



Effect of Low Mixing Speed on the Properties of Prolonged Mixed Concrete

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Abstract

The mixing process of concrete consists of dispersing the constituent ingredients (i.e. cement, admixtures, sand, and gravel) in water to homogeneous and solid product. The properties of the final product depend on mixing parameters such as mixing time and mixing speed. Ready Mixed Concrete (RMC) should be mixed for a long time with limited speed until delivered to the working site. This long time depends on long transport distances and traffic conditions. The present study investigated the effects of long mixing time on the properties of concrete without any change in its proportions during the mixing process and the effects of using the chemical admixtures: super plasticizers and retarders on its effectiveness, using a drum batch mixer. It has two directions of rotation: one for mixing concrete and the other for discharging it. This research identified concrete mixtures with local available materials i.e. cement, sand as fine aggregates, dolomite as coarse aggregates, water and chemical admixtures. Mixtures were prepared with the same cement and water content with constant sand to dolomite ratio with different dosages of chemical admixtures. Chemical admixtures were used to keep concrete flow during mixing. Mixtures were prepared with low mixing speed 1rpm for identified long mixing times more than 90 minutes from adding water to other components Slump and compressive tests were used as measurement tools of fresh and hardened concrete Retempering with extra water or chemical admixtures was prevented through mixing, so mixtures were extracted without target slump value. Findings showed that low mixing speeds made mixtures more effective for long times, the exceeding mixing time led to minimize water to cement ratio due to reduction of water content, and there was an inverse relationship between slump flow and compressive strength in case of no re-tempering. Therefore, slump flow of mixtures decreased by time, but on the other hand, compressive strength enhanced i.e. stiffening took place. The present study proved that the properties of the final product depends on mixing parameters such as mixing time and mixing speed, and that Ready Mixed Concrete (RMC) would be more effective if mixed for a long time with limited speed until transported to the work site. In addition, chemical admixtures with prolonged mixed concrete should be used to improve workability rather than compressive strength.

Keywords: Mixing Time; Mixing Speed; Superplasticizers; Retarder.

1. Introduction

Concrete is one of the most construction material widely used all over the world. The final form of concrete depends on the properties of the selected raw materials and the mixing process conditions. Selections and proportions of raw materials are based on the required characteristics of concrete, and the mixing process disperses the constituent ingredients i.e. cement, sand and gravel in water to get homogeneous and solid components. This complex process depends on the mixing method, the mixing time and the mixing speed. Ready Mixed Concrete (RMC) is used all over

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the world for many building constructions. RMC was first used in 1913 when concrete was prepared outside the work site and transported ready made for use. [1]. Nowadays, RMC is preferred to be used rather than concrete prepared in situ because of its high control and high quality. The main problem of RMC is the longtime of transportation from concrete mixing station to the work site. This time varies according to the distance between the mixing station and the work site in addition to traffic conditions. RMC should include the required properties at the end of mixing time. It should be in suitable uniform throughout the given batch to keep its fluidity during transportation in order to be easily casted while keeping the required strength. Long mixing time affects workability and compressive strength of RMC. Selecting appropriate mixing speed and dosage of chemical admixtures is very essential to get the required properties at the end of the mixing process. American Society for Testing and Materials (ASTM) published the first ASTM C94 specifications for RMC in 1935 [2]. These standard specifications limited discharging RMC within 1.50 hour after water is introduced to the cement or after introductions of cement to moist aggregates. These specifications set Drum Revolution Counts (DRCs) not exceeding more than 300 revolutions. It should be noted that DRCs depends on rotation speed and mixing time. This limitation of time and revolutions has not been changed since publication while mixing instruments, chemical admixtures added and all concrete industry have been developed. Nowadays, RMC is subjected to long mixing time more than the time specified by ASTM and high value of DRCs. Researchers have been working to develop specifications to ensure their conformity with the requirements of modern industry of concrete. Therefore, there is a pressing need for the present study to investigate the effects of low mixing speed and long mixing time on fresh and hardened properties of concrete mixtures with various dosages of chemical admixtures. The present study starts from the endpoint of the previous studies that dealt with the same topic. However, it exceeds in its experimental program that was implemented to investigate the effectiveness of long mixing time on the properties of concrete without any change in its proportions during the mixing process and the effects of using the chemical admixtures: super plasticizers and retarders on its effectiveness. There is no need for re-tempering with more water or chemical admixtures in this study.

2. Literature Review

Concrete mixing time and speed and RMC occupy the interest of many researchers in the field of civil engineering. Although many studies limit the mixing time to no longer than 90 minutes, many construction projects require time longer than that specified time. This can be attributed to long transport distances, traffic, and delays in construction [3].

Discharge time plays an important part in the effectiveness of concrete properties. It has two definitions according to ASTM C94 specifications. (1) The time measured from introduction of mixing water and cement to discharge all quantity of concrete. (2) The time measured from introduction of cement to aggregates until discharging concrete completely. The authors noted that the second definition was useful in case of moisture content of coarse or fine aggregates exceed 3 percent and 6 percent by weight, respectively [2]. However, the present study adopts the first one because it suits its nature and achieves its objectives.

