Effects of Withholding Mixing Water and Retempering On Compressive Strength of Concrete

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Abstract

Owing to delay in placing of concrete because of any factor like failure of any equipment, improper site conditions, inexpert handling and also due to placing at slow rate in heavy reinforcement, and difficult location and type of structure to avoid segregation, concrete may undergo loss of workability because of which it may not be fit for the desired purpose and turned into wastage. This causes loss of material, effort, time and money especially in mass concreting. Process of retempering is commonly adopted in this condition and also in hot weather concreting to restore lost workability. This study evaluates the effects on compressive strength of concrete of retempering with both withholding mixing water initially followed with later addition of the withheld mixing water and redosage with water in excess of design water-cement ratio. The effects of varying the withholding time and amount of water withheld were examined. The result of this study showed that retempering with withholding mixing water appears to have no negative effect on the compressive strength characteristics of the concrete and retempering with redosage of water results in a significant reduction in the compressive strength of the concrete.

Keywords: *Compressive Strength, Concrete, Retempering, Witholding Mixing Water.*

1. INTRODUCTION

Casting delay of concrete is one of the common problems face off by the concrete industry. The delay in placing of concrete may arise because of any factor like glitch in casting machinery, improper site conditions, unskilled handling practices etc. which result in loss of material and money. Concrete undergoes loss of workability and strength when kept for long hours before casting and may not be fit for the purpose for which it was mixed.

Concrete industry also involves very large projects with use of heavy mass of concrete for construction. In such projects the concrete which has lost its workability due to delay in placing or time lapse in placing cannot be discarded and declared unfit for use so easily as it involves high loss of economy, time and efforts. Also concrete be placed at a slow rate to avoid segregation in conditions like heavy reinforcement and difficult type and location of the structure. Also in hot weather concreting, many troubles arise; increased concrete temperature, loss of workability, and decreased setting time are just a few. All these problems lead to the desire to retempering to regain its workability at placing.

To extricate such problems withholding of mixing water or redosage of water and retempering of concrete can be done depending upon suitability to make the concrete workable and fit for use.

The process of remixing of concrete, if necessary with addition of just the required quantity of water is known as "Retempering of Concrete". Sometimes a small quantity of extra cement is also added while retempering. Retempering can be done by withholding mixing water i.e. reduction of mixing water which is mixed at initial batching, from water content specified in mix design and added later to simulate conditions to obtain better workability. Also retempering with redosage i.e. with water content greater than required for design water cement ratio, to achieve the desired slump can be done.

Retempering of concrete, which has been questioned although adopted for many years is a common construction practice. Retempering is done mainly to recover workability of concrete but strength of retempered concrete has to be good enough such that it does not result in degraded quality concrete. Therefore it is essential to study the effects of withholding mixing water and retempering on compressive strength of concrete.

2. MATERIALS AND METHODOLOGY

In this experimental work, materials used in the preparation of concrete are cement, sand, coarse aggregates, and water. Ordinary Portland Cement of 43 grade was used for making concrete, the specific gravity of which is 3.15. Locally available natural river sand passed through 4.75 mm sieve was used as fine aggregates. Through sieve analysis it was found to be of zone II grading as per IS 383:1970 specification for coarse and fine aggregates from natural sources for concrete. The specific gravity of fine aggregate is found to be 2.62. Locally available Coarse aggregates of machine crushed broken stone type was used which was angular in shape. Coarse aggregates of 20mm and 10mm sizes, confirming to IS: 383-1970, was used in fractions having specific gravity of 2.81. Water used for mixing as well as for curing was ordinary tape water which was potable and free from chemical substances and suspended particles.

2.1Methodology

In this experimentation, M25 grade of concrete was designed as per IS: 10262 – 2009 and testing program was examining the effect of retempering on the compressive strength of concrete. Utilised

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retempering methods were retempering with withholded water and retempering with redosage of water. Major variables which were examined are amount of water withheld and length of withholding time.

