Compressive Strength and Physical Properties Behavior of Cement Mortars with addition of Cement Klin Dust

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Abstract

Cement Klin Dust (CKD) was the waste of almost cement industry factories, so that in this paper utilization of CKD as filler in cement and/or concrete was the main objective. CKD from the Karbala cement factory had been used and analysis to know the chemical composition of the oxides was done. In this paper cement mortars with different weight percentages of CKD (0,5,10,20,30,40) had been prepared. Physical properties such as density and porosity were done in different age curing (3, 7, 28) day. In addition, mechanical properties included the coefficient of thermal conductivity and compressive strength had also observed with different age (3,7, and 28) for all prepared specimens. From the obtained the experimental results and their discussion, it was clear that the addition (20%) of CKD had the good results in cement mortars.

Key words: Cement mortars, CKD, thermal conductivity, compressive strengthening.

الخلاصة

غبار فرن السمنت هو مخلفات من معامل صناعة السمنت، لذلك في هذا البحث استخدام غبار فرن السمنت كمادة مالئة في السمنت والخرسانة هو الهدف الرئيسي . استخدم فرن غبار السمنت من معمل سمنت كربلاء وتم تحليله لمعرفة التركيب الكيميائي للأكاسيد.في هذا البحث حضرت مونة السمنت مع اضافة نسب وزنية مختلفة من فرن غبار السمنت (0،5،10،20،30،40). الخواص الفيزياوية مثل الكثافة والمسامية تم حسابها عند اعمار تقسية مختلفة (3،7،28) يوم. بالأضافة الى ذلك الخواص الميكانيكية المتضمنة معامل التوصيل الحراري و مقاومة الأنضغاط تم قياسها بأعمار مختلفة (3،7،28) ولكل العينات المحضرة . من نتائج العملي المستحصلة ومناقشتها تبين ان الأضافة 20% من غبار فرن السمنت اظهر نتائج جيدة في مونة السمنت.

الكلمات المفتاحية:- مونة السمنت ، غبار فرن السمنت ، الموصلية الحرارية ، مقاومة الانضغاط .

1. Introduction

A composite material defined an incorporation of two or more substances possessing unique properties that are not present in the original components individually. These materials consist of two phases, one is knew matrix and the other is reinforcement phase. In comparison with bulk material, composite material has high stiffness, high strength and low density. The matrix phase characterized by temperature resistance, chemical resistance, and transfer load to reinforcement. It should be noted here, the reinforcement phase is most important compared with matrix in the composite materials because it is stiffer and stronger. Reinforcement phase may consist of particulate or fiber. Composite materials reinforced by Particulate have dimensions approximately identical in all directions. Continuous fiber composites which usually tend to be stronger than particulate composites particulate (Campbell, 2010).

Cement production is a significant industry in the Iraq and all of the world. As with most big manufacturing industries, the minor materials will produce. These manufacturing by-pass and unwanted materials must be processed responsibly to prevent environmental pollution(Adaska,2008). Cement is consumed in the biggest tonnages. Portland cement is manufactured by crushing and intimately mixture clay and lime bearing minerals in the suitable quantities and then heating the blend to about 1400^{o}C in a revolving kiln, this process, occasionally called calcination, produces chemical and physical variations in the raw materials. The resultant "clinker" produce is then crushed into a very small fine powder then mixed with a small quantity of gypsum to delay the setting process .This produce known as portland cement (Callister,2009).

During the fabrication of cement, a large amount of dust can be produced cement kiln dust (CKD). In advance production techniques, it is possible to recycle most of the CKD with the clinker making process. However, it is not achieved because the high alkali amount in the CKD. Most standard specifications limited the alkali quantity in portland cement less than 0.6% in order to prevent the alkali aggregate reaction [M. Maslehuddin,2009]. CKD is a fine material produced as a result of cement production. Usually, CKD compose of alkali compounds and clinker particles , which can be high percent in lime content. These particulates are selected by the exhaust gases and collected in particulate matter control equipment like the electrostatic precipitators and cyclones(Adaska,2008).

