VOL. 14, NO. 4, FEBRUARY 2019 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

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INVESTIGATIONS ON STRENGTH OF CONCRETE BY REMIXING CONCRETE MIXES

K. L. Bidkar and P. D. Jadhao
Civil Engineering Department, K. K. Wagh Institute of Engineering Education and Research, Nashik, India
Email: kisanbidkar@gmail.com

ABSTRACT

The aim of present work is to study durability properties due to overlaying of concrete as well as intermittent curing conditions. Adequate curing is necessary with proper method of its application for a newly placed concrete to achieve the enviable qualities and accepted durability of the hardened concrete In the present experimental work, study the behaviors of over-layered specimens with different blend ratio, time lag and different intermittent curing conditions examined for strength parameters.

Keywords: over-layed concrete, blend ratio, time lag, delayed curing, intermittent curing.

1. INTRODUCTION

Nowadays the casting delay is common phenomenon which especially faced by concrete industries and ready mix concrete industries. These result in considerable loss of workability which tends the concrete to become unworkable and harsh. The casting delay is mainly influenced by the traffic, also location of construction site in relation to central batching plant [1, 2]. There are also some factors which causes delaying process is that improper methods of handling, work scheduling, lack of site organization and the breakdown of equipment. To overcome such problem the practice of re-tempering is frequently performed to keep concrete workable by restoring the initial slump to cope up with expending casting operation and also reducing consolidation efforts. Casting delay results in overlaying which is a term attributed to the blending of two different individual mixes of the same mix type but of different r and t values into a single composite mass called selfed mass, and the corresponding strength of which be termed as selfed strength.

The strength of concrete also depends on curing of concrete. Concrete curing is fundamental to achieve quality and durable concrete [3]. This study examines the influence of curing methods [4, 5] on the mechanical strength development of concrete. Different curing methods are usually adopted to evaluate the compressive strength of concrete [6, 7]. This study reports the laboratory results of the curing method on the compressive strength of concrete. Though the exact lab curing practice is not possible on field, up to certain extent the suggested methods can be applied in due consideration of site conditions. Curing may be applied in a number of ways and the most appropriate means of curing may be dictated by the site or the construction method. [8, 9, 10]

This progress report based on the methodology related to overlaying of concrete, its durability as compared to the conventional concrete and it is determined by using the compressive test. The effect of intermittent curing is also studied by taking test for different curing conditions.

2. RESEARCH SIGNIFICANCE

Researchers studied the strength of composite mixes using general selfing and crossing theory with different blend ratio and different time lag, as well as curing effects with different blend ratio and different time lag separately. [11, 12]. But extensively work on different curing condition and overlaying with different blend ratio and different time lag are missing. The column problem is also not considered. Hence in this work column concreting with different blend ratio, different time lag, with intermixing of different grade of concrete mainly combination of (M20 and M30) with varying cumulative conditions is considered.

3. EXPERIMENTAL INVESTIGATION

The entire investigation and experimental work was carried out form identification of problems up to the result and discussion for problem. The following chart gives Work carried out with the sequence of the activities from starting to the end of investigation.

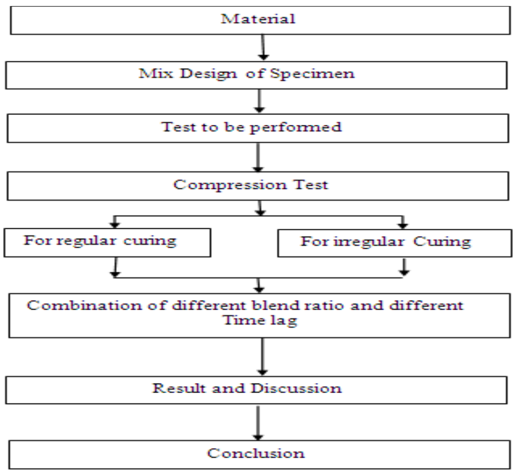

Figure-1. Flow chart of methodology.

3.1 Materials

Ordinary Portland cement (OPC 53) grade is used. The physical properties and chemical analysis of the cement and slag powders are listed in Table-1.

Table-1. Physical properties of ordinary Portland cement- 53 grade.

Properties	Results	Limits and standard
Fineness	**<10**	**5%**
Normal consistency	29.2%	Recommended value of Pn as per IS -12269 : 1989 is 26% to 33%
Specific gravity	2.5	IS 2386(Part- III) -1963
Setting time		IS 4031 (PART 5) –1988
Initial	46 min	Not less than 30 min
Final	400 min	Not greater than 600 min
Soundness Test		
Le-Chat expansion	3mm	10mm maximum
Compressive strength		
3 days	30.10 N/mm^2	
7 days	43.20 N/mm^2	
28 days	52.85 N/mm^2	

Table-2. Specific gravity, bulk density, voids ratio and absorption of fine aggregates.

Material	Specific gravity	Bulk density(kg/m^3)	Void ratio	Absorption (%)
Fine aggregate	2.5	1812.72	0.336	1.0

Table-3. Specific gravity, bulk density, voids ratio and absorption of coarse aggregates.

Material	Specific gravity	Bulk density (kg/m^3)	Void ratio	Absorption (%)
Coarse aggregate 20mm	2.61	1618.43	0.437	0.5

3.2 Specimens

Compression test of concrete specimen is most widely used for the testing of its compressive strength. Cube of size 150 mm x 150 mm x 150 mm. After 24 hours cube is remolded and placed in water. Compression test can be carried out in 28 days. Specimens stored in water shall be tested immediately on removal from the water and while they are still in the wet conditions. Surface water and grit shall be wiped off the specimen and any projecting find removed specimens when received dry shall be kept in water for 24 hours before they are taken for testing.

Specimen shall be placed in the machine in such a manner that the load shall be applied to opposite sides of the cubes as cast, that is, not to the top and bottom. The load shall be applied without shock and increased continuously at a rate approximately 140 kg/cm^2/min. The maximum load applied to the specimen shall be recorded and the appearance of the concrete.