Retempering was done considering 45 min delay and 75 min delay with 5% and 10% withholding of water. In addition to the effect of withholding mixing water, the effect of redosage with 5% water above and beyond the design water-cement ratio required at 45min and 75 min time delay was examined. This redosage attempts to restore lost workability which is reduced as a result of extended delays in placing of the concrete. Properties of the concrete examined were including unit weight and compressive strength. These properties are used to measure the main requirement expected of quality concrete i.e. strength.

Specimen series for testing compressive strength of concrete is as shown in table 2.1 below. Here C stands for control mix with 0% water withheld, RW stands for retempering with withholded mixing water and RD stands for retempering with redosage of water. Also superscript number of this nomenclature shows time delay and subscript number shows percentage of water withheld or redose.

After mixing of all the ingredients in dry state, the required quantity of water (all water added initially for control mixes and specified amount of water withholded which was added latter after specified time delay for different batches as can be seen in table 2.1) was added in the mix and thoroughly mixed. At this stage, the fresh concrete was kept for specified time delay (for RW and RD series) and thereafter witholded water or redosage of water was added, after that the fresh concrete was poured into the moulds and the specimens of size 150 x 150 x 150 mm were casted with sufficient compaction through tamping rod. All the specimens were demoulded after 24 hours of their casting and then cured for 7 days and 28 days. After curing the specimens were weighed and then tested for the compressive strength under compression testing machine of 200 tonne capacity as per IS: 516-1959.

Table -2.1

Designation of Mixes for Specimen Series

TIME DELAY / WATER WITHHELD	No delay	45 min	75 min	No delay (with 5% redose)	45 min (with 5% redose)	75 min (with 5% redose)
0% Withheld	C^0 (Control mix)	C^{45} (Control mix)	C^{75} (Control mix)	RD^0_0	RD^{45}_0	RD^{75}_0
5% Withheld	X	RW^{45}_5	RW^{75}_5	X	RD^{45}_5	RD^{75}_5
10% Withheld	X	RW^{45}_{10}	RW^{75}_{10}	X	RD^{45}_{10}	RD^{75}_{10}

3.0 RESULTS AND DISCUSSIONS

The unit weight of concrete specimens casted and results of compressive strength test for 7 days curing and 28 days curing at two different time delay, two different percentage of water withheld and redosage of water are given as in Tables (from Table-3.1 to Table-3.3), and their corresponding graphs are shown in Figures (from graph 3.1 to graph 3.4).

From these results inference can be drawn based on the following discussion.

Increasing trend observed in series $C^0 \rightarrow C^{45} \rightarrow C^{75}$ as shown in the graph 3.1 and graph 3.3 is because of decrease in w/c ratio with time due to loss of moisture in atmosphere by evaporation and partly due to decrease in air content of concrete with time but there is not much difference because as the time passes mix becomes more stiff and require more effort for a given compaction and test was done under same compacting effort.

Unit weight of RW_5 and RW_{10} series is more than C series as can be seen in table 3.3, which is the indication of increased strength. But there is not much difference in strength of C and RW series because when water is added after hydration of the cement has begun and mixing is restarted, it commonly happens especially in mixture with low w/c ratio that the water is not distributed throughout the entire mixture but is mixed only into the larger spaces between the aggregates. The material already adhering to aggregate remains as a rim of darker material with a low w/c ratio around the aggregate particles and in the re-entrant angels.

Table -3.1

Compressive Strength at 7 days in N/mm^2

TIME DELAY / WATER WITHHELD				with 5% redose		
	No delay	*45 min*	*75 min*	*No delay*	*45 min*	*75 min*
0% Withheld	25.29	25.43	25.58	19.77	20.78	21.95
5% Withheld	X	28.78	29.79	X	21.36	22.53
10% Withheld	X	28.05	28.63	X	21.07	22.24

