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Enhancement of Mix Design for Early Strength Concrete

By applying and studying an Experimental work

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الملخص العربي:

أصبحت الحاجة لاستخدام خرسانة مبكرة المقاومة من اهم المتطلبات المرجوه في المشروعات الضخمة ولذلك اهتم الباحثين حديثا بالعمل علي تطوير الخلاطات الخرسانية مبكرة المقاومة بشتي الطرق المختلفة التي تعطي الكفاءة المرجوه باقل تكلفة اقتصادية ممكنه. تهتم هذه الدراسة بتحسين خواص الخلطات الخرسانية التقليدية وذلك للحصول علي مقاومة مبكرة للإجهادات المختلفة وذلك بتقليل نسبة الماء/ الاسمنت من 0.50 إلي 0.35و 0.30 في الخلطات الخرسانية ، وللحفاظ علي درجة التشغيلية والهبوط للخرسانة تم استخدام ملدنات مخفضة للماء من النوع A وملدنات عالية التخفيض للماء من النوع F المتوافقة مع المواصفة الامريكية للإضافات الكيميائية للخرسانة (ASTM C494) وكذلك تم دراسة تغيير محتوي الاسمنت في الخلطة من 400 كجم /م^3 إلي 450 كجم /م^3 و 500 كجم/م^3 في وجود الاضافات عالية التخفيض للماء مع نسبة ماء / الاسمنت 0.35 وقد تم دراسة كل من مقاومة الضغط والانحناء والشد الانفلاقي عند اعمار 1، 3، 7، 28 يوم كما تم تعيين معاير المرونة عند عمر 28 يوم لكل الخلطات. واظهرت النتائج ان استخدام الاضافات عالية التخفيض للماء مع تقليل نسبة الماء للاسمنت الي 0.30 وكذلك استخدام الاضافات عالية التخفيض للماء مع نسبة ماء/ اسمنت 0.35 بمحتوي اسمنتي 450 كجم/م^3 سجلت زيادة في مقاومة الاجهادات المبكرة وقاربت نتيجة مقاومة الضغط لها عند عمر 3 ايام نتيجة مقاومة الضغط عند عمر 28 يوم لخلطة التحكم وكانت قيم مقاومة الضغط عند عمر 7 ايام اعلى من مقاومة الضغط لخلطة التحكم عند عمر 28 يوم بتكلفة زائدة في حدود 28 الي 29% علي الترتيب من تكلفة خلطة التحكم. بينما سجلت الخلطة المحتوية علي 500 كجم/م^3 اسمنت واضافات عالية التخفيض للماء ونسبة ماء للاسمنت 0.35 مقاومة اعلي عند عمر 3 ايام عند مقارنتها بمقاومة خلطة التحكم عند عمر 28 يوم وكانت نسبة الزيادة في التكلفة في حدود 40%.

ABSTRACT :

The use of early strength concrete in the present is one of the most common demands for producing the pre-strength concrete; Majority of using pre-strength concrete now in the capital projects aim the researchers to study the ways to make the early strength concrete more efficient and economical in the same time. This study aim to improve the process of design and produce; economic and efficient concrete by the local common materials on Egypt. An experimental program contains seven different concrete mixes cast and testes in the HBRC lab in Egypt. The variables are changing cement content from 400 kg/m^3 to (450&500) kg/m^3 Also change in water/ cement ratio was studied and use water reduce chemical admixtures type A and high range water reduce chemical admixture Type F to keep the slump as same as control mix. The mechanical properties as compressive, flexural, and splitting tensile strength at ages 1, 3, 7, and 28 days were studied. Also, 28 days modulus of elasticity for all mixes was determined. An economic study applied to compare the mixes contains different cement content with different types of chemical admixtures refer to control mix.

Results revealed that reduce water cement W/C ratio from 0.50 to 0.30 with using type F as chemical admixture and when increase water cement content to 450 kg/m^3 with W/C ratio 0.35 and type F as chemical admixture is resulted in increase in early strength and the strength at age 3 days almost equal the 28 days strength for control mix. The cost of these mixes were raise by (28 to 29) % respectively compared with the cost of control mix, and its strength after 7 days was more than 28 days strength of control mix. While, using cement content 500 kg/m^3 with W/C ratio 0.35 and Type F chemical admixture resulted in strength after 3 days more than 28 days strength for control mix, but the cost was raised by about 40%.
Keywords*:* concrete; cement; chemical admixture blending ratio; compressive strength; Early Strength.

1. INTRODUCTION

Accelerated construction techniques have become a popular alternative to using traditional construction techniques in the capital projects because of the reduction of time spent in field activities. To date, the materials developed for closure pours have been based on proprietary components, so a need has arisen for development of mixes that use generic components. The goal of this research was to create a method to develop concrete mixtures that are designed using generic constituents and that satisfy performance requirements of accelerated projects construction, primarily high early strength and long-term durability.

A literature review was performed on each of the constituents that will be considered in the development of the high-early strength concrete mixture designs.

S. F. Breña and S A. Civjan, (2018), develop the concrete mixtures, they were studied various proportioning methods. They work to create a method to develop concrete mixtures that are designed using generic constituents and that satisfy performance requirements of accelerated bridge construction closure pours in New England, primarily high early strength and long-term durability. Two concrete mixtures were developed with a primary goal of reaching high-early strength while maintaining constructability. The secondary goal of the concrete mixtures was to be durable; therefore, measures were taken during the development of the concrete mixture to generate a mixture that also had durable properties. Based on the results seen while developing these concrete mixtures, a concrete mixture design specification was written for concrete mixtures used for accelerated bridge construction closure pour applications. They concluded that reaching a compressive strength of 4000 psi in 12 hours is difficult to achieve while maintaining adequate constructability and while using non-proprietary materials. A compressive strength of 3500 psi after 12 hours of curing at 80°F was attainable while maintaining constructability and meeting durability goals. Therefore, if a compressive strength equal to 4000 psi is required, then the concrete should be given 14 hours to cure, or the concrete should be cured at a higher temperature.

