Retempering of Fresh concrete and its Effect on Concrete Strength

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Abstract:

Properties of fresh concrete are important because they affect the achievement of the desired properties of the hardened concrete and on this basis the need of sufficient workability of concrete arises. Generally full compaction with less amount of entrapped air voids can be obtained with more workable concrete mixes, this consequently results in an increase in compressive strength. The workability of fresh concrete reduces considerably with passage of time and the workability loss is more under hot weather condition as well as transportation from the patching plant to the site. This paper is devoted to study the effects of using water and super plasticizer as a retempering plasticizer agent on enhancing workability and compressive strength for both plain and super plasticizer concrete.

Trial sets of concrete mixes were conducted with the variations of water content, super plasticizer, and measuring their initial slumps. With passing of time for both water or super plasticizer were added and their slump were recorded. This process is repeated each 15 minutes interval up to 90 minutes. A set of cubes was taken at each time to figure out the effect of the added water or the super plasticizer on the strength.

The ratio of super plasticizer used in this study was 1 liter per 100 kg of cement (based on the manufacture manual).

From this paper the site engineer can estimate the amount of super plasticizer that he needs to enhance his concrete workability, and he can estimate and expect the strength for his case.

Keywords: Retempering of fresh concrete, Water and super plasticizer agents, Workability, Compressive strength, Plain and super plasticized concrete.

Introduction:

This paper is designed to present the results of a comprehensive investigation to study the effect of using water and super plasticizer as retempering agents on workability and compressive strength for plain and super plasticizer concrete. Experimentation showed some development in compressive strength by retempering with super plasticizers .

It is known that the initial workability of concrete can be increased significantly by the addition of water and some admixtures particularly super plasticizer[2],[6]. However the main drawback of super plasticizer application is that the effectiveness of the fluidizing process ends after 30 to 60 minutes and super plasticizer [2]. The plain concrete workability loss is much more rapidly than the super plasticizer concrete. The workability of concrete can be rejuvenated by the process of retempering in which the

retempering agent is added to the concrete which has lost enough workability to become workable. The amount of retardation depends upon many factors including: admixture concentration, dosage rate, concrete proportions, and ambient and concrete temperatures [3]. Experimentation showed some development in compressive strength by retempering with super plasticizers [4].

The objective of this study is to investigate and discuss the effects of using water and super plasticizer as retempering agents on workability and compressive strength for both plain and super plasticized concrete.

Material and mixes:

Cement: Portland cement that satisfies ASTM C 150 is used. Physical properties of cement used are shown in Table (1).

Table (1) Physical properties of cement.

TEST	RESULT	ASTM C 150 - SPECIFICATION LIMIT
Consistency	27.5%	27-33%
Initial setting time	3.44hrs	Not less than 30 minutes
Final setting time	6hrs	Not more than 10hrs.
Soundness	2mm	Not more than 10 mm

Aggregates: The coarse and fine aggregate used is dry and clean. A sample of sieve analysis of fine and coarse aggregate is shown in table (2) and table (3). The coarse aggregate used in mixing of concrete meets the specification ASTM C 136. it has the specific gravity of 2.65, crushing value of 13% and an impact value of 25%.

Table (2) Sieve analysis of fine aggregate

Sieve No.	7	14	25	50	100	200
Cumulative (%) Passing	100	99.7	99.3	48.7	4.7	2.3

Table (3) Sieve analysis of coarse aggregate

Sieve No.	37.5	19	10	5
Cumulative (%) Passing	100	100	48.5	1.5

Water: Water used for concrete mixing and in retempering process is tap water

Super Plasticizer: The type of super plasticizer used in the mixing of concrete is Rheo-build 1000 which is a water soluble sulphonated polymers based admixtures which allows mixing

water to be reduced considerably and concrete strength to be accelerated significantly particularly at early ages.The Rheobuild "1000" meets ASTMC-494 (type A and F) and UNI 8145.

The Rheobuild "1000" is generally dispensed at a rate of one liter per 100 kg of cement.

Experimental programe:

The aim of concrete mix design is to evaluate the proportions of the components needed to make concrete that would provide the followings:

a- Quality required for comparative study.

b- The best economy.

