

Verifying Cement Compressive Strength Test Result Using the Most Effective Parameters

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Abstract

This study was conducted to analyze factors influencing the compressive strength test. The purpose is to introduce various factors affecting the accuracy of the compressive strength test in accordance with current standards and evaluate the effect of some effective parameters such as equipment (loading rate of automatic compression machine, jolting or vibrating), mortar preparation, sample preparation, etc. To check the reproducibility of the compressive strength test a program was developed to assess the possible modes through changes in loading rate, standard sand, sample preparation, and operator. The changes of each parameter were measured within 2, 7 and 28-day interval, while other conditions were considered as constant based on the EN 196-1 and ISIRI 393 standards. According to the test results, the most important factors in creating the difference in results are the type of the sand and loading rate. The changes in the reproducibility percentage using different sands with softer grains increases the coefficient of variation and reduced performance of the test. Also in some cases, with increasing the loading rate up to 40%, the compressive strength of 28 days is increased by 13%.

Keywords: *Coefficient of variation, Reproducibility, Loading rate*

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Extended Abstract:

1. Introduction

Compressive strength is one of the most important physical parameters in determining cement quality and usage. Due to the increasing growth of concrete structures and consequently increased consumption of cement in the world, the need for the concrete production with high durability and strength is of great importance (Taeb et al., 1995).

Among the factors affecting the compressive strength of mortar and concrete include the type and quality of the members (cement phases, softness, fineness, and aggregation), the percentage of members or concrete mix design and curing conditions (Caldarone, 2008). The lack of accurate measurement can lead to incorrect analysis of the impact of these factors (Taeb et al., 1995; Bekaeian, 1997). Cement compressive strength tests are usually done based on the standards EN 196-1, DIN 1164, BS 4550 or ASTM C109.

Among the factors influencing the test are the mold type and size. Cube molds have better strength than the cylindrical ones (Del Viso et al., 2008, Torreti et al., 2002). Thus, in accordance with the standard cube molds with the standard dimensions $16 \times 4 \times 4$ are selected. The loading rate of the test machine is another factor affecting the change in compressive strength. Very low applied rate results to creep phenomenon, and as the loading rate increases, the compressive strength of mortar increases as well (Aggoun et al., 2008). For the standardization of cement, two types of sand are used: Standard German sand and Ottawa standard sand. Each of these sands according to their defined standards in their countries have specific specifications, including: grain size, silica content, rounding, as well as compressive and flexural strengths (Iranian National Standard, 2004).

2. Materials and methods

In this study, nine samples of cement type 1-425 were analyzed in terms of the effect of changing the sand, sample preparation method and loading rate (EN 196-1, 2018, ISIRI 393, 2009). Loading rate 2 was 1.5% higher than the standard loading rate. The loading rate of the automatic compression machine for each sample was measured by a rate of 2400 Newton per second (loading rate 1) and with 50% increase in rate (loading rate 2).

In preparing the mortar two types of reference sand with different aggregation was used. Type 1 sand had a softer aggregation than type 2 (reference sand). Grain size distribution and limit PSD of used reference sand according to EN 196-1 is included in Table 1. Also, Grain size curve for two types of sand is shown in fig. 1.

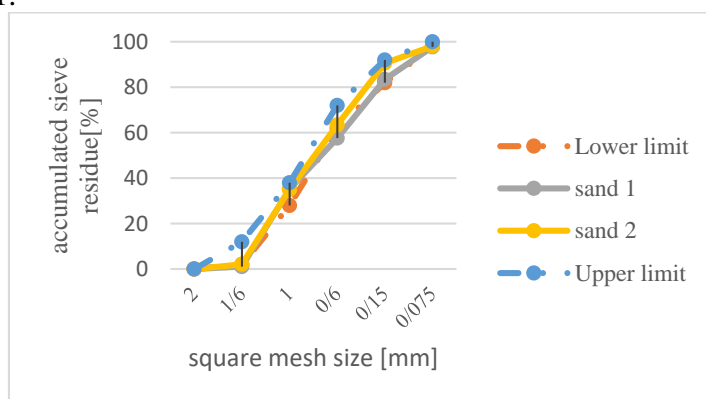


Fig1. Grain size curve for two types of sand

2.1. *Parameters' matrix*

Reproducibility of compressive strength test is the close agreement between the obtained results from similar cement samples in different laboratories under the factors such as different systems, the likelihoods of different reference cements and the possibility of their performance time. In the case of the 28-day compressive strength, reproducibility between the laboratories with conventional operation and the above-mentioned conditions should be less than 4% which is discussed as the coefficient of variation (Huang et al., 2010). The equipment used in the compressive strength test is calibrated. The test method from the step of preparation up to measuring the strength is fully in accordance with the conditions mentioned in ISIRI 393 and EN 196-1 standards and listed in Table 1.

Table 1. Evaluation matrix of effective parameters in the compressive strength test

	Curing	Loading rate	Type of the sand	Mortar preparation
Curing	-	*	*	*
Loading rate	*	-	*	*
Type of the sand	*	*	-	*
Mortar preparation	*	*	*	-

3. Results and discussion

3.1. *2-day strength results*

The comparison of CVs regarding different source of variation (SOV) is presented in fig. 2. It showed that the comparison between softer sand and standard sand in different loading rate was not significantly different for 2-day compressive strength (fig. 2 (a)). Also, there is no significant difference between CVs of different loading rates in each of the mortars (fig. 2 (b)).

The effect of loading rate is less than the cement prepared with the different sands. Also changing the type of sand increases coefficient of variation, increase in short-term compressive strength and reduced reproducibility.

3.2. *7-day strength results*

The precision of 7-day strength data of cement mortar prepared by different mortar sand in two loading rate is significantly different. The mean value of CV of mortar by the standard loading rate was significantly smaller than each sample that the increased force required to break it (fig. 3).

3.3. *28-day strength results*

Fig. 4 showed that the distribution of data obtained from mortar prepared by different sand (fig. 4 (a)) was far more concentrated than that of different Loading rate (fig. 4 (b)). Conversely, due to the increased force required to break each sample, increasing the loading rate has a greater impact on the increase in 28-day compressive strength. These changes have reduced reproducibility for sand type 2 with higher ratio.

4. Conclusion

Based on the results of the tests the following contents are concluded:

1. Increasing the loading rate increases the compressive strength up to 15 percent. Increasing the loading rate in 28-days samples has had a greater impact on short-term increase in compressive strength.
2. Change in the method of preparation with vibrator rather than Jolting leads to 2% change in results, by changing the method of pouring the mortar in the mold it is possible to pass this error. Also the use of sand type 2 (reference sand) reduced this difference.
3. The most important factor in creating variation in results is associated with the sand type. So sand type 1 results in greater strength than the reference type. Also the reproducibility changes are increased by this type of sand.

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