weight and dry density and workability of concrete depends upon many factors, e.g. quality and quantity of cement, water and aggregates; batching and mixing; type of mixture, mixing time, placing, and compaction and curing. Concrete was produced in laboratory using pan type mixture. Concrete properties – weight density, dry density workability and compressive strength was studied by carrying out experimental study.

Researcher worked on mixing time and compressive strength of concrete and established some relation for 7 Day's compressive strength, 28 Day's compressive strength and 2 months compressive strength. Refer Figure 1 for relation between mixing time and compressive strength of concrete. The graph showing the relationship between the compressive

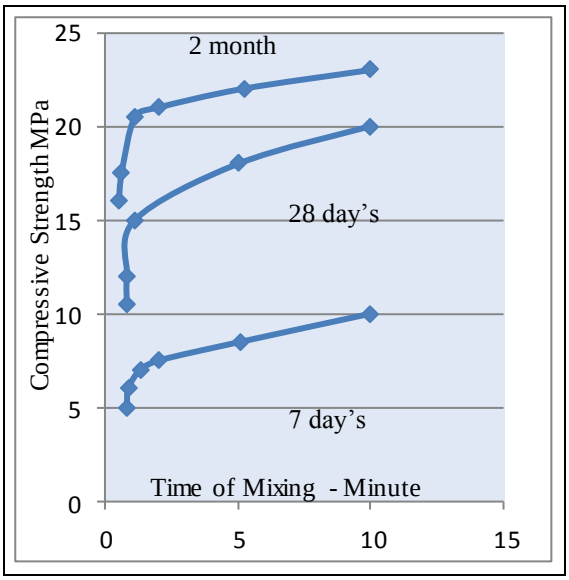

Figure 1: Strength and Mixing time of Concrete [1]

Strength of concrete and mixing time of concrete mixer in minutes is parabolic in nature.

Properties of concrete depend on

1. Proper Mixing of concrete,
2. mixing time,
3. Type of concrete mixture.

In construction activities on site, general practice adopted by engineer is use nominal mix and mixer for concrete production. No importance is given for mixing time in spite of it has direct impact on properties of concrete. There is need to study effect of change in mixing time on properties of concrete. In present research work main thrust was given to mixing time. Study was carried out by changing mixing time from 1 minute to 10 minutes without changing mix proportion, concrete is produced. The effect of mixing time on wet density, dry density, workability and compressive strength of concrete was experimentally studied and reported.

At the time of production of concrete slump and compaction factor was recorded for measurement of workability of concrete. Wet weight and dry weight of concrete were recorded and from this weight dry and wet density of concrete were calculated. All the observations regarding 7 days compressive strength, 28 days compressive

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strength, slump of concrete, compaction factor of concrete, wet and dry weight of concrete were presented in Tables below. Figure 2 shows the concrete mixture used in laboratory to produce concrete.

Figure 2: Concrete Mixer used in Laboratory

Revolution of concrete mixer was 25 revolutions per minute. Figure 3 below shows the plate vibrator which was used to cast concrete cubes in laboratory by giving vibration.

Figure 3: Table Vibrator [5]

Figure 4 shows UTM 40 ton capacity which was used to find compressive strength of concrete cube.

Figure 4: Compression Test on Concrete Cube

Concrete was produced in laboratory using above proportion. Empty weight of cube moulds and weight of mould with concrete was recorded. All results obtained were tabulated below (Table 1); from obtained results wet density of concrete was calculated.

Material:

Ordinary Portland cement, Natural River sand, coarse aggregate from crusher of size 12 mm (1/2 inch), 20 mm (3/4 inch) and potable water was used to produce concrete in laboratory.

Specimens:

Concrete was produced using nominal mix. Cube mould of size 15 x 15 x 15 cm was used. Ten mixes was prepared by changing mixing time by 1 minute. For each mix, six cubes were cast and kept for water curing. After water curing of 7 days and 28 days, compressive strength was recorded.

