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EFFECT OF STONE CUT POWDER AND LIMESTONE POWDER ON THE PROPERTIES OF PORTLAND POZZOLAN CEMENT CONCRETE

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ABSTRACT

This study was carried out to empirically examine the effectiveness of the use of available waste of construction materials in Jordan on the properties of Portland Pozzolan cement concrete by studying the effects of blending of local limestone powder waste as filler materials and local stone cutting powder (Al-Khamkha) with cement and sand on the performance of fresh and hardened limestone- Al-Khamkha–Portland Pozzolan cement concrete with different replacement of cement and fine aggregate.

To study the performance of limestone-Al-Khamkha– Portland Pozzolan cement concrete , different concrete mixes were prepared with cement and sand blended with limestone powder and Al-Khamkha with replacement of Portland Pozzolan cement by limestone powder (0% , 5% , 10% and 20 %) by weight of cement and replacement of fine sand by Al-Khamkha (0%, 5%, 7%, and 10%) by weight of sand. Furthermore, studying the behavior of limestone- Al-Khamkha–Pozzolan cement concrete the concrete cubes specimens were cured in Dead Sea water for 28 days and three months and the compressive strength was investigated.

The investigation of this study, therefore, has revealed that compressive strengths of concrete from 5% Lime powder and 5 % Al-Khamkha blended Portland Pozzolan cement increased the compressive strength by 7.41% more than the control concrete

specimens. For the other replacement levels, reduction in compressive strength is observed. Observation on the test results also indicate that the compressive strength of all concrete specimens cured in Dead Sea water for 90 days was reduced.

Keywords: Compressive strength, Pozzolan cement, Local material, limestone, Al-Khamkha, Dead Sea water

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1. INTRODUCTION

Recycling of industrial waste materials in construction industry has the potential to reduce the cost of construction projects substantially. These waste materials can be blended with concrete the commonly used building materials ingredients or can replace one of concrete compounds such as cement, or sand, or coarse aggregate.

As well as low cost there are many advantages to be gained from recycling of industrial waste materials in cement-based construction materials such as the solution of the environmental pollution and sustainable use of natural resources

Research on the use of industry waste materials in construction is in progress in the all entire world and a considerable amount of construction materials studies have been performed to empirically study the effects of addition of waste materials on the properties of concrete [1]. A review of the literature[2,3,4,5,6,7,8,9,10,11] leaves no doubt that use of Limestone as inert filler, additive or aggregate in concrete production is attractive option for recent research studies in construction materials .

Jordan is endowed with different types of naturally available materials such as building and ornamental stones (including marble), cement raw materials, sand, gravel, crushed stone and natural sand and others. In Jordan there is extensive production and extensive use of building stones in construction industry, and stone cutting industry waste (Al-Khamkha) having desirable qualities and can be used in concrete construction and some research on utilities of this type of material in construction have been performed [12,13,14].The use of such industrial by-product or waste material can result in saving of energy and conventional materials.

Full knowledge of concrete behavior that made from local materials and study of its physical and mechanical properties is important in any local construction industry to understand the concrete behavior that made from local available materials.

This paper was carried out to investigate the influence of limestone powder and stone cut powder (Al-Khamkha) on the fresh and hardened properties of Portland Pozzolan cement concrete and also the durability characteristics. To achieve this, two local materials , limestone and stone cut powder (Al-Khamkha)) were used to make limestone- Al-Khamkha concrete with different replacement of cement and fine aggregate, using of these locally available materials in concrete production results in green concrete .

