CHAPTER 4

TEST RESULTS AND DISCUSIONS

4.1 Introduction

This chapter contains slump, setting time, compressive strength, tensile strength, modulus of elasticity, and durability test result.

4.2 Slump test results

Table (4-1) contains the slump test results of concrete mixes. It includes initial slump, retempering time, and elapsed time

Table (4-1) presents the slump test results of concrete mixes.

Mix	Initial slump (mm)	Retempering Time (min.)	Elapsed time 30 Min.		Elapsed time 60 Min.	
			*Before	*After	*Before	*After
M1	130					
M2	140					
M3	140	30	80	140		
M4	140	60			30	150
M5	150	30	70	150		
M6	130	60			20	160
M7	140	30	80	150		
M8	140	60			30	180
M9	170					
M10	180	30	120	220		
M11	170	60			80	200
M12	180					
M13	180	30	80	240		
M14	180	60			60	220
M15	150	30	80	170		
M16	160	60			50	180
M17	170	60			70	190

Table (4-1) Slump test results of concrete mixes (continue)

Mix	Initial slump (mm)	Retempering Time (min.)	Elapsed time 30 Min.		Elapsed time 60 Min.	
			*Before	*After	*Before	*After
M18	170	60			50	80
M19	150	60			60	130
M20	130					
M21	130	60			20	130
M22	130					
M23	150	60			20	170
M24	120					
M25	120	60			40	150
M26	120					
M27	110	60			50	240
M28	170					
M29	180	60			60	240
M30	140					
M31	150	60			40	170
M32	130					
M33	140	30	40	180		
M34	180	60			60	240
M35	160	60			50	250
M36	180	60			60	200
M37	150	60			60	220
M38	160					
M39	180	30	120	230		
M40	160	60			40	180
M41	150	-	-	-		
M42	160	60			40	210

4.2.1 Effect of types of initial admixture on initial slump

Figure (4-1) shows the effect of initial admixture type on initial slump. This figure shows that the use of a mixed admixture of 1% Type G + 0.5% of Type F (either based on naphthalene or melamine) ensures higher initial slump than that of the use of Type G.

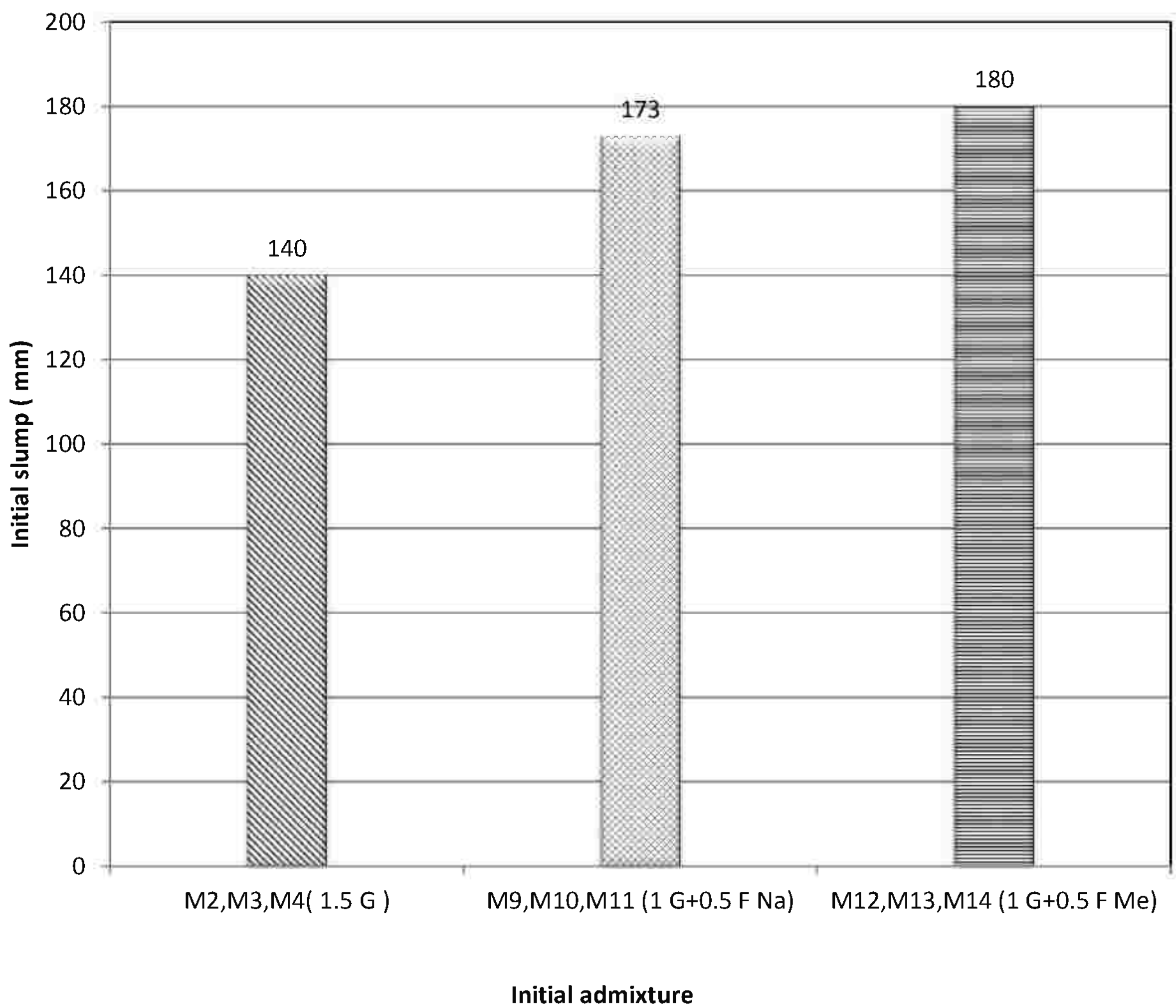

Figure (4-1) Effect of initial admixture type on initial slump

4.2.2 Effect of types of initial admixture on slump before retempering and slump loss:

Figure (4-2) shows that the use of a mix of Type G and Type F (based on naphthalene) ensures the lowest slump loss. A mix of Type G and Type F (based on melamine) decreases the slump loss at elapsed time of 60 minutes compared with that of the use of Type G only.

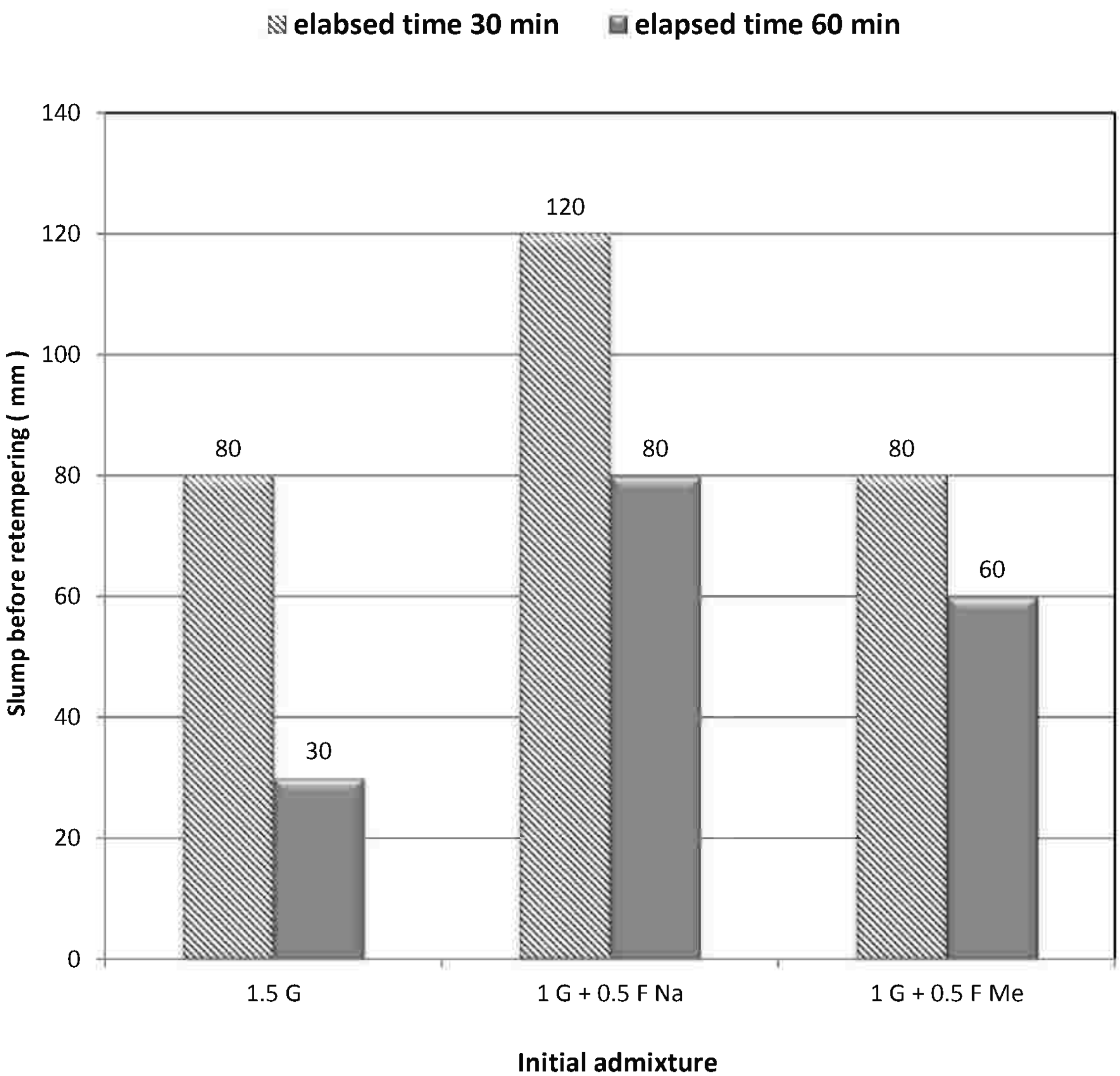

Figure (4-2) Slump after different elapsed time for different initial admixture type

4.2.3 Effect of cement content after elapsed time of 60 minutes:

Figure (4-3) shows the effect of cement content on initial slump, before and after retempering for concrete mixture containing Type G admixture

It is clear that cement content has generally a slight effect on slump after elapsed time of 60 minutes or after retempering because of the increase of admixture content (1.5 % of cement content).

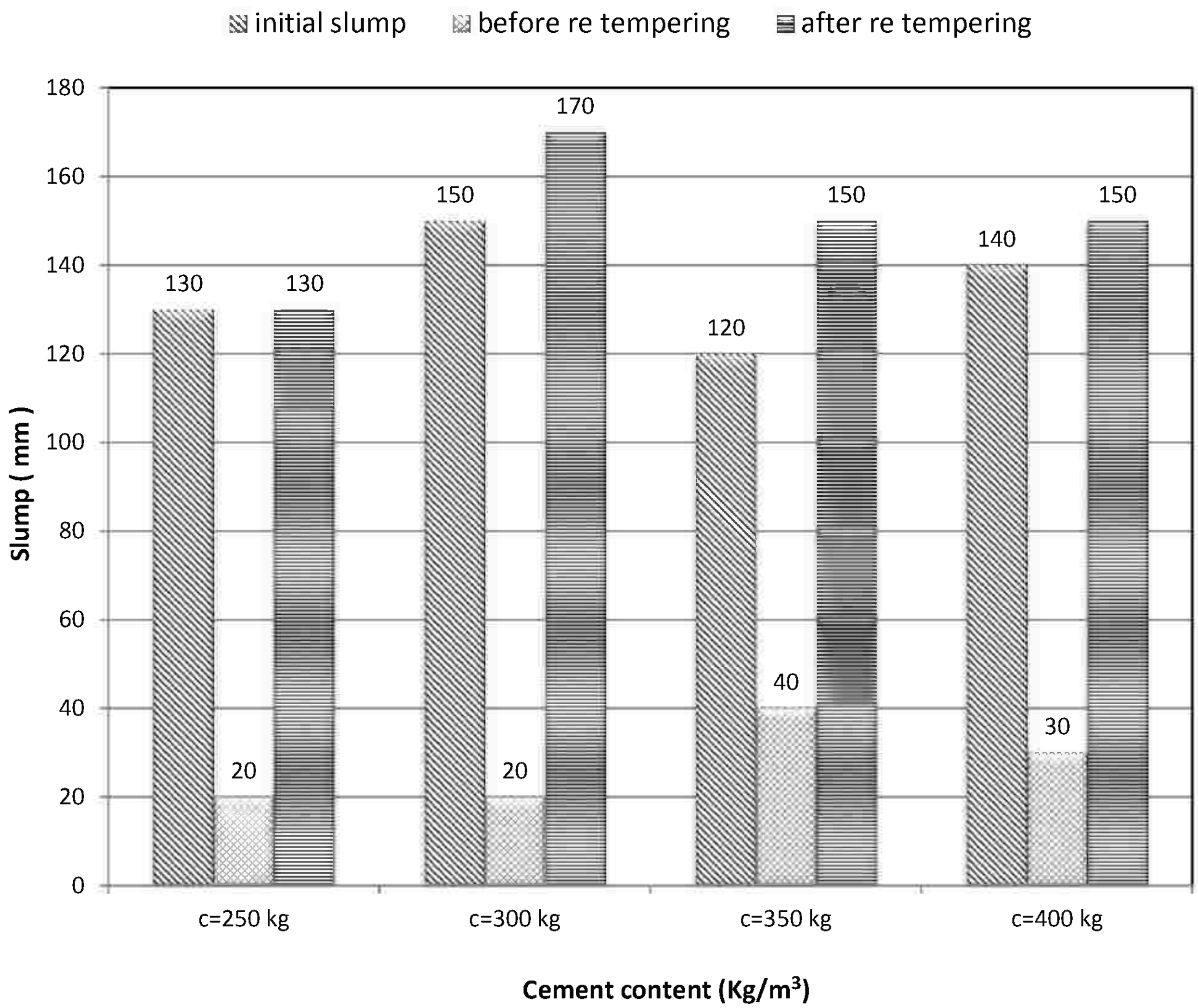

Figure (4-3) Effect of cement content on initial slump, before and after retempering for concrete mixture containing Type G admixture

4.2.4 Effect of retempering admixture on slump at 30, and 60 min.

Figures (4-4) and (4-5) show the effect of type of retempering admixture for concrete with different initial admixture on slump after retempering at 30 and 60 minutes, respectively.

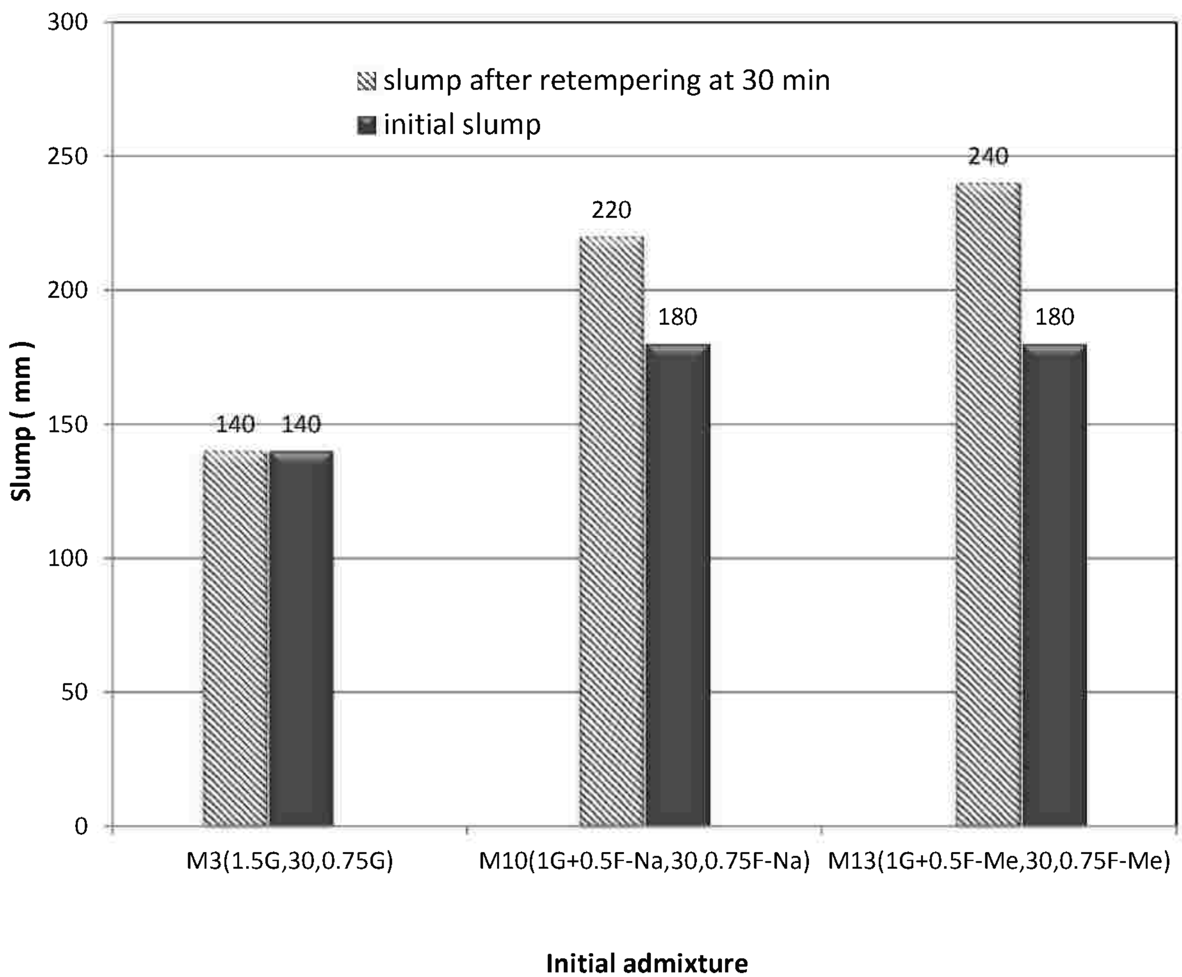

Figure (4-4) Effect of type of retempering admixture for concrete with different initial admixture on slump after retempering at 30 minutes

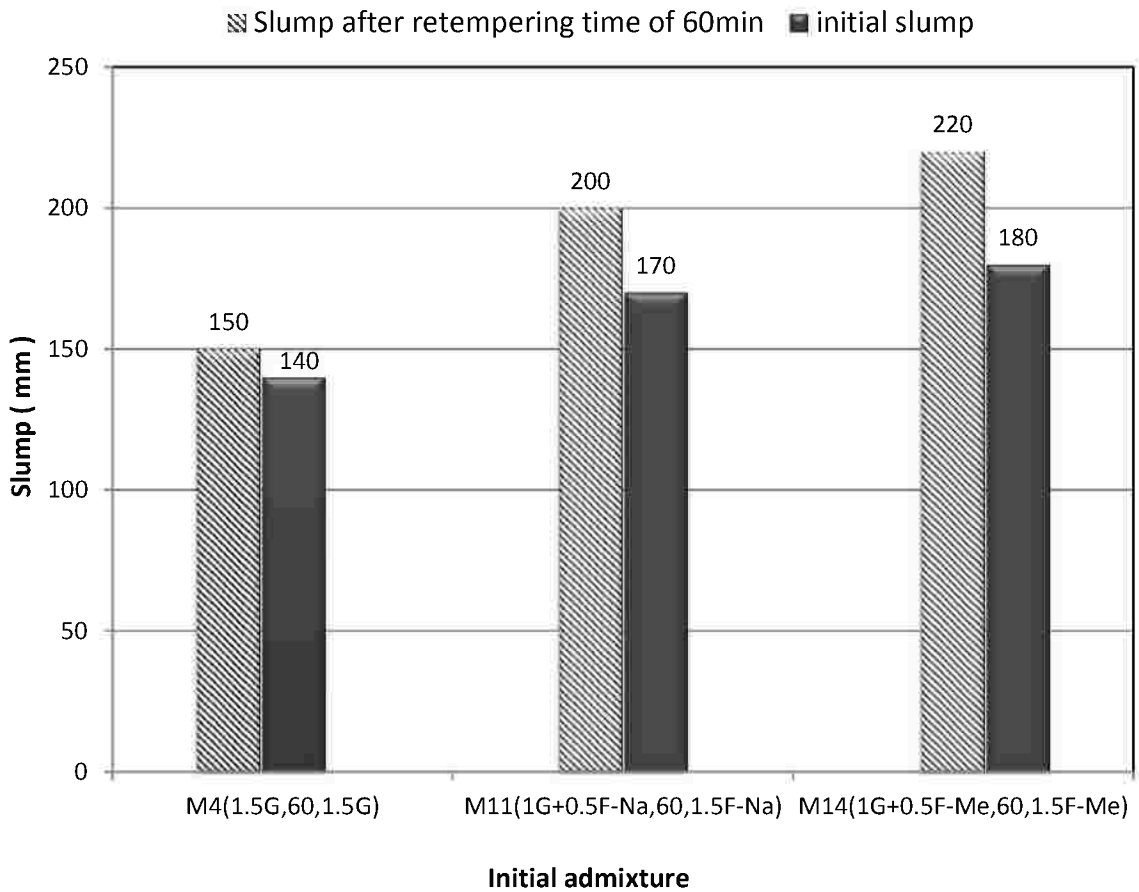

Figure (4-5) Effect of type of retempering admixture for concrete with different initial admixture on slump after retempering at 60 minutes

Figure (4-4) and Figure (4-5) show that the use of Type F-Me in retempering concrete with a mixed admixture (1% G + 0.5% F-Me) achieves highest slump. Also the use of Type F-Na has higher slump than that of Type G.

Figure (4-6) shows the effect of retempering admixture type on slump at 30 and 60 minutes for concrete with initial admixture of Type G (1.5%). It's clear that at 30 and 60 minutes of retempering time the use of Type F increases the slump compared with that of Type G.

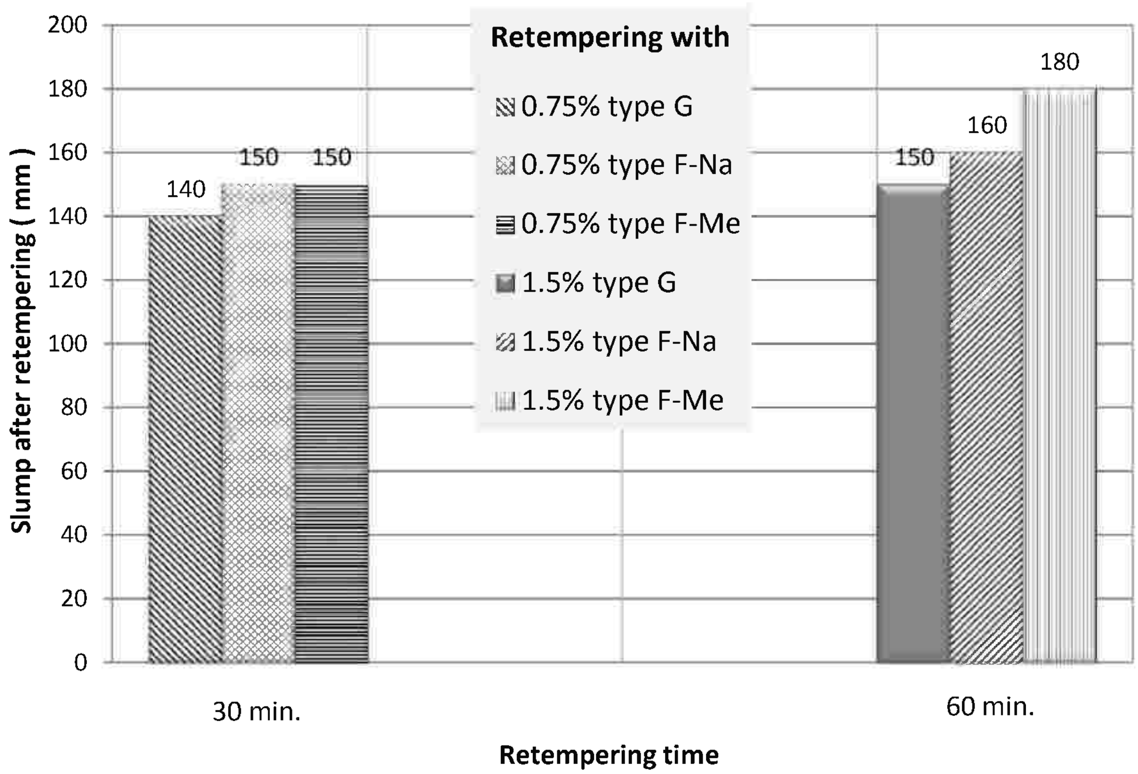

Figure (4-6) Effect of retempering admixture type on slump at 30 and 60 minutes for concrete with initial admixture of Type G (1.5%)

4.3 Setting time:

4.3 Setting time test results:

Table (4-2) contains initial and final setting time test results of different concrete mixes.

Table (4-2) Setting time test results.

Mix	Initial setting time		Final setting time	
	hr	minute	hr	minute
M1	5	5	8	5
M2	6	20	10	20
M3	25	0.0	28	45
M4	26	45	30	55
M5	11	40	15	30
M6	26	0.0	32	30
M7	8	0.0	12	5
M8	10	5	14	10
M9	6	50	9	50
M10	12	25	16	—
M11	15	26	19	30
M12	6	35	9	15
M13	17	50	20	50
M14	14	30	21	0.0
M15	16	40	20	10
M16	19	30	23	30
M17	14	5	18	10
M18	10	15	13	35
M19	19	45	24	0.0
M20	10	5	13	10
M21	17	5	21	15

Tables (4-2) Initial and final setting time test results (continue)

Mix	Initial setting time		Final setting time	
	hr	minute	hr	minute
M22	10	40	14	10
M23	20	0.0	24	30
M24	9	40	13	20
M25	23	5	27	5
M26	22	45	26	50
M27	120	12	144	—
M28	9	30	14	5
M29	30	5	35	10
M30	20	30	24	45
M31	30	5	38	0.0
M32	6	45	10	55
M33	11	0.0	15	25
M34	60	5	68	25
M35	12	40	16	5
M36	12	50	15	45
M37	10	40	13	0.0
M38	18	0.0	22	17
M39	35	5	40	—
M40	54	50	60	35
M41	17	20	22	20
M42	46	35	51	5

4.3.1Effect of type of initial admixture:

Figure (4-7) shows the effect of type of initial admixture on initial and final setting. One can conclude that the use of 1.5 % Type G delays initial and final setting time compared with that of concrete without admixture. This delay is 1.25 and 2.22 hours respectively. This result agrees with ASTM C494 requirements.

Also the use of a mix of Type G and Type F either based on naphthalene or melamine delays setting time compared with that of control mix. They also ensure lower final setting time compared with that of Type G.

4.3.2Effect of retempering admixture:

Figure (4-8) shows the effect of retempering admixture Type and content on initial setting time for concrete with 1.5% Type G at different retempering time.

It shows that retempering after 30 minutes using 0.75% Type G considerably delays initial setting time compared with that of control mix, this delay is 18 hour and 42 minutes. If 1.5 % Type G was used after 60 minutes, this delay reaches 20 hour and 27 minutes.

The use of 0.75 % of Type F-Na after 30 minutes delays the initial setting by 5.36 hour. If 1.5 % of the same admixture is used after 60 minutes, this delay reaches 19.7 hr compared with that of control mix. Retempering using 0.75 % and 1.5% of Type F-Me after 30 and 60 minutes respectively delays the initial admixture by 1.7 and 3.78 hour respectively compared with control mix.

It is clear that retempering using melamine yields good result. Use of melamine shows a reasonable retardation. The use of 1.5 % of naphthalene, and 0.75, and 1.5% of Type G considerably retards initial setting time.

Figure (4-9) shows the same relation for final setting time. The same conclusion of Figure (4-8) can be obtained here also.

