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EFFECT OF CEMENT KILN DUST ON SOME PROPERTIES OF SELF-COMPACTING CONCRETE TITLE

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Abstract
In the paper, Feasibility of preparing self-compacting concrete (SCC) was evaluated. Six mixes are designed to replace part of the cement with cement kiln dust (CKD). The first mix without replacement is the control mixt through which the rest of the mixtures are compared. As for the remaining five mixtures, part of the cement was replaced with CKD, and the replacement ratios are (2.5, 5, 7.5, 10, 12.5%), sequentially. Where the ratio of water to cement was constant is 0.3 in all mixes SCC. Then the viscosity, flow ability, passing ability and segregation properties of all mixes were examined, and then some mechanical properties (compressive resistance, dry density, ability of water absorption) were examined for all mixes. The results indicate a decrease in the workability (passing ability, flow ability, and segregation) and mechanical properties (compressive strength and density) and also led to an increase in the viscosity of (T500), as well as an increase in the water absorption ability of SCC. In general, the mechanical properties of some mixes are acceptable compared to the reference mix, especially when it is replaced by a few percentages.
Keywords: Self-compacting concrete, Cement kilt dust, Workability.

ÇİMENTO FIRIN TOZUNUN KENDİLİĞİNDEN YERLEŞEN BETONUN BAZI ÖZELLİKLERİ ÜZERİNE ETKİSİ

Özet
Bu yazıda, kendiliğinden yerleşen beton (KYB) hazırlamanın fizibilitesi değerlendirilmiştir. Çimentonun bir kısmını çimento fırın tozu (CKD) ile değiştirmek için altı karışım tasarlanmıştır. Değiştirilmeyen ilk karışım, geri kalan karışımların karşılaştırıldığı kontrol karışımıdır. Kalan beş karışımda ise çimentonun bir kısmı CKD ile değiştirilmiştir ve ikame oranları sırasıyla (2.5, 5, 7.5, 10, 12.5%) 'dir. Suyun çimentoya oranının sabit olduğu durumlarda, tüm karışımlarda SCC 0.3'tür. Daha sonra tüm karışımların viskozite, akış kabiliyeti, geçiş kabiliyeti ve segregasyon özellikleri incelenmiş, ardından tüm karışımlar için bazı mekanik özellikler (basınç direnci, kuru yoğunluk, su emme kabiliyeti) incelenmiştir. Sonuçlar, işlenebilirlikte (akış kabiliyeti, geçiş kabiliyeti ve ayrışma) ve mekanik özelliklerde (basınç direnci ve yoğunluk) bir azalma olduğunu ve ayrıca (T500) 'ün viskozitesinde bir artışa ve ayrıca SCC'nin su emme kabiliyetinde bir artışa yol açtığını göstermektedir. . Genel olarak, bazı karışımların mekanik özellikleri, özellikle birkaç yüzde ile değiştirildiğinde, referans karışıma kıyasla kabul edilebilir.
Anahtar Kelimeler: Kendiliğinden yerleşen beton, Çimento kilt tozu, İşlenebilirlik.

1. Introduction

Self-compacting concrete is high-performance type that is relatively new, as it is known to be a self-compressing concrete. Where the laying of this concrete is formed and reinforcement encapsulation without vibration (Concrete, S. C., 2007). and can be used in areas of dense reinforcement due It can spread, it has resistance to separation and excellent deformation according to the specifications (Concrete, S. C., 2005). Where this type is considered one of the types of concrete, SCC is one of the developments of concrete, the self-compacting. This type of concrete invented by Japanese researchers to solve the problem of lack of labor experience in addition to places of the overlap of reinforcement , which led to its invention because it is characterized by high flow and can

be compacted in all corners of the frame without the need for vibrator, This type of concrete was suggested by the Japanese author Okamura, in 1986 (Okamura et. al., 2003). 1988 is considered the first year in which the first prototypes were completed to experiment with self-compacting concrete. The performance was satisfactory in everything including hardening shrinkage, denseness after hardening, drying, denseness after hardening , heat of hydration The properties of concrete were defined as:

Fresh: self-compacted.

Early age: Void initial flaws.

Hardened: Safeguard from factors external.

