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The Disposal of Cement Kiln Dust (CKD) and Construction Waste with Use them in Cement Brick Manufacture for Environmental Cleanliness and Protection

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Abstract – Since cement became the most important construction material on the ground after the steel industry, cement factories spread all over the world in huge numbers, so dust that flies from its kilns covers the sky, in addition to construction wastes of various types, a real environmental problem that worries scientists, specialized researchers and officials in the whole world, where causing a lot of chronic and deadly diseases of human life, so it became necessary to find a solution to this problem to disposal of these substances. For these reasons, the aim of this study was to exploit the cement kiln dust (CKD) from the exhausts of cement factories and construction waste polluting the environment, to benefit and disposal of them at the same time in the manufacture of building materials and construction for the most important engineering building material in the world, namely, cement bricks. The study dealt with cement kiln dust (CKD) as an additive to improve the strength of the compressive strength of cement bricks, in which ordinary Portland gray and white cements were used at rates of 8%, 10% 12%, 14 and 16%. Cement kiln dust (CKD) was added to the cement mixture consisting of construction waste and cement at rates of 10%, 20%, 30% and 40%. The samples were stored in the water for a 7-day period time. All samples were tested to find the compressive strength. The results of the tests showed the obtained compressive strength is less than the local reference brick pressure strength, but these strengths are acceptable for construction work. Therefore, the addition of cement kiln dust (CKD) to cement mixtures consisting of cement, construction waste aggregates and natural soft aggregates has strengthened the idea of using it in the production of cement bricks, so that it can be used in many areas of civil engineering applications such as pedestrian walkways, public garden corridors, car terminal floors, retaining walls and channels water drainage and others, in addition to the direct economic return, and the positive health and environmental returns in the long run.

Keywords: flying dust, white porcelain cement, gray porcelain cement, construction waste, resistance to pressure, and fine structural aggregate.

1. Introduction

The human beings depend on the environment, and are closely related to it. If this bond was broken, the human balances would be disturbed, and serious diseases would befall them and lead them to the end of human life on the earth. Hence, the continuation of human life on earth is at stake, and for this reason the environment must be preserved and carefully preserved severe, therefore, the environment must be protected and preserved by introducing a modern and distinct quality waste management system. The CKD of cement factories and construction waste are one of the wastes pose a danger to the environment and to the public health of the human being, there should be expansion in research and practical and applied experiences to know effective economic and scientific methods and ways to disposal of these dangerous wastes, by exploiting and benefiting it, and using it in the fields of civil engineering applications which benefit the human being in his life, such as building roads, concrete mixtures, in making cement bricks, in paving the floors of factories, warehouses, car stations, parks, footpaths, and in building water channels, retaining walls, and etc. other applications include engineering, in addition to protecting the environment from its dangers and damages, and to good economic returns in the short and long term.

1.1 Cement Kiln Dust Waste (CKD)

It is a very fine dust that is similar in appearance to Portland cement. CKD is composed of raw materials that have not changed thermally, dried clay, calcined limestone; ash from fuels and minerals where newly formed and which correspond to all stages of treatment by forming clinker, cement dust is mainly a cement clinker that does not fully meet commercial specifications [1].

Any possible application of dust is governed by the physical and chemical composition of dust. In practical terms, dust differs from one place to another in the chemical, mineral and physical composition, depending on several factors, including: raw materials used type of furnace operating, dust collection facility, fuel used, and the design [2].

The gases emitted from the chimneys of the cement factories appear in the form of thick white clouds, where the dust is the main factor causing these clouds, and these very soft dusts contain chlorides, sulfates, alkali, and quicklime, and these are dangerous in terms of health and environment, and exposure to them causes serious problems as it is an absorbent material for moisture and alkalinity, It is also a corrosive substance and contains some harmful elements and heavy metals such as hexavalent chromium, cobalt and nickel, and workers in cement factories usually get infections in the upper respiratory tract, and these products are called cement kiln (CKD) dust, or the passing cement dust (PCD), that causes serious environmental and health deterioration as a result of the pollution it causes in the air inside the cement factories and the environment surrounding the factories [3].

Table No. (1) Shows the typical composition of flying dust from cement kilns.

Constit-uent	$CaCO_3$	SiO_2	CaO	K_2SO_4	$CaSO_4$	Al_2O_3	Fe_2O_3	KCl	MgO	Na_2SO_4	KF	Others	Total
By weight (%)	55.5	13.6	8.1	5.9	5.2	4.5	2.1	1.4	1.3	1.3	0.4	0.7	100

Source: Bureau of Mines, IC 8885, Haynes and Kramer, 1982

This dust caused by the cement industry is considering one of the most dangerous sources of environmental pollution because of the fineness of its grains; the least amount of air can be carried easily and spread over large areas of the cement factories over hundreds of square kilometers, when a person inhales it, it leads to respiratory diseases, Eyes and skin allergy diseases too, in addition to eliminating the entire plant family without exception, and it is also cement dust can pollute drinking water by spreading and leaking dust into lakes, rivers and waterways [4].

This dust has become a serious environmental problem that costs hundreds of millions of dollars a year in burying and disposing of it. The UK cement industry has estimated more than 200,000 tons per year of landfills can be saved, if the excess dust can be recycled in the clinker making process or if alternative uses can be found [5].

1.2 Global Production of Flying Dust from Cement Kilns

Global production of cement kiln dust (CKD) of cement factories reaches 30 million tons annually [6]. About 15 million tons of CKD are produced annually by American cement factories. A medium-sized cement plant may produce up to 30,000 tons of CKD annually. An analysis of existing data, including data collected by the American Portland Cement Association (USPCA) from the operators of cement manufacturing facilities, the agency estimated in 1995 the cement industry had a clinker capacity of 77 million metric tons and a net CKD generation of 4.08 million metric tons disposed of in land filling. Data for 1995 indicate that 24 out of 110 cement factories (22%) feast of recycling all the collected dust to the oven, and an additional 12 stations (11%) transport all the components generated from cement outside the site for beneficial use. The agency estimates the remaining two thirds of the cement factories (74 facilities) have annual requirements for disposal of the dust caused by deducting chlorine left at 3.3 million metric tons in 1995 [7].

