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Experimental Study of the Effect of Limestone Powder on Concrete Compressive Strength and Workability in Jaresh City

YASSER I. O. YAHIA
Department of Civil Engineering , Jaresh University , Jaresh , Jordan
Email: yasseribrahim646@gmail.com

Abstract

This study investigates the experimental laboratory work of concrete to determine the optimum amount of limestone powder to be used in concrete mixes. To handle this purpose 30 concrete cubes were prepared for testing to achieve a compressive strength of 25 MPa According: ASTM (211.1-81). The samples were classified into four different categories according to the ratio of the limestone powder that added to the specimens such as follow; 0%, 1%, 2%, 10% and 15% of cement ratio. For all tests, the cubes were left in curing until testing at the age of 3, 14 and 28 days respectively. The specimens were loaded to failure and the averages of compressive strength were used for comparison purposes. To measure the workability flow table test has been conducted on the fresh concrete directly. Results were compared to null limestone powder samples and revealed that the average compressive strength of samples with ratio 2% was increased by 5% and 9.5% at age 14 days and 28 days respectively. On the other hand, adding 15 % of limestone powder causes significant reduction of compressive strength 43% and 28% and age 14 days and 28 days respectively. The flow table tests revealed an increment in the workability of fresh concrete with 0% a, 1% and 2% of limestone powder used in concrete mixes. An ideal ratio of limestone powder is 2% was recommended in this research study.

Keywords: *Limestone Powder, Compressive Strength, Flow Table, Workability.*

Introduction

Concrete is a mixture of sand and gravel held together with a paste of cement and water. Sometimes one or more admixture is added to change and increase certain characteristic of the concrete such as its workability, durability, and time of hardening. One of most important chemical admixture that common used in concrete is lime. Lime improved workability and allowed to rework mortars without wastage; it also lowered strength and stiffness making PC mortars more deformable. However, in the last decades, the use of hydrated lime as an admixture has largely decreased due to the indiscriminate use of chem. ical admixtures. According to Jackson and Dhir (1988) Plasticisers are the most common chemical admixture, accounting for almost 50% of all admixture sales in the UK (Newman & Choo, 2003). They are extensively used by ready-mix companies to optimize their mix design; especially at low to medium slump. Current plasticizers are usually based on lingo-sulphonate salts (natural polymers derived from wood processing in the paper industry) (Hewlett, 1988). A solution to reduce the cost is the use of mineral admixture such as limestone powder added to concrete during the mixture procedure (EN 197-1:2000 Cement. Composition) By substituting a quantity of cement with filler the paste properties on different levels are affected: chemical – introducing new reaction or modifying the existing ones during the hydration process, physical – improved nucleation, dilution effect – adjusting distance between cement particles and filler effect – filling the Small pores between cement particles. The use of filler is a common practice in European countries, especially in France and Sweden, where it is stored in silos alongside the concrete plants (Bibm, Cembureau) Limestone powder are sedimentary rocks primary of calcium carbonate. The filler represents a by-product of limestone powder crushers which has been accumulated in large volumes and constitutes a source of environmental pollution. The addition of this improves the workability, deformability and stability of fresh self compacting concrete (H. Okamura, M. Outchi).

Literature Review

In this literature review section provides the necessary background information on concrete technology in general, along with materials used for concrete manufacturing with a strong focus on concrete aggregate. The fine and coarse concrete aggregates are reviewed in terms of their properties, and the testing techniques used in the characterization of concrete aggregate are also reviewed. In addition, background information on the basic engineering properties of conventional concrete is presented including its acoustic characteristics. With reference to coarse aggregate and conventional concrete, porosity has been identified as one of the most decisive properties affecting the physical, mechanical, and acoustic characteristics of concrete, subsequently, literature on porosity of coarse aggregate and concrete is reviewed. Concrete is a mixture of paste and aggregates (rocks). The paste, composed essentially of Portland cement and water, coats the surface of the fine (small) and coarse (larger) aggregates. Through a series of chemical reactions called hydration, the paste hardens and gains strength to form the rock-like mass known as concrete. Lime has been used as the basis for the pozzalonic material in concrete for thousands of years. Portland cement's development in the late eighteenth century and its adoption as the primary pozzalonic material in concrete resulted in the displacement of lime as the primary cementitious material. Lime has a number of properties that are of interest in the development of long term durability of materials, particularly the slow carbonation rate and resulting self-healing properties (Ridi, F, Warner, R.F).

Although the fine and coarse aggregate in concrete matrix provide inert filler, the aggregates' petrographical, physical and mechanical properties can significantly affect concrete plastic and hardened characteristics. Nawy (1997) defines the most important properties of aggregate for ordinary concrete being the particle size distribution, aggregate shape, porosity and possible reactivity with cement. Nawy (1997) also states that surface texture has significant influence on concrete strength, since cubically shaped crushed stones with a rough surface appear to produce higher strength concrete than smoother faced uncrushed gravel, as bonding between aggregate and cement paste is increased. Concrete admixture enhances the workability of concrete by its powerful deflocculating and dispersing effect on the cement particles which in turns helps to produce high workable concrete or enables in significant reduction in free water content. M S Shetty (2008).