Where this concrete was known to have high durability Because to the low ratio of water to cement by (Gagne et. al., 1990). Where it has been used all over the world in the name of high-performance concrete, meaning it is a high-durability concrete Subsequently, this term was changed to Self-Compacting High Performance Concrete which was changed by Okamura (Okamura et. al., 2003). Advantages of Self-compacting concrete : Reducing the cost of labor, labor and equipment. and proper uniformity can be ensured without the need for vibrator. and the concrete surface is self-leveling. And construction time can be shortened by speeding up work. And it can fill concrete in highly reinforced areas easily. And reduce in job site noise. And increase the build quality. It leads to better productivity. And allow flexibility in reinforcement details without the need bundle reinforcement. And forms smooth surfaces that are free bleeding. Disadvantages of Self-compacting concrete : Higher material cost. And the quality control standard must be high for its production. And high lateral pressure on formwork. And higher pumping resistance. And these shortcomings are reduced through good and improved mix design and proper work management (Ozawa et. al., 1992). Cement kiln dust (CKD), it is a fine powdery material resemble to Portland cement. It is considered a secondary product from manufacturing cement. Its particles are micron-sized. They are collected when producing cement clinker from electrostatic precipitators (Collins et. al., 1983). About 30 million tons are produced per year all over the world, where some quantities of CKD are returned to the furnace, where it is considered part of the raw materials (Dyer et. al., 1999). The largest part of CKD contains a high percentage of alkali. With the advancement in modern technologies, this dust can be benefited from and the clinker industry again. However, it cannot be used because it contains high percentages of alkali due to the international standards' compliance with the use of low alkali content in cement. To determine 0.6% equivalent of Na2o to avert the possibility of the presence of alkali content in the reaction because the reaction of silica with alkali produces some reactive aggregates in concrete (Daous, M. A., 2004). The effect of replacing CKD with a percentage of (20, 30%) part of the weight of cement used in the concrete mix was studied. It had a clear impact on the concrete properties, as it was concluded that the higher the replacement ratio leads to a decrease in passing , flow and segregation in addition to reducing density and compressive strength (Viacava et. al., 2012). Where another researcher replaced different proportions (10, 20, and 30)% of CKD instead of a portion of the cement, find that the flow ability, passing and segregation in addition to density, water absorption ability and compressive strength will decrease With an increase in replacing of cement by CKD (Najim et. al., 2016). In another study, cement was replaced with CKD at a rate of (20 and 30)% in the concrete mixture. It was concluded that with the increase in the percentage of replacement, it leads to a decrease in flow ability and passing ability , addition to segregation and compressive strength (Salih et. al., 2018).

2. Experimental Program

2.1. Self-Compacting Concrete

In the study. Ordinary Portland cement (OPC) with specific gravity (3.14 g/cm^3) was used according to Iraqi specifications No. 5 (Iraqi Standard Specification, 1984). Where fine aggregate (sand) with a maximum size of (4.75 mm) was used, and coarse aggregate (gravel) with a maximum size of (10 mm), and both fine and coarse aggregates according to the requirements of Iraqi specifications No. 45 (Iraqi Standard Specification, 1984). CKD was used as pozzolanic material with specific gravity (2.07 g/cm^3). superplasticizer (SP) was used Sika® ViscoCrete®-5930 L IQ according to ASTM C-494 Types F (P. ASTM, 2011).

2.2. Mix Proportion

In this study. Six mixes of SCC were prepared and designed according to EFNARC 2005 (Concrete, S. C., 2005). Table 1 presents SCC mix proportions. Where the first mix without any replacement of cement, its components is cement, coarse and fine aggregates, superplasticizer and water, This mix is considered a control to the rest of the mixes in when the cement was replacement by CKD in successive proportions (2.5, 5, 7.5, 10, 12.5%).

Table 1. Mix proportion of SCC

Mix ID	Cement	Cement kiln dust	Water	Coarse agg.	Fine agg.	Super plasticizer
CKD0	550	0	165	870.5	858.6	8.2
CKD2.5	536.25	13.75	165	870.5	858.6	8.2
CKD5	522.5	27.5	165	870.5	858.6	8.2
CKD7.5	508.75	41.25	165	870.5	858.6	8.2
CKD10	495	55	165	870.5	858.6	8.2
CKD12.5	481.25	68.75	165	870.5	858.6	8.2

2.3. Test Method

Among the workability characteristics of SCC are flowability, diffusion, separation and viscosity, which were tested on fresh concrete according to European standards EFNARC 2005 (Concrete, S. C., 2005). By slack flow, estimation of flowability , where T_{500} (time of concrete flow to reach a diameter of 500 mm) is considered to be viscosity. The passability was estimated. also measure segregation. After each all operability tests, 2 cylinders (H=200 mm, D=100 mm) were casting for compressive strength, 2 cubes (100*100 mm^2) for density determination, and 2 discs (H=50 mm, D=100 mm) for determination of water absorption for each mix. After 24 hours, the specimens was extracted from The mold was placed in the curing basin for 28 days, After that all specimens tested.