Trejo and Chen investigated effects of long mixing time on concrete properties. The researchers aimed to examine the current 90-minute placement limit and determine the possibility of applying it to the current concrete technology. The researchers used 8 rpm and 15 rpm as mixing speeds for different times up to 90 minutes. Results showed that slump decreased as a function of increasing mixing time. Laboratory mixtures had slump value approximately from 0 to 30 % of the initial slump after 90 minutes of mixing. Chemical admixtures affected lower slump loss values at 60 minutes of mixing and exhibited better workability. Using high dosage of chemical admixtures was preferred for high slump values and better workability than recommended dosage. Results showed that slump decreases with high value of DRCs (high mixing speed and/or long mixing time). On the other hand, compressive strength of all mixtures enhanced when mixing speed was 8 rpm for time up to 180 minutes i.e. 1440 DRCs. In addition, there was a reduction in strength of mixtures when mixing speed was 15 rpm for 120 minutes i.e. 1800 DRCs. The researchers concluded that 90-minute placement limit was not trusty indicator for discharging RMC to construction site because many of mixtures got suitable workability at the end of mixing [3].

Two theories that described how retardation mechanism of cement hydration works. First theory, the adsorption theory assumed that cement particles adsorbs the retarder, so cement hydration delayed. Second theory, the precipitation theory assumed that retardation takes place due to precipitation of calcium salts layer from retarder on cement particles surface. Because of this layer, cement is isolated from hydration reactions with water. The authors also reported that exceeding mixing time of concrete leads to grinding effect of cement particles. This effect is accomplished with removing adsorbed layers of retarder or precipitated calcium salts from cement surface. Therefore, the retarding mechanism fails to work when the concrete is mixed continuously for long duration (i.e. long transportation of ready mixed concrete) [4].

Workability of concrete as a measurement of fresh stage is affected by some factors such as mixing time, speed, aggregates nature and water to cement ratio. Stiffening of concrete as a measurement of hardened stage is influenced by some factors such as cement reactions with water called cement hydration and reduction of mixed water content.

The researchers also assessed that the compressive strength was found to increase with exceeding mixing time. The researchers indicated that exceeding mixing time is accompanied with grinding effect of cement grains. This effect gets grains finer and removes hydration products from their surface. Hence, more cement reacts with water and hydration rate increases. The result is development in strength of concrete. The authors reported that low mixing speeds allows water to be free in voids between constituents for long times. The researchers added that free water decreases friction between cement and aggregates particles [4]. Limits of time were established long ago when mixers had only low mixing speed [5].

The relationship between compressive strength and time of mixing after re-tempering with constant mixing speed was studied. The researchers found positive relationship between strength and mixing time. They explained this relation because of the loss of water due to evaporation and aggregate absorption. Loss of water led to reduction of water to cement ratio (w/c). Results showed that when mixtures prepared with speed 4 rpm and 240 minutes of mixing i.e.960 DRCs, achieved large slump loss with better strength. The author indicated that workability of concrete negatively affected by increasing the value of DRCs in contrast to compressive strength [6].

Nehdi and Al-Martini prepared concrete mixtures with different types of Water Reducer Admixture (WRA) and exposed mixtures to prolonged mixing up to 110 minutes and high temperatures. The authors concluded that slump values reduced by longer mixing times due to reduction of water content. In addition, mixtures with high dosages of WRA exhibited less reduction in slump. The author also reported that RMC get approximately two-third of its workability at the end of delivering at high temperature weather [7].

Chen and Trejo discussed the effect of exceeding DRCs on fresh and hardened properties of concrete. The author identified 300 revolutions as a lower limit for ready-mixed concrete industry. Mixtures in this study subjected to much higher DRCs and got adequate workability and uniformity next to appropriate mechanical properties and durability [8].

When mixing speed increased, cement hydration was accelerated besides increasing of hydration heat. This could take place weather the mixture contained super plasticizer or not [9].

Another study prepared concrete mixtures at speed 20 rpm for 5 minutes to get homogeneity. The mixing speed was lowered to be 6 rpm as a simulation of RMC. The mixer was stopped every 15 minutes intervals to conduct slump tests. The mixing process was not finished until the final slump reached less than or equal to 2 cm and specimens for compressive strength were extracted. The researchers reported that concrete with high dosage of super plasticizer is still workable for long duration and get higher compressive strength, tensile strength and young modulus compared to mixtures without admixtures. It is better to use dosage of chemical admixtures at two stages than using the same dosage at the beginning of mixing process only as it keeps concrete more workable for longer duration [10].

The effects of super plasticizer (SP) and retarder (R) admixtures on concrete properties were studied. Concrete Mixtures were subjected to mixing times up to 300 minutes and specimens were extracted each 30 minutes. The researcher referred that slump values decrease with time for all mixtures. Retarded concrete has longer setting time than concrete with super plasticizer. Setting of concrete leads to reduction of slump value. In addition, using SP and retarder makes concrete in liquid state for long times and hence reduces slump loss during transportation. After 5 hours, results showed that retarded concrete retains slump value more than concrete with SP. The researcher indicated that using both chemical admixtures enables concrete to have better strength. However, at high dosages cohesiveness reduces. The results showed that R achieved lower strength than desired at early ages, but it enhanced at later ages. In addition, over dosage of retarder reduces the compressive strength because of delaying of reaction of C_3S and C_3A . Results also showed that SP increases strength at all ages because of extra free water used for mixing [11].

Indicated that homogeneity of Ready Mixed Concrete was increased by increasing number of DRCs. The number of drum revolutions is increased by increasing mixing time and/or mixing speed [12]. The strength of concrete is affected by density. The properties of foamed concrete and found that strength increased with high density [13]. This result was accepted by the research, which discussed the properties of high strength concrete mixes [14].

Using mixing water with lower temperature led to a relative increase in slump flow and enhanced workability of mixture [15]. The author also reported that using cold water induce a reduction of initial concrete mix temperature during mixing and casting.