Table -3.2

Compressive Strength at 28 days in N/mm^2

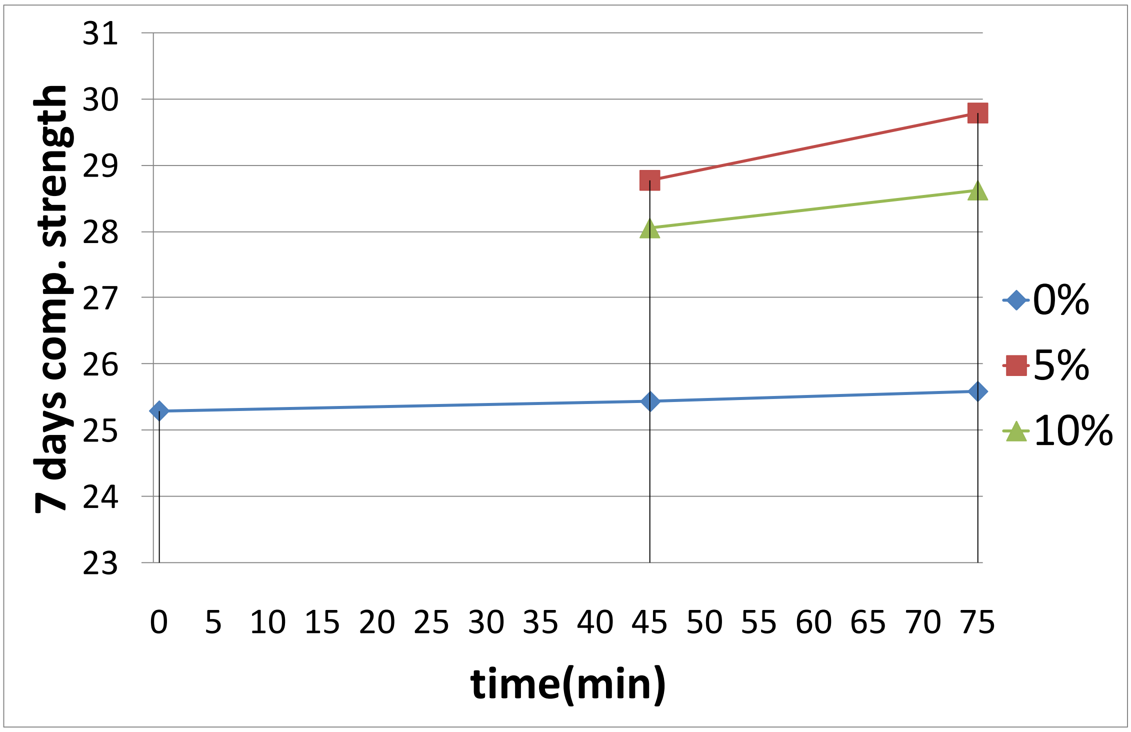
TIME DELAY / WATER WITHHELD				with 5% redose		
	No delay	*45 min*	*75 min*	*No delay*	*45 min*	*75 min*
0% Withheld	36.48	38.66	39.82	31.83	32.55	34.01
5% Withheld	X	42.73	44.18	X	33.57	34.73
10% Withheld	X	41.27	42.58	X	32.7	34.44

