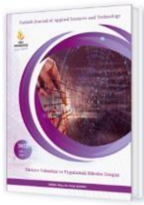
Türkiye Teknoloji ve Uygulamalı Bilimler Dergisi



ISSN: 2528-8652 e-ISSN: 2822-2660 2024, 5(2):94-113
Period Biannually Founded 2017 Publisher Siirt University https://dergipark.org.tr/tr/pub/tubid

Investigation of Strength Development in Conventional and High Strength Concrete Under Different Curing Conditions

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Research Article

Received

14/06/2024

Accepted

07/08/2024

DOI

10.70562/tubid.1501310

Abstract

During the 1960s, concrete with compressive strengths of 41 MPa and 52 MPa were commonly utilized in the USA. More recently, there has been a shift towards using concretes with compressive strengths ranging from 80 MPa to 100 MPa in structures constructed with in-situ concrete and prestressed concrete structural elements. The study focused on examining the strength development of both traditional and high-strength concretes under various curing conditions. To achieve this, cube samples were subjected to central pressure tests to assess their strength development. The concrete production process involved weighing silica fume and superplasticizer for each aggregate class, cement, saturation water, and mixed water, specifically for high-strength concretes. According to the experimental work plan, concrete cube samples were produced and subsequently tested using central pressure tests. The produced concretes were classified into C55, C20, and C12 classes. The study revealed that while similar behaviours were observed in high-strength and conventional concretes subjected to different curing environments, the difference in curing temperature had a more significant impact on strength development than the inadequacy of curing in water. It is worth noting the potential benefits of conducting similar studies on various types of concrete.

Keywords: High strength concrete, conventional concrete, compressive strength, different curing conditions

1. Introduction

Concrete, also known as traditional concrete, is a composite material made by blending cement, aggregate, water, and, when necessary, an additive. In other words, normal Durable concrete and higher strength concrete have always existed together. High Durable concrete, on the other hand, is very different from its predecessors in terms of quantity and quality (1). Today, the regulatory provisions and equations that guide the calculation of reinforced concrete mostly unchanged 400 kgf cm^{-2} from element tests made with concrete less than whether the same equations and records have been obtained for high-strength concrete. Whether it is valid or not has not yet been clarified (2). The mixture is carefully placed into molds of the desired shape and size without gaps and then hardens under appropriate maintenance conditions. The most common use of concrete today can be traced back to the invention of reinforced concrete in the 1850's.

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The first publication on concrete reinforced with steel bars was written by François Coignet in 1855. The first patent for reinforced concrete elements was obtained a few years later by Joseph Monier. The development of reinforced concrete in Europe and America quickly followed this. In the years following 1900, regulations on reinforced concrete, concrete mixture calculations and related strength and water formulas, ideal granulometry curves, the first prestressed concrete systems and the first effective vibration were developed, the first reinforced concrete structureswere built in Turkey and the first Turkish Portland Cement Standard was published. In the years following 1950, reinforced concrete regulations developed in Europe and America and a transition wasmade from elastic theory to the bearing capacity method. In the 1970-80s and the following years, it wasobserved that industrial concrete production and prefabrication developed in the world and in our country (3). The definition of high strength concrete is constantly changing. In the 1950s, concrete witha standard cylinder (150x300 mm) compressive strength of 34 MPa was considered high strength concrete. In the 1960s, concretes with compressive strengths of 41 MPa and 52 MPa were used on the market in the USA. In the recent past, concretes with compressive strengths varying between 80 MPa and 100 MPa have been commercially applied in structures made with in-situ concrete and prestressed concrete structural elements. Additionally, by using very high strength aggregate, concretes with compressive strength reaching 250 MPa could be produced. The definition of high strength concrete may vary depending on the production technology prevalent in the production region. If the compressivestrength of the concrete used in the region is 30 MPa, concrete with an fc value of 50 MPa can be accepted as high strength concrete by the engineers in that region. In addition, if the compressive strength of the concrete used in the region is 50 MPa, then concrete with an fc value of 80 MPa can be considered as high-strength concrete in that region (4). Therefore, the definition of high strength concrete may vary from country to country. Table 1 gives the compressive strength limits of high- strength concrete according to the regulations of some countries (5).

Table 1. Strength limits of high strength concrete according to some regulations (5)

Regulation	Minimum compressive strength (MPa)	Maximum compressive strength (MPa)	Sample type
TS 500	50	-	Cylinder Ø=150mm, h=300 mm
ACI 318-89 CAN-A23.3 M84	62-69	100	Cylinder Ø=150mm, h=300 mm
CEB-FIP (MC90)	60	80	Cylinder Ø=150mm, h=300 mm
DIN 1045	55	115	Cube a=150 mm
BS 8110	60	110	Cube a=150 mm
NS 3473	65	105	Cube a=150 mm
Rak-MK4	60	100	Cube a=150 mm

There are three approaches to the production of high-strength concrete, which is widely used in today's buildings:

- To prevent failure by selecting all materials of concrete with great care and applying a strictquality control program,
- Increasing workability, improving the void system and reducing the heat of hydration by using

pozzolanic additives such as fly ash and ground blast furnace slag,

- In the mixture design, the aim is to reduce the w/c ratio to the lowest level that will not force the compaction that can be achieved in practice, and to use plasticizing chemical additives for this purpose.

Although these approaches have been known for a long time, superplasticizer chemicals that have emerged with technological developments in recent years have made these processes much easier (6). Concrete workability, cement paste and transition properties are closely related to the water/cement ratio in concrete. By reducing this ratio, concrete with fewer voids can be produced. At the same time, transition zone properties can be improved by reducing the maximum aggregate grain diameter. However, the improving effect of these two approaches on concrete strength has a certain upper limit. In order to exceed this limit, it is necessary to prevent the formation of calcium hydroxide ($Ca(OH)_2$) crystals, which exist in the concrete structure and are seen as the weak side of concrete. These crystals have a hexagonal structure and are easily broken. By using these additives, which are ligno sulfonate, naphthalene, melamine or polymer based, the w/c ratio can be reduced below 0.30. An important point here is the fact that small changes in such low w/c ratios significantly change concrete strength. For conventional concrete, the cement dosage is between 300-350 kg/m3. It should be kept between 400-500 kg/m3 for high-durability concrete (7).