The absolute volume method was used in this paper.

$$\frac{w/c \times c}{1000} + \frac{c}{1000\ \rho_c} + \frac{A/c \times c}{1000\ \rho_a} = 1.0 \qquad (1)$$

where ρ_a, ρ_c are the specific gravity of aggregate and cement respectively.

w/c water cement ratio.

A/c Aggregate cement ratio.

Several mix proportions design were used, also plain and super plasticized concrete in which the recommended dosage of super plasticizer is 1% of cement weight is used.

Mix design programmer:

Three sets of tests were carried out in this investigation are as follows:

• Plain concrete mix and water as a retempering agent designated by MPW.
• Plain concrete mix and super plasticizer as a retempering agent designated by MPS.
•Super plasticized concrete mix and super plasticizer as a retempering agent designated by MSS.

Each set of tests mentioned above consists of three mixes (i.e. different water cement ratio), and are devoted for retempering studies. as shown in table (4) and table (5).

Table (4) Mixes MPW1, MPW2, MPW3 Plain concrete.

Mix No. W/C	MPW1 0.45	MPW2 0.5	MPW3 0.55
Sand	14.82 Kg	14.51 Kg	14.20 Kg
Cement	14.82 Kg	14.51 Kg	14.20 Kg
Water	6.67 Kg	7.25 Kg	7.81 Kg
Aggregate	44.47 Kg	43.51 Kg	42.6 Kg
Slump	50 mm	100 mm	200 mm

Table (5) Mixes MSS1, MSS2, MSS3 Super plasticized concrete.

Mix No. W/C	MPS1 0.35	MSS2 0.40	MSS3 0.45
Sand	15.50 Kg	15.16 Kg	14.82 Kg
Cement	15.5 Kg	15.16 Kg	14.82 Kg
Water	5.43 Kg	6.06 Kg	6.67 Kg
Aggregate	46.51 Kg	45.47 Kg	44.47 Kg
Super	0.155E-3 m^3	0.152E-3 m^3	0.148E-3 m^3
plasticizer	30 mm	45 mm	200 mm
Slump			

A concrete mixer having a capacity of 0.25 m^3 was used for mixing the fresh concrete. The quantity for mixing used was enough for 10 cubes, we use nine specimens for each mix, for all mixes the slump test was carried out before and after the retempering according to ASTM (143-78) to monitor (investigate) the change of slump with elapsed time for the retempering mixes. For all mixes the retempering were added at times (15, 30, 45, 60, 75 minutes) until the slump reaches the original or initial level before the application of the retempering agent. The amount of the retempering agents added are determined by trials.

For the retempering mixes in all series, 150 mm cubes are cast at selected elapsed time up to 90 minutes after first mixing (control mix) to determine the influence of elapsed time on the retempering concrete. A vibrating table was used to achieve full compaction of the molded specimens. Noting that the mixer was nearly operating all over the period of retempering while during the standing period, slump test and cast of specimens are carried out. Precautions are not taken to avoid evaporation of water from concrete mixes, however all tests are conducted during the months of November, December, and January.

The test specimens were stored in the laboratory environments (25□C). After 24 hours the test specimens are molded and stored until testing. The compressive strength test was carried out at 28 days according to the testing procedure in BS 1881.

Results and discussion:

The results of slump tests and compressive strength of specimens, and all the addition needed of water or super plasticizer to restore the workability of concrete mix. these results were tabulated and drawn in figures and classified as follows.

Table (6) to table (14) referred to fresh concrete which indicate the variation of slump with elapsed time for the retempered mixes. Figures were drawn to compare the effect of the retempering agents on fresh concrete.

Tables (15) to table (22) referred to test specimens which indicate the change of strength at 28 days with elapsed time for the retempered mixes. Figures were drawn to investigate the effects of the retempering agents on concrete strength. Noting that for workability and compressive strength results were limited to elapsed time of 90 minutes from beginning of concrete mixing. The time were divided to six equal intervals of 15 minutes.

Tables (6), (7), and (8) show the slump values with elapsed time for different mixes using water as agent.