Table -3.3

Observed Unit Weight in N/m^3

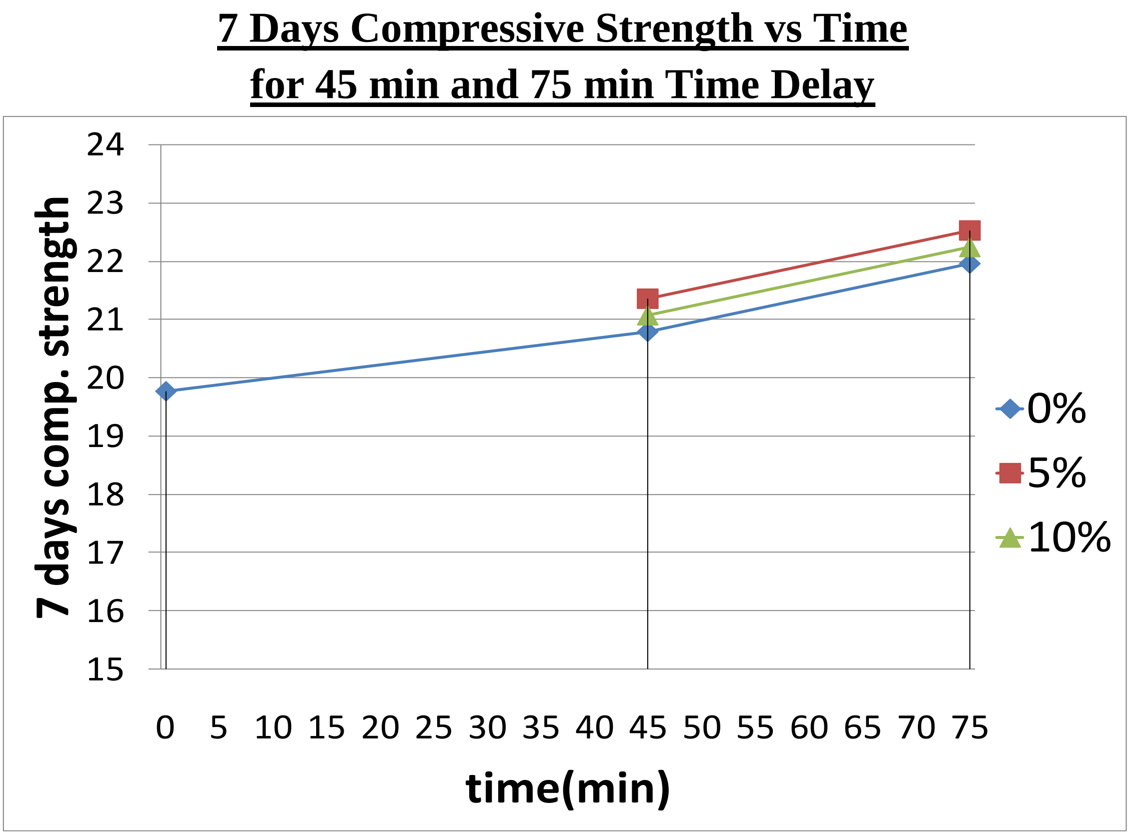
TIME DELAY / WATER WITHHELD				with 5% redose		
	No delay	*45 min*	*75 min*	*No delay*	*45 min*	*75 min*
0% Withheld	23835	24125	24125	21509	22091	22672
5% Withheld	X	25579	25869	X	22381	22963
10% Withheld	X	25579	25579	X	22091	22963