2. METHODOLOGY

The main objectives of the study are to study the effects of using local limestone powder waste as cement replacing filler, and to study the effects of using local stone cutting powder (Al-Khamkha)as sand replacing on the performance of Portland Pozzolan cement concrete. To achieve these objectives, two major experiments were designed. The first experiment was

done to determine the effects of replacing part of Portland Pozzolan cement with local limestone powder waste and replacing part of silica sand with local stone cutting powder (Al-Khamkha) on concrete performance such as workability, and compressive strength. Following experiment one, another experiment was performed to study the compressive strength of limestone- AlKhamkha–Pozzolan cement concrete for different curing condition and curing periods by using dead sea water as curing water for 28 and 90 days, and compare the compressive strength measured values with specimens of pure Portland Pozzolan cement concrete

3. MATERIALS USED IN STUDYING THE PROPERTIES OF LIMESTONE- ALKHAMKHA–POZZOLAN CEMENT CONCRETE

3.1. Cement

For studying the effects of limestone and Al-Khamkha on the properties of concrete, it was proposed to use Portland Pozzolan cement used in Jordan. This cement is manufactured according Jordanian standard specifications 1-30 / 2016 and European standard EN-197-1/2011 was used.

3.2. Coarse Aggregate

Throughout the experiment, crushed coarse aggregates of 20mm maximum size from the local crushing plants were used.

3.3. Fine Aggregate

Silica sand passing through 4.75 mm sieve and retained on 600 μm sieve, conforming to local specifications was used as fine aggregate throughout the experiment. The silica sand is free from clay, silt and organic impurities.

3.4. Water

Throughout the investigation, tap water supplied for drinking consumption at JERASH city was used for was used for mixing concrete samples. For curing of hardened concrete samples, drinking water and Dead Sea water were used. Dead Sea water has been used for the curing of concrete to study durability of limestone- Al-Khamkha concrete. The Dead Sea water is characterized by high salinity and high mineral content. The composition of tap water and Dead Sea water are shown in table (1) according to [17].

Table 1 Typical chemical composition of Dead Sea water and tap water [17]

Chemical Composition	Concentration Mg/l	
	Tap water	**Dead sea water**
Na	45.9	36110
SO_4	65.4	420
TDS	438	341
CL	62.1	226900

3.5. Limestone

Natural limestone powder waste produces as by-product of local limestone aggregates crushers was used in this study as cement replacing filler. These natural limestone fillers are available on the Jordan market and are commercially sold for many civil engineering purposes like plastering and tiling.

3.6. Stone Cutting Powder Waste (Al-Khamkha)

In this test, Stone cutting powder waste (Al-Khamkha) from The Jordan Processing Factory in Jarash city was used as sand replacing filler. In this study, the researchers focused on use of Al-Khamkha waste powder with its original (natural) fineness. However as the powder comes out in slurry form from the factory, drying turns it to large conglomerate grain form than to powder form; this required a certain manual grinding to get its natural (original) fineness.

4. EXPERIMENTAL PROGRAM

4.1. Concrete Specimens Preparation

For studying the effects of replacing parts of cement and sand by limestone and Al-Khamkha, design mix is done using ACI method for 25MPa of concrete. A plain mix (without limestone and Al-Khamkha) was used for the comparison as benchmark. The proportion of the materials as per the design is given in Table (2 ,3) below.

Table 2 Proportion of replacement of Portland Pozzolan cement and silica sand

Code	Limestone powder (%)	AL – khmkha (%)	Cement (%)	Silica Sand (%)
P.C	--	_	100	100
C (5%LM +5%K)	5	5	95	95
C (7%LM)+ (10% K)	7	10	93	90
C (10%LM)+ (20%K)	10	20	90	80

Description of the concrete specimen code is

- **P.C** - Plain concrete
- **F.A** - Fine aggregate
- **LM** - Lime stone Powder
- **C.A** - Course aggregate
- **K**- AL-KHAMKHA
- **W/C** - Water cement ratio

Table 3 Proportion of materials for trial mixes

Code	Cement kg/m3	Water kg/m3	W/C	C.A kg/m3	F.A kg/m3	K kg/m3	LM kg/m3
P.C	11.162	5.54	0.5	31.75	24.52	0	0
C(5%LM +5%K)	10.6039	5.54	0.5	31.75	23.294	1.226	0.5581
C(10%LM)+ (20%K)	10.045	5.54	0.5	31.75	19.622	4.905	1.1162
C(7%LM)+ (10% K)	10.380	5.54	0.5	31.75	22.076	2.452	0.7813

4.2. Curing

After the concrete was cast and finished the specimens were left in the mold for 24 hours after which they were released from the mold then parts of specimens were cured in drinking water and the other part were cured in Dead Sea water until test period.