Table (6) Plain concrete mix, MPW1 "w/c = 0.45" and water as retempering agents.

Time(min)	0	15	30	45	60	75	90
Slump(mm)	50	20	20	30	20	30	35
Addition (m^3)	---	2.0E-4	2.2E-4	2.5E-4	2.1E-4	1.5E-4	1.2E-4
Cumulative(m^3)	---	2.0E-4	4.2E-4	6.7E-4	88E-4	10.3E-4	11.5E-4

Table (7) Plain concrete mix, MPW2 "w/c = 0.5" and water as retempering agents.

Time(min)	0	15	30	45	60	75	90
Slump(mm)	100	70	70	75	80	80	85
Addition (m^3)	---	2.5E-4	2.5E-4	1.8E-4	1.8E-4	1.6E-4	1.0E-4
Cumulative(m^3)	---	2.5E-4	5.0E-4	6.8E-4	8.6E-4	10.2E-4	11.2E-4

Table (8) Plain concrete mix, MPW3 "w/c = 0.55" and water as retempering agents.

Time(min)	0	15	30	45	60	75	90
Slump(mm)	200	140	140	140	150	160	170
Addition (m^3)	---	2.9E-4	3.0E-4	2.8E-4	2.5E-4	1.8E-4	1.5E-4
Cumulative(m^3)	---	2.9E-4	5.9E-4	8.7E-4	11.2E-4	13.0E-4	14.5E-4

Tables (9),(10) and (11) show the slump values with elapsed time for different mixes using super plasticizer as agent.

Table (9) Plain concrete mix "w/c = 0.45", MPS1 and super plasticized as retempering agents.

Time(min)	0	15	30	45	60	75	90
Slump(mm)	50	20	15	15	20	30	40
Addition (m^3)	---	0.11E-4	0.16E-4	0.15E-4	0.12E-4	0.09E-4	0.07E-4
Cumulative(m^3)	---	0.11E-4	0.27E-4	0.42 E-4	0.54E-4	0.63E-4	0.70E-4

Table (10) Plain concrete mix "w/c = 0.5", MPS2 and super plasticized as retempering agents.

Time(min)	0	15	30	45	60	75	90
Slump(mm)	100	70	55	60	75	75	90
Addition (m^3)	---	0.15E-4	0.27E-4	0.08E-4	0.12E-4	0.14E-4	0.08E-4
Cumulative(m^3)	---	0.15E-4	0.42E-4	0.50E-4	0.62E-4	0.76E-4	0.84E-4

Table (11) Plain concrete mix "w/c = 0.55", MPS3 and super plasticized as retempering agents.

Time(min)	0	15	30	45	60	75	90
Slump(mm)	200	140	115	120	150	150	175
Addition (m^3)	---	0.30E-4	0.40E-4	0.35E-4	0.25E-4	0.20E-4	0.10E-4
Cumulative(m^3)	---	0.30E-4	0.70E-4	1.05E-4	1.30E-4	1.50E-4	1.60E-4

Tables (12),(13) and (14) show the slump values with elapsed time for different mixes using super plasticizer as agent.

Table (12) Super plasticized concrete mix "w/c = 0.35", MSS1 and super plasticized as retempering agents.

Time(min)	0	15	30	45	60	75	90
Slump(mm)	30	0	0	10	15	15	20
Addition (m^3)	---	0.6E-4	0.5E-4	0.45E-4	0.3E-4	0.25E-4	0.2E-4
Cumulative(m^3)	---	0.6E-4	1.1E-4	1.55E-4	1.85E-4	2.1E-4	2.3E-4

Table (13) Super plasticized concrete mix "w/c = 0.4", MSS2 and super plasticized as retempering agents.

Time(min)	0	15	30	45	60	75	90
Slump(mm)	45	0	10	10	20	20	20
Addition (m^3)	---	0.5E-4	0.4E-4	0.45E-4	0.2E-4	0.2E-4	0.15E-4
Cumulative(m^3)	---	0.5E-4	0.9E-4	1.35E-4	1.55E-4	1.75E-4	1.9E-4

Table (14) Super plasticized concrete mix "w/c = 0.45", MSS3 and super plasticized as retempering agents.

