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EFFECTS OF CONTINUOUS MIXING ON MECHANICAL PROPERTIES OF CONCRETE

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ABSTRACT

Mixing time and Temperature have adversely influenced on the mechanical properties of concrete. The traveling time of the transit mixture from the plant to the work site is critical, especially where the forecast of travelling time is difficult due to a traffic jam or other uncertainties. At the same time, the ambient temperature at concrete casting time is another factor. A laboratory study was conducted to investigate the impact of different mixing time on the performance of concrete and find out its effect on concrete. To achieve the study goal, the concrete mixtures drum was continuously rotated for up to 5, 60, 120 and 180 min maintaining a constant rotation of 15 per minute under a controlled temperature of 25°C and 40°C. The effects of prolonged mixing scheme under various temperatures on critical properties such as the slump loss, compressive strength, splitting tensile strength and permeability of concrete were done at 3, 7, 28 and 90 & 120 days age of concrete. The results showed that concrete can undergo substantial slump loss when subjected to prolonged mixing at 40℃ temperature. At 25℃ temperature, compressive strength decreased with the increase of mixing time; but at 40℃ temperature, reverse result was observed. At 25℃ temperature, splitting tensile strength decreased, however, at 40℃ temperature splitting tensile strength was increased with mixing time and the Permeability of concrete was increased with increasing of mixing time and temperature.

Keywords: *Mixing time, Temperature, Strength, Permeability*

1. INTRODUCTION

Concrete is a structural material widely used in the construction industry. The physical properties of aggregates, chemical composition of binding materials as well as water cement ratio influence on the properties of concrete. Since the long-term properties of concrete are seriously affected by its degree of compaction, it is vital that the consistency or workability of the fresh concrete be such that the concrete can be properly compacted, transported, placed and finished easily without segregation. The mixing time of the concrete production have a profound effect on the working performance and the strength property (Dong, et. Al. 2011). For mixing over a long period, workability decreases with time due to loss of moisture from the mix. To restore the workability, water is to be added and finally gives a lower strength of concrete (Neville, 2000). However, according to Shetty (1982), Long time mixing of concrete will generally result in increase of compressive strength of concrete within limits. Due to mixing over long periods, the effective water cement ratio gets reduced, owing to the absorption of water by aggregate and evaporation. It is also possible that the increase in strength may be due to the improvement in workability on account of excess of fines, resulting from the abrasion and attrition of coarse aggregate in the mix, and from the coarse aggregates themselves becoming rounded. The length of mixing time required for sufficient uniformity of the mix depends on the quality of blending of materials during charging of the mixer: simultaneous feed is beneficial. To ensure the uniform workable of concrete and good strength properties, an appropriate and economic mixing time should not be ignored (Dong, F., MingKai, Z. and HuaGang W. 2011). The

performance of concrete are also affected by temperature because of the loss of workability. On a hot weather it becomes necessary to increase the water content of the concrete mix in order to maintain desire workability. The amount of mixing water required to bring about a certain change in workability also increases with temperature (Gambhir, 2009). Although a higher temperature during placing and setting increases the very early strength, if may adversely affect the strength from about 7 days onwards. The explanation is that the rapid initial hydration appears to form products of a poorer physical structure, probably more porous, so that a proportion of the pores will always remain unfilled (Neville, 2000). In connection with the influence of temperature during the early life of concrete on the overall structure of the hydrated cement paste, it is useful to recall that a low early again of strength has a beneficial effect on strength also when the hydration is showed down by the use of retarders. Water reducing and reduction in the long-term strength of admixture free concrete placed at a high temperature. It should be realized, however, that their effect arises from water reduction and therefore a lower water cement ratio. It has been found that high early temperature has negative impacts on later strength of concrete. Some researchers investigated the adverse effect on long term strength of concrete due to high initial temperature. High initial rate of hydration due to increased temperature retards the subsequent hydration and produces a non-uniform distribution of the products of hydration. Its reason is that at high initial rate of hydration, there is insufficient time available for the diffusion of the products of hydration away from the cement particle and for a uniform precipitation in the interstitial space. Some field tests have confirmed the influence of temperature at the time of concrete placement. Typically, for an increase of 5^0C (9^0F) there is a decrease in strength of 1.9 MPa (270 psi) (Donson, C. J. and Rajagopalan, K. S. 1979).
The coupled effects of ambient temperature and mixing time on the slump loss of fresh concrete are critical for hot weather concreting. The quality of concrete can be adversely affected during mixing, placing, and curing at elevated temperatures (Abbasi FA and Al-Tayyib AJ. 1983). So mixing time and temperature are an important factor which effect on the properties of concrete such as workability, strength, durability, stiffness, ductility, hardness, elasticity etc. Among them, in this study attention is given on workability, strength, permeability and absorption of concrete.

