Utilizing Mineral Industrial Waste as Additives for Improving Concrete Characteristics

By

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Abstract

Concrete is the most widely used construction material and, for the most part, is produced using non-renewable natural resources and energy intensive processes which emit greenhouse gasses. There exists an opportunity to improve the sustainability of this industry by further exploring the use of alternative materials on the contrary, the amounts of solid waste, especially industrial by-products are increasing dreadfully due to population growth and increase of economic activities. There is an increasing need to come up with innovative ideas to recycle the generated waste and to use it developing useful materials such as concrete.

This study examines the suitability of industrial wastes as a possible substitute for cement. Experiments were carried out to determine absorption water, slump, density and the compressive strengths of concrete with crushed ceramic waste red bricks, pottery, iron flings and aluminum flings, and to compare them with those of control mix concretes. Using 10% of each waste, Test results indicated that red brick (RB) wastes and Iron filings (IR) pumice concretes had good compressive strengths. Furthermore, it was found that water absorption of aluminum flings(AF) was Higher than that of control mix and Pottery (P) concretes was lower than that of control mix. Test results also showed that higher volume was obtained from aluminum flings(AF) than control mix. And using 5%,10% and15% of chromium waste from tannery industry replacement cement and aggregate in concrete mixes .Altogether, our results are very promising indication that there is a strong potential to recycle some of the industrial waste and to use them in a future industry of environment-friendly concrete.

Dedication

"Say: Allah will see your works and so will His Messenger and the believers; then you shall be returned to the Knower of the unseen and the visible and He will inform you of what you were doing." [9.105]

Praise be to Allah in the beginning and in the end

To our true source of hope, to the people who keep us going through struggles and hardships, our parents.

To our dearest friends, your encouragement and continuous support is only matched by your big hearts and pure souls.

Thank you from depths of our hearts.

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From the heart, thank you

Contents

Abstract II

Dedication III

Acknowledgment IV

Tables VII

Figures VIII

Chapter One 1

Research Proposal 1

1.1 Introduction 2

1.2 Scope of the Study 3

1.3 Goals and Objectives 4

1.4 Research Importance 5

1.5 Research Methodology 5

1.5.1 Materials........5

1.5.2 Equipment's........5

1.5.3 Experimental Procedure........5

1.6 Budget 6

1.7 Action Plan 7

Chapter Two 9

Literature Review 9

2.1 Introduction 10

2.1.1 Components of Concrete........10

2.1.2 Concrete Standards........11

2.2 Industrial Waste 12

2.2.1 Mineral Industrial Waste........13

2 .2.2 Local Industrial Wastes / byproducts........14

2.3 Solid Waste Management 16

2.3.2 Waste reduction and reuse........16

2.3.3 Recycling........16

2.3.4 Waste Collection........17

2.3.5 Treatment & Disposal........17

2.4 Concrete Previous Research 17

2.4.1 Utilizing Waste in Concrete........17

2.4.1.1 Aggregate Replacement........17

2.4.1.2 Cement Replacement........20

2.4.3 Artificial stone........27

Chapter Three 29
Experimental Work.. 29
3.1 Methodology 30
3.2 Materials and Equipment 30
3.3Procedure 31
3.4Addition of industrial waste 34
3.5Preliminary Results.. 35
Chapter Four .... .41
Recycling Chromium Waste from leather Tanning in Concrete...41
4.1Introduction …………………..…………………...........................…………............42
4.2 Experimental Methodology...43
4.3Results and Discussions……………………………………………………………………………….43
4.3.1 Utilizing Chromium Waste ($Cr(OH)_3$ in Concrete for Partial Replacement of fine aggregate.43
4.3.2Utilizing Chromium Waste ($Cr(OH)_3$ in Concrete for Partial Replacement of cement……..…50
Conclusion……………………………………………………………………………………..……..55
Recommendation………………………………………………………………………………… 56
References…………...57