Mazloom, and Ranjbar prepared Self-Compacting Concrete (SCC) mixtures with constant proportions and varied percentage of super plasticizer only (from 0.40% to 1.60% of cement weight) [16]. The authors studied the effect of super plasticizer and silica fume on the relation between workability and strength of SCC mixtures. Results indicated that high dosage of SP increases slump value of mix but led to reduction of compressive strength. The authors refereed to adverse relation between workability of SCC mixes and compressive strength.

Mixing time could be shortened by increasing the velocity of mixing tool [17]. The authors prepared a SCC mixture and measured its flow by j-ring test and found that concrete reaches maximum flow at 720 s with a tool velocity = 1.3 m/s although it reached maximum flow at 120 s with velocity 8.7 m/s.

Ravina (1996) [18] prepared concrete mixtures with retarder, Water Reducer Admixture (WRA) and fly ash for mixing time up to 180 minutes. The author measured the compressive strength of mixtures. He indicated that strength increased linearly with time in different rates. Fly ash is used with high volume as a binder instead of cement. However slow setting leads to reduction in strength [19].

Effect of mixing time and dosage of super plasticizers of Self-Consolidated Concrete (SCC) was studied [20]. This study prepared SCC mixtures with mixing time up to 90 minutes and examined fresh and hardened properties. Mixtures had different dosage of super plasticizer. The results showed that segregation and bleeding of SCC reduced by exceeding mixing time. The authors found that high dosage of super plasticizers reduced the negative effects of long mixing times on the properties of concrete.

Mixtures of cellular lightweight concrete were prepared with mixing speed 15, 30, 45, 60 and 75 rpm [21]. The compressive strength of concrete increased by increasing mixing speed up to 45 rpm but there was a reduction in strength at mixing speeds 60 and 75 rpm.

Another attempt presented many trials of concrete with various mixing times and speeds. Tests examined the properties of cast-in-place concrete [22]. The recommended mixing time was 2.50 minutes with rotational speed 28 rpm and differed according to the study area. Mixing time can be reduced with high mixing speed but in case of self-compacting concrete, excessive speed has a large influence on its workability [23]. Bad mixing is the result of too short time or slow water loading rate [24]. Bad mixing has bad effects on the mechanical properties of mortars. Ready mixed concrete has waste between 1% and 13% [25]. Part of this waste comes from job sites due to bad mixing.

From literature review, some previous researches were based on preparing concrete with supplementary cementitious materials for long mixing time. Other researches prepared concrete with speeds 8 rpm and 15 rpm. Other researches depended on re-tempering concrete with admixtures to maintain target slump. However, the present study presents concrete prepared by different mixing speed i.e. 1, 8, 15 and 25 rpm. Concrete included local materials without supplementary cementitious materials and prepared with no re-tempering.

3. Materials and Experimental Program

3.1. Materials

All concrete materials (cement, aggregates, chemical admixtures and water) were locally imported to laboratories at normal temperature. Mixtures had cement type I 42.5 N and complied with requirements of the Egyptian standard specifications and has specific weight = 3.15. Cement was protected from humidity. Dolomite used as coarse aggregates and has a specific weight = 2.70. The grading curve and physical properties of dolomite is shown in Figure 1 and Table 1 respectively. Sand passing from sieve No 4 (4.75 mm) and retained on sieve No.200 (75 μ m) used as fine aggregates and has a specific weight =2.65. The grading curve and physical properties of sand is shown in Figure 2 and Table 2 respectively. Both types of aggregates were clean and washed by water to remove dust. Submersing aggregates before using was essential to remain water content in mixtures as designed. Sika viscocrete-3425 used as a high performance super plasticizer concrete admixtures (SP) and it met the requirements of ASTM-C- 494 types G and F and BS EN 934 part 2: 2001. The main properties of Sika viscocrete are shown in Table 3. Addicrete BVS used a high range water reducing, super plasticizer and set retarding concrete admixture (SP,R) and it met the requirements of ASTM-C- 494 type G, EN 934 and EN 1899. The main properties of Addicrete BVS are shown in Table 4.

Table 1. Physical Properties of Dolomite

Property	Result	Egyptian Specifications
Specific weight	2.70	-
Bulk density (t/m ³)	1.65	-
Coefficient of abrasion (Loss Anglos) %	20	< 30
Coefficient of Impact %	14	< 30
Absorption %	1.5	< 2.50
Clay and dust content %	1	< 3.0

