Producing High Workable & High Strength Concrete Mix Having 6 Hour Retardation

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Abstract. The goal of this study is to work out different experiments for retarding concrete setting time, which needed to reach slump 15 cm after six hours from mixing of concrete having grade C700. Six hours comprise 1.5 hour for transporting and 4.5 hours needed for constructability method, this long time for casting concrete is owing to a long transporting time of the concrete from the plant to the site and also the time needing for casting the concrete by using the slide form of high ring concrete wall, for these reasons there are needs to retard the concrete setting time with increasing the workability for concrete, using super-plasticizers is one of the best methods to improve the properties of the concrete, from fundamental experimental investigations on retardation, setting time and the concrete mixture with high strength of 626 kg / cm\textsuperscript{2} after 7 days and 755 kg / cm\textsuperscript{2} after 28 days can be achievable by using super-plasticizers.

1. Introduction
Concrete has been developed quickly in the last decades to save a significant need for the construction industry in the world so that it considers the most common building material for many years and is expected to remain also in the future decades. And hence the concrete considers is a vital construction material that has extensive usage around the world. The concrete has distinct properties like Durability, Workability, fire resistance, and any molding shape, which lead to widespread use. Different forms of concrete have been created and built for various infrastructures like huge concrete dams, reinforced concrete buildings, concrete bridges, and precast concrete components.

To improve concrete quality, there are many factors that engineers should identify to reach the required performance of constructability, and it can be realized by strength, workability, and durability, which is related to real properties.
The quality of concrete in a structure is identified not only by the appropriate selection of its gradients and their proportions, but also by suitable methods in the casting, production, transportation, compacting, and curing of the concrete of the actual structure, often on-site. Although the actual quality of concrete can be affected by these processes [1]

The level of available design of the Mixture doesn't the same level of structural design. It is more suitable to determine as a procedure for selecting the type of mixture ingredients and their proportions. The required properties of the mixture and its proportions can be achieved by methods of a trial batch, this type of mixture is called a designed mixture.

The components of concrete have been created from the primary four (Portland cement, water, coarse and fine aggregate) to comprise chemical and mineral admixtures.

Setting can happen as water reacts with Portland cement (POC), which then gradually hardens with cohesive aggregates binding. The longer this process goes on, the less the concrete is workable enough to be placed and finished during construction.

To increase workability, it should be added water, but it leads to a shortage in the strength of the concrete and hence its durability. So that using additives can be the solution to delay the setting time of the concrete, the chemical additives, including water reducers, retarding admixtures, and hydration stabilizers, can be used for delaying the setting. Water reducers means decreasing the amount of water, which is necessary in a mixture process, creating it possible by extend the setting time without leakage in workability and durability. On another meaning, it can be slow the interaction between water and cement, and Hydration stabilizers delay the beginning of the setting.

Retarding admixture means an admixture that can be used to delay the setting time of concrete [15]. And it may cause cement set retardation by any of the following processes:

1. Adsorption of the retarding compound on the surface of cement particles, forming a protective layer which slows down hydration interaction;
2. Adsorption of the retarding includes nuclei of calcium hydroxide, poisoning their growth, which is necessary for the hydration process of cement after the end of the induction period;
3. Formation of the congregation with calcium ions, increasing their solubility and discouraging the creation of the nuclei of calcium hydroxide; and
4. deposition around cement particles of insoluble derivatives of the retarding components created by interaction with the highly alkaline aqueous solution, forming a protective layer [16].

Concrete mixtures also include the air-entraining factors, detergent-like additives that increase the durability of concrete by boost the creation of air bubbles within the concrete.

The setting of concrete can convert the fresh concrete from the liquid stage to the solid stage. It is crucial to determine the setting time to extend the duration required for transporting and placing of concrete. And it can be known as the beginning of rigidity of the fresh concrete. It is different from hardening, while it depicts the growth of identifiable strength. Setting precedes hardening, but it can be confirmed that both of setting and hardening are gradual changes, which are controlled by the cement hydration process.

On the other hand, the initial set expresses nearly the time at which fresh concrete can't be casting or handled, while the final set nearly the time at which the hardening starts. Fresh concrete will have lost measurable slump before the initial set, while measurable strength will be almost achieved after the final set.

Knowledge of the setting properties is vital in the field of concrete industry. It can be very useful in managing scheduling through the life cycle of the construction project such as concrete transporting & placing & compacting and finishing. All information about the construction method or the period of transporting is necessary to decide the use of a retarding admixture or accelerator or not, and the hydration process starts immediately when the water mix adds to the cement. The different mineral admixtures have different chemical, mineralogical compositions, and different particle characteristics, they could have various components affecting the characteristic of concrete inclusive of the concrete setting.