Time(min)	0	15	30	45	60	75	90
Slump(mm)	200	200	130	150	150	160	200
Addition (m^3)	---	---	0.65E-4	0.42E-4	0.4E-4	0.2E-4	---
Cumulative(m^3)	---	---	0.65E-4	1.07E-4	1.47E-4	1.67E-4	---

EFFECT OF RETEMPERING ON WORKABILITY:

Figs. (1), (2), and (3) show the original slump and changes of slump losses with time for different water-cement ratios for both types of concrete (plain and super plasticized concrete), theses figures indicates that the rate of slump loss increases with the increase of water cement ratio, Particularly this rate increase rapidly when super plasticizer was added to the concrete mix.

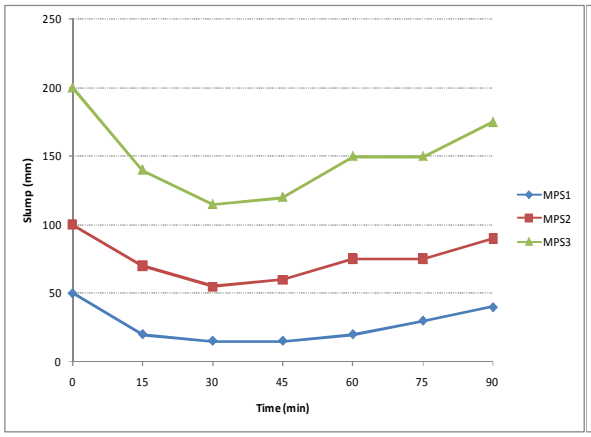

Fig. 1 Change of slump with time for plain concrete water as retempering agent, w/c =0.45,0.5,055.

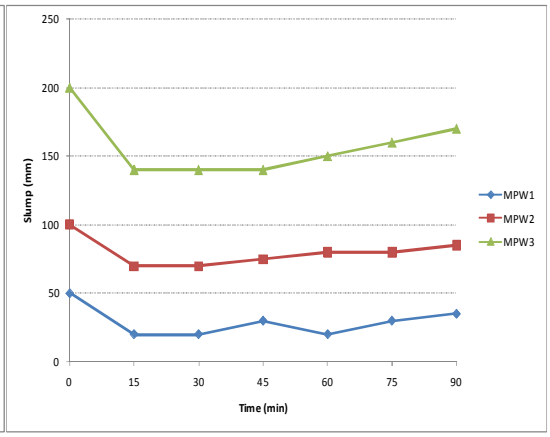

Fig. 2 Change of slump with time for plain concrete and super plasticizer as retempering agent, w/c = 0.45,0.5,0.55

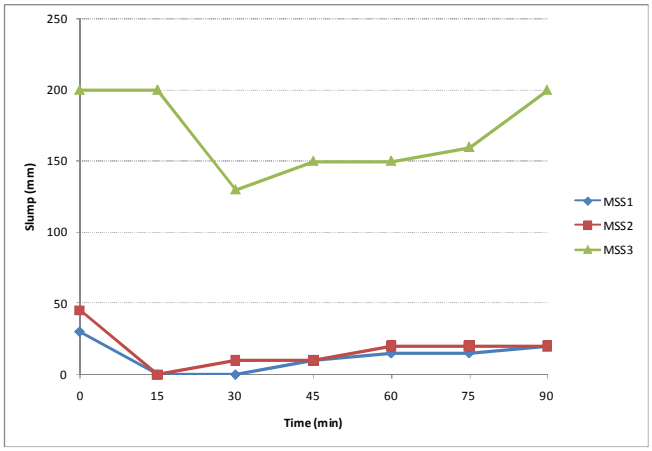

Fig. 3 Change of slump with time for super plasticized concrete "super plasticizer as retempering agent", w/c = 0.35, 0.4, and 0.45

Tables (15), (16) and (17) show the summary of 28 days compressive strength values for selected concrete.

Table (15) Plain concrete mix " w/c = 0.45 ", MPW1 and water as retempering agent.