The Portland Cement Association estimates that 11.7 million metric tons of the total CKD collected by air pollution control devices in 1995, and this figure represents a decrease from the estimated amount of 12.7 million metric tons of the total CKD generated in 1990, and there are wide differences between ovens in the net amount of CKD that is generated. In the year 1995, the industrial recycling of dust amounted to 7.8 million metric tons of the total amount generated from the factories, as most materials are disposed in the site without any reuse or reclamation, and in a survey that included 60% of cement factories in the United States it was found that due to its high alkaline content, therefore a large quantities of cement kiln dust cannot be returned to the furnace [7]. See table (2) which shows estimates of the quantities of dust residues from and not used.

Table 2. Illustrated the estimates net quantities used of CKD and other quantities of CKD residue.

	Pant	Net CKD (metric tons/yr)	Beneficially Used CKD (metric tons/yr)	Wasted CKD (metric tons/yr)
Total All Companies	**110**	**4,084,393**	**767.739**	**3,316,654**

(Source: (Tarun R. Naik, 2003, p. 12 of Ref. 16)

Due to the large number of cement manufacturing facilities around the world, may be CKD represents an alternative to soil stabilizers, it is properly to be useful and effective for the cost compared to other soil stabilizers such as lime, Portland cement, bitumen, and etc., and moreover, CKD recycling is an attractive alternative because it is cheap, in addition it is availability of great quantities. In parts of the countries of the world, CKD is being used increasingly for soil stabilization, and the data from some studies have demonstrated additional credibility for using CKD to stabilize the soil under appropriate conditions, and the focus is on the impact of soil type and the effectiveness of CKD [17].

Alternative applications to cement kiln dust include the agricultural sector - land reclamation as a source of potash / lime and animal feed, and in civil engineering - soil filling, stabilization and soil leakage resistance were used. As for the building materials sector, it is involved in the manufacture of lightweight aggregates, manufacture of concrete blocks, manufacture of low-strength concrete, concrete mortar, building cement and the manufacture of glass. It is also used in the purification of wastewater and water treatment, as well as in helping coagulation and stability of sludge, and also is used in the control of trimester such as sulfur absorption, waste treatment and hardening treatment [7], [8].

It is worth noting, the ability of this dust to absorb water stems from its chemically dried nature, which that results from the heat treatment, where it receives from the oven system. The process of absorbing water or what is called moisturizing releases a large amount of latent heat in the unprepared dust; it is a phenomenon that can be usefully exploited by using it, for sterilization of mixed materials, while dust can be used in cleaning sewage water [9].

1.3 **Objectives of the Study**

1. Eliminate cement kiln dust and construction waste in order to protect the environment.
2. Economical saving.
3. Land areas saving were occupied by landfill sites for these wastes.
4. Utilizing as much as possible of them in the manufacture of building materials such as concrete mixes, light cement aggregate and cement bricks, as well as using them in paving roads, footpaths, garden floors, car stations, and others.

1.4 Some Previous Studies Conducted on CKD

Assayed and his colleagues studied the effect of cement kiln dust on the strength of cement resistance and the corrosion of concrete steel. The study concluded that adding cement kiln dust as a substitute for cement mortar to a target of 5% has an adverse effect on the strength of concrete resistance and on the agitation of reinforced concrete, and there is no any effect on the corrosion of concrete steel [10]. Bates and his colleagues reached the result in their research on the effect of adding dust to the concrete mixture, the strength of pressure resistance and increases when using dust in concrete in appropriate proportions with ordinary Portland cement [11].

Contasa and his colleagues have commented in their study the use of dust in concrete achieves a high efficiency of concrete strength and dust can be used to increase the adhesive strength of the cement mixture [12]. In a study by Khaled Hassan Hawi in the use of CKD as a partial substitute for sand on the properties of recycled coarse aggregate of concrete, the research included a study of all properties of slump, strength of pressure, tensile strength, absorption, and density. The results showed a significant positive impact on increasing the compressive strength of the concrete by increasing the percentage of substitution sand with CKD as the concrete ages, this increase reaches 45% higher than the compression strength of the reference mixture at the age of 90 days [13].

Bashar Tarazi and his colleagues studied the physical and mechanical properties of manufactured cement bricks when adding cement kiln dust to the cement mixture, they found in their study the effect of dust on the cement brick mixture, showed the unit of weight, compressive strength and bending decreased with increasing dust in the mixture, and commented the use of the ratio dust to cement up to 50% is positive for the production of this type of cement bricks in terms of product cheapness and environmental friendliness [14]. In a study by R. Sri Ravindraraji (1982) to know the effect of dust on the strength of cement concrete when added partially as a substitute for cement, the study showed the dust is an adhesive material as it had effects on some engineering and physical properties of concrete [15].

It is worth noting the recycling and use of cement kiln dust and construction waste is one of the best alternative methods for the benefit of the environment, and progress in knowledge and requirements of civil engineering applications such as road construction, concrete industry, cement brick production, soil stabilization and improvement, and the production of concrete in large quantities in various construction works in this age makes it possible to use the dust of cement kiln factories and construction wastes to increase savings economically, in addition to disposing of them to protect the environment. Therefore, many researches have been conducted and are still being done on a large scale in this field to reduce the damage and benefit from it in the manufacture of concrete mixtures and the production of brick and cement mortar, in improving the soil and others, or by adding them to the concrete mixture.

On the level of the various researches carried out on cement dust and its effect on the properties of cement mortar, concrete mixture and the manufacture of cement bricks, for example, not limited to [17 -33]. As for the research on the scope of improving and fixing soil and building roads [35 – 48]. And in the field of some researchers conducted in the field of construction waste [49 – 62].