2. METHODOLOGY

2.1 Preparation of specimen

The concrete was prepared with 1:2.3:3.4 proportion of cement: C. Aggregate: Fine Aggregate and target slump value 80±3mm. In mixing concrete, a tilting concrete mixer was used. Coarse aggregate was weighted by water sprayed over it before 24 hours of casting to achieve SSD condition. The concrete mixer drum was moistened and then the weighted aggregate was poured in the mixer machine and rotated for 1minute and thereafter 2minutes with addition of cement. Finally tap water was added in two stages, at first 70% of water had been added and rotated the mixing hopper for 1minute and additional 2minutes rotation was performed after mixing the rest amount of water without stopping the mixer machine and finally adjusted initial slump value 80mm shown in Figure 1. After this the mixer machine had been continuously rotated for 5minutes, 60minutes, 120minutes and 180minutes for the test. In every 20minutes initial slump were adjusted by adding extra water. Concrete slump value of 5 minutes mixing time was considered as reference one. The additional water was added at regular interval throughout the mixing time. The concrete was poured in cylindrical molds of 100mm diameter and 200mm height after completion of target time. Casting of mixed concrete was made in traditional way, filling from above and manual compaction confirmed with tamping rod in three layers and finally finished the top surface shown in Figure 2. A closed chamber was prepared to maintain the temperature shown in Figure 3. After 24 hours, they were submerged in water for curing about 3days, 7days, 28days, 90days and

120days as required for the test. This process was performed at 25℃ and 40℃. Curing was performed according to ASTM C192.

Figure 1: Mixing of Concrete

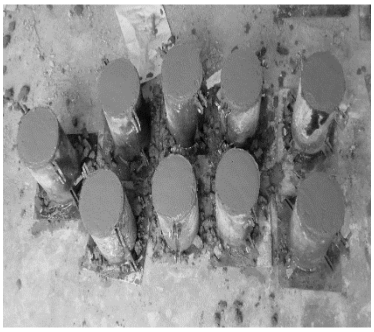

Figure 2: Concrete specimen

Figure 3: Control chamber

2.2 Testing

In this study, uniaxial compressive strength test on cylinder specimens (4 in x 8 in) at the age of 3, 7, 28, 90 and 120 days were performed according to ASTM C39. Splitting tensile strength test was also performed. Permeability test on concrete samples were performed according to ASTM C1202. In this test, 50 mm thick slices of 100 mm nominal diameter concrete cylinders were collected from cylindrical samples of 100 mm diameter and 200 mm height. The sides of the cylinder specimen were coated with epoxy and left to be dried. Then it had been put in vacuum chamber for 3 hours. The specimen had been kept for vacuum saturation for 1 hour and allowed to soak for 18 hours. It was then assembled with the test device. The left hand side (-) of the cell was filled with a 3% NaCl solution. The right-hand side (+) of the test cell was filled 0.3N NaOH solution. Figure-3.7 illustrates rapid chloride permeability test setup. After that the system was connected with a 60-volt DC current for 6 hours. Readings were taken at regular interval of 30 minutes. At the end of 6 hours the sample was removed from the cell and amount of coulombs passed through the specimen was calculated. Test setup is shown in Figure-4.