Elapsed Time (min)	0	15	30	45	60	75	90
Strength (MPa)	48.7	45.47	44.28	42.60	42.50	37.56	34.60
Change in strength %	------	-6.63	-9.0	-12.5	-12.5	-22.87	-29.0

Table (16) Plain concrete mix " w/c = 0.50 " MPW2 and water as retempering agent.

Elapsed Time (min)	0	15	30	45	60	75	90
Strength (MPa)	42.5	40.72	40.03	37.56	36.97	34.40	32.03
Change in strength %	-----	-4.1	-5.8	-11.62	-13.0	-19.0	-24.63

Table (17) Plain concrete mix " w/c = 0.55 " MPW3 and water as retempering agent.

Elapsed Time (min)	0	15	30	45	60	75	90
Strength (MPa)	39.54	38.94	36.77	35.88	34.2	34.0	32.0
Change in strength %	----	-1.52	-7.0	-9.26	-13.5	-13.5	-19

Tables (18), (19) and (20) show the summary of 28 days compressive strength values for selected concrete.

Table (18) Plain concrete mix " w/c = 0.45 " MPS1 and super plasticizer as retempering agent.

Elapsed Time (min)	0	15	30	45	60	75	90
Strength (MPa)	48.78	48.89	58.50	58.22	52.67	43.56	42.0
Change in strength %	------	+0.22	+19.92	+19.35	+7.97	-10.7	-13.9

Table (19) Plain concrete mix " w/c = 0.50 " MPS2 and super plasticizer as retempering agent.

Elapsed Time (min)	0	15	30	45	60	75	90
Strength (MPa)	44.02	46.67	53.33	50.00	45.39	41.13	39.50
Change in strength %	------	+6.0	+21.0	+13.6	+2.23	-6.50	-10.27

Table (20) Plain concrete mix " w/c = 0.55 " MPS3 and super plasticizer as retempering agent.

Elapsed Time (min)	0	15	30	45	60	75	90
Strength (MPa)	42	43.11	49.8	43.11	40.89	35.98	33.33
Change in strength %	------	+2.64	+18.57	+2.64	+2.64	-14.8	-20.6

Tables (21), (22) and (23) show the summary of 28 days compressive strength values for selected concrete.

Table (21) Super Plasticizer concrete mix " w/c = 0.35 " MSS1 and super plasticizer as retempering agent.

Elapsed Time (min)	0	15	30	45	60	75	90
Strength (MPa)	62.22	55.11	70.31	62.5	60.67	60.0	55.56
Change in strength %	------	-11.4	+13	+0.45	-2.5	-3.6	-10.7

Table (22) Super Plasticizer concrete mix " w/c = 0.40 " MSS2 and super plasticizer as retempering agent.

Elapsed Time (min)	0	15	30	45	60	75	90
Strength (MPa)	55.22	52.67	66.67	60.0	58.0	45.33	38.0
Change in strength %	------	-4.6	+20.74	+8.7	+5.0	-25.3	-31.18

Table (23) Super Plasticizer concrete mix " w/c = 0.45 " MSS3 and super plasticizer as retempering agent.

Elapsed Time (min)	0	15	30	45	60	75	90
Strength (MPa)	48.44	48.0	60.0	53.33	47.11	44.0	38.67
Change in strength %	------	-1.0	+23.9	+10.0	-2.75	-9.2	-20.2

Effect of retempering on compressive strength:

The change in strength expressed as a percentage of the initial strength are included in Figs (4), (5), (6) and (7) for plain concrete the increase on water cement ratio causes in general a reduction in compressive strength Fig. 4 shows (-19% for MPW3, -24% for MPW2, -29% for MPW1) where the addition were water.

