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# A Case Study of Cement Performance in Different Concretes

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## ABSTRACT

Cement manufacturers control the standard characteristics of products, but concrete manufacturers select cement with different criteria, such as workability and compressive strength of concrete. Therefore, some issues such as reaction with additives, achieving strength process, and performance in different applications are less considered. There are few references and studies in the field of how to check and perform cement in all types of concrete; So, in this study, an attempt has been made to take a comprehensive and detailed look at this subject with multiple criteria. In this extensive research, 10 samples of Portland cement type II were prepared from 9 cement factories, and their physical, chemical, and mechanical characteristics were determined. Then, 50 different concrete mix designs were divided into five groups (1-Unworkable, 2-Workable, 3-Medium Workable, 4-High Workable, and 5-High Workable with admixture), and 400 specimens at different ages were determined for compressive strength. In group 1 (NC), cement samples 3, 1, 4, and 7, with values of 41.2, 38.1, 37.8, and 36.4MPa, respectively, obtained the highest 28-day compressive strength in concrete. In group 2 (HPC), cement samples 7, and 1 with 50.8 and 50.2MPa showed the highest 28-day compressive strength. This comparison in group 3 (RCC) for cement samples 9, and 10 with 28-days concrete compressive strength of 1.39MPa had the highest values. In group4 (NC, w/c:0.65), cement sample 8 with a 28-day concrete strength of 36.5MPa, and in group5 (NC, w/c:0.76), cement samples 2, 6 with a 28-days concrete strength of 5, respectively 25.0 and 24.5MPa showed the highest results in their group.

**Keywords:** **Slump, fineness, cement, compressive strength, ratio W/C.**



## 1. INTRODUCTION

The most common criteria for selecting cement for concrete producers are efficiency gain (slump [1] paste), the characteristic strength of concrete, and price. In some concrete mix design methods, concrete strength is based on the strength of cement mortar [2-3]; but in others, it is not considered much [4]. In some cement standards, the characteristics of cement have been determined with a prescriptive look [5-6], and in others, with a functional point of view, the general characteristics of cement have been presented [7-8], and there is still no limit to the performance of concrete.

We know that cement paste must completely cover the surfaces of the aggregates and form strong chains by filling the space between them [9]; also, the rheological behavior of concrete depends on the rheological parameters of cement paste such as ductility and elasticity-viscosity [10]. In order to provide a suitable paste, the water demand is very important in workability. Various resources, the minimum ratio of water to cement (W/C) for complete hydration of cement, introduced from 0.2 to 0.22; But in this ratio, the efficiency is so low that making and compacting that dough is very difficult. Therefore, the amount of water is the first limitation for optimal workability in concrete (without additives). [11], which is related to cement and aggregates, and it seems that determining the standard consistency of cement [12] or flow table [13] is not a very effective method in this regard.

Kockal and Turker (2005) investigated the changes in the properties of concrete with different types of cement exposed to various environmental conditions. They used three different types of cement (ordinary Portland cement PC 42.5 (CEM I 42.5), portland composite cement PKC-A 42.5 (CEM II/A-M 42.5), and PKC-B 32.5R (CEM II/B-M 32.5R)) in their study and used investigated the effects of variable environmental conditions on plastic shrinkage of fresh concrete and cement paste, compressive strength, modulus of elasticity, capillary absorption and drying shrinkage of hardened concrete. Unlike PC 42.5 cement paste, these researchers observed plastic shrinkage cracks in PKC-B 32.5 and PKC-A 42.5 pastes. The water absorption coefficients of all the concretes stored in the natural environment at all ages were higher compared to the coefficients of the concretes stored in the laboratory [14]. In similar research, the effect of cement types (and not type II Portland cement corresponding to brand types) and its application have been investigated [15-16]. Regardless of the need for fluctuation limitation in quality results [17], optimal selection and appropriate analysis to select the appropriate cement in the concrete mix is the main goal of this study. In this study, while presenting the results of various experiments conducted in the Research and Development Center of Tehran Cement Industrial Complex (Fig1), an attempt has been made to introduce appropriate criteria for selecting cement for concrete production.