2. Literatures survey

(Hassan *et.al.*,2013), investigated using CKD as a mixed cement and studying the different partial addition of CKD on the important characterization of concrete and mortar cement. It was observed that the increasing of weight percentage additions of CKD led to decrease the compressive strengthening and also tensile strength for all specimens of concrete and mortars at different ages (Hassan *et.al.*,2013).

(Salah Farhan A. Sharif,2010), studied effect addition of CKD on characterization of portland cement. Different weight percents of CKD were mixed with ordinary and white portland cement. The results shown when ordinary and white portland cement mixed with 25 percentage of CKD led to increase with about 39 % and 31 % of the amount of water for normal consistency. With increasing weight percent of CKD led to decrease initial and final time. Also the compressive strengthening decreases with increasing addition of CKD above 10 % (Hilal,2010).

(A. Mohammad and N. Hilal, 2011), investigated the effect of addition admixture CKD to concrete. Different additions of CKD were added to concrete. Compressive strength, slump, flexural strength , static modulus of elasticity and splitting tensile were tested. It was reported that the use of CKD led to significant decreasing in strength of concrete in general and this decreasing increase with the increasing of CKD (Sharif, 2010).

(M. Maslehuddin *et.al.*,2009), investigated estimation the characterization of CKD when mixed with cement concretes. Samples of concrete were prepared with different weight percent of CKD (0, 5, 10, and 15)%. With increasing amount of CKD led to decrease the compressive strength for all specimens, he also noted there was not significant reduction compressive strength at 5% addition(Maslehuddin,2009).

3. Materials and Experimental Procedure

The materials used in this study were high sulfate resistant cement known as Al-Jisr and cement klin dust obtained from Karbala cement Factory. The physical and chemical analyses results of the used cement are given in table (1) and table (2).

Cement klin dust was a by- product from of cement industry in Karbala cement Factory. Table (3), shown the chemical composition of cement klin dust used in this work.

Fine sand passed through 0.85 mm sieve size .

Table (1): Physical analysis of cement used.

Physical Requirements		IQ.S 5/1984 Standard for High sulfate Resistant Cement	
		Limitation	Test Result
Finesse (Blaine) m^2/kg		≥250	329
-Initial setting time minute		≥45	181
-Final setting time hours		≤10	3:40
Soundness (expansion) %		≤0.8	0.60
Compressive strength is to not less than (mN/m^2)	3d	≥15.0	25.8
	7d	≥23.0	34.6

Table (2): Chemical analysis of cement used

Chemical Requirements	IQ.S 5/1984 Standard for High sulfate Resistant Cement	
	Limitation	Test Result
Lime saturation coefficient %	0.66-1.02	0.98
Magnesium Oxide (as Mgo) %	≤5.0	1.80
Sulfate Content (as So_3) %	2.5 if C_3A ≤5	2.40
Loss on ignition (as LOI) %	2.8 if C_3A ≥5	
Non soluble substance %	≤ 4.0	3.14
Tricalcium Aluminates (C_3A) %	≤1.5	0.70
	≤3.5	3.15

Table (3): Analysis of CKD, weight percent

Chemical components	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	SO_3	K_2O	Na_2O	LOI
Wt %	15.25	3.54	3.82	62.40	1.43	4.67	0.88	0.01	7.65

4. Specimens preparation

Preparation of cement mortars includes the following steps:

1- Lubricating the mold to facility remove the mortar of cube.
2- The component of mortars includes (cement, sand, water, and CKD) were prepared with different weight percentages of CKD as partial replacement of cement, as shown in table (4).
3- Mixing the standard component with each other.
4- Fix the mold in a shaking device which is shaking work for one minute. During shaking the mixture pour in the mold (the purpose of operation shaking is to fill the mold without porous of mixture).
5- After one minute ended the mold is removed from shaking device and left to solidified for 24hr.
6- After 24 hour ended the mortars are removed from the molds carefully, and marked then soaked in water tank to get hard solidified until the age of test specimens.