Slump is the most essential test for workability (e.g., ASTM C 143 or BS 1881:Part 102). The main goal of this test is to relate the change in water content with changing in the slump. For illustration, increasing the slump value leads to a lowering in the strength of concrete.
Nevertheless, various factors are affecting also in the changing of a slump not only higher water content but also the cement components as well as the grading and shape of aggregates.

To increase the slump value of the concrete, it can be achieved by adding chemical admixtures or lower water content. Changes in cement component or cement fineness often lead to a change in the effectiveness of chemical admixture and hence the changing in a slump. The slump test is considering a necessary test to clarify any changing inconsistency or fluidity during the transporting of the concrete and also retarder the setting time of concrete. However, the cause of the change is not easy to detect.

Workability often refers to the ease of transporting, casting of concrete, and mixing without excessive bleeding or segregation. So that there are more needs to compare between different mixtures. [1]

No single test can survey every one of these properties (workability, durability, slumping, etc). In fact, most of these cannot be easily assessed even though some standard tests have been established to evaluate them under specific conditions (not always similar to that occurring on-site)

The primary purpose of the current study is to investigate the workability and to slump, the experimental studying helps us to increase setting time for transportation operation from the plant to a far construction project and in case of retard the setting time during the pouring of specialist construction.

In recent years, many types of research have been studied in different cases about setting time, workability, and durability, which are the most critical factors that affected the characteristics of concrete.

B. Sri Umniati, Puput Risdanareni, Fahmi Tarmizi Zulfikar had an undertaking to expand the workability of geopolymer concrete by utilizing retarder admixture (Plastocrete RT6 Plus). Using distinct percentages of fly ash quantity (0.2%, 0.4% and 0.6%) in the satisfied of retarder. To perform the direct, geopolymer concrete without retarder (0%) were also made. The activator manner in this study was Na2SiO3 add to NaOH10M discharge, with a proportion of 1:5. The terminate liable an optimal makeup of geopolymer concrete with 0.6% retarder, where initial setting time occurs after 6.75 hours, the final setting time occurred after 9.5 hours. furthermore, the geopolymer concrete slump was 8.8 cm, and the slump flow was 24 cm. [2]

The hot weather leads to the fast evaporation of water from the surface of the fresh cement paste. Using the retarders to exchange the accelerating realization of hot weather on the concrete setting time, and it can be treating the effects of various extraordinary conditions. [3]

The retarder mixture can be used in retarding the setting time of concrete [4] This phenomenon can lead to one or more of the process among which; the admixture molecules are adsorbed on the surface of the cement particles, and it can be stopping the reactions between cement and water.

M. H.R. Khudhair, M.S. Elyoubi [5] have reached to methodology to enhance the mechanical performance of mortars and/or concrete, including the porosity /the capillary absorption / the compressive strength and decreasing the amount of mixing water used.

The chemical additives can affect the setting and hardening of Portland cement. Different types of retarders and accelerators are known. The commitment recommendations from the American Concrete Institute clarify the narrative of the effects of additives upon the characteristics of concrete [6]

In the past, the reaction of the organic material in the retarding setting is not known and not fully understanding the effects of their reactions [7]. Taplin [8] supposed that organic substances retard by adsorption either on the surface of the clinker minerals to protect them from water attacks, or on the surface of a coherent coating of hydration products to stop the transporting of material to or from the clinker surface.

Mortars containing ordinary Portland cement and micro-silica setting time are more significant than mortars with nano-SiO2 particles setting time. [9]

Bazid Khan and Muhammad Ullah [10] discovered that the effects of admixture on setting time of cement pastes are relying on the type of cement and dose of the admixture. It can be lead to set retardation of the three different kinds of cement used,

Cement Paste was created, which gradually stiffens and hence hardens. Setting means the stiffening of cement paste [11].

Fundamentally, the setting is a mechanism to change the concrete from an initial state, a scattered concentrated suspension, to a final state, a connected and strengthened system of particles. The chemical reactions between cement particles and water (cement hydration) can cause this transformation in the practice of cement and concrete [12]. Normal setting time of cement is referred to as hydration of Alite (impure C3S) and composition of the calcium silicate hydrate (CSH) phase [13].
Using the retarders to inhibit the accelerating effects of high temperatures which reduced the setting time, or to solve the problems results from unfavorable delays between mixing and placing occur [14]. Concrete setting properties are the most vital part of the concrete construction phase (Brooks et al., 2000) [17]. It assists in the evaluation of different concreting processes transporting, casting, consolidation, and hydration. The casting of fresh concrete in the formwork relies on the concrete setting time, which makes the concrete hardening (Clear and Harrison, 1985) [18].