3. Result and discussions

3.1. Rheological Properties

In Table 2 is the workability results for whole mixes, Table 3 is the classification of SCC in this research according to EFNARC 2005 (Concrete, S. C., 2005).

Table 2 . Result of workability for all mixes

Mix	Flowability	T_{500}	passing ability	Segregation
	mm	Sec	%	%
CKD0	750	3.26	0.956	13.77
CKD2.5	745	4.47	0.938	8.78
CKD5	735	6.5	0.929	7.99
CKD7.5	720	7.5	0.908	6.21
CKD10	700	10.29	0.858	5.86
CKD12.5	690	11.82	0.849	4.55

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Table 3 . Classification for specification of SCC.

Testing	Classes	Values
Flowability	SF-1	550 to 650
	SF-2	660 to 750
	SF-3	760 to 850
Viscosity T_{500}	VS-1	≤ 2
	VS-2	≥ 2
passing ability	PA-1	≥ 0.8 using two rebars
	PA-2	≥ 0.8 using three rebars
Segregation resistance	SR-1	≤ 20
	SR-2	≥ 15

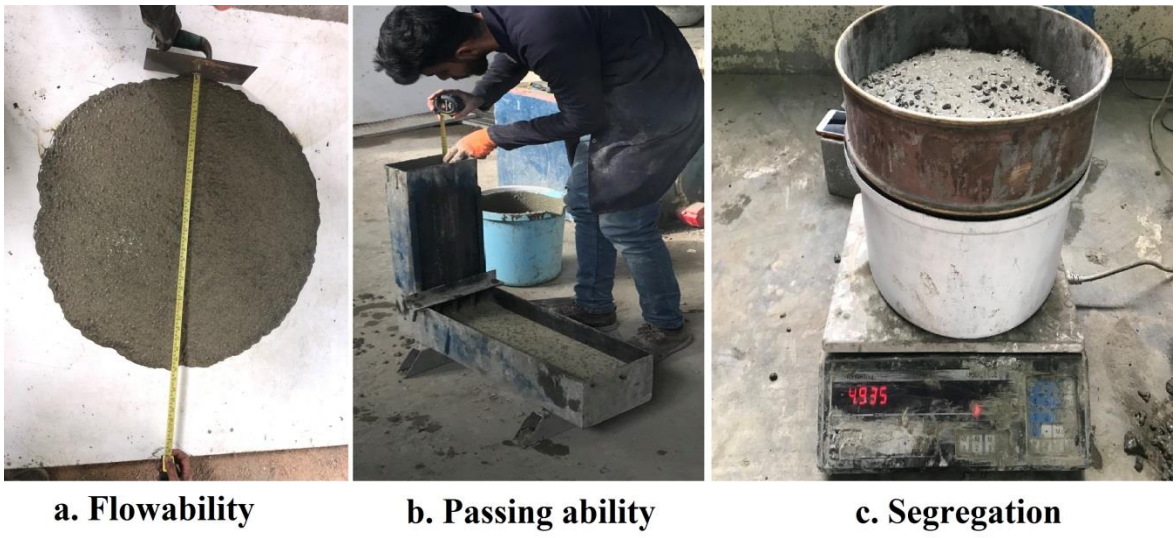

Figure 1. Processes of workability property tests

3.1.1. Flowability

The results of this test are shown in Figure 2. Where it was found that the values ranged between (690–750 mm). All mixes are classified as SF-2. It was noticed that the flowability decreased as increase further replacing cement with CKD. These results are consistent with the researcher (Viacava et. al., 2012) who states that when rise percentage of cement replaced with CKD, it leads to a decrease in workability of SCC. Show of this test in figure 1. a.

3.1.2. Viscosity

Viscosity is evaluated through the T500 flow time test, where the values range from (3.26-11.82 sec.), and as shown in Table 2. It was noted that all mixtures are classified as VS-2. Through Figure 3, it was observed that T500 increases as increase further replacing cement with CKD. These results are fully consistent with the study (Viacava et. al., 2012), which states that the greater the replacement ratio leads to raise in the time of the T500 flow.