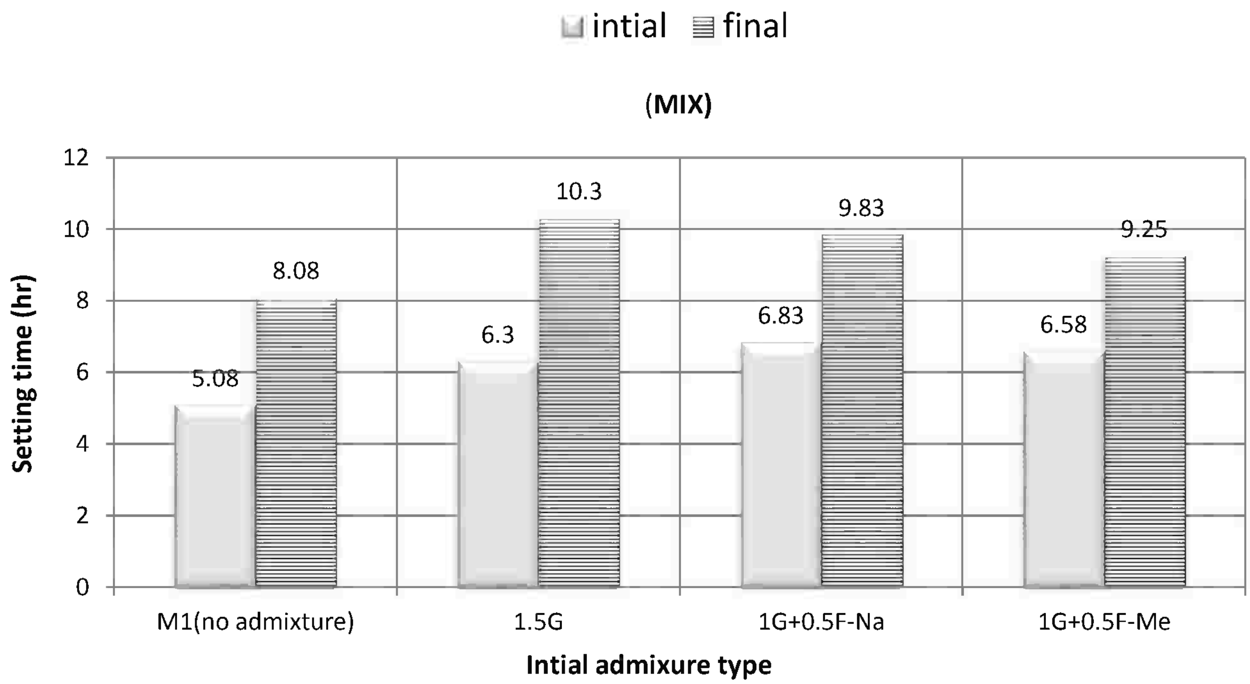

Figure (4-7) Effect of initial admixture type on setting time

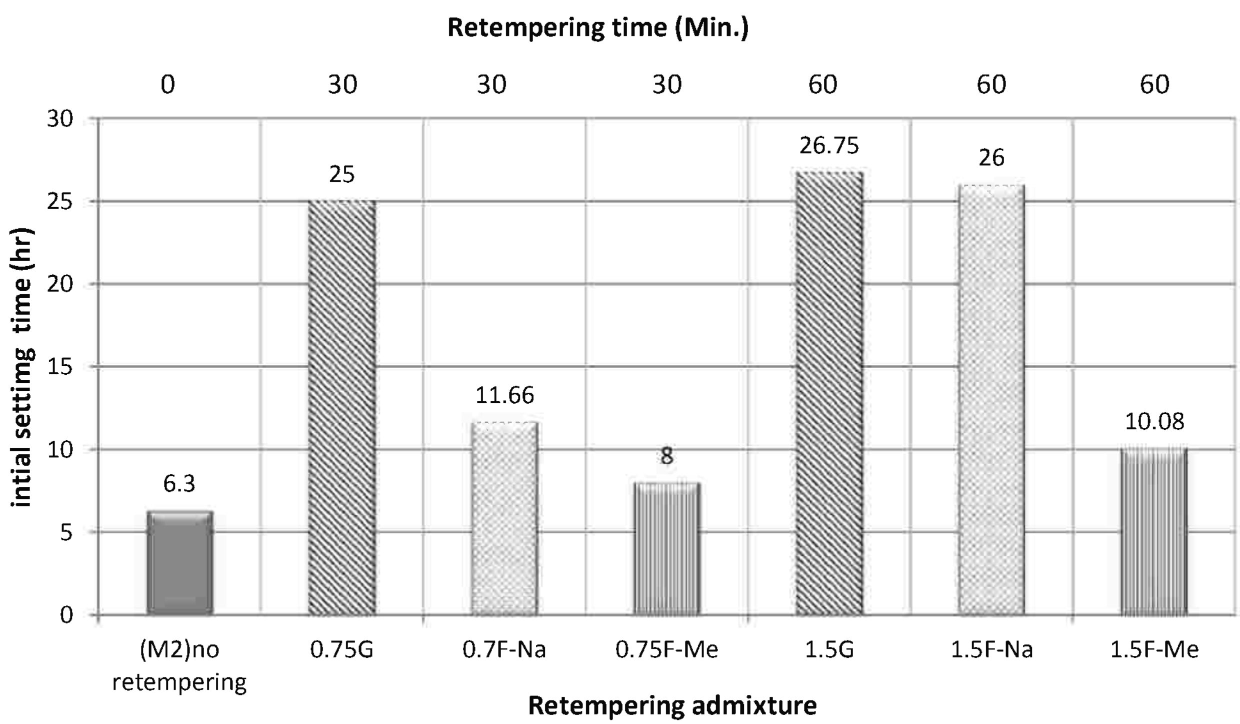

Figure (4-8) Effect of retempering admixture type on initial setting time for concrete with initial admixture of Type G (1.5%)

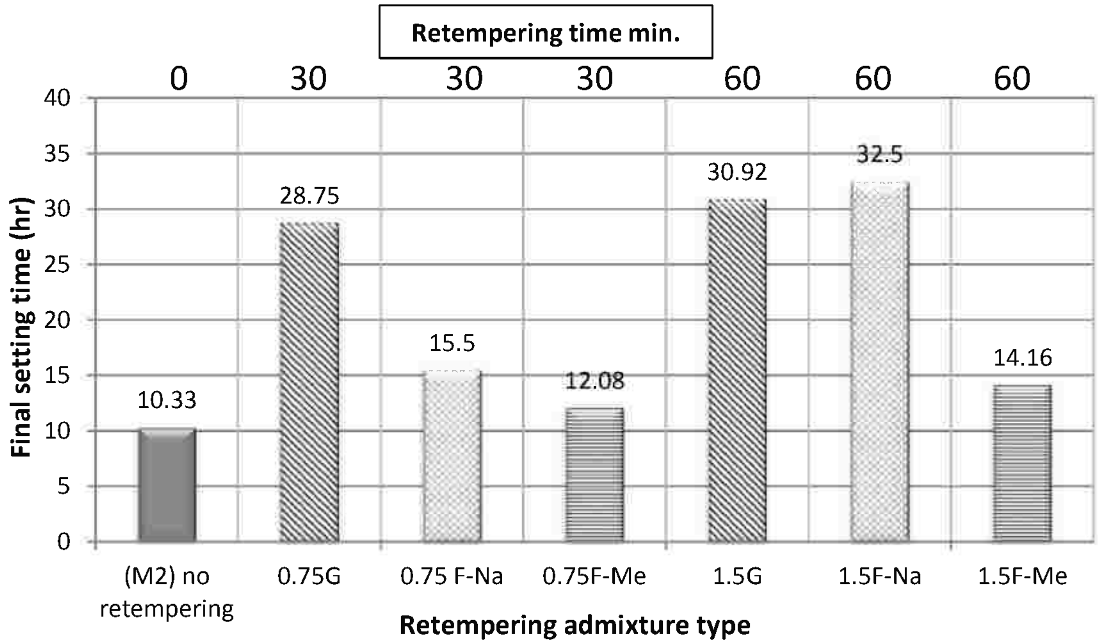

Figure (4-9) Effect of retempering admixture type on final setting time at retempering time of 30 and 60 minutes.

4.3.3Effect of a mixed retempering admixture on setting time:

Figure (4-10) shows the effect of using a mix of Type G and Type F of different bases and different retempering admixture at different times on setting time.

This figure shows that the use of a mix of Type G and Type F based on naphthalene as an initial admixture and Type F of the same base as retempering admixture decreases the negative effect of Type G (compare Mixes M10 and M11 with Mixes M3, M5 and M6) on setting time, see Table (4-2).

Comparison of figures (4-8) and (4-9) with Figure (4-10) shows that, concrete has 1.5 % Type G and re-tempered with Type F-Me shows lower setting time than that with 1.0 % Type G and 0.5 % melamine and retempered with melamine. So it is not prefered to mix Type G with Type F based on melamine.

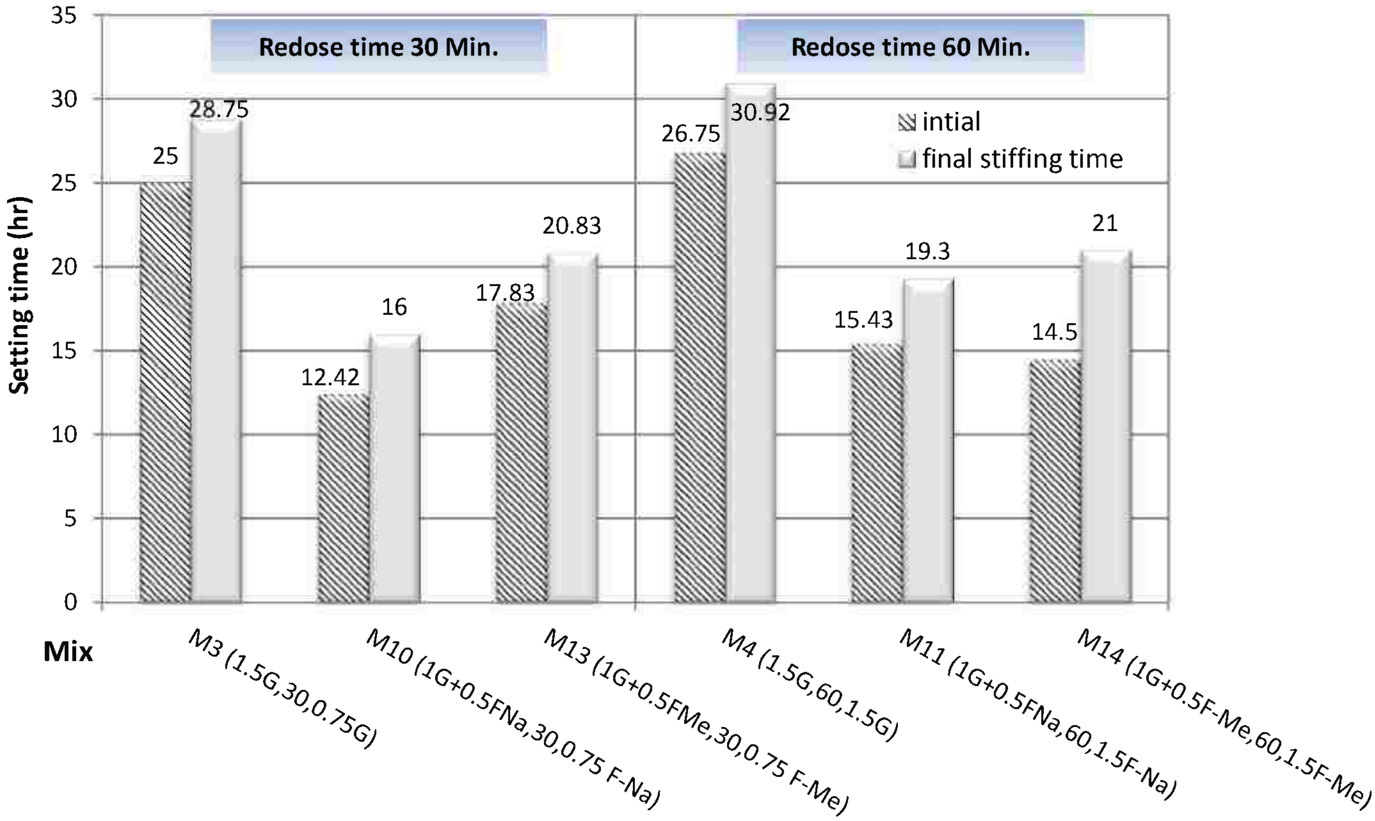

Figure (4-10) Effect of using a mix of Type G and Type F admixture and different retempering admixture at different times on setting time.

4.3.4 Effect of using Type C and Type G based on polycarboxylic:

Figure (4-11) shows the effect of using Type C admixture as a retempering admixture on setting time.

This figure shows that retempering using Type C shows lower setting time compared with that of retempering using 1.5 % of Type G. Retempering using a mix of Type C and Type G shows lower setting time. As Type C content increases setting time decreases. The use of 0.75 % Type G and 0.20 % Type G based on polycarboxylic slightly increases setting time compared with Mix M6.

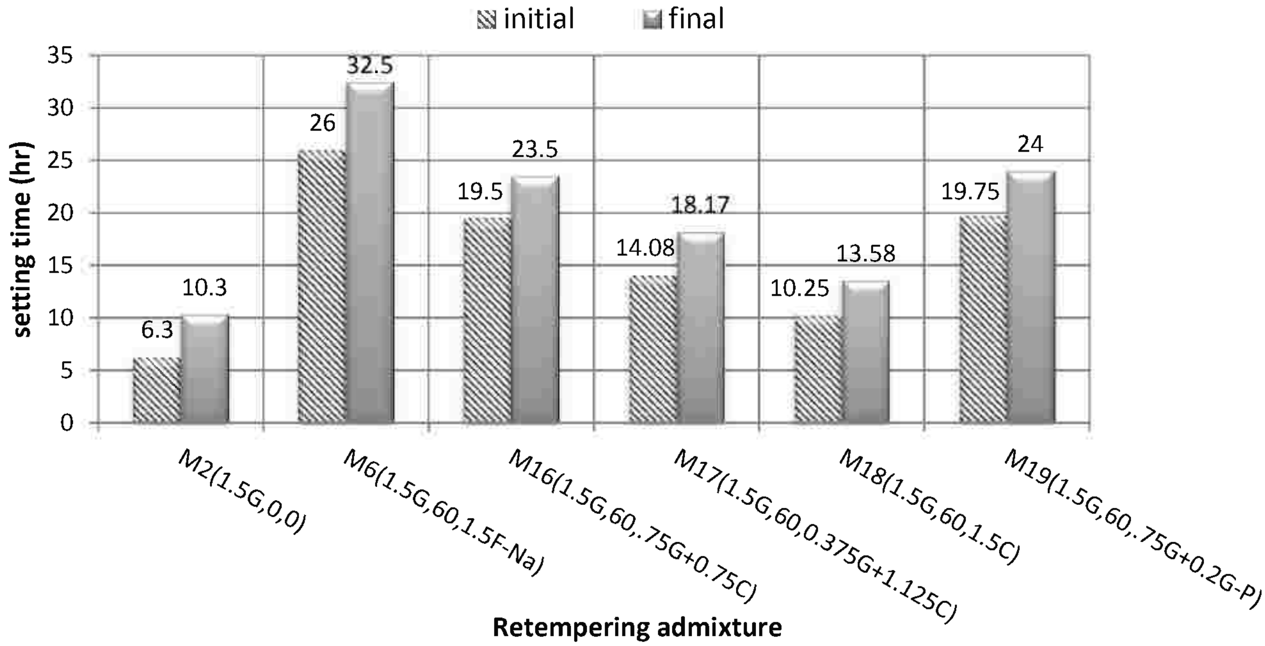

Figure (4-11) Effect of retempering after 60 minutes using rapid hardening admixture and Type G of polycarboxylic on setting time.

4.3.5 Effect of cement content and source of CEM I:

Figure (4-12) shows the effect of cement content of CEM I 42.5 N on initial setting time. This figure shows that for concrete with maximum dosage of Type G and without retempering, as the cement content increases the initial setting time decreases and, for concrete with cementitious material of 460 kg cement and 40 kg silica fume, the initial setting time considerably increases due to the existence of 20 kg of Type G. The content of C_3A and $C_3S/\ m^3$, decreases due to the presence of silica fume.

Figure (4-13) shows the previous relation but for final setting time. The figure shows almost the same conclusion of Figure (4-12). Figure (4-14) and Figure (4-15) show the effect of cement source, grade and, (SO_3/C_3A) ratio on setting time respectively.

Figure (4-14) shows that CEM I 32.5 N yields the highest initial setting time, this may tends to the lower fineness of this cement. The figure shows also that the setting time depends on the source of CEM I because of the difference of chemical compositions of cement. Figure (4-15) shows that setting time depends on (SO_3/C_3A) ratio and % retained on sieve No.200 of cement.

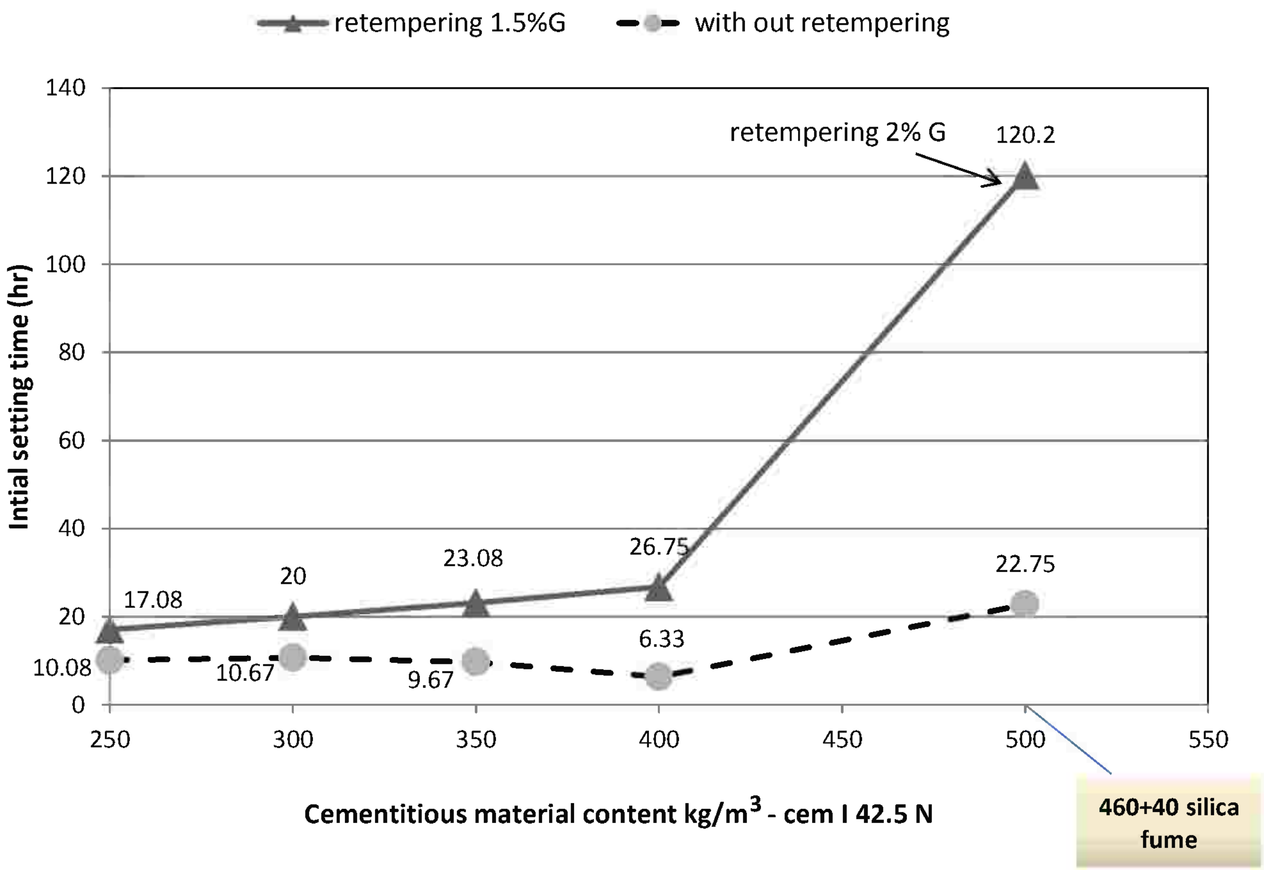

Figure (4-12) Effect of cement content of CEM I 42.5 N on initial setting time for concrete with initial admixture of Type G (1.5%).

4.3.6 Effect of retempering on setting time of sulfate resisting cement S.R.C

Figure (4-16) shows the effect of retempering using different dosages of Type G on initial setting time of concrete with 400 kg/m^3 cement content and different sources of sulfate resisting cement.

This figure shows that for concrete without retempering, sulfate resisting cement of source (1) considerably decreases the initial setting time compared with source (2). Source (2) has a lower C_3A content. As C_3A increases, setting time decreases. Retempering using 0.75% Type G for source (2) highly increases initial setting time. Retempering using 1.5 % Type G considerably increases the initial setting time. These results are logic because sulfate resisting cement has a low C_3A value that affects setting time.

So it is not recommended to use an over dose of Type G in case of S.R.C concrete.

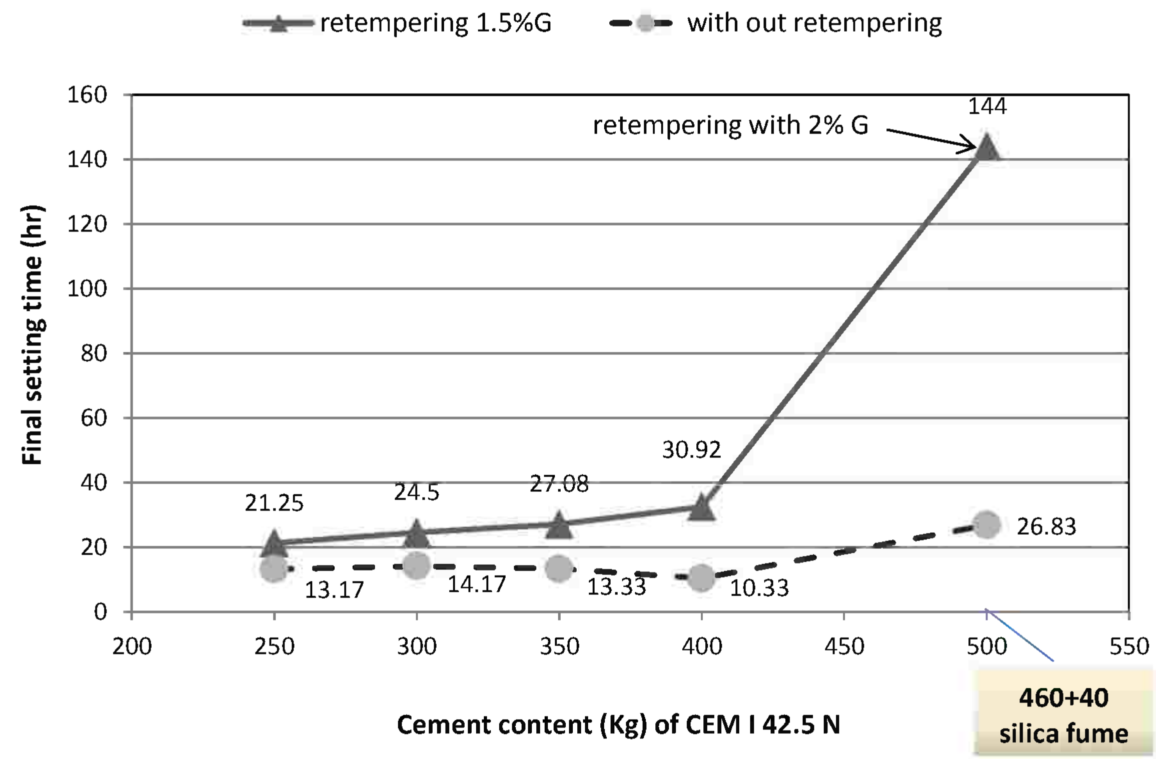

Figure (4-13) Effect of cement content of CEM I 42.5 N on final setting time for concrete with initial admixture of type G (1.5%)

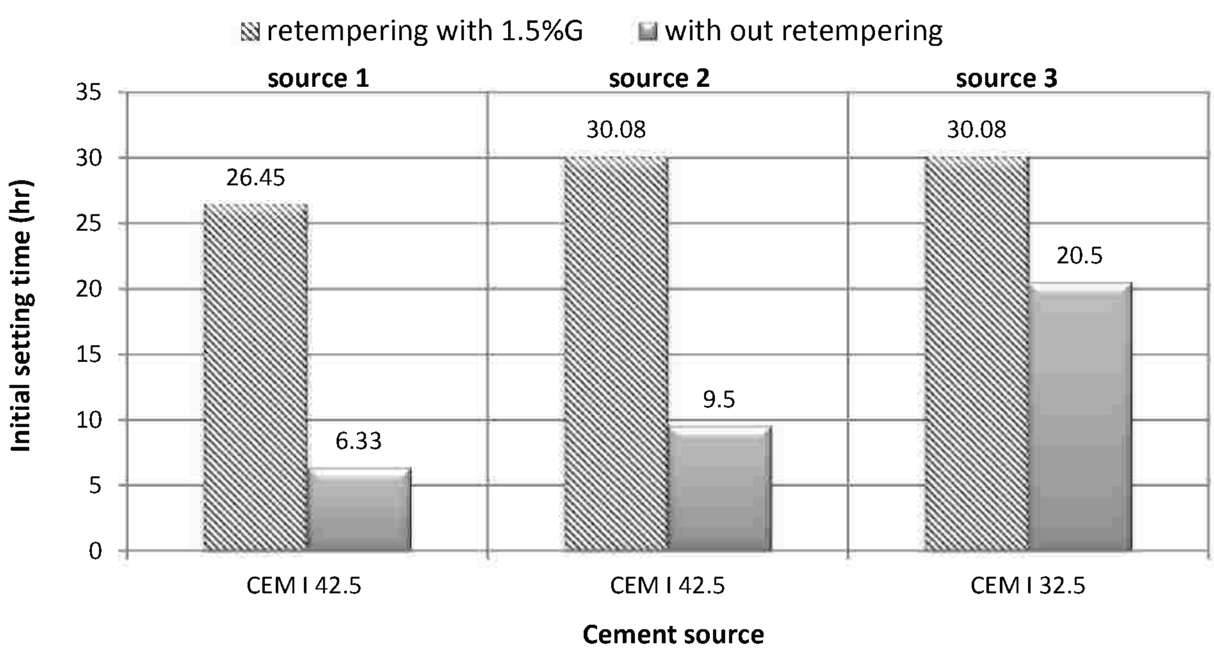

Figure (4-14) Effect of source and grade of CEM I for concrete with 400 kg/m^3 cement content and 1.5% G initial admixture

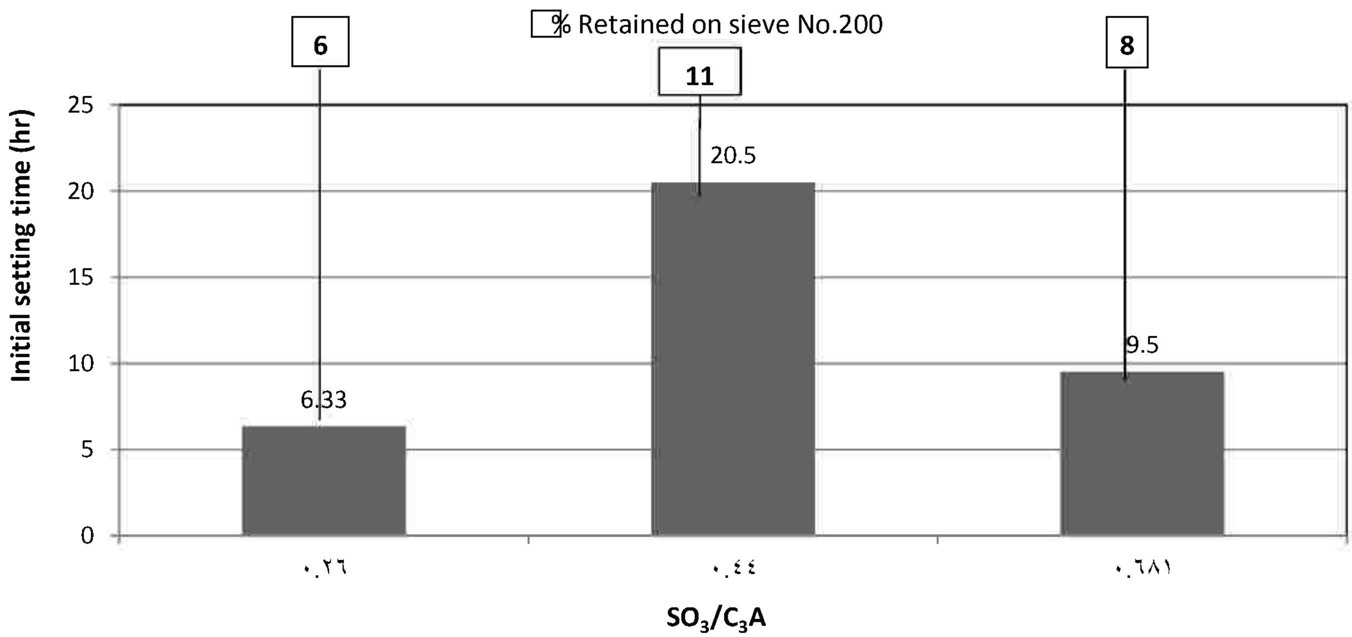

Figure (4-15) Effect of SO_3/C_3A ratio, and % retained on sieve No.200 of cement on initial setting time for CEM I cement for concrete with 400 kg/m^3 cement content and 1.5% G of initial admixture

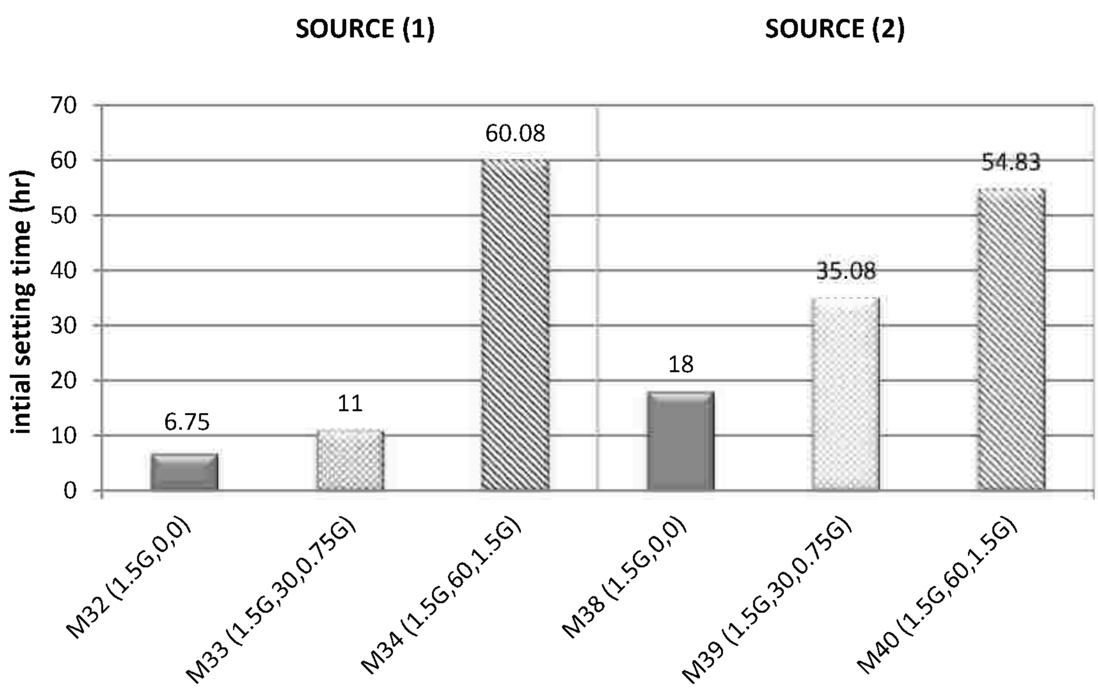

Figure (4-16) Effect of retempering using different dosages of Type G on initial setting time of concrete with 400 kg/m^3 cement content and different sources of sulfate resisting cement

4.4 Cube compressive strength test results:

4.4.1 Effect of retempering on one day compressive strength for CEM I 42.5 N:

Table (4-3) summarizes the cube compressive strength test results for all mixes after 1, 3, 7, 28 and 90 days.

Table (4-3) Cube compressive strength test results

Mix No.	Compressive strength(N/mm^2)				
	Age (Day)				
	1	**3**	**7**	**28**	**90**
M1	3.23	12.25	20.50	29.40	34.50
M2	3.06	25.00	38.00	55.80	54.84
M3	0.00	21.29	37.60	54.40	56.00
M4	0.00	15.00	35.95	50.70	50.40
M5	2.29	21.70	40.36	54.90	55.00
M6	0.00	22.50	39.69	53.80	53.20
M7	16.38	32.87	45.44	58.69	59.30
M8	14.58	35.50	45.19	58.92	61.37
M9	4.00	27.20	39.42	52.00	57.51
M10	7.30	28.00	41.50	56.84	58.80
M11	5.04	25.78	38.63	54.35	54.50
M12	5.08	26.50	38.62	51.12	56.08
M13	1.50	27.90	38.00	49.90	52.40
M14	1.60	26.45	37.66	50.43	52.15
M15	0.00	23.47	37.20	50.80	51.00
M16	0.00	28.84	35.06	43.20	45.10
M17	1.00	30.00	39.00	45.20	42.00
M18	4.02	32.55	44.30	54.90	53.60
M19	0.15	18.27	41.10	52.65	50.08

M20	2.05	7.28	11.68	21.00	23.96
M21	0.22	8.08	15.07	25.50	25.90

Table (4-3) Cube compressive strength test results (Continue).