The hard behavior of the matrix can specify the final and initial hardening time of concrete. The initial setting time of the concrete points to the onset of the hardening of the mixture and the final setting time points to the adequate hardness of the concrete mixture (Naik et al., 2001) [19]. (Brooks et al., 2000) Studies showed that increasing of content of fly ash within the binder follows with increasing in setting time [17]; Carette and Malhotra, 1984) [20].

Niragi Dave a, Anil Kumar Misra , Amit Srivastava, S.K. Kaushik [21] found that setting time of tripartite blended concrete created from FA and GGBs referred to retarding initial hardening time in the range of 60–120 min, in the thesis using additives to achieve the set time after 6.5 hours is our target to save construction requirements

M. Davraz [22] discusses the measurements of Setting times dependent on PH, EC, and T changes of fresh mortars. With increasing BA concentration, ph, electrical conductivity, T values of the mortars will reduce, and on the other hand, setting times of mortars will increase.

Chaiyakrit, Ram, Chalermschai [23] solve the problem of the slump of concrete by using the second dosage of superplasticizer (naphthalene based type F) which add during the process to recover the slump loss, eventually, the compressive strength and setting time of concrete can achieve after dosage with chemical admixtures type F (superplasticizer, naphthalene based) for slump recovery. On the other hand, the addition of the second dose of superplasticizer will rise, setting times accordingly to additives dose. As for fly ash concrete, the prolongation effect was higher as the replacement of fly ash increase. The prolongation effect can reach up to 4 hours. The acceptable range of compressive strength for the re-dosed concrete ranges between ±10%.

Megahd Ahmed H., M. M. Rashwan , and Mostafa A. showed that After 25 cycles of durability tests, control specimens with the control admixture (secrete wp) and without admixture showed a considerable decrease of their compressive strength. But specimens modified with the suggested admixture (BM 2010) showed respectively a small increase of their compressive strength by about 7% if compared with the same specimens before these cycles of durability test. The suggested admixtures showed a better influence compared to the control admixture secrete wp [24][25].

2. Experimental
The characteristic of materials was used in the experimental to create concrete mixes as followings:

2.1 Materials

2.1.1 Aggregate
The aggregate used in the experimental crushed basalt (as a coarse aggregate), sand (as fine aggregate) have properties as in table (1), (2), and Fig. (1 a&b)

| Table (1): Properties of Aggregate |
|-----------------------------------|
| Property                          | Basalt | Sand  |
| Volume weight (t/m3)              | 1.59   | 1.68  |
| Specific gravity                  | 5      | 2.5   |
Table (2): sieve analysis of aggregate.

| Sieve size | % Passing by weight | Basalt | Sand |
|------------|---------------------|--------|------|
| 40mm       | 100                 | ---    | ---  |
| 20mm       | 98.31               | ---    | ---  |
| 10mm       | 39.94               | ---    | ---  |
| 5mm        | 1.97                | ---    | ---  |
| 2.5mm      | ---                 | 100    | ---  |
| 1.25 mm    | ---                 | 99.96  | ---  |
| 0.63 mm    | ---                 | 88.57  | ---  |
| 0.31 mm    | ---                 | 58.35  | ---  |
| 0.16 mm    | ---                 | 18.7   | ---  |
| No. 100    | ---                 | 8.13   | ---  |

Fig. 1a. Aggregate sieve analysis (crushed stone)

Fig. 1b. Aggregate sieve analysis (sand)
2.1.2. Cement
Ordinary Portland Cement (OPC) conforming to Egyptian standard was used. The physical properties of the used cement are shown in Table (3)

| Table (3): Cement Properties. |
|--------------------------------|
| Fineness of cement | 3300 cm²/gram. | 3300 cm²/gram |
| Strength of cement | 2 day | 248 Kg/cm² | ≥100 Kg/cm² |
| | 28 day | 425 Kg/cm² | ≥325 Kg/cm² |
| Setting time | Initial | 2:12 hour | ≥75 minute |
| | Final | 4:45 hour |

2.1.3. Silica fume
Silica fume was used in the process to produce silicon metal and ferrosilicon alloys. Properties of silica fume comprises high content of amorphous SiO2 & particle size of 0.1 -0.2 micron with spherical shape, the percentages of chemical component were taken in the experimental as shown in table (4), and the originate of production for the component is Egyptian Ferroalloys Co. in Edfo city.