Parameshwar N. et al. (2017), studied the early strength development of Reactive Powder Concrete (RPC) under different curing regimes and compared with standard water curing condition. Four different curing regimes have been considered: ambient air curing, hot air curing, hot water bath curing and accelerated curing. Test results indicate that, among the four different curing regimes, hot water bath curing gives higher strength. The combined curing regime has considerably enhanced the compressive strength of RPC by about 63% as is evident by the rise in compressive strength from 110 MPa (standard curing) to 180 MPa (combined curing).

Shahin Eskandarsefat, (2018), was considered the cold weather concreting techniques, using concrete additives and High Early strength cement. He examined the effects of mix-water temperature on some of the performance and mechanical properties of concrete made with High-Early strength cement. The experimental program included the tests for both fresh (or plastic) and hardened concrete with various water temperatures in the range of 5 – 90 °C. Based on the experimental results and field-practices' observations it could be concluded that the optimum mixing water temperature range is 50 ± 5 °C when using High-Early strength cement. In addition to the examined compressive strength, bleeding and optimum slump of mixtures were observed within the same temperature range. The higher temperature of mixing water out of this range resulted in higher bleeding, segregation, and further relative failures in this study.

A study performed by Han et al. (2013) performed to determine the effect of high range water reducing (HRWR) admixture on strength of concrete investigated the effect of various HRWR dosages to cement ratios (by mass), in the range from 0 to 1.2%. These dosages were studied for a high and low w/cm ratio. The optimum HRWR dosage leading to the ideal dispersion of cement particles in the mortar and maximum compressive strength was found to be 1% for the w/cm ratios studied (0.3 and 0.6).

Water reducing admixtures have also shown to increase the entrained air in concrete (ACI Committee E-701 2003; Kosmatka et al. (2003)). Consequently, the air content in the mixture should be checked when water reducers are used, and the air entraining admixture dosage may have to be modified. Water reducing admixtures may also increase drying shrinkage, despite the water reduction. This increase is typically small compared to other factors that cause shrinkage (Kosmatka et al. 2003).

The water-to-cementitious materials ratio (w/cm) has a significant impact on many properties of plastic and hardened concrete. In fact, w/cm has been recognized as the most important quantity associated with strength and durability (Hover and Stokes 1995). Many studies have shown the correlation between compressive strength and permeability with w/cm, Lower w/cm ratio results in higher compressive strength and lower permeability. By lowering the w/cm ratio, the water content is decreased and in turn, drying shrinkage and cracking is also reduced (Kosmatka et al. (2003)).

The use of chemical admixtures and other cementitious materials has proven essential to improve placement of concrete with low w/cm ratios. Guidelines for choosing a w/cm ratio for high-strength concrete can be found in ACI 211.4R (ACI Committee 211 (2008)).

2. RESEARCH PROGRAM

An experimental program was carried out to study the behavior concrete mixtures using different design mix to produce concrete with early strength. This paper presents the fresh and hardened properties of seven concrete mixtures. The main parameters investigated in this study were: coarse chemical admixtures type (group I), cement content (group II), and water/cement ratio (group III). In this study natural sand was used as fine aggregates, while dolomite was used as coarse aggregates. A coarse aggregate to fine aggregate ratio of 2:1 were kept invariant in all concrete mixtures.

The aggregates' grading determined in accordance with EN 12620. The nominal maximum aggregate size is 14mm. Natural siliceous sand was considered for Fine aggregates. The physical and mechanical properties of both fine and coarse aggregates have been assessed and controlled following to the standards EN 1097 and EN 933. Tables 1 summarized the examined values. It is worth mentioning that in order to avoid any inconsistency regarding aggregates, and controlling the temperature of each specimen, concrete samples were prepared for each specimen under controlled temperature (ambient and components) and proportionated mix materials.

CEM I 42.5N compatible with Egyptian standard 4756-1 was used in all mixes Table 2 shown cement properties. Also, tap drinking water were used in the concrete mixes. Locally conventional limestone aggregates, common production and curing procedures used in all concrete mixes.

Table 1: Properties of coarse and fine aggregate

Specimen	Specific weight	Volumetric weight kg/m^3	Absorption %	Fine particles %	Crushing value %	Coefficient of abrasion %
Dolomite	2.67	1.47	2.0	1.8	19.3	22.5
sand	2.6	1.46	0.57	1.2	-	-

Table 2: Properties of Cement

Properties		Measured Values	Limits of the E.S.S*
Fineness (cm2/gm)		3500	
Specific Gravity		3.15	
Expansion (mm)		1.2	Not more than 10
Initial Setting Time (hrs : mins)		1 : 40	Not less than 60 min
Initial Setting Time (hrs : mins)		3 : 20	
Compressive strength (N/mm2)	2 days	18.6	Not less than 10
	7 days	33.7	
	28 days	47.8	Not less than 42.5 and not more than 62.5

Mix design was carried out according to ACI mix design guidelines considering the nominal maximum aggregate size of 14 mm and 80 – 100 mm as the reference slump. Water/cement ratio (W/C), workability and aggregate quantities selected to be suitable to verify each variable in this research. Table 3 represents the details of the mix proportions. Two types of chemical admixtures Type A and Type F compatible with ASTM 494 were used. The two types were used separately and also used together in one mix.