3.3 Column specimen

Used 2% steel of column area

$A_{ST=}$2/100*15*150=450mm^2

Used 4 bars of 12mm, A_{ST} provided=452.16 mm^2

Allowable load P = σ_{cc} A_C + σ_{SC} A_{SC}

σ_{cc} =5 N/mm^2

A_C = (150*150-3.14/4*122*4)=22047.84mm^2

σ_{SC} = 190 N/mm^2

A_{SC} = 452.16mm^2

P = 196.149 kN

3.4 Items of investigation

In current work the part of experimental done which are as follows:

Casting of cube of M_{20} for blend ratio=0 and time lag =0 similarly for blend ratio 1, 2, 4 and infinity at time lag 60min.,120min.,180min. for each blend ratio. For every specimen have three samples. All specimens tested after 28 days in CTM Machine.

Some typical practical problem often encountered at construction site concerning partially set concretes in blending or those of similar kind.

This work is mainly divided into two main categories

Category 1

Direct application of the concept in which two mixes of different type are blend together into a resultant single composite one, at time lag t (Blend ratio 1, 2, and 3 for time lag of one, two and three hour).

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Table-4. Details of specimen for blend ratio 1, 2 and 3 for time lag of 1, 2 and 3 hour.

Blend ratio	**Time lag** (hours)	**Improper curing** (days)	**Delayed curing** (days)	**Regular curing** (days)
1	1	$W_{14}\,A_{14}$	$A_{14}\,W_{14}$	$W_{28}\,A_0$
1	2	$W_{14}\,A_{14}$	$A_{14}\,W_{14}$	$W_{28}\,A_0$
1	3	$W_{14}\,A_{14}$	$A_{14}\,W_{14}$	$W_{28}\,A_0$
2	1	$W_{14}\,A_{14}$	$A_{14}\,W_{14}$	$W_{28}\,A_0$
2	2	$W_{14}\,A_{14}$	$A_{14}\,W_{14}$	$W_{28}\,A_0$
2	3	$W_{14}\,A_{14}$	$A_{14}\,W_{14}$	$W_{28}\,A_0$
3	1	$W_{14}\,A_{14}$	$A_{14}\,W_{14}$	$W_{28}\,A_0$
3	2	$W_{14}\,A_{14}$	$A_{14}\,W_{14}$	$W_{28}\,A_0$
3	3	$W_{14}\,A_{14}$	$A_{14}\,W_{14}$	$W_{28}\,A_0$

Category 2

Indirect or analogous application of concept in which the given problem can be transformed into equivalent one to that of category 1 where physically mixing of two different quantities into single one ,may not be involved at all. (Blend ratio 1 for time lag of 1, 2 and 3 hour).

Table-5. Details of specimen for column with different percentage of concrete filling.

Blend ratio	**Time lag** (hours)	**Column filled** (%)	**Column filled** (mm)	**Regular curing** (days)
1	1	25	175 mm	$W_{28}\,A_0$
1	1	50	350 mm	$W_{28}\,A_0$
1	1	75	525 mm	$W_{28}\,A_0$

Details of specimen

Table-6. Details of specimen.

Test	**Dimension of specimen**	**No of samples**
Compression test	150 mm x 150 mm x 150 mm	3
Compression test	750 mm x 150 mm x 150 mm	3

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Table-7. Details cubes with different time lag, blend ratio and curing conditions.

S. No	Blend ratio (r)	Time lag (t) min	M20 curing
1	1	60	A0W28,A_7W_{21},A14W14,$A_{21}W_7$,A28W0
2		120	A0W28,A_7W_{21},A14W14,$A_{21}W_7$,A28W0
3		180	A0W28,A_7W_{21},A14W14,$A_{21}W_7$,A28W0
4	2	60	A0W28,A_7W_{21},A14W14,$A_{21}W_7$,A28W0
5		120	A0W28,A_7W_{21},A14W14,$A_{21}W_7$,A28W0
6		180	A0W28,A_7W_{21},A14W14,$A_{21}W_7$,A28W0
7	4	60	A0W28,A_7W_{21},A14W14,$A_{21}W_7$,A28W0
8		120	A0W28,A_7W_{21},A14W14,$A_{21}W_7$,A28W0
9		180	A0W28,A_7W_{21},A14W14,$A_{21}W_7$,A28W0
10	infinity	60	A0W28,A_7W_{21},A14W14,$A_{21}W_7$,A28W0
11		120	A0W28,A_7W_{21},A14W14,$A_{21}W_7$,A28W0
12		180	A0W28,A_7W_{21},A14W14,$A_{21}W_7$,A28W0

Table-8. Details of column with different blend ratio for time lag of 90 minute.

S. No.	Blend ratio (r)	Time lag (t) min	M20 curing
0	0	0	A_0W_{28}
1	1	90	A_0W_{28}
2	3	90	A_0W_{28}
3	infinity	90	A_0W_{28}

3.5 Details of casting work

The process of casting is also divided into two categories mainly-

Casting for category 1: mainly include cubes of size 150 mm x150 mm x 150 mm

Casting for Category 2: mainly include column of size750 mm x 150 mm x150 mm

Compression test for column

Compression test are generally used to determine the compression strength of the material .A column of 750 mm x 150 mm x 150 mm cast. The columns is remolded after 24 hours of casting. The column is laid vertically on UTM Machine and load is applied on top face of column through either one or two point of contact until the sample fall. The strain gauges are used with wheat stone bridge circuit.

Strain gauge placed on surface of column and it is connected to circuit and multimeter is connected to circuit. The multi meter gives the supply in voltage. The difference between voltages is substituted in formulae to get the deflection. The cube specimen shall then be placed in the UTM machine in such a manner that the upper surface at the time of casting the load shall be applied to the uppermost surface as cast in the mold. The load shall be increased up to the specimen fails, and the maximum load applied to the column specimen during the test on UTM machine shall be recorded. Deflection and compression strength are also recorded.