Tables

Table	Name	Page
Table 1.1	The budget required for the research project.……………………………..	6
Table 1.2	Action plan for the second semester 2017/2018…..……………………….	7
Table 1.3	The budget required for the research project.……………..…………..…...	8
Table 2.1	Specification for Concrete Classes ………………………….………….	10
Table 2.2	Design details of different types of concrete sample…….…………..……	10
Table 2.3	Classification of minerals wastes …………………………………………	13
Table 2.4	Concrete using industrial waste as an aggregate replacement…………….	17
Table 2.5	Concrete using industrial waste as a cement replacement ....…………	21
Table 2.6	Use of waste/ byproduct in artificial stone production …………...……….	27
Table 3.1	Composition of concrete mixtures…………………………………………	31
Table 3.2	Compressive strength KN After 7days...	35
Table 3.3	Compressive strength KN After 28 days..	35
Table 3.4	Ruselt of Slump..	37
Table 3.5	Ruselt of Water absorption...	39
Table 3.6	Density g/cm^3 After..	41
Table 4.1	Experimental of concrete mix design for partial replacement aggregate…..	44
Table 4.2	Experimental of concrete mix design for partial replacement of cement …	50

Figures

Figure	Name	Page
Figure 2.1	The waste composition in Palestine 2011...	12
Figure 2.2	Distribution of solid waste generation in the West Bank 2010	13
Figure 2.3	Classification of ceramic wastes by type and production process…..	15
Figure 2.4	Compressive strength of copper slag mortars as a function of replacement level	22
Figure 3.1	The flow diagram of the methodology adopted for the study……….	33
Figure 3.2	Compressive strength KN after 7days................................	36
Figure 3.3	Compressive strength KN after 28 days............................	36
Figure 3.4	Slump of different samples of the concrete mixed with 10% wastes.	38
Figure 3.5	Water absorption %..	39
Figure 3.6	Density gm/ cm^3.....................	40
Figure 4.1:	Compressive strength for three samples each percentage waste after 7 days	45
Figure 4.2:	Increment ratios in compressive strength after 7days…………..……	45
Figure 4.3:	Compressive strength for three samples each percentage waste after 28 day.	46
Figure 4.4:	Increment ratios in compressive strength after 28 days…………..….	46
Figure 4.5.	Decreasing ratios in the slump……………………………….…….	47
Figure 4.6:	Slump of different ratio of chromium waste in concrete mixed……...	47
Figure 4.7:	Water absorption…………………………………………………...	48
Figure 4.8:	Decreasing ratios in Water absorption…………...……………..…….	48
Figure 4.9	Dry densities of waste concrete mixes……………….…………….….	49
Figure 4.10:	Decreasing in dry density…………………………………….…….	49
Figure 4.11:	Compressive strength for three samples each percentage waste after 7 days..	51
Figure 4.12:	Increment ratios in compressive strength after 7days. ……………....	51
Figure 4.13:	Compressive strength for three samples each percentage waste after 28 days..	52
Figure 4.14:	Increment ratios in compressive strength after 28days. ……………….………..	52
Figure 4.15:	Slump of different ratio of chromium waste in concrete mixed. …………..…	53
Figure 4.16:	Water absorption……………………………..……………………...……..	54
Figure 4.17	Dry densities of waste concrete mixes……………………………………….	54
Figure 4.18:	Decreasing in dry density. ………….……………….………………...…….	55

Chapter One

Research Proposal

1.1 Introduction

Concrete is a mixture that contains cement, sand and water with the addition of a kind of aggregate, and some additives. Concrete is one of the most important building materials of the modern era, especially reinforced with iron to become an 'reinforced concrete[1]. The Romans are the first to use concrete in history, about 2,000 years ago. It has been used in most of their buildings for it is easy to setup and to be implemented with a simply trained workforce.

Concrete is a family of different material like binding material (cement+ fly ash), fine aggregate, coarse aggregate and water. Today construction cost is very high with using conventional materials due to unavailability of natural materials. This problem can be solved by total replacement of concrete with different material which is not convenient in terms of required properties. Due to this limitation of unavailability of material which plays the vital role of concrete we have only choice of partial replacement of concrete ingredients by waste materials. Over 3.3 billion tons of cement was consumed globally in2010 [2].

Prompted by the drain of raw materials, the world has to find new alternatives materials that satisfy the need of cement which is the basic material in concrete, which be affordable with good quality and price. However, the need of concrete Add materials in concrete to improve the properties of concrete and the exploitation of industrial waste. Industrial waste disposal is an important factor affecting the safety of human life, the sustainable development of areas and the efficiency of many industries, including construction, housing and community services. One of the main ways to recycle industrial waste, in view of the hierarchy, is the production of building materials, including environmentally friendly aerated concrete products, with the characteristics of the standard [3].