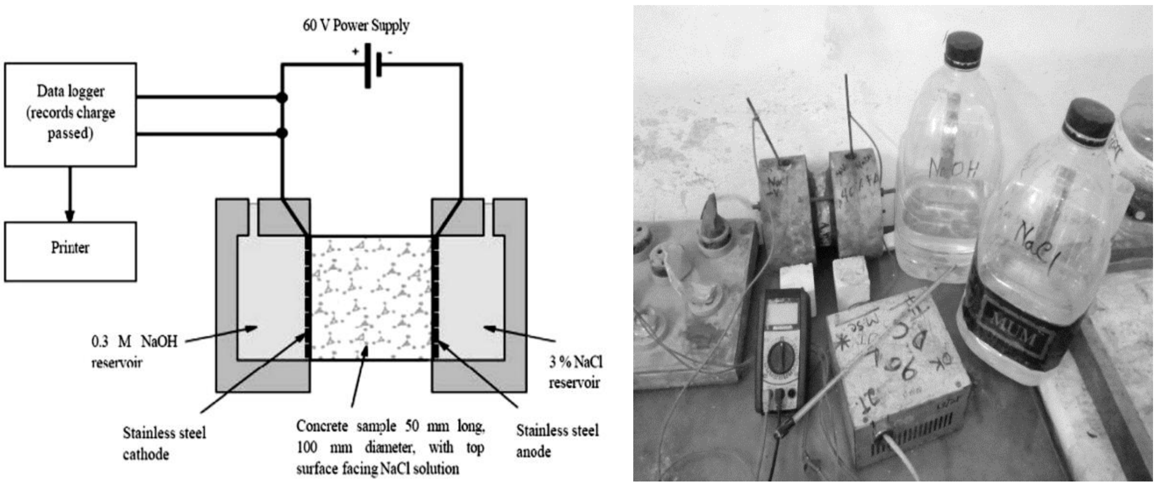

Figure 4: Rapid chloride permeability test setup

3. RESULTS AND DISCUSSIONS

3.1 Compressive strength

In this research work, the compressive strength is gradually decreased with increasing of mixing time showed in Figure 5. Due to adding extra water in the mixer the w/c ratio was increased and that's why the strength of concrete gets reduced at 25℃ temperature. The graph shows that when the mixing time was 5min then the strength was high compared to the mixing time at 60, 120 and 180 minutes.

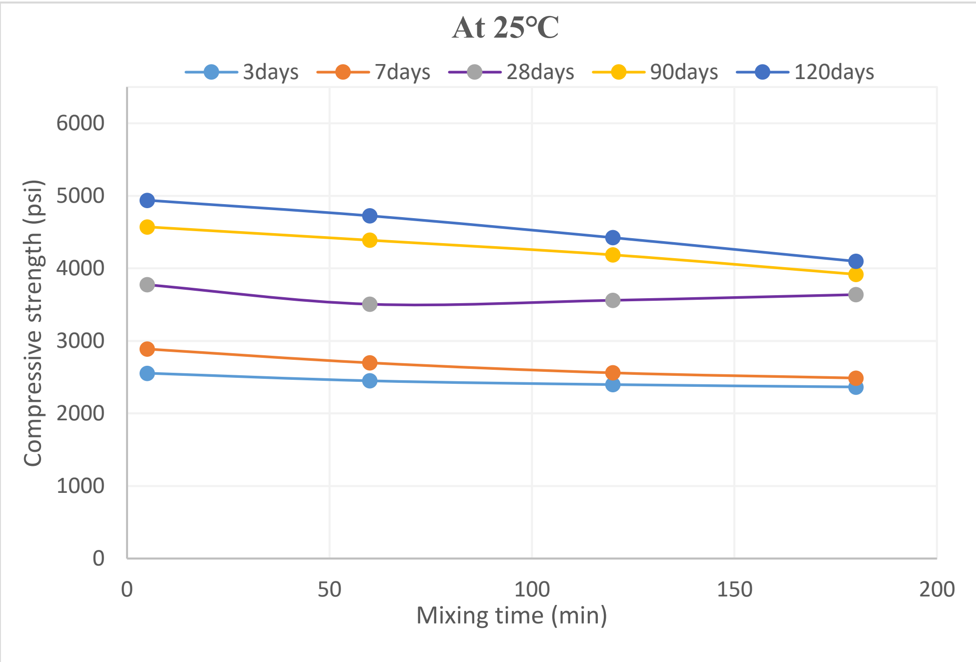

Figure 5: Compressive strength at different mixing time (25^{0}C Temperature)