3.6 Analytical investigation

Experimental procedure

For compressive strength, cubes of dimension 150 x 150 x150 mm were cast and tested as per IS 516: 1959[14].

Concrete cubes different curing conditions, blend ratios and time lags

The cubes for different curing conditions (W_{14} A_{14}, A_{14}, W_{14}, W_{28} A_0), for various blend ratio 1,2 and 3 as well as three time lags 1, 2, 3 hours are used for test

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Table-9. Results of specimen for blend ratios 1, 2 and 3 for curing conditions W_{14} A_{14}, A_{14} W_{14} and W_{28} A_0.

Blend Ratio (r)	**Time lag** (hour)	**Curing condition**	**Average compressive strength** (N/mm²)
1	1	W_{14} A_{14}	36.45
	2	W_{14} A_{14}	34.82
	3	W_{14} A_{14}	33.17
2	1	W_{14} A_{14}	35.69
	2	W_{14} A_{14}	31.46
	3	W_{14} A_{14}	25.12
3	1	W_{14} A_{14}	35.02
	2	W_{14} A_{14}	29.33
	3	W_{14} A_{14}	24
Blend Ratio (r)	Time lag (hour)	Curing Condition	Average Compressive Strength (N/mm²)
1	1	A_{14} W_{14}	27.6
	2	A_{14} W_{14}	25.51
	3	A_{14} W_{14}	24.61
2	1	A_{14} W_{14}	27.16
	2	A_{14} W_{14}	20
	3	A_{14} W_{14}	19.87
3	1	A_{14} W_{14}	25.06
	2	A_{14} W_{14}	19.02
	3	A_{14} W_{14}	18.56
1	1	W_{28} A_0	39.41
	2	W_{28} A_0	34.67
	3	W_{28} A_0	33.98
2	1	W_{28} A_0	34.5
	2	W_{28} A_0	30.5
	3	W_{28} A_0	25.4
3	1	W_{28} A_0	34.91
	2	W_{28} A_0	29.56
	3	W_{28} A_0	24.5

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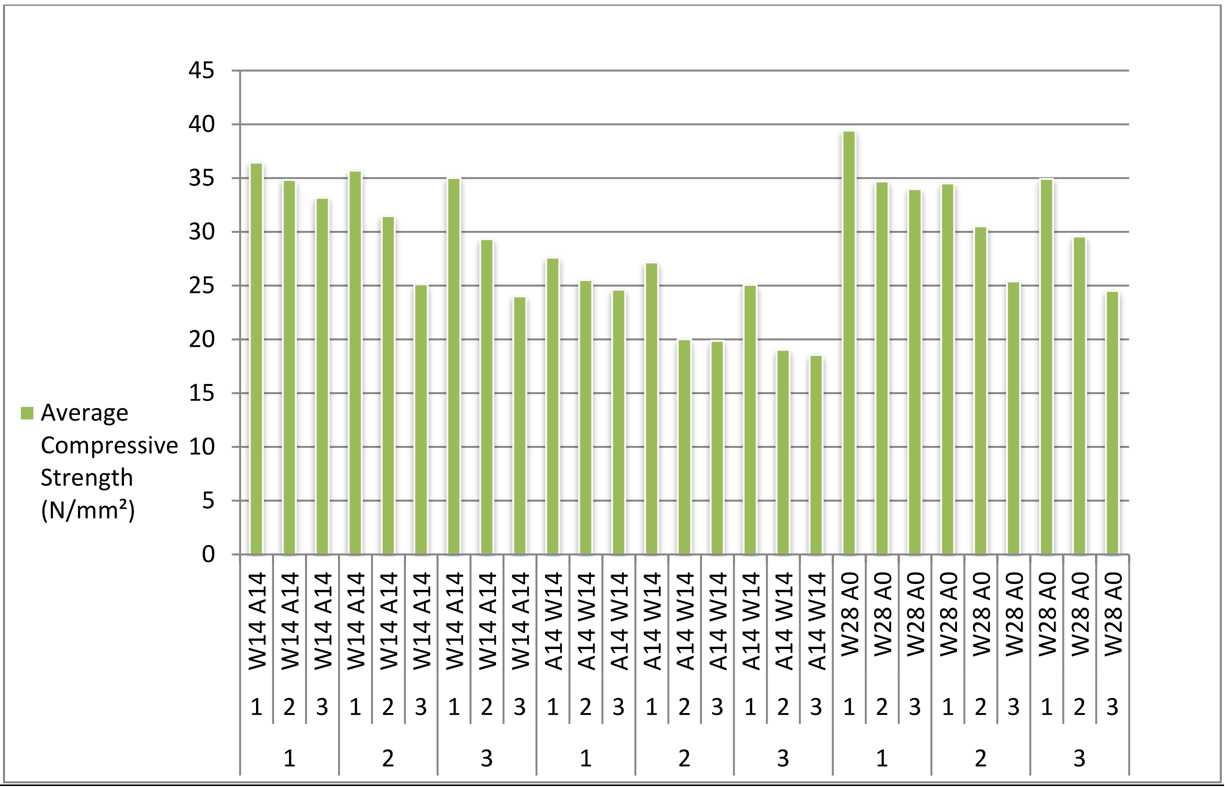

Graph-1. Variation of strength of concrete due different curing conditions, time lag and blend ratio.

Concrete columns filling with different percentages

The columns are filled 25% in first layer, followed by overlay for second layer as 75%, 50% in first layer, followed by second overlay as 50% , and 25% in first layer, followed by second overlay as 75% The effect on strength for column filling of different percentage is tested.

Table-10. Results of column specimen concreting for 25% first layer filling, followed by overlay of next 75% delayed second layer filling.

