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Research Article

Chemical Specifications for Raw Materials Used in The Kufa Cement Industry in Iraq

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Abstract: This paper aims to provide background information on raw materials included in the cement industry that have chemically examined. The raw materials entering the factory examined, which include stone, crude oil, iron dust, sand, and gypsum, as it found that the total carbonate ratio is 89 percent as a weight ratio and the sulfide is smaller or equal to 1 percent as a weight ratio, and the magnesium carbonate is smaller or equal to 3 percent. For iron dust with sand, the total carbonates of the mixture were smaller or equal to 85 percent, and magnesium carbonate was smaller or equal to 3 percent. Silica oxide also examined in the sand were the results of the examination were greater than 85 percent. For sulfide oxide smaller than 1 percent, as well as for iron dust, the proportion of oxide Ferric is higher than 55 percent, the percentage of alumina oxide is less than 10 percent, silica oxide is less than 20 percent, as well as for crude oil, as it contains less than 4 percent of sulfide oxide, as well as primary and secondary gypsum examination, and it found that sulfide oxide is greater than 31 percent if the gypsum is Secondary and greater than 42 percent if the gypsum is primary. Materials are non-soluble smaller than 8 percent if it was secondary gypsum and less than 5 percent if the primary gypsum. Where these models examined and analyzed, and the storage location of the models examined were determined.

Keywords: Cement Composition, Cement Industry, Cement Elements, Cement Production, Cement Properties.

1. Introduction

Cement has known since ancient times with the discovery of a kind of natural rock that can be calcined to produce a product that will harden when mixed with water. The ancient Egyptians, for example, used materials such as cement to make all the construction of the pyramid. While the Greeks and Romans used volcanic ash mixed with lime to make cement. In the current era of globalization, cement needed in human life, including making buildings such as roads, office houses, school buildings, shopping centers, entertainment centers, and other significant construction works [1]. Therefore, the level of demand for cement products from day to day is getting better both in terms of quality and quantity. The condition of the cement industry itself is growing very fast now. Many new cement companies have sprung up, and new cement factories have been established [2].

All of them are competing to gain a significant market share during society. From the competition that arises in the end, the strong will be the winner. Reliable in terms of capital, quality of production, and corporate profits [3]. Meanwhile, cement factories faced a dilemma situation where the natural resources used as raw materials for the cement industry are decreasing and limited in number. An increase in the number of existing cement plants and expanded production capacity causes a reduction in the availability of deposits of raw materials that exist in nature. Another challenge is the environmental issue that often

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exhaled during society, which manifested in the form of stringent laws and regulations by the government [4]. All of this forces the cement industry players to try to rack their brains to find innovations and breakthroughs in overcoming the challenges faced.

Kufa Cement Factory is one of the formations of the General Company for Southern Cement of the Ministry of Industry and Minerals. This factory located in Iraq in the province of Najaf/Kufa District This plant was established in 1977 by the Danish company and the number of production lines four and production 1.781.000 tons annually and works in a wet way, as well as the production of clinker 1.728.000 Tons per year as the produced cement, conforms with the necessary specifications and standards of the Ministry of Industry and Minerals as well as applying a quality system following international standards (2008 - ISO 9001). The Kufa Cement Factory has a vital role in informing the reconstruction process by providing Iraq from the north to the south with the cement material. The location of the Kufa Cement Factory in the Najaf governorate has chosen because of the abundance of raw materials of high quality that included in the cement industry where stone quarries located near the factory in the Najaf sea area As well as dirt quarries located in the Kifl and Dahisia regions, the factory produces ordinary Portland cement and salt-resistant [5].

Cement is any substance that binds together other materials by a mixture of chemical processes known collectively as a setting. Cement are dry powders and will not be confused with concretes or mortars, but they are a crucial constituent of both of those materials, during which they act because of the 'glue' that provides strength to structures. Mortar may be a mixture of cement and sand, whereas concrete also includes rough aggregates; because it is a serious component of both of those building materials, cement is a particularly important construction material. Utilized in the assembly of the various structures that structure the fashionable world, including buildings, bridges, harbors, runways, and roads. Also used for facades and other decorative features on buildings. Demand is continually increasing, increasingly from the Middle East, and thus cement is among the most consumed commodities after water [6]. We often consider cement used in construction, Either hydraulic or non-hydraulic, depending on the strength of the cement in the presence of water [7].