| Table (4): Chemical component of used silica fume. |
|-----------------------------------------------|
| The component | Sio2 | Fe2O3 | Al2O3 | MgO | Na2O | K2O | CaO | H2O | L.O.L | C |
| Percentage | Min. | Max. | Max. | Max. | Max. | Max. | Max. | Max. | Max. | Max. |
| of component | 92% | 1.5% | 1.5% | 1.0% | 0.8% | 1.3% | 0.5% | 1.0% | 2.0% | 1.5% |

2.1.4. Water
The water used in the concrete mixtures is validated for drinking

2.1.5. Additives
Sikament NN:
A superplasticizer without retarder (ASTM C494 Type F) "A highly effective dual-action liquid superplasticizer to produce free-flowing concrete or as a substantial water-reducing agent for promoting high early and ultimate strengths.

Sikament R2008:
A superplasticizer (ASTM C494 Type G) "A highly effective superplasticizer with a set retarding effect for producing free-flowing concrete in hot climates. Also, a substantial water reducing agent for promoting high early and ultimate strengths". with a density of 1.185 Kg/L
2.2 Concrete mixtures
The test for studying the setting time and strength concrete is based on producing high strength concrete after 28 days, the high strength concrete after 28 days were about 700 Kg/cm². Concrete mix trails proportion is shown in table (5).

| Mix No. | Cement Content (Kg/m³) | Sand Content (Kg/m³) | Coarse Agg. Content (Kg/m³) | Silica Fume content (Kg/m³) | Sikament R2008 Liter/m³ | Sikament NN Liter/m³ | Water content (Liter/m³) | Initial Slump (cm) |
|---------|------------------------|----------------------|-----------------------------|-----------------------------|-------------------------|-----------------------|--------------------------|-------------------|
| 1       | 500                    | 727                  | 890                         | 50                          | 8                       | 8                     | 200                      | 25                |
| 2       | 500                    | 727                  | 890                         | 50                          | 8.75                    | 8.75                  | 200                      | 26                |
| 3       | 500                    | 727                  | 890                         | 50                          | 10.75                   | 10.75                 | 200                      | 28                |
| 4       | 500                    | 727                  | 890                         | 50                          | 11.75                   | 8.75                  | 200                      | 27                |

A superplasticizer was used (Sikament R2008, Sikament NN). Six standard cubes 15 x 15 x 15 cm were cast from each mix and cured in laboratory.

2.3 Fabrication of tested samples
the mixture of 0.1 m³ capacity can be used in the composition of the constituent materials .in the beginning, mix the dry aggregates, cement, silica fume and aggregate for a one minute and then add the water which mixed with admixtures to create continuity mixing of the component until reaching to the homogenous constituent, this process will take two minutes to finish
Erect the experimental specimens by using steel forms, before pouring the specimens, and there are some steps to follow:
- Grease all the interior form to simplify the extraction of the concrete beams
- Transporting the concrete of the plant by hand shovels with steel form
- Execution the compaction by using the mechanical vibrator
- No of specimens is three cubes with 15 cm side length
- Removing the forms after one day from pouring for all specimens.
- In the final process, the concrete specimens by submerging in the water tank until 28 days.

2.4 Instrumentation (Description of the testing machine)
Using the testing machine (MATEST to 100 tons up) to execute the static load, which loaded from zero until failure.
3. Results and Discussions
The results from lab tests done for the concrete compressive strength and the workability of the fresh concrete, just a slump test has been done to get the fresh concrete properties.

The average values of cube strength of 7 and 28 days for each mix are shown in table (6) and fig (2).

Table (6) The average of cubic strength

| Mix No. | Compressive strength Kg/cm² (Average of three cubes) |
|---------|---------------------------------------------------|
|         | After 7 days | After 28 days |
| 1       | 610          | 668           |
| 2       | 616          | 678           |
| 3       | 640          | 711           |
| 4       | 626          | 755           |

Fig.2 Compression strength of concrete mixes
Effect of mixing two types of superplasticizer with retarder and superplasticizer without retarder on Slump Loss has been investigated. The results of slump loss for superplasticizer with and without retarded on concrete shown in Fig 3 and 4. Figures confirmed that slump decreases with increasing time. It also showed that the hydration technique produces calcium silicate hydrate, which fills the pores between the combination and particles of aggregates and cement. As a result, the setting of the concrete will reduce concrete fluidity, hence, reduce the slump too. When observation is carried out on adding of super plasticized with and without retarded, growth in dosage of the chemical admixtures will increase concrete setting time, in view that both of the superplasticizers with and without retarder will help to preserve the concrete liquidity for an extended time, and as a result, lessen the slump loss during transportation of concrete to site. However, the overdosage of these admixtures will not cause excessive slump. If comparisons are made between the superplasticizers with and without retarder, the sitting time for retarded concrete is longer than the plasticized without concrete. After 360 mins (6 hours) as a result, the end showed that retarder gives higher power in keeping the concrete slump than the superplasticizers without retarder does at the same dosage.