2. Laboratory Program, Materials and Experiments Used

2.1 Laboratory Program

The scheme of the practical program for the proposed mixtures is dealt with in eighteen groups (18) so that all the materials to be used for this research are grey cement and white cement, dust and structural residual as show in the table (3). The percentage of materials changes every time except for the percentage of the water, it is fixed only adding 2% in each increase the percentage of cement in order to compensate the amount required to complete the reaction of cement and the absorption of other materials to water.

Table 3: Illustrated Laboratory Program

Group	Gray Cement	Fine Aggregate	Water	CKD	Construction Waste
1	8 %	82.50%	9.50%	0%	0%
	10%	80.50%	9.50%	0%	0%
	12%	78.50%	9.50%	0%	0%
	14%	76.50%	9.50%	0%	0%
	16%	74.50%	9.50%	0%	0%
Group	**White Cement**	**Fine Aggregate**	**Water**	**CKD**	**Construction Waste**
2	8 %	82.50%	9.50%	0%	0%
	10%	80.50%	9.50%	0%	0%
	12%	78.50%	9.50%	0%	0%
	14%	76.50%	9.50%	0%	0%
	16%	74.50%	9.50%	0%	0%
Group	**Gray Cement**	**Construction Waste**	**Water**	**CKD**	**Fine Aggregate**
3	8 %	82.50%	9.50%	0%	0%
	10%	80.50%	9.50%	0%	0%
	12%	78.50%	9.50%	0%	0%
	14%	76.50%	9.50%	0%	0%
	16%	74.50%	9.50%	0%	0%
Group	**White Cement**	**Construction Waste**	**Water**	**CKD**	**Fine Aggregate**
4	8 %	82.50%	9.50%	0%	0%
	10%	80.50%	9.50%	0%	0%
	12%	78.50%	9.50%	0%	0%
	14%	76.50%	9.50%	0%	0%
	16%	74.50%	9.50%	0%	0%
Group	**Gray Cement**	**Fine Aggregate**	**Water**	**CKD**	**Construction Waste**
5	8 %	82%	9.50%	10%	0%
	8%	72%	9.50%	20%	0%
	8%	62%	9.50%	30%	0%
	8%	52%	9.50%	40%	0%
Group	**Gray Cement**	**Fine Aggregate**	**Water**	**CKD**	**Construction Waste**
6	12%	78%	9.50%	10%	0%
	12%	68%	9.50%	20%	0%
	12%	58%	9.50%	30%	0%
	12%	48%	9.50%	40%	0%
Group	**Gray Cement**	**Fine Aggregate**	**Water**	**CKD**	**Construction Waste**
7	16%	74%	9.50%	10%	0%
	16%	64%	9.50%	20%	0%
	16%	54%	9.50%	30%	0%
	16%	44%	9.50%	40%	0%
Group	**Gray Cement**	**Construction Waste**	**Water**	**CKD**	**Fine Aggregate**
8	8 %	82%	9.50%	10%	0%
	8%	72%	9.50%	20%	0%
	8%	62%	9.50%	30%	0%
	8%	52%	9.50%	40%	0%

Group	Gray Cement	Construction Waste	Water %	CKD	Fine Aggregate
9	12%	78%	9.50%	10%	0%
	12%	68%	9.50%	20%	0%
	12%	58%	9.50%	30%	0%
	12%	48%	9.50%	40%	0%
Group	**Gray Cement**	**Construction Waste**	**Water**	**CKD**	**Fine Aggregate**
10	16%	74%	9.50%	10%	0%
	16%	64%	9.50%	20%	0%
	16%	54%	9.50%	30%	0%
	16%	44%	9.50%	40%	0%
Group	**White Cement**	**Fine Aggregate**	**Water**	**CKD**	**Construction Waste**
11	8 %	82%	9.50%	10%	0%
	8%	72%	9.50%	20%	0%
	8%	62%	9.50%	30%	0%
	8%	52%	9.50%	40%	0%
Group	**White Cement**	**Fine Aggregate**	**Water**	**CKD**	**Construction Waste**
12	12%	78%	9.50%	10%	0%
	12%	68%	9.50%	20%	0%
	12%	58%	9.50%	30%	0%
	12%	48%	9.50%	40%	0%
Group	**White Cement**	**Fine Aggregate**	**Water**	**CKD**	**Construction Waste**
13	16%	74%	9.50%	10%	0%
	16%	64%	9.50%	20%	0%
	16%	54%	9.50%	30%	0%
	16%	44%	9.50%	40%	0%
Group	**White Cement**	**Construction Waste**	**Water**	**CKD**	**Fine Aggregate**
14	8 %	82%	9.50%	10%	0%
	8%	72%	9.50%	20%	0%
	8%	62%	9.50%	30%	0%
	8%	52%	9.50%	40%	0%
Group	**White Cement**	**Construction Waste**	**Water**	**CKD**	**Fine Aggregate**
15	12%	78%	9.50%	10%	0%
	12%	68%	9.50%	20%	0%
	12%	58%	9.50%	30%	0%
	12%	48%	9.50%	40%	0%
Group	**White Cement**	**Construction Waste**	**Water**	**CKD**	**Fine Aggregate**
16	16%	74%	9.50%	10%	0%
	16%	64%	9.50%	20%	0%
	16%	54%	9.50%	30%	0%
	16%	44%	9.50%	40%	0%
Group	**Gray Cement**	**Construction Waste**	**Fine Aggregate**	**CKD**	**Water**
17nth	8 %	74%	10.00%	26.72%	9.50%
	8%	64%	20.00%	23.46%	9.50%
	8%	54%	30.00%	20.22%	9.50%

Group	White Cement	Construction Waste	Fine Aggregate	CKD	Water
18	8 %	74%	10.00%	26.72%	9.50%
	8%	64%	20.00%	23.46%	9.50%
	8%	54%	30.00%	20.22%	9.50%

2.2 Materials used

2.2.1 Ordinary Portland cement

The cement used in this research is the ordinary local gray and white Portland cement produced at the Arab Union Cement Factory in Zliten, which is located east of the city of Tripoli with a distance of 180 km, with strength of 42.5 Newton, and it conforms to the Libyan standard specifications No. (340/2009) and the British (BS EN 179).