Thus, the non-hydraulic cement will not be placed underwater or in wet conditions; instead, it will be adjusted because it dries and reacts with carbon dioxide in the air. It is often attacked by some aggressive chemicals after setting [3]. Hydraulic types of cement (e.g., Portland cement) set and become adhesive thanks to a reaction between the dry ingredients and water. The reaction leads to mineral hydrates that are not very water-soluble then are quite durable in water and safe from chemical attack. This enables setting in wet conditions or underwater and further protects the hardened material from chemical attack. The chemical change for Portland cement found by ancient Romans used volcanic ash [3].

Therefore, this current work is done to create a database for the specifications of raw materials (stone - sand - iron dust - crude oil - gypsum) that are used in the Kufa cement industry in Iraq to benefit researchers who work in developing this field.

2. Raw Materials Mixing

The first step in making cement is in the raw materials and grouping them so that the required chemical composition reacted by the heat produced from the furnaces. For the reaction to complete well, the raw materials used in the cement industry will be ground. Mixed, prepared for the oven, and the ground materials heated to extremely high temperatures. Since the ultimate composition and properties of cement specified within rather strict bounds, it would be supposed that the wants for the raw mix would be similarly strict. Because it seems, this is often not the case. While it is vital to possess the right proportions of calcium, silicon, aluminum, and iron, the general chemical composition, and structure of the individual raw ingredients can vary considerably. The rationale for this is often that at the very high temperatures within the kiln, many chemical components within the raw ingredients are burned off and replaced with oxygen from the air. Table1 lists just a few of the various possible raw ingredients which will be wont to provide each of the most cement elements [5].

Table 1. Raw Ingredients Used to Provide Each of The Main Cement Elements.

Calcium	Silicon	Aluminum	Iron
Limestone	Clay	Clay	Clay
Marl	Marl	Shale	Iron Ore
Calcite	Sand	Fly Ash	Mill Scale
Aragonite	Shale	Aluminum	Shale
Shale	Fly Ash		Blast Furnace Dust
Sea Shells	Rice Hull Ash		
Cement Kiln Dust	Slag		

The cement industry considered of strategic industries. Simple with the industry compared to significant industries and depends on the supply of the required raw materials for it. Cement is a hydraulic adhesive for building materials, meaning that it will become an adhesive when mixed with water. In general, there are three types of cement raw materials, namely clinker/slag cement (70% to 95%, which is the result of the combustion of limestone, silica sand, iron sand, and clay), gypsum (about 5%, as a hardening retarding agent) and material third, such as limestone, pozzolan, fly ash, and others. If the third element is not more than about 3%, generally, it still meets the quality of OPC (Ordinary Portland Cement). However, if the third material content is higher to around 25% maximum, then the cement will change to PCC (Portland Composite Cement) type [8].

Ordinary Portland Cement is Portland cement that is used for all kinds of construction if no select properties are needed, for example, resistance to sulfate, heat hydration. Ordinary Portland Cement contains the main compounds as in the table below

Table 2. Composition of Main Cement Compounds [9].

Chemical Names	Chemical formula
Tricalcium silicate (C_3S)	$3CaO.SiO_2$
Dicalcium silicate (C_2S)	$2CaO.SiO_2$
Tricalcium aluminate (C_3A)	$3CaO.Al_2O_3$
Tetracalcium aluminofert (C_4AF)	$4CaO.Al_2O_3.Fe_2O_3$
Gypsum	$CaSO_4.2H_2O$

- C_3S and C_2S are the most dominant compounds in cement and provide cement properties. When exposed to water, C_3S will immediately hydrate and produce heat.
- Whereas C_2S reacts with water slower, so it only affects the hardening of the cement after more than seven days of age and provides ultimate strength. C_2S also makes cement resistant to chemical attack and reduces drying losses.
- The C_3A element (the third element) is exothermically hydrated and reacts very quickly to give strength after 24 hours.
- The fourth element, C_4AF, has less influence on cement hardness. The small iron content in white cement will give a little C_4AF content in cement, so the quality of cement will increase in terms of strength.