**Figure1.** Laboratory of R&D Tehran Cement

## 2. MATERIALS AND METHODS

### 2.1. MATERIALS PROPERTIES

Portland cement samples of type II have been prepared and coded from 9 factories in Mashhad, Zaveh, Nain, Shahroud, Abyek, Tehran, Qom, Saveh and Sabzevar.

Figure 2 and Table1 show the characteristics of aggregates used in this study.

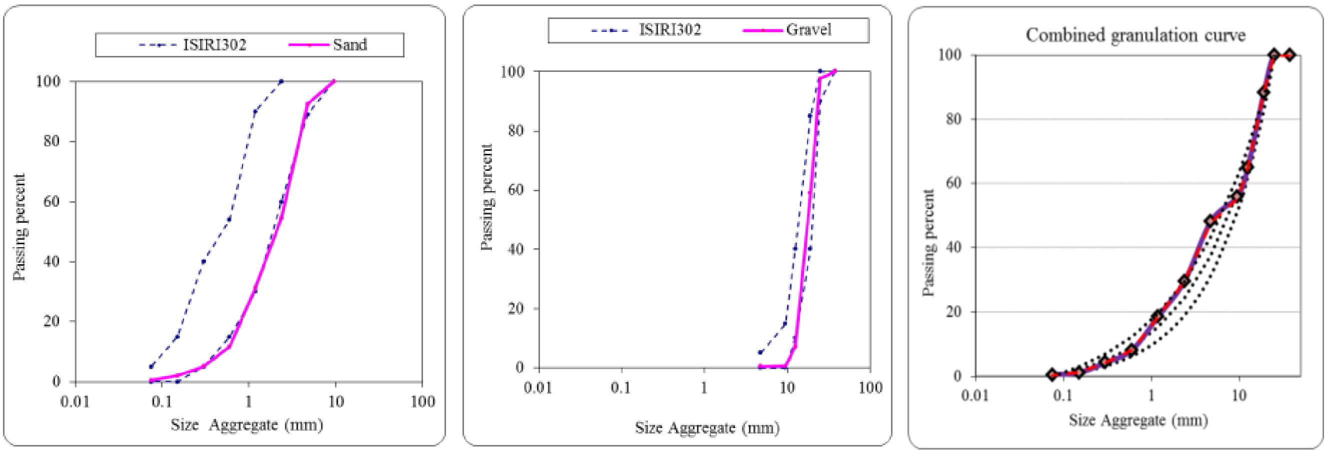


**Figure 2.** Particle size curves of sand, gravel & composition

**Table1.** Technical specifications of materials

| Type | MSA | fineness modulus (FM) | Water absorption (%) | ρ (SSD) | Fracture (%) | Passing percent of sieve 200 |
|---|---|---|---|---|---|---|
| **gravel** | 25 | 7.5 | 1.4 | 2.55 | 62 | 0.9 |
| **sand** | * | 3.8 | 2.4 | 2.58 | * | 1.1 |

The results of chemical, physical and mechanical analyzes of cement samples are also collected in Tables2 and 3.