III. PRIOR APPROACH

For a particular mixer, a relation between mixing time and uniformity is provided. Mixing less than 1 to 1.25 minutes result a significantly variable concrete but prolonging the time of mixing beyond these values render no significant improvement in uniformity. The length of mixing time depends on quality of blending materials during charging of mixture. [3]

The exact value of mixing time is also a function of size of mixture. A minimum mixing time of 1 minute for mixer size of 1 cum. yd (3/4 cum. m) and 15 additional seconds for each addition cubic yard is giving satisfactory uniformity of mixing. [4]

Mixing time is counted from the time when all the solid materials have been put in the mixer. Mixing time should count from the time when the entire ingredient has been discharged into the mixer. Exceptions many modern large mixers perform satisfactorily with a mixing time of 1 to 1.5 minutes. In high speed pan mixers, the mixing time can be as short as 35 seconds when lightweight aggregate is used, the mixing time, less than 5 minutes, may hamper developments of strength for better result. Sometimes mixing of aggregate with water for 2 minutes is done first followed by 3 minutes mixing after cement is added. [5]

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IV. OUR APPROACH

Cement OPC of 43 grade cement was used. Fine aggregate natural Godavari river sand was used. Coarse aggregate crushed angular 20 mm and 12 mm size were used; potable water was used to production of cement concrete of grade M20. Material used in following proportion (by weight, and nominal mix provisions of IS 456-2000) [1]

Laboratory Proportion to produce M 20 grade concrete
C:F.A:C.A:W/C RATIO (by weight)

1:1.67:3.31:0.6

Cement =10 Kg; Sand (F.A.) =16.7 Kg

12 mm C.A= 8.30 Kg; 20 mm C.A. =24.80 Kg

Water= 6 Ltr

Properties of Fresh Concrete

Concrete differs from conventional concrete in that its fresh properties are vital in determining whether or not it can be placed satisfactorily. The various aspects of workability which control its filling ability, its passing figure carefully controlled to ensure that its ability to be placed remains acceptable.

Concrete is primarily strong in compression and in actual construction, the concrete is used in compression. Higher the compressive strength better is the durability. Bond strength also improves with the increase in compressive strength and is important in R.C.C. work. Compressive strength also indicates extent of control exercised during construction.

Concrete was produced using nominal mix. Cube mould of size 15 x 15 x 15 cm was used. 10 Number of mixes was prepared by changing mixing time by minute. For each mix, six cubes were cast and kept for water curing. After water curing of 7 days and 28 days, compressive strength was recorded, after carrying compression test on cubes.

All the observations regarding 7 days compressive strength, 28 days compressive strength, slump of concrete, compaction factor of concrete, wet and dry weight of concrete were presented in Table below.

Table 1: Comparison for Various Mixes with Different Mixing Time and Weight Density of Concrete