S. No.	Load kN	Deflection mV	Strain	Stress developed
1	0	48	0.003197	102.2976
2	30	52	0.003463	110.8224
3	60	65	0.004329	138.528
4	90	89	0.005927	189.6768
5	120	82	0.005461	174.7584
6	150	105	0.006993	223.776
7	180	114	0.007592	242.9568
8	210	150	0.00999	319.68
9	240	138	0.009191	294.1056
10	260	186	0.012388	396.4032
11	280	205	0.013653	436.896
12	290	215	0.014319	458.208
13	300	227	0.015118	483.7824
14	305	239	0.015917	509.3568
15	310	245	0.016317	522.144

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Table-11. Results of column specimen concreting for 50% first layer filling, followed by overlay of next 50 % delayed second layer filling.

S. No.	Load kN	Deflection mV	Strain	Stress developed
1	0	42	0.002797	89.5104
2	30	49	0.003263	104.4288
3	60	59	0.003929	125.7408
4	90	64	0.004262	136.3968
5	120	73	0.004862	155.5776
6	150	83	0.005528	176.8896
7	180	101	0.006727	215.2512
8	210	128	0.008525	272.7936
9	240	160	0.010656	340.992
10	270	162	0.010789	345.2544
11	300	152	0.010123	323.9424
12	330	148	0.009857	315.4176
13	350	164	0.010922	349.5168
14	370	201	0.013387	428.3712
15	383	240	0.015984	511.488

Table-12. Results of column specimen concreting for 75% first layer filling, followed by overlay of next 25 % delayed second layer filling.

S. No.	Load kN	Deflection mV	Strain	Stress developed
1	0	42	0.002797	89.5104
2	30	48	0.003197	102.2976
3	60	59	0.003929	125.7408
4	90	101	0.006727	215.2512
5	120	78	0.005195	166.2336
6	150	89	0.005927	189.6768
7	180	126	0.008392	268.5312
8	210	113	0.007526	240.8256
9	240	124	0.008258	264.2688
10	270	150	0.00999	319.68
11	290	180	0.011988	383.616
12	320	200	0.01332	426.24
13	340	180	0.011988	383.616
14	360	225	0.014985	479.52
15	377	235	0.015651	500.832

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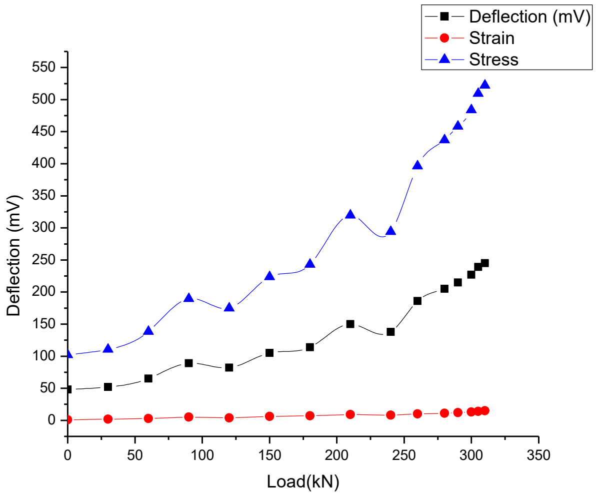
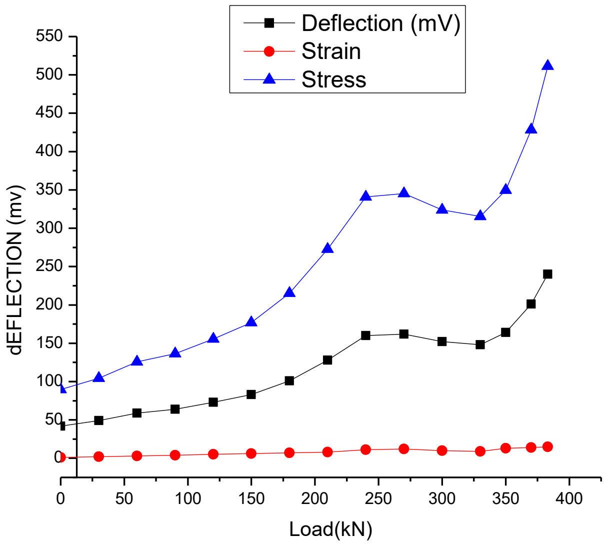
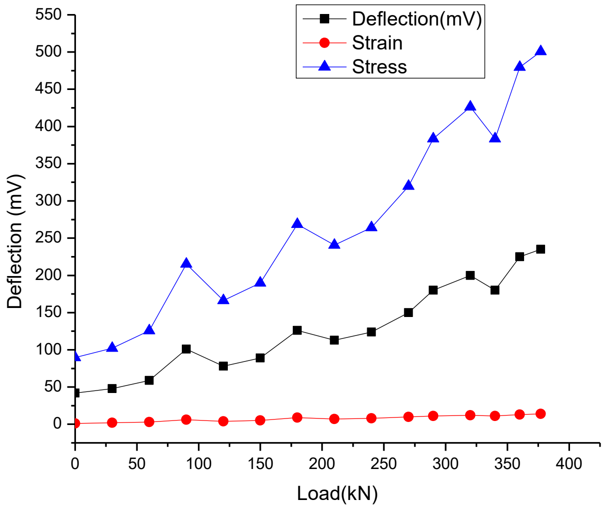


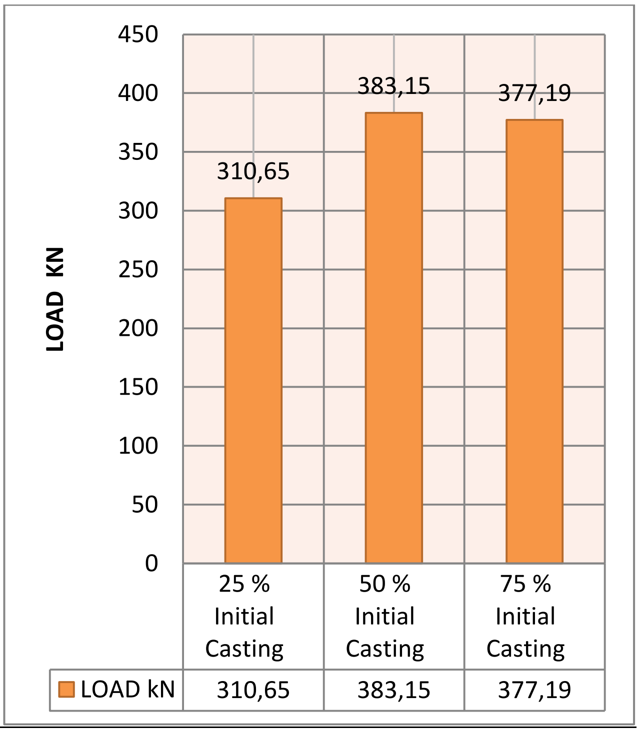
Graph-2. Representation of load vs deflection, strain and stress for initial 25 % column concreting.