Mix No.	Compressive strength(N/mm^2)				
	Age (Day)				
	1	3	7	28	90
M22	1.58	12.14	22.91	36.24	38.02
M23	0.00	12.71	23.2	33.74	38.8
M24	0.76	18.32	25.15	39.20	43.56
M25	0.00	12.62	32.85	48.20	50.00
M26	0.45	22.82	38.33	59.90	60.57
M27	0.00	0.00	14.00	30.92	37.10
M28	4.93	21.60	34.2	48.00	49.01
M29	0.00	18.00	34.18	47.28	51.46
M30	1.36	27.20	34.11	47.80	49.10
M31	0.00	13.00	26.56	38.90	38.36
M32	4.73	21.06	43.17	55.12	56.00
M33	3.13	17.19	40.80	49.60	47.41
M34	0.00	0.23	15.23	37.84	38.60
M35	1.10	25.86	45.56	57.90	58.00
M36	6.60	36.00	49.22	65.36	67.82
M37	12.28	35.00	48.93	62.77	63.71
M38	0.20	18.21	38.05	56.25	57.11
M39	0.00	7.00	34.84	51.79	51.80
M40	0.00	2.08	25.98	45.0	47.70
M41	0.32	12.13	29.84	48.62	55.00
M42	0.00	5.36	26.20	50.56	51.80

Figure (4-17) shows the effect of retempering admixtures (at 30 minutes) on one day cube compressive strength. From this figure it's clear that, the use of 0.75% of Type G or 0.75% of Type F based on naphthalene has negative effect on one day cube compressive strength. Moreover, using 0.75% of Type G yields zero one day cube compressive strength. However, the use of 0.75% of Type F chemical admixture based on melamine enhances one day cube compressive strength when it's used as a retempering admixture after 30 minutes, this enhancement in one day compressive strength is 435% compared with control mix.

The effect of retempering admixtures at 60 minutes on one day cube compressive strength is shown in Figure (4-18). One can conclude that, retempering with Type F based on melamine (F-Me) increases one day compressive strength compared with control mix, this enhancement is 376%. Retempering with Type G or Type F based on naphthalene (F-Na) achieves zero one day compressive strength.

The previous results ensure that retempering using melamin decreases the retarding effect of Type G even when it is compared with control mix without retempering.

4.4.2 Effect of retempering on three days compressive strength for CEM I 42.5 N:

Figure (4-19) shows the effect of retempering after 30 minutes with different admixtures on 3 days compressive strength. From this figure, retempering with either Type G (0.75%) or Type F based on naphthalene (0.75%) slightly decreases 3 days compressive strength. Retempering with Type F based on melamine still enhances cube compressive strength compared with control concrete.

Figure (4-20) shows the same relation of figure (4-19) for retempering after 60 minutes with 1.5% of different types of admixtures. Retempering with 1.5 % G considerably decreases 3 days compressive strength, this decrease is 40%, compared with that of control mix. Retempering with 1.5 % Type F based on naphthalene decreases 3 days compressive strength, this decrease is 10 %. Retempering with 1.5 % Type F – Me enhances 3days compressive strength, this increases is 42 %.

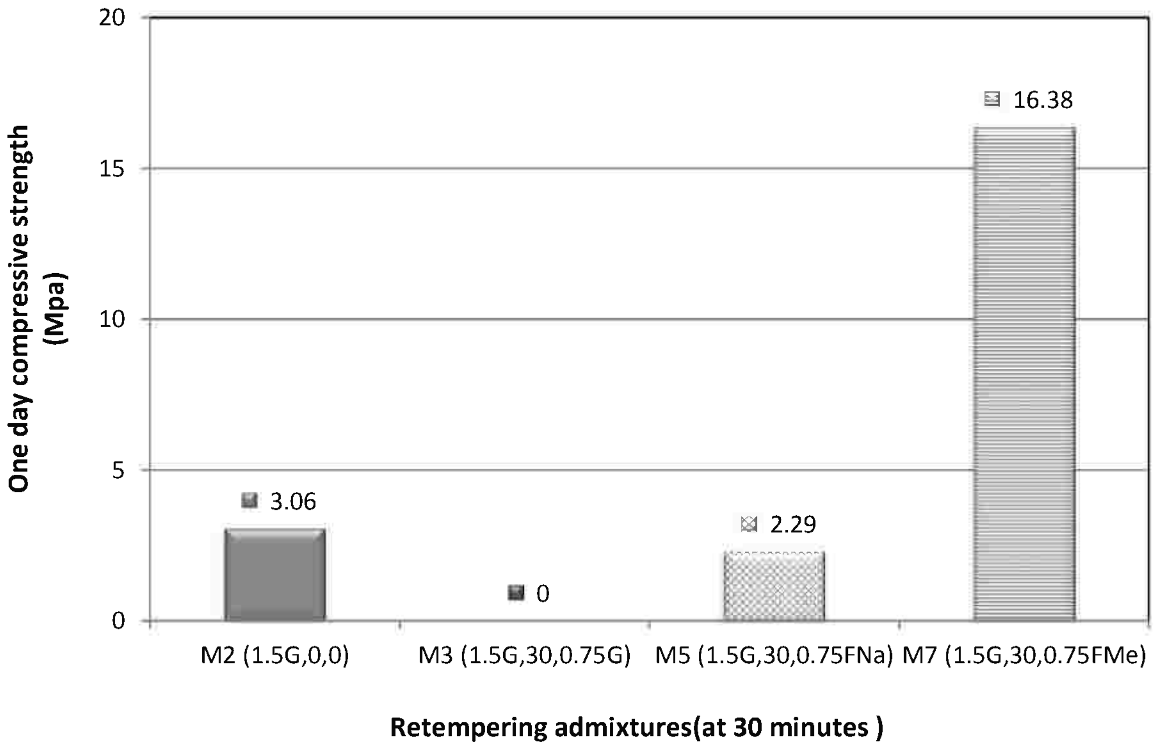

Figure (4-17) Effect of 30 minutes retempering admixture on one day cube compressive strength for concrete containing 400 kg/m3 cement content (CEM I 42.5 source one)

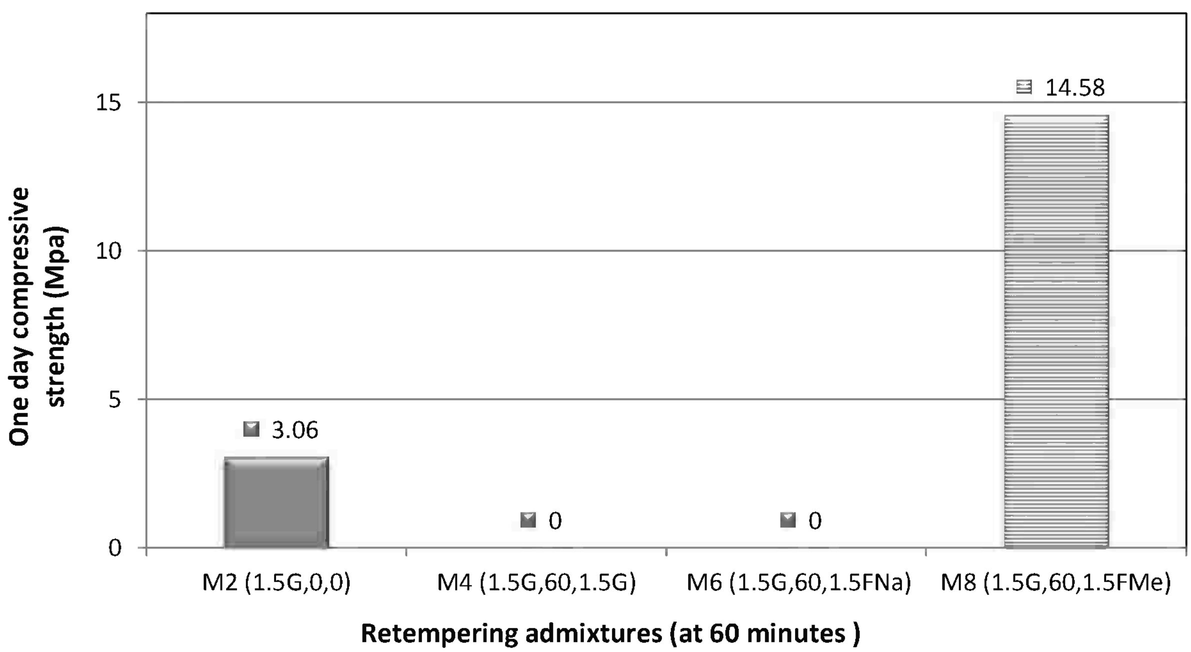

Figure (4-18) Effect of 60 minutes retempering admixture one day cube compressive strength for concrete with 400 kg/m3 cement content (CEM I 42.5 N source one)

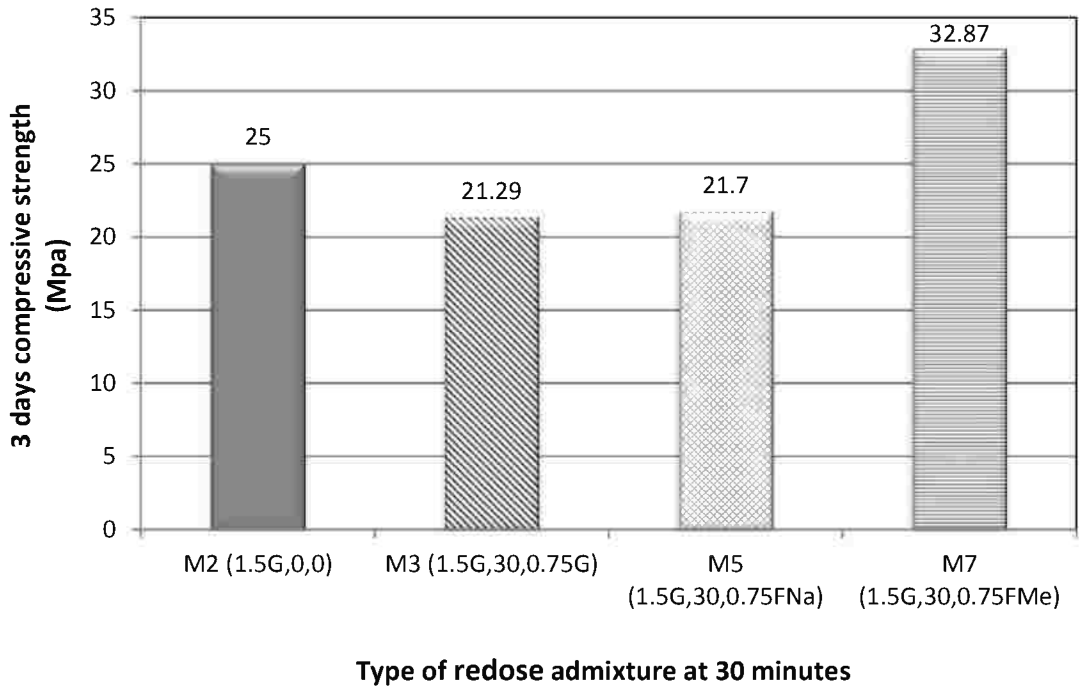

Figure (4-19) Effect of 30 minutes retempering admixture on 3 days cube compressive strength for concrete containing 400 kg/m3 cement content (CEM I 42.5 source one)

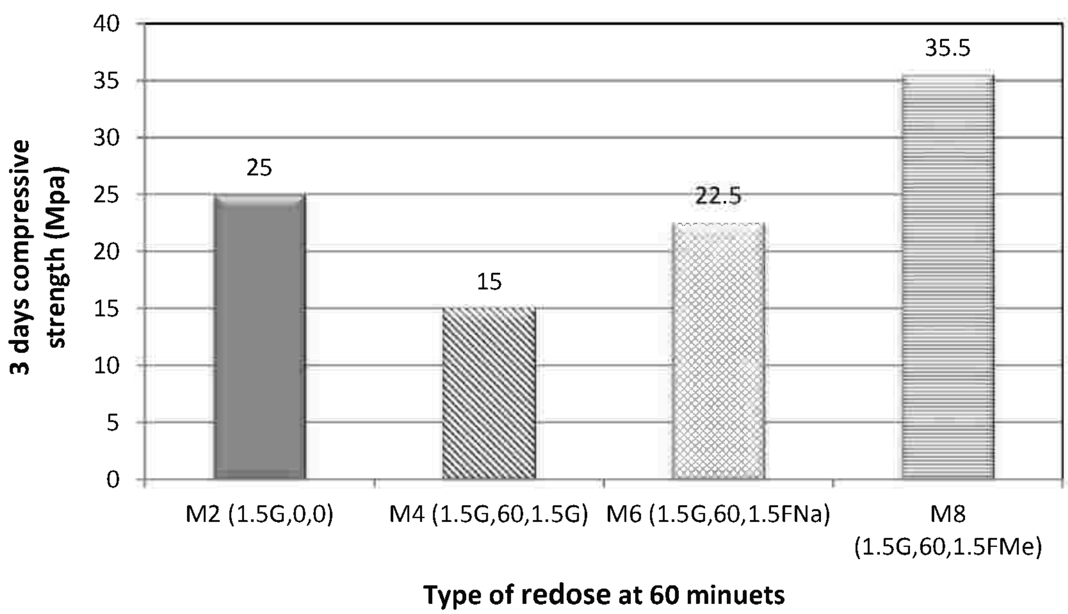

Figure (4-20) Effect of 60 minutes retempering admixture 3 days cube compressive strength for concrete with 400 kg/m3 cement content (CEM I 42.5 N source one)

4.4.3 Effect of retempering on 7, 28, and 90 days compressive strength for CEM I 42.5 N:

Figure (4-21) shows the effect of type of retempering admixture on 7, 28, and 90 days compressive strength. From this figure it's clear that retempering using 0.75% of Type G or using 0.75% of Type F-Na has a comparable compressive strength test result compared with control mix. Also, retempering using 0.75% that of Type F-Me increases 7, 28, and 90 days strength by 19. 6, 5.2, and 8.1% compared with control mix respectively.

Figure (4-22) shows the effect of retempering using 1.5% of different admixtures at 60 minutes on 7, 28, and 90 days cube compressive strength. From this figure retempering using Type G decreases 7, 28 and 90 days compressive strength. This reduction is 5.4, 9.1 and 8.1 % at 7, 28, and 90 days respectively. Also, retempering using Type F-Na shows almost the same compressive strength of control mix. Finally, retempering using Type F-Me enhances concrete compressive strength at different ages. This enhancement is 18.9, 5.6, and 11.9% at 7, 28, 90 days compared with control mix respectively.

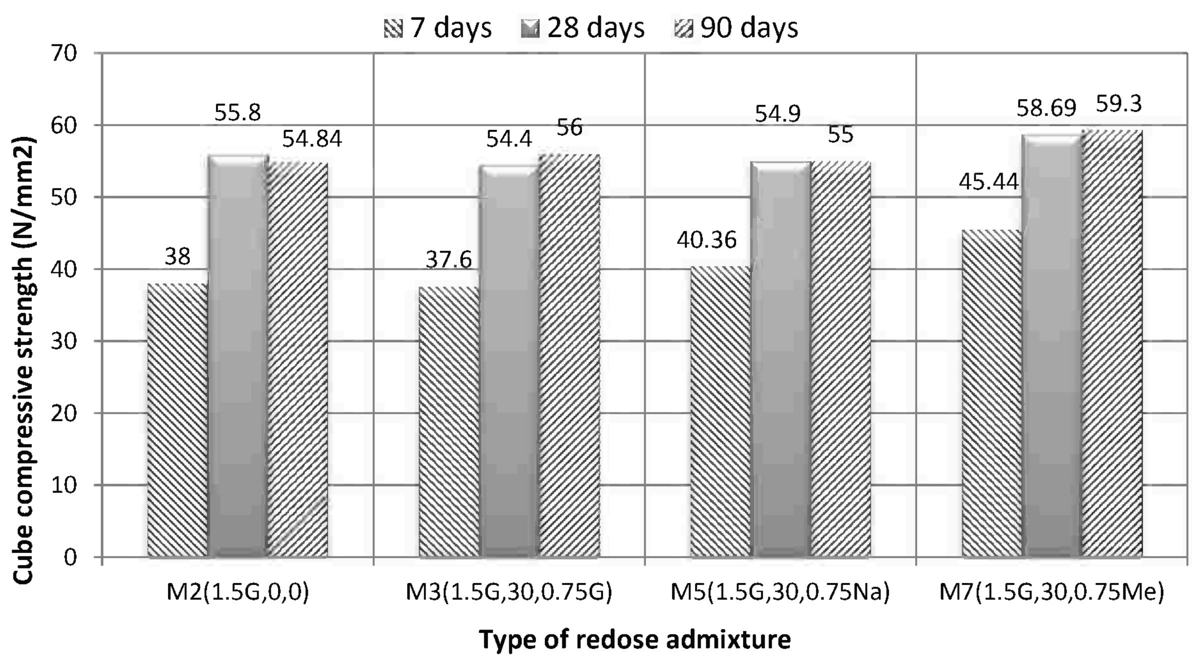

Figure (4-21) Effect of 30 minutes retempering admixture on 7, 28, 90 days cube compressive strength for concrete with 400 kg/m3 cement content (CEM I 42.5 N source1)

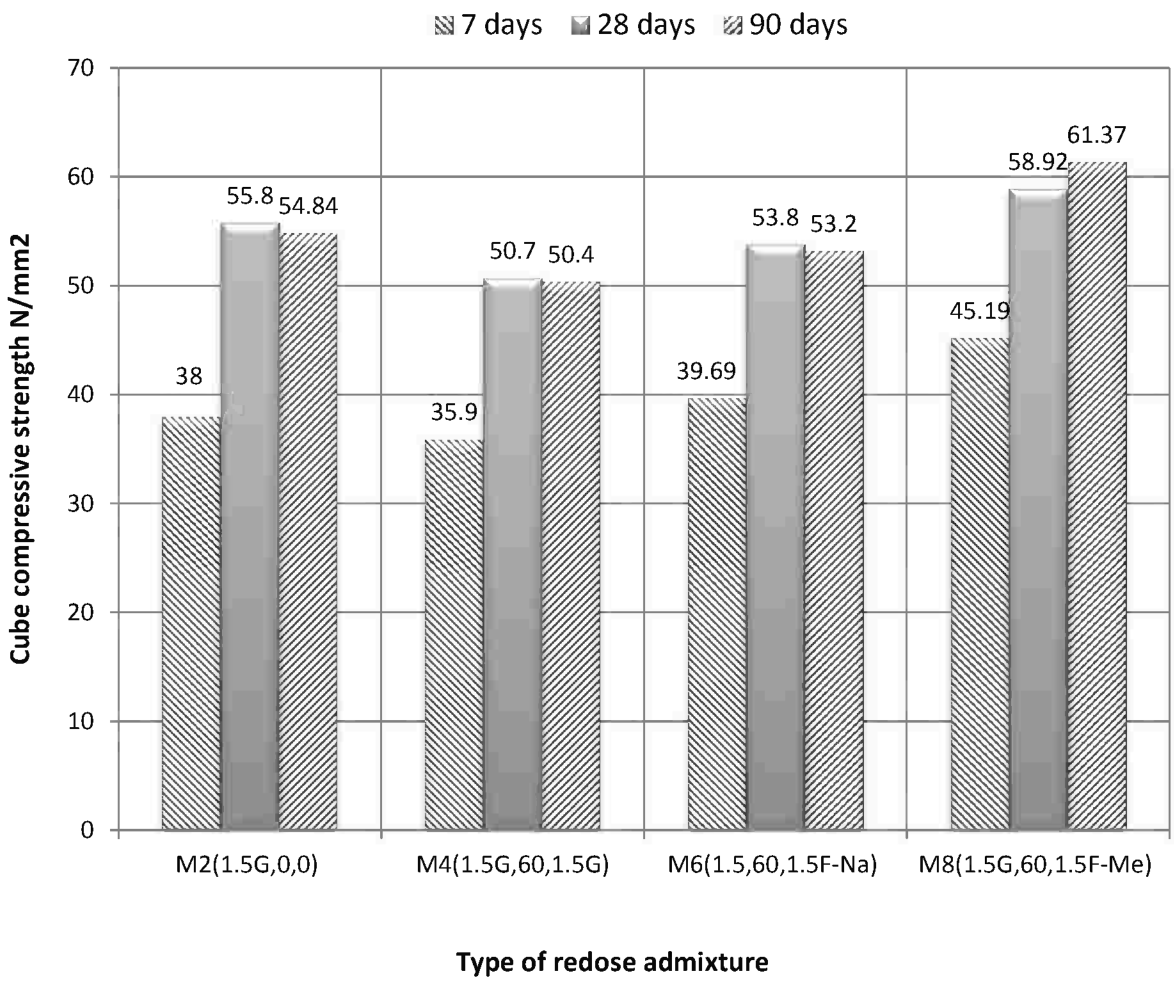

Figure (4-22) Effect of 60 minutes retempering admixture on 7, 28, 90 days compressive strength for concrete with 400 kg/m^3 cement content (CEM I 42.5 N source1)

4.4.4 Effect of initial mixed admixtures types on concrete cube compressive strength:

Figure (4-23) shows the effect of type of initial mixed chemical admixture on concrete compressive strength at different ages. From this figure the use of a mix of Type G and Type F chemical admixture based on naphthalene or melamine as an initial dosage generally has a slight effect on compressive strength at different ages. Generally, the use of Type F chemical admixture based on melamine has generally higher concrete compressive strength than that of other mixes.

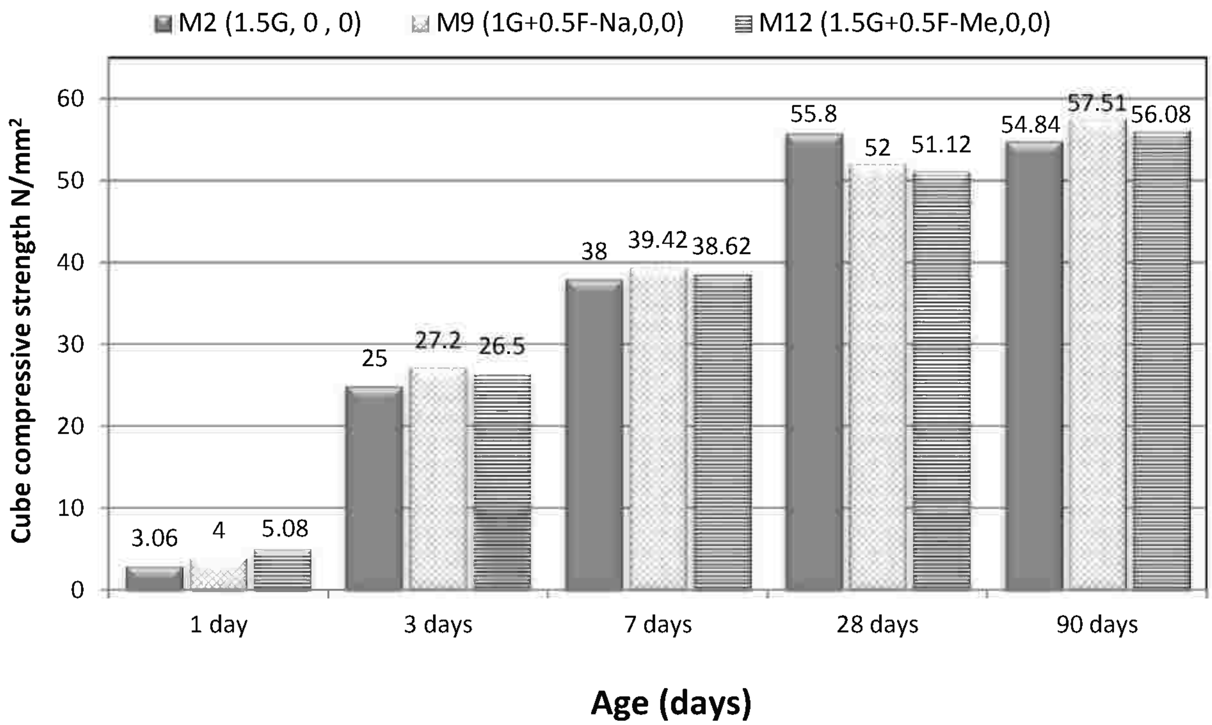

Figure (4-23) Effect of using a mix of Type G and Type F of different bases on cube compressive strength at different ages, for concrete with 400 kg/m^3 cement content (CEM I 42.5 N source1)

4.4.5 Effect of different retempering admixtures on compressive strength of concrete with mixed initial admixtures:

Figures (4-24), and (4-25) show the effect of different retempering admixture and mixed initial admixtures on 1, and 3 days cube compressive strength at retempering time of 30, and 60 minutes, respectively. From this figures one can conclude that, retempering with Type F based on naphthalene for concrete has a mixed admixtures (1.0% Type G + 0.5 Type F based on naphthalene) enhances one and three days compressive strength compared with retempering with Type G. The enhancement in 3 days strength is 31.5, and 71.8 % for retempering time of 30 and 60 minutes respectively. Also, the use of a mix of Type G and Type F based on melamine, slightly improves one day compressive strength, while a considerable enhancement in 3 days compressive strength is achieved.

4.4.5.1 Effect on 7, 28, and 90 days cube compressive strength:

Figures (4-26), and (4-27) show that the use of a mix of Type G and Type F based on naphthalene slightly enhances the 7, 28, and 90 days compressive strength compared with the use of Type G only or the use of a mix of Type G and Type F based on melamine

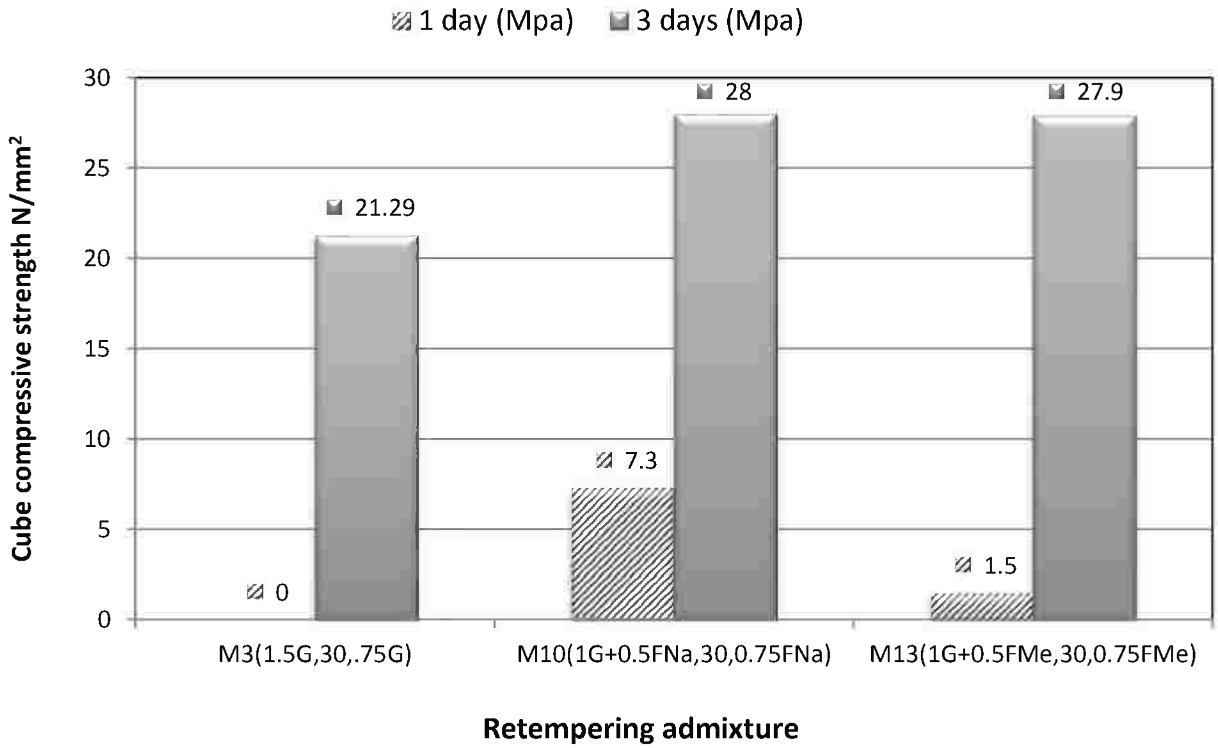

Figure (4-24) Effect of different retempering admixtures on one and three days cube compressive strength (retempering at 30 minutes)

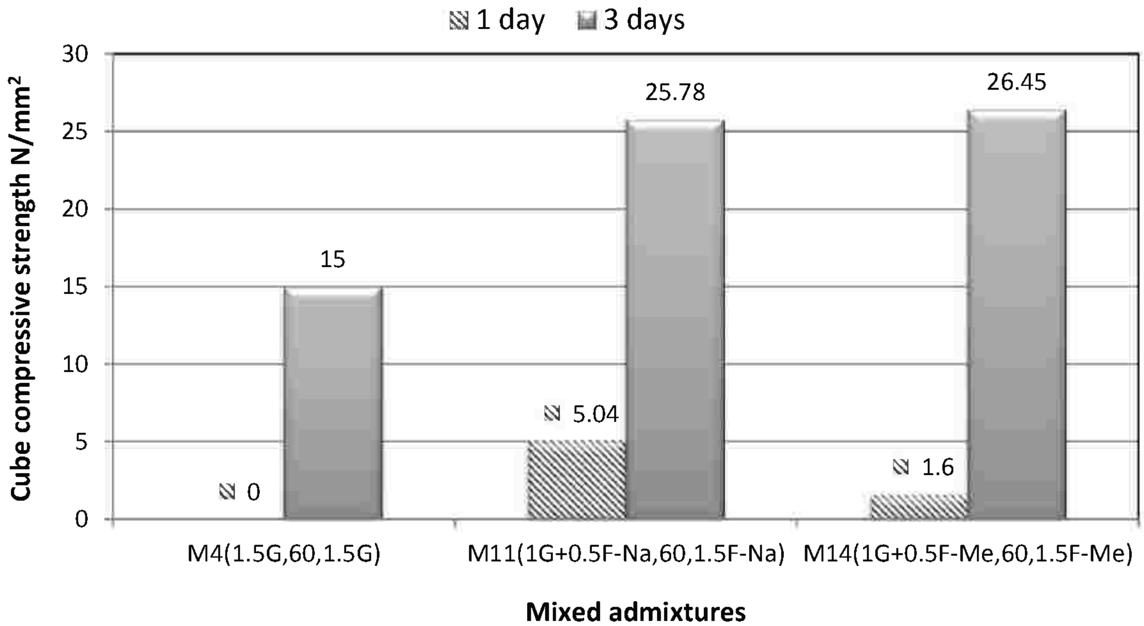

Figure (4-25) Effect of mixed admixtures on one and three days cube compressive strength (retempering at 60 minutes)