3. Raw Materials of Cement

3.1. Gypsum

Gypsum is a white limestone or fine-grained. It consists of calcium carbonate. Mud and quartz are the most common impurities. Most gypsum is a soft, friable rock that does not require explosives in mining [10]. Gypsum material, which is called aqueous calcium sulfate, is brought to the Kufa Cement Factory from the quarries of Anbar Province in Iraq because of its quality, but after the distance was one of the difficult challenges, so there was an alternative to these quarries, where exploration was carried out in Najaf because of its proximity to the factory and found material Primary and secondary gypsum included in the cement industry Gypsum material is an essential primary material added to cement in the penultimate stage with 3% of clinker where the acceptable mixing limits for sulfide oxide are from 31% to 40% for secondary gypsum and primary gypsum from 40% to 44% and the materials Insoluble from 5% To 11% if the gypsum is secondary and from 3% to 6% if the gypsum is primary and rejection is in the presence of a percentage of sulfide oxide higher than 30% for the secondary gypsum and also if the sulfide oxide ratio exceeds 43% for the primary gypsum and is rejected in the event that the proportion of non-receptive materials increases The solubility is about 8% for the secondary gypsum and more than 6% for the primary gypsum. Thus, the gypsum rejected if it does not achieve the mixing limits accepted above and is replaced by an excellent quality to mix.

3.2. Limestone

Limestone is one of the primary materials involved in the manufacture of cement and is in the form of extensive deposits, covering hundreds of square kilometers, and is relatively different in thickness and quality. Therefore, limestone material can be large and long-lived, mining limestone layers that can be hundreds of feet thick over areas of several square kilometers. Many mines produce multiple products, and crushed rocks may remain impure enough for specific uses suitable as road heaps. Thus, limestone brought from quarries owned by the Kufa Cement Factory, which is 35 km away from the factory and then transferred to crushers for crushing and transported by the rubber conveyor and then stored in the factory warehouses and transferred to the mills feeding area—before that, examined the laboratory before sent to the feeding area. Limits are Mixing for calcium carbonate from 85% to 98%, mixing limits for sulfide oxide from 1.5% to 0.5%, mixing limits for magnesium carbonate from 1.5% to 5%, thereby rejecting the primary material (limestone) if the carbonate ratio Calcium is less than 85%, and if the percentage of sulfur oxide was Greater than 1.5%, and if the proportion of magnesium carbonate is greater than 3% and thus be withdrawn models that I said or abounded confused about the above borders and isolate and re-send replaced by good qualities to mix.

3.3. Clay

It is a primary material used in the manufacture of cement, and it is a soft material that is mainly aqueous alumina silicate ($Al_2Si_2O_5$) (OH), it contains 23.5% alumina, 46.5% silica and is used in the manufacture of white ceramics and the packing and coating of paper. Also used as a filling material in Paints, rubber, plastics, and many other products [6].

Where the proportions of aluminum oxide and silicate differ according to the type of clay. As the clay material has a vital role in the manufacture of cement that is mixed in specific proportions with other materials used in the manufacture of cement, such as limestone, iron dust, and other materials involved in the manufacture of cement. Where the Kufa Cement Factory intentionally brought the most beautiful clay from Al-Diwaniyah Governorate from Al-Dahisia district, which is 50 km from the cement factory, which contains 15% soil and is chosen by the Geological Survey Department of Al-Diwaniyah Governorate. The dirt in the mud contains 42% of silicon oxide. The moisture content of the clay material must be less than 55%. Where the acceptance limits for the clay material are from 45% to 57%, so that if the humidity exceeds 57%, preserved, and the amount of water added to the soil reduced. Then it is transferred to the clay crusher, and the mixing ratio is from 55% to 60%. The soil in the clay also contains iron oxide by 5.5%, calcium oxide by 18%, magnesium oxide by 5%, and sulfur dioxide by 1%. Also, it contains alkali with a severe ratio, which is potassium oxide and sodium by 0.2%, and these ratios approved from Before the Iraqi Quality Evaluation and Control Authority used in the manufacture of Kufa cement in Iraq.