**Table2.** Chemical result of cement samples

| Parameter | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| **Sio2** | 21.78 | 20.48 | 20.28 | 21.36 | 20.7 | 20.58 | 22.24 | 20.0 | 20.16 | 20.56 |
| **Al2O3** | 6.07 | 4.95 | 5.92 | 4.86 | 4.75 | 5.06 | 4.58 | 5.12 | 5.48 | 5.3 |
| **Fe2O3** | 3.67 | 3.51 | 3.55 | 3.36 | 3.51 | 3.43 | 3.85 | 3.6 | 3.58 | 3.8 |
| **CaO** | 63.06 | 64.4 | 63.17 | 64.06 | 62.05 | 62.38 | 62.5 | 63.17 | 62.16 | 62.94 |
| **MgO** | 2.09 | 1.69 | 2.82 | 2.82 | 3.7 | 3.62 | 2.74 | 3.22 | 2.66 | 1.85 |
| **So3** | 1.55 | 2.13 | 1.81 | 1.85 | 3.21 | 2.76 | 2.17 | 1.92 | 2.89 | 2.43 |
| **Na2O** | 0.527 | 0.384 | 0.299 | 0.185 | 0.053 | 0.084 | 0.076 | 0.524 | 0.776 | 0.535 |
| **K2O** | 0.564 | 0.595 | 0.636 | 0.59 | 0.613 | 0.628 | 0.575 | 0.471 | 0.498 | 0.657 |
| **LOI** | 0.79 | 2.14 | 1.71 | 1.27 | 1.43 | 1.68 | 1.44 | 2.12 | 1.62 | 1.92 |
| **C3S** | 40.7 | 62.2 | 53 | 55.7 | 49.2 | 50.8 | 42.9 | 60.1 | 49.7 | 52.0 |
| **C2S** | 31.7 | 11.8 | 18.1 | 19.2 | 22.2 | 20.7 | 31.4 | 12.0 | 20.3 | 19.7 |
| **C3A** | 9.9 | 7.2 | 9.7 | 7.2 | 6.6 | 7.1 | 5.6 | 5.7 | 5.8 | 7.6 |
| **C4AF** | 11.2 | 10.7 | 10.8 | 10.2 | 10.7 | 10.4 | 11.7 | 10.9 | 10.9 | 11.6 |
| **ALM** | 1.65 | 1.41 | 1.67 | 1.45 | 1.35 | 1.48 | 1.19 | 1.42 | 1.53 | 1.39 |
| **SIM** | 2.24 | 2.42 | 2.14 | 2.6 | 2.51 | 2.42 | 2.64 | 2.29 | 2.23 | 2.26 |
| **LSF** | 89.4 | 98.37 | 95.6 | 94.59 | 94.23 | 94.77 | 89.05 | 98.11 | 95.28 | 94.94 |
| **Na2O+0.658K2O** | 0.90 | 0.78 | 0.72 | 0.57 | 0.46 | 0.50 | 0.45 | 0.83 | 1.10 | 0.97 |

**Table 3.** Physical and mechanical result of cement samples

| Parameter | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Normal consistency (%)** | | 23.0 | 25.0 | 24.5 | 24.5 | 23.5 | 24.0 | 23.0 | 23.5 | 23.5 | 24.5 |
| **Setting time (min)** | initial | 120 | 135 | 210 | 215 | 175 | 190 | 200 | 120 | 140 | 215 |
| | Final | 175 | 200 | 280 | 295 | 230 | 265 | 270 | 185 | 200 | 290 |
| **flexural strength (MPa)** | 3days | 3.4 | 4.3 | 3.2 | 3.7 | 3.6 | 3.4 | 3.0 | 3.4 | 3.2 | 3.4 |
| | 7days | 4.1 | 5.5 | 5.0 | 4.8 | 4.5 | 4.7 | 4.3 | 5.1 | 4.6 | 4.3 |
| | 28-days | 6.1 | 6.8 | 6.6 | 6.7 | 6.8 | 6.5 | 5.7 | 6.5 | 6.0 | 6.2 |
| **Compressive strength (MPa)** | 3days | 20.8 | 26.5 | 20.5 | 22.8 | 22.6 | 23.8 | 18.6 | 21.1 | 19.8 | 17.7 |
| | 7days | 33.4 | 39.6 | 34.9 | 36.7 | 30.9 | 32.9 | 27.0 | 33.6 | 28.6 | 27.9 |
| | 28-days | 48.3 | 49.6 | 48.2 | 51.6 | 42.7 | 44.4 | 36.8 | 45.6 | 40.5 | 33.8 |
| **Flow table (mm)** | | 19.2 | 19.0 | 19.2 | 19.6 | 18.9 | 18.8 | 18.9 | 18.5 | 18.8 | 19.5 |
| **Blaine (kg.m2)** | | 376.2 | 341.8 | 284.7 | 289.0 | 304.0 | 294.2 | 292.0 | 331.5 | 320.7 | 282.0 |
| **ρ (gr.cm3)** | | 3.12 | 3.05 | 3.08 | 3.05 | 3.09 | 3.13 | 3.05 | 3.11 | 3.07 | 3.06 |

## *2.2. METHODS*

Concrete mixtures were prepared in 5 groups (Fig3) with cement grade of 400 kg.m$^3$ and 73% sand with 27% gravel (Figure 4 and Table 4).