Various materials such as fly ash, blast furnace slag, rice husk ash, and silica fume are suitable for use as pozzolans in construction. Silica fume, in particular, has a high SiO_2 ratio, often exceeding 90%, and its fineness can be 50-60 times greater than that of cement. One of the advantages of using pozzolans is their ability to lower the cement hydration temperature, which helps prevent the formation of thermal cracks (8). Research has indicated that high-strength concrete exhibits lower inherent creep compared to conventional concrete of the same age. Experiments have demonstrated that high-strength concrete experiences a 25-50% reduction in creep compared to conventional concrete. Furthermore, under similar drying conditions and relative stresses, including overloads, high-strength concrete demonstrates lower creep deformation, creep coefficient, and intrinsic creep. The curing method applied to concrete also influences its creep behavior, with factors such as a low water-to-cement ratio and high degree of hydration at loading time contributing to reduced creep potential (9-11).

Table 2. Some equations for the modulus of elasticity of high-strength concrete (11)

ACI 318-89	$\mathrm{Ec} = 0.043\,\rho 1.5\sqrt{\mathrm{fc}}$
FIP/CEB	$\mathrm{Ec} = 104\,(fck + 8)1/3$
ACI Committee 363	$\mathrm{Ec} = 3320\sqrt{fc} + 6900$
Ahmad et. al.	$\mathrm{Ec} = (1/29510)\rho 2.5(\sqrt{fc})65$
Norwegian Code	$\mathrm{Ec} = 9500(fcc)0.3(\rho/2400)$
Shah et. al.	$\mathrm{Ec} = (1/28)\rho 1.5\sqrt{\mathrm{f}c}$

Almost all engineering properties of concrete are expressed in terms of uniaxial compressive strength. Measured compressive strength of the concrete sample; It depends on the curing conditions, the age of the concrete at the time of the test, the loading rate, geometry, size and the stiffness degree of the sample. Although it has a thixotropic character, that is, it is fluid, being very cohesive, the material tends to drift and decompose in underwater castings gets in the way (12).

It is known that concrete is a material that is quite resistant to pressure but very weak to tension (1/20 to 1/10 of its compressive strength). Therefore, the tensile strength of concrete is not taken into account when calculating the bending loads that concrete elements can carry. However, it is very important to know the tensile strength of the concrete for deformation calculations of concrete and for the calculations of the minimum longitudinal tensile reinforcement to be used to prevent the tensile steel from breaking in case of sudden element cracking. Tensile strength of concrete; It can be found by direct tensile test, split cylinder test and rupture modulus test. Curing conditions have a more significant effect on the tensile strength of high-strength concrete elements than conventional concrete.

Table 3. The relationship between tensile strength and compressive strength of high-strength concrete (5)

Proposing the relation	**Relation**
ACI 363	$\text{fcts} = 0.59\sqrt{fc}$
TS 500	$\text{fcts} = 0.53\sqrt{fc}$
CEB-FIP	$\text{fcts} = 0.6 + 0.06fc$
Carrasquillo and others	$\text{fcts} = 0.54\sqrt{fc}$
Thornfeldt	$\text{fcts} = 0.3(fck)$
Yerlici and Ersoy	$\text{fcts} = 0.36fck$
Arıoğlu and Köylüoğlu	$\text{fcts} = 0.573fc0.700$
Arıoğlu and Köylüoğlu	$\text{fcts} = 0.321(fc)$

Some studies on high-strength concrete-reinforcement adherence in the last 20 years are given below. Rosenberg and Gaids observed from a series of pull-out tests they performed on two classes of high-strength concrete, one with silica fume and the other without silica fume, that a 50% increase in compressive strength could lead to a 40% increase in bond strength. There are some doubts about whether the bending behavior of high-strength concrete structural elements can be explained by generally used bending formulas. The difference in stress-strain properties between high-strength concrete and conventional concrete is the main reason for the differences in their behavior. Researchers have focused on evaluating the suitability of the rectangular pressure block recommended by ACI 318-89 for high-strength concrete. ACI 318-89 specifies the minimum tensile reinforcement ratio for conventional concrete elements as σmin=1.4/fy (MPa). In high-strength concrete beams, a greater amount of tensile steel is required to prevent brittle failure before reaching the carrying capacity, which is caused by the rupture of the tensile steel. The minimum tensile steel ratio is calculated based on the concept that the moment the cracked section will carry with a steel tension of fs=2fy/3 should be equal to the moment required to crack the same section. In this calculation, the maximum tensile stress that the concrete can carry is determined based on the rupture modulus (fr). The influence of concrete compressive strength on the shear strength of elements becomes more significant as the ratio of the cutting opening to the depth of the element decreases. It has been noted that in short beams where the shear span to member depth ratio (a/d) is 1.5 and 20 MPa ≤ fc ≤ 103 MPa concrete is used, the ACI Building Code calculation equations for deep beams provide considerably lower values than the actual shear strength. However, it was also observed that the maximum shear strength increased with increasing amount of tensile reinforcement.