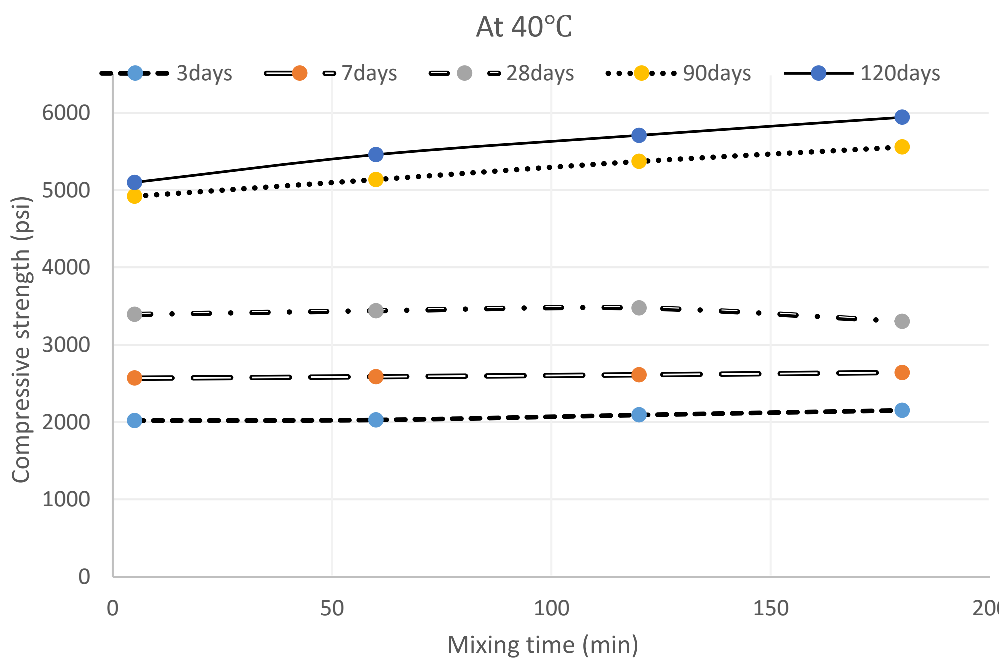

Figure 6: Compressive strength at different mixing time (40^{0}C Temperature)

On the other hand, at 40℃ temperature, the strength increased with the increasing of mixing time. It shows the opposite result compared to 25℃ temperature. It is observed From Figure 6 that, the variation of compressive strength at different mixing time. Initially, the strength is low and after increasing of mixing time the strength is increased. At mixing time 180 minutes the result of compressive strength is higher than other mixing time of 5, 60 and 120minute.

Table 1 shows the Compressive strength test results**.** It is obtained from research work. The above graphs are based on this table.

Table 1: Compressive strength test results

Mixing Time (minute)	**Temperature (ºC) (±3)**	**Compressive strength (psi)**				
		3days	7days	28days	90days	120days
5	25	2555	2888	3774	4572	4939
	40	2020	2568	3392	4920	5100
60	25	2450	2698	3506	4388	4724
	40	2028	2587	3440	5136	5458
120	25	2398	2560	3560	4186	4423
	40	2092	2612	3476	5370	5708
180	25	2365	2488	3638	3918	4097
	40	2152	2642	3303	5556	5941

3.2 Splitting tensile strength

It is seen from Figure 7, that splitting tensile strength increases with the increasing of mixing time for 40℃ temperature. On the other hand, at 25℃ temperature strength decreases with the increasing of mixing time.