**Figure 3.** Laboratory operations

3-Stiffy (Unworkable) | 1-Pasty (workable) | 4-Fluidy (Medium Workable) | 5-Fluidy (High Workable) | 2-Fluidy (High Workable with admixture)

**Figure 4.** Mixing test concretes with different efficiencies

**Table 4.** Basis for prepare concrete mixes

| Purpose and application | additive | workability (slump) | W.C | group |
|---|---|---|---|---|
| Performance in ordinary concrete (NC) | No | S2 | * | **1** |
| Performance in HSC | 1% (PCEs) | S4 | 0.40 | **2** |
| Performance in zero-slump concrete [18] | No | S1 | 0.40 | **3** |
| performance in NC and high w/c | No | S3 | 0.65 | **4** |
| performance in NC and high w/c | No | S4 | 0.76 | **5** |

## 3. RESULTS AND DISCUSSION

Compressive strength test carried out to the samples in 3, 7, 28, 90, 180 and 360 days and the results reported in the Tables 5-9.

**Table 5.** Results of concrete mixtures-group1

| **Parameter** | | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Slump (cm)** | | 7.0 | 6.5 | 7.0 | 7.0 | 7.5 | 7.0 | 7.0 | 6.5 | 7.0 | 6.5 |
| **w/c** | | 0.52 | 0.52 | 0.52 | 0.50 | 0.53 | 0.51 | 0.56 | 0.53 | 0.52 | 0.58 |
| **Density of fresh concrete (t/m3)** | | 2.32 | 2.37 | 2.40 | 2.31 | 2.39 | 2.39 | 2.31 | 2.32 | 2.30 | 2.37 |
| **Compressive strength (MPa)** | 3days | 14.0 | 11.9 | 16.4 | 12.7 | 12.9 | 10.5 | 18.9 | 10.3 | 8.9 | 8.9 |
| | 7days | 18.2 | 23.1 | 35.4 | 20.5 | 24.9 | 11.1 | 22.9 | 21.1 | 15.9 | 15.9 |
| | 28-days | 38.1 | 35.6 | 41.2 | 37.8 | 34.2 | 28.9 | 36.4 | 27.3 | 22.8 | 22.8 |
| | 90days | 45.2 | 42.8 | 43.4 | 40.7 | 45.2 | 33.0 | 42.3 | 32.3 | 27.4 | 27.4 |
| | 180days | 45.4 | 46.5 | 44.8 | 45.4 | 46.1 | 39.0 | 43.4 | 37.7 | 30.1 | 30.1 |
| | 365days | 45.1 | 48.3 | 47.4 | 50.2 | 48.9 | 40.4 | 46.4 | 39.5 | 31.2 | 31.2 |

**Table 6.** Results of concrete mixtures-group2

| Parameter | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Slump/slump flow (cm) | | 55 | 37 | 60 | 13 | 18 | 37 | 16 | 3 | 50 | 41 |
| w/c | | 0.40 | 0.40 | 0.40 | 0.40 | 0.40 | 0.40 | 0.40 | 0.40 | 0.40 | 0.40 |
| Density of fresh concrete (t/m3) | | 2.38 | 2.38 | 2.37 | 2.41 | 2.33 | 2.34 | 2.34 | 2.40 | 2.37 | 2.40 |
| Compressive strength (MPa) | 7days | 30.7 | 30.0 | 29.7 | 42.4 | 43.2 | 35.1 | 41.7 | 24.8 | 38.6 | 38.6 |
| | 28-days | 50.2 | 41.2 | 47.9 | 49.6 | 45.2 | 47.3 | 50.8 | 44.8 | 45.0 | 45.0 |
| | 90days | 59.6 | 57.7 | 53.6 | 51.3 | 58.6 | 60.0 | 51.5 | 50.6 | 46.6 | 46.6 |