5. TEST RESULTS AND DISCUSSIONS

5.1. Workability of Limestone- AlKhamkha–Pozzolan Cement Concrete

In this experiment slump of all mixes with constant water to cement (W/C) ratio were measured to get information about workability changes due to the limestone powder and Al-Khamkha.

As it is shown below in table 4 and figure 1 concrete mixes with Portland Pozzolan substituted by limestone powder and silica sand substituted by Al-Khamkha show slump reduction than the concrete control mix. This is due to the reduction of the sand quantity as some part of the sand is replaced by Al-Khamkha and as the particle size of the Al-Khamkha

used was very fine than the silica sand which results in higher particles surface area that results in higher water demand.

Table 4 Slump of concrete specimens prepared with limestone- AlKhamkha – Portland Pozzolan cement

Code	Slump (mm)	Workability	Compaction factor
P.C	50	Low	0.83
C(5%LM +5%K)	35	Very low	0.74
C(7%LM)+ (10% K)	28	Very low	0.73
C(10%LM)+ (20%K)	18	Very low	0.73

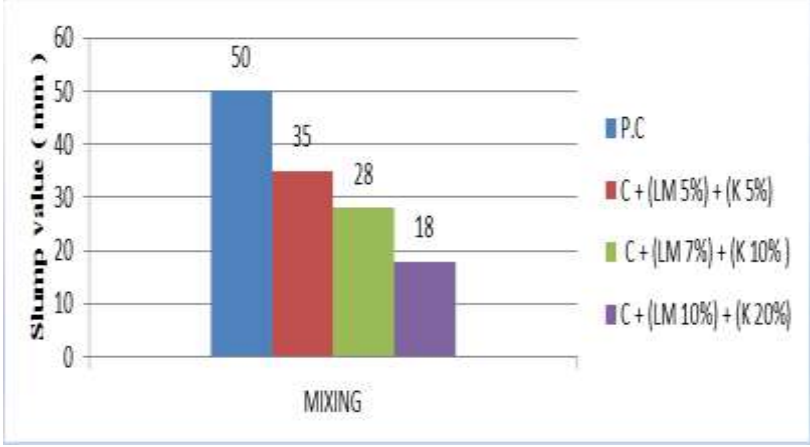

Figure 1 Variation of Slump test value for concrete specimens prepared with Portland Pozzolan cement blended with limestone powder and silica sand blended with Al-Khamkh

5.2. Compressive Strength of Limestone- AlKhamkha –Pozzolan Cement Concrete Specimens Cured in Tap Water

As shown in Table 5 and figure 2 below the degree of effects of the limestone- AlKhamkha on 7 days compressive strengths are different. 5% replacement of limestone powder and 5% replacement of AlKhamkha, on Portland Pozzolan cement concrete resulted in a compressive strength reduction than the control PC mix at 7 days (12.52% compressive strength reduction was observed).

7% replacement of limestone powder, and10% replacement of AlKhamkha on Portland Pozzolan cement concrete resulted in a compressive strength reduction than the PC control mix (27.88%compressive strength reduction was observed). 10% replacement of limestone powder, and20% replacement of AlKhamkha on Portland Pozzolan cement concrete resulted in a compressive strength reduction than the control (14.43%compressive strength reduction was observed).