4. Result and Discussions

Laboratory results obtained for the raw materials used in the manufacture of cement material for the period from 1/1/2020 to 1/31/2020 within the laboratories of the Kufa Cement Factory in Iraq in cooperation with the Technical Engineering College in Najaf. As the raw materials play an essential role in the quality and stability of the product, the raw materials should be of close, non-fluctuating specifications. Whereas, the chemical (laboratory) requirements for the raw materials needed to produce cement, as the required limits for the magnesium carbonate present in the limestone, are smaller or equal to 3% compared to the value obtained through laboratory testing was 0.77%. As the required value for sulfate in limestone is smaller or equal to 1%, while the value obtained in the laboratory was 0.79%. While the value of sulfates in the sand was smaller or equal to 1% as a required value, since the value obtained laboratory is 0 .98%, and for gypsum, the required value is greater or equal to 31% of sulfates, while the value obtained laboratory for sulfates It was 32.16%. While the required value for silica in limestone is smaller or equal to 5%, compared to the value obtained from the laboratory for silica is 2.23%. Likewise, for sand material, the required value according to the required specifications is greater or equal to 85%, while the value that was Laboratory acquisition is 92.62%.

Regarding triple iron oxide, the required iron dust ratio within the standard is greater or equal to 55%, while the value obtained through laboratory testing was 24.45%. Likewise, concerning triple aluminum oxide (alumina), the percentage of iron dust is smaller or equal to 10%, while the value obtained laboratory for alumina is 3.57%. As shown in Table 3, which clarifies the values of raw materials used in the cement industry that obtained in the laboratory.

Table 3. The Use of Chemical Raw Materials in Cement Date January 1 Through January 31, 2020

Compound	Limestone	Clay	Iron	Sand	Kiln feed	Gypsum
SIO_2	2.23	39.90	9.86	92.62	13.34	-
AL_2O_3	0.53	15.24	3.57	2.04	3.24	-
FE_2O_3	0.29	4.94	75.24	0.78	3.40	-
MgO	0.77	5.25	-	0.08	2.20	-
SO_3	0.79	0.48	-	0.98	1.09	32.16

The American Standard Testing and Material (ASTM) C150 defines cement as' hydraulic cement (cement which not only hardens by reacting with water but also forms a waterproof product) produced by the crusher clinker which is composed of calcium silicate hydraulics, usually containing one or more form of calcium sulfate as an inter-soil addition [11]. The European Standard EN 197-1 uses cement clinker is a hydraulic material consisting of at least two-thirds the mass of calcium silicate, (3CaO·SiO2, and 2CaO·SiO2), the rest consists of aluminum and iron-containing clinker phases and other compounds. The ratio of CaO to SiO2 cannot be less than 2.0. The content of magnesium oxide (MgO must not exceed 5.0% by mass) [12], [13]. The last two conditions have established in German Standards, issued in 1909).

Cement formed from 90% clinker, together with a limited amount of calcium sulfate (which controls the specified time), and up to 5% of the small constituents (fillers) according to various standards. Clinkers are nodules (diameter, 0.2–1.0-inch (5–25 mm) of sintered material that produced when the raw mixture of predetermined composition heated to high temperatures.

Key chemical reactions that define Portland cement from other hydrated lime occur at this high temperature (> 1300 ° C (2370 ° F)) and is when winding (Ca_2SiO_4) is combined with calcium oxide (CaO) to form alite (Ca_3SiO_5) [14].

Cement clinkers are made by heating, in a cement kiln, a mixture of raw materials to calcination temperatures above 600 ° C (1112 ° F) and then fusion temperatures, which are around 1450 ° C (2640 ° F) for modern cement, to stick material into clinker. Ingredients in the cement clinker alit, winding, tri-calcium aluminate, and tetra-calcium aluminum ferrite. Aluminum, iron, and magnesium oxide are present as fluxes which allow calcium silicate to form at lower temperatures, and contribute little to strength [15]. For special cement, such as Low Heat (LH) and Sulfate Resistant (SR) types, it is necessary to limit the amount of tricalcium aluminate ($3CaO \cdot Al_2O_3$) formed. The main raw material for making clinkers is usually limestone ($CaCO_3$) mixed with a second material containing clay as an aluminum-silicate source. Usually, impure limestone containing clay or SiO_2 used. The $CaCO_3$ content in limestone can be as low as 80%. Secondary raw materials (ingredients in raw mixes other than limestone) depend on the purity of limestone. Some materials used are clay, shale, sand, iron ore, bauxite, fly ash, and slag. When a cement kiln burned by coal, coal ash acts as secondary raw material.