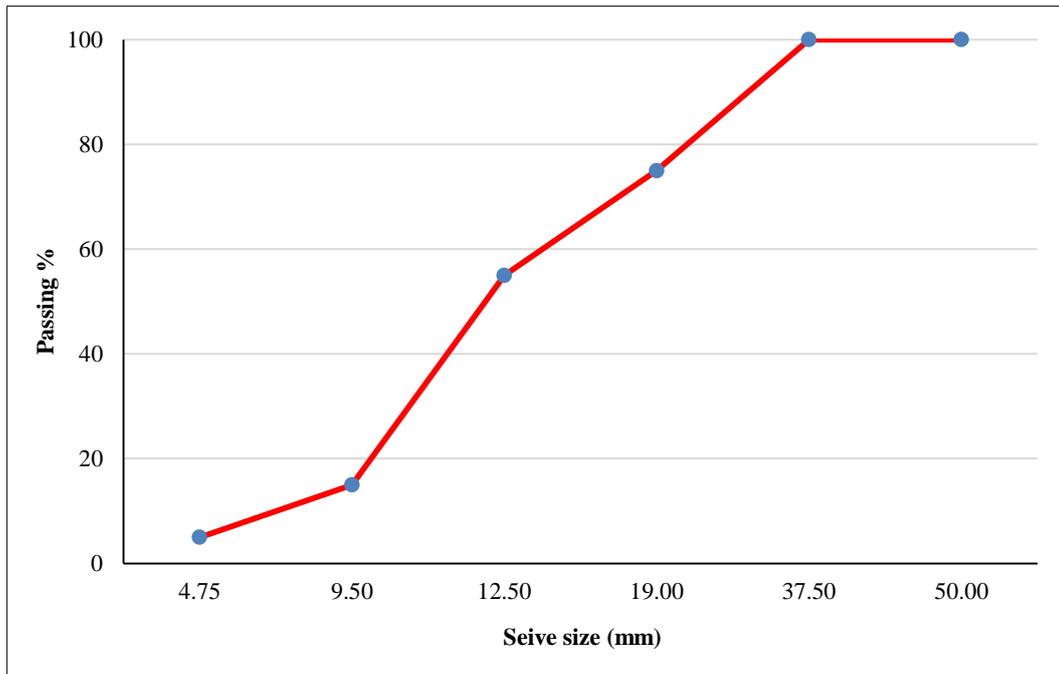


Figure 1. Grading Curve of Dolomite

Table 2. Physical Properties of Sand

Property	Result	Egyptian Specifications
Specific weight	2.65	-
Bulk density (t/m ³)	1.65	-
Fineness modulus	2.73	-
Finer materials passed from sieve No 200 %	2.40	< 3.0

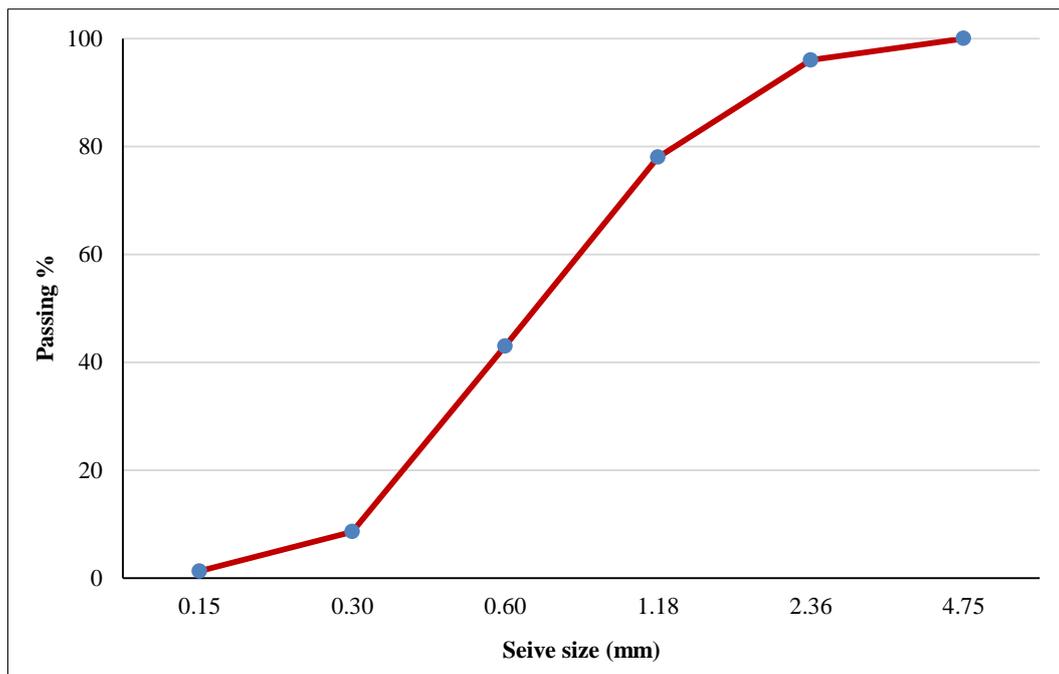


Figure 2. Grading Curve of Sand

Table 3. Physical Properties of Sika viscocrete

Property	Result
Base	Aqueous solution of modified polycarboxylates
Appearance	Liquid
Density (Kg/lit)	1.08
P ^H value	4.0
Solid content	40 % by weight
Recommended dosage	For medium workability: 0.20 to 0.80 % by weight of cement For high workability, high strength or SCC 1.0 to 1.50 % by weight of cement

Table 4. Physical Properties of Addicrete BVS

Property	Result
Base	Sodium ligno sulphonate + Napthalin sulphonate
Appearance	Brown Liquid
Density (Kg / lit)	1.21
Chloride content	Nil
Air entrainment	Nil
Compatibility	All types of Portland cement
Recommended dosage	Increase workability or increase strength with the same workability: 0.15 to 2.0 % by weight of cement For high workability: Up to 3.0 % by weight of cement

3.2. Experimental Program

The present study included seven mixtures of concrete. One mixture was conventional concrete as reference one with no admixtures. Three mixtures had Sika viscocrete-3425 as super plasticizer admixture at percentage 0.60, 1.0 and 2.0% by weight of cement. Another three mixtures had Addicrete BVS as super plasticizer and retarder admixture at percentage 0.60, 1.0 and 2.0% by weight of cement. It should be noted that all mixtures had the same content of cement (350 kg/m³) and water (175 kg/m³) i.e. W/C (Water to cement ratio) = 0.50 and had the same dolomite to sand ratio.(D/S=2). Table 5 shows the mixtures proportions of each component. Absolute volume method was used to determine quantities of materials.