Similarly the test results on the 28 days as shown in Table 5 and figure 3 ,compressive strength showed effect in different degree. 5% replacement of limestone powder, and5% replacement of AlKhamkha, on Portland Pozzolan cement concrete resulted in little degree strength enhancement than the control PC mix at 28 days(8% compressive strength increase was observed).

7% replacement of limestone powder, and10% replacement of AlKhamkha on Portland Pozzolan cement concrete compressive strength at 28 days resulted in a compressive strength reduction than the PC control mix (21.45%compressive strength reduction was observed). 10% replacement of limestone powder and 20% replacement of AlKhamkha on Portland

Pozzolan cement concrete gave comparable strength as that of the PC control mix in 28 days (only 2.2%compressive strength reduction was observed).

Table 5 Averaged strengths of concrete specimens prepared with limestone- AlKhamkha – Portland Pozzolan cement at 7days 28 days

Code	S.No	Average compressive strength					
		7 days			28 days		
		Strength (Mpa)	Average compressive strength (MPa)	7 days Average compressive strength deviation from the control concrete mix (%)	Strength (Mpa)	Average compressive strength (MPa)	28 days Average compressive strength deviation from the control concrete mix (%)
PC	1	17.11	17.25	0	23.12	24	0
	2	17.33			24.42		
	3	17.33			24.42		
C(5%LM +5%K)	1	13.33	15.09	12.52 Decrease	23.55	25.92	8 Increase
	2	16.44			30		
	3	15.5			24.22		
C(7%LM)+ (10% K)	1	19.5	14.76	14.43 Decrease	27.43	23.47	2.2 Decrease
	2	16			24.13		
	3	8.8			18.87		
C(10%LM)+ (20%K)	1	9.33	12.44	27.88 Decrease	23.11	18.85	21.45 Decrease
	2	15.55			18.22		
	3	12.44			15.22		

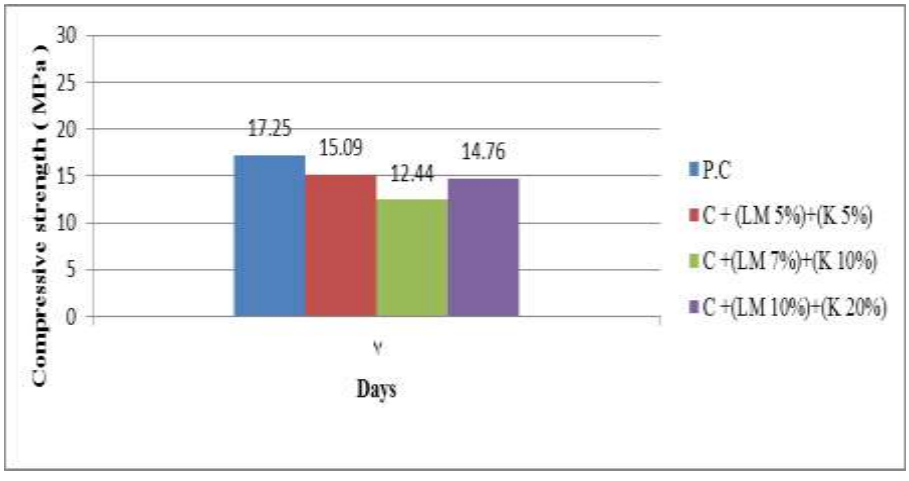

Figure 2 Averaged strengths of concrete specimens prepared with limestone- AlKhamkha – Portland Pozzolan cement at 7days