2.2.2 Fine Aggregate

The aggregate used was obtained from the crushers of the city of Tarhuna, and it was conducted on a sieve analysis and specific weight test, which is in conformity with the Libyan standard specifications No. 49/2002 {and test specifications MQL (2006: 252).

2.2.3 Construction Waste

The waste of construction used obtained from the demolition of the old buildings was obtained in Salah Al-Din and Qasr Bin Ghashir regions. The unwanted materials, such as wood, plastic, etc., were separated, and they were also manually broken by hammers, after which they were placed in sieves and screening process to obtain the required sizes for this research.

2.2.4 Water

The water used was obtained from water network of the city of Qasr Bin Ghashir, which is safe for drinking and other human use. It is also suitable for construction work according to specification of Libyan Standard MAS 294 and compared to the standard specifications {1988/294}.

2.2.5 Cement Kiln Dust (CKD)

Cement kiln dust waste (CKD) were obtained from the cement factory of Sooq Al-Khamis which is located southeast of Tripoli and is 70 km away from it.

3. Mixing and Pouring Method

• Processing and preparation of steel molds with measurements of 7 × 14 ×28 cm, and they are well cleaned, dried, and then their sides are painted with oil.

• All materials are prepared of aggregate, cement and water, and their weight is according to the proportions determined for the mixture in the practical program planned for this study.

• Mix the ingredients of the mixture, which is dry until it is well mixed and homogeneous.

• Add the water according to the prescribed percentage (9.5%) and mix the ingredients well until the materials are well homogeneous with the water, keeping in mind that 2% of the water is added at every increase in the cement proportion, dust and construction waste content for absorption and reactions.

• The mixture is poured into steel molds on two layers, distributed and compacted well by 25 dams per layer by a hammer with a weight of 2.5 kg with a good leveling and smooth of the sample surface.

• Leave the sample in the mold at least two hours, then remove from the molds, then leave it in the air for 24 hours.

• The samples are then placed in a basin with water for 7 days, which is the treatment period time.

• After the treatment period, the bricks are taken out and outer surface is carefully dried with a dry towel and tested directly to measure the strength of the pressure resistance according to the specifications.

Tests Used

4.1 Sieve analysis

This test was performed on all types of samples for the fine natural aggregate used in this research according to the American standard (ASTM-D 422-1966), noting that the drying process was done in the laboratory with natural air.

4.2 Specific Weight of Fine Aggregate, Cement Kiln Dust and Construction Waste

This test was done for fine natural aggregates, construction waste, and fly dust, according to American Standards (ASTM-854-1958).

4.3 Treated

After 24 hours of the process of pouring the bricks inside the molds, the molds are carefully disassembled, and then the bricks are placed for all the mixtures in a fresh water basin at the laboratory temperature for seven days period time.

4.4 Compressive Strength

The compressive strength test of the samples obtained was done using a pressure gauge. (Serial Number: 1796-8-2539) (International E L E)), which has a maximum pressure of 2000 kN. The sample was placed on the device base so that it is in the center between the two gravity loading bases, then the load was applied to the sample at a rate of 4 kN / s according to American Standard No. (ASTM-C39) and the test results were recorded.

4. Results Analysis and Discussion

5.1 Sieve Analysis, Specific Weight, Absorption, Compressive Strength

5.1.1 Sieve Analysis

Through studying results of the sieve analysis of fine aggregate shown in table (1) and through figure (1), which represents the granular gradient of natural aggregate used in the locally produced brick mix and its comparison with the lower and upper bounds of the Libyan specification No. (49), can conclude the following: 1. The used fine aggregate falls within the limits of the Libyan (49) lower and higher specifications. 2. The used aggregate is generally closer to the lower limits of the Libyan specifications number (49)., 3. This aggregate contains approximately 3% of clay and silt, and this percentage within the limits of the Libyan specifications No. (49), which it was determined the maximum amount of soft materials should not exceed 4%.

Fig. 4. Sieve Analysis of Fin Nature Aggregate

Sieve Diameter	Occupying Wight (gm)	Occupying Percent	Acclamation Percent	Pass percent
4.75	6.8	0.68	0.68	99.32
2.36	200.8	20.08	21.48	78.52
2	79.7	7.97	29.45	70.55
0.25	460.8	46.08	75.53	24.47
0.15	106.2	10.62	86.15	13.85
0.075	107	10.7	96.85	3.15
PAN	40.4	4.04	100.89	0

Fig. 5. Show the Location of the granular gradient curve of the fine natural aggregate Compared to the lower and upper Libyan specification curves

Sieve Diameter	Pass percent	Specification Limits	
		Min. Limit	Max. Limit
4.75	99.32	100	100
2.36	78.52	80	100
2	70.55	70	90
0.25	24.47	5	70
0.15	13.85	-	15
0.075	3.15	-	5