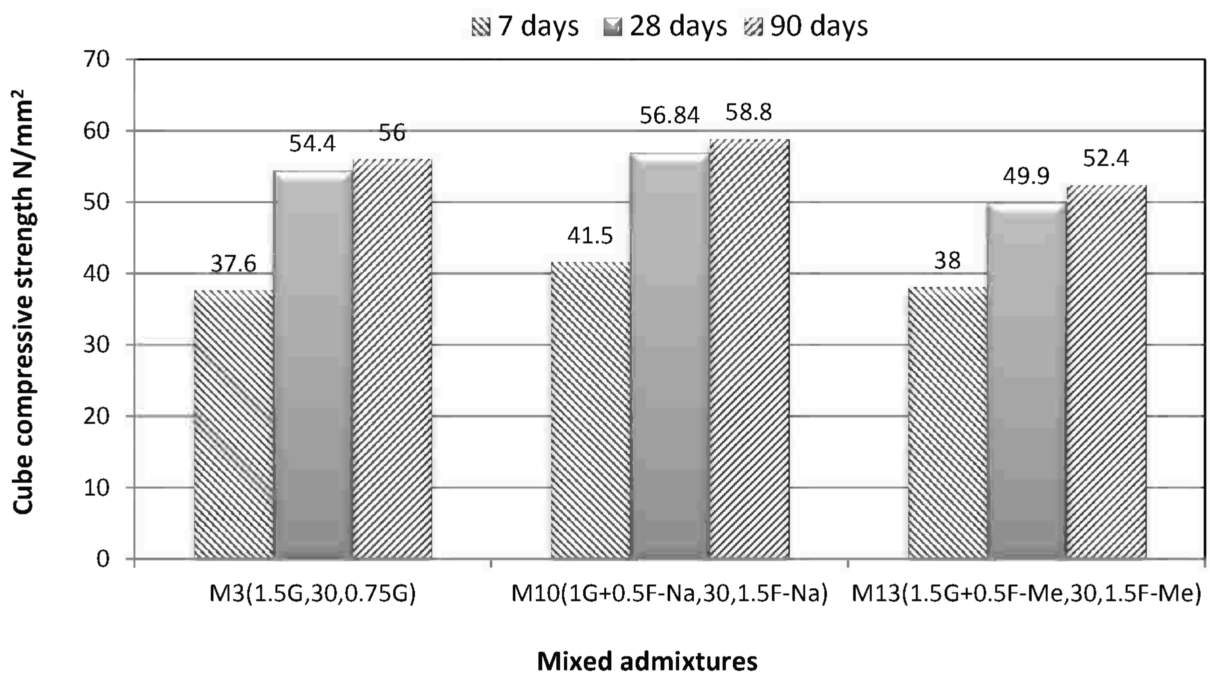

Figure (4-26) Effect of mixed admixtures on 7, 28, and 90 days cube compressive strength (retempering at 30 minutes)

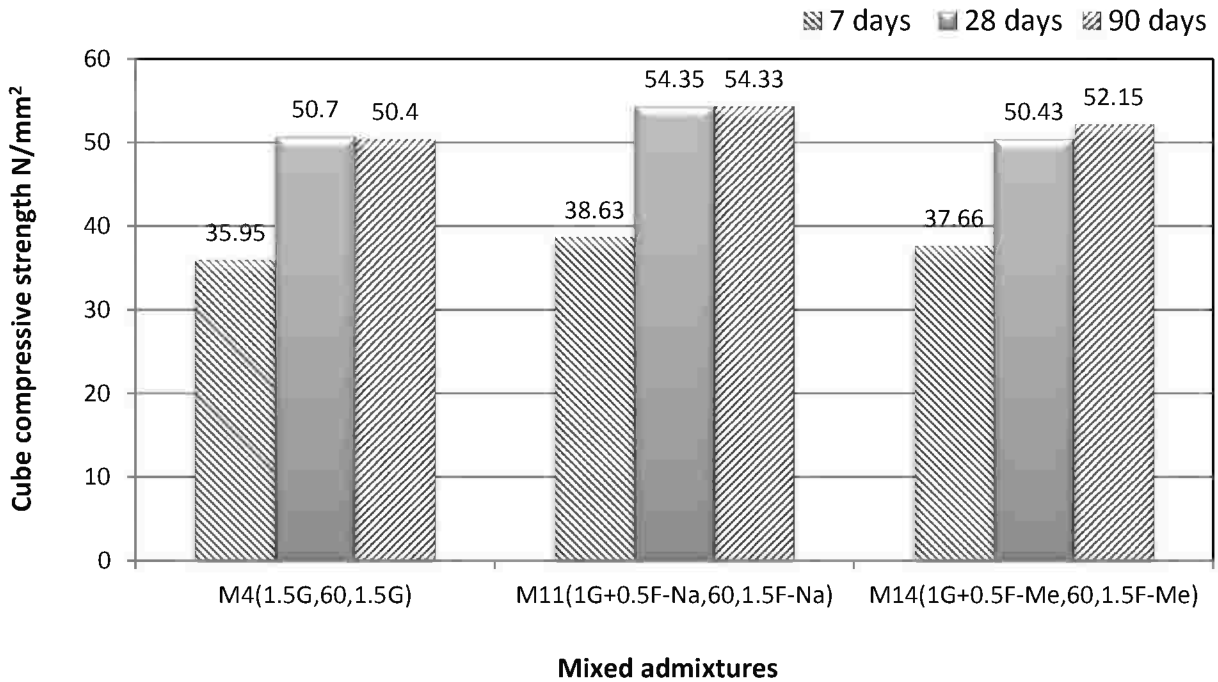

Figure (4-27) Effect of mixed admixtures on 7, 28, and 90 days cube compressive strength (retempering at 60 minutes)

4.4.6 Effect of retempering using accelerators:

The effect of retempering using Type C chemical admixtures or retempering using Type C mixed with Type G chemical admixture is shown in Figures, (4-28) and (4-29). From this figures it's clear that generally retempering with accelerator improves compressive strength at different ages especially at early ages. Also retempering with a mix of Type G and accelerator improves 3 days strength but decreases 28 and 90 days compressive strength.

It is not recommended to use a mix of Type G and Type C as retempering admixtures. Comparison of Figure (4-28) with Figures (4-17), (4-19), shows that retempering with Type F based on melamine or accelerator yields the best results of cube compressive strength at 1 or 3 days. The accelerator did not enhance the workability.

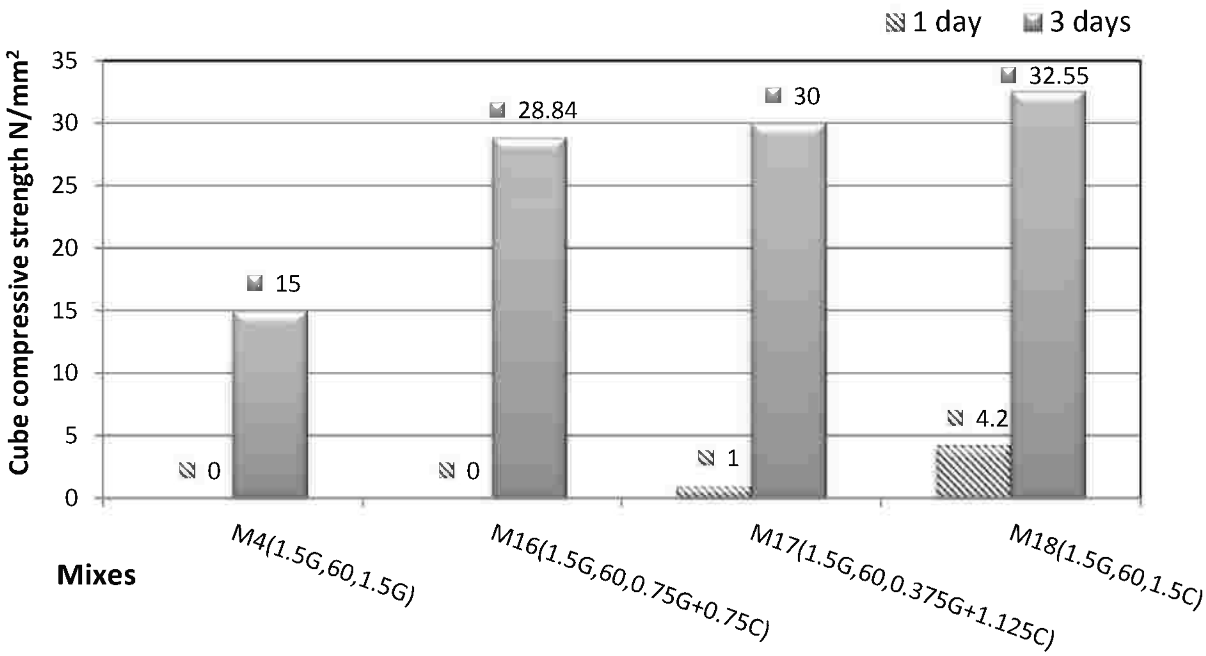

Figure (4-28) Effect of retempering with Type G and accelerator (C) on one and three days cube compressive strength (Retempering at 30 minutes)

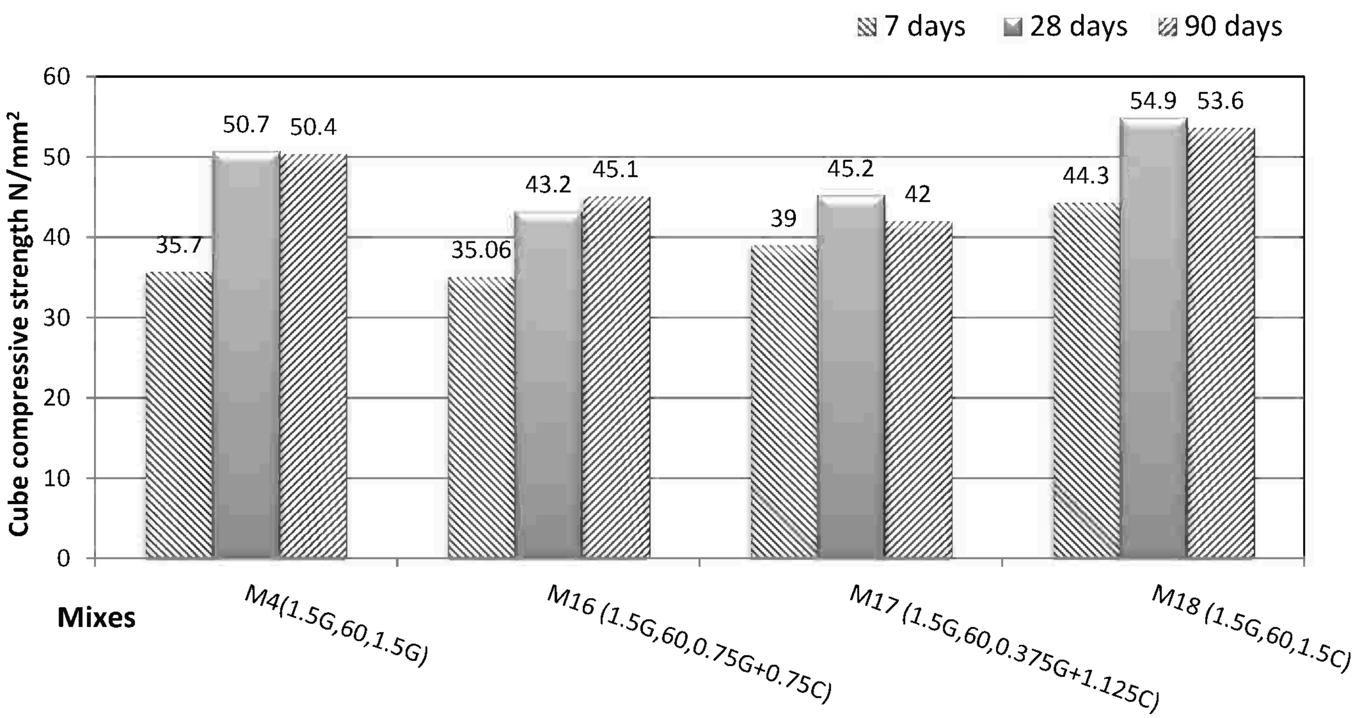

Figure (4-29) Effect of retempering with Type G and accelerator (C) or carboxylic on 7, 28, and 90 days compressive strength (retempering at 60 minutes)

4.4.7 Effect of retempering using superplasticizer based on polycarboxylic:

This effect is given in Figure (4-30). Retempering using a mix of Type G (0.75%) and polycarboxylic (0.20%) doesn't affect significantly the compressive strength compared with retempering using Type G (1.5%) and control mix without retempering.

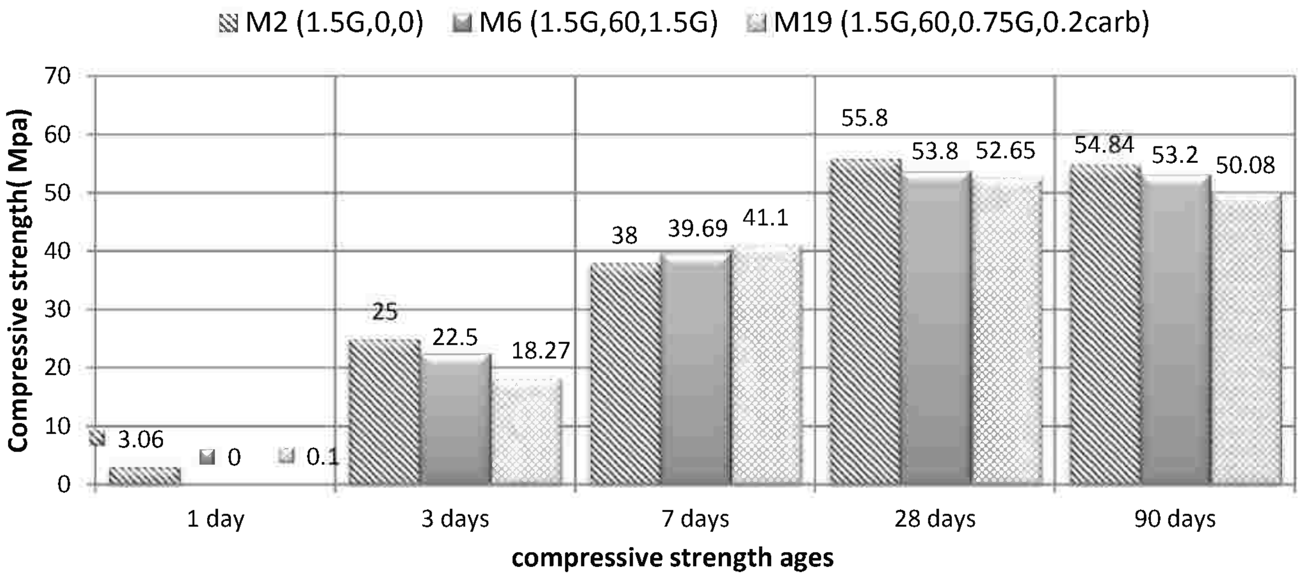

Figure (4-30) Effect of polycarboxylic admixture on cube compressive strength

4.4.8 Effect of cement content and retempering using 1.5% Type G on cube compressive strength

Figure (4-31) shows the relation between cement content and one, and 3 days cube compressive strength. All cement contents were re-tempered using 1.5 % Type G except cement content of 460 kg and 40 kg silica fume where 2.0 % of Type G is used. Retempering using Type G at 60 minutes eliminates one day strength.

For low cement content (250 kg/m^3) and moderate cement content (300 kg/m^3) retempering using 1.5% Type G slightly enhances 3 days cube compressive strength. The effect of mixing for 60 minutes overcomes the retardation effect. For high cement content (400 kg/m^3) retempering decreases 3 day strength, the retarding effect is effective than mixing effect for 60 minutes. Hussin [45] and others [56] concluded that re mixing of concrete enhances compressive strength due to evaporation of mixing water and homogenty of the mix.

For cementitious material of 500 kg/m^3 (460 cement and 40kg silica fume), retempering using 2 % Type G yield zero 3 days cube compressive strength. This may tend to the presence of high content of Type G (20 kg). For concrete without retempering, the use of 460 ordinary Portland cement and 40 silica fume yields lower 3 days cube compressive strength than the use of 400 kg/m^3 ordinary Portland cement, the presence of silica fume decreases the hydration process in the presence of 20 kg of Type G.

Effect on 7, 28 and 90 days compressive strength

Figure (4-32) shows the previous relation for 7, 28 and 90 days. For concrete without retempering, 7, 28 and 90 days cube compressive strength increases as cement content increases. This is an expected phenomenon, where cementitious material enhances and W/C ratio decreases.

For low cement content (250 kg/m^3) and moderate cement content (300, 350 kg/m^3) retempering at 60 minutes generally enhances 7, 28 and 90 days cube compressive strength compared with control concrete. The effect of mixing overcomes the retarding effect. For high cement content (400 kg/m3), retempering decreases 7, 28 and 90 days cube compressive strength.

For concrete with 460 kg of ordinary cement + 40 kg of silica fume, retempering with 2% Type G considerably decreases 7, 28 and 90 days strength. This may tend to the use of 20 kg of Type G which considerably retards the setting especially in the presence of silica fume.

4.4.9 Effect of source and grade of ordinary Portland cement on cube compressive strength.

Figures (4-33), (4-34), and (4-35) show the effect of cement type, grade, and retempering on cube compressive strength at different ages. Figure (4-33) shows that retempering using 1.5% Type G after 60 minutes eliminates one day cube compressive strength for different cement types. Both sources of CEM I 42.5 N shows the same trend for 3 days cube compressive strength, where the reduction in 3 days cube compressive strength due to retempering is 15 and 17 % for the two sources respectively. This reduction is 52% for CEM I 32.5 N.

Figures (4-34) and (4-35) show that the two sources of CEM I 24.5N almost have the same behavior on the 7 and 28 cube compressive strength, where the effect of retempering is negligible. Retempering decreases 7, 28 and 90 days cube compressive strength of CEM I 32.5 N by 22.1, 19, and 22% respectively. The retempering with 1.5 % Type G considerably decreases cube compressive strength of CEM I 32.5 N concrete at different ages.

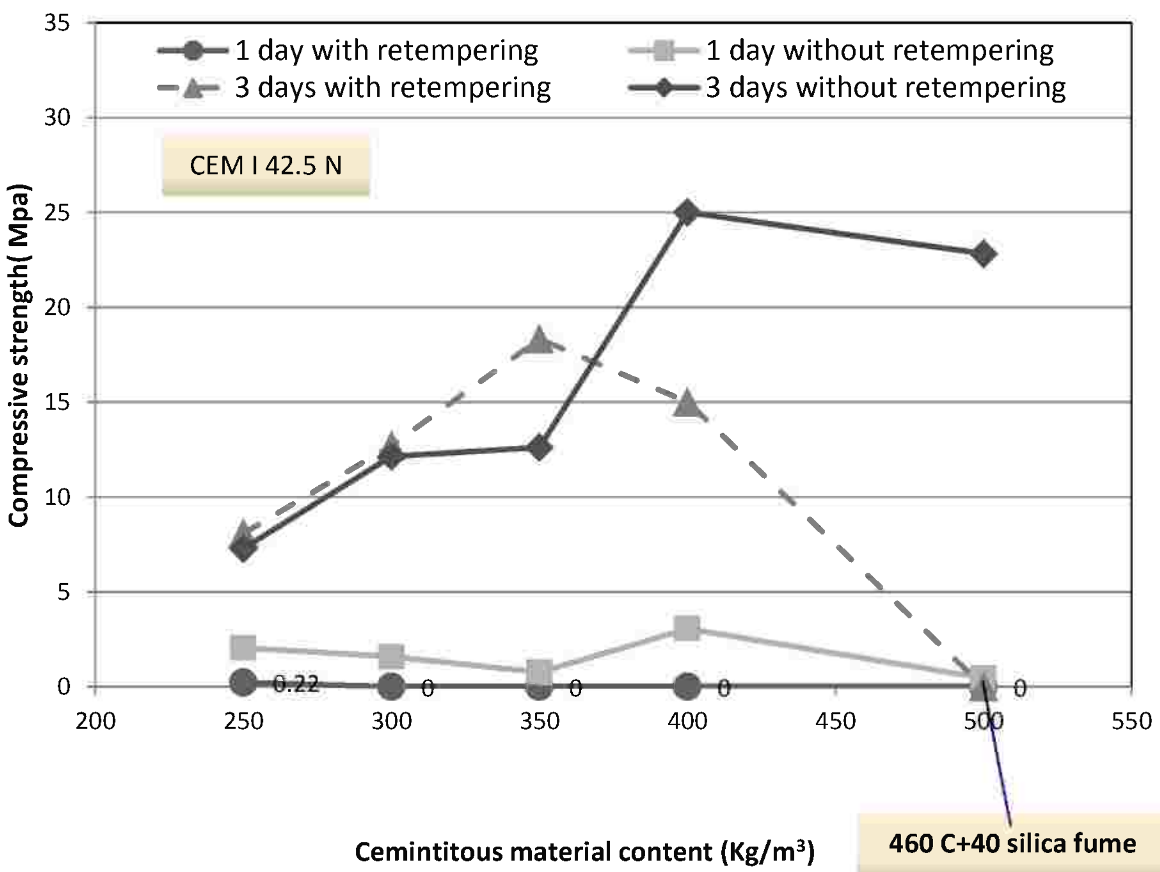

Figure (4-31) Effect of cement content and retempering using Type G on 1 and 3 day cube compressive strength

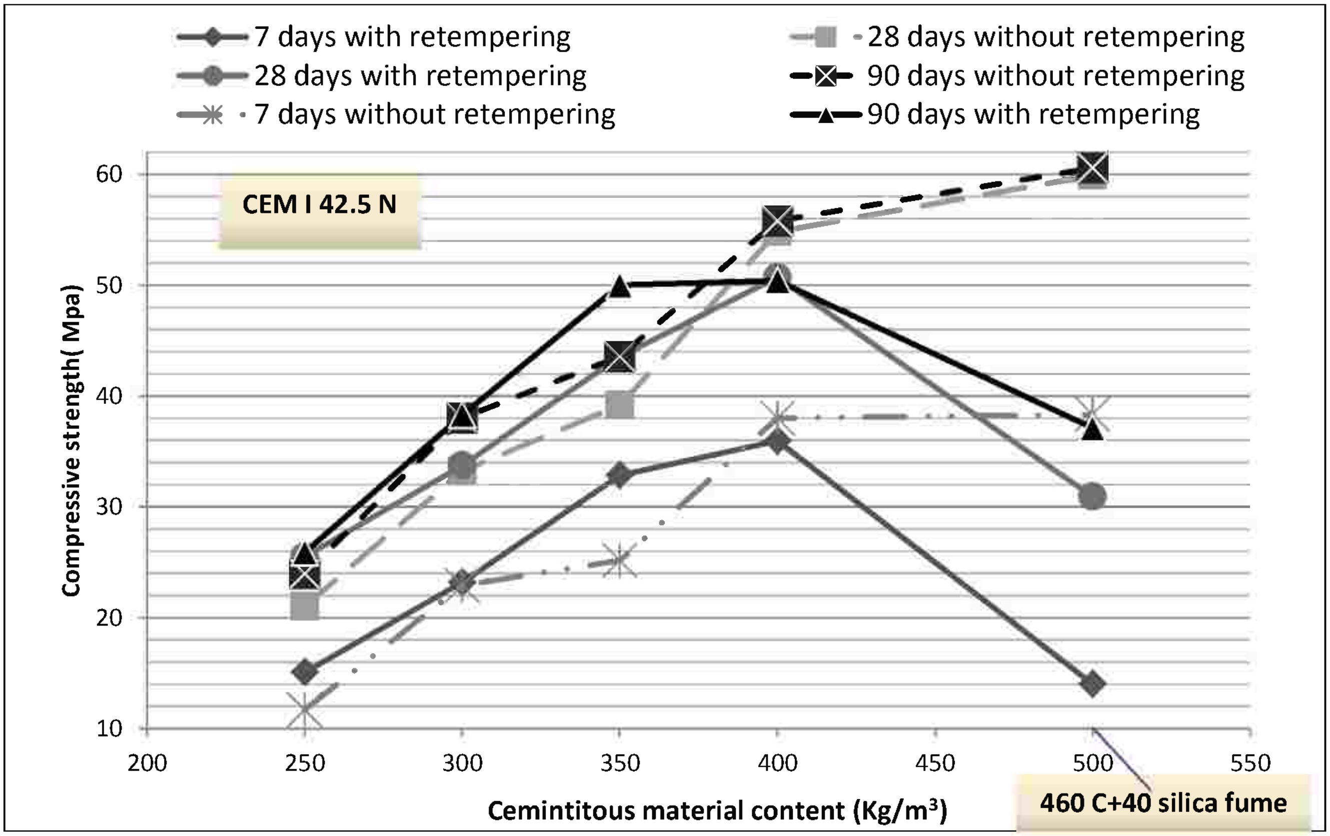

Figure (4-32) Effect of cement content and retempering using Type G on 7, 28 and 90 days cube compressive strength

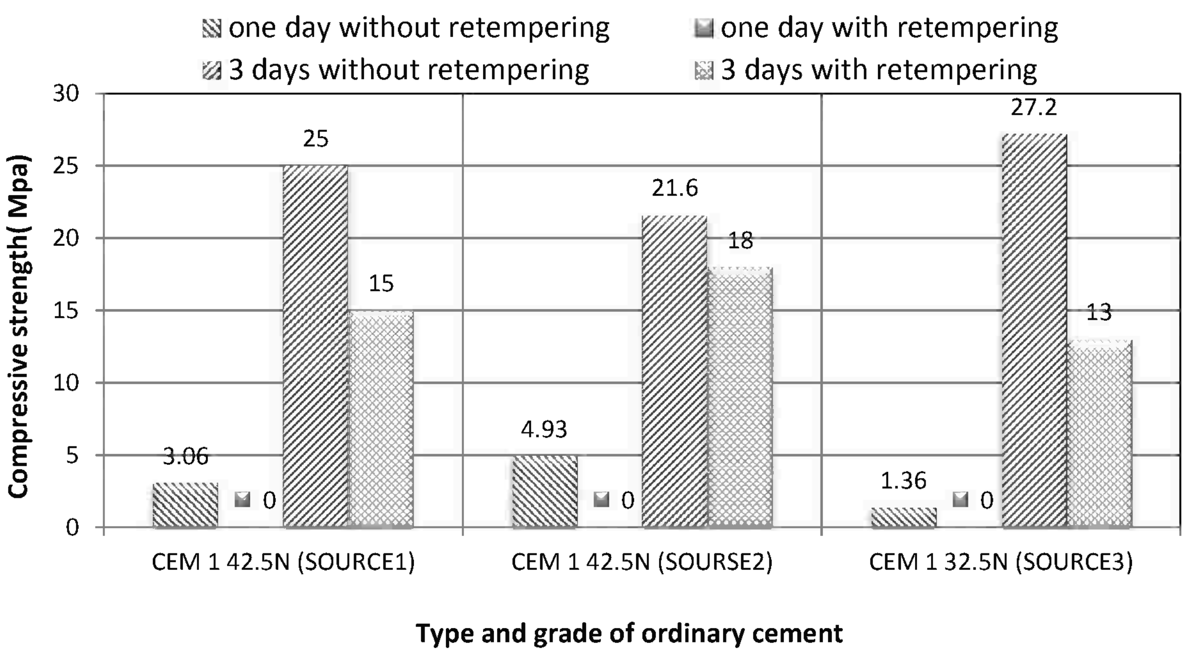

Figure (4-33) Effect of source and grade of ordinary cement and retempering on one and three days cube compressive strength for concrete with 400 kg/m^3 cement content

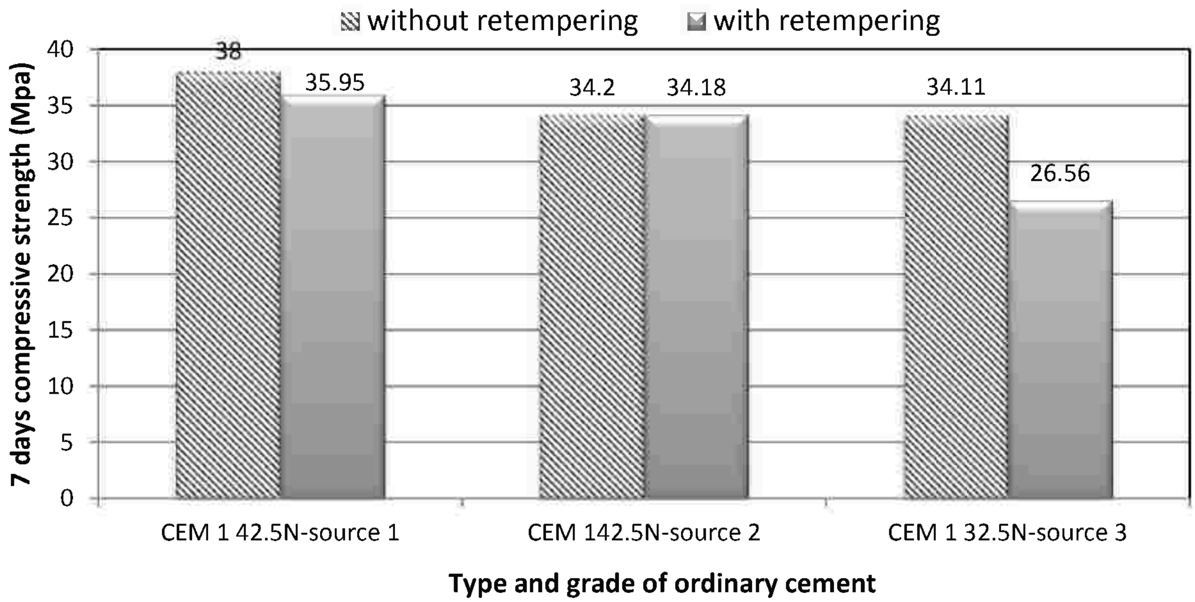

Figure (4-34) Effect of Type and grade of ordinary cement and retempering on 7 days cube compressive strength for concrete with 400 kg/m^3 cement content

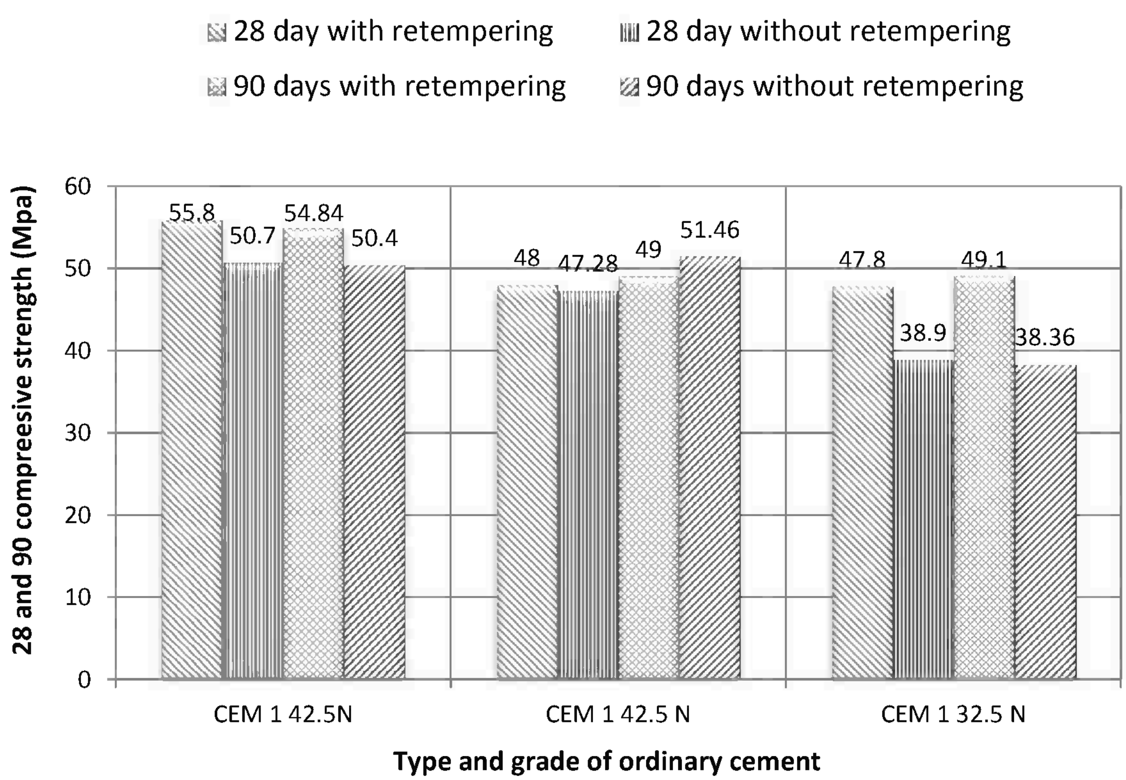

Figure (4-35) Effect of Type and grade of ordinary cement and retempering on 28 and 90 cube days compressive strength for concrete with 400 kg/m^3 cement content

4.4.10 Effect of source of sulfate resisting cement on retempering and compressive strength

Figures (4-36) and (4-37) show the effect of retempering using different dosages at different times on one and 3 days cube compressive strength, for different sources of sulfate resting cement.