Studies on the punching effect on reinforced concrete elements were conducted in the region where concrete compressive strength varies between 20 MPa and 40 MPa. There are not enough tests to create reliable empirical formulas for high-strength concrete elements. The ratio of test results to calculated values decreases inversely proportional to increasing concrete compressive strength. Based on the shear values in beams, the Norwegian Building Code has set a limit that the punching strength in high-strength concrete elements will not increase after fc = 74 MPa. In De Larrard and Malier's research, this is claimed that the situation can only be explained by inherent shrinkage (13,14). In a line produced with traditional and high-strength concretes crack by working the reinforcement of the working floor slabs to the maximum stress value widths are lower in high-strength concrete floor slabs observed (15). Here, in the axial pull-out test, shear perpendicular to the reinforcement the absence of forces, the local compressive stresses applied by the support, the concrete cover This test is due to the fact that the thickness of the concrete is very large and that tensile cracks do not occur in the concrete. Although it poses major drawbacks, Standard Belgian Articulated Beam Tests It should be noted that there are no such drawbacks (16). Researchers suggested rectangular pressure pressure according to ACI 318-89 they paid special attention to the suitability of the block for high-strength concrete (17). Maximum strength of square-section, less reinforced beams under bending effect it generally depends on the properties of the tensile reinforcement. Therefore, different and improved it has little effect on the calculation of the bending strength of compression blocks. σ- due to the difference in properties, the location and size of the force resultant in concrete despite its differences, the rectangular pressure block recommended by ACI 318-89 is a high-strength It is widely used for concrete (18).

Most of the chemical reactions between cement and water normally take place in the early days of concrete. Therefore, the presence of sufficient water and temperature in the concrete is of great importance, especially in the first days of concrete production. The process of keeping sufficient water and temperature in the concrete and maintaining this environment in order to ensure adequate hydration of the concrete, especially in the first days, is referred to as concrete curing (19).

In a study conducted by Wu et al. (19,20), the impact of coarse aggregate type on various properties of concrete was thoroughly examined. The properties investigated included compressive strengths, splitting tensile strengths, fracture energies, characteristic lengths, and elasticity modules of concretes with 28-day target compressive strengths of 30 MPa, 60 MPa, and 90 MPa. The study utilized crushed quartzite, crushed granite, limestone, and marble as the coarse aggregates. Furthermore, a range of water/cement ratios, specifically 0.26-0.44 and 0.55, were chosen for the experiment. It was noted that the choice of coarse aggregate type significantly impacts the characteristics of high-strength concrete. Specifically, the study revealed that high-strength concrete made with crushed quartzite exhibited 10-20% higher compressive and split tensile strength compared to that made with marble. However, the differences in strengths of concrete made with different coarse aggregates were found to be minimal when targeting a compressive strength of 30 MPa.

2. Material and Method

Strength developments of traditional and high-strength concretes under different curing conditions examined. For this purpose, central pressure tests were carried out on cube samples produced. The same type of aggregate was used in traditional and high strength concrete production. The aggregate used is "limestone" from the Trabzon region. K.T.Ü. on thin sections of limestone rock. Examinations were made in the Department of Geological Engineering and mineralogical properties were determined (21). A view of these aggregates is shown in Figure 1, and the mineralogical properties are shown in Table 4.

Figure 1. Limestone aggregate used in experiments

Table 4. Mineralogical properties of limestone rock (3)

Rock Name	Mineral Type	Situation of the Mineral in the Rock	Mineral Percentage
Limestone	Calcite	Micritic cemented limestone, partially aged microfossils	99.5
	Opaque	-	0.5

In Table 5, the mechanical properties of limestone aggregate are given.

Table 5. Mechanical properties of limestone rock (3).

Average compressive strength (MPa) (On core samples with dimensions Ø=75mm, h=150mm)	Average bending tensile strength (MPa) (on core samples with dimensions of 40x40x160 mm)	Elastic modulus (MPa)	Poisson's ratio
74	17	46000	0.17

The absolute volume method was used in the composition calculations of traditional and high strength concrete. Wc, Wa, Vw and Vh represent the cement mass (kg m^{-3}), aggregate mass (kg m^{-3}), water volume (dm^3) and trapped air volume (dm^3) in 1 m^3 of concrete, respectively; γc and γa represent the saturated dry surface content of cement and aggregate, respectively. Absolute volume of aggregates to indicate their unit mass (kg dm^{-3}):

$$Va = Wa/\gamma a = 1000 - (Wc/\gamma c + Vw + Vh) \quad (1)$$

The calculation of the aggregate mass is determined by a specific formula. When the aggregate consists of multiple separate classes, the mass of each class is denoted by βi and γai, representing the total mass and the saturated dry surface unit mass ratio of each class, respectively.

$$\sum (\beta i \times Wa/\gamma ai) = 1000 - (Wc/\gamma c + Vw + Vh) \quad (2)$$

It is calculated with the formula. When the total aggregate mass calculated from this formula is multiplied by the mass ratio of each aggregate class, the masses of each aggregate class are determined separately.

$$Wai = \beta i \times Wa \quad (3)$$

The aggregate masses obtained in this way are saturated dry surface aggregate masses. To find the aggregate mass values in natural humidity from these values, SEi and DNi are the amount of saturation water required for each aggregate class to show the mass water absorption and natural moisture rates for each aggregate class, respectively;

$$DSi = (SEi - DNi) \times Wai \quad (4)$$

It is calculated with the formula. Total saturation water is obtained from the expression below by adding the saturation water amounts of each aggregate class.

$$DS = \sum DSi \quad (5)$$

In the method described above, water/cement ratios and cement dosages were initially determined for both traditional and high-strength concretes. For conventional concrete, the water/cement ratios were set at 0.50 and 0.70, with a cement dosage of 300 kg m^{-3}. On the other hand, high-strength concretes were designed with a water/cement ratio of 0.30 and a cement dosage of 500 kg m^{-3}.

Furthermore, in the composition of high-strength concrete, 10% of the weight of cement was silica fume (SD), and 2% of the combined weight of cement and silica fume was superplasticizer additives (SAK). The specific concrete compositions determined are detailed in Table 6 below.