Mixing time minute	Empty Weight of cube mould	Filled Weight	Wet Weight	Wet Density of concrete	Wet Density of concrete
	Kg	Kg	Kg	Kg/m^3	Kg/m^3
1	10.3	19.3	9	2666.67	2686
	10	19.1	9.1	2696.30	
	9.2	18.35	9.15	2711.11	
	10.45	19.4	8.95	2651.85	
	9.3	18.45	9.15	2711.11	
	10	19.05	9.05	2681.48	
2	9.35	18.95	9.6	2844.44	2780
	10.05	18.95	8.9	2637.04	
	9.45	18.65	9.2	2725.93	
	9.1	18.5	9.4	2785.19	
	9.7	19.3	9.6	2844.44	
	9.95	19.55	9.6	2844.44	
3	9.35	18.95	9.6	2844.44	2780
	10.05	18.95	8.9	2637.04	
	9.45	18.65	9.2	2725.93	
	9.1	18.5	9.4	2785.19	
	9.7	19.3	9.6	2844.44	
	9.95	19.55	9.6	2844.44	
4	9.35	18.75	9.4	2785.19	2767
	9.95	19.35	9.4	2785.19	
	9.1	18.55	9.45	2800.00	
	10.05	19.05	9	2666.67	
	9.7	19.05	9.35	2770.37	
	9.45	18.9	9.45	2800.00	
5	10	19.55	9.55	2829.63	2765.40
	10	19.35	9.35	2770.37	
	9.2	18.65	9.45	2800.00	
	10.45	19.25	8.8	2607.41	
	9.3	18.7	9.4	2785.19	
	10.3	19.75	9.45	2800.00	
6	9.3	18.55	9.25	2740.74	2767
	10	19.15	9.15	2711.11	
	9.2	18.85	9.65	2859.26	
	10.45	19.59	9.14	2708.15	
	10.3	19.55	9.25	2740.74	
	10	19.6	9.6	2844.44	
7	10.45	19.75	9.3	2755.56	2758
	10.3	19.65	9.35	2770.37	
	10	19.45	9.45	2800.00	
	9.3	18.4	9.1	2696.30	
	10	19.1	9.1	2696.30	
	9.2	18.75	9.55	2829.63	
8	10.45	19.15	8.7	2577.78	2780
	10.3	19.8	9.5	2814.81	
	10	19.35	9.35	2770.37	
	9.3	18.7	9.4	2785.19	
	10	19.6	9.6	2844.44	
	9.2	18.95	9.75	2888.89	
9	10.45	19.15	8.7	2577.78	2745
	10.3	18.85	8.55	2533.33	
	9.2	19.1	9.9	2933.33	
	10.3	19.8	9.5	2814.81	
	10	19.6	9.6	2844.44	
	10	19.35	9.35	2770.37	
10	9.3	18.3	9	2666.67	2733
	10	19.5	9.5	2814.81	
	9.2	18.5	9.3	2755.56	
	10.45	19.15	8.7	2577.78	
	10.3	19.8	9.5	2814.81	
	10	19.35	9.35	2770.37	

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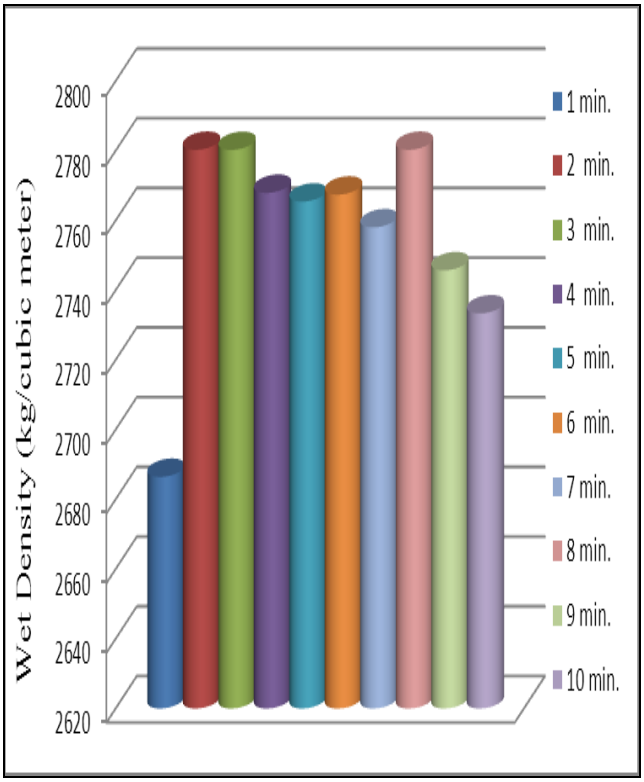