Table 3: Mixtures Configurations

mix	Group	Cement content (kg)	w/c	Type of admixture
E0	I&II&III	400	0.50	-
E1	I&II&III	400	0.35	Type F
E2	I	400	0.30	Type F
E3	II	450	0.35	Type F
E4	II	500	0.35	Type F
E5	III	400	0.35	Type A
E6	III	400	0.35	Type A&F

Mixing and casting procedures were in accordance with ASTM C 192; however some changes considered simulating field practices in ready mix operations. Each specimen was fabricated separately while the components and the ambient (laboratory) temperatures were strictly controlled to provide a constant condition for all the casted specimens.

Mixing process was kept constant to supply the same homogeneity and uniformity for all mixtures. It started by mixing all of powders/aggregates. Mixing water and chemical admixture were mixed together before adding them to the powders/aggregates and mixed for 2 min. until the mixture became homogenous. The fresh concretes were cast into cubes of 150 mm side long moulds (for compressive strength tests), cylinders of 150 × 300 mm (for splitting tensile strength and modulus of elasticity tests, and prisms of 100 × 100 × 500 mm (for flexural strength tests). After casting, the moulds were vibrated for 1 min to remove air bubbles. The specimens were demolded after 24 h form casting and cured in water till the age of testing.

After curing, all specimens were tested at ages of 1, 3, 7 and 28 days except the specimen of modulus of elasticity was tested at age 28 days only.

Mix (E0) considers as control mix without chemical admixture and its cement content is 400 kg/m^3 with w/c ratio is 0.50.

This investigation aims to modify concrete mix design by using several cement contents or w/c ratios and chemical admixture types to get early strength properties with minimum cost by using same type of cement and available aggregates. To obtain the investigation objective an experimental program design and consisted of 3 groups. First group (I) consisted of 3 mixtures include control mix and other concrete mixes with different w/c ratio (0.35, and 0.30) (mixes E1, and E2) with same chemical admixture type F respectively. Second group (II) consisted of 4 mixes include control mix and other concrete mixes with different cement contents (400, 450 and 500 kg/m^3) for mixes (E1, E3, and E4) respectively, with same chemical admixture type F and w/c ratio was 0.35. Last group (III) consisted of 4 mixes include control mix and other mixes with different chemical admixture types F, A, and combination of the two types A&F (mixes E1, E5, and E6) respectively, with same cement content 400 kg/m^3 and w/c ratio was 0.35.

TEST RESULTS AND DISCUSSIONS

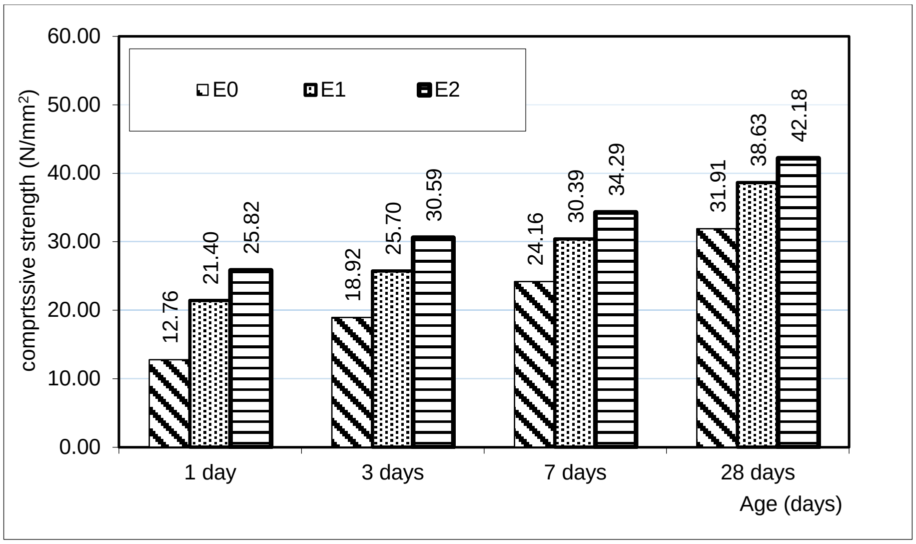
Compressive strength, flexural strength, and tensile strength applied for the all mixes were studied. Also, modules of elasticity were determined. All tests results shown in table (4).

Table 4: Testes results:

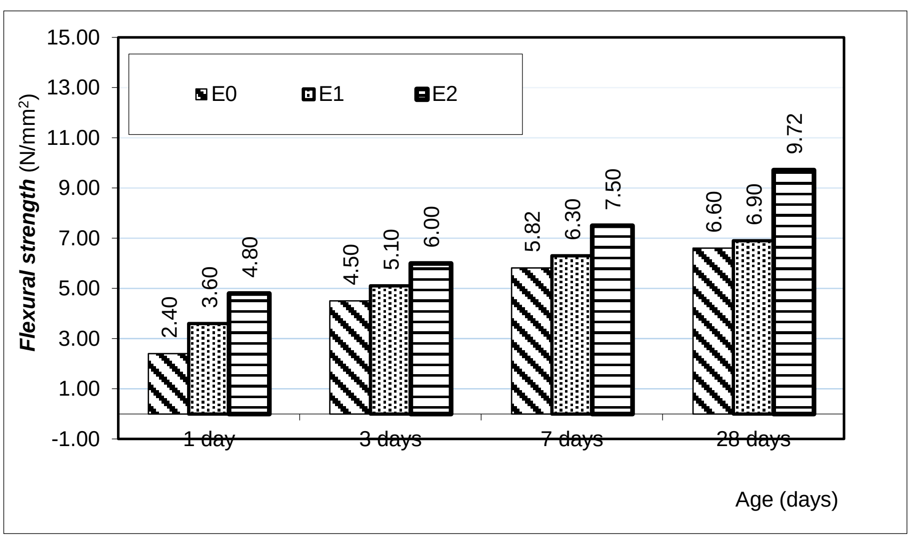
mix	Strength (MPa)	Results (MPa)				Modules of elasticity (GPa)
		1 day	3 days	7days	28days	
E0	Compressive. Strength	**12.76**	**18.92**	**24.16**	**31.91**	25.5
	Flexural strength	**2.40**	**4.50**	**5.82**	**6.60**	
	Splitting tensile strength	**1.17**	**1.88**	**2.54**	**3.17**	
E1	Compressive. Strength	**21.40**	**25.70**	**30.39**	**38.63**	29
	Flexural strength	**3.60**	**5.10**	**6.30**	**6.90**	
	Splitting tensile strength	**1.59**	**2.38**	**2.77**	**3.26**	
E2	Compressive. Strength	**23.13**	**36.86**	**36.06**	**42.74**	30
	Flexural strength	**4.80**	**6.00**	**7.50**	**9.72**	
	Splitting tensile strength	**1.98**	**2.79**	**3.26**	**3.93**	
E3	Compressive. Strength	**25.82**	**30.59**	**34.29**	**42.18**	29.5
	Flexural strength	**4.62**	**5.70**	**7.20**	**8.40**	
	Splitting tensile strength	**1.87**	**2.66**	**2.96**	**3.65**	
E4	Compressive. Strength	**26.96**	**33.18**	**36.92**	**44.27**	30.5
	Flexural strength	**5.10**	**6.60**	**8.40**	**10.02**	
	Splitting tensile strength	**2.11**	**2.83**	**3.40**	**3.82**	
E5	Compressive. Strength	**16.80**	**21.75**	**28.31**	**35.45**	27.5
	Flexural strength	**3.00**	**3.60**	**5.40**	**6.90**	
	Splitting tensile strength	**1.49**	**2.09**	**2.41**	**2.97**	
E6	Compressive. Strength	**18.36**	**24.91**	**30.54**	**37.29**	28.5
	Flexural strength	**3.30**	**4.50**	**6.00**	**7.20**	
	Splitting tensile strength	**1.63**	**2.24**	**2.55**	**3.07**	

Group I: Effect of water/ cement ratio with type F as chemical admixture (Haigh rang water reduce admixture):

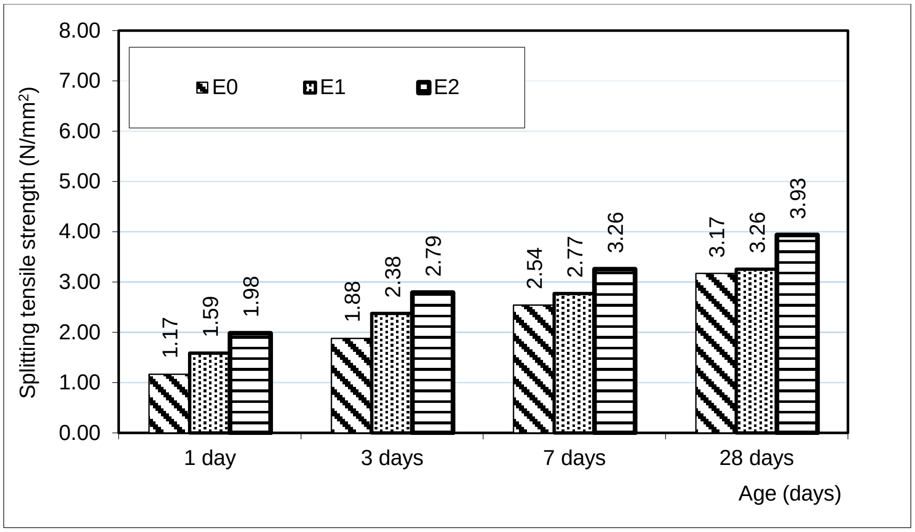
In this group, reduce the water content and add a type F chemical admixture to keep the slump as control mix, in order to increase early strength of the concrete mixes. Mixes (E1, and E2) with w/c 0.35, and 0.30 respectively were compared with the control mix E0. Figures Number (1, 2 and 3) shows the effect of w/c ratio on the compressive, flexural, and splitting tensile strength respectively at age 1, 3, 7, and 28 days



Figuer (1): Effect of w/c Ratio on The Compressin Strength



Figuer (2): Effect of w/c Ratio on The Flextural Strength



Figuer (3): Effect of w/c Ratio on The Splitting Tensile Strength

It is clear that is reduseing the w/c ratio from 0.50 to 0.35 and 0.30 is resulted an encreasing in strengths at all ages. The mix E1 (w/c= 0.35 with type F chemical addmixture) recorded increasing in compressive strength by (70, 35, 26 and 22)% at ages 1, 3, 7 and 28 days respectivily when compared with control beam E0. While E2 (w/c= 0.30 with type F chemical addmixture) recorded increasing in compressive strength by (100, 61, 42 and 32)% at ages 1, 3, 7 and 28 days respectivily when compared with control beam E0. It was observed that the rate of increasing in compressive strength was deceased with time, that may be attributed to the rapid rate of hydration happens with low water content.

Also, it was observed that the compressive strength for mix E1 reach near to the compressive strength of control mix E0 after 7 days, while mix No. E2 with w/c ratio equale 0.30 was recorded compressive strength after 3 days almoste equale the compressive strength of E0 after 28 days and after 7 days the compressive strength of mix No. E2 resulted in increasing by about 7.5% when compared with the compressive strength after 28 days for control mix.