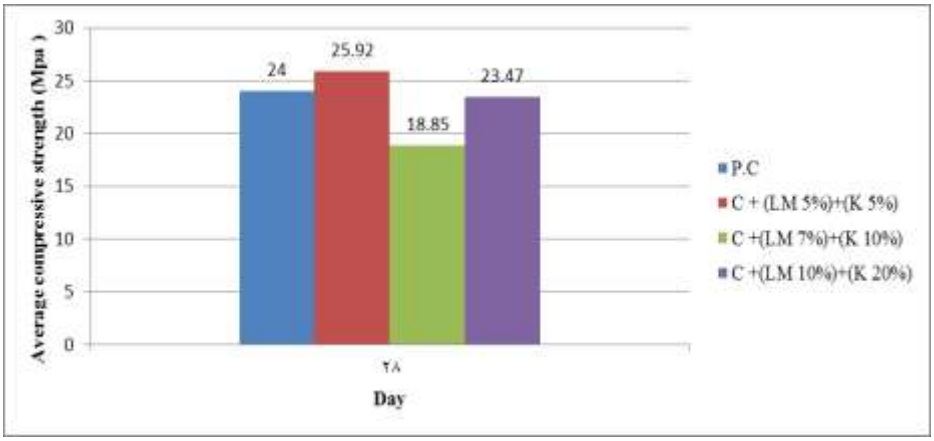

Figure 3. Averaged strengths of concrete specimens prepared with limestone- AlKhamkha – Portland Pozzolan cement at 28days

5.3. Compressive Strength behavior of limestone- AlKhamkha –Pozzolan cement concrete Specimens cured in Dead Sea water

Curing of limestone- AlKhamkha –Pozzolan cement concrete Specimens in Dead Sea water was carried out to study the different aspects of deterioration of limestone- AlKhamkha – Pozzolan cement concrete by using both plain water and sea water over a period of 28 and 90 days curing.

Tables (6) and Figs. 4 to 5 present the experimental results of compressive strength of limestone- AlKhamkha –Pozzolan cement concrete specimens for different curing periods.

These tables and figures clearly demonstrate that PC concrete shows higher strength at 28 and 90 days ages than that for limestone- AlKhamkha –Pozzolan cement concrete. But for relatively longer curing periods for all concrete samples, the differences between the compressive strength results are seen to be decreased.

The concrete specimens with 10% replacement of limestone powder and 20% replacement of AlKhamkha gave lower strength deterioration for longer curing periods.

Table 6 Averaged compressive strengths of concrete specimens prepared with limestone- AlKhamkha – Portland Pozzolan cement cured in Dead Sea water at 28days 90 days

Code	Average compressive strength			
	Average compressive strength (MPa)	**28days Average compressive strength deviation from the control concrete mix (%)**	**Average compressive strength (MPa)**	**90 days Average compressive strength deviation from the control concrete mix (%)**
PC	29.2	-	26.81	-
C(5%LM +5%K)	28.44	2.60 Decrease	21.92	18.23- Decrease
C(7%LM)+ (10% K)	20	31.5 Decrease	19.85	25.96 -Decrease
C(10%LM)+ (20%K)	24	17.81 Decrease	17.48	34.80- Decrease

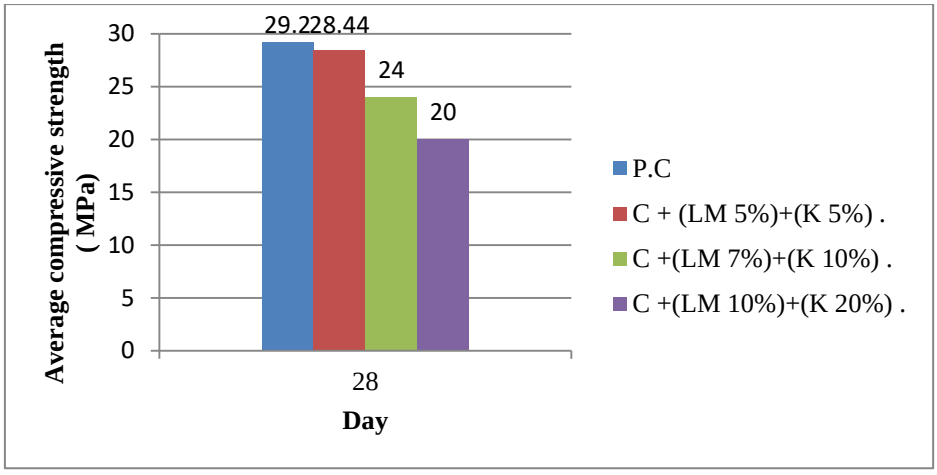

Figure 4. Averaged compressive strengths of concrete specimens prepared with limestone-AlKhamkha – Portland Pozzolan cement cured in Dead Sea water at 28days