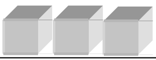
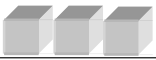
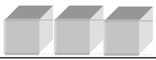
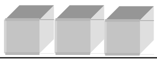
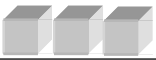
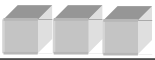
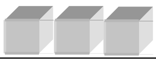
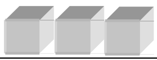
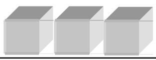
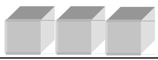
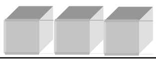
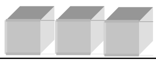
Table 6. Mineralogical properties of limestone rock (3)

Concete Type	Total agrega kg m^{-3}	Saturation water kg m^{-3}	Mixing water kg m^{-3}	Cement kg/m^3	S/Ç	SD kg m^{-3}	SAK kg m^{-3}
High Strength	1622	40	165	500	0.33	50	11.0
Traditional	1878	46	150	300	0.50	--	3.0
	1724	42	210	300	0.70	--	--

2.1. Concrete production plan

It was previously stated that the aim of this study was to examine the strength development of traditional and high-strength concretes under different curing conditions. For this purpose, first of all, a production plan was made. According to this planning, samples were produced to be kept in the curing environments shown in Table 7 below. This plan has been applied three times: for conventional concrete, for the two different water/cement ratios mentioned above, and for high-strength concrete. The experiments carried out in the standard cure environment were also repeated in cold environmental conditions and thus a total of 6 groups were produced.

Table 7. Concrete production plan

	EXPERIMENT AGE (days)			
	3	7	28	90
Always in the air				
3 days in water, then in air				
7 days in water, then in air				
28 days in the water, then in the air				
Number of Samples	6	9	12	12

2.2. Production and placement of concrete

For the production of concrete, each aggregate type, along with cement, saturation water, mixed water, and high-strength concretes, was prepared by weighing silica fume and superplasticizer. Coarse, medium, and fine aggregates were combined in a pre-moistened 60-liter capacity inclined-axis concrete mixer (Figure 2) and mixed for 3 minutes with the addition of saturation water. Following this, after adding cement, mixed water was incorporated for another 3 minutes to yield the concrete. In high-strength concretes, silica fume was added to the cement and superplasticizer was added to the mixing water beforehand and placed in the concrete mixer in the same order mentioned above. The concrete was placed in pre-lubricated cube molds of 150 mm x 150 mm x 150 mm in two stages and tightened on the vibration table (Figure 3). The vibration table was operated for 5 seconds at each placement stage.

Figure 2. Inclined axis concrete mixer

In order to eliminate the inevitable differences that may arise between concretes from production to production, multiple batch production was carried out in order to pour a large number of concrete samples at the same time. Concrete was poured at once for a series of cube molds provided for this purpose. Performing the concrete pouring in this Figure also enabled the test program to be followed in a more accurate Figure.

Figure 3. Vibration table

2.3. Curing conditions of concrete and their age at the test

It was previously stated that the production plan (Table 7) created for the experiments was applied twice to each different concrete, for the standard cure environment and the cold cure environment. This application was possible because concrete production coincided with the winter months. As the cold cure environment, an unheated section of the laboratory with an ambient temperature of 13˚C ± 2˚C and the cure tank in this section were used. The relative humidity of the environment was 70% ± 10%, and the temperature of the water in the cure tank in this environment was 11˚C ± 2˚C. The standard cure environment was provided in cure tanks with water temperature of 22˚C ± 2˚C.

The concrete cube samples were carefully removed from their molds 1 day after production. They were then stored in either cold or normal room temperature environments in the laboratory until the testing phase, as per the experimental work plan (Figure 4).

Figure 4. Some of the samples kept in the laboratory environment (air)

Others were stored in standard or cold water for 3 days, 7 days, 28 days and 90 days. The tanks where the standard cure application was made can be seen in Figure 5. Concrete cube samples were subjected to central pressure testing on the 3rd, 7th, 28th and 90th days.

Figure 5. Tanks where standard cure is applied

2.4. Central pressure tests of concrete samples

As mentioned in the second section, central pressure tests were carried out on concrete cube samples in accordance with the experimental work plan, after a large number of productions. For the experiments, a computer-controlled hydraulic press with a capacity of 2500 kN which was brought to the laboratory within the scope of a project supported by the KTÜ Scientific Research Projects Unit (22), was used in the KTÜ Construction and Materials Laboratory. Central loading tests were carried out under a constant loading rate of 6 kg s^{-1} in accordance with TS EN 12390-3 (23). A view of the cube samples at the time of the experiment is given in Figure 6.

Figure 6. Experiment set

3. Results

The strength development - time relationships obtained from the central pressure tests performed on the concrete cube samples produced in the Figure above are given in Figure 7 for the standard environment and Figure 8 for the cold environment for high-strength concretes with a water/cement ratio of 0.30. The same relationships are given in Figure 9, Figure 10, Figure 11 and Figure 12 for conventional concretes with water/cement ratios of 0.50 and 0.70, in the same order.