**Table 7.** Results of concrete mixtures-group3

| Parameter | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Slump (cm) | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| w/c | | 0.40 | 0.40 | 0.40 | 0.40 | 0.40 | 0.40 | 0.40 | 0.40 | 0.40 | 0.40 |
| Density of fresh concrete (t/m3) | | 2.36 | 2.34 | 2.36 | 2.35 | 2.33 | 2.38 | 2.38 | 2.35 | 2.33 | 2.36 |
| Compressive strength (MPa) | 7days | 25.3 | 28.2 | 25.8 | 23.7 | 27.9 | 23.6 | 21.3 | 13.5 | 25.0 | 25.0 |
| | 28-days | 31.3 | 32.8 | 33.6 | 33.5 | 37.0 | 27.9 | 23.9 | 17.8 | 39.1 | 39.1 |
| | 90days | 35.6 | 35.6 | 35.0 | 36.6 | 38.7 | 30.9 | 25.9 | 21.4 | 40.7 | 40.7 |

**Table 8.** Results of concrete mixtures-group4

| Parameter | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Slump/slump flow (cm) | | 35 | 38 | 16 | 23 | 15 | 19 | 11 | 12 | 13 | 33 |
| w/c | | 0.65 | 0.65 | 0.65 | 0.65 | 0.65 | 0.65 | 0.65 | 0.65 | 0.65 | 0.65 |
| Density of fresh concrete (t/m3) | | 2.35 | 2.27 | 2.30 | 2.22 | 2.27 | 2.23 | 2.34 | 2.21 | 2.37 | 2.32 |
| Compressive strength (MPa) | 7days | 14.2 | 14.3 | 17.8 | 19.1 | 16.7 | 18.9 | 10.0 | 21.9 | 15.8 | 12.7 |
| | 28-days | 21.9 | 27.5 | 24.1 | 26.2 | 23.2 | 24.9 | 22.7 | 36.5 | 25.6 | 18.4 |
| | 90days | 26.1 | 33.0 | 27.9 | 28.9 | 27.9 | 28.4 | 27.0 | 37.4 | 31.0 | 23.4 |

**Table 9.** Results of concrete mixtures-group5

| Parameter | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Slump/slump flow (cm) | | 40 | 50 | 40 | 33 | 45 | 35 | 34 | 54 | 27 | 55 |
| w/c | | 0.76 | 0.76 | 0.76 | 0.76 | 0.76 | 0.76 | 0.76 | 0.76 | 0.76 | 0.76 |
| Density of fresh concrete (t/m3) | | 2.21 | 2.25 | 2.18 | 2.19 | 2.19 | 2.23 | 2.25 | 2.21 | 2.22 | 2.18 |
| Compressive strength (MPa) | 7days | 10.6 | 17.8 | 12.7 | 12.7 | 13.3 | 17.1 | 10.4 | 15.8 | 17.4 | 11.9 |
| | 28-days | 17.4 | 25.5 | 19.5 | 19.1 | 18.6 | 24.5 | 19.4 | 21.1 | 22.8 | 21.6 |
| | 90days | 27.9 | 31.1 | 25.1 | 25.0 | 24.2 | 29.3 | 20.7 | 25.3 | 24.8 | 23.3 |
| | 180days | 30.9 | 32.7 | 26.6 | 26.3 | 24.5 | 31.3 | 21.6 | 25.8 | 27.9 | 27.2 |
| | 365days | 33.6 | 34.2 | 27.9 | 26.6 | 25.6 | 34.5 | 22.7 | 26.3 | 29.5 | 27.9 |

From the point of view of obtaining 28-days compressive strength of standard mortar, cement samples No. 4 and 2 showed the highest values with 51.6 and 49.6 MPa, and samples 10 and 7 showed the lowest values with 33.8 and 36.8 MPa. The process of obtaining the strength of standard mortar in the samples was varied, in which we can see the positive effect of increasing the amount of Alite, fineness, and also decreasing the effect of alkalis and LOI in 28-day strength of cement (Fig5).