From results, the increase of the dose of superplasticizer with retarder to 2.35% mixed with superplasticizer without retarder dose 1.75% will gain the minimum slump loss with time needed (6 Hours).
The effect of adding of superplasticizers with and without retarder on Compressive Strength of concrete with different dosages are shown in Fig. 5 and 6. This test is performed at age 7 and 28 days. The values of compressive strength for the different dosage of superplasticizer with and without retarder are then shown as in Fig 4 and 5 & 6. From the figures, strength gains from adding chemical admixture is discovered by way of the growth in compressive strength with age. At an early age (7 days from casting), the strength is high for a reason that reaction of cement particles with water is active. Hence, the slope of the curve for age 28 days is less steep compared with an early age.

![Figure 4](image_url)

**Fig. 4** Effect of superplasticizers with and without retarder on workability loss based on slump

![Figure 5](image_url)

**Fig. 5** Effect of superplasticizers type and dosage on compressive strength After 28 days
Mix of admixtures doses show different behavior on the cubic strength of concrete. At age 7 days, the growth of dose of superplasticizer with retarder growth of concrete cubic strength until dose 2.15%, on the other hand, more increasing of dose until 2.35% reduces the strength, the cause for this phenomenon is that addition of retarder to the concrete will put off the reaction of C3S and C3A. As a result, strength development is low. This varies happened only after 7 days from casting for adding the same dose from each admixture type, in which inclusion of superplasticizer with retarder will improve cubic strength at a later age. For superplasticizer without retarder, the increase of dosage will increase the cubic strength for every age also until dose 2.15%. Considering that the addition of superplasticizer without retarder will provide water for concrete mixing, the hydration technique will not be disturbed, but it is expanded with adding of additional water from the deflocculation of cement particles. Hence, growth in dosage will increase the entrapped water and promote hydration of cement. Though the growing dosage of admixture will increase the compressive strength, there will be nonetheless a top of the line limit for using admixture. While the dosages go beyond this limit, the boom in dosage will become most effective in reducing the compressive strength.

This phenomenon occurs because the overdosage of superplasticizers with retarder & superplasticizers outstanding of retarder will purpose bleeding and segregation, to be able to affect the cohesiveness and uniformity of the concrete. As a result, cubic strength will less if the used dosage is beyond the optimum dosage. For early age, cubic strength of concrete containing a mix of plasticizers with retarder 2.15% and awesome plasticizers without retarder 2.15% exceeded to 640 kg/cm². While, overall performance of higher dosage decreases the cubic strength. But, for a long time (28 days), cubic strength, blend of plasticizers with and without retarder provide proper result, in which the cubic strength exceeds to 755 kg/cm².

4. Conclusion
This paper was conducted to study the effects of superplasticizer and retarder on properties of high strength concrete with characteristic strength of 700 kg/cm², which having slump 15 cm after 6-hour retardation. The properties investigated were workability (slump), and compressive strength. However, the conclusion, which follow are drawn based on experimental results and observations presented earlier. These conclusions are of necessity specific to this study, is related to the type of superplasticizer with retarder and superplasticizer without retarder, an environmental condition during testing, testing method, etc. Nevertheless, the findings of this investigation should provide a significant contribution towards the knowledge on the effect of mixing of superplasticizer with retarder (Type G) and superplasticizer without retarder (Type F) on properties of concrete.
The properties of concrete containing superplasticizer with and without retarder (Type G & Type F) had been successfully studied. From the results of the study presented earlier, the following conclusions are offered:

- The workability of concrete can be increased by the addition of a mix of superplasticizer with retarder (type G) with dose 2.35% and superplasticizer without retarder (type F) with dose 1.75 % by weight of cement content for each one.
- Slump loss can be reduced by using the chemical admixtures superplasticizer with retarder (type G) with a dose of 2.35% mixed with superplasticizer without retarder (type F) with a dose of 1.75 %.
- Compressive strength is improved by superplasticizer with and without retarder for ages 28 days.
- Saving concrete workability with slump 15 cm until 6 hours with gaining compressive strength 755 Kg/cm² can be achieved by adding a mix of superplasticizer with retarder (type G) with dose 2.35 % and superplasticizer without retarder (type F) dose 1.75 % of cement content for each one (such as mix 4).

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