Objectives of the Research

The aim of this investigation is to study the possibility of using the (lime) Hydrated in the production of concrete, and to increase the strength of concrete when adding specific proportions of lime within the standard specifications. The raw materials were obtained from Jarash area (Mahajer -Jordan). Another aim of this study is to determine the optimum ratio of the (lime) Hydrated with respect to cement ratio that gives good enhancement in concrete properties.

Research Approach

To achieve these goals some experimental tests were conducted. Some of tests were conducted to the raw materials that collected from Mahjer Jaresh, such as aggregate and sand in order to get the engineering properties of these materials. The following tests were conducted:

1-Seive Analysis
2- Specific Gravity

In order to obtained suitable amount of limestone powder that gives improvement of concrete properties, the samples were divided in to five categories according to the ratio of limestone powder to cement. At each category six cube specimens were prepared and tested, the categories are:

1. Three cube specimens with Null lime
2. Three cube specimens with 1% lime
3. Three cube specimens with 2% lime
4. Three cube specimens with 10% lime
5. Three cube Specimens with 20% lime

Tests conducted on concrete after prepared are:

1- Slump Test
2- Flow table test
3- Compressive Test

Work Plan and Experimental Matrix

Mix Design of Concrete Samples

After determination of engineering properties (grain size distribution, specific gravity,) of raw materials such as (course/fine aggregate and sand), a mix design is conduced to prepare the specimen according to the categories mention above. The mix design ratio that used in this study is (1:2:2.6), whereas the lime ratio is added according to these categories:

1. Null lime
2. 1% of cement ratio
3. 2% of cement ratio
4. 10% of cement ratio
5. 15% of cement ratio

The following table gives the details of course/fine aggregate and cement ratio that used for samples preparation.

Table .1 Illustrate the Mix Design Ratio Details of Specimens

Lime (kg)	Fine Aggregate (kg)	Corse Aggregate (kg)	Cement (kg)	Water (kg)	Lime (%) /cement
0	14.883	18.933	7.1680	4.374	0 %
0.0716	14.883	18.933	7.0963	4.374	1 %
0.1433	14.883	18.933	7.0246	4.374	2 %
0.7168	14.883	18.933	6.4512	4.374	10 %
1.0752	14.883	18.933	6.0928	4.374	15 %

Results Analysis and Discussion

In this study, a concrete specimen compression test was carried out for all samples with different limestone powder ratio and at age 3 days, 14days and 21 days respectively. All Results were compared to compressive strength of samples with no limestone powder content.

Compression Test of Cube specimen at age 3 days with limestone powder ratio (0%, 1%, 2%, 10% and 15%)

The average compressive strength of the sample without limestone powder at the age of 3 days is 9.87 MPa and this value is increased by 2.5% and 20%, when added limestone powder ratio of 1% and 2 % respectively. On the other hand, the value of compressive strength was decreased by 30% and 48% when added limestone powder ratio of 10% and 15 % respectively. Figure 1 shows the average compressive strength of samples with different limestone powder ratio and table 2, illustrates test results for all samples.

Compression Test of Cube specimen at age 14 days with limestone powder ratio (0%, 1%, 2%, 10% and 15%)

The average compressive strength of the sample without limestone powder at the age of 14 days is 22.65MPa and this value is increased by 4% and 5%, when added limestone powder ratio of 1% and 2% respectively. In contrast, the value of compressive strength was decreased by 21% and 43% when added limestone powder ratio of 10% and 15 % respectively. Figure 1 shows the average compressive strength of samples with different limestone powder ratio and table 2, illustrates test results for all samples.

Compression Test of Cube specimen at age 28 days with limestone powder ratio (0%, 1%, 2%, 10% and 15%)

The average compressive strength of the sample without limestone powder at the age of 28days is 24.33 MPa and this value is increased by 6.6% and 9.5%, when added limestone powder ratio of 1% and2 % respectively. In contrast, the value of compressive strength was decreased by 18% and 28% when added limestone powder ratio of 10% and 15 % respectively. Figure 1 shows the average compressive strength of samples with different limestone powder ratio and table 2, illustrates test results for all samples.