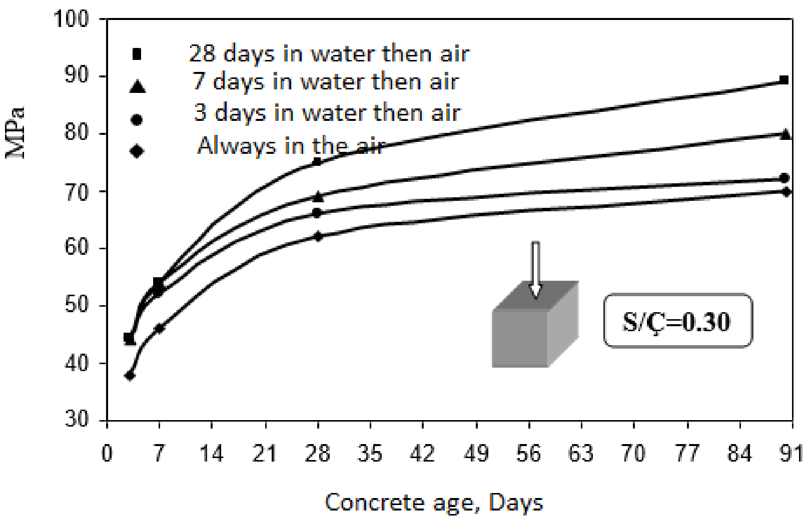


Figure 7. Strength development of high strength concrete in standard environment

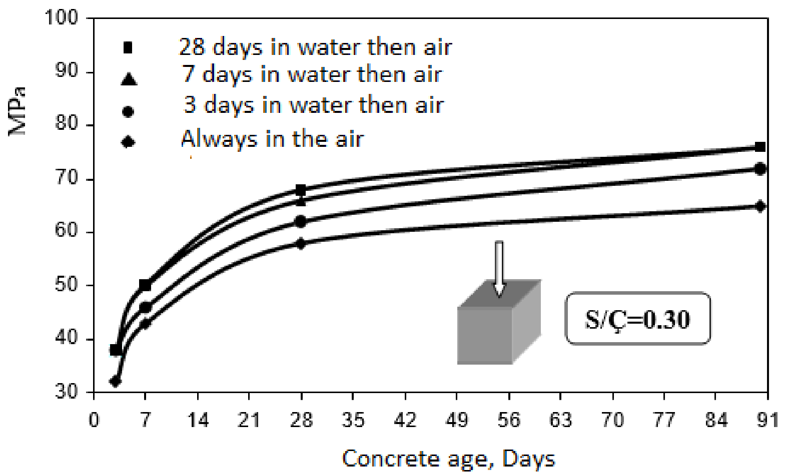


Figure 8. Strength development of high strength concrete in cold environment

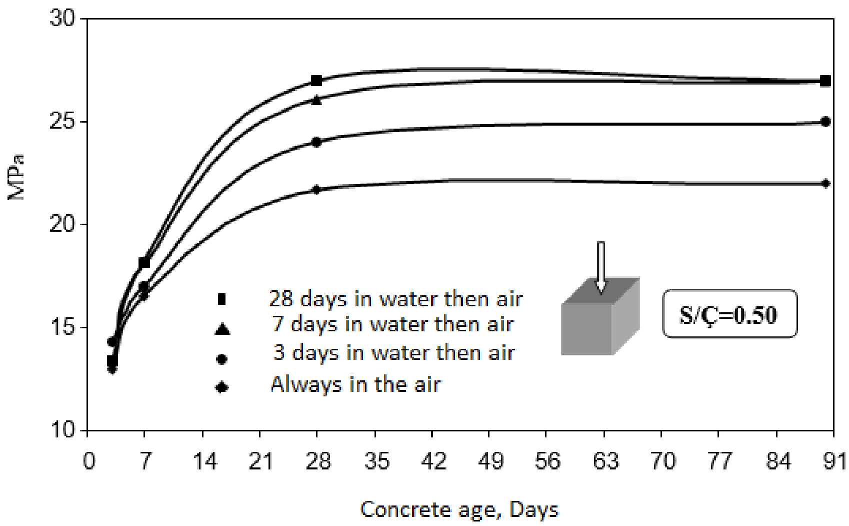


Figure 9. Strength development of conventional concrete in standard environment

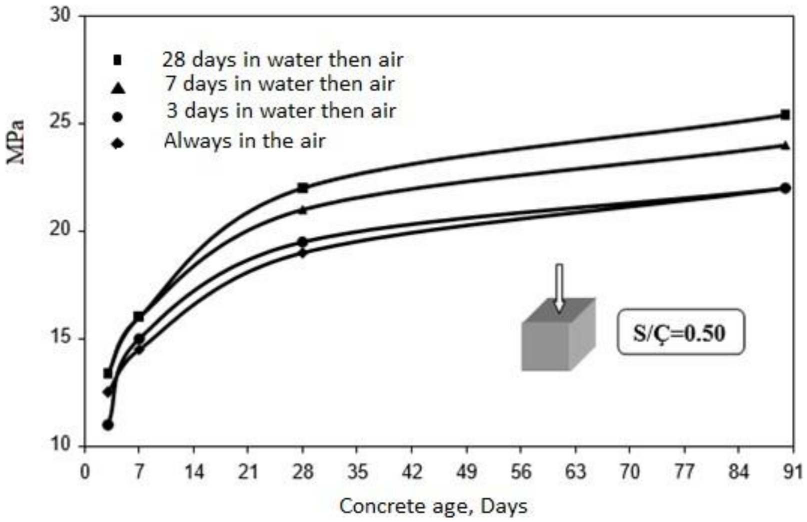


Figure 10. Strength development of traditional concrete in cold environment

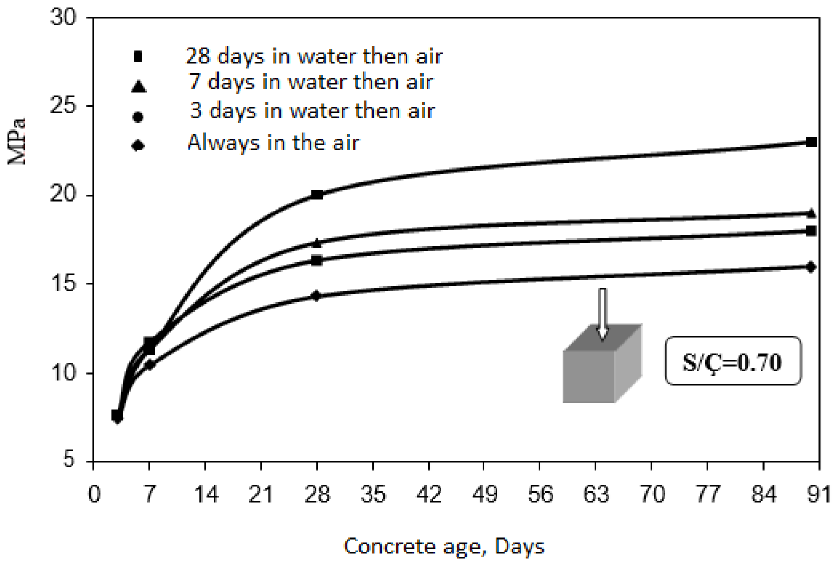


Figure 11. Strength development of conventional concrete in standard environment

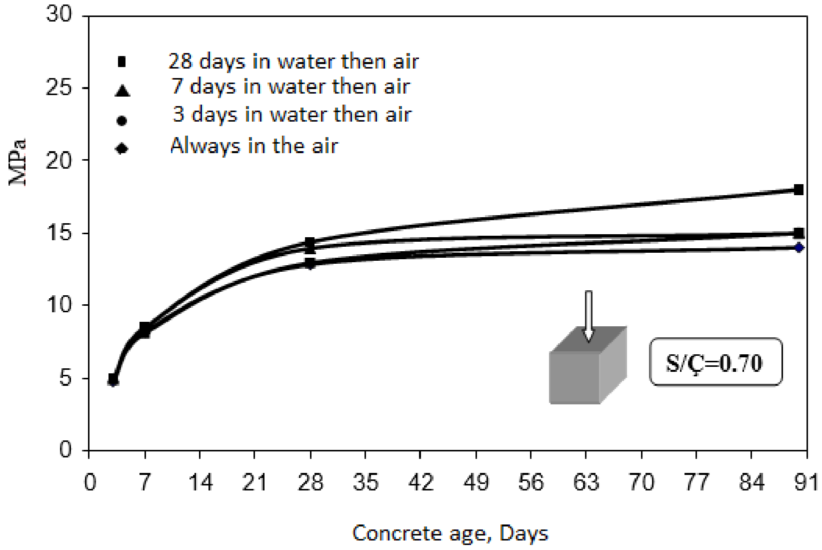


Figure 12. Strength development of traditional concrete in cold environment

In accordance with the experimental work plan, some of the 150 mm concrete cube samples were kept in air, and some were kept in water for certain periods of time for cold cure