7 Days Compressive Strength vs Time for 45 min and 75 min Time Delay



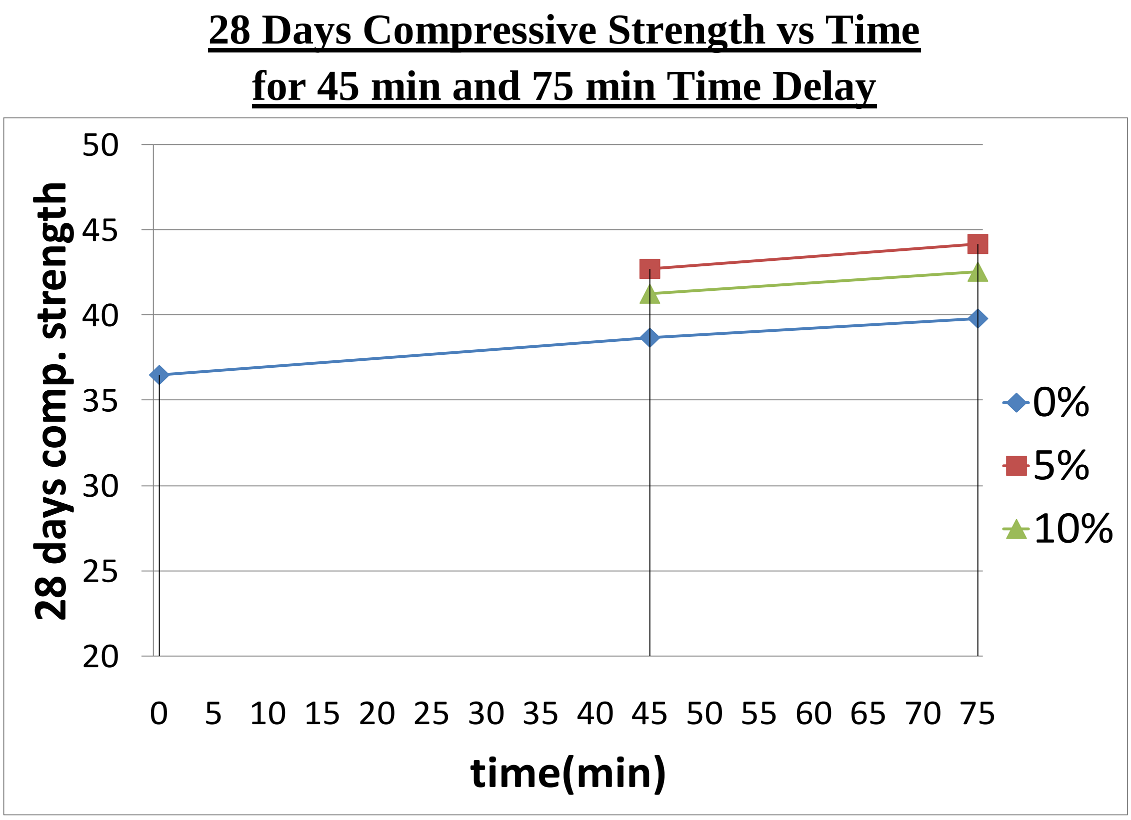
Mix Without Redosage

Graph - 3.1



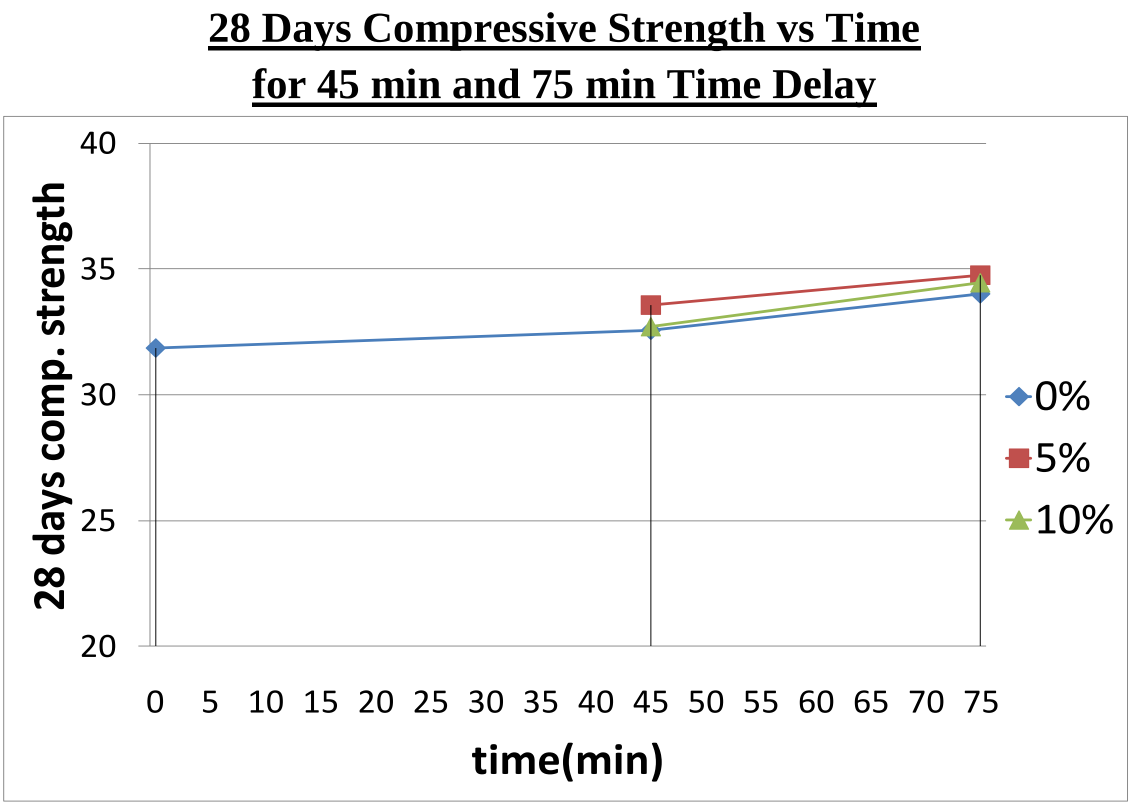
Mix With Redosage

Graph - 3.2



Mix Without Redosage

Graph – 3.3



Mix With Redosage

Graph – 3.4

Patches of the original paste may remain and can be found to be completely surrounded by the paste with higher water content. When the rims indicating incomplete mixing are present, a large portion of the cement can be concentrate in the thin bands of very rich paste around the aggregates and in lumps of original paste. The remainder of the paste is relatively depleted of cement and is thereby weaker. Thus it can be seen that areas of high w/c ratio can exist in close proximity to the areas of low w/c ratio which becomes the weakest zone.

In $RW_5^{45} \rightarrow RW_5^{75}$ and $RW_{10}^{45} \rightarrow RW_{10}^{75}$ small increase in strength as shown in graph 3.1 and graph 3.3, is due to decrease in w/c ratio with time but not much increase is observed because of increased stiffness of mix in $RW^{45} \rightarrow RW^{75}$ series with time which causes less compaction at same effort. Though, RW_{10} mixes are harsher initially than RW_5. It is observed that strength is not differed much but strength of RW_{10} is less by small amount than RW_5.

Strength of RD series is less than C series as can be seen in table 3.1 and table 3.2 because w/c ratio of RD series is higher than C series. $RD_0^0 \rightarrow RD_0^{45} \rightarrow RD_0^{75}$ series indicates increase in strength as shown in graph 3.2 and graph 3.4 due to loss of water to the atmosphere by evaporation with time. But increase is very small due to increased stiffness of mix with time and because of presence of areas of high w/c in close proximity to areas with low w/c ratio around the aggregates causes decrease in strength.

Strength of RD_5 and RD_{10} as can be seen in table 3.1 and table 3.2 is observed to be less than RW_5 and RW_{10} because of more w/c ratio. It will be worthwhile to recall the relationship between aggregate and paste which are two essential ingredients of concrete. Workability of the concrete mass is provided by the lubricating effect of the paste and is influenced by the amount and dilution of the paste. The strength is limited by the strength of the paste, since aggregate are far stronger than the paste compound. Since the properties of the concrete are governed to a considerable extent by the quality of paste, the more dilute the paste, the greater the spacing between cement particles, and thus the weaker will be the ultimate paste structure.