Retempering using 0.75% Type G for source one (C_3A=1.22+%, C_3S = 69.417%), decreases one day cube compressive strength by 33.8%. It decreases the 3 days compressive strength by 18.3%. Retempering using 1.5% Type G yields almost zero strength at one, and 3 days age for both sources. The early cube compressive strength of source (1) generally is higher than that of sources (2) as the $C_3A + C_3S$ content of the former is higher than that of the later.

Figures (4-38) and (4-39) show the effect of retempering using different dosages at different times on 7, 28, and 90 days cube compressive strength for different sources of sulfate resisting cement.

Retempering using 0.75% Type G at 30 minutes decreases 7 days cube compressive strength by 5.5 and 8.44 % for source (1) and source (2) respectively. Retempering using 1.5% Type G at 60 minutes decrease 7 days cube compressive strength by 64.72 and 32% for the used sources respectively.

For source (1), retempering using 0.75, and 1.5% decreases 28 days by 10.01 and 31.07 % respectively. This decrease is 7.93, and 20 % for the second source. For source (1), retempering using 0.75, and 1.5% decreases 90 days by 15.33 and 45 % respectively. This decrease is 9.32, and 17.41 % for the second source.

These results ensure that the effect of retempering depends on source of sulfate resisting cement.

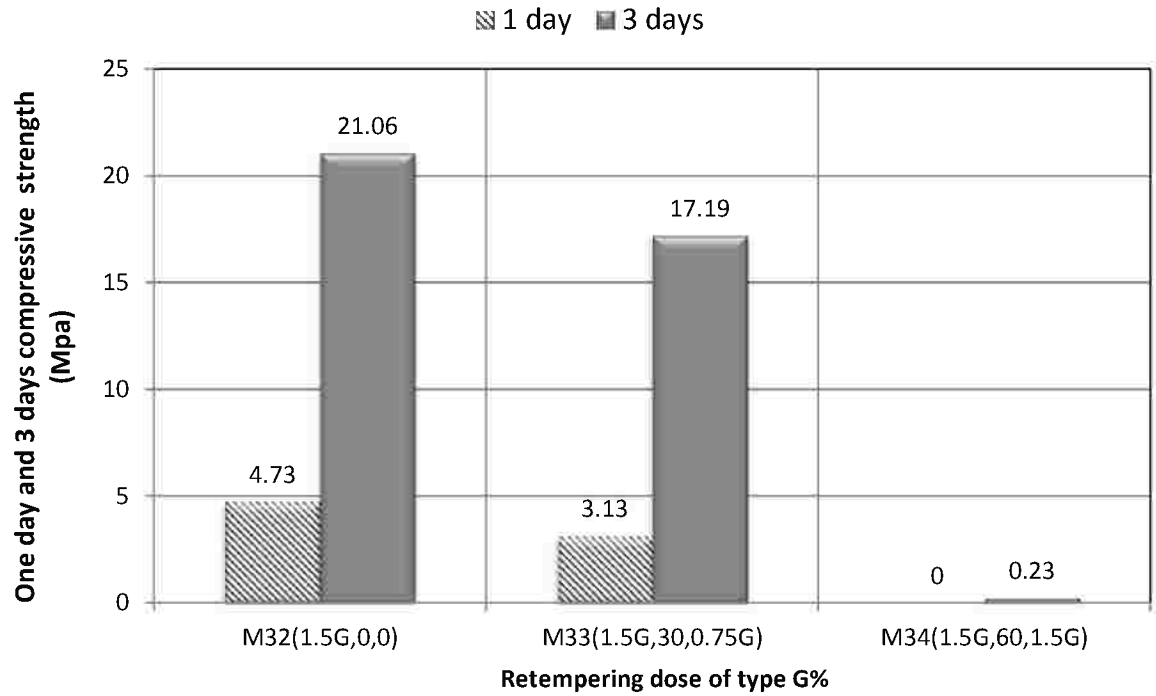

Figure (4-36) Effect of retempering using 0.75% and 1.5% Type G on 1 and 3 days cube compressive strength of S.R.C (source1) for concrete with 400 kg/m^3 cement content

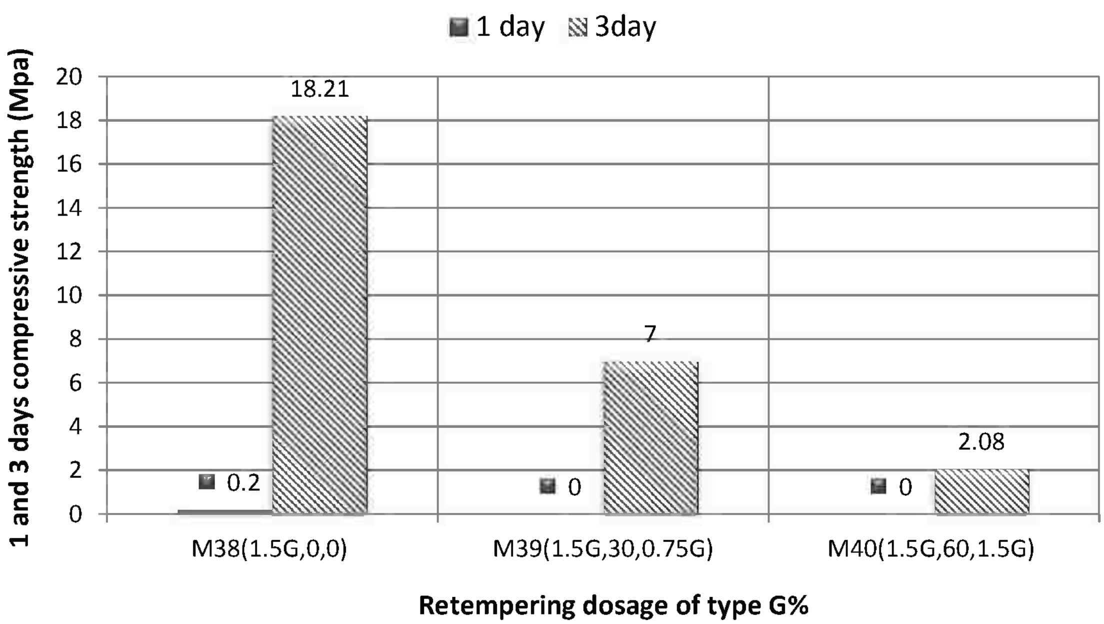

Figure (4-37) Effect of retempering using 0.75% and 1.5% Type G on 1 and 3 days cube compressive strength of S.R.C concrete (source 2) for concrete with 400 kg/m^3 cement content

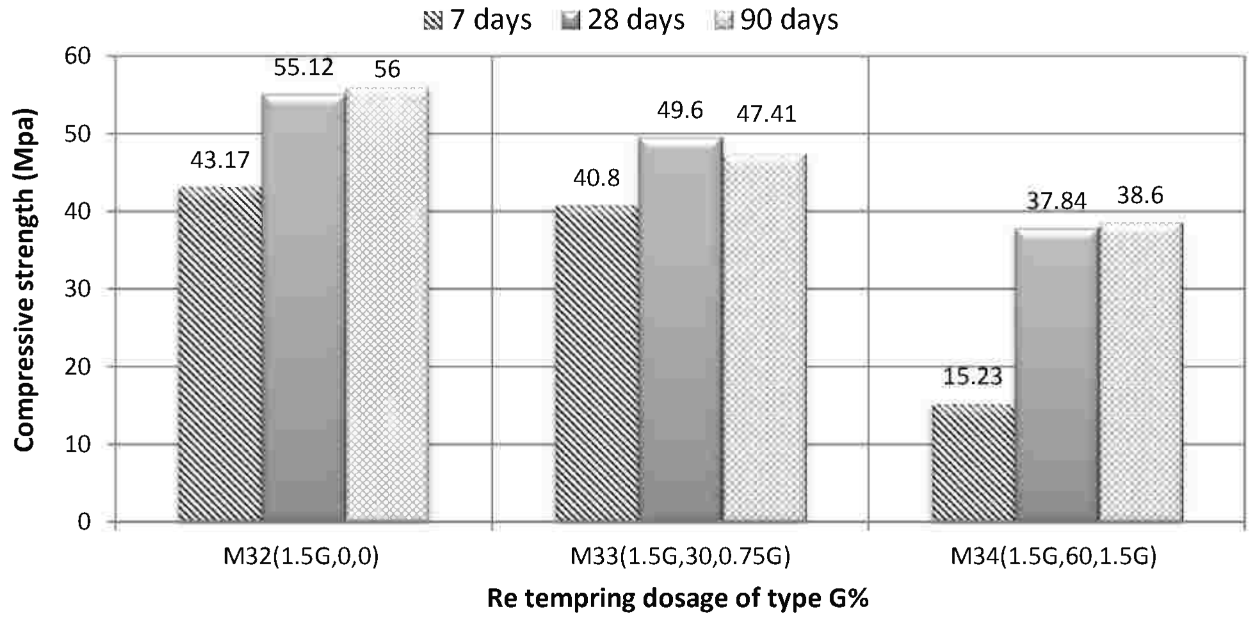

Figure (4-38) Effect of retempering using 0.75% and 1.5% Type G on 7, 28 and 90 days cube compressive strength of sulfate resisting cement (source 1) for concrete with 400 kg/m^3 cement content

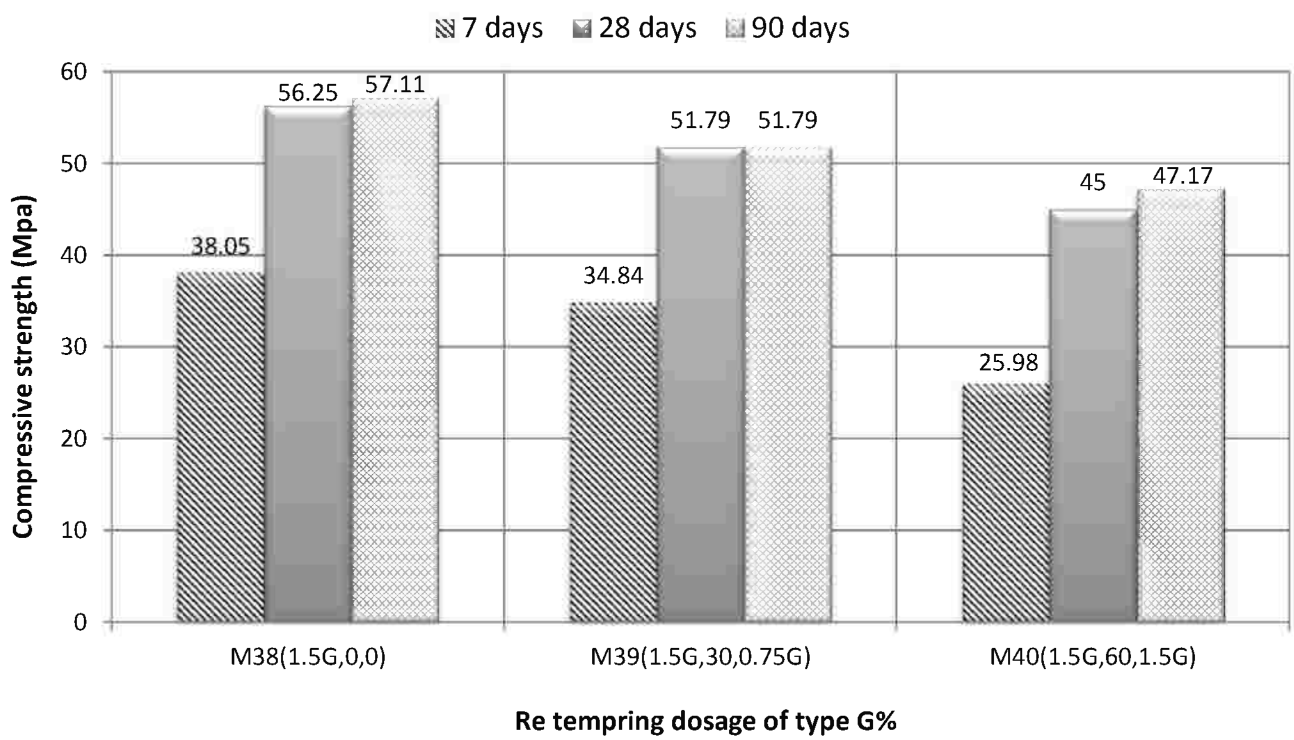

Figure (4-39) Effect of retempering using 0.75% and 1.5% Type Gon 7, 28 and 90 days compressive strength of sulfate resisting cement (source 2) for concrete with 400 kg/m^3 cement content

4.4.11 Effect of type of initial admixture and retempering admixture on cube compressive strength of sulfate resisting cement:

Figures (4-40) and (4-41) show this effect for sulfate resisting cement concrete. Retempering using 1.5 % of Type G destroys one and 3 day cube compressive strength. It considerably decreases 7, 28 and 90 days strength compared with other types.

Retempering using Type F based on naphthalene enhances 3, 7, 28 and 90 days cube compressive strength. Retempering using Type F based on melamine, considerably increases one, 3, 7, 28 and 90 days compressive strength when it is compared with Type G. Mixing and retempering with Type F based on melamine shows the highest one day compressive strength.

4.4.12 Effect of silica fume:

The comparison of compressive strength test results Mix 38 (has no silica fume) and those for Mix 41(has silica fume) shows that the use of silica fume with sulfate resisting concrete using maximum dose of Type G, table (4-3), decreases the initial compressive strength (one, 3, and 7 days). Retempering using 1.5 % Type G decreases the initial compressive strength (Mixes 41 & 42).

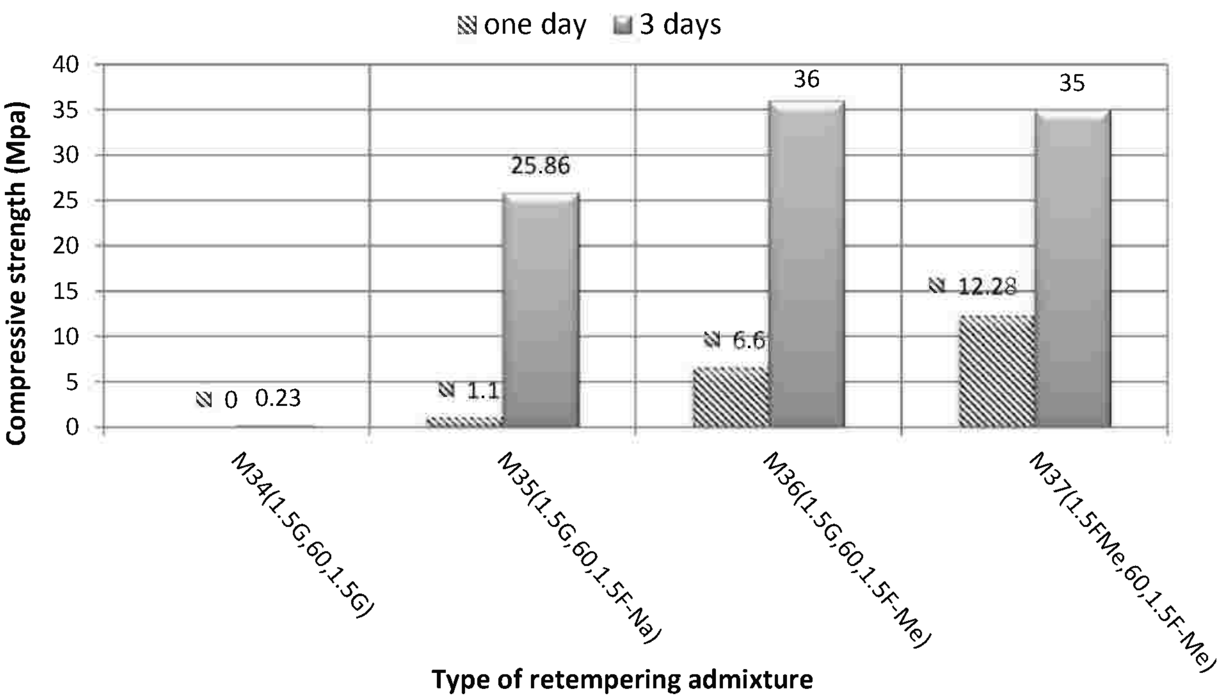

Figure (4-40) Effect of type of initial and retempering admixture on 1 and 3 days compressive strength for concrete with 400 kg/m^3 cement content (S.R.C, source 1)

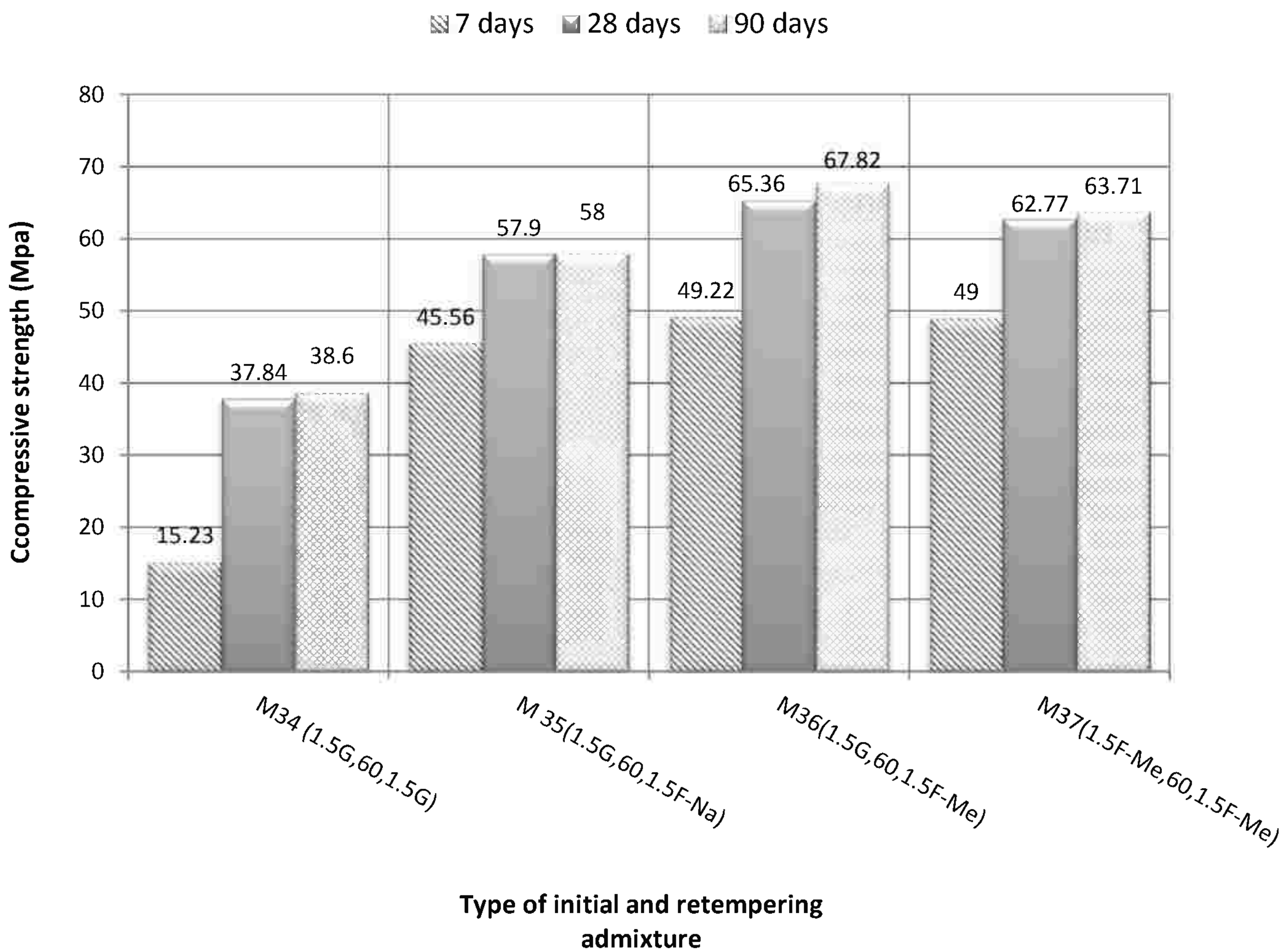

Figure (4-41) Effect of type of initial and retempering admixture on 7, 28 and 90 days compressive strength

4.5 Effect of retempering on 90 day splitting tensile strength

Table (4-4) presents, cylinder compressive strength, splitting tensile strength, and modulus of elasticity at 90 days.

Table (4-4) Cylinder compressive strength, splitting tensile strength and modulus of elasticity at 90 days.

MixNo.	Cylinder compressive strength (N/mm^2)	Splitting tensile strength (N/mm^2)	Modulus of Elasticity (KN/mm^2)
M1	36.40	3.04	28.33
M2	50.06	4.18	30.05
M3	57.10	4.36	27.45
M4	50.60	3.50	28.20
M5	55.00	3.36	30.31
M6	62.26	3.76	28.71
M7	58.41	4.51	33.82
M8	58.30	4.98	32.59
M9	52.24	4.24	31.08
M10	53.26	4.05	26.98
M11	51.00	3.90	29.67
M12	53.00	3.98	32.38
M13	51.68	3.18	31.50
M14	46.40	4.06	35.60
M15	48.00	2.80	33.05
M16	40.19	2.30	26.00
M17	37.47	2.08	27.50
M18	41.60	3.42	31.28
M19	36.45	2.86	31.48
M20	20.30	1.66	21.00
M21	24.06	2.20	21.40
M22	36.11	2.96	28.00
M23	30.58	2.40	26.00
M24	39.22	3.66	29.59
M25	41.28	2.92	28.00

Table (4-4) Cylinder compressive strength, splitting tensile strength and modulus of elasticity at 90 days (continue).

Mix No.	Cylinder compressive strength (N/mm^2)	Splitting tensile strength (N/mm^2)	Modulus of Elasticity (KN/mm^2)
M26	47.37	3.84	34.80
M27	29.78	2.46	27.43
M28	42.50	3.77	38.41
M29	40.86	3.56	34.62
M30	39.11	3.74	36.61
M31	36.50	3.10	32.20
M32	48.05	2.60	32.54
M33	40.91	2.48	27.09
M34	33.56	2.55	24.98
M35	44.77	4.10	32.66
M36	49.47	4.10	37.71
M37	45.50	4.58	40.34
M38	47.32	3.70	36.80
M39	40.19	2.84	32.61
M40	48.00	2.98	28.60
M41	46.13	3.40	32.17
M42	37.13	3.60	31.14

4.5.1 Effect of retempering using Type G and Type F based on naphthalene and melamine

Figure (4-42) shows this effect using concrete with an initial maximum dosage of Type G. Retempering after 30 minutes using 0.75 % of, Type G, and Type F based on melamine enhances splitting tensile strength by 4.3 % and 7.9 respectively. Retempering using Type F based on naphthalene decreases the splitting strength by 19.6 %.

Retempering after 60 minutes using 1.5 % of Type G and naphthalene decreases this strength by 16.3 % and 10 %, respectively. Retempering using 1.5 % melamine enhances this strength by 19.1 %.

Figure (4-43) shows the relation between 90 days splitting tensile strength and type of initial admixture. One can conclude that the type of initial admixture (Type G or Type F or mixing of them) has a slight effect on splitting tensile strength. All concretes with admixtures have higher tensile strength than concrete that of concrete without admixture.

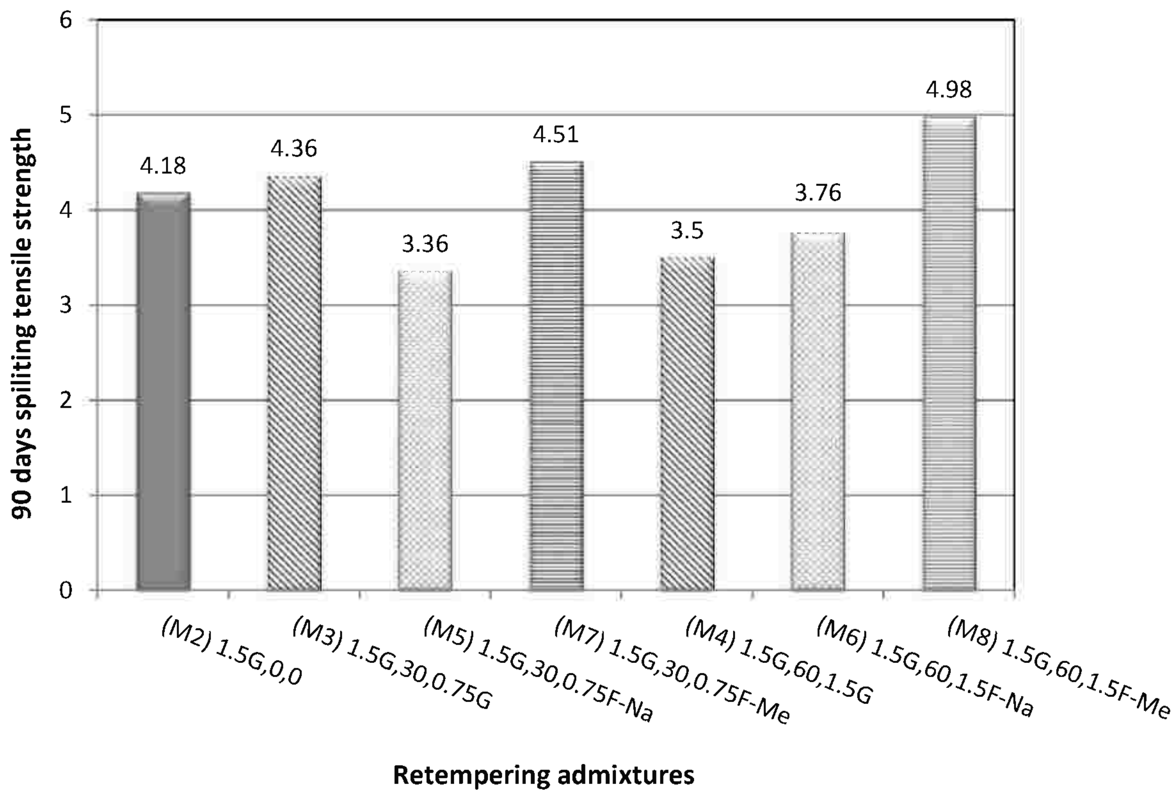

Figure (4-42) Effect of retempering admixtures at different dosages on 90 day splitting tensile strength for concrete containing 1.5 % G initial admixture and 400 kg/m^3 cement content

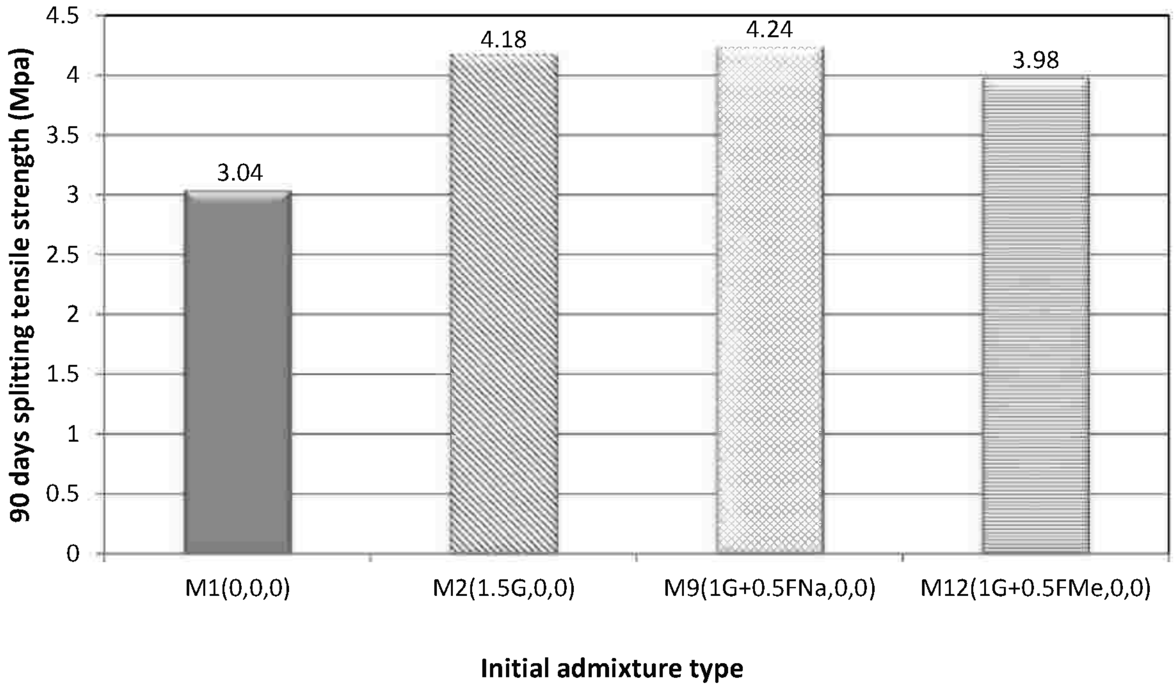

Figure (4-43) Effect of initial admixture Type on 90 days splitting tensile strength for concrete containing 400 kg/m^3 cement content

4.5.2 Effect of using a mix of Type G and Type F and different retempering admixtures:

Figure (4-44) shows the effect of using a mix of Type G and Type F admixture and different retempering admixture at different times on tensile strength.

This Figure (4-44) clarify that, the use of a mix of Type G and Type F based on naphthalene or melamine and the use of 0.75 % of Type F as a retempering admixture after 30 minutes decreases the tensile strength.

At 60 minutes a slight enhancement is recognized due to retempering using Type F instead of retempering using Type G.