and standard cure, as explained in the previous section, on the 3rd, 7th, 28th and 90th days, which are the test ages. subjected to central pressure testing. In order to see the effect of curing in standard and cold environments on concrete strength, the strength differences resulting from the bar diagrams drawn for all curing conditions of high-strength and conventional concrete are given below (Figures 13-24).

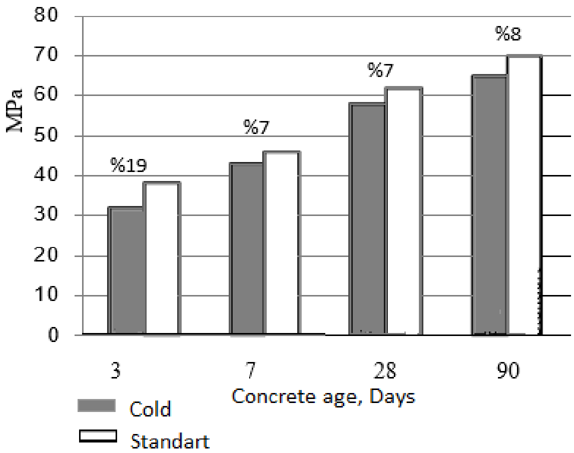


Figure 13. Strength differences in YDB samples always cured in air

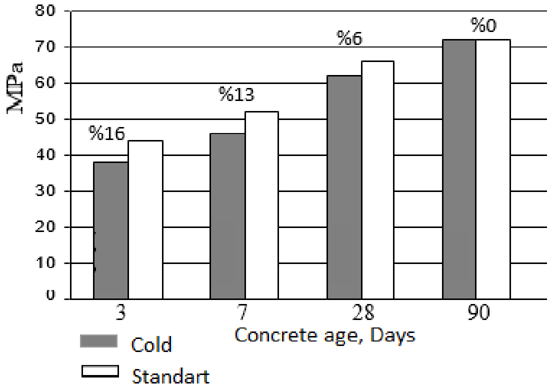


Figure 14. Strength differences in YDB samples cured in air after 3 days in water

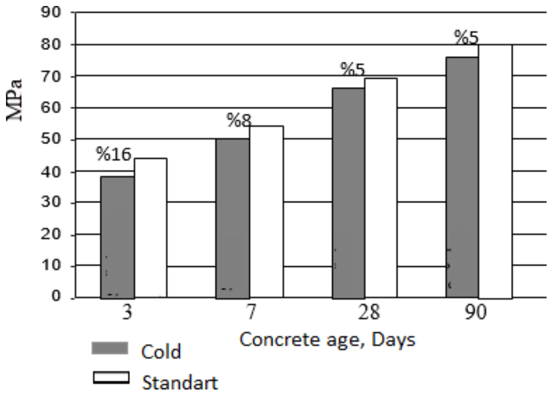


Figure 15. Strength differences in YDB samples cured in air after 7 days in water

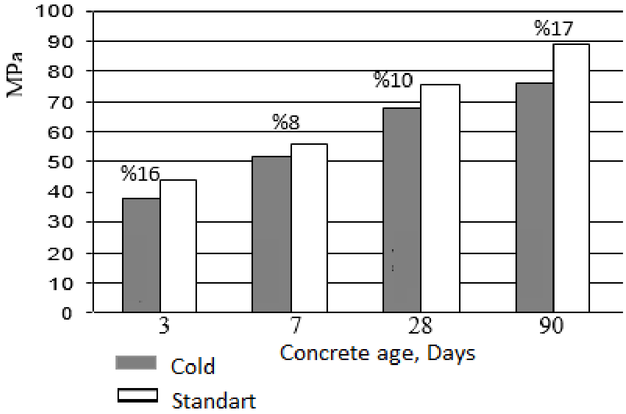


Figure 16. Strength differences in YDB samples cured in air after 28 days in water