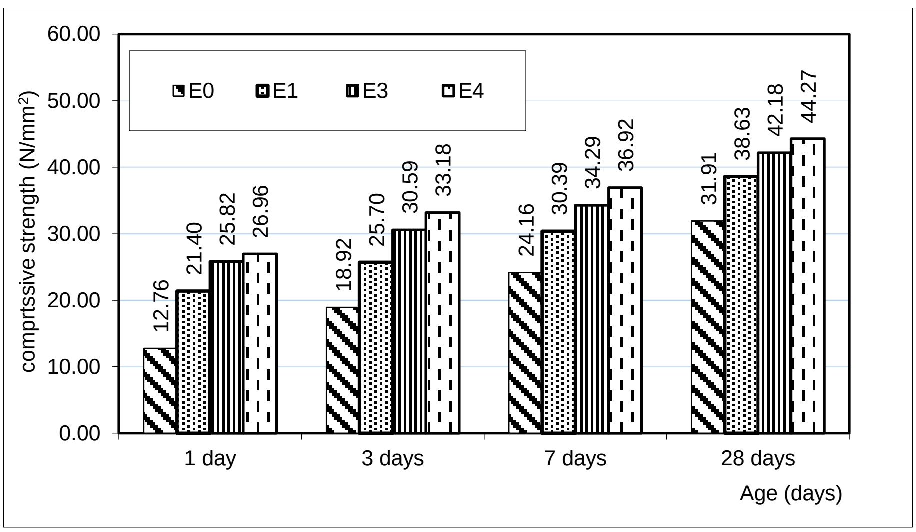
On the other hand, The mix E1 recorded increasing in flextural strength by (50, 43, 8 and 5)% at ages 1, 3, 7 and 28 days respectivily when compared with control beam E0. While E2 recorded increasing in flextural strength by (100, 33, 29 and 27)% at ages 1, 3, 7 and 28 days respectivily when compared with control beam E0. It was observed that the rate of increasing in flextural strength is less than the rate of increasing in compressive strength. E1 reach near to the flextural strength of control mix E0 after 7 days, while mix E2 with w/c ratio equale 0.30 was recorded flextural strength after 3 days almoste equale the flextural strength of E0 after 28 days and after 7 days the flextural strength of mix No. E2 resulted in increasing by about 14% when compared with the flextural strength after 28 days for control mix.

Also, The mix E1 recorded increasing in splitting tensile strength by (36, 27, 9 and 3)% at ages 1, 3, 7 and 28 days respectivily when compared with control beam E0. While E2 recorded increasing in splitting tensile strength by (69, 48, 28 and 20)% at ages 1, 3, 7 and 28 days respectivily when compared with control beam E0. It was observed that the rate of increasing in splitting tensile strength is less than the rate of increasing in compressive and flextural strength.

E1 reach near to the splitting tensile strength of control mix E0 after 7 days, while mix E2 with w/c ratio equale 0.30 was recorded splitting tensile strength after 3 days almoste near the splitting tensile strength of E0 after 28 days and after 7 days the flextural strength of mix E2 resulted in increasing by about 3% when compared with the splitting tensile strength after 28 days for control mix.

Group II: Effect of cement content:

In this group, studied the effect of increase cement content to improving the concrete strength with reduced the w/c ratio to 0.35 and add type F chemical admixture to keep the slump as control mix. Three cement contents were used as (400, 450 and 500 kg/m^3) for mixes (E1, E3 and E4) respectively. Figure (4) shows the variation of compressive strength for group II at the ages of 1, 3, 7 and 28 days



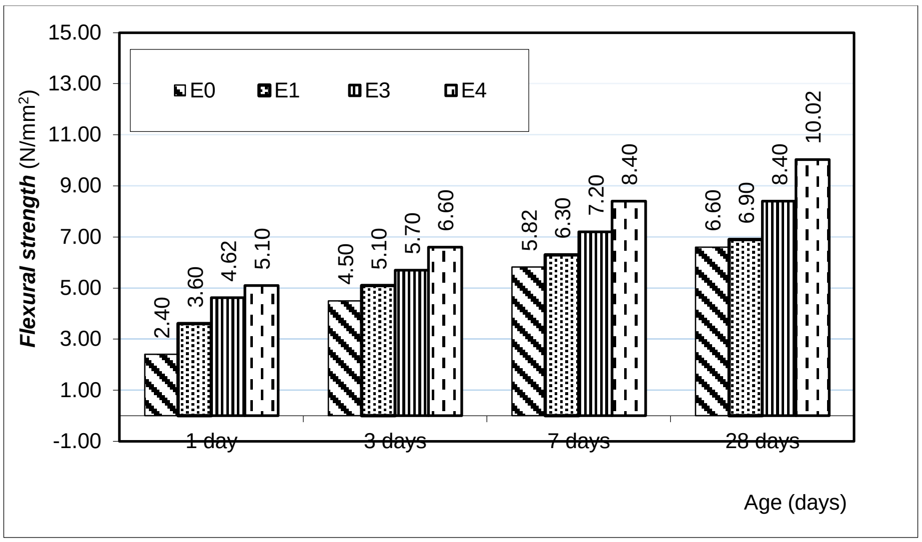
Figuer (4): Effect of Cement content on The Compressin Strength

The increase of cement content from 400 kg/m^3 (mix E1) to 450 kg/m^3 (mix E3) enhanced the 1, 3, 7 and 28 days compressive strength significantly by (20, 19, 13 and 9)% respectively. Also, it was observed that the compressive strength for mix E3 reach near to the compressive strength of control mix E0 after 3 days, and after 7 days the compressive strength of mix E3 resulted an increasing by about 7.5% refer to the compressive strength after 28 days for control mix E0.