3.1.3. Passing ability

The passing is evaluated through the L-Box test, where the values range from (0.85 - 0.96) as shown in Table 2. It was noted that all mixtures are classified as PA-2. Through Figure 4 it was observed that PA decreases as the proportion of cement replaced by CKD increases. These results are in complete agreement with the study (Najim et. al., 2016), which states that the greater the percentage of replacement leads to a decrease in PA. Show of this test in figure 1. b.

3.1.4. Segregation resistance

Shown the results of the test in table 2. Where it was found that the values ranged between (4.55 - 13.77) . All mixes are classified as SR-1. Through Figure 5 It was noticed that the segregation decreased as increase further replacing cement with CKD. These results are consistent with the researcher (Salih et. al., 2018), who states that when raising the percentage of cement replaced with CKD, it leads to a decrease in percentage segregation of SCC. Show of this test in figure 1. c.

3.2. Hardened Properties

In Table 4 is result of the mechanical properties for all mixes.

Table 4. Result of mechanical properties

Mix	Density (Kg/m3)	Compressive mpa	Absorption %
CKD0	2460	55	1.50
CKD2.5	2450	53	1.69
CKD5	2435	52	1.77
CKD7.5	2425	50	1.85
CKD10	2410	49	1.90
CKD12.5	2390	47	2.02

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3.2.1. Compressive strength

Cylindrical specimen were used in this test according to (ASTM C39-04, 2011). Through table 4, it was observed that the compressive strength values ranged between (47-55 mpa). Show figure 6, watch notice that as increased replacement percentage cement by CKD leads to a lessening in the compressive strength, a decrease that is considered a little gradually. This was confirmed by the researcher (Abdulhamed, 2022). as increase further replacing cement with CKD increases, it leads to a decrease in the compressive strength.

3.2.2. Dry density

Cube specimen were used in this test . Through table 4, it was observed that the dry density values ranged between (2390-2460 kg/m^3). After watching figure 7, watch notice that as increased replacement percentage cement by CKD, leads to a decrease in the dry density. This was confirmed by the researcher (Viacava et. al., 2012). as increase further replacing cement with CKD increases, it leads to a decrease in the dry density.

3.2.3. Water absorption

Disc (H=50 mm, D=100 mm) specimen were used in this test . Through table 4, it was observed that water absorption values ranged between (1.50-2.02%). show figure 8, watch notice that as increased replacement percentage cement by CKD leads to a increase in the water absorption. This was confirmed by the researcher (Najim et. al., 2016). as increase further replacing cement with CKD increases, it leads to a increase in the ability water absorption.

4. Conclusion

Has been the knowledge on some the fresh properties (workability) and mechanical behavior of SCC using replacement part of the cement with CKD to prepare SCC. Arrive at the following conclusions:

i. In general, when part of the cement is replaced with CKD, it reduces the flow of concrete, but in a small proportion, when the cement is replaced in small proportions, and all the mixtures used in this research are within the specifications where they are classified as SF-2.
ii. The viscosity is affected when part of the cement is replaced with CKD, which leads to an increase time of T_{500} in SCC.
iii. As for the passing ability, it will also be affected when part of the cement is replaced with CKD, cause in a reduction in the passing of concrete, and all the mixtures used in this test are within the specifications where they are classified as PA-2.
iv. The segregation resistance is also affected when part of the cement is replaced with CKD, which leads to a reduction in concrete separation, and all the mixtures used in this test are within the specifications where they are classified as SR-1. Where it is considered good to reduce segregation in SCC because this type of concrete is greatly affected by segregation.
v. When part of the cement is substituted by CKD, the compressive strength of concrete is reduced. But this decrease is relatively small when using small percentages of replacement. This is good because CKD can be used in this type of concrete to reduce environmental waste.

vi. As for the dry density, it will be affected when part of the cement is replaced with CKD, which leads to reduction in the concrete density. The reason is that CKD has a lower specific gravity than (OPC).

vii. When part of the cement is replaced with CKD, it increases the water absorption capacity of the SCC. Because of CKD's ability to absorb water.

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CONFLICT OF INTEREST

The authors declare that they have any no conflict of interest from publishing this research.

AUTHOR STATEMENT

The authors declare that ethics have been adhered to and that all research content will be published and available online.

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