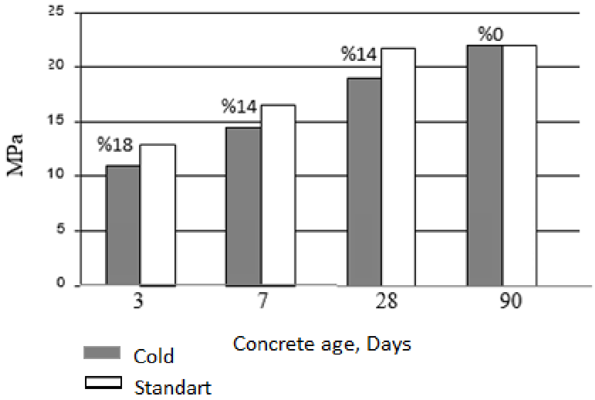


Figure 17. Strength differences in conventional concrete (S/C=0.50) samples that are always cured in air

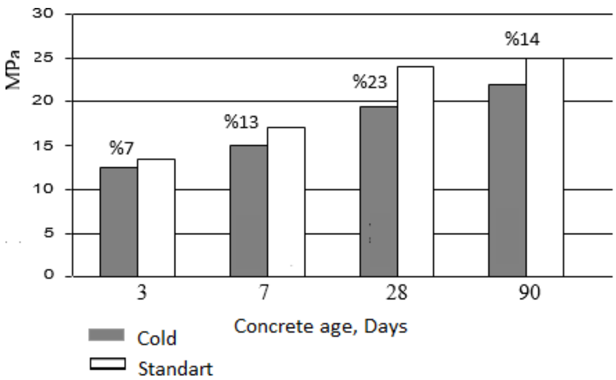


Figure 18. Strength differences in conventional concrete (W/C=0.50) samples cured in air after 3 days in water

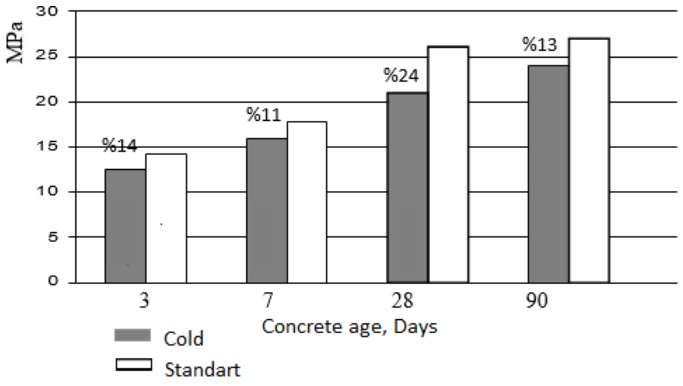


Figure 19. Strength differences in conventional concrete (W/C=0.50) samples cured in air after 7 days in water

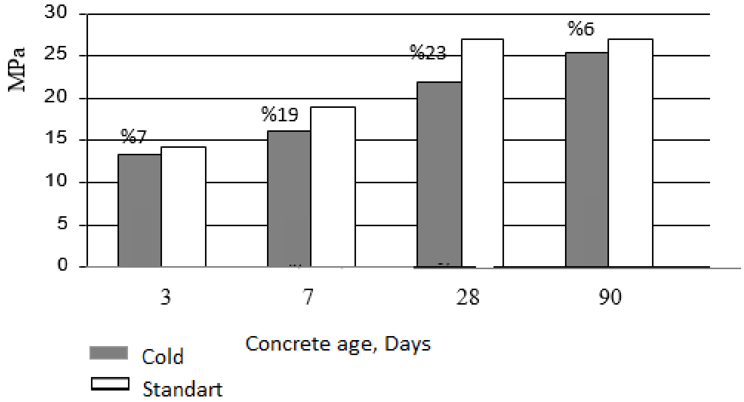


Figure 20. Strength differences in conventional concrete (W/C=0.50) samples cured in air after 28 days in water

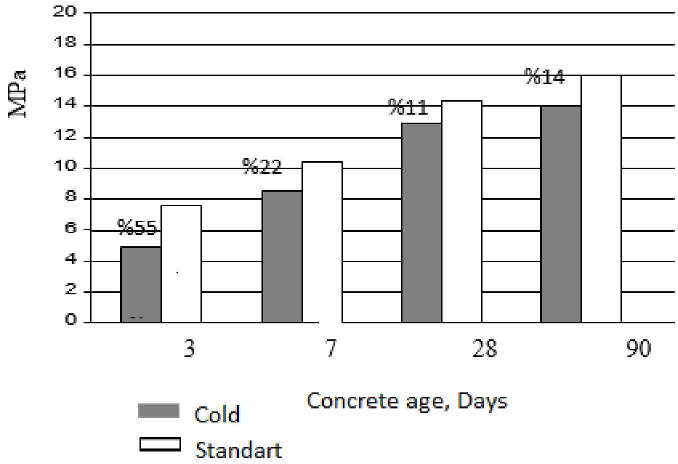


Figure 21. Strength differences in conventional concrete (S/C=0.70) samples that are always cured in air

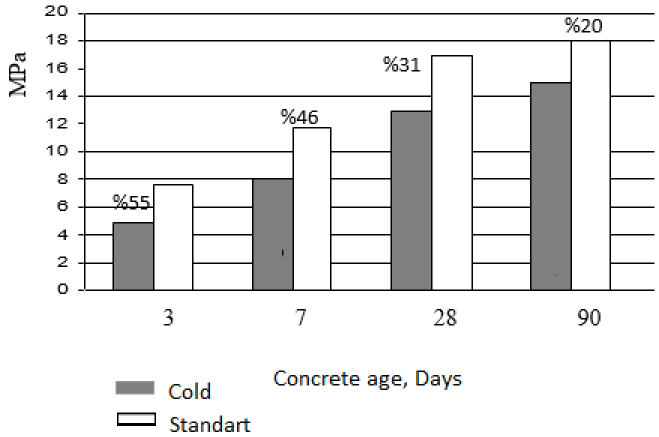


Figure 22. Strength differences in conventional concrete (W/C=0.70) samples cured in air after 3 days in water