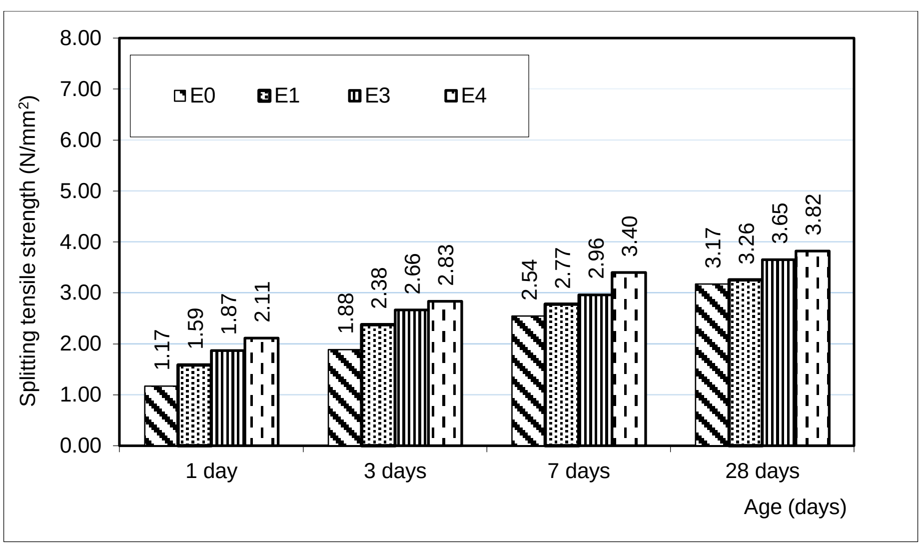
On the other hand, it can be seen also, that increasing cement content from 400 kg/m^3 (mix E1) to 500 kg/m^3 (mix E4) enhanced the 1, 3, 7 and 28 days compressive strength significantly by (26, 29, 21 and 39)% respectively. Also, it was observed that the compressive strength for mix E4 resulted an increase by about 4% refer to the compressive strength after 28 days for control mix E0.

The early strength development of cement content has been attributed to a greater fineness of particles. The increased fineness means results in a higher surface area of cement particles that interact with mixing water in the concrete mixture. The larger surface area has a direct effect on the rate at which cement hydrates, predominantly during the early period of hydration, and therefore, the rate at which strength is gained (ACI Committee E-701 2013).

Variation of cement content had a significant effect on the performance of the test mixtures especially from the flexural and splitting tensile strength point of view. The 1, 3, 7 and 28 – day flexural strengths for the group II are shown in Figures (5 and 6).



Figuer (5): Effect of Cement Content on The Flextural Strength



Figuer (6): Effect of Cement Content on The Spletting Tensile Strength

As observed from the figures, increasing cement content caused a significant improving effect on the flexural and splitting tensile strength at age 1, 3, 7 and 28 days by about (28, 12, 14 and 22)% respectively for flexural strength of mix No. E3 (with 450 kg/m^3) compared to mix E3 (with 400 kg/m^3). While for splitting tensile strength the results of mix E3 recorded increasing by about (18, 12, 7 and 12) % at ages (1, 3, 7 and 28) days respectively compared to mix E3. It was observed that the flexural strength of E3 recorded increasing by about 9% after 7 day refer to 28 days flexural strength for control mix E0.

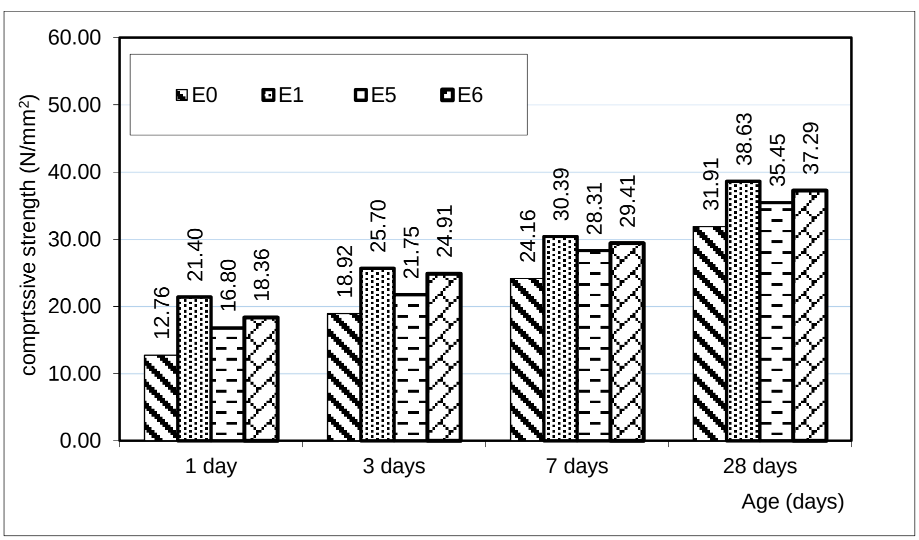
On the other hand, E4 (with 500 kg/m^3) recorded increasing in flexural strength by about (42, 29, 33 and 45) % at age (1, 3, 7 and 28) days respectively when compared with E1 (with 400 kg/m^3). Also, it was observed that the flexural strength of E4 reach the flexural strength of control mix E0 after 3 days only.