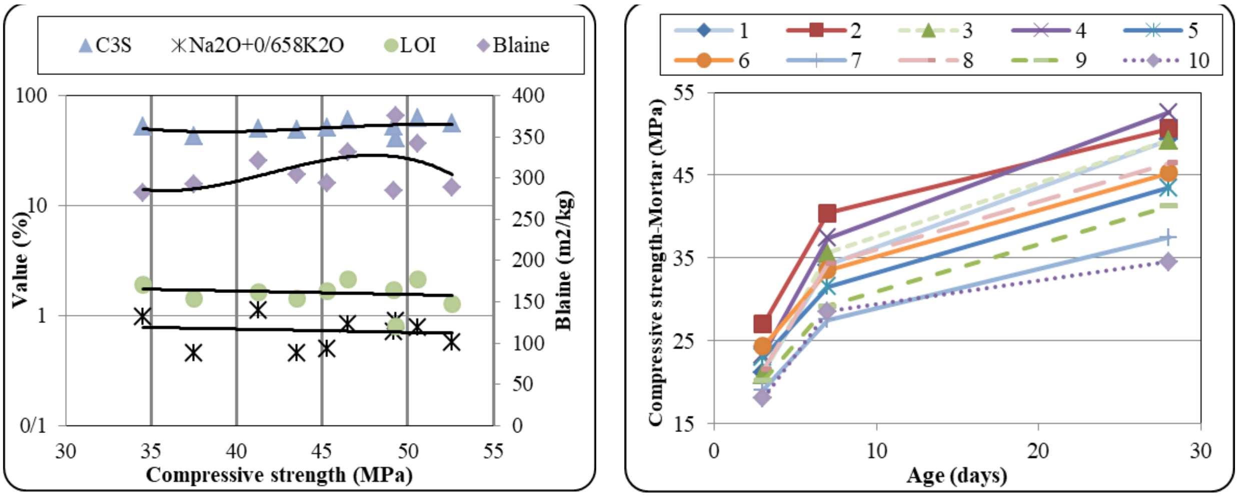


**Figure 5.** The process of obtaining the strength of samples and investigating the factors affecting the 28-day resistance of standard mortar

Differences in the physical and chemical properties of the samples were significant. Limited results of flow table tests (19.6-18.5 mm) and normal consistency (23-25%) do not show much cement performance in concrete. Cement PSD obtained an important effect on the performance of fresh concrete and the process of concrete strength [19], which was observed in laboratory operations. Due to the direct effect of the Alite phase on strength, for cement with high initial strength, a minimum Alite phase of 55% has been proposed for clinker [20]. An increase in alkalis in the cement will accelerate the setting time and increase the slump. In samples 9 and 10 (the highest amounts of alkalis), an increase in the slump trend was observed. Graphs of compressive strength trend in the two groups of best and worst concrete mixtures without additives are shown in Fig 6. In the group1 (concrete with normal strength), cement samples 3, 1, 4, and 7, with values of 41.2, 38.1, 37.8, and 36.4 MPa, respectively, have the highest 28-day compressive strength, and cement samples 9 and 10 with 8 22 MPa obtained the lowest 28-days (and 180-day) compressive strength in concrete. In group 5 (ordinary concrete with w/c: 0.76), cement samples 2 and 6 showed the highest results with 28-day concrete strength of 25.5 and 24.5 MPa, respectively, and cement 1 and 5 showed the lowest result. A comparison of the results showed that due to the increase in w/c, the decrease in resistance was small in the short term and high in the long term.