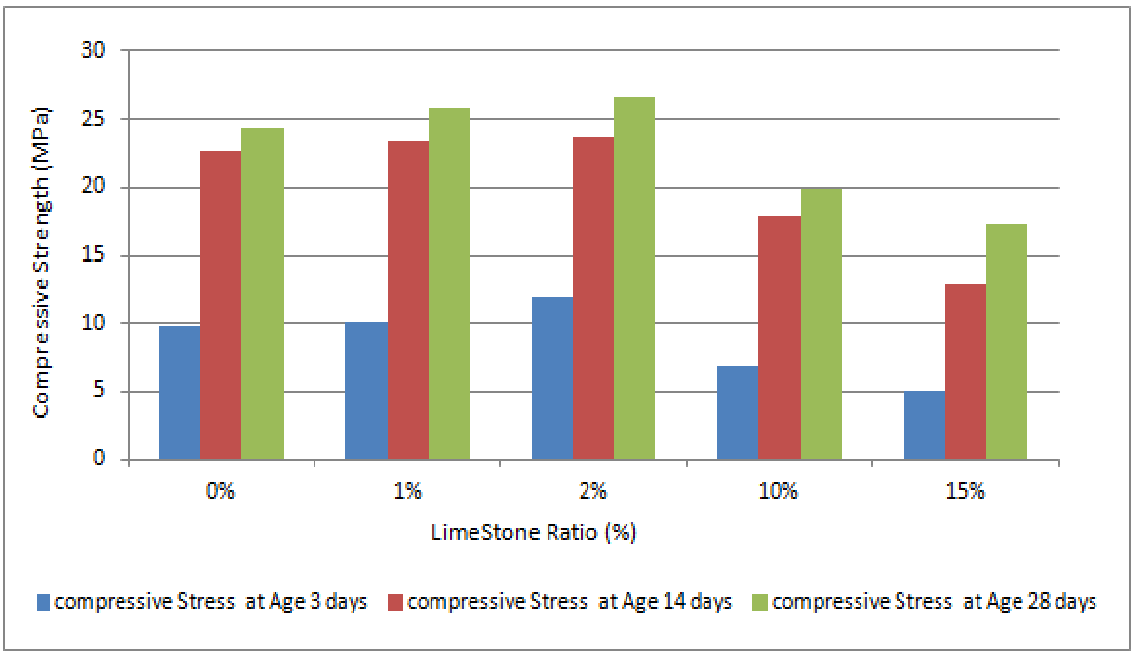

Figure 1 shows the average compressive strength of samples with different Rubber Ratio

Table 2. Illustrates Test Results for All Samples

Sample Type	Sample Composition Limestone powder (%)	Sample Age (Days)	Average Compressive Strength (MPa)	Standard Error	Specific Compressive Strength (MPa/Kg/m^3)
Cube	0	7	7.85	0.181	3.6
-	1	7	8.66	0.604	3.9
-	2	7	9.93	0.319	4.51
-	10	7	6.86	0.098	3.12
-	15	7	5.54	0.276	2.52
Cube	0	14	14.72	0.456	6.7
-	1	14	16.07	0.363	7.3
-	2	14	17.04	0.357	7.74
-	10	14	10.73	0.381	4.88
-	15	14	8.66	0.452	3.94
Cube	0	28	24.3	0.378	11.04
-	1	28	25.94	0.637	11.8
-	2	28	26.64	0.802	12.11
-	10	28	18.8	0.582	8.54
-	15	28	17.23	0.617	7.83

According to the results analysis the following results discussion were drown:

- Adding 2% of limestone powder to concrete mixture has a significant effect to improve the compressive strength of concrete cube specimens at age 3 days; 14 days and 28 days it can be reached up to 20%, 5% and 10% respectively. This is also can be linked to the work of H. Okamura (2003) and M. Uysal , M. Sumer (2011) who stated that the addition of this improves the workability, deformability and stability of fresh self compacting concrete as well as the compressive strength of concrete.
- Adding 10% of limestone powder to concrete mixture cause reduction of compressive strength of concrete at ages 3 days, 14 days and 28 days by the ratio up to 30%, 21% and 18% respectively. However it can be connected to A. Bradu and N. Floreia (2015) who stated that reduction of compressive strength observed by adding limestone powder more than 10% of cement ratio.
- Adding 15% of limestone powder to concrete mixture cause decrease of compressive strength of concrete at ages 3 days, 14 days and 28 days by the ratio up to 48%, 43% and 28% respectively. However it can be connected to Nawy (1997) who stated that reduction of compressive strength observed by adding 20% of limestone powder that replaced cement content.
- Since the cement content play a significant role on improving the compressive strength of concrete due to hydration process, however, replacing 10% or more of cement content with limestone powder result in significant reduction in compressive strength of concrete.

Conclusion

The following conclusions are drawn based on the laboratory test results used in this study:

- It has been observed that adding replacing 1% - 2% of cement with limestone powder or on concrete has a significant effect on increasing the compressive strength of concrete cube samples with a range between 5% -20% since limestone powder filler improves the properties of concrete.
- The measurements show that the replacement of cement with limestone powder with range (1%- 2%) increases the workability.

- The general conclusion derived from the investigation is that the reduction of compressive strength of concrete at age 28 days varies between 18%-28%, when 15% of limestone powder was added to concrete. So that the compressive strength was reduced significantly when limestone powder was used to replace cement more than 15% of the mixture.
- The small value of standard error for all samples indicated that how the average compressive strength was accurate.
- Further experimental studies are needed to understand the behavior of Jerash row material of concrete such as coarse aggregate and fine aggregate.

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