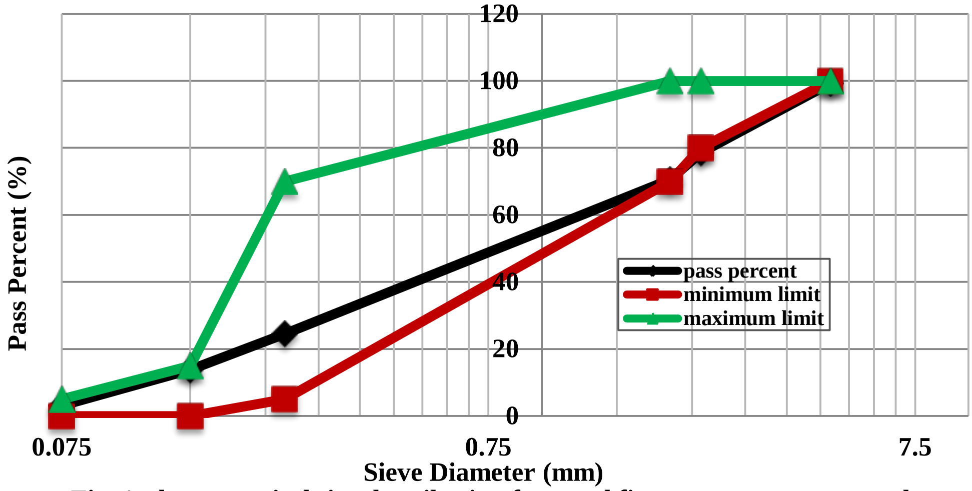

Fig. 1. shows particel size destributin of natural fine aggregate, upper and lower limits of libyan spedcifiction

5.1.2 Specific Weight

The results of laboratory tests showed the specific weight of the natural aggregate used is 2.70 and it conforms to the American specifications ASTM C33 - 87, which sets the limits for the specific weight from 2.5 to 2.7. The specific weight of obtained cement kiln dust CKD) is 2.75 and construction waste is 2,135.

5.1.3 Absorption:

The results showed the absorption percent of natural aggregate is 2.98%, and this percentage is considered among the limits of the Libyan specifications number (99) in which the absorption percent was determined by no more than 3% of the dry weight, and this result is considered among American specifications ASTM C 127 which The absorption ratio for the fine aggregate was determined between 2 to 3, while the absorption ratio for the structural waste aggregate is 11.2 and this result is greater than the natural aggregate, as well as greater than the absorption ratio defined by the Libyan specification No. (49) by 10%, and the reason is due to the high proportion of pores where the construction waste are contains, which led to higher water absorption capacity, and also high pores percentage led to low specific weight and dry density. According to the report submitted by Egbe E. Andrew (2012), the results values for model cement kiln dusts such as loess on Ignition (LOI) vary between 20-35, pH between 12.48 - 12.65, particle size (D5 = 2.8 µm to 5.5 µm, as well as in the gradation (Cu = 5 – 25), and the surface area is between 1400 to 2300 cm^2/g.

5.1.4 Compressive strength

The results of the pressure resistance shown in table (5), when using ordinary gray and white Portland cement by adding them to both natural aggregate and structural waste aggregate, in addition to using cement kiln dust (CKD) as an additive to be tested to support compressive strength. The percentage of cement used in this research are 8%, 10%, 12%, 14%, and 16% as a weight percentage of nature aggregate, while the ratio of CKD to the mixture are 10%, 20%, 30%, and 40% as a weight percentage of nature aggregate. Factory concrete mixtures have been produced in conformity with the local mixtures for the brick industry, for purpose of comparing them with the cement mixtures proposed in this research, which are added to the CKD for the purpose of trying to reach a better product than the local product or at least the same.

Table 5. Results of compressive strength for mixtures of both natural agg. and construction waste agg. with grey cement and white cement (7 days curing time)

Cement (%)	Compressive Strength (G. Cement+N.Agg.) (Nlmm^2)	Compressive Strength (G. Cement+C.Waste) (Nlmm^2)	Compressive Strength (W. Cement+N.Agg.) (Nlmm^2)	Compressive Strength (W Cement+C.Waste) (Nlmm^2)
8	26.30	34.50	29.00	19.30
10	35.47	36.70	30.87	28.23
12	45.67	28.87	37.27	22.87
14	47.57	50.80	37.67	18.00
16	61.40	50.40	54.57	18.83

G: Grey, N: Natural, Agg: Aggregate, C: Construction, W: White, CKD: Cement Kiln Dust.

Figure (2) shows the relationship between the strength of the pressure resistance of the bricks produced in the laboratory according to the proportions of the applicable local bricks and conforming to the local specifications are (12% cement + 9.5% water + 78.9% fine natural aggregate) which was adopted in this study as a model result of the comparison and to represent the rest tests results. The mixtures are formed once using gray cement and once using white cement in addition to using both natural and construction waste, and the period time of store is 7 days. Through the figure notice the behavior of the curves movement the pressure resistance increases with an increase in the cement percentage of the mixture except for only one curve, which decreased by increasing the proportion of cement, which is a curved white cement with construction waste. It is clear from the results and conduct of the curves, the compressive strength values for the bricks consisting the gray cement mixture are greater than the white cement mixture, and this may be due to two reasons: The presence of iron oxide and shell clay from the components of gray cement increases the strength by interacting with water. As for white cement, it is free of the two those elements. And the second reason: it may be caused by natural aggregate, which is harder than the aggregate of construction waste. This is self-evident because the presence of a high amount of pores in the aggregate of construction waste and its composition of several elements weakens of compressive strength.

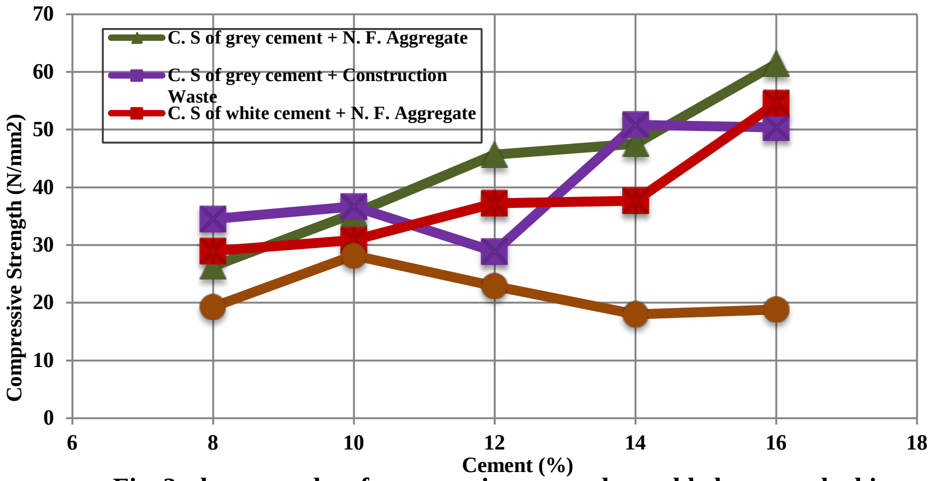

Fig. 2. shows results of compressive strength at added grey and white OPC to both fine aggregate and constrution waste.