For splitting tensile strength E4 recorded increasing by about (33, 19, 23 and 17) % at age (1, 3, 7 and 28) days respectively when compared with E1 and the value of splitting tensile strength of E4 after 7 days was more the value of the splitting tensile strength of control mix E0 after 28 days by about 7.2%.

Group III: Effect of chemical admixture type:

In this group, studied the effect of different type of chemical admixture to improve the concrete strength by reduces the w/c ratio to 0.35 and used same cement contents as (400 kg/m^3). Using type F as chemical admixture was studied for mix E1 while type A was used in mix E5. A combination of type and type F was used in mix E6.

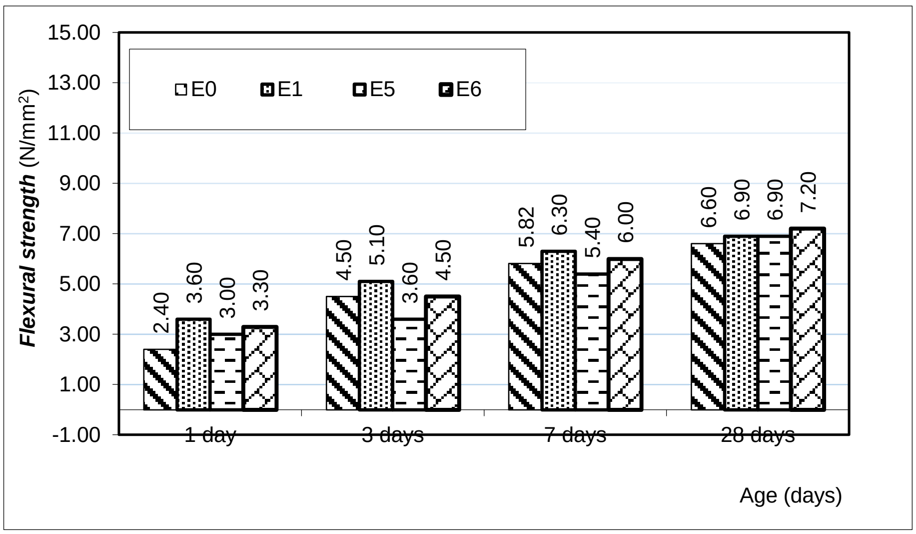
The compressive strength of the studied concrete mixtures is presented in Figure 7.



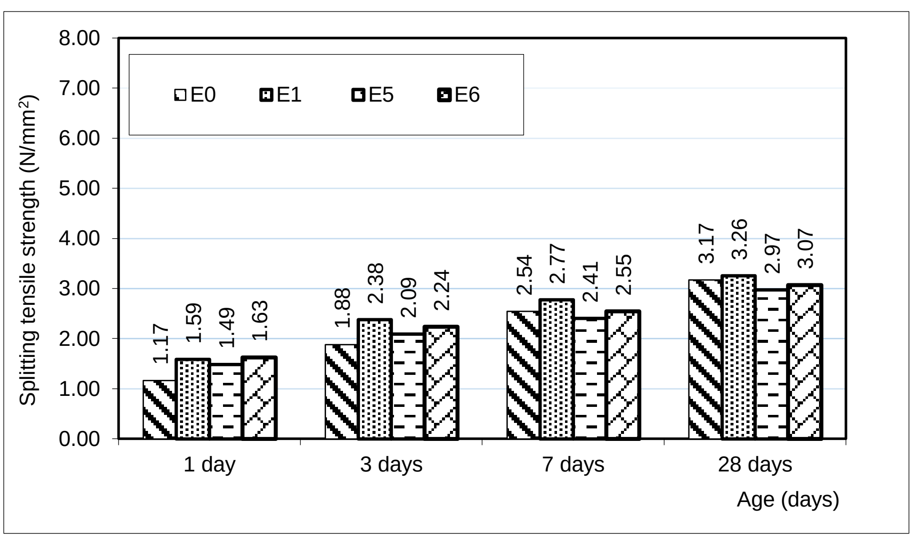
Figuer (7): Effect of Chemical Addmiture Type on The Compressin Strength

There were increasing by about (70, 35, 26 and 22)% for concrete specimens tested at age 1, 3, 7 and 28 days respectively when used type F as chemical admixture E1 compared with control mix E0 and the compressive strength of E1 after 7 days was closed to the compressive strength of control mix E0 after 28 days. While type A mix E5 recorded increasing by about (32, 15, 17 and 11)% for concrete specimens tested at age 1, 3, 7 and 28 days respectively compared with control mix E0.

Figures 8 and 9 shows the flexural strength, splitting tensile strength respectively; test results for group III mixtures at age of 1, 3, 7 and 28 days can be observed that results are in agreement and follow the same trend of the results of compressive strength.



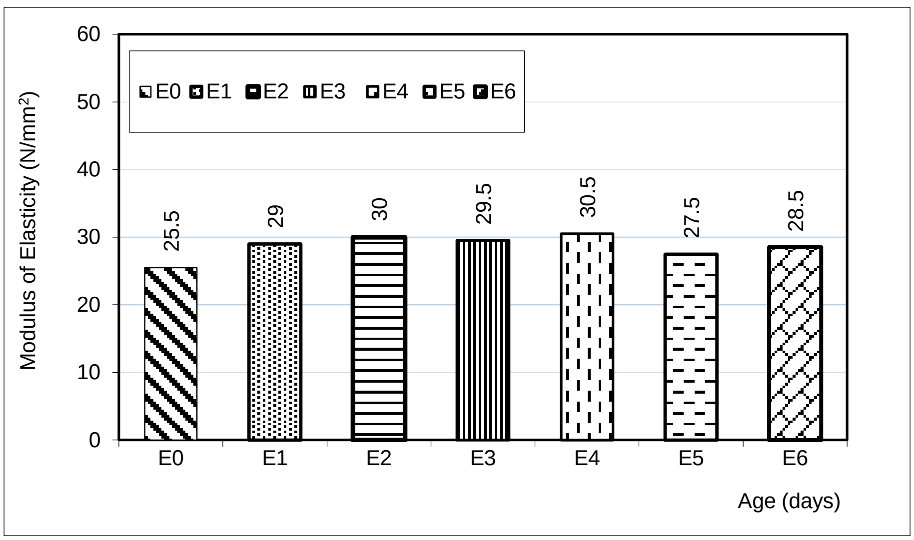
Figuer (8): Effect of Chemical Addmiture Type on The Flextural Strength