Table 5. Mixtures Proportions

Mix No.	Cement content %	W/C	Aggregates		Chemical Admixtures	
			Dolomite %	Sand %	SP % (Sika viscocrete)	SP , R % (Addicrete BVS)
M 1					0	
M 2					0.6	0
M 3					1	0
M 4	100	0.5	66.67	33.33	2	0
M 5					0	0.6
M 6					0	1
M 7					0	2

Experimental program of this research is shown in Figure 3. It aimed to distinguish the influence of low mixing speeds during long times on workability and strength of mixtures as a simulation of RMC industry according to the standard specifications of ASTM C94 [26]. Drum batch mixer is used in mixing process and it belongs to reversing type mixer. It has two directions of rotation, one direction for mixing concrete and the other one for discharging it. There are two groups of blades existed inside the drum. One group drops materials upward and downward for mixing and the other group pushes the concrete product into the opening for discharging. Mixtures were mixed according to

protocol shown in Figure 4 with speed 8 rpm for first three minutes and then the speed decreased to be 1 rpm for remaining time. Slump test was used as a measurement tool of fresh properties of concrete and compressive strength test used as a measurement of hardened properties. Specimens were extracted for slump and compressive strength tests after zero minutes (3 minutes from start point), 45 minutes (48 minutes from start point) and 90 minutes (93 minutes from start point). Slump shape depended on the workability degree of specimens as shown in Figure 5. Every mixture was casted after slump test in metallic cubes and compacted well. Approximately one day was enough for specimens to be hardened and extracted from metallic cubes. Specimens were immersed in water pool for curing till the day of compression test in normal temperature at laboratory. At the specified test day, specimens were extracted from water pool and were air-dried for 15 – 20 minutes. Contacted face of cube with bearing plate of testing machine was cleaned well to avoid friction that affected the test result. The cubes were placed in the testing machine according to ASTM C 109 [27] specifications. Normal load affected the cube was increased at constant rate until failure. Samples of mixtures under compression test were shown at Figure 6.

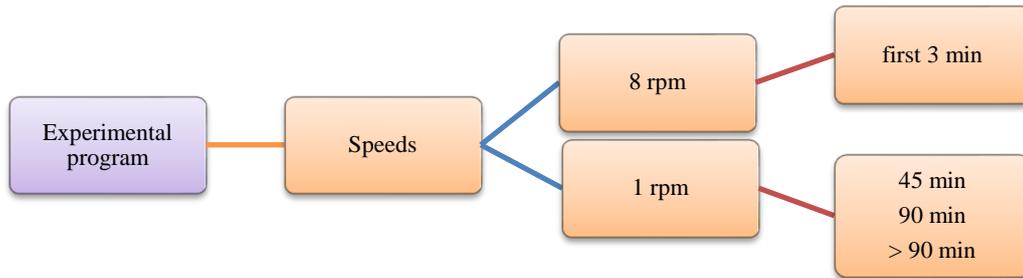


Figure 3. Experimental Program of Research

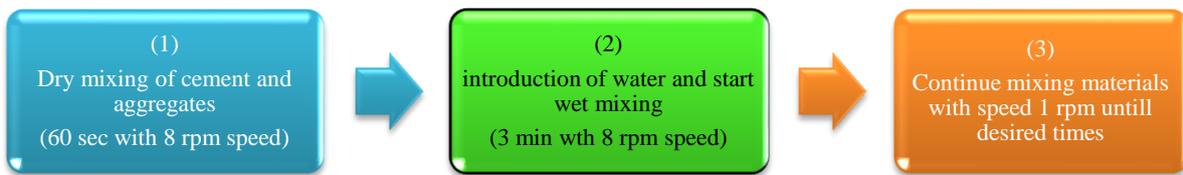


Figure 4. Mixing Protocol



Figure 5. The Slump Shape of Mixtures



Figure 6. Mixtures under Compression Test

4. Analysis and Discussion of Results

Results analysis shows that mixing times reaches 130 min for all mixtures with variation of slump values according to the quantity of super plasticizer and retarder. Mixtures were not able to continue more than 130 minutes because of no workability. Reference mix with no chemical admixture reached 90 min with slump = 20 mm i.e. not suitable for casting. Mixing time increased to 130 min for mixture with 2 % Sika viscocrete (SP) or 2 % Addicrete BVS (SP+R) with slump 70 mm and 80 mm respectively. Slump of mixtures decreased with time. For M3 with 1% SP, the slump values are 200, 150 and 35 mm at times 0 & 45 and 90 minutes respectively with reduction rate 1.11 mm/min and 2.55 mm/min. For M6 with 1% SP,R the slump values are 220, 180 and 40 mm at times 0 & 45 and 90 minutes with reduction rate 0.88 mm/min and 3.11 mm/min. These results were consistent with previous research, which referred to reduction of slump because of cement hydration and mixing water reduction

Slump of mixtures increased with an increase in dosage of such admixture. With high dosage of chemical admixtures, mixture continued workable for mixing time higher than 90 min. At time = 45 min, the slump of M1, M2 with, M3 and M4 = 60 mm, 120 mm, 180 mm and 190 mm respectively. Slump increased about 100 %, 200 % and 216 %. At time = 45 min, the slump of M 1, M 5 with, M6 and M7 = 60 mm, 110 mm, 150 mm and 170 mm respectively. Slump increased about 83.3 %, 150 % and 183.33 %. Overall, slump values of mixtures with SP were higher than values of mixtures with SP, R. Figures 7(a) and (b) show the effects of mixing time and dosage of SP or SP+R on slump of mixtures.