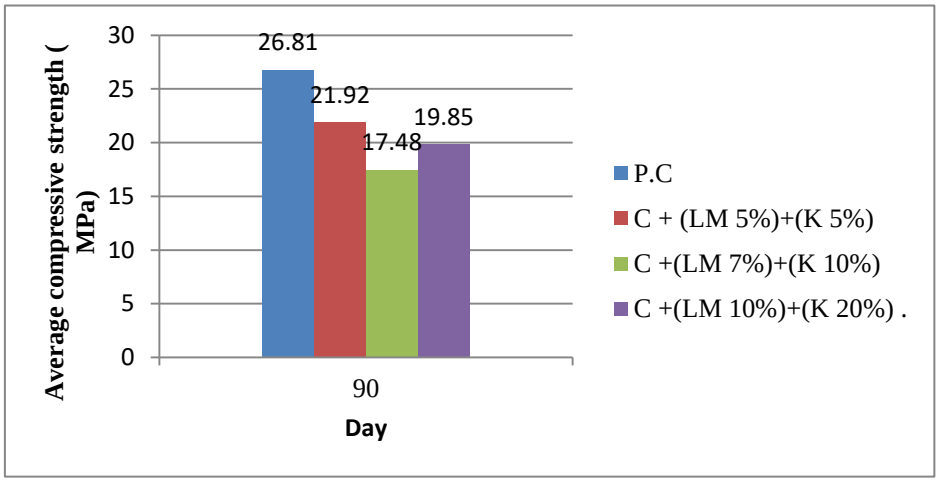

Figure 5. Averaged compressive strengths of concrete specimens prepared with limestone-AlKhamkha – Portland Pozzolan cement cured in Dead Sea water at 90 days

6. CONCLUSIONS

In this study, recycling of limestone waste powder and stone cutting waste powder (Al-Khamkha) for the production of Portland Pozzolan cement concrete has been studied and the following conclusions are made.

- The investigation revealed that replacing of Portland Pozzolan cement with limestone powder up to 10 % and replacing of silica sand by Al-Khamkha up to 20 % reduces the slump of concrete mixes.
- Replacement of Portland Pozzolan cement by limestone powder at 5% replacement range and replacement of silica sand by Al-Khamkha at 5% gives higher compressive strength than that of 100% Portland Pozzolan cement. Replacement of Portland Pozzolan cement at 7%, and replacement of silica sand by Al-Khamkha at 10% result in compressive strength reduction than that of 100% Portland Pozzolan cement concrete. However replacement of Portland Pozzolan cement at 10%, and replacement of silica sand by Al-Khamkha at 20% result in compressive strength comparable as of 100% Portland Pozzolan cement concrete.

- The study indicates that limestone powder up to 10% can replace Pozzolan cement and stone cutting powder (Al-Khamkha) up to 20% can replace sand with performance improvement of concrete strength.
- Stone cutting powder (Al-Khamkha) from The Jordan Processing Factory can replacement part of sand in concrete production; But the current disposal methods of the waste by the factories is not comfortable for using it. Therefore the Jordan stone cutting processing factories should undergo investigation how and where to dispose it in such a way that it will be easy for accessing the waste.
- Limestone- AlKhamkha –Pozzolan cement concrete shows better resistance against strength deterioration. Among all the concrete, limestone- AlKhamkha –Pozzolan cement concrete mix specimens with 10% replacement of limestone powder and 20% replacement of AlKhamkha shows the least strength deterioration in Dead seawater environments.

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