Figuer (9): Effect of Chemical Addmiture Type on The Spletting Tensile Strength

The results of group III show that the strengths increased due to reduction in w/c ratio and using type F as chemical admixture resulted in highest strength compared with using type A or combination between type A and F. Also, it was observed that the compressive, flexural, and splitting tensile strength after 7 days was reach near strength of control mix E0 at age 28 days.

The results of static modulus of elasticity (MOE) at age of 28 days are shown in figure 10 which indicates that the MOE of concrete increased by (14, 18, 16, 20, 8 and12) for concrete mixes with different w/c ratio and /or cement content and / or chemical admixture types when compared with those of the control (E0). This is due to the same reason for the increasing in compressive strength. On the other hand, the high cement content (E4) resulted an increasing in modulus of elasticity more the lower w/c ratio (E2). The increase in MOE with the high cement content concrete can be attributed to the pore filling ability. This increases the compressive strength which subsequently increases the MOE.



Figuer (10): Modulus of Elasticity values for All Mixes

COST ESTIMATION

Table (5) shown the estimation of the percentage of the cost raise from the control mix and the other mixes

Table 5: Cost Estimation

mix	Cement content (kg)	Type of admixture	w/c	Target compressive strength age (days)	% of the cost raise
E0	400	-	0.50	28	-
E1	400	Type F	0.35	≈ 7	19
E2	400	Type F	0.30	≈ 3	28
E3	450	Type F	0.35	≈ 3	29
E4	500	Type F	0.35	3	40
E5	400	Type A	0.35	28	9
E6	400	Type A&F	0.35	28	14

From Table (5), the target strength of control mix can be obtained after near to 7 days by reduce the w/c ratio from 0.50 to 0.35 with using type F as chemical admixture (E1) and the cost will increase by about 19%. Also, it can obtained after near to 3 days when reduce the w/c ratio to 0.30 with type F chemical admixture (E2) or increase cement content from 400 kg/m3 to 450 kg/m3 in the present of type F chemical admixture with w/c ration 0.35 (E3) but the cost will increased by about (28 and 29)% respectively E4 that was used 500 kg/m3 cement content in the present of type F chemical admixture and 0.35 w/c ratio is recorded more that the target strength at age 3 days while the cost was increased by about 40%.

On the other hand, use of type A chemical admixture or the combination of type A and Type F resulted in increasing in strength but not obtained the target strength before 28 days and the cost was increased by about (9 and 14)% respectively

CONCLUSIONS

An experimental study was carried out to investigate enhancement the concrete mix strength to obtain the strength of concrete mix in early age by using different water cement ratio with high range water reducing admixtures Type F and different cement content. Also using of water reducing admixtures Type A was studied. The extra cost of the studied mixes was compared with the cost of control mix. The following conclusions can be drawn from the study:

1. All concrete mixes showed a significant increase in the compressive, flexural, and splitting tensile strengths. The cement content 500 kg/m^3 led to the highest enhancements of strengths.
2. Reduce water cement ratio from 0.50 to 0.35 with using type F as chemical admixture (E1) to keep the slump measurement as control mix that result an increase in early strength and the strength at age 7 days almost equal the 28 days strength for control mix. The cost of this mix was raise by 19 % refer to the cost of control mix.

3. Reduce water cement W/C ratio from 0.50 to 0.30 with using type F as chemical admixture to keep the slump measurement as control mix (E0). Mix (E2) which increases water cement content to 450 kg/m^3 with W/C ratio 0.35. Additive type F as chemical admixture used in (E3) give an increase in early strength when the strength at age 3 days almost equal the 28 days strength for control mix. The cost of these mixes (E2 and E3) were raise by (28 and 29)% respectively refer to the cost of control mix (E0) and both mix (E2 and E3) compressive strength after 7 days was more than 28 days compressive strength of control mix (E0).
4. Using cement content 500kg/m^3 with W/C ratio 0.35 and high rang water reducing (HRWR) Type F chemical admixture in mix (E4); resulted a higher compressive strength after 3 days than the compressive strength 28 days strength for control mix. While the cost was raised by about 40% refer to control mix (E0).
5. Using of water reducing admixtures Type A or combination of Type A and Type F with reducing W/C ratio from 0.50 to 0.35 resulted an increasing in strengths at all ages compared with control mix but can't obtain the 28 days strength for control mix at early ages.
6. There are many potential benefits of using HRWR, as superplasticizers, rather than conventional or mid-range water reducers. HRWRs act in a similar manner to conventional water reducers, except that HRWRs have a greater dispersion effect on cementitious materials is that high range water reducers may minimize set retardation that may occur when using conventional water reducers. The use of HRWR has also shown to improve strength properties of hardened concrete. The strength of concrete containing HRWR is normally higher than what is expected of the lower w/cm ratio alone.
7. There are also several potential disadvantages of using HRWR instead of conventional or mid-range water reducers. One disadvantage is the greater cost of the HRWR admixture.

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