Table (4): Mixed composition of prepared mortar specimens

No. of mixed	CKD (wt%)	Mix proportion by weight cement: sand: CKD
1	0	1:3:0
2	5	1:3:5
3	10	1:3:10
4	20	1:3:20
5	30	1:3:30
6	40	1:3:40

Compressive Strength Test

The Compressive strengthening of hardened cement mortars was done according to (ASTM C109) (ASTM, 2010). Figure (1) shown compression device of concrete and building materials.

Fig.1:Compression device of concrete

The Thermal Conductivity Test

In the body, the energy transfer from higher temperature to the lower temperature zone when the temperature gradient present. The heat transfer of energy is occurs by conduction, the heat transfer rate for each unit area is proportional to the temperature change as shown below**:**

$$\mathbf{q_x/A \backsim \partial T/\partial x} \qquad \textbf{(1)}$$

We can insert proportionality constant

$$\mathbf{q_x = -\,kA\,\Delta T/\Delta x} \qquad \textbf{(2)}$$

Equation (2) is called Fourier's law of heat conduction. It is important to note this equation used for calculation the energy transferred by conduction (Holman, 2010).

In the experimental part in this study used thermal conductivity device as shown in figure (3) and the equation in the work is [P.A Hilton, 2008]:

$$\mathbf{K = L_s *[\{K_1+(T_{av}* K_2)+\{ (K_3+(K_4*T_{av}))*HFM \}+\{(K_5+(K_6*T_{av}))*HFM^2\}] / \Delta T} \qquad \textbf{(3)}$$

K1 = -42.942, K2 = 0.8186, K3 = 9.7938, K4 = -0.0456, K5 = -0.0319, K6 = 0.0028

$\Delta T = T_2 - T_1$

Fig.2: Thermal conductivity device

Density and Porosity Measurements

The compact samples of concrete are drying in the oven at 150 ^{o}C for (7-8) hrs. Weight and dimensions of each specimen were measured to determine the volume change and to calculate geometrical densities and porosities according to ASTM C642-97 as shown in equations (3) and (4) (ASTM C642-97, 2010):

$$\mathbf{A.D} = \rho_L \frac{W1}{W1-W2} \qquad \textbf{(4)}$$

$$\mathbf{A.P\ \%} = \left[\frac{W3-W1}{W3-W2}\right] * \mathbf{100} \qquad \textbf{(5)}$$

5. Results and discussion

5.1 Compressive Strength Test Results

The compressive strength was determined at ages of 3,7,28 day for cement mortar specimens with different amounts of CKD. Figure (2) shows the compressive strength for the different weight percentages of CKD that add to mortars samples at period 3,7and 28 days. It has been shown that the compressive strengthening dropped with increasing weight percentages of CKD at all ages, due to the high ratio of alky oxides (Na_2O, K_2O) where these oxides are weak in mechanical properties in comparison with cement material. Furthermore, table (3) was shown that 7.5% loss of ignition in the chemical percentage of composition, this percentage was high and causes the decreasing in mechanical properties especially compressive strength. From this figure the 20% addition from CKD lowered compressive strength, and this small decreasing according to the high addition of CKD, therefore the 20% of CKD consider good addition.