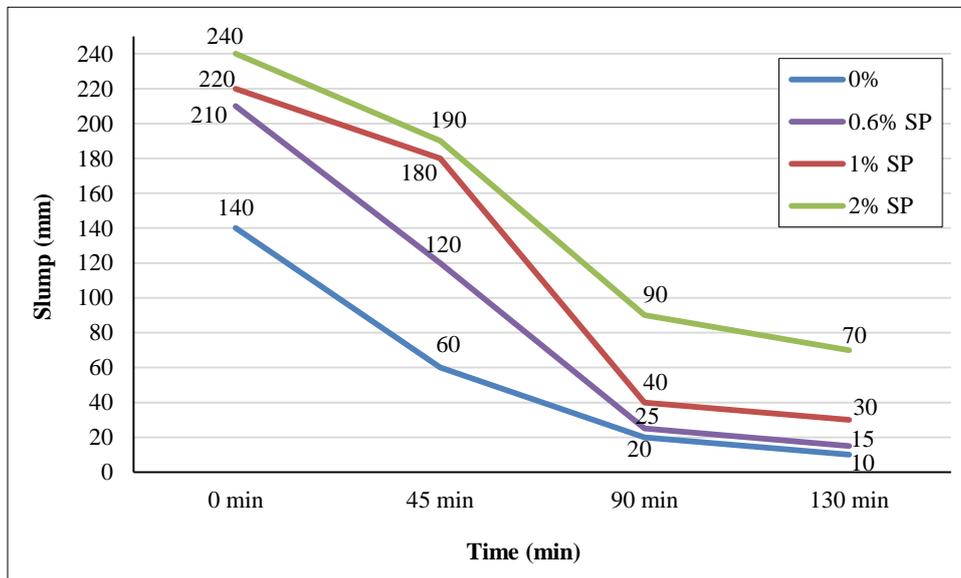


Figure 7(a). Effects of SP Admixtures on Slump Values of Mixtures at Different Times

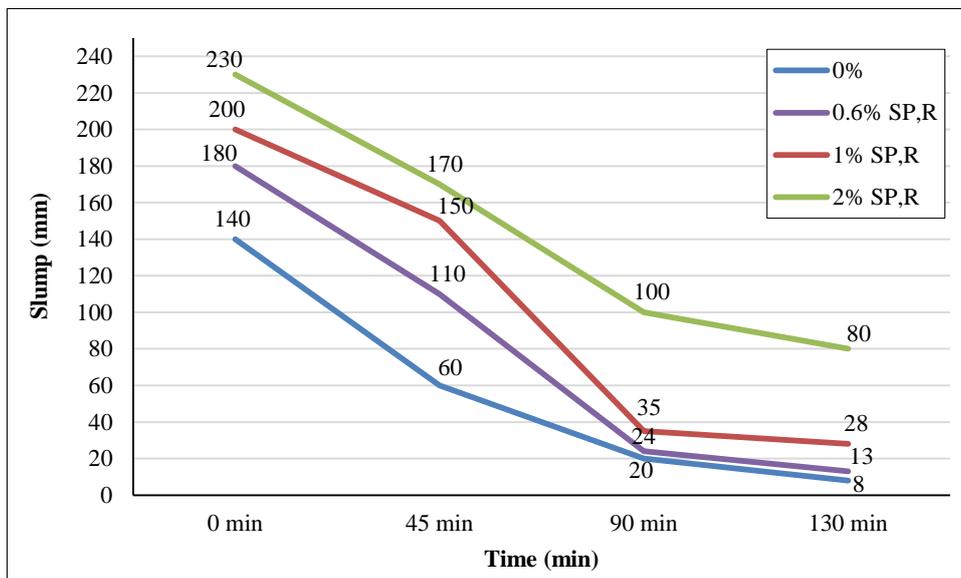


Figure 7(b). Effects of SP+ R Admixtures on Slump Values of Mixtures at Different Times

Figures 8(a) and (b) show the effects of mixing time and dosage of SP or SP+R on 28-day compressive strength of mixtures. For 28 days compressive strength , M3 with 1% SP got 286, 318 and 361 kg/cm² at times 0, 45 and 90 min with growth rate 11.11 and 26 % respectively. M6 with 1% SP,R got 295, 325 and 365 kg/cm² at times 0, 45 and 90 min with growth rate 16.94 and 23.70% respectively Results showed that compressive strength increased with exceeding mixing time. This development of strength was a result of grinding effect of cement particles. This leads to get finer cement and establish hydration reactions rapidly. Reduction of water content leads to minimization of water to cement ratio, so more strength obtained.

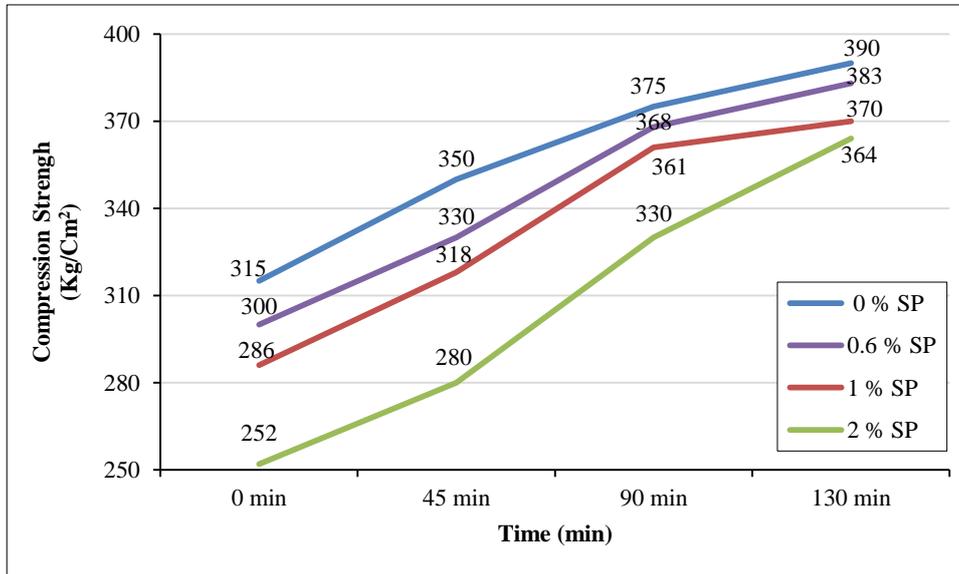


Figure 8(a). Effects of SP Admixtures on 28-day Compressive Strength Values of Mixtures at Different Times