Graph-3. Representation of load vs deflection, strain and stress for initial 50 % column concreting.



Graph-4. Representation of load vs deflection, strain and stress for initial 75 % column concreting.



Graph-5. Results of column concreting in layers.

Results of compressive strength of cubes: The cubes for different curing conditions (A_0 W_{28}, A_7 W_{21}, $A_{14}W_{14}$, $A_{21}W_7$, $A_{28}W_0$), for various blend ratio 1,2,4 and ∞ as well as three time lags 1, 2and 3 hours are used for test.

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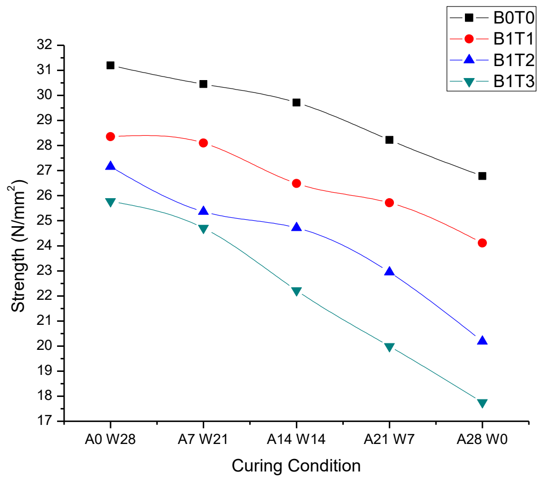
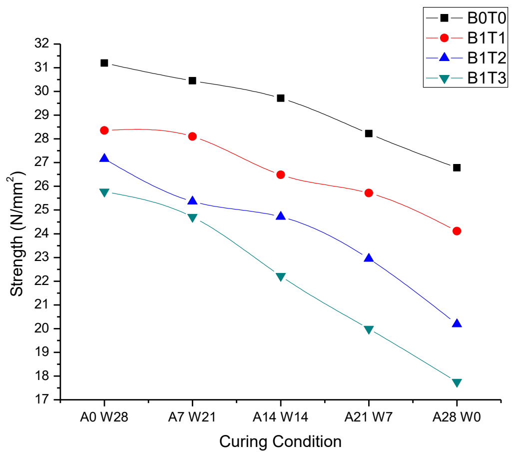
Table-13. Compressive strength of cubes in MPa.

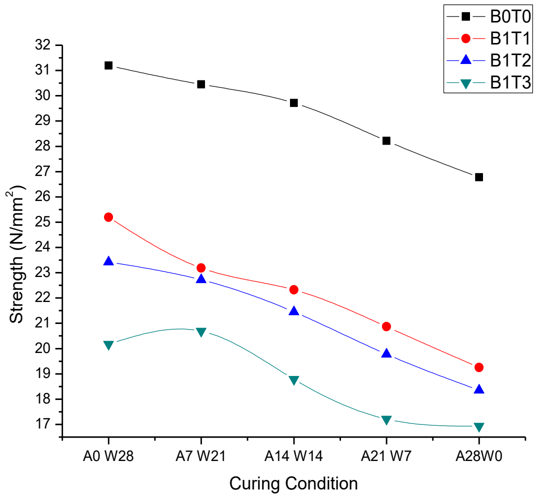
S. No.	Specimen	Curing condition				
		$A_{00}W_{28}$	$A_{07}W_{21}$	$A_{14}W_{14}$	$A_{21}W_{07}$	$A_{28}W_{00}$
1	$A(r_0, t_0)$	31.200	30.455	29.715	28.220	26.780
2	$A(r_1, t_1)$	28.355	28.100	26.490	25.720	24.110
3	$A(r_1, t_2)$	27.160	25.365	24.720	22.950	20.185
4	$A(r_1, t_3)$	25.770	24.710	22.215	19.990	17.750
5	$A(r_2, t_1)$	29.190	28.685	27.495	25.575	24.195
6	$A(r_2, t_2)$	26.335	26.050	25.115	23.760	22.585
7	$A(r_2, t_3)$	24.615	23.135	21.345	19.920	16.735
8	$A(r_4, t_1)$	25.910	23.190	22.325	20.870	19.250
9	$A(r_4, t_2)$	23.425	22.720	21.450	19.775	18.355
10	$A(r_4, t_3)$	20.720	20.690	18.785	17.215	16.935
11	$A(r_{\infty1}, t_1)$	22.555	20.485	19.455	17.620	16.245
12	$A(r_{\infty2}, t_2)$	19.470	18.215	17.680	15.485	14.670
13	$A(r_{\infty3}, t_3)$	16.115	15.858	14.950	12.955	11.555



Graph-6. Strength vs. curing condition for blend ratio 1.



Graph-7. Strength vs. curing condition for blend ratio 2.



Graph-8. Strength vs. curing condition for blend ratio 4.