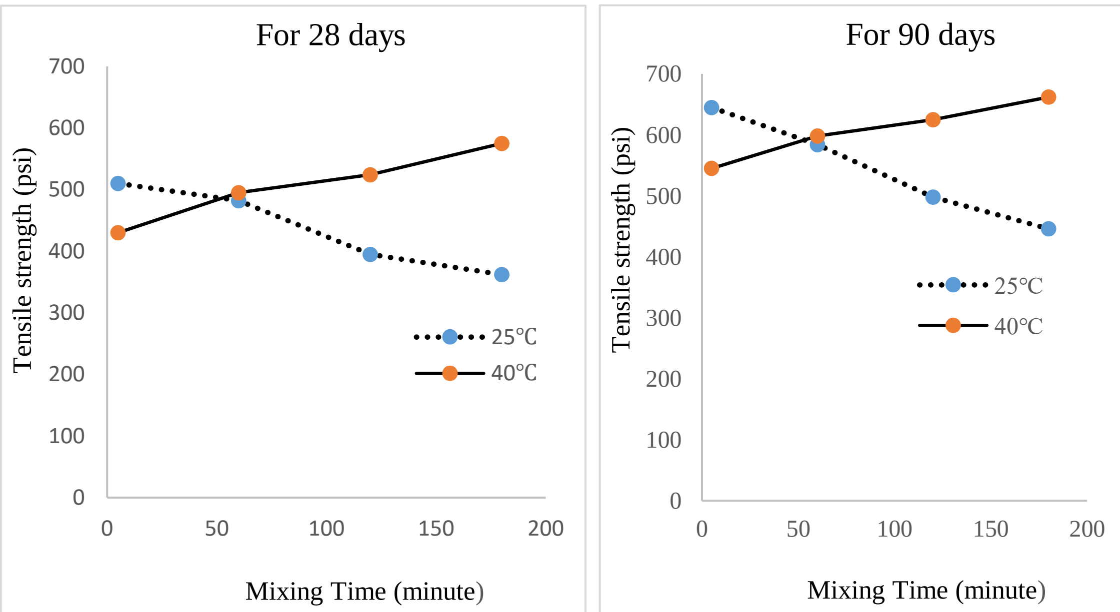

Figure 7: Tensile Strength at different mixing times and temperature

Table 2 shows the result of Tensile strength of concrete at different time and temperatures.

Table 2: Tensile strength test result

Mixing Time (minute)	Temperature (ºC) (±3)	Splitting Tensile Strength (psi)	
		28days	90days
5	25	510	645
	40	430	545
60	25	482	584
	40	495	598
120	25	395	498
	40	524	625
180	25	362	446
	40	575	662

3.3 Permeability test result

From research, it is observed that At 25℃ temperature, the permeability result is in between the range of 1000-2000C, which shows low permeability. On the other hand, initially for the 40℃ temperature at mixing time 5-100 minute, the result is in between 1000-2000C, which means at this mixing time the permeability is low, but after that, the permeability result becomes moderate according to ASTM C1202. When the temperature is high then the hydration process becomes very fast and for that reason, the permeability of concrete increased with the increase of mixing time and temperature.

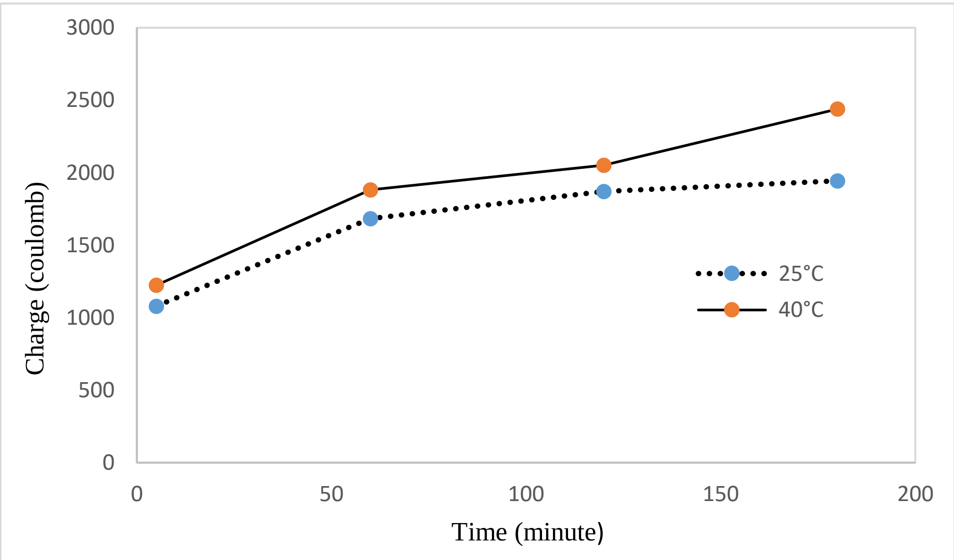

Figure 8: Effects of mixing time at different temperature on Permeability

Table 3 shows the result of Charge Passed at different mixing time& temperatures

Table 3: Charge Passed at different mixing time & Temperature

Mixing Time (minute)	**Temperature (ºC) (±3)**	**Charge Passed, Q (Coulombs)**
5	25	1080
	40	1224
60	25	1683
	40	1881
120	25	1872
	40	2052
180	25	1944
	40	2439

4. CONCLUSIONS

Based on the findings of this work, the following conclusions are summarized.

Water demand for Concrete of constant workability at 40℃ temperature was high compared to 25℃ temperature. At 25℃ casting temperature, the Compressive strength was decreased with the increasing of mixing time, however, reverse result was found at 40℃ temperature.

At 25℃ temperature splitting tensile strength decreases but at 40℃ temperature splitting tensile strength increases with mixing time. The permeability of concrete was increased with increasing of mixing time and temperature.

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