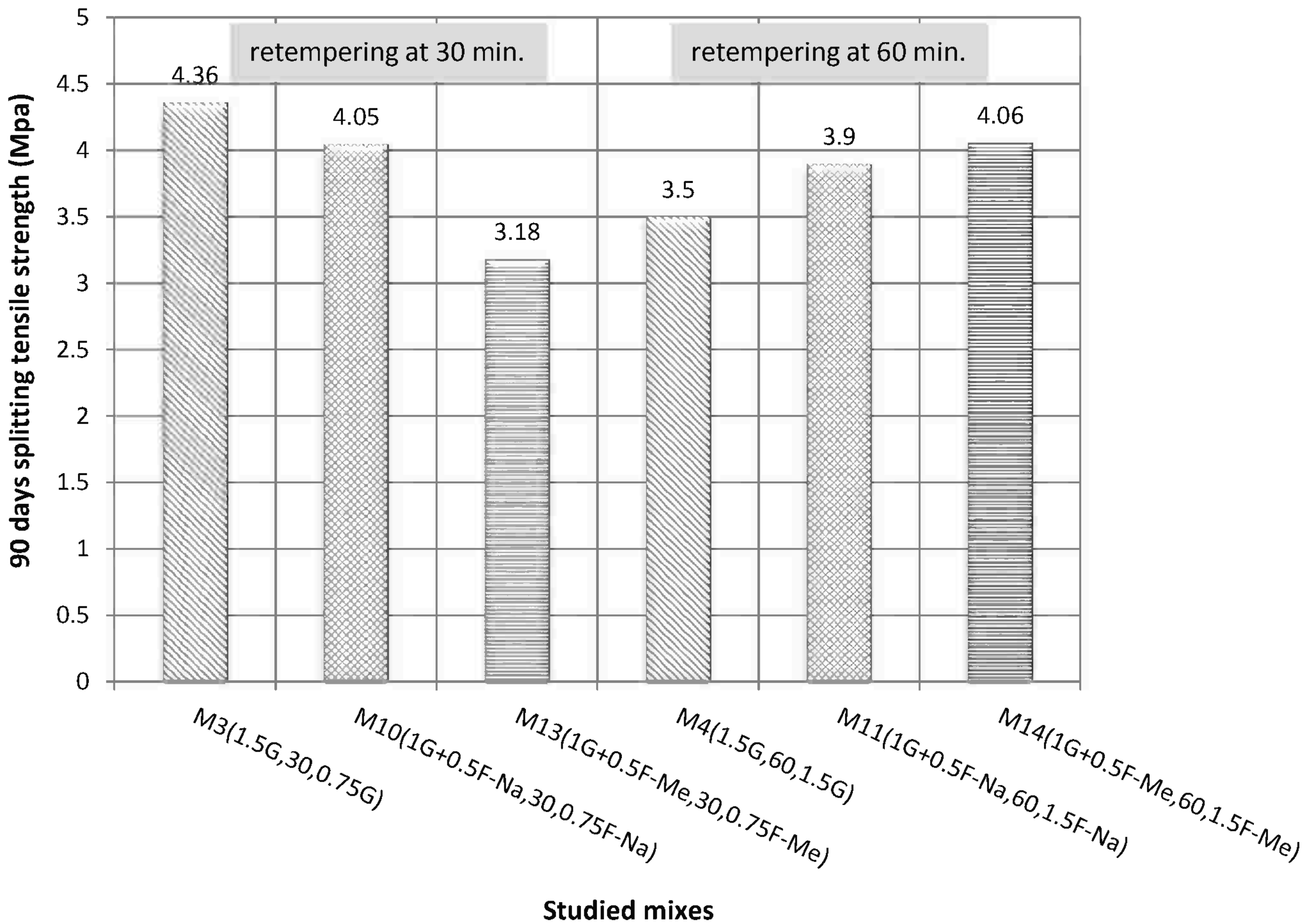

Figure (4-44) Effect of using a mix of Type G and Type F admixture and different retempering admixture at different times on splitting tensile strength

4.5.3 Effect of using Type C, a mix of Type G and C, and a mix of Type G and polycarboxylic admixture:

This effect is shown in Figure (4-45). It shows that the use of a mix of Type G and Type C as retempering admixture descrease significantly splitting tensile strength; it decreases the strength approximately by 50 %. This figure also shows that using 1.5 % of an accelerator decreases the strength by 18.18 %. The use of 0.75 % of Type G and 0.20 % Type G based on polycarboxylic, decreases the strength by 31.6 %.

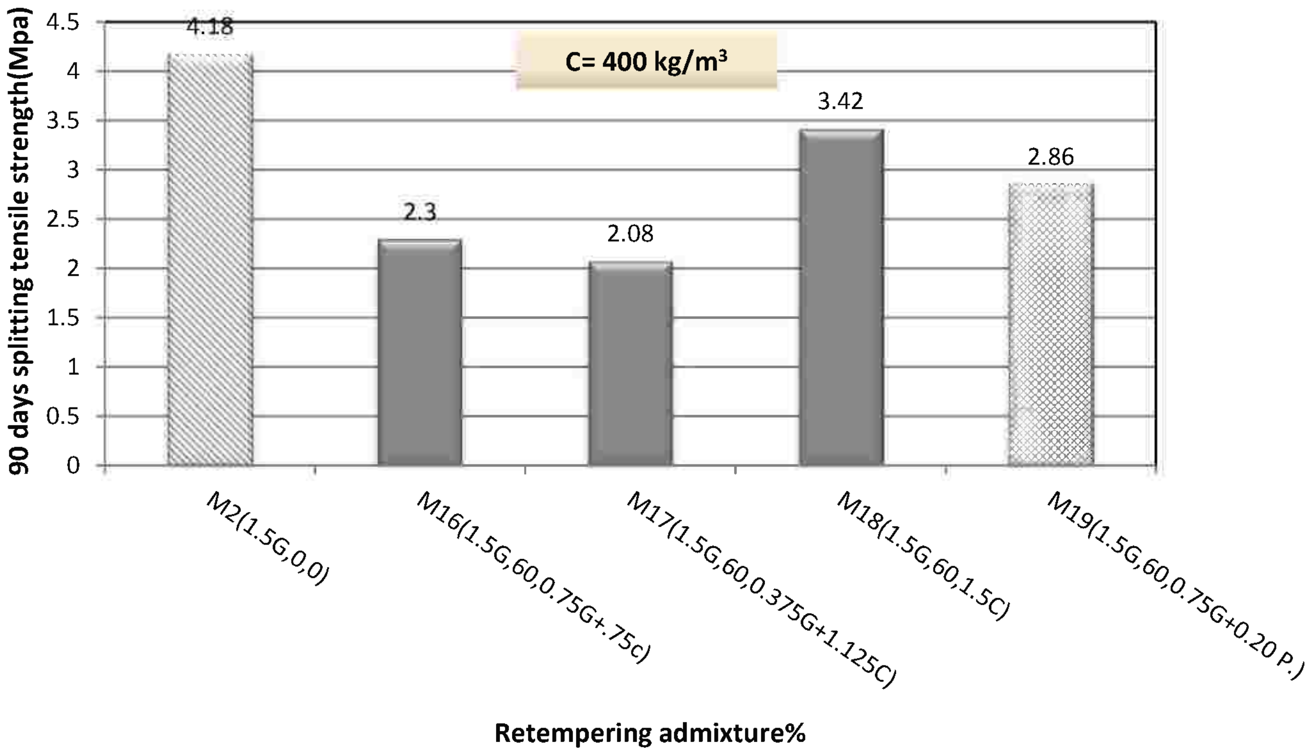

Figure (4-45) Effect of retempering after 60 minutes using rapid hardening admixture and Type G or polycarboxylic on 90 days splitting tensile strength

4.5.4 Effect of cement content on splitting tensile strength:

This effect is shown in Figure (4-45). One can conclude that the increase of cement content generally increases the splitting tensile strength for concrete without retempering (just after mixing). For concrete re-tempered after 60 minutes of mixing, it is easy to recognize that for all cement contents except cement content of 250 kg/m3, retempering using 1.5 % of Type G decreases tensile strength.

For cement content of 300, 350 and 400 kg/m^3, this decrease is 18.91, 20.2, and 16.3 % respectively. For poor concrete (C= 250 kg/m^3) an enhancement of 32.5 % is achieved. For high cementitious material, (Cement of 460 kg and silica fume of 40 kg), a considerable decrease of 36 % is observed. This negative effect may tends to the high content of Type G (20 kg/m^3) in the presence of silica fume.

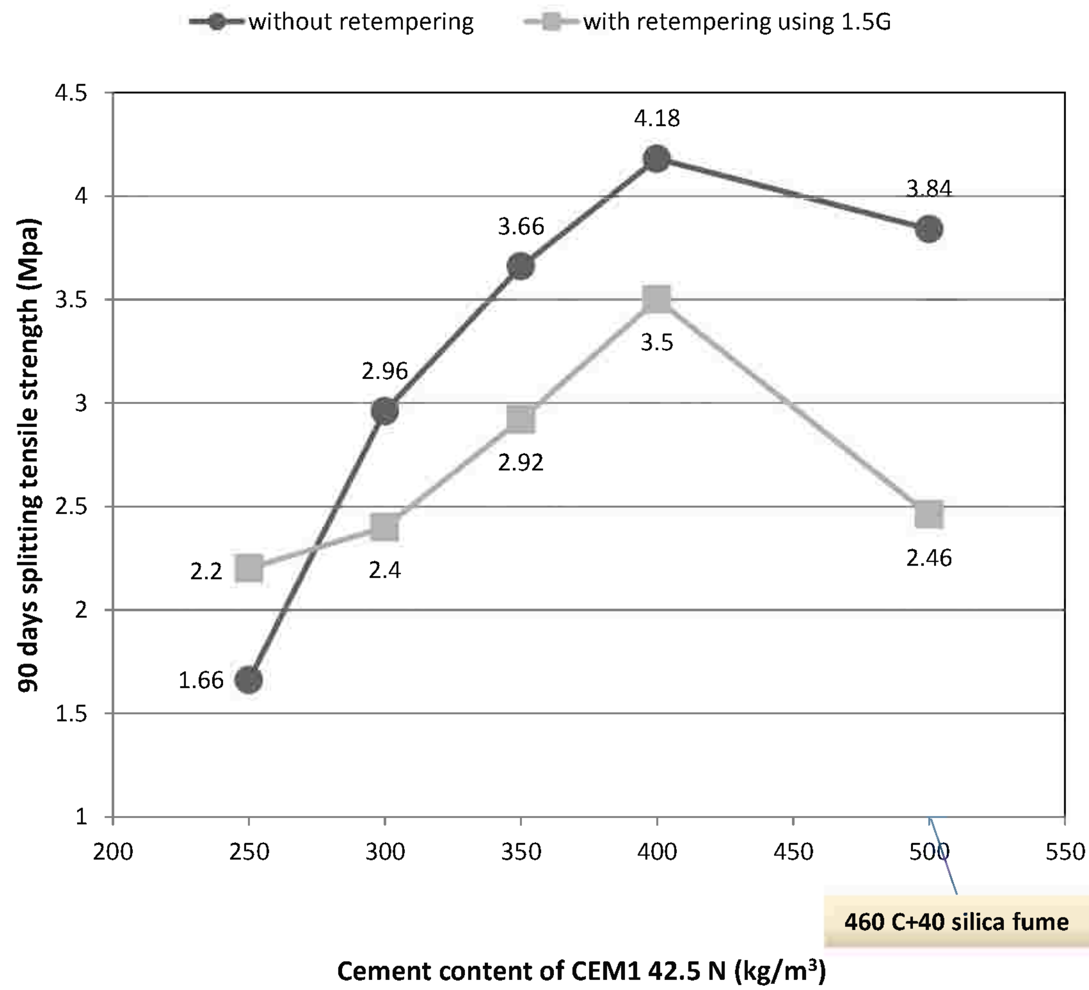

Figure (4-46) Effect of cement content of CEM I 42.5 N for concrete with and without retempering (retempering using 1.5% G after 60 minutes).

4.5.5 Effect of source and grade of ordinary Portland cement on splitting tensile strength:

This effect is presented in Figure (4-46). It shows that, for all sources of ordinary Portland cement, retempering using 1.5 % G reduces tensile strength. CEM I 32.5 N shows the lowest spilliting tensile strength. Retempering for source (1), source (2) and source (3) decreases tensile strength by 16.3, 5.57, and 17.1 % respectively. One must not use Type G as retempering admixture for CEM I 32.5 N concrete having the maximum dosage of Type G.

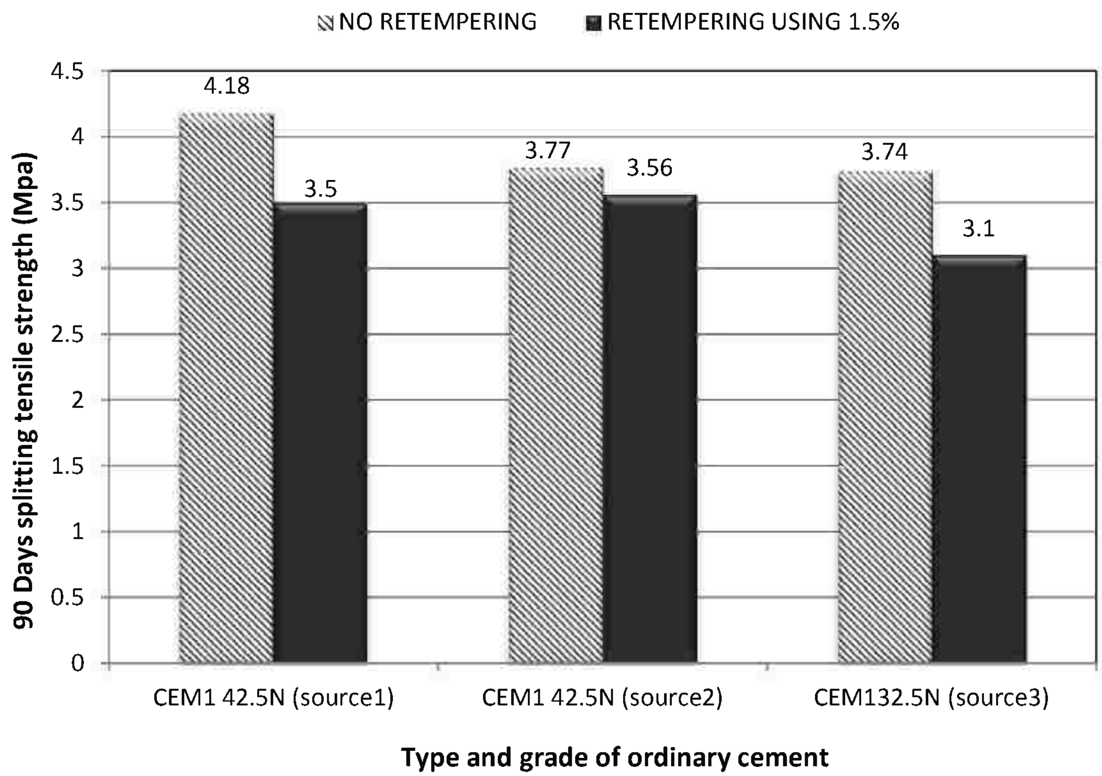

Figure (4-47) Effect of grade and source of ordinary cement and retempering using 1.5 % Type G at 60 minutes on splitting tensile strength for concrete with 400 kg/m^3 cement content.

4.5.6 Effect of retempering on tensile strength of different sulfate resisting cement:

This effect is presented in Figure (4-48). It shows that, retempering using 0.75 % and 1.5 % of Type G admixture for source (1) of S.R.C decreases tensile strength by 4.6, and 1.96 %. This reduction is 23.24 and 19.46 % for source (2) of sulfate resisting cement. Source (1) has C_3A of 1.463 and source (2) has C_3A of 1.22.

Table (4-4) shows that retempering using of 1.5 Type F based on melamine (Mix 36) ensures tensile strength of 4.1 N/mm^2, a considerable enhancement is achieved compared with retempering using 1.5 Type G (Mix 34) (has a tensile strength of 2.55 N/mm^2).

Figure (4-49) shows the effect of type of initial admixture and type of retempering admixture on 90 days splitting tensile strength of source (1). One can conclude that retempering using Type F either based on naphthalene or melamine considerably enhances tensile strength by 60.8 and 60.8 % respectively compared with retempering using Type G. This figure also shows that using Type F as an initial and retempering admixtures yields the highest tensile strength value.

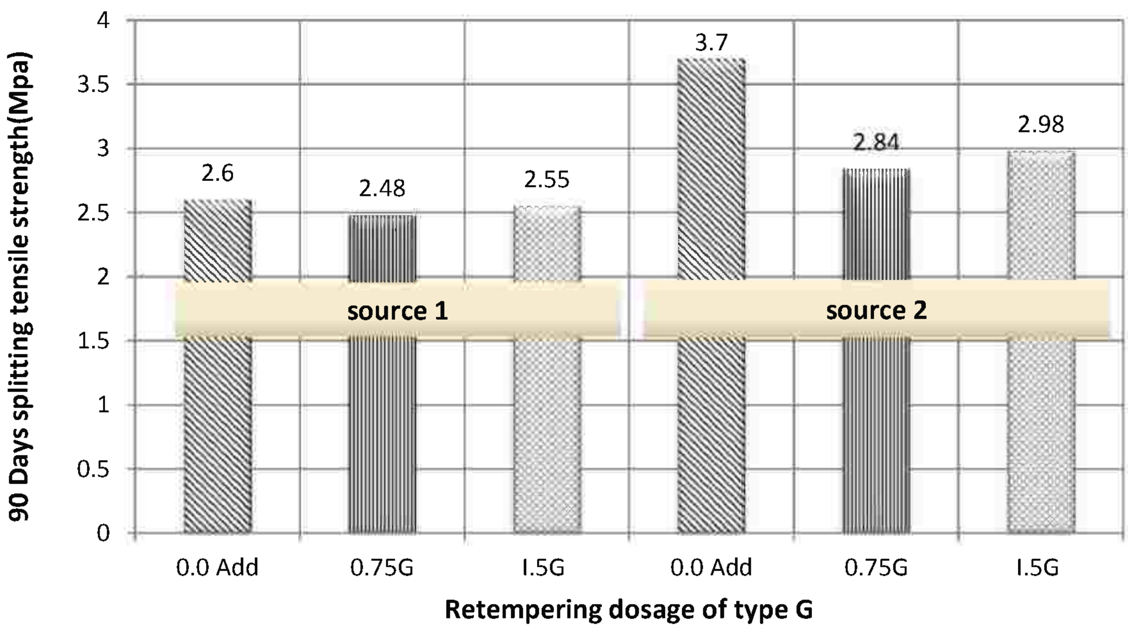

Figure (4-48) Effect of retempering after 30 and 60 minutes using different dosages of Type G and different sources of sulfate resisting cement on tensile strength for concrete with 400 kg/m^3 cement content.

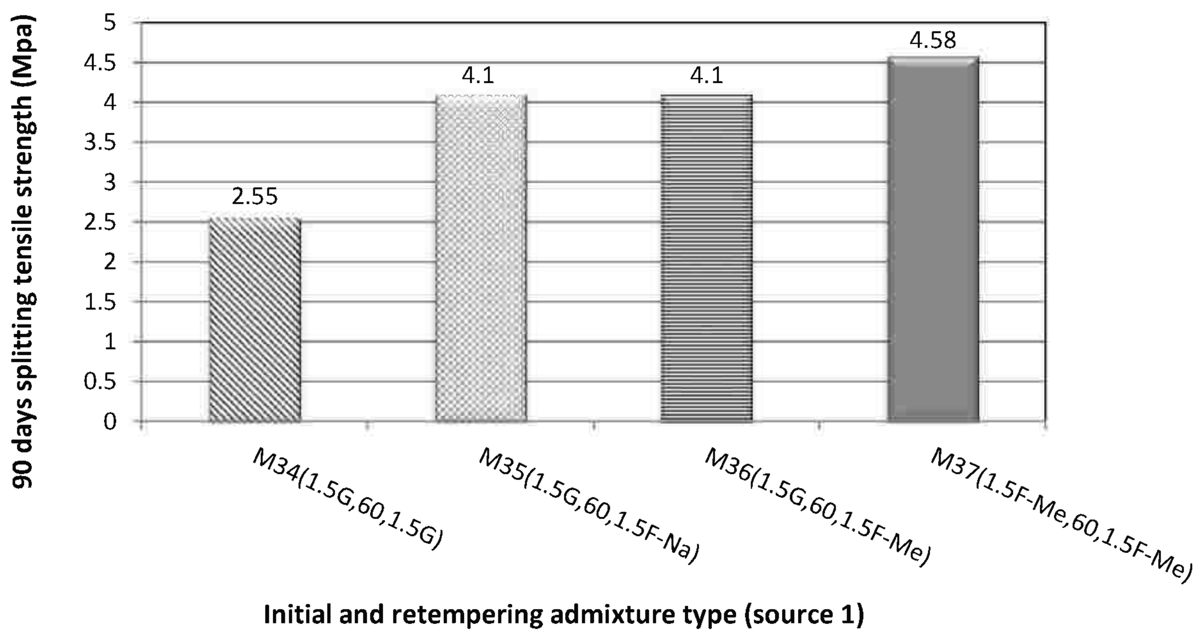

Figure (4-49) Effect of initial and retempering admixture type on splitting tensile strength of sulfate resisting cement for concrete with 400 kg/m^3 cement content.

4.6 Effect of retempering on 90 days modulus of elasticity:

4.6.1Effect of different types of admixtures:

Figure (4-50) shows the effect of retempering admixture at different dosages and times. Retempering using 0.75%, and 1.5% Type G at 30 and 60 minutes decreases modulus of elasticity by 8.7 and 6.2% respectively compared with that of control mix without retempering. Retempering using Type F (Naphthalene) at 30 minutes doesn't affect modulus of elasticity while retempering at 60 minutes decreases it by 4.50 %. Retempering using Type F (Melamine) at 30 and 60 minutes enhances the modulus by 12.5, and 8.2 % respectively.

Figure (4-51) shows the effect of Type and dosage of initial admixture on 90 days modules of elasticity. It's easy to recognize that the use of any type of admixture ensures higher modulus of elasticity than that of concrete without admixture. This is expected due to the highest w/c ratio for concrete without admixtures. It's clear that concrete without admixture has the lowest modulus than others. The use of 1.0 % Type G and 0.5 % Type F (Melamine) has the highest modulus of elasticity.

Figure (4-52) shows the effect of initial admixture Type and dosage, and retempering admixture Type At different time on 90 days modulus of elasticity. One can conclude that the use of a mix of Type G and Type F (Melamine) as an initial admixture, and Type F (Melamine) as a retempering admixture after 30 and 60 minutes enhances modulus of elasticity compared with that of Mixes M3 and M4. Also the use of a mix of Type G and Type F (Naphthalene) and Type F (Naphthalene) as a retempering admixture, doesn't affect modulus of elasticity.

Figure (4-53) shows the effect of using a mix of Type G and Type C as a retempering admixture after 60 minutes on 90 days modulus of elasticity. This figure shows that the use of a mix of Type G and Type C as a retempering admixture after 60 minutes decreases the modulus of elasticity. Retempering using 1.5 % of Type C or 0.75 % of Type G and 0.20 % polycarboxylic slightly enhances modulus of elasticity.

Figure (4-54) shows the effect of retempering using an over dosage of Type G on 90 days modulus of elasticity for concrete with different cementitious material contents. For concrete without retempering, the increase of cement content considerably increases the modulus of elasticity. It is easy to recognize that, for all cement contents except 250 kg/m^3, retempering using 1.5 % of Type G decreases modulus of elasticity. For cement content of 300, 350 and 400 kg/m^3 this decrease is 7.14, 5.4, and 6.2 % respectively. For poor concrete (C= 250 kg/m^3) a slight enhancement is observed. For high cementitious material content (460 kg of cement, and 40 kg of silica fume) a considerable decrease of 21.1 % is observed.

4.6.2 Effect of source and grade of ordinary Portland cement on modulus of elasticity:

This effect is shown in Figure (4-55). This figure shows that for all cement sources and grade of ordinary Portland cement, retempering using 1.5 % Type G reduces modulus of elasticity of source (1), source (2), and source (3) by 6.16, 9.9, and 12.0 % respectively. CEM I 32.5 N shows the most reduction and this may be due to the low surface area of the cement.

4.6.3 Effect of retempering on modulus of elasticity of different sulfate resisting cement

Figure (4-56) shows the effect of cement sources and, retempering using Type G on 90 days modulus of elasticity. This figure shows that, for source (1) S.R.C, retempering using 0.75 and 1.50 % of Type G admixture decreases modulus of elasticity by 16.7, and 23.2% respectively, this reduction is 11.4, and 22.3% for second source of sulfate resisting cement.

4.6.4 Effect of retempering using Type F with sulfate resisting cement

Figure (4-57) shows the effect of type of initial admixture on 90 days modulus of elasticity. Retempering using 1.5 % Type F based on melamine (Mix 36) yields modulus of elasticity of 37.71 KN/mm^2, see table (4-4). A considerable enhancement is achieved, compared with retempering using 1.5 % Type G (Mix 34) that has modulus of elasticity of 24.98 KN/mm^2. Using 1.5 % of Type F based on melamine as an initial admixture and retempering admixture (Mix 37) at 60 minutes, has a modulus of elasticity of 40.34 KN/mm^2.

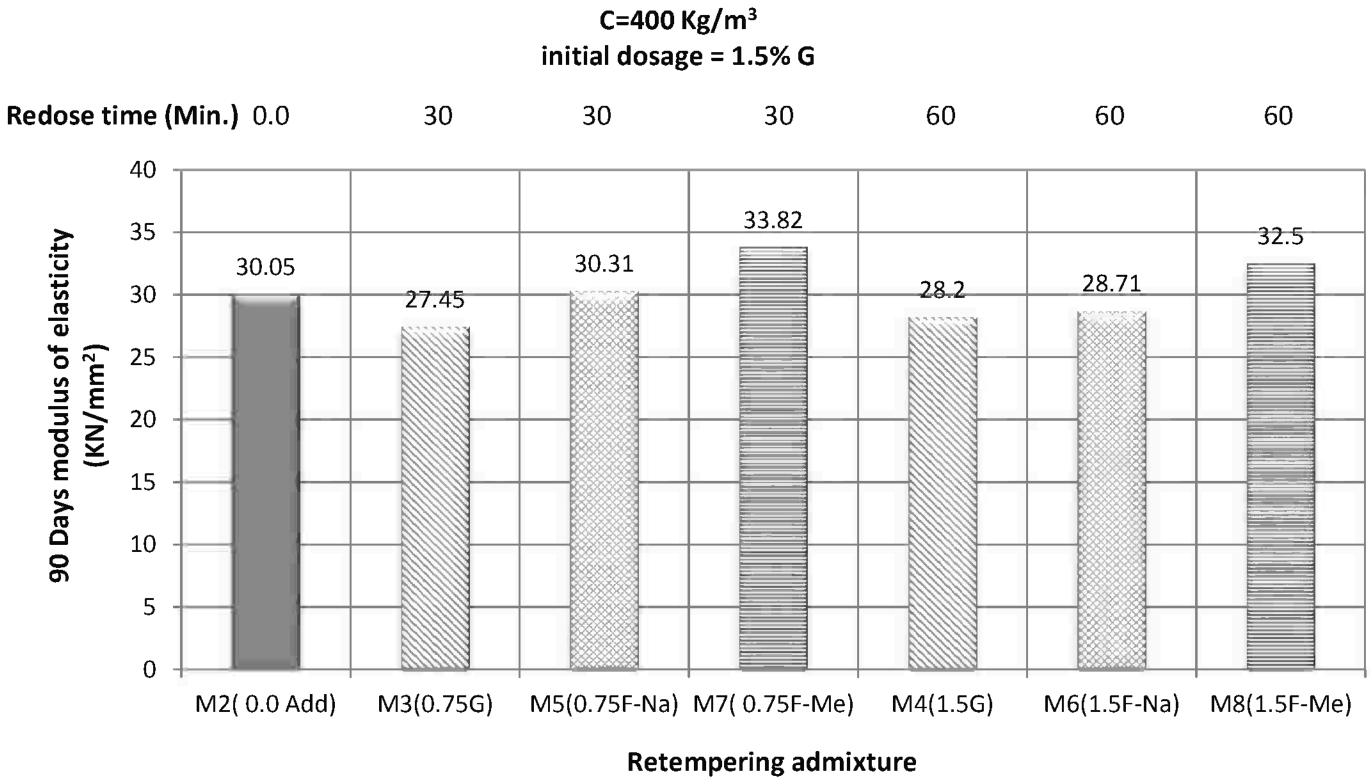

Figure (4-50) Effect of retempering admixture at different dosages and times on 90 days modulus of elasticity

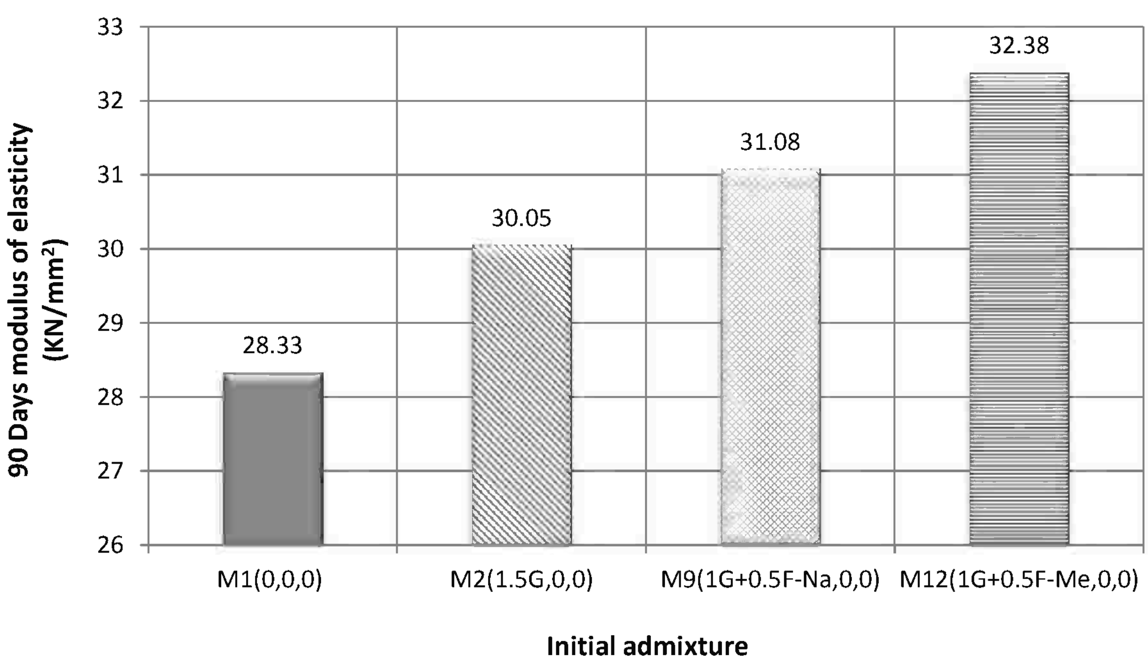

Figure (4-51) Effect of initial dosage of admixture on 90 days modulus of elasticity for concrete with 400 kg/m^3 cement content.