G: Grey, N: Natural, Agg: Aggregate, C: Construction, W: White, CKD: Cement Kiln Dust.

This is confirmed by figure (3) and the results are shown in table (6), where find the results of gray cement mixtures are higher at all points than white cement mixtures, despite the presence of both types of aggregates in the mixtures at same proportions.

Table 6. results of compressive strength for mixtures of both natural agg. and construction waste agg. Once with grey cement and Another Once with white cement (7 days curing time)

Cement (%)	Water (%)	Natural aggregate (%)	Construction Aggregate (%)	Compressive Strength (Grey Cement+C.Waste Agg.+N. Agg.) (Nlmm^2)	Compressive Strength (White Cement+N.Agg.+C. Waste Agg.) (Nlmm^2)
8	9.5	41.25	41.25	30.40	24.15
10	9.5	40.25	40.25	36.09	29.55
12	9.5	39.25	39.25	35.67	30.07
14	9.5	38.25	38.25	49.57	27.84
16	9.5	37.25	37.25	55.40	36.70

G: Grey, N: Natural, Agg: Aggregate, C: Construction, W: White, CKD: Cement Kiln Dust.

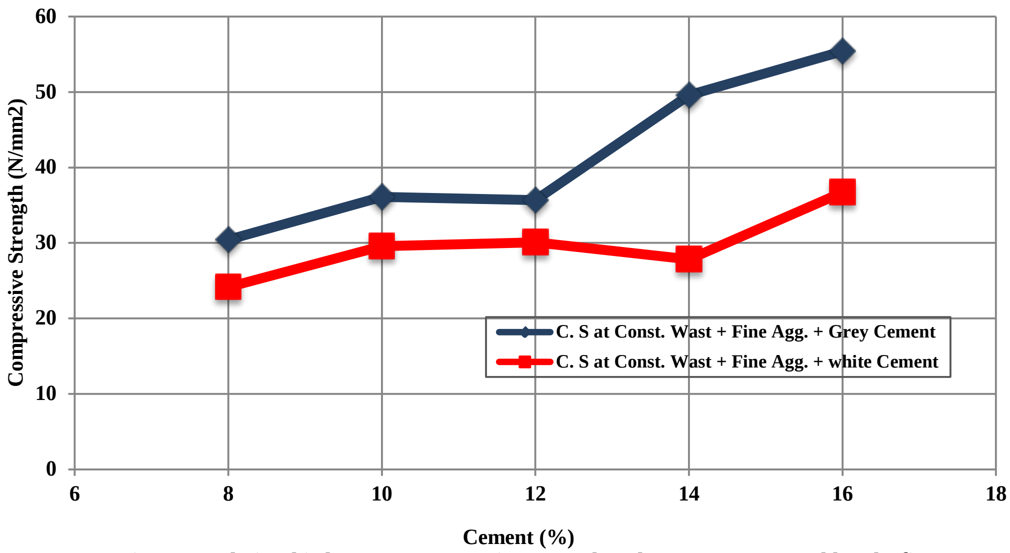

Figure 3. relationship between compressive strength and cement parecent add to the fine aggregate and construction waste mixture (period time 7days)

As for figure (4), it represents the compressive strength when adding the CKD to mixtures consisting of natural aggregates and waste aggregates with gray cement only, table (7) shows the results, notice through the course of the curves, the movements of the curves almost decreased by adding the CKD to most of mixtures, as note the best curve at adding 16% cement with the aggregate of construction waste, while the rest of the points of the curves, the results are very close to each other. In the fact, through showing to the curves of figure (4) illustrates the adding CKD did not lead to an increase in strength, on the contrary, it was found the increase proportion of CKD in the mixture, the strength is decrease and this is due to several reasons. First: the size of the CKD grains is very fine, where are equal to grains of cement or smaller than it, this means it's the surface area is very high, which led to inability the amount of cement to be completely covered and connected together. Second: CKD has a high water absorption property and these results in cement not obtaining the amount of water needed to complete reaction.

Table 7. illustrated results of compressive strength at used grey cement with natural aggregate and construction waste aggregate separated (7 days period time)

CKD (%)	Compressive Strength of C. W.agg. at 8% grey Cement (N/mm2)	Compressive Strength of N. Agg. at 8% grey Cement(N/mm2)	Compressive Strength of C. W.agg. at 12% grey Cement(N/mm2)	Compressive Strength of N. Agg. at 12% grey Cement(N/mm2)	Compressive Strength of C. W.agg. at 16% grey Cement(N/mm2)	Compressive Strength of N. Agg. at 16% grey Cement(N/mm2)
0	34.5	26.3	28.87	45.67	50.4	61.4
10	12	21.56	26.53	18.5	38.13	25.5
20	9.1	17.63	21.16	15.9	28.4	19
30	21.3	17.76	19.86	15.2	34.83	18.16
40	16.36	13.06	18.36	11.56	25.1	14.36

G: Grey, N: Natural, Agg: Aggregate, C: Construction, W: White, CKD: Cement Kiln Dust.