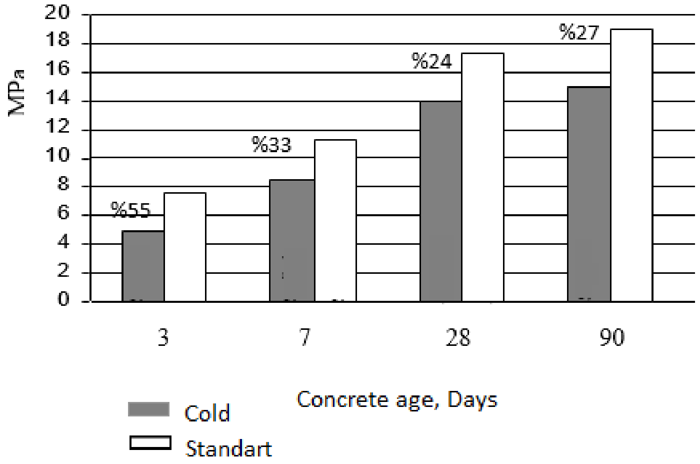


Figure 23. Strength differences in conventional concrete (W/C=0.70) samples cured in air after 7 days in water

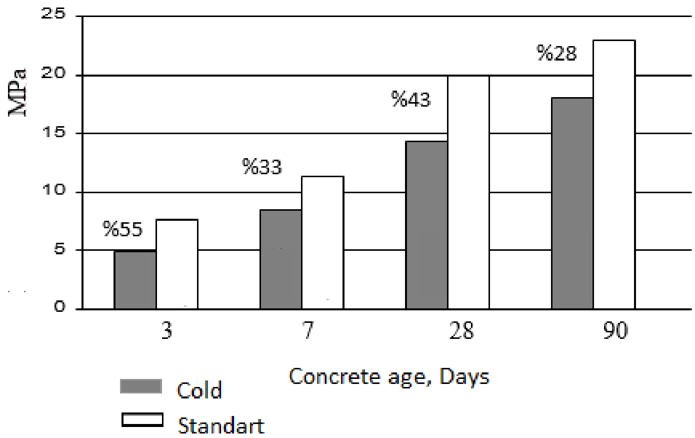


Figure 24. Strength differences in conventional concrete (W/C=0.70) samples cured in air after 28 days in water

4. Conclusion

Samples kept in an environment where the temperature is 25 °C ± 2 °C are 19% higher in 3 days, 7% in 7 days, 7% in 28 days and 8% in 90 days than samples kept in a cold environment (13˚C ±2˚C), for example, for high strength concrete, has gained strength. Therefore, a temperature difference of approximately 12˚C between the environments causes an average strength increase of 10% in high- strength concrete, 12% in conventional concrete with W/C = 0.50, and 26% in conventional concrete with W/C = 0.70. (Figures 13, 17, and 21). The differences between these increases can be explained by the different heats of hydration occurring in concretes. Similar differences emerged for other cure conditions.

When the bar diagrams given for all other hot environment and cold environment cures, where they were kept in water for a certain period of time and then kept in air until the test, were evaluated together; Compared to cold environment curing, hot environment curing caused an average strength increase of 10% in high strength concrete, an average of 14% in conventional concrete with S/C = 0.50, and an average of 34% in conventional concrete with W/C = 0.70. Based on the 28-day strength of concrete cured in standard environments; in high-strength concrete, concrete that remained in water for28 days gained 21% more strength than concrete that was never immersed in water. The same rates are24% for conventional concrete with W/C=0.50 and 40% for conventional concrete with W/D=0.70. If asimilar comparison is made for a cold environment, it is 17% in high strength concrete, 16% in conventional concrete with S/C = 0.50, and 10% in conventional concrete with S/C = 0.70.

As it is known, in order to obtain quality concrete, all three stages of production, placement and curingmust be carried out properly and carefully. Therefore, the change in strength that occurs with the changeof ambient temperature in samples that are always cured in air, becomes even more important in our country since the cure phase is generally the stage that is given the least attention in the concrete industry.In practice, since concrete is mostly left alone after being poured and placed, it turns out that the most suitable season for concrete pouring is spring. The results and recommendations obtained from the experimental and theoretical studies carried out on the produced C55, C20 and C12 classes concrete aresummarized below.

- In samples that were not cured in water at all, the 28-day compressive strength of high-strength concrete increased by 7% compared to the cold environment. These increases were 14% for conventional concrete with W/C=0.50 and 11% for conventional concrete with W/D=0.70.
- In high-strength concrete cured in a standard environment, 90-day-old samples provided a 19% increase in strength compared to 28-day samples. The same rates were 0% for conventional concrete with W/C=0.50 and 15% for conventional concrete with W/C=0.70.
- In traditional concretes with W/C=0.50 cured in a standard environment, samples that were not cured at all achieved 61% of the 28-day strength in 7 days, and those cured for 3 days achieved61% in 7 days.
- Those cured for 7 days gained 63% and 66% in 7 days.
- In conventional concretes with W/C=0.70 cured in a standard environment, samples that were not cured at all gained 52% of the 28-day strength in 7 days, those cured for 3 days gained 59%in 7 days, and those cured for 7 days gained 57% in 7 days.

Acknowledgements

The machines in the KTÜ Construction and Materials Laboratory were used in the studies, and also myteacher, Prof. Dr. Selim Pul who we lost in 2021. I would like to express my gratitude to for his contributions.

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