Recently in many countries, industrial by-products and wastes are widely used as cement components in cement concretes. Detailed studies of using different sources of cement additives are an important part of understanding behavior of new low-cost construction materials made from industrial by- products and wastes. By the treatment of by-products and wastes, production theory and practice of building materials has been developed very rapidly all over the world[4].

Additionally, the current global waste generation levels are approximately 1.3 billion tons per year and are expected to reach 2.2 billion tons by 2050. With this rapidly generation of waste, the world needs to get rid of it in environmental friendly ways[5] .

In concrete parlance the word admixture is used to designate a material added to the concrete mixture, either before or during mixing, to modify its properties in some way. Producers use admixtures primarily to reduce the cost of concrete construction; to modify the properties of hardened concrete; to ensure the quality of concrete during mixing, transporting, placing, and curing; and to overcome certain emergencies during concrete operations [6]. The word addition applies to materials that are underground or blended with Portland cement either to aid in manufacture, to modify the way the product behaves or replacement of cement. Some materials, notably air-entraining agents, may be used either as additions or admixtures to accomplish a single purpose[7].

In modern cement and concrete technology, addition of active mineral additives (fly ash, silica fume, slag, natural pozzolan, etc.) is of great scientific significance [8].

Several works have already been carried out to verify the application of partial substation of wastes products, have investigated on utilization of lime stone waste and marble powder wastes have successfully demonstrated the application of demolished concrete, glass and plastics as partial substitutes to concrete. cement replaced with other materials as Mr.R. Balamurugan observed that on partial substitution of 20% of cement with hypo sludge in concrete, the compressive strength was 21.11MPa [9].

Project has strongly focused on the utilize of the materials content of mineral wastes with little effort spent on their value as construction and industrial minerals. If industrial applications could be found for mineral waste it would improve the profitability of using in the manufacture of concrete and reduce the costs of waste treatment and disposal and improve the efficiency of resource utilization.

The aim of this project is to utilize local wastes/byproducts materials, such as Alum, Clay and ceramic, and others to enhance concrete quality and reduce the effects of those wastes.

1.2 Scope of the Study

The main elements of the mixture that will be used in this study are ceramic, pottery, red brick، Iron filings, aluminum flings and cement. Other materials and industrial wastes will be used for the next semester. An assessment of the effectiveness of a solidification process can be made only by testing the quality of the material used and produced. In this study, the collected industrial waste sample is to be mixed with the binding material (i.e. cement) and aggregates to obtain the new product (i.e. concrete). The properties evaluated for the solidified concrete are compressive strength, slump, water adsorption and the density.

The quality of the mixtures differs according to the proportions of the additives. For better understanding, a large number of samples are need to be analyzed from industrial wastes.

The industrial wastes are to be collected in untreated and partially degraded condition, which was later grinded and sieved before mixing into the concrete.

Problem Statement

This project answers the following question:

Is it technically feasible to improve the quality of concrete (Type B-250) by using alternatives and additives from industries waste?

The following sub-problems will be answered:

1.What is the effect of addition (minerals industrial waste) on concrete in terms of compressive strength, water absorption and other required characteristics?
2.What are the potentials of adding (waste) on the compressive strength, water absorption and slump?
3. How does industrial waste behaves inside concrete mixtures?

1.3 Goals and Objectives

Main goal:

The main goal of this project is to exploit byproducts/waste of local industries to produce and improving concrete characteristics.

Specific Objectives:

1. To source and identify potential waste from factories.
2. To make concrete samples by using various additives from industries waste.
3. To assess the characteristics of the industrial solid waste collected from the industry's.
4. To conduct tests to the addition of a suitable waste, partially replacing the cement in the mix.
5. To assess the compressive strength, slump, density and water absorption of the concrete mixed with different ratios of mineral industrial waste

1.4 Research Importance

Improving and expanding the industrial sector in Palestine and having a constant need of controlling its environmental effects have increased the interest in industrial waste management. Subsequently, this project addresses the need of controlling industrial wastes disposal, for it is based on the concept of employing wastes as a resource in concrete production process

1.5 Research Methodology

This research is based on the scientific experimental approach, which is mainly about using compressive strength, water absorption ratio and other variables as tools to examine the effectiveness of using industrial waste in producing concrete.