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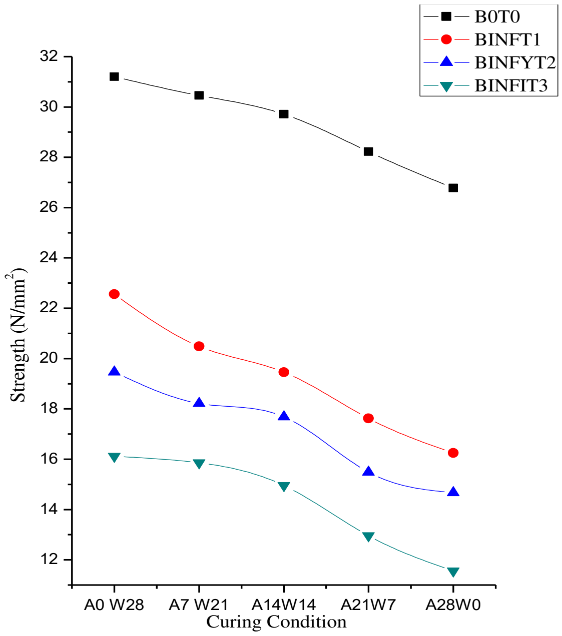
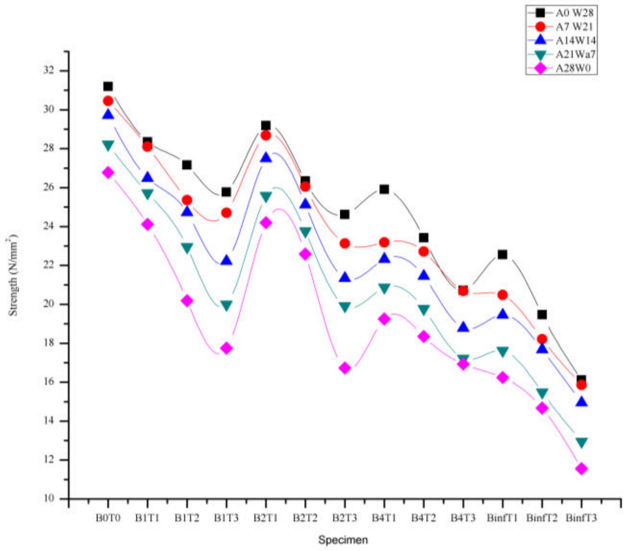


Graph-9. Strength vs. curing condition for blend ratio infinity.



Graph-10. Compressive strength vs. curing condition for all conditions of curing.

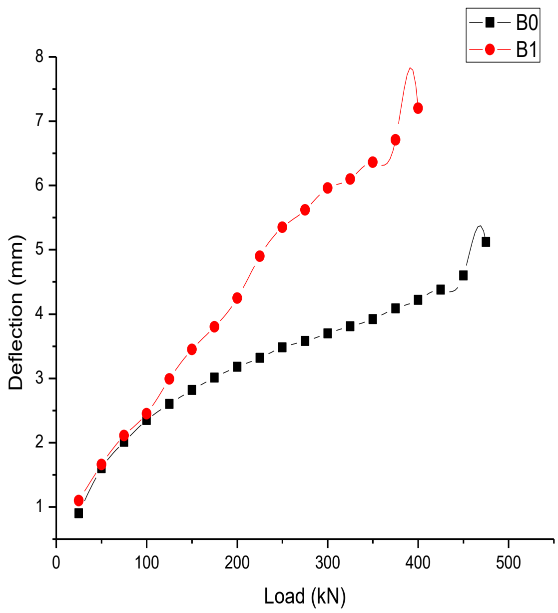
Column for different blend ratio and time lag

The columns prepared at different blend ratio (0, 1, 3, and ∞) and time lags (0 and 90 minute) testes for deflection and strength.

Table-14. Results of column for different blend ratio and time lag.

S. No.	Blend ratio (r)	Time lag t (Minute)	Peak load (kN)	Deflection (mm)	Strength (kN/mm^2)
1	0	0	474.660	5.120	21.096
2	1	90 min.	422.400	7.200	17.630
3	3	90 min.	382.750	7.900	17.011
4	infinity	90 min.	318.000	9.490	14.133

The graph 11, 12, and 13 shows the comparative variation of deflection Vs. load, between column with blend ratio 1, 3, ∞ and conventional specimen respectively. Last graph. 14 represent comparison of all conditions to each other.