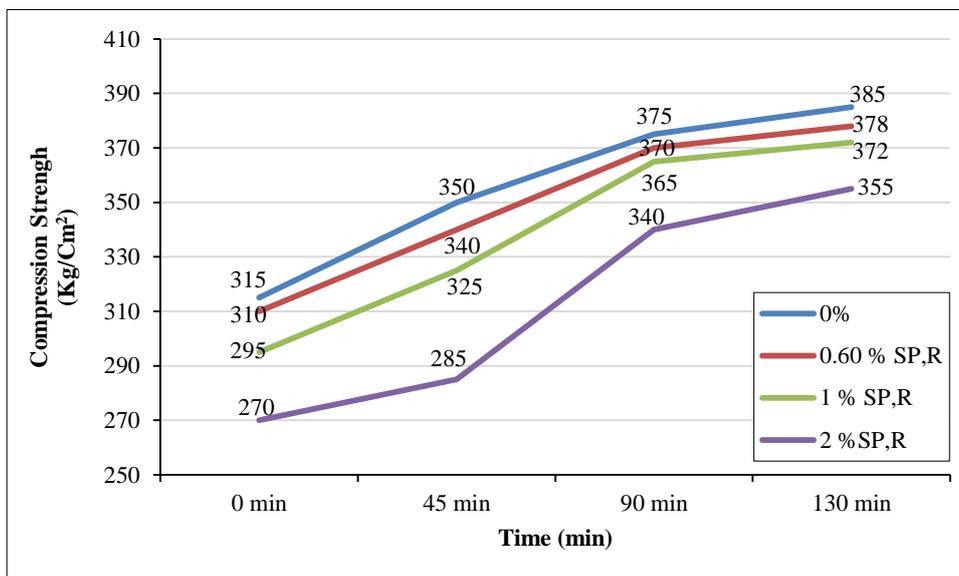


Figure 8(b). Effects of SP+R Admixtures on 28-day Compressive Strength Values Of Mixtures at Different Times

Results assessed that using high dosage of super plasticizer performed high values of slump but had an adverse effect on compression strength. Mixture 1 with no chemical admixtures had maximum strength compared to other concretes but it had the least slump value (not workable). Mixture 3 with high dosage of SP (2%) had the least strength of mixtures but it was suitable to be used. Figures 9(a) and (b) indicated the influence of SP or SP+ R admixtures respectively on both slump and compressive strength of mixtures at different times. The main function of chemical admixtures is to disperse cement and other components particles from each other and let water be free, thus hydration reactions delay. The main purpose of using such admixtures is to increase the fluidity (slump) of the mix rather than to reduce the amount of mixing water especially for continuous agitated mixed concrete.