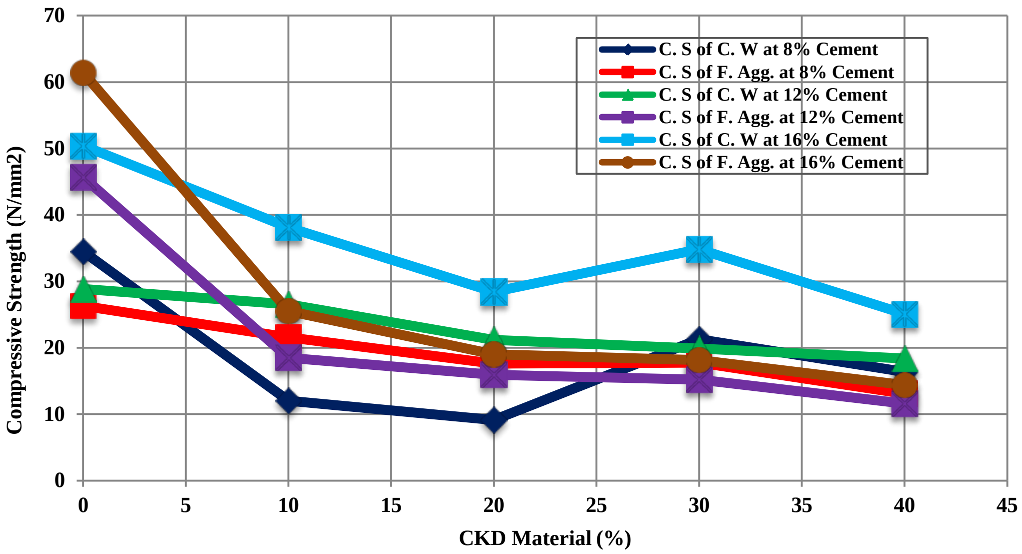

Fig. 4. the relationshipe between CKD and compressive strength at used grey OPC, natural aggregate and construction waste.

G: Grey, N: Natural, Agg: Aggregate, C: Construction, W: White, CKD: Cement Kiln Dust.

As for adding white cement to the mixture in which both the natural aggregate and the aggregate of the structural waste are used separately, where results are shown in table (8), which is represented by figure (5). Through the curve can be notice the strength decrease with increase CKD at all of cement proportions in mixtures, the reason of strength decrease, as same as reasons in dissected previously of figure (4). Comparing the compressive strength resulting from the use of both white cement and gray cement, find the strength when is using gray cement are greater, whether when adding CKD or without it, and this is due to the containment of gray cement to iron oxide and clay, and these two elements lead to increase the addition of the reaction and then increase the strength; and the addition to the presence of free lime released from the reaction of cement with water, which interacts with the amorphous silica (called pozolonic reaction) present in the aggregates, which cause to increases the strength.

Table 8. illustrated results of compressive strength at used white cement with natural aggregate and construction waste aggregate separated (7 days period time)

CKD (%)	Compressive Strength of C. Waste at 8%White Cement (N/mm2)	Compressive Strength of Ntural Agg. at 8% White Cement(N/mm2)	Compressive Strength of C. Waste at 12% White Cement (N/mm2)	Compressive Strength of Ntural Agg. at 12% White Cement (N/mm2)	Compressive Strength of C. Waste at 16% White Cement (N/mm2)	Compressive Strength of Ntural Agg. at 16% White Cement (N/mm2)
0	29	19.3	22.87	37.27	18.83	54.57
10	29.4	31.03	28.9	34.6	30.33	32.9
20	20.8	35.83	26.26	26.73	25.1	44.9
30	16.73	25	20.46	48.7	22.03	32.2
40	15.53	22	18.63	31.4	17.96	31.5

G: Grey, N: Natural, Agg: Aggregate, C: Construction, W: White, CKD: Cement Kiln Dust

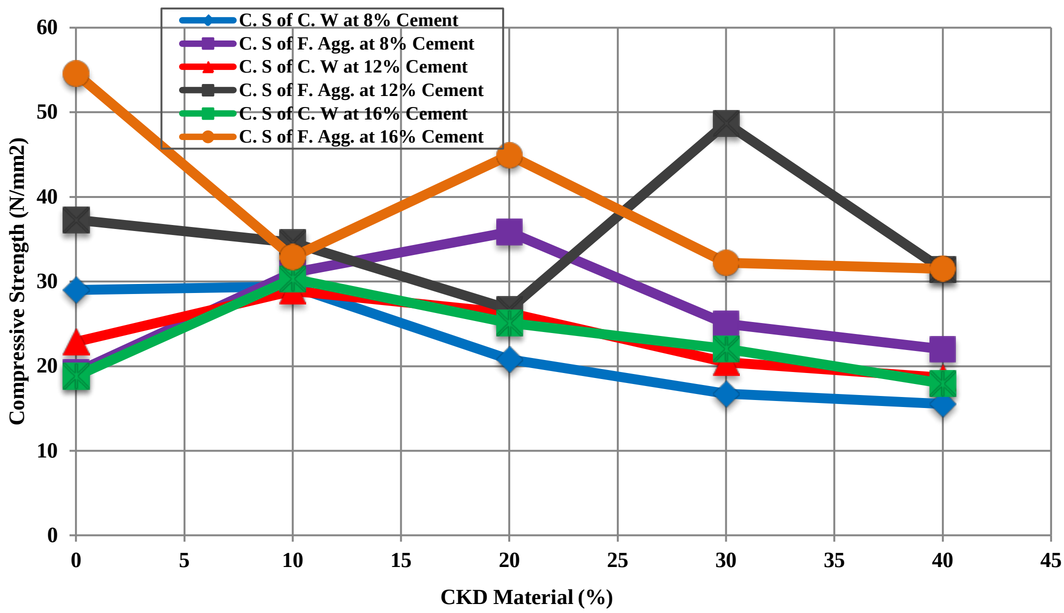

Figure 5. relationshipe between CKD and compressive stregth at used white OPC, natural aggregate and construction waste (period time 7 days)

G: Grey, N: Natural, Agg: Aggregate, C: Construction, W: White, CKD: Cement Kiln Dust.