Graph-11. Load vs. deflection for blend ratio 1

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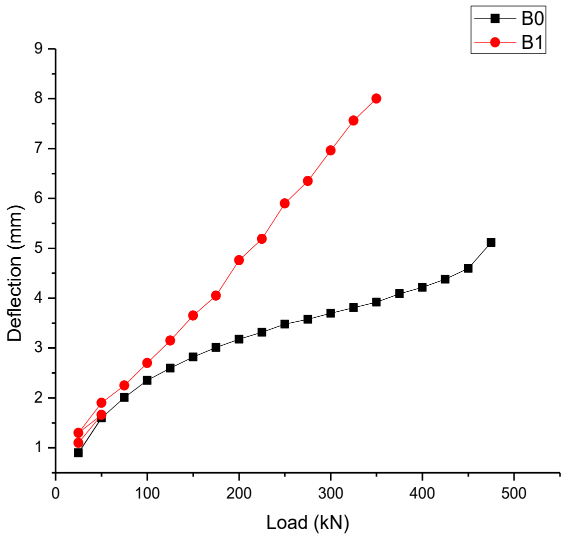
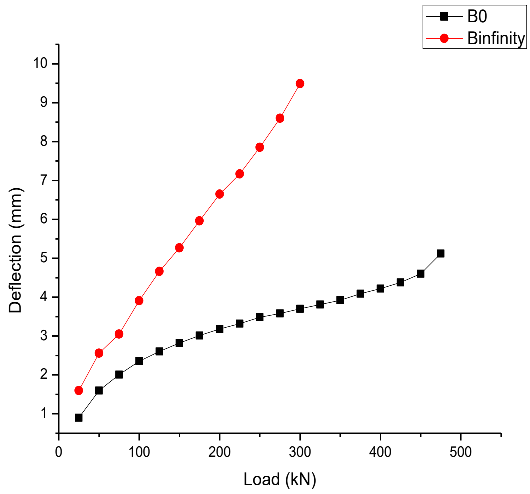
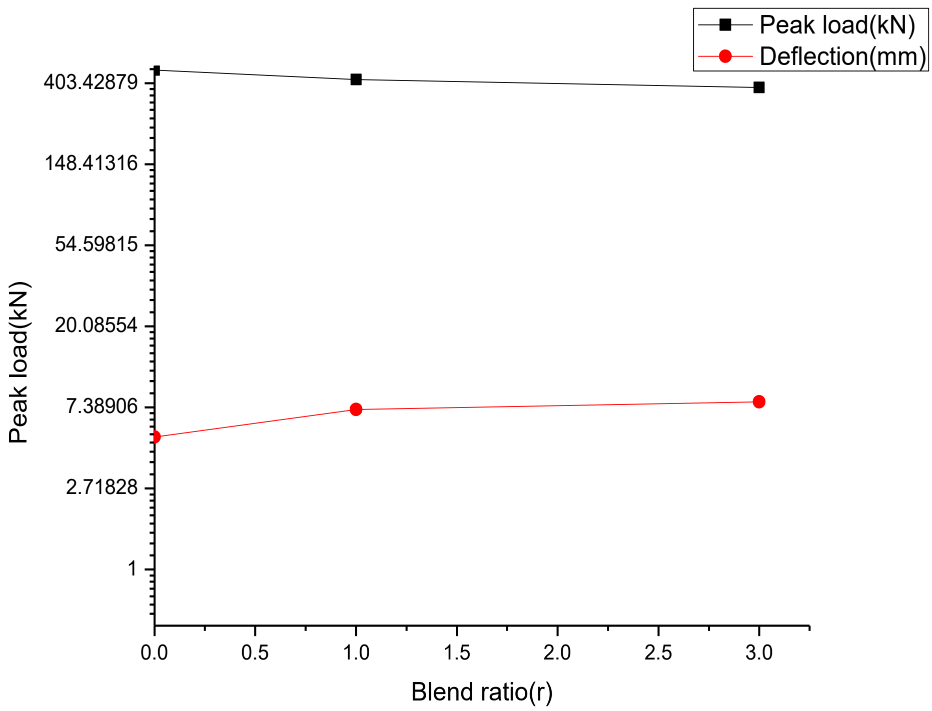


Graph-12. Load vs. deflection for blend ratio 3.



Graph-13. Load vs. deflection for blend ratio infinity.



Graph-14. Load vs. deflection for compare all condition.

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Table-15. Results from strain gauge for column blend ratio =0.

S. No.	Load kN	Deflection mV	Strain	Stress developed
1	25	115	0.00767	245.46
2	50	128	0.00854	273.20
3	75	141	0.00940	300.95
4	100	152	0.01014	324.43
5	125	161	0.01074	343.64
6	150	169	0.01127	360.71
7	175	175	0.01167	373.52
8	200	184	0.01227	392.73
9	225	191	0.01274	407.67
10	250	204	0.01361	435.42
11	275	210	0.01401	448.22
12	300	218	0.01454	465.30
13	325	227	0.01514	484.51
14	350	236	0.01574	503.72
15	375	244	0.01627	520.79
16	400	251	0.01674	535.73
17	425	263	0.01754	561.35
18	450	270	0.01801	576.29
19	474	275	0.01834	586.96

Peak load =474.660 kN, Compreesive stress=21.096 N/mm^2

Table-16. Results from strain gauge for column blend ratio=1.

S. No.	Load kN	Deflection mV	Strain	Stress developed
1	25	111	0.00740	236.92
2	50	118	0.00787	251.86
3	75	122	0.00814	260.40
4	100	130	0.00867	277.47
5	125	136	0.00907	290.28
6	150	143	0.00954	305.22
7	175	150	0.01001	320.16
8	200	159	0.01061	339.37
9	225	167	0.01114	356.44
10	250	176	0.01174	375.65
11	275	182	0.01214	388.46
12	300	188	0.01254	401.27
13	325	195	0.01301	416.21
14	350	206	0.01374	439.69
15	375	215	0.01434	458.90
16	400	223	0.01487	475.97
17	422	231	0.01541	493.05

Peak load =422.40kN, Compreesive stress=17.63N/mm^2

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Table-17. Results from strain gauge for column blend ratio= 3.

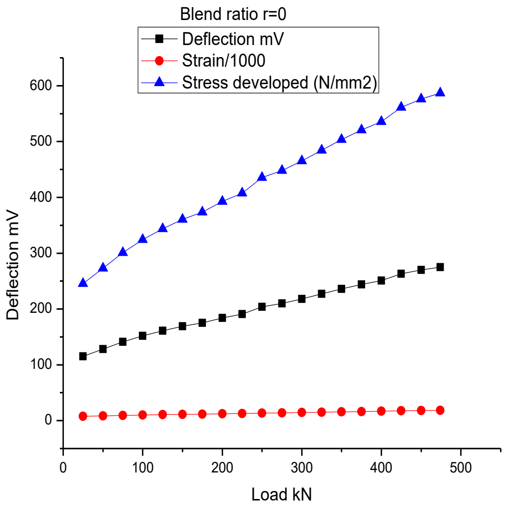
S. No.	Load kN	Deflection mV	Strain	Stress developed
1	25	108	0.00720	230.52
2	50	112	0.00747	239.05
3	75	119	0.00794	253.99
4	100	126	0.00840	268.93
5	125	131	0.00874	279.61
6	150	138	0.00920	294.55
7	175	144	0.00960	307.35
8	200	150	0.01001	320.16
9	225	157	0.01047	335.10
10	250	163	0.01087	347.91
11	275	172	0.01147	367.12
12	300	179	0.01194	382.06
13	325	184	0.01227	392.73
14	350	193	0.01287	411.94
15	375	201	0.01341	429.01
16	382	210	0.01401	448.22