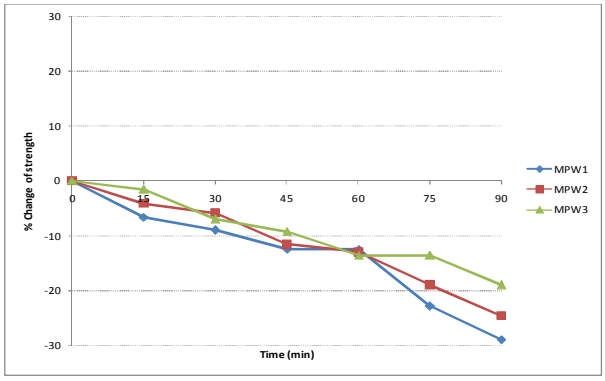

Fig.4 Change of compressive strength with time for plain concrete and water as retempering agent w/c=0.45,0.5,0.55

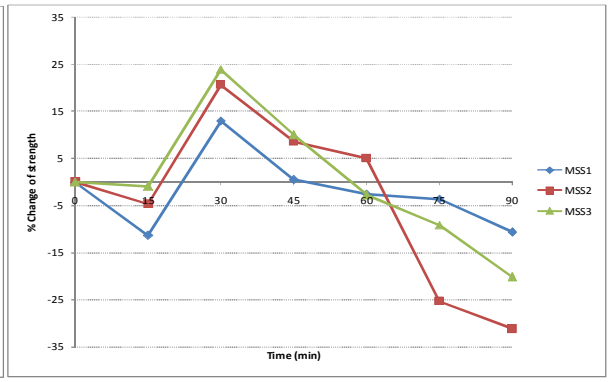

Fig.5 Change of compressive strength with time for super plasticized concrete and super plasticized as retempering agent. w/c=0.35,0.4,0.45.

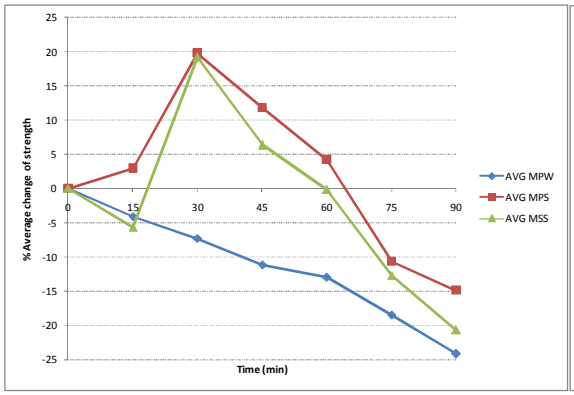

Fig.6 Change of compressive strength with time for plain concrete and super as retempering agent w/c=0.45,0.5,0.55

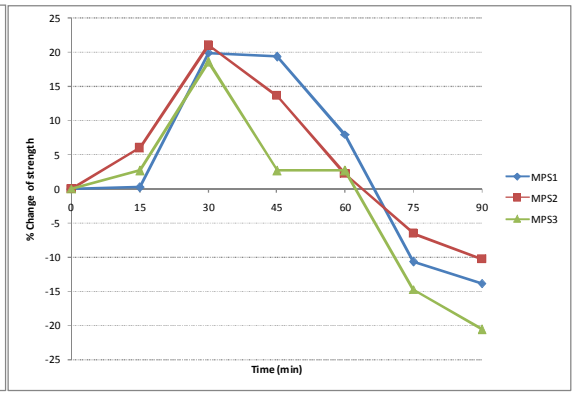

Fig.7 AVG. change of compressive strength with time for both types of concrete, water and super as retempering agents.

Conclusions:

1. The strength-gain characteristics of super plasticizer retempered concrete, particularly at times of 15 minutes from the beginning of concrete mix. After 60 minutes a considerable reduction in compressive strength occurs.
2. The highest strength gained was achieved at 30 minutes from the beginning of concrete mix.
3. The strength gain characteristics of super plasticizer retempered concrete is better than water retempered concrete.
4. The capability of super plasticizer to keep the concrete workable is reduced as more retempering increases especially at elapsed time of 60 minutes.
5. The concrete slump loss is proportional to the initial slump level.

Recommendations:

1. It is recommended to use super plasticizer generally as a retempering agent compared with water due to the increase of both workability

and strength particularly at elapsed time between 15-30 minutes from beginning of concrete mix for both types of concrete.

2. When the super plasticizer was added after 60 minutes from the concrete mix, decreasing of compressive strength has been observed, therefore; it is recommended that more study should be done toward this point.

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