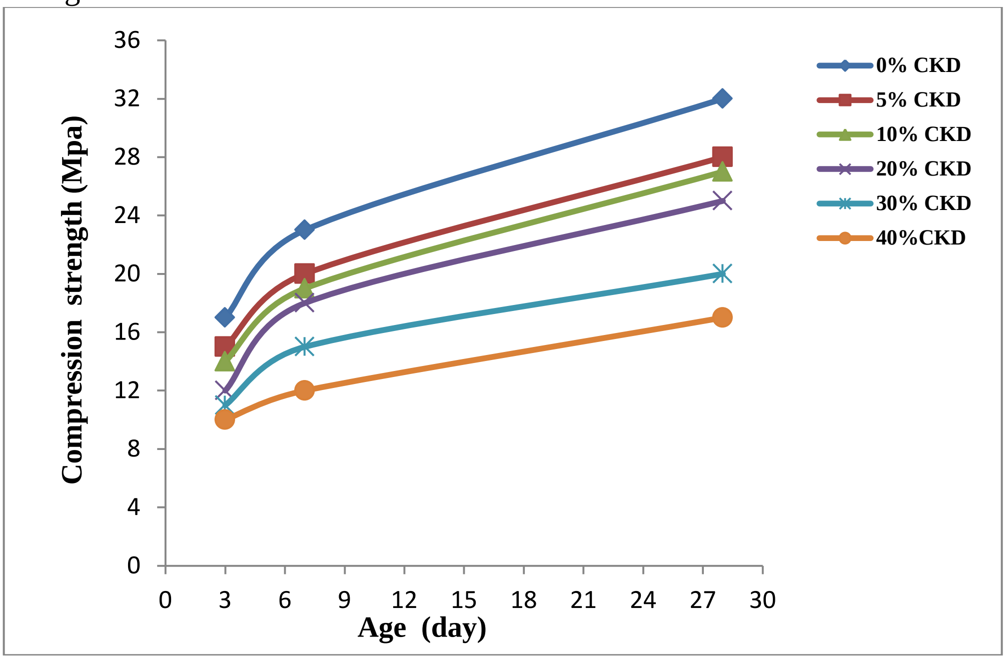

Fig.3: Compressive strength with age

5.2 Thermal Conductivity Test Results

Figure (3), shows coefficient of thermal conductivity with different percentages of CKD that add to cement mortars samples. Coefficient of thermal conductivity was decreased when increasing CKD percentage caused by increasing porosity with an additional amount of CKD. It is clear that at 20% CKD very small effect on coefficient of thermal conductivity, whereas increasing CKD % leads to highly decreasing in thermal conductivity coefficient up to (0.67 W/m ^{o}C), therefore a higher percentage of CKD (40%) is preferred for the production of mortars for thermal insulation engineering applications.

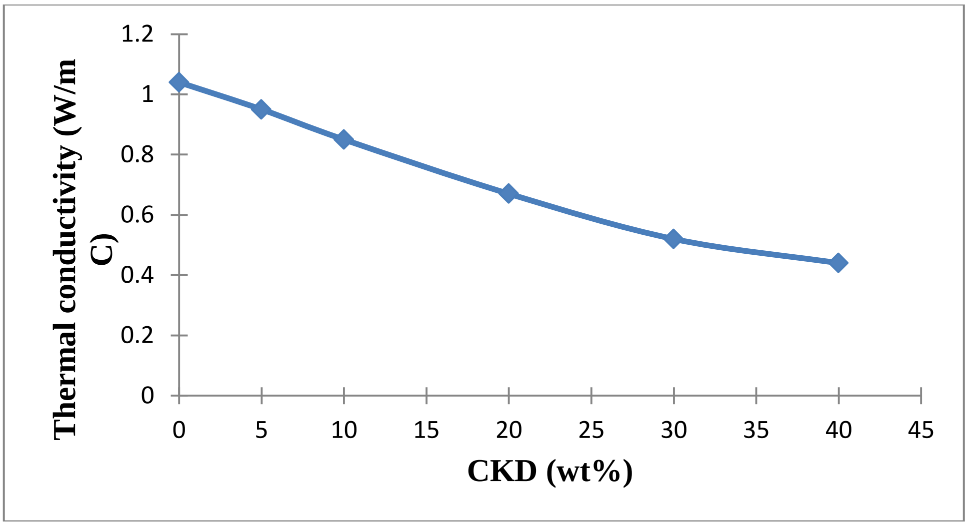

Fig. 4: Coefficient of thermal conductivity versus CKD

5.3 Density and Porosity Measurements

Figure (5) presents the density versus hardened cement mortars with different weight percent of CKD at 28 day age. It has been shown that the density of mixed cement mortars is decreased with increasing the amount of CKD. This may be due to the increasing of micro pores in their microstructure. Figure (6) presents the porosity of same hardened cement mortars. It is clear that the porosity increase with increasing the amount of CKD for all specimens, due to high loss of ignition content in the CKD.