Peak load =382.750 kN ,Compreesive stress=17.011N/m

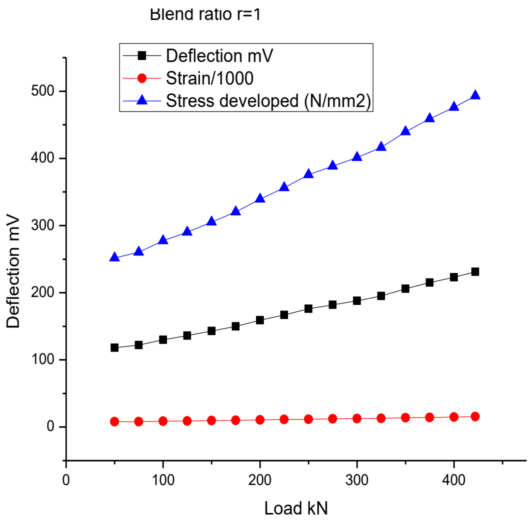
Table-18. Results from strain gauge for column blend ratio =∞.

S. No.	Load kN	Deflection mV	Strain	Stress developed
1	25	105	0.00700	224.11
2	50	112	0.00747	239.05
3	75	120	0.00800	256.13
4	100	125	0.00834	266.80
5	125	133	0.00887	283.88
6	150	141	0.00940	300.95
7	175	149	0.00994	318.03
8	200	157	0.01047	335.10
9	225	164	0.01094	350.04
10	250	171	0.01141	364.98
11	275	179	0.01194	382.06
12	300	186	0.01241	397.00
13	318	190	0.01267	405.54

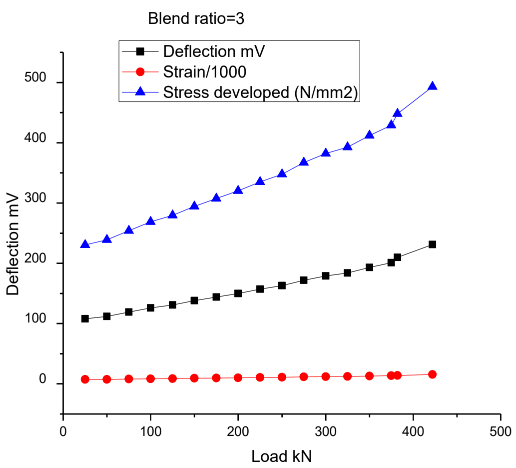
Peak load =318.00kN, Compreesive stress=14.133N/mm^2



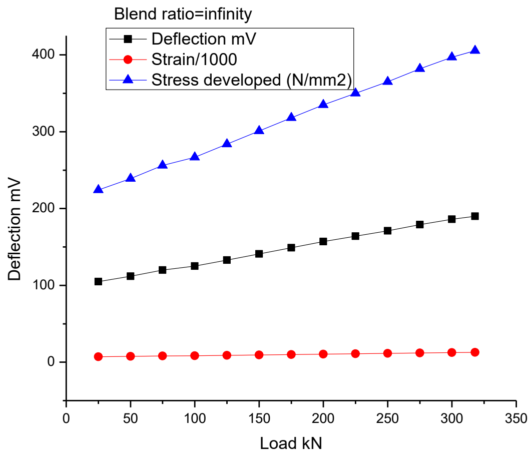
Graph-15. Results from strain gauge for column blend ratio =0.



Graph-16. Results from strain gauge for column blend ratio =1.



Graph-17. Results from strain gauge for column blend ratio =3.



Graph-18. Results from strain gauge for column blend ratio =∞.

4. EXPERIMENTAL RESULTS AND DISCUSSION

Variation of compressive strength of concrete due different curing conditions, time lag and blend ratio is shown in Graph 1.

The load - deflection relationship of columns filling in different proportion for initial layer followed by next layer is shown in Graph. 2, 3, 4

Results of column concreting in layers is shown in Graph. 5

Cube strength Vs. different curing conditions relationship for blend ratio 1, 2, 4 and ∞ is shown in Graph 6, 7, 8 and 9. Graph 10 indicates the graphs show that there is slowly decrease in strength with increase in blend ratio and time lag. Graph 10 represents variation of strength for all curing conditions and blend ratios considered.

The Graph 11, 12 and 13 shows the comparative variation of deflection Vs. load between column with conventional specimen and blend ratio 1, 3 and ∞ respectively.

Load vs. deflection for blend ratio 1, 3 and ∞ and time lag of 90 minute for columns is shown in Graph 14.

Results from strain gauge for column blend ratio =0, 1, 3 and ∞ are shown in Graph. 15, 16, 17and 18 respectively.

5. CONCLUSIONS

- Based on the results of this experimental investigation, the following conclusions are drawn:
- The compressive strength of partially set concrete goes on reducing as the time lag exceeds towards final setting time.
- The effect of reduction of compressive strength of partial set concrete can be overcome by blending with same grade or higher grade of concrete, overlaying it with M20.
- The concrete gives maximum strength for $W_{28}A_0$ curing conditions as compared to other intermittent

curing conditions i.e. regular curing gives better results as compared to irregular and delayed curing.

- The concrete tested for blend ratio r=1 and 2 up to time lag 120 minute gives better strength as compared to r and t having more values than these. Concrete with blend ration three and infinity gives poor strength so in practice this concrete should be discarded. As time lag is increased, the concrete becomes more set, hence it is preferred to use concrete before final setting the time.
- Improvement in compressive strength of overlaying concrete is due to improvement in fresh properties of blended concrete i.e. workability and compaction.
- Results of column specimen concreting for 50% first layer filling, followed by overlay of next 50 % delayed second layer filling gives better load caring capacity as compared to column specimen concreting for 25% first layer filling, followed by overlay of next 75% delayed second layer filling.
- Suggested value for concreting is for 40 % to 60 % first layer filling followed by remaining percentage overlay for next delayed second layer filling. The optimum result is achieved at 50% first layer filling, followed by overlay of next 50 % delayed second layer filling

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