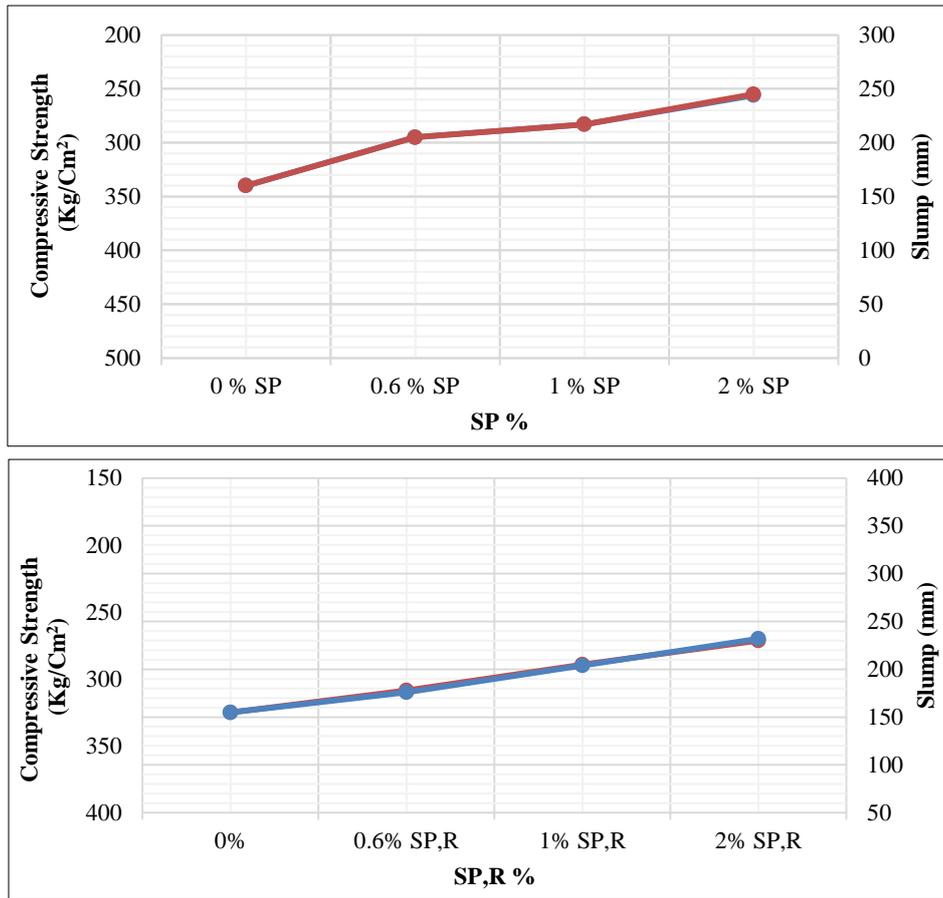
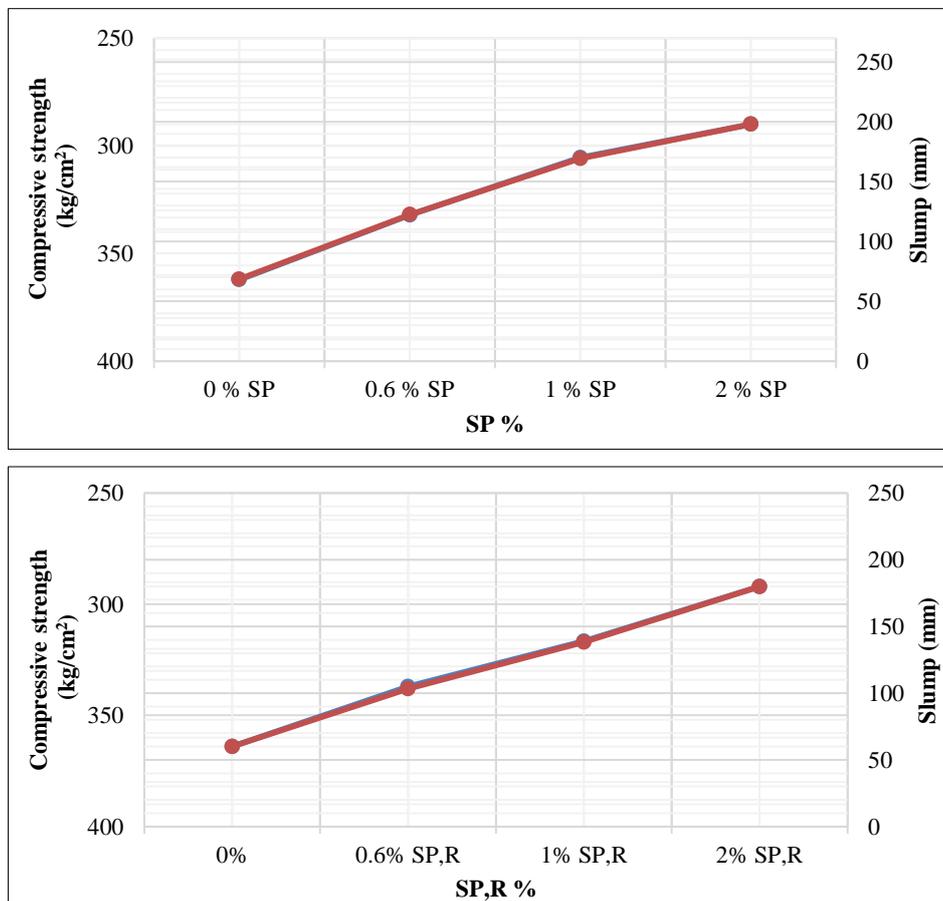


Figure 9 (a). Effects of Admixtures on both Slump and 28- Day Strength at Speed 1 Rpm and Time 0 min



Figures 9 (b). Effects of Admixtures on both Slump and 28- Day Strength at Speed 1 Rpm and Time 45 min

5. Conclusion

The present study investigates the effects of long mixing time on the properties of concrete without any change in its proportions during the mixing process and the effects of using the chemical admixtures: super plasticizers and retarders on its effectiveness, using a drum batch mixer. It aims to solve the problem of RMC that requires long times until transported to the work site. Results show that (1) low mixing speeds make mixtures workable for long times, so it is suitable for transporting RMC for long distances, (2) Using chemical admixtures improves the workability of mixtures according to the used dosage and mixtures, (3) high dosage gives high slump flow for long times compared to other mixes, (4) Super plasticizers make mixes flow more than retarder but mixes with retarder loose slump at smaller rates compared to other mixes, (5) Workability of concrete decreases as a function of exceeding mixing time especially when there is no re-tempering by water or chemical admixtures, (6) Compressive strength of concrete increases linearly with increasing mixing time but it is very important to measure workability of concrete and confirm for ease of use. Therefore, it can be concluded that fresh and hardened properties of concrete are affected by the properties of the used materials and the mixing process. Mixing process parameters include mixing tool, mixing speed and mixing time.

The present study proves the effects of mixing time, mixing speed and chemical admixtures on fresh and hardened properties of concrete mixed with constant quantities of other solid components, and that concrete had the same properties from the start to the end of the long mixing time process. If there is no target slump of mixtures (no re-tempering during mixing), exceeding mixing time leads to reduction of w/c ratio, which leads to reduction of slump value and improvement of strength. It means that compressive strength has an adverse relationship with slump value of mixtures when re-tempering is prevented. Chemical admixtures have not good effect on compressive strength of mixtures, so conventional concrete with no admixtures has high strength. On the other hand, it has zero slump and can't be useful for casting. For RMC, using chemical admixtures for enhancing workability is better than developing strength to overcome long time problems. Selecting dosage of chemical admixture and mixing speed depends on required mixing time (delivery time) and required flow at work site to give required strength. The present study suggests to study the effects of using high dosage of chemical admixtures up to 2 % of cement weight on concrete properties when mixed with low mixing speed for long times up to 180 minutes. The mixing speed variable during mixing process is recommended to be studied because of its importance in the industry of RMC. In addition, concrete with target slump should be considered for future researches.

6. Funding

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8. Conflicts of Interest

The authors declare no conflict of interest.

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