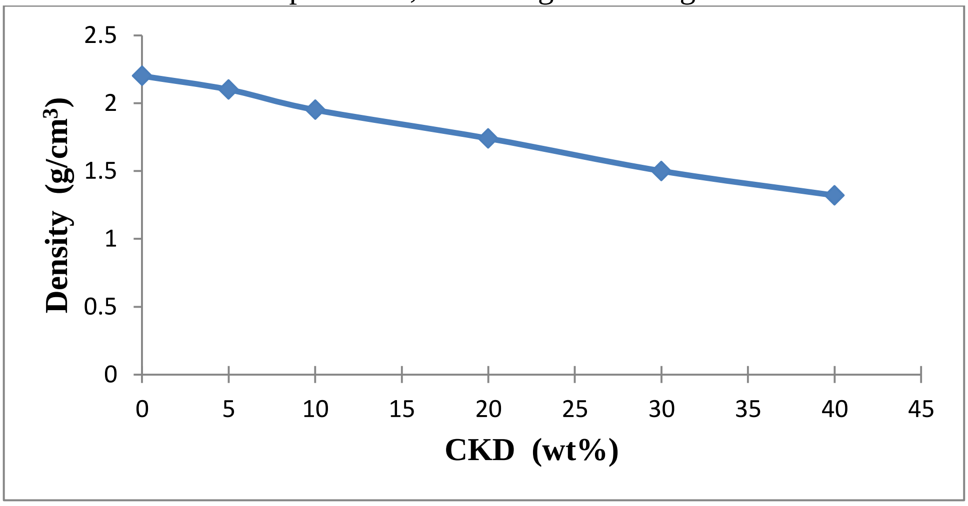

Fig. 5: Density of cement mortars with different percentages of CKD

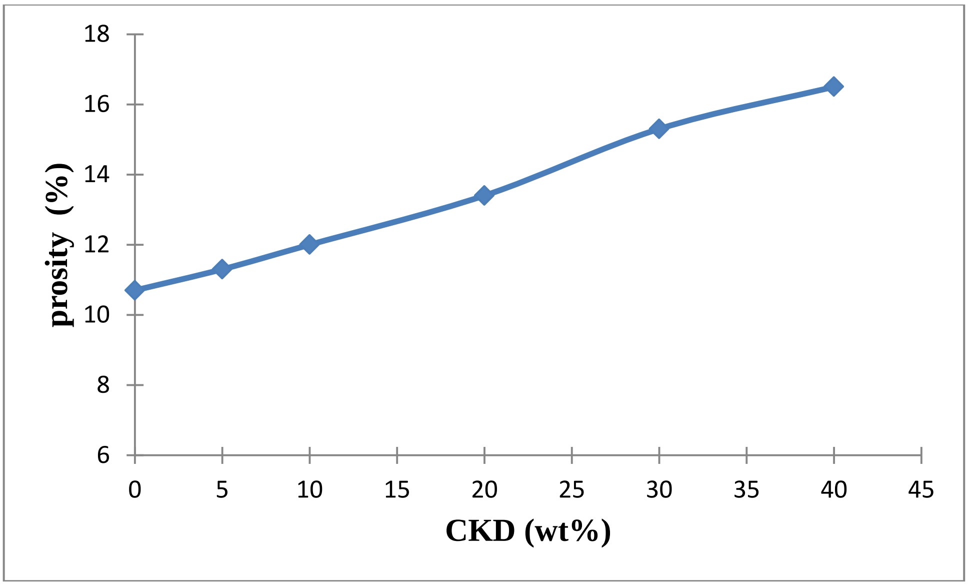

Fig. 6: porosity of cement mortars with different percentages of CKD

6. Conclusions

From obtained results, several conclusions may be drawn as:

1. Porosity was increased when adding the CKD into cement mortars.
2. The low addition percentages of CKD don't effect on the compressive strength.
3. The addition about (20-40) % of CKD lead to high decreasing in compressive strength.
4. The addition CKD to the cement mortars lead to decreasing value of thermal conductivity coefficient.

7. References

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