Materials and equipment used, as well as experimental procedure will be illustrated in the following subsections.

1.5.1 Materials

The following materials are used in this project:

1. Portland cement Type I
2. The by-products/wastes materials:
   (ceramic, iron filings, aluminum flings, pottery, red brick and tannery sludge)
3. Aggregates: two types of coarse aggregate (medium and fine).
4. Concrete admixtures
5. Rotem sand.
6. Tap water.

1.5.2 Equipment's

The following apparatus and equipment's are used in this project:

2. Oven to dry samples and materials.
3. Molds to pour the mixture in certain dimensions(10cm×10cm×10cm).
4. Concrete compression machine. (Matest, Italy).
5. Slump test equipment's.

1.5.3 Experimental Procedure

In order to achieve the objective of the project, the following steps will be followed:

1. Prepare the wastes/ by-products to reuse in the mixtures.
    a) Grind the ceramic, iron filings, aluminum flings, pottery, red brick from waste into fine powder.
    b) Collect powder wastes and Pour the powder on the right sieve for each type .

2. Test all the material to confirm that they conform to ASTM specifications.
3. Perform samples with different ratios of wastes/ by-products with different properties.
4. Test slump, compressive strength, water absorption for the performed samples.
5. Data analysis and presentations in charts and tables.

1.6 Budget

The required budget is estimated at 2500 NIS as illustrated in Table 1.1 below.

Table 1.1 The budget required for the research project

No.	Item	Description	Amount	Cost (NIS)
1	Transportation	Sampling	-	160
2	Row material	Cement – sand-aggregate		500
3	Compressive strength tests	Each test costs 30 NIS	30	900
4	Water absorption tests	Each test costs 70	6	420
5	Miscellaneous	Bottles, vessels …etc	-	100
	Total			2500

1.7 Action Plan

This research project will be implementing in two stages. The action plans for the two stages are illustrated in Table 1.2 and in Table 1.3 below.

Table 1.2: Action plan for the second semester 2017/2018.

Month / Task	January				February				March				April			
	Wk_1	Wk_2	Wk_3	Wk_4	Wk_1	Wk_2	Wk_3	Wk_4	Wk_1	Wk_2	Wk_3	Wk_4	Wk_1	Wk_2	Wk_3	Wk_4
Identifying project idea																
Stating research																
Literature Review																
Preparing research proposal																
Selecting concrete formulas																
Sourcing and Preparing raw material																
Performing preliminary experiments																
Preliminary experiments results analysis																
Documentation																

Table 1.3: Action plan for the first semester 2018/2019.

Month / Task	September				October				November				December			
	Wk_1	Wk_2	Wk_3	Wk_4	Wk_1	Wk_2	Wk_3	Wk_4	Wk_1	Wk_2	Wk_3	Wk_4	Wk_1	Wk_2	Wk_3	Wk_4
Investigate the effect of adding waste on the formula.																
Investigate the effect of utilizing different wastes on the formula.																
Testing different characteristics for concrete																
Data analysis and preparation of chart results and tables																
Documentation																

Chapter Two

Literature Review

2.1 Introduction

2.1.1 Components of Concrete

The basic component in concrete is calcium silicate cement prepared by having a combination of calcium, silicon, aluminum, and iron. Cement manufacturing process should be carefully observed and controlled to result in having cement that meet particular chemical and physical specifications [10].

The Palestinian market consumes around 2.2 million tons of Cement each year,1.5 million of which in the West Bank and the other 0.7 million in the Gaza Strip. It is predicted that by the year 2018 the demand for Cement in the Palestinian market would reach 2.7 million tons. Furthermore, it is predicted that this demand would approximate 3.77 million tons by the year 2028. This means that the annual demand growth rate will be around 3% [11] .

Aggregates are inert granular materials such as sand, gravel, or crushed stone that, along with water and Portland cement, are an essential ingredient in concrete. For a good concrete mix, aggregates need to be clean, hard, strong particles free of absorbed chemicals or coatings of clay and other fine materials that could cause the deterioration of concrete. Aggregates, which account for 60 to 75 percent of the