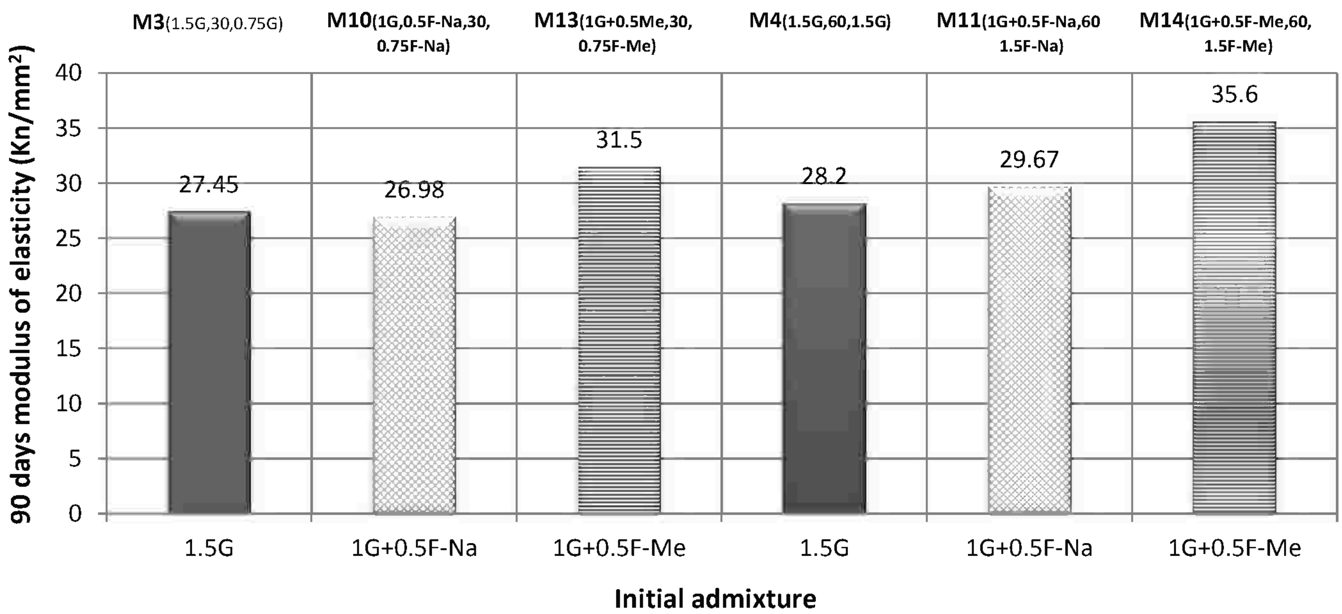

Figure (4-52) Effect of a mix of initial admixtures and retempering type on 90 days modulus of elasticity for concrete with 400 kg/m^3 cement content.

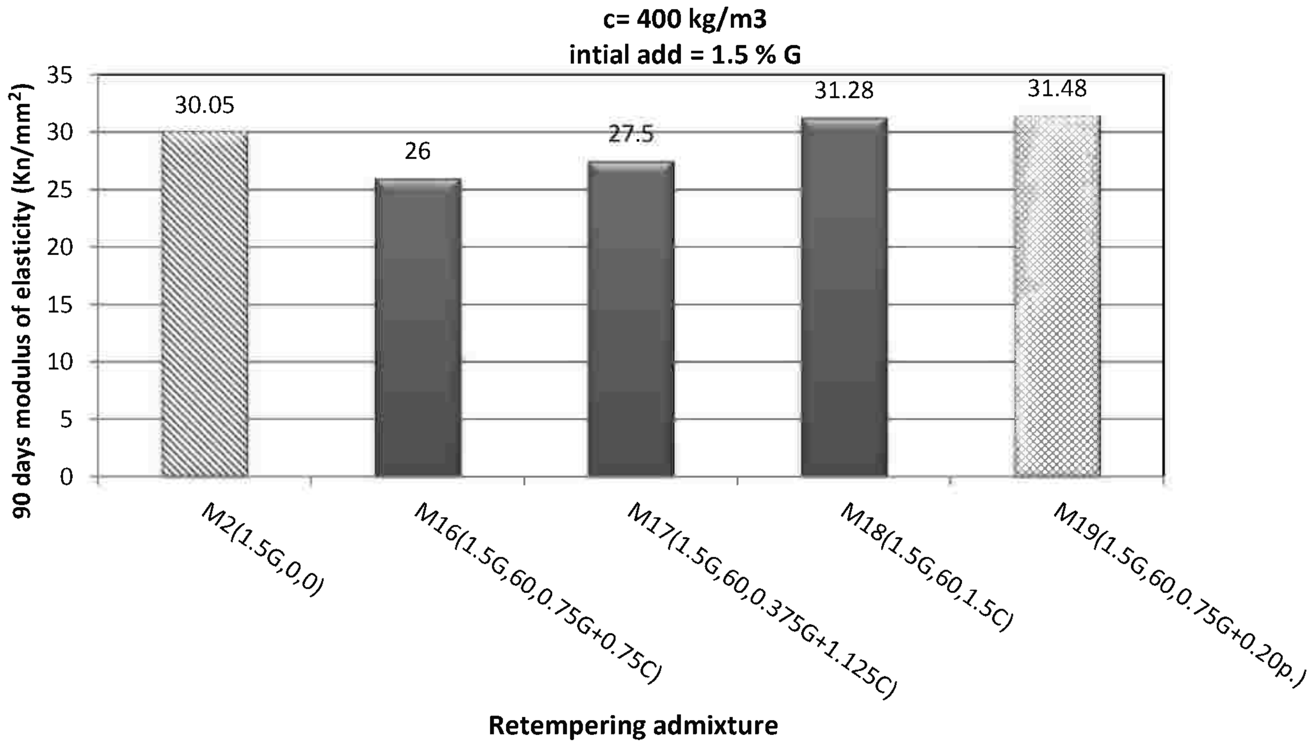

Figure (4-53) Effect of use a mix of Type G and Type C as a retempering admixture after 60 minutes on 90 days modulus of elasticity

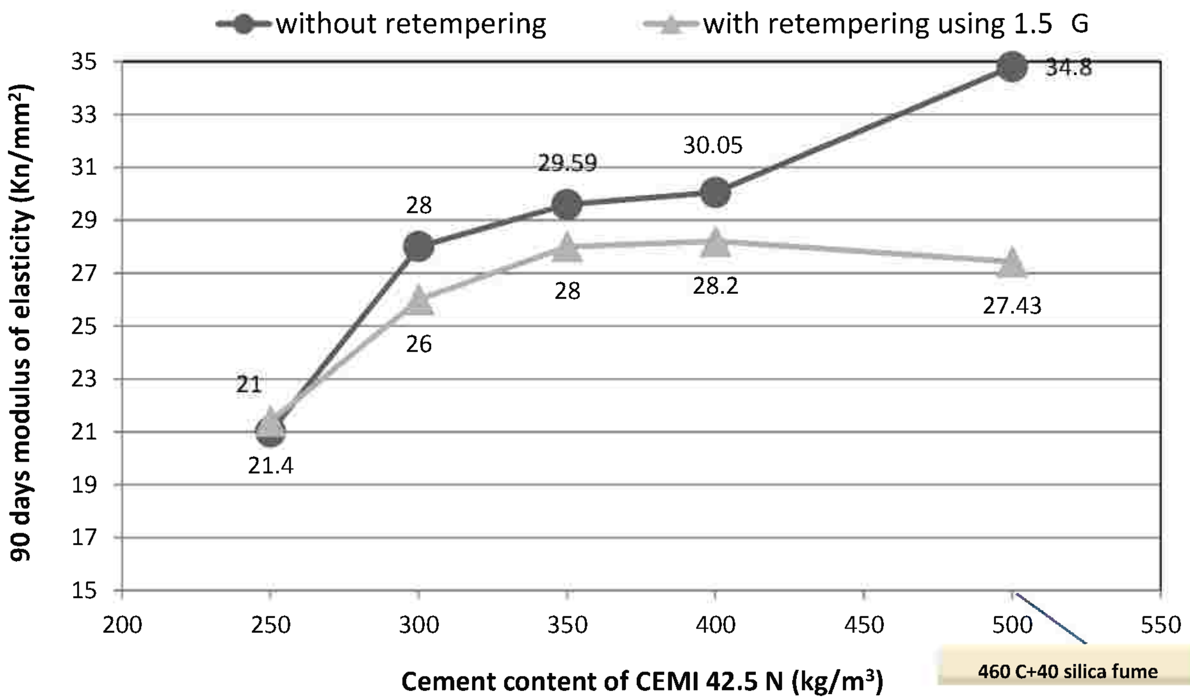

Figure (4-54) Effect of retempering using an over dosage of Type G on 90 days modulus of elasticity for concrete with different cementitious material contents.

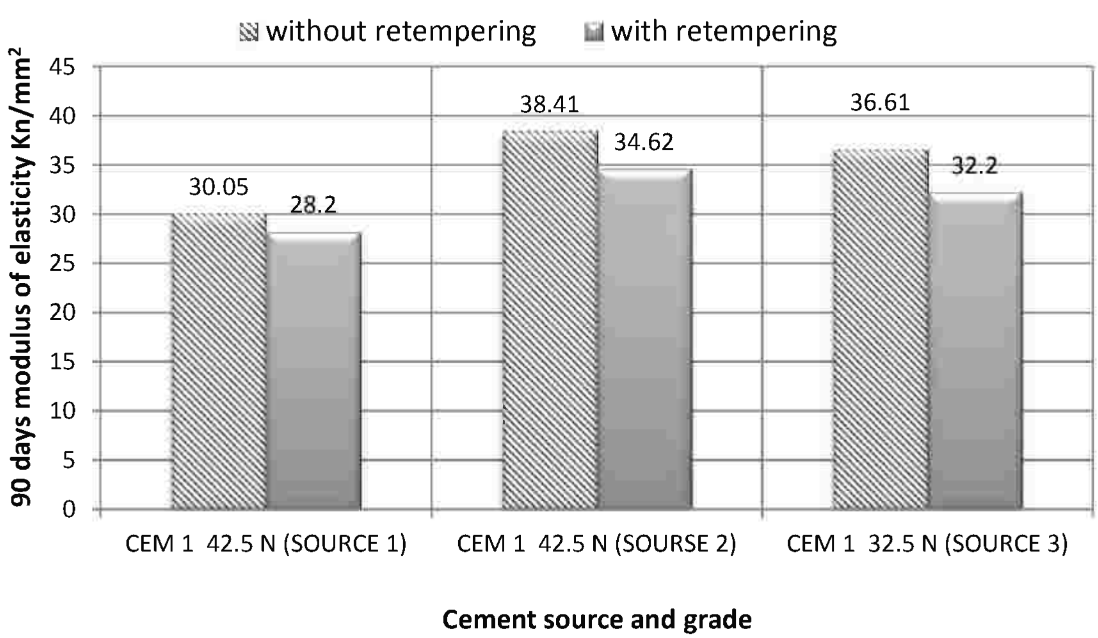

Figure (4-55) effect of cement sources and grade of ordinary Portland cement, retempering using 1.5 % Type G, on 90 days modulus of elasticity for concrete with cement content of 400 kg/m^3.

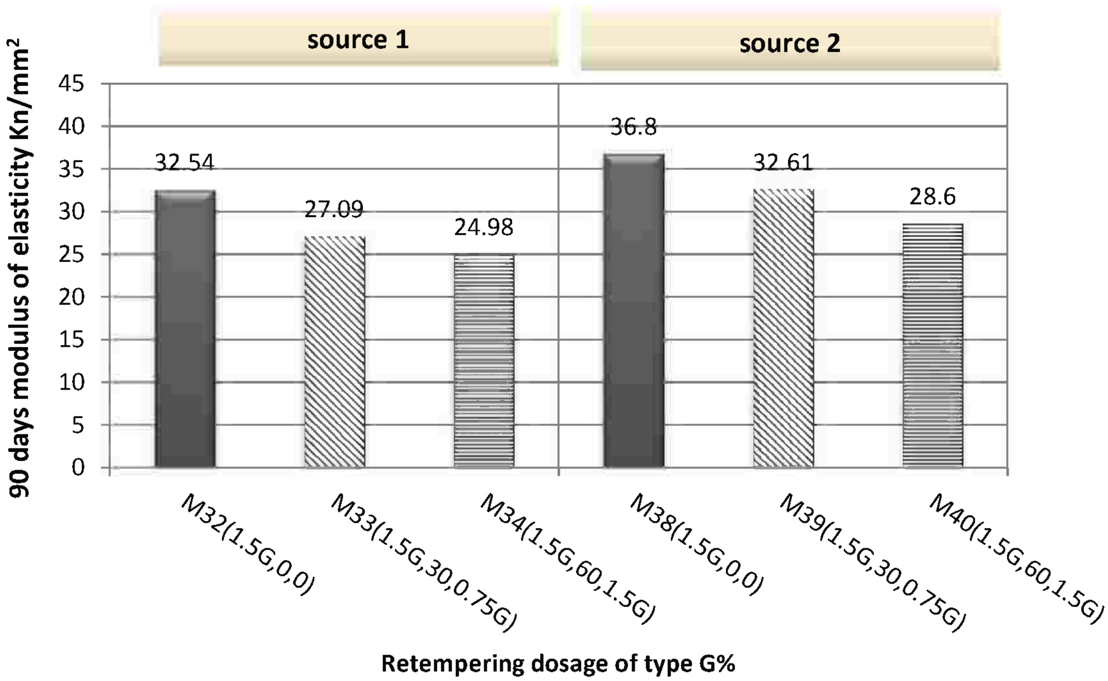

Figure (4-56) Effect of retempering after 60 min. using different dosages of Type G and different sources of sulfate resisting cement on 90 days modulus of elasticity for concrete with 400 kg/m^3 cement content.

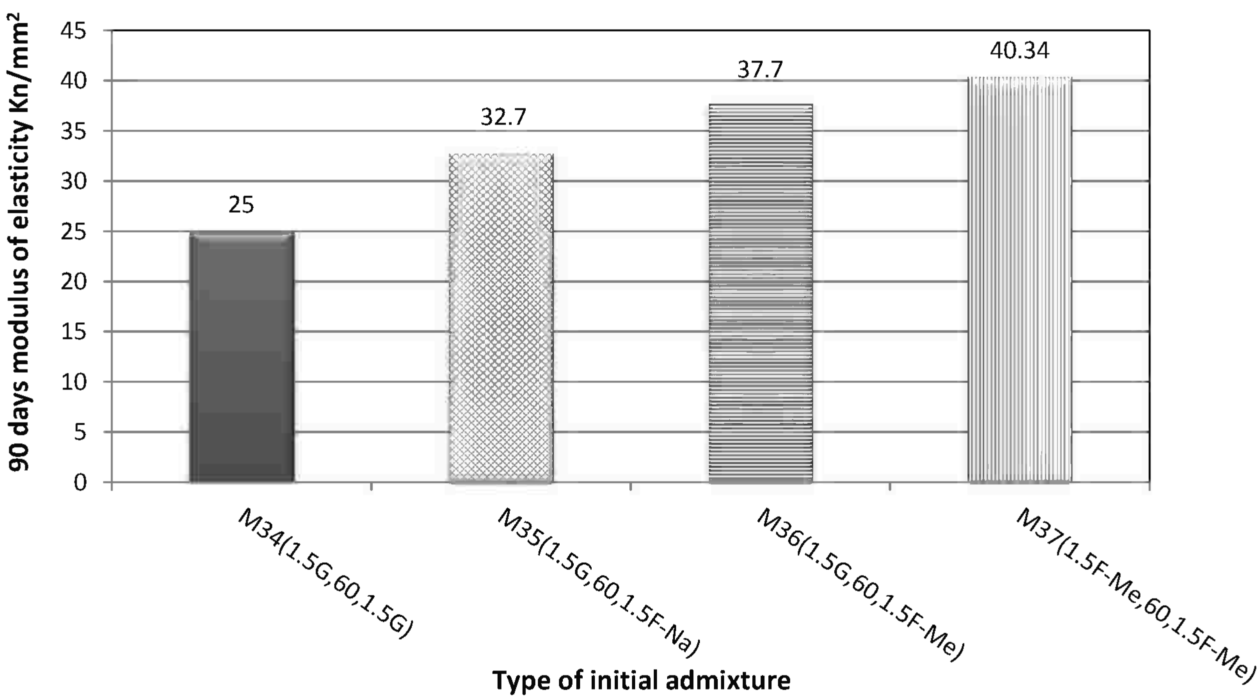

Figure (4-57) Effect of type of initial admixture on 90 days modulus of elasticity of sulfate resisting cement concrete for cement content of 400 kg/m^3.

4.7 Effect of retempering on 90 days percentage of water absorption after immersion:

Table (4-5) contains durability indices that include absorption, bulk specific gravity and voids.

4.7.1 Effect of retempering on ordinary Portland cement concrete

Figure (4-58) shows the effect of retempering admixture at different dosages and time on 90 days percentage of water absorption. Retempering after 30.0 minutes using 0.75% of Type G, Type F-Na and Type F-Me increases natural absorption by 3.0, 6.3 and 4.78 % respectively compared with that of concrete with initial admixture of 1.5 % Type G. Retempering after 60.0 minutes using 1.5% Type G, and Type F-Na decreases absorption by 6.1 and 10.5 % respectively. Retempering using 1.5% of Type F, based on melamine increases absorption by 10.4 %.

Figure (4-59) shows the effect of initial admixture type on absorption. From this figure one can conclude that concrete without admixture has the highest 90 days percentage of absorption due to the increase of w/c. The use of Type G shows the lowest percentage of absorption. The use of a mix of Type G and Type F slightly increases absorption compared with the use of Type G only.

Figure (4-60) shows the effect of using a mix of Type G and Type F admixture and different retempering admixture at different times on percentage of water absorption. It's clear that the use of a mix of Type G and Type F as an initial admixture and Type F as a retempering admixture increases percentage of water absorption compared with the use of Type G.

Figure (4-61) shows the effect of retempering after 60 minutes using rapid hardening admixture and Type G or polycarboxylic on 90 days percentage of water absorption. One can conclude that the use of a mix of the Type G and Type C as a retempering admixture after 60 minutes generally increases the percentage of absorption compared with that of control mix. The use of 0.75 % Type G and 0.20 % polycarboxylic increases absorption by 13.0 %. Retempering using 1.5 % Type C increases absorption by 22.5 %, this may tend to the non-homogeneity of the cement gel.

Figure (4-62) shows the effect of cement content of CEM I 42.5 N on percentage of water absorption. This figure shows that the increase of cement content generally decreases percentage of absorption. Retempering using 1.5 % Type G decreases absorption. The use of 2 % of Type G with silica fume concrete highly increases percentage of absorption.

Figure (4-63) shows the effect of Type and grade of ordinary Portland cement and retempering using 1.5 % Type G at 60 minutes on absorption. It shows that retempering using 1.5 % Type G with CEM I 42.5 N of the two sources concrete decreases absorption. This may tends to the presence of polymers in modified ligno sulfonates that fill the pores. It slightly increases absorption for CEM I 32.5 N compared with that of concrete without retempering due to the retardation effect.

Table (4-5) Durability indices.

Mix NO.	Water Absorption%	Bulk specific gravity	Voids%
M1	8.20	2.10	19.5
M2	6.49	2.16	15.0
M3	6.69	2.16	13.9
M4	6.04	2.18	13.9
M5	6.90	2.18	16.2
M6	5.81	2.24	13.6
M7	6.80	2.20	15.8
M8	7.17	2.19	17.0
M9	6.80	2.17	16.0
M10	6.81	2.19	16.8
M11	6.89	2.20	16.2
M12	7.04	2.16	16.2
M13	7.39	2.15	16.5
M14	6.98	2.18	16.4
M15	7.75	2.21	18.1
M16	6.02	2.24	15.4
M17	8.10	2.08	19.6

Table (4-5) Durability indices (continue).

Mix NO.	Water Absorption%	Bulk specific gravity	Voids%
M18	7.95	2.11	19.0
M19	7.34	2.12	16.7
M20	8.29	2.10	19.7
M21	8.10	2.11	18.3
M22	8.09	2.14	18.4
M23	7.16	2.16	15.9
M24	8.10	2.13	18.3
M25	7.60	2.15	17.2
M26	7.31	2.15	17.1
M27	9.41	2.10	21.2
M28	6.35	2.23	14.9
M29	6.05	——	13.85
M30	6.39	2.20	15.5
M31	6.46	2.18	16.0
M32	6.26	2.23	14.8
M33	6.52	2.19	15.2
M34	6.03	2.25	14.5
M35	5.74	2.27	13.6
M36	5.20	2.29	12.9
M37	4.77	2.31	12.3
M38	5.58	2.25	13.8
M39	6.60	2.20	15.3
M40	5.73	2.24	14.8
M41	7.48	2.19	17.9
M42	7.23	2.18	17.3

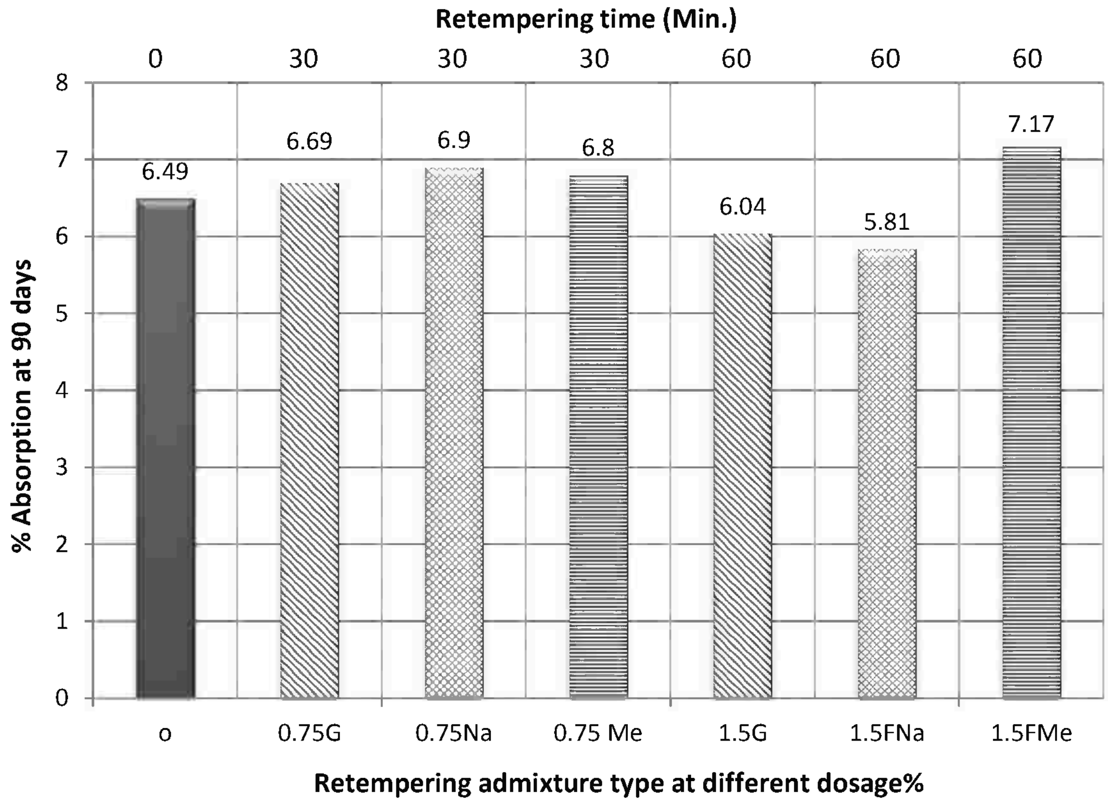

Figure (4-58) Effect of retempering admixture Type at different retempering time and dosage for concrete with 1.5 % G initial admixture and 400 kg/m^3 cement content on 90 days absorption percent (concrete has 1.5 G).

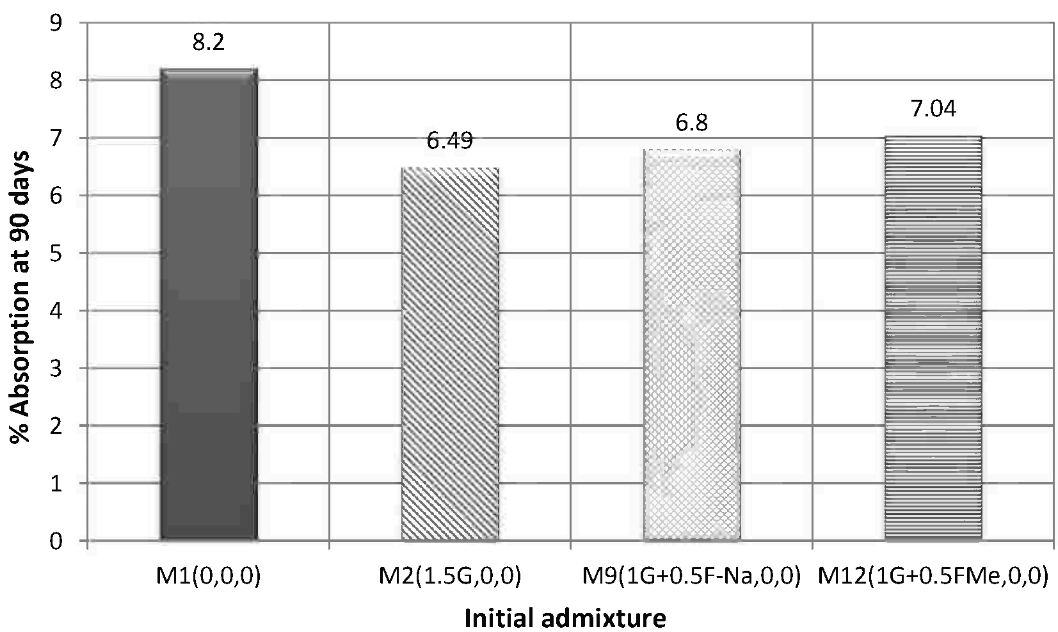

Figure (4-59) Effect of initial admixture type on 90 days on absorption percent for concrete with 400 kg/m^3 cement content

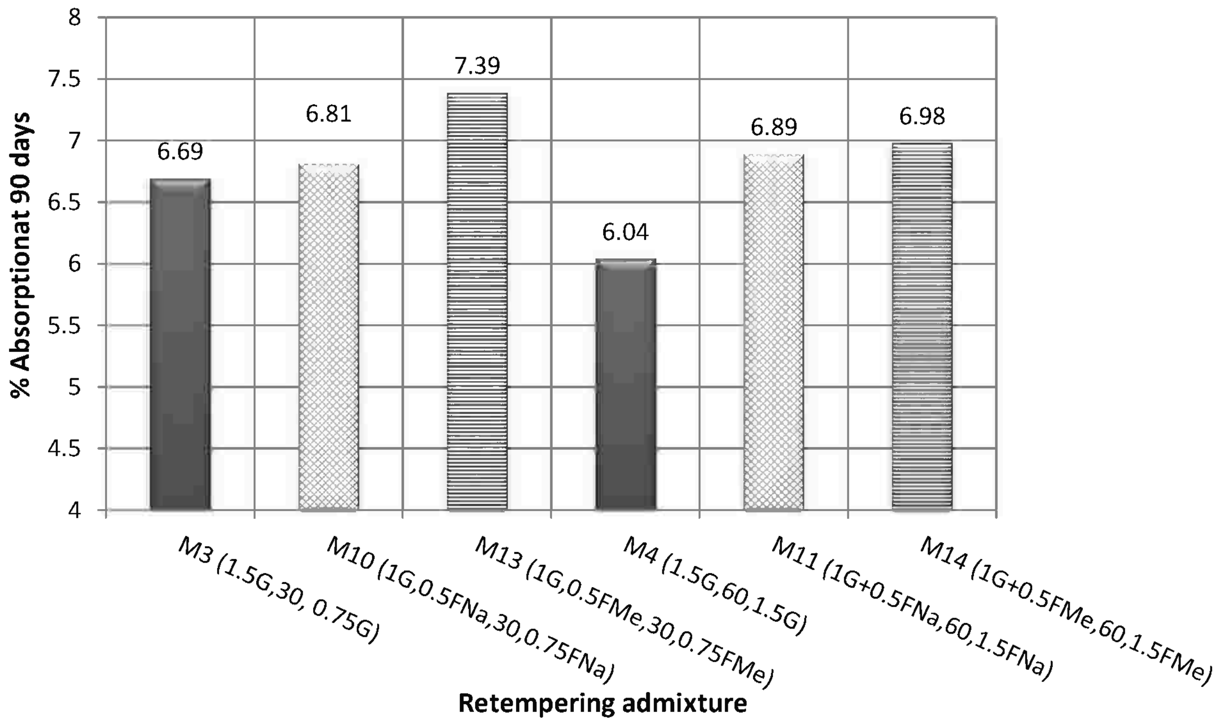

Figure (4-60) Effect of using a mix of Type G and Type F admixture and different retempering admixture at different times on percentage of absorption for concrete with 400 kg/m^3 cement content

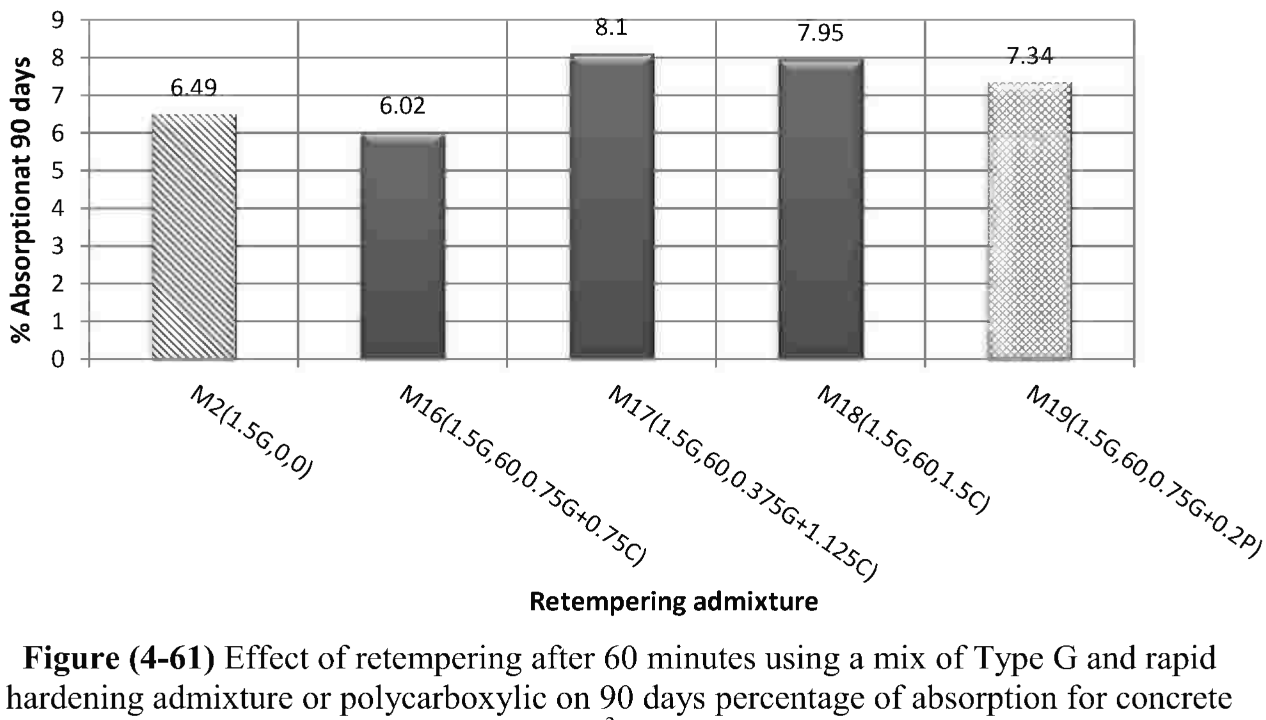

Figure (4-61) Effect of retempering after 60 minutes using a mix of Type G and rapid hardening admixture or polycarboxylic on 90 days percentage of absorption for concrete with 400 kg/m^3 cement content