Figure 5: Graph of mixing time v/s wet density of concrete

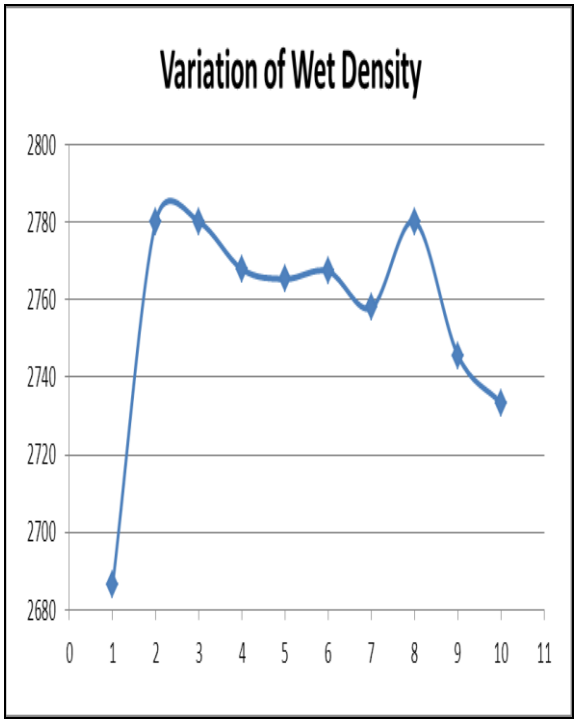

Figure 6: Graph of mixing time v/s wet density of concrete

Graph was plotted to show values of wet density of concrete against water cement ratio. (Figure 6)

Table 2: Comparison for Various Mixes with Different Mixing Time and Dry Density of Concrete

Mixing time (Minute)	Dry Weight(cube)	Dry Density	28 Days Dry Density
	Kg	Kg	Kg/m^3
1	8.75	2592.5	2610
	8.7	2577.7	
	8.9	2637.0	
	8.75	2592.5	
	8.85	2622.2	
	8.9	2637.0	
2	9.1	2696.3	2684
	8.95	2651.8	
	8.7	2577.7	
	9.2	2725.9	
	9.15	2711.1	
	9.25	2740.7	
3	9.3	2755.5	2711
	8.9	2637.0	
	9.1	2696.3	
	9.2	2725.9	
	9.15	2711.1	
	9.25	2740.7	
4	9.15	2711.1	2696
	9.2	2725.9	
	9.05	2681.4	
	8.9	2637.0	
	9.2	2725.9	
	9.1	2696.3	
5	9.25	2740.7	2706
	9.2	2725.9	
	9.25	2740.7	
	9	2666.6	
	9	2666.6	
	9.1	2696.3	
6	9.1	2696.3	2706
	9.1	2696.3	
	9.2	2725.9	
	9.2	2725.9	
	9.1	2696.3	
	9.1	2696.3	
7	9.3	2755.5	2694
	9.05	2681.4	
	8.8	2607.4	
	9.15	2711.1	
	9.15	2711.1	
	9.1	2696.3	
8	9.45	2800.0	2726
	9.2	2725.9	
	9.1	2696.3	
	9.15	2711.1	
	9.1	2696.3	
	9.2	2725.9	
9	9.2	2725.9	2709
	9.2	2725.9	
	9.05	2681.4	
	9.15	2711.1	
	9	2666.6	
	9.25	2740.7	
10	9.15	2711.1	2721
	9.3	2755.5	
	9.35	2770.3	
	9.1	2696.3	
	9.2	2725.9	
	9	2666.6	

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Changing mixing time diagram was plotted in Figure below (Figure 7)