Table (9) shows the results which are represents in figure (6), in fact, the percent used 8%, has been chosen economically because the cement has a high price comparing to other materials and as the lowest percent used in this research with both natural aggregate and construction waste aggregate in an equal proportion with each other with add CKD to this mixture. It has been shown through path of curves the gray cement curve decreases with the increase of all CKD proportions, but when using white cement find the strength in first addition of CKD (10%), decreased, then after that the strength began to increase with increasing CKD, and this increase of strength may be due to several reasons The first: the CKD contains a high percentage of free lime and this leads to its interaction with silica, and this reaction is called a pozolonic reaction, which increases the strength. Second: the material of CKD is very soft, therefore, it is considered a filler material of the voids between the particles of aggregates, and this in turn leads to a decrease in voids and an increase in density, this results an increase in strength. Adding dust to the brick mixture has advantages. (1) It is characterized by light weight, because the density of CKD is less than the density of natural aggregate. (2) It is characterized a low permeability to water because the addition of CKD leads to filling the voids of aggregates used, because the size of CKD grains is much smaller than the aggregates grains. (3) In addition to the cheap price of wastes and its exploitation is environmental protection.

Table 9. results of compressive strength for mixtures of both natural agg. and construction waste agg. with grey cement and white cement (7 days curing time)

CKD (%)	Compressive Strength (Grey Cement + Construction Waste) (Nlmm^2)	Compressive Strength (White Cement + Natural fine Agg.) (Nlmm^2)
0	24.15	30.40
10	16.31	27.56
20	18.10	22.17
30	20.60	20.98

G: Grey, N: Natural, Agg: Aggregate, C: Construction, W: White, CKD: Cement Kiln Dust.

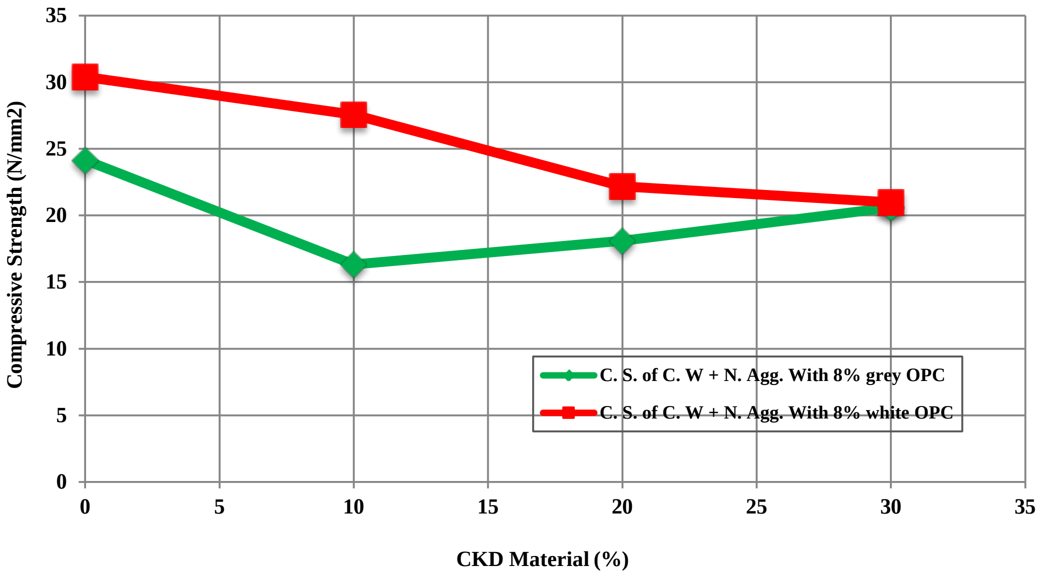

Figure 6. the relationship between CKD add to mixture of construction waste and natural aggregate used grey and white cement (period time 7 days)

G: Grey, N: Natural, Agg: Aggregate, C: Construction, W: White, CKD: Cement Kiln Dust.

Referring to both figures (4) and (5), where shows from each point of CKD percentage when cement is added to it in different proportions, whether gray or white cements, the strength increases with increasing the cement percent, but these increases are not large, they are very close to each other, and can exclude them increasing the percentage of 16% cement, whether white or gray cements, it is considered almost the highest in both cases. From figure (5) can an exception adding proportion 12% white cement when adding 30% CKD, it is the highest value of strength is recorded, this is may be a severe case or perhaps a real value, and its interpretation is that the percentage of cement with the proportion of CKD in addition to the proportions of both natural aggregate and water was very proportionate as best mix of all other mixtures, so that gave better interaction and thus gave a better strength, and perhaps this also applies to proportion 30% of CKD with 16% cement add to the construction waste aggregate and water as shown in figure (4).

5. Conclusions

After analyzing and discussing the results, conclude the following:

1. The compressive strength of the local bricks produced in the laboratory increases with increasing ratio of cement of gray and white types, together with the natural and construction aggregates.
2. The results showed the highest value of the compressive strength of the local brick, were using gray cement and white cement with 16% natural aggregate.
3. The results indicated the compressive strength when using construction waste aggregate with gray cement was better used than white cement.
4. The results showed when adding to types of aggregates in one mixture, and in equal proportion, whether with gray cement or white cement, the compressive strength increases with increasing cement percentage.
5. The results indicated the compressive strength decreases when increase CKD to all ratios, whether with gray cement or white cement, as well as in the two cases of the use of aggregates, whether natural aggregate or construction waste aggregate.
6. The results illustrated the highest- compressive strength is when using gray cement and waste aggregate in the mixture.
7. The results showed the best compressive strength was conducted when adding CKD to the mixture of two types of aggregates were with gray cement.
8. The results indicated the compressive strength decreases with increase ratio of CKD to the mixture with both types of cement used.

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