In short, the process of making this cement is that all raw materials mixed; these raw materials must be dust-free. Dust that produced from this raw material will be captured by the dust catcher so that the dust does not pollute the air. The materials accommodated. After being accommodated, these materials then put into a preheater suspension. This preheater suspension serves to heat up by spraying hot air. Then the ingredients are put into a rotary kiln (a sizeable rotating oven) and burned at a temperature of ± 1400º C to produce small black granules called clinkers (semi-finished materials). The clinker then housed inside the silo clinker. From the silos clinker, then put into the cement mill. This cement mill is a place where the mixing process with gypsum occurs. After the cement mill, enter the cement silo. The final stage of the cement manufacturing process is packaging, which will then distributed to the market.

Beginning with a 1992 study, Japanese researchers incorporated in NEDO have examined the possibility of ash from burning waste and dirty water deposits as cement material. From these results, it is known that the ash from combustion waste contains the same elements as the necessary ingredients of cement in general [16]. In 2001, the first factory in the world to turn trash into cement officially operated in Chiba. The cement product is called Eko-cement. Every year, the Japanese population dumps around 37 million tons of burning rubbish. Then the waste is burned (incinerated) and produces ash (incineration ash), reaching 6 tons/year. From this ash, they then used as material for making eco-cement. This ash and dirty water deposits contain compounds in the formation of ordinary cement, namely oxide compounds such as CaO, SiO_2, Al_2O_3, and Fe_2O_3. Therefore, this incineration ash can function as a substitute for clay, which used in the formation of ordinary cement [17].

5. Conclusion

The main conclusions that could conclude from this paper are:

- We conclude that the required percentage within the specifications of the evaluation and specific control device for magnesium carbonate is smaller or equal to 3%, while the ratio obtained laboratory is 0.77% and is considered within the required standard but is considered a low percentage. Therefore, it is preferable to find a better type of stone Limestone, which contains magnesium carbonate, is more significant than 0.77% and does not exceed 3%. While the proportion of sulfate in limestone is excellent and within the required specification.
- The sulfate content in the sand is an ideal ratio, as the laboratory value was 0.98%, while the required value within the established specifications is less or equal to 1%.
- The percentage of sulfate in gypsum according to laboratory tests was 32.16%, while the required ratio within the established specifications is greater or equal to 31%. Thus, the gypsum material is considered good and acceptable in the manufacture of cement and within the specification.
- The percentage of silica in limestone that examined in the laboratory was 2.23%, while the required percentage within the established standard is smaller or equal to 5% and thus considered within the standard. However, with low rates, therefore it is preferable to find a better limestone and not exceed the proportion of silica in it 5% more.
- The sand entering the cement industry considered an acceptable and good material because it contains a percentage of silica 92 .62% that has tested in the laboratory. In contrast, the required percentage within the established specification is greater or equal to 85%, and thus the sand material is considered acceptable and valid in the manufacture Cement.
- The percentage of iron trioxide in iron dust should be the required percentage according to the established specifications is greater or equal to 55%, while the value that examined laboratory is 75.24%, which is considered a good and acceptable percentage. Thus,

iron dust is an excellent material in the manufacture Cement.

- The percentage of alumina in iron dust according to the required and approved standard is smaller or equal to 10%, while the value that was laboratory tested was 3.57%, which is within the standard but is considered a low percentage. Therefore, it is preferred that the percentage of alumina in iron dust increased so that it does not. It exceeds 10% within the required standard.
- The percentage of silica in clay according to the required standard should be in the range of (38% - 42%), while the value examined in the laboratory was 39.9%. Thus, the clay material is acceptable and valid in its use in the manufacture of cement.

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