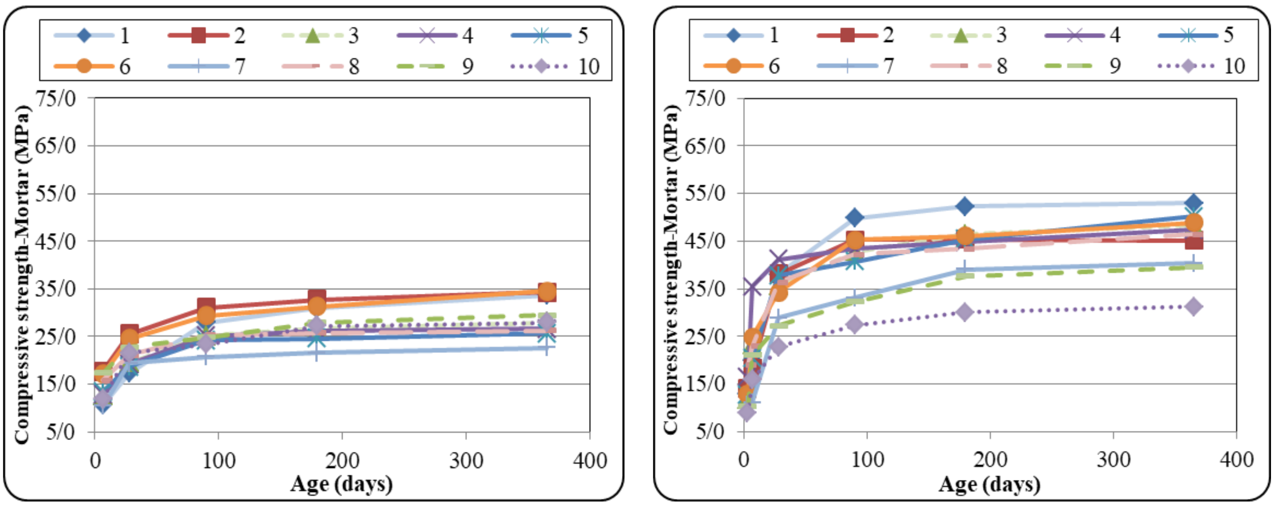


**Figure 6.** Diagram of compressive strength of group1 and group5

In group2 (high strength concrete with additives), cement samples 7 and 1 with 28-days compressive strength of 50.8 and 50.2 MPa have the highest compressive strength, and cement samples 2 and 8 with 41.2 and 44.8 MPa have the lowest 28-days compressive strength in concrete. In group 3 (concrete with zero slumps), cements 9 and 10 had the highest compressive strength of 28-days concrete of 39.1 MPa, and cements 8 and 7 showed the lowest result. The difference in the strength of concrete in group 3 compared to group 2 can be related to incomplete hydration of cement and concrete density. Suppose the degree of cement saturation decreases (approximately less than 80%) due to the structure of the hydrated cement paste and the very capillary spaces. In that case, the water is not very permeable, and as a result, the hydration is incomplete or very slow. This degree of saturation is also different in different types of cement, and the reason for the performance and observation of various resistances in cement is related to this issue (Fig7).

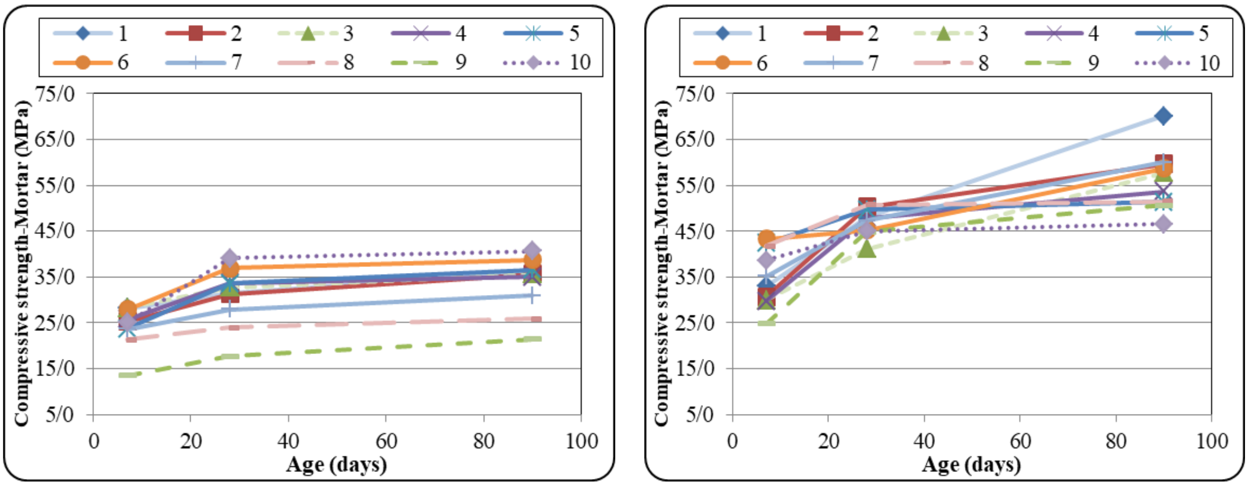


**Figure 7.** Diagram of compressive strength of group2 and group3

The results in group 2 showed that some cement had an adverse reaction in response to this amount of additive. Considering the results of standard mortar strength and the above 5 groups of concrete mixes, we can say that the resistance of concrete resistance to cement mortar resistance is not permanent [21].