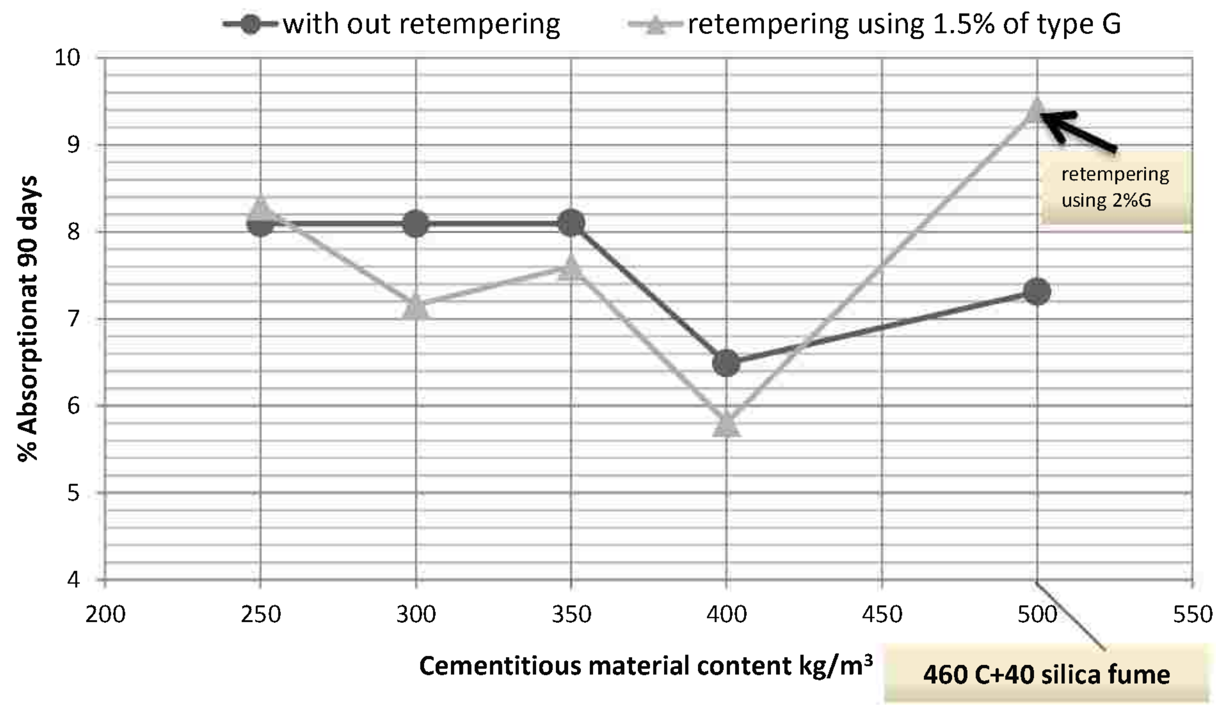

Figure (4-62) Effect of cement content of CEM I 42.5 N on percentage of water absorption

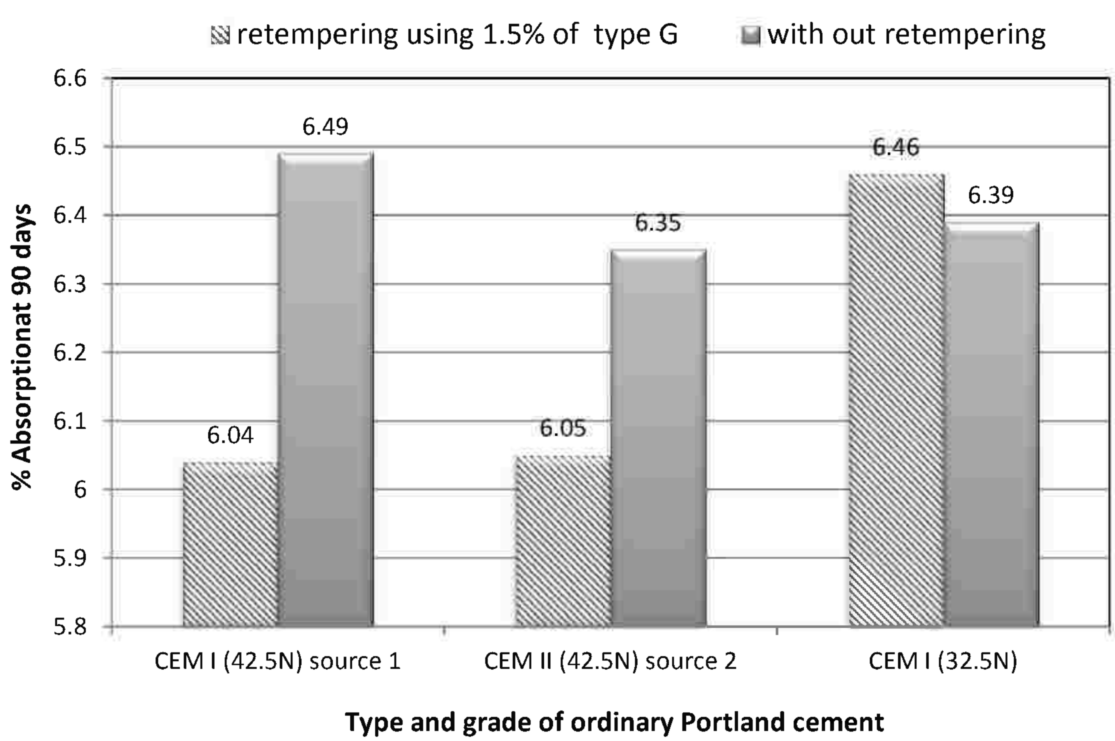

Figure (4-63) Effect of source and grade of ordinary Portland cement and retempering using 1.5 % Type G at 60 minutes on 90 days percentage of water absorption for concrete with 400 kg/m^3 cement content

4.7.2 Effect of retempering on 90 days percentage of water absorption of different sulfate resisting cement:

Figure (4-64) and Figure (4-65) show the effect of retempering admixture on absorption of sulfate resisting cement of the two sources. These figures show the same behavior for the two sources of cement. Retempering using 0.75 % Type G increases absorption while retempering using 1.5 % Type G slightly affects absorption. This may tend to the long mixing time (60 minutes compared with 30 minutes).

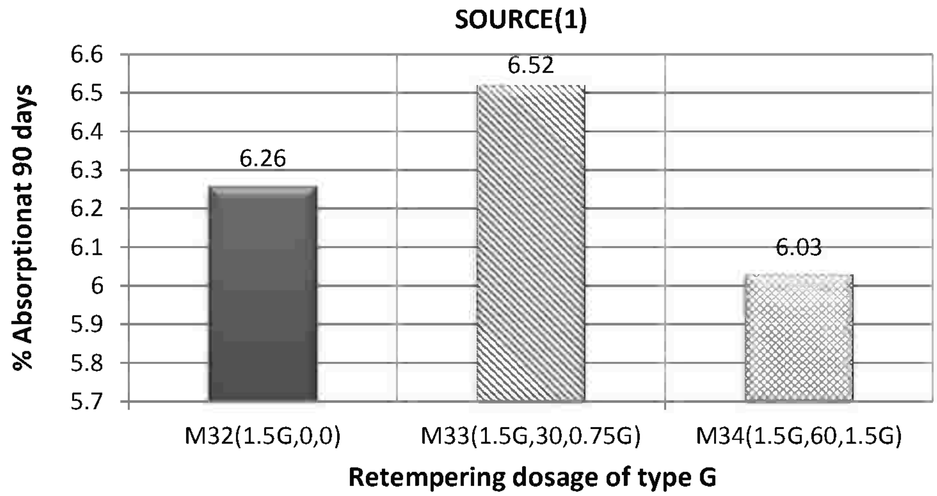

Figure (4-64) Effect of retempering using different dosage of Type G on 90 days percentage of absorption of sulfate resisting cement concrete with 400 kg/m^3 cement content

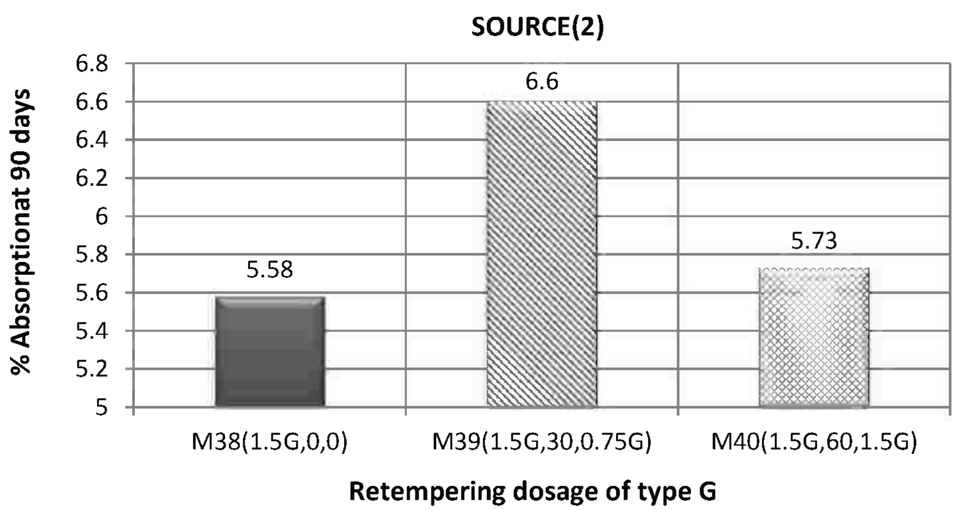

Figure (4-65) Effect of retempering using different dosage of Type G on 90 days percentage of absorption of sulfate resisting cement concrete with 400 kg/m3 cement content

4.8 Effect of retempering on volume of permeable pore space (% voids)

4.8.1 Effect of retempering on ordinary Portland cement concrete on voids.

Figure (4-66) shows the effect of retempering admixture type on 90 days percentage of voids. One can conclude that voids generally increase if retempering using Type F is used compared with that of control mix. This increase ranges from 5.3 to 13.3 %.

Retempering using Type G slightly decreases voids. This decrease ranges from 7.3 and 9.3 %. All mixes containing chemical admixture have lower voids than concrete without admixture (Mix M1 see Table (4-5)).

Figure (4-67) shows the effect of initial admixture type on percentage of voids. The use of chemical admixture yields lower voids compared with that of concrete without admixture. This may be due to the decrease of w/c.

Figure (4-68) shows the effect of using a mix of Type G and Type F admixture and different retempering admixture at different times on 90 days percentage of voids. It's clear that the use of a mix of the Type G and Type F as an initial admixture and Type F as a retempering admixture increases voids compared with the use of Type G. As an example retempering using 1.5% Type F based on melamine for concrete containing 1% Type G and 0.5% Type F based on melamine, increases the voids by 18.0 % compared with the use of Type G (Mix M4).

Figure (4-69) shows the effect of retempering after 60 minutes using rapid hardening admixture and Type G of polycarboxylic on 90 days percentage of voids. One can conclude that the use of a mix of the Type G and Type C as a retempering admixture after 60 minutes increases voids. As an example retempering using 0.75 % of Type G and 1.125 % Type C increases voids by 30.7 % compared with that of concrete without retempering. The use 0.75 % Type G and 0.2 % polycarboxylic increases voids by 11.4%. Retempering using 1.5 % Type C increases voids by 26.7 %.

Figure (4-70) shows the effect of cement content of CEM I 42.5N and retempering on 90 days percentage of voids. It's easy to recognize that as cement content increases voids generally decreases due to the decrease of w/c. Retempering using 2 % of Type G for concrete with silica fume increases voids due to the high retardation effect. Up to cement content of 400 Kg/m^3, retempering of concrete at 60 minutes decreases voids.

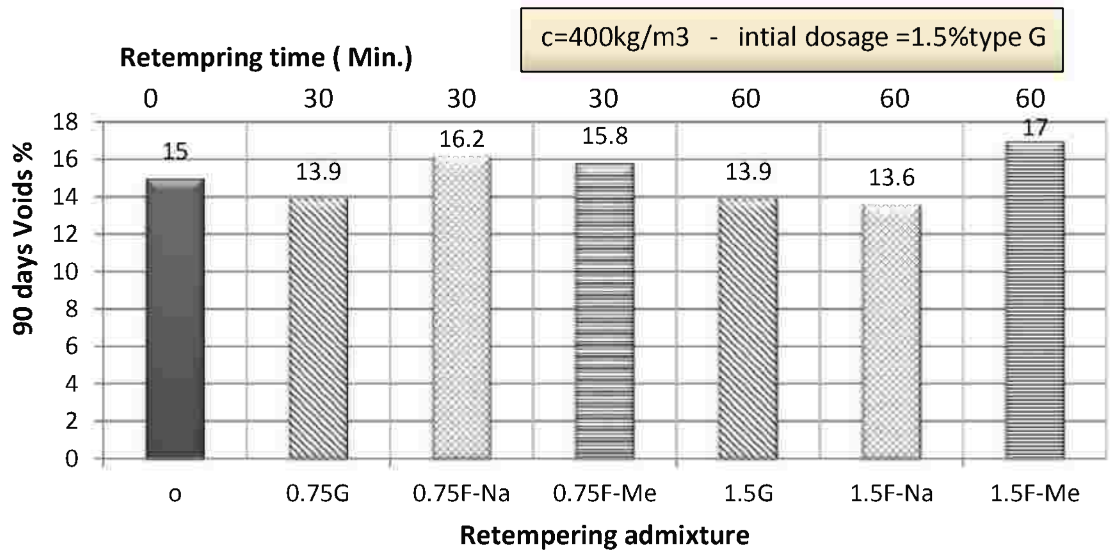

Figure (4-66) Effect of retempering admixture type on 90 days percentage of voids

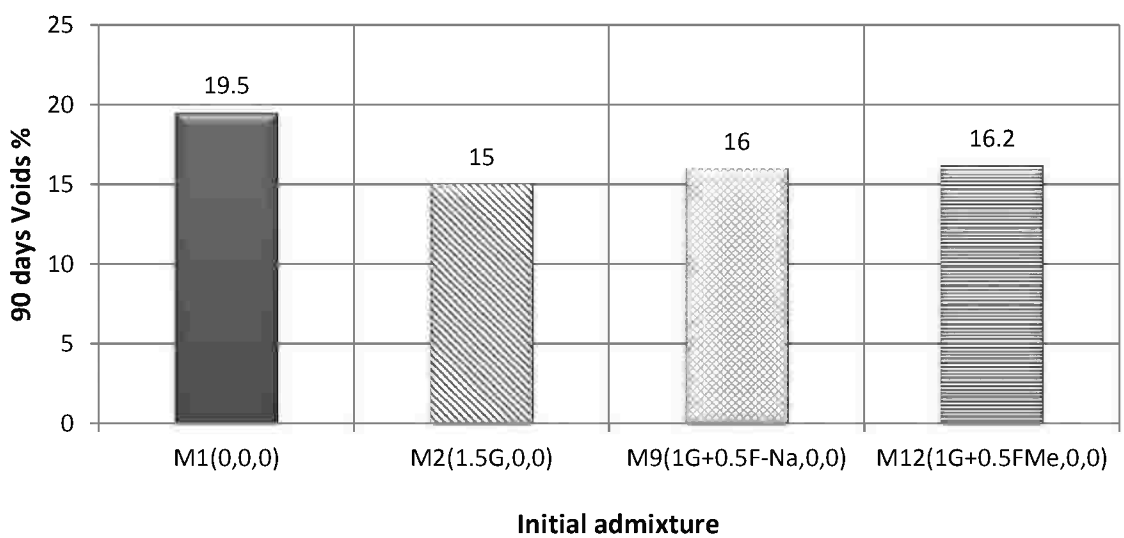

Figure (4-67) Effect of initial admixture type on 90 days percentage of voids for concrete with 400 kg/m^3 cement content

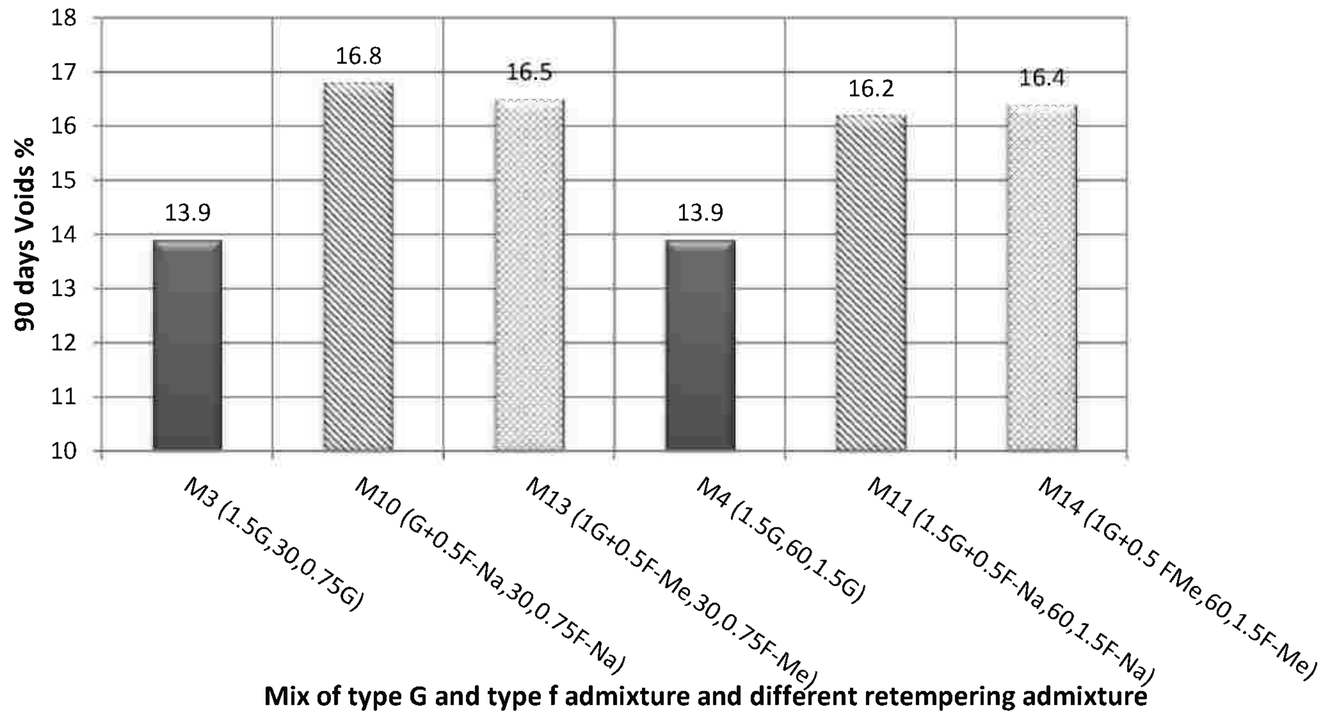

Figure (4-68) Effect of using a mix of Type G and Type F admixture and different retempering admixture at different times on 90 days percentage of voids for concrete with 400 kg/m^3 cement content

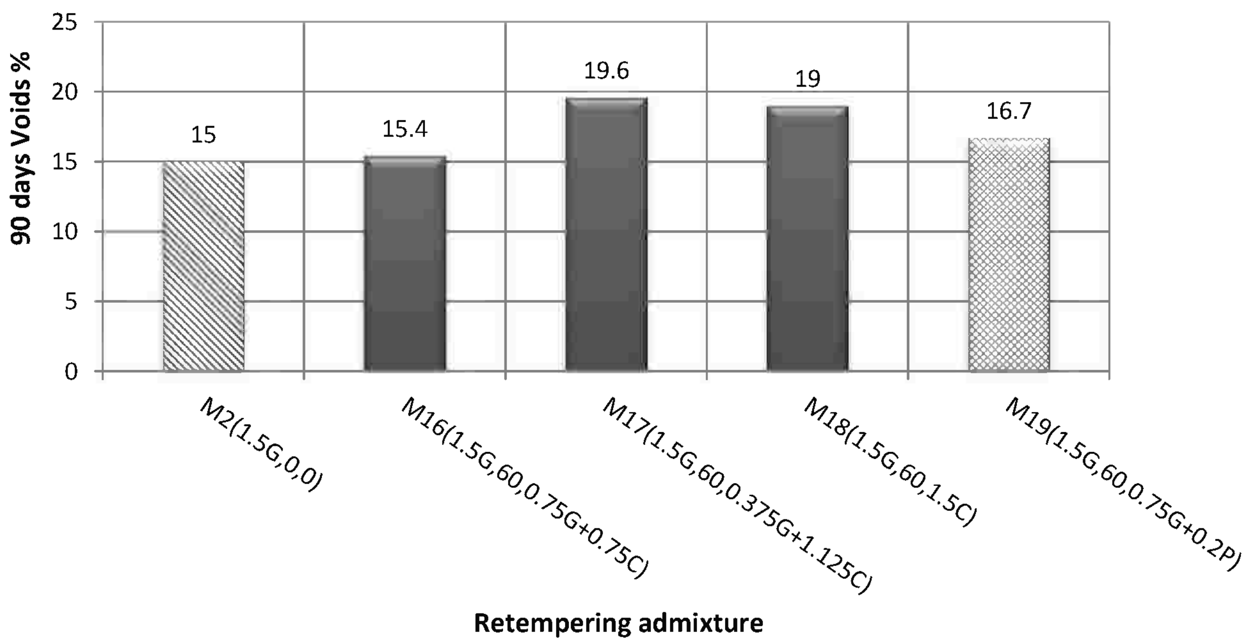

Figure (4-69) Effect of retempering after 60 minutes using rapid hardening admixture and Type G of polycarboxylic on 90 days percentage of voids for concrete with 400 kg/m^3 cement content.

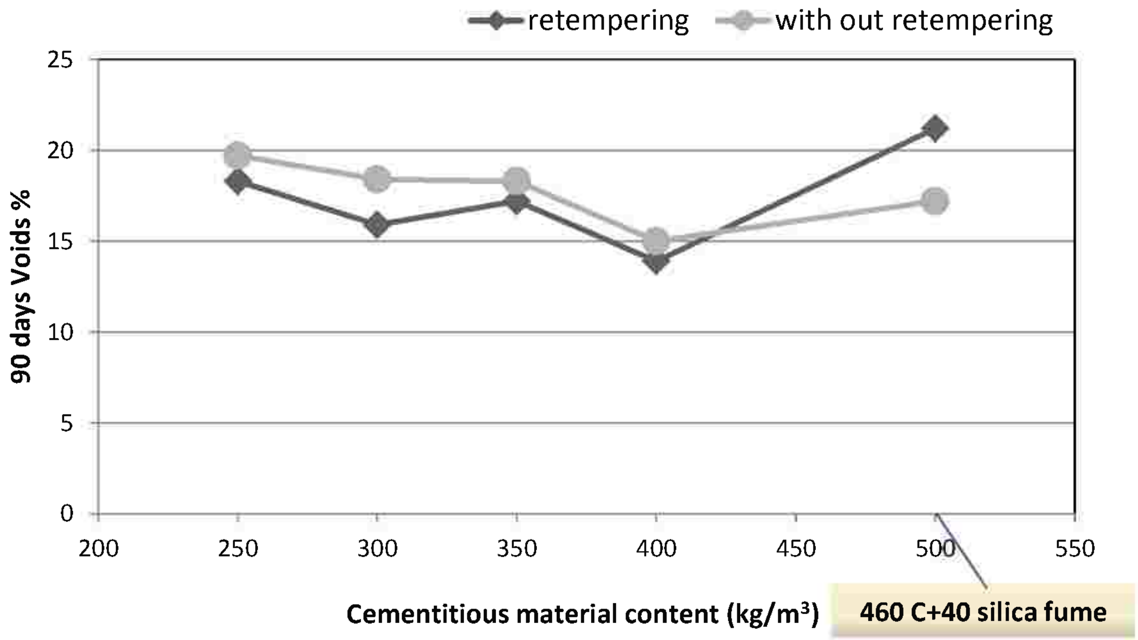

Figure (4-70) Effect of cement content of CEM I 42.5N and retempering on 90 days voids percentage

4.8.2 Effect of source and grade of ordinary Portland cement on voids:

Figure (4-71) shows the effect of source and grade of ordinary Portland cement and retempering using 1.5 % of Type G at 60 minutes on 90 days percentage of voids. It's clear that the two sources of CEM I 42.5 N almost shows the same behavior as retempering decreases voids. CEM I 32.5 N yields higher voids than that of CEM I 42.5 N.

4.8.3 Effect of retempering on percentage of voids of different sulfate resisting cement sources:

Figure (4-72) shows the effect of retempering admixture using different dosages of Type G on percentage of voids of concrete with different sources of sulfate resisting cement. One can recognize that retempering using 0.75% and 1.5 % of Type G generally increases voids. For concrete without retempering, source (2) (Alexandria factory) has lower voids than that of source (1) (El Amrya factory).

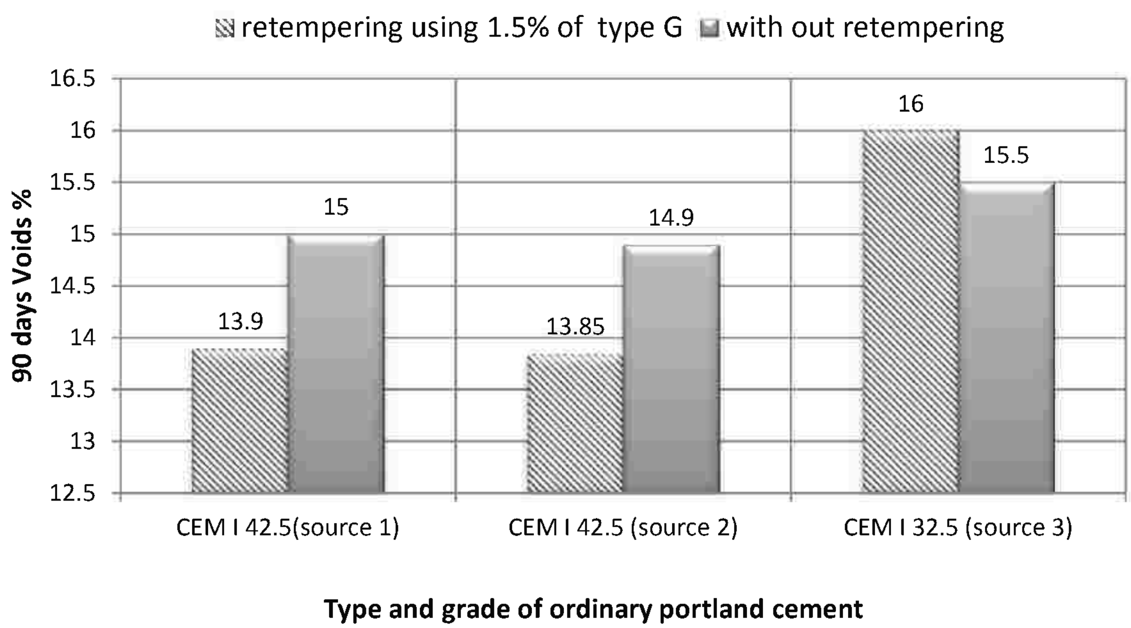

Figure (4-71) Effect of source and grade of ordinary Portland cement and retempering using 1.5 % of Type G at 60 mins on voids.

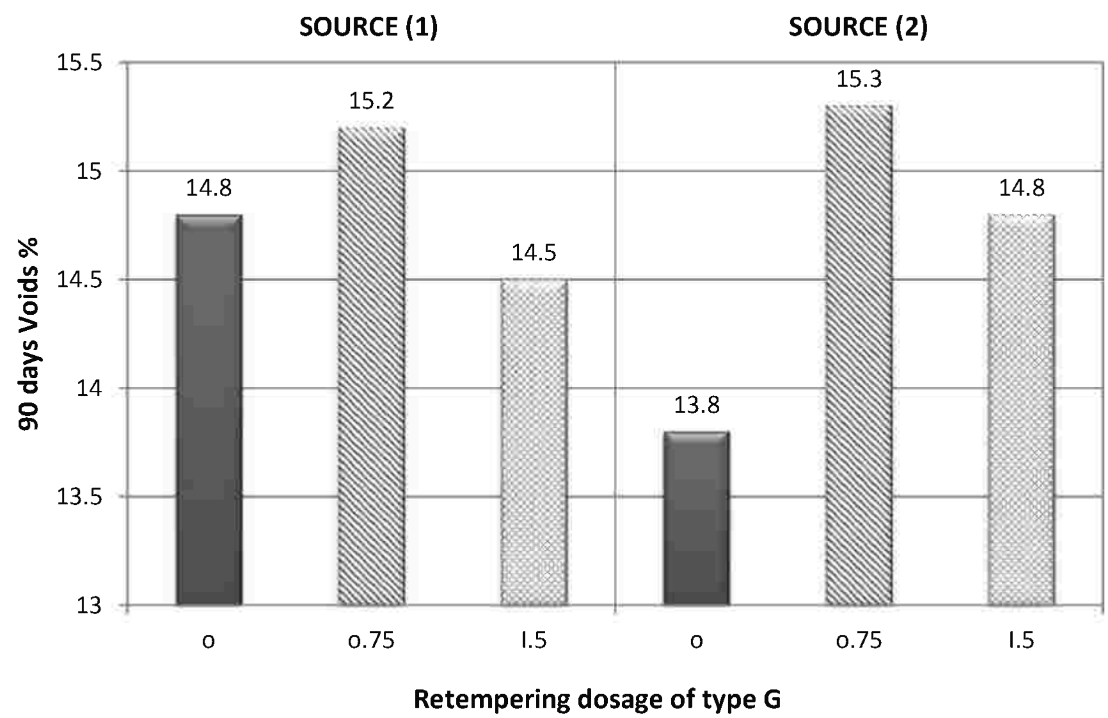

Figure (4-72) Effect of retempering admixture using different dosages of Type G on 90 days percentage of voids of concrete with different sources of sulfate resisting cement and 1.5 % G initial admixture and cement content of 400 kg/m^3

4.8.4 Effect of retempering using Type F with sulfate resisting cement:

Retempering using 1.5 % Type F, Table (4-5), based on melamine (Mix 36) yields voids of 12.9%. A decrease is achieved compared with retempering using 1.5 % Type G (Mix 34) that has voids of 14.5 %. Using 1.5 % of Type F based on melamine as initial and retempering admixture (Mix 37) has voids of 12.3 %.