$RD_5^{45} \rightarrow RD_5^{75}$ and $RD_{10}^{45} \rightarrow RD_{10}^{75}$ series indicates increase in strength as shown in graph 3.2 and graph 3.4 by very small amount because of decrease in w/c ratio but there is not much difference because of increased stiffness of mix in $RD^{45} \rightarrow RD^{75}$ series with time which causes less compaction at same effort. RD_{10} mixes are harsher initially than RD_5. It is observed that strength is not differed much but strength of RD_{10} is less by small amount than RD_5.

4. CONCLUSIONS

The results of this study of retempered concrete shows that examined properties of the concrete undergo changes. Some of the important changes that engineers should be aware of include:

1. Retempering with withholding mixing water appeared to have no negative effect on the compressive strength characteristics of the concrete. In this method greater compressive strength than control mix was observed which indicates final water-cement ratio is the governing factor for compressive strength.
2. Strength gain characteristics was approximately same for all the mixes examined which indicates that it is independent of time of withholding, amount of water withheld and redosage.
3. Retempering with redosage of water results in a significant reduction in the compressive strength of the concrete.
4. Increase in the compressive strength of the concrete was observed with increase in time delay. This increased strength could be due to loss of water through evaporation which results in lower water-cement ratio.

Based upon the conclusions obtained in this study, engineers should not allow retempering with redosage of water. The effect of retempering with withholding and later addition of water to concrete is positive in terms of compressive strength. As well as retempering has contribution to waste minimization and resources conservation because as concrete industry also involves mass concreting. In such condition large amount of concrete is get wasted due to delay in placing or time lapse. It can be minimised by retempering. Also cost of construction will also be reduced because of minimised wastage which in turn also saves time and effort.

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