Given that the number of experiments is limited in most construction activities, preparing a control checklist for observations of the properties of test concrete mixes helps to better understand the cement. It is recommended to prepare a list of objective controls and observations to get an overview of the characteristics of fresh concrete and to complete a test concrete mix during construction. Table 10 is completed as an example for cement 4. In the end, by scoring each mixture and cement, a good view of its types will be obtained.

**Table10.** Specifications of fresh concrete test mix with cement 4 and group 1

| **Status of laboratory concrete mix** | | | | **Parameter** | |
|---|---|---|---|---|---|
| Very high | high | medium | low | | |
| - | - | - | ✓ | **Bleeding** | |
| - | - | ✓ | - | **formidability** | |
| - | - | ✓ | - | **Workability** | |
| - | - | ✓ | - | initial | **Finishing** |
| - | - | - | ✓ | Delayed | |
| - | ✓ | - | - | initial | **sticky** |
| - | - | ✓ | - | Delayed | |
| - | - | ✓ | - | **Rough texture** | |
| - | - | - | ✓ | **segregation** | |
| - | ✓ | - | - | **Slump loss (1 hour)** | |

## 4. CONCLUSION

Experience shows that the climatic conditions of the project, relative humidity, and concrete transport conditions (cement setting time, amount of alkalis, amount of cement & slump loss trend) should definitely be considered for the selection of cement in each project separately and regardless of the results. This study showed that the test results of cement are slightly different from their performance in concrete.

- From the point of view of obtaining 28-days compressive strength of standard mortar, cement samples No. 4 and 2 showed the highest values with 51.6 and 49.6 MPa, and samples 10 and 7 showed the lowest values with 33.8 and 36.8 MPa.
- In the group1 (concrete with normal strength), cement samples 3, 1, 4, and 7, with values of 41.2, 38.1, 37.8, and 36.4 MPa, respectively, have the highest 28-day compressive strength, and cement samples 9 and 10 with 8 22 MPa, obtained the lowest 28-days (and 180-day) compressive strength in concrete.
- In group2 (high strength concrete with additives), cement samples 7 and 1 with 28-days compressive strength of 50.8 and 50.2 MPa have the highest compressive strength, and cement samples 2 and 8 with 41.2 and 44.8 MPa have the lowest 28-day compressive strength in concrete.
- In group 3 (concrete with zero slumps), cements 9 and 10 had the highest compressive strength of 28-days concrete of 39.1 MPa, and cement 8 and 7 showed the lowest result.
- In the fourth group (normal concrete with w/c: 0.65), cement sample 8 with a 28-day concrete strength of 36.5 MPa, and cement samples 10 and 1 showed the lowest resistance with 18.4 and 21.9 MPa.
- In group 5 (ordinary concrete with w/c: 0.76), cement samples 2 and 6 showed the highest results with 28-days concrete strength of 25.5 and 24.5 MPa, respectively, and cement 1 and 5 showed the lowest result.
- Comparison of mortar and concrete results showed that some parameters had an effect on mortar and others on concrete strength, so there should be no emphasis on fixing concrete strength to mortar strength.
- The optimal w/c ratio and optimum performance in different types of cement were varied and should be designed according to the concrete conditions.
- Given that experiments are limited in most construction activities, preparing a control checklist for observations of the properties of test concrete mixes helps to better understand the cement, so a table was suggested.
- Although the parameters of Alite, residue on the 45-micron sieve, LOI, alkalis, setting time, and normal consistency of cement are very important in its quality, monitoring the performance of cement in concrete is important according to the application and type of concrete.

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This work was carried out in collaboration among all authors.

CONFLICT OF INTEREST

The author (s) declared no potential conflicts of interests with respect to the authorship and/or publication of this paper.

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