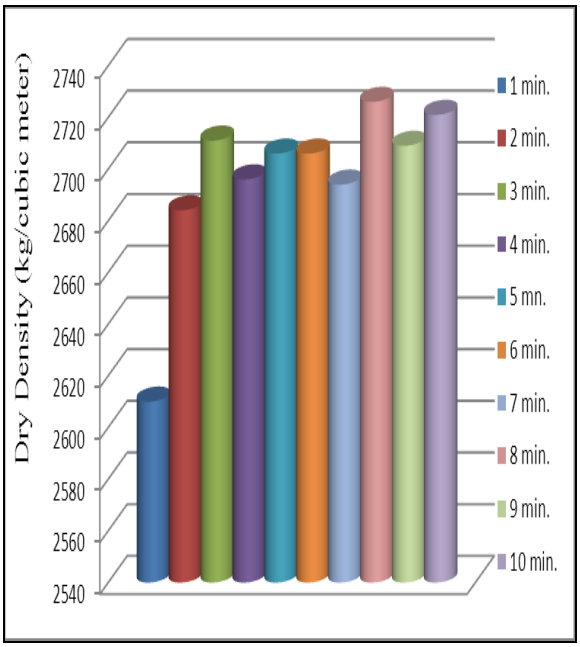

Figure 7: Graph of Mixing Time v/s Dry density of concrete

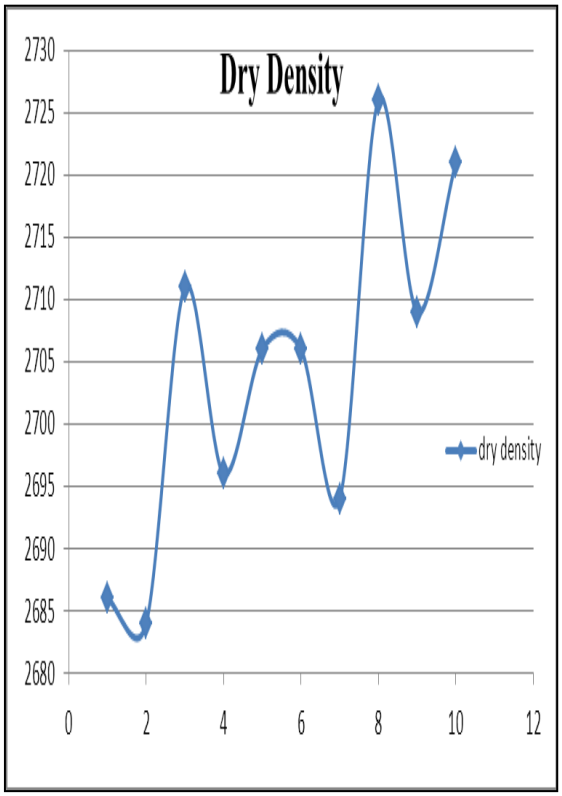

Figure 8: Graph of Mixing Time v/s Dry density of concrete

Table 3: Comparison Different Mixing Time with Compaction Factor of Concrete Mixes

mix	Mixing time (Minute)	Compaction factor
1	1	0.957
2	2	0.956
3	3	0.946
4	4	0.938
5	5	0.937
6	6	0.934
7	7	0.944
8	8	0.945
9	9	0.948
10	10	0.944

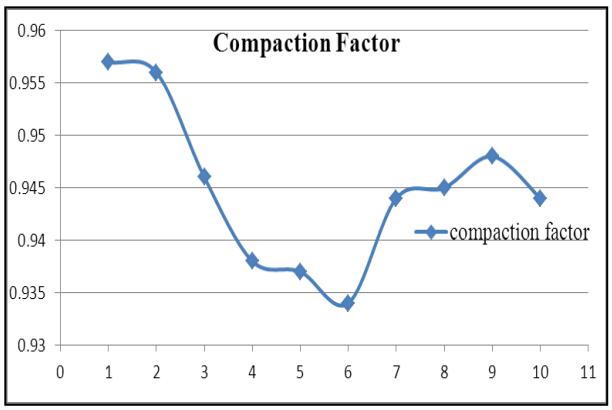

Figure 9: Graph of Mixing Time v/s wet Compaction Factor

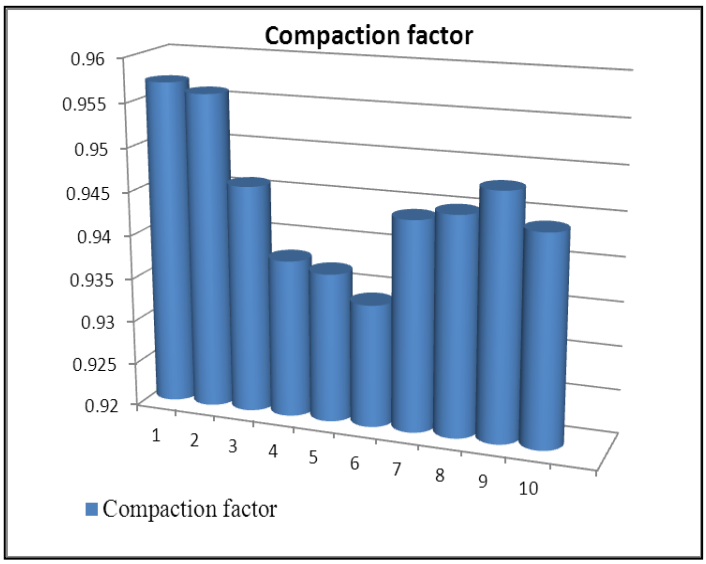

Figure 10: Graph of Mixing Time v/s wet Compaction Factor

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Table 4: Comparison Different Mixing Time with slump of Concrete Mixes

Mix	Mixing time(minutes)	Slump mm
1	1	120
2	2	118
3	3	110
4	4	93
5	5	93
6	6	90
7	7	93
8	8	94
9	9	99
10	10	107

A graph was plotted to show variation in slump with change in mixing time below (Figure 11)

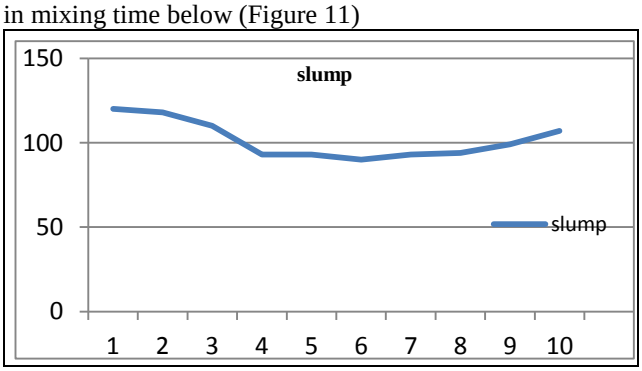

Figure 11: Variation slump of concrete with different Mixing Time

Figure 12 shows comparison of slumps

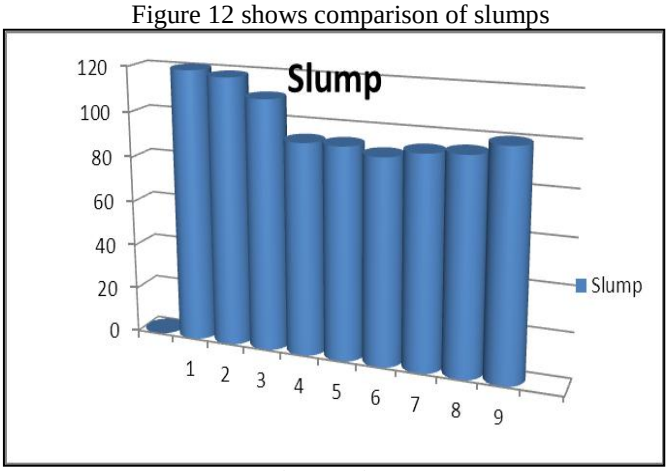

Figure 12: Comparison of slump of concrete with Mixing Time

Table 5: Comparison Different Mixing Time with Slump & Compaction Factor of Concrete Mixes

Mixing Time	Slump mm	Compaction factor
1	120	0.957
2	118	0.956
3	110	0.946
4	93	0.938
5	93	0.937
6	90	0.934
7	93	0.944
8	94	0.945
9	99	0.948
10	107	0.944

Concrete cubes of size 15×15×15 cm were tested after water curing of 7 days under Compression Testing Machine. Results obtained were recorded in Table below (Table 4). Compressive strength calculated and tabulated in Table below.

Table 6: Comparison Mixing Time and Compressive Strength (7 Days) of Concrete

Mix	Mixing time (Minute)	Load kN	Comp. Strength N/mm^2	Av. Comp. Strength N/mm^2
1	1	300	13.33	13.04
		300	13.33	
		280	12.44	
2	2	340	15.11	16.15
		380	16.89	
		370	16.44	
3	3	410	18.22	18.96
		420	18.67	
		450	20.00	
4	4	410	18.22	19.26
		460	20.44	
		430	19.11	
5	5	430	19.11	19.85
		420	18.67	
		490	21.78	
6	6	440	19.56	20.15
		480	21.33	
		440	19.56	
7	7	450	20.00	20.15
		490	21.78	
		420	18.67	
8	8	430	19.11	20.00
		470	20.89	
		450	20.00	
9	9	430	19.11	20.00
		430	19.11	
		490	21.78	
10	10	470	20.89	19.85
		430	19.11	
		440	19.56	

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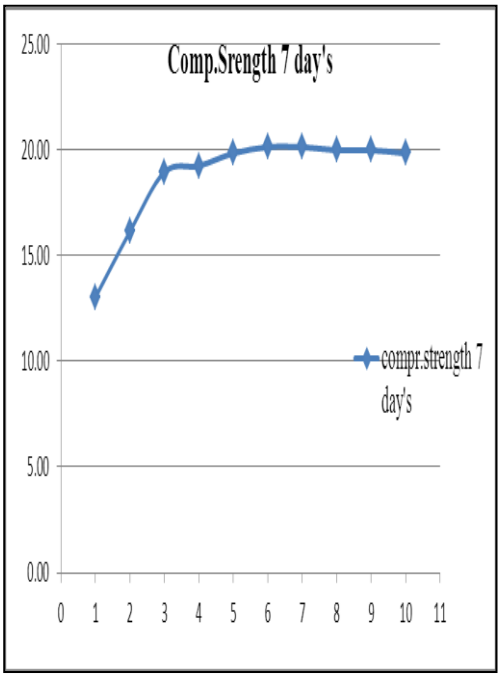

Figure 13: Graph of Mixing Time v/s Compressive Strength (7 Day's)

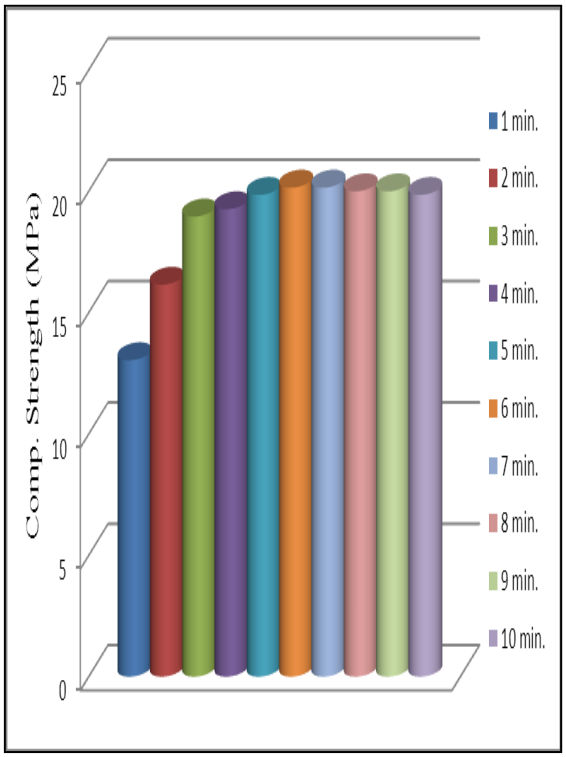

Figure 14: Graph of Mixing Time v/s Compressive Strength (7 Day's)

Table 7: Comparison Mixing Time and Compressive Strength (28 Days) of Concrete

Mix	Mixing Time	Load (kN)	Comp. Strength (N/mm^2)	Av. Comp. Strength ($N/mm^{2)}$
1	1	400	17.78	20.44
		540	24.00	
		440	19.56	
2	2	600	26.67	25.04
		570	25.33	
		520	23.11	
3	3	660	29.33	28.59
		670	29.78	
		600	26.67	
4	4	670	29.78	30.96
		750	33.33	
		670	29.78	
5	5	680	30.22	31.11
		760	33.78	
		660	29.33	
6	6	680	30.22	31.26
		730	32.44	
		700	31.11	
7	7	660	29.33	31.11
		710	31.56	
		730	32.44	
8	8	620	27.56	29.63
		740	32.89	
		640	28.44	
9	9	700	31.11	29.78
		650	28.89	
		660	29.33	
10	10	740	32.89	29.63
		630	28.00	
		630	28.00	

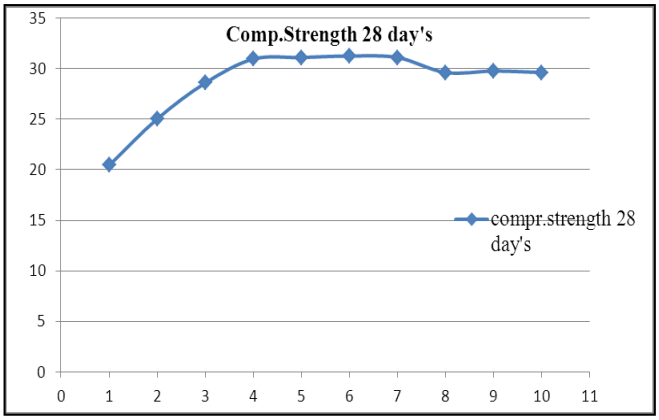

Figure 15: Graph of Mixing Time v/s Compressive Strength (28 Day's)

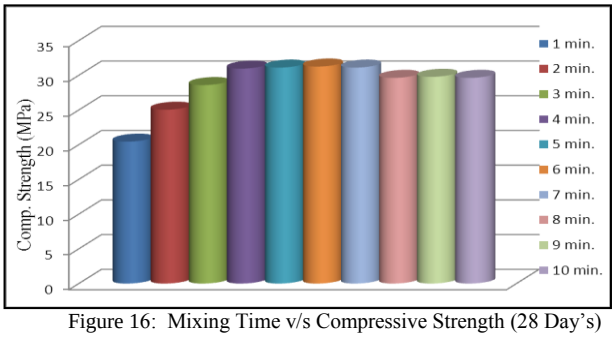

Figure 16: Mixing Time v/s Compressive Strength (28 Day's)

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28 days compressive strength was calculated and tabulated in Table 5 above. Obtained value suggest as mixing time increases 28 Days Compressive Strength of concrete decreases

V. CONCLUSION

From the results obtained & following observations it was concluded that the workability, compressive strength of concrete was higher when the mixing time is within 4 to 7 minutes.

1) Slump Values
1. For initial three minutes of mixing slump value is higher due to inadequate mixing time.
2. From 4 to 7 minutes of mixing the slump value is better than that of other durations of mixing.
3. From 8 to 10 minutes of mixing the slump value again increases due to segregation of concrete ingredients caused by prolonged mixing.

2) Compaction factor
1. For initial two minutes of mixing results shows higher values compaction factor. But due inadequate mixing, the concrete cannot be properly compacted.
2. For final 2 minutes also, the results are higher due to inadequate compaction but due to segregation of material.

3) Compressive Strength of Concrete
1. For initial two to three minutes of mixing, results shows low values of compressive strength is due to adequate mixing
2. For mixing time within 4 to 7 minutes the compressive strength was maximum
3. Further mixing may result in lower strength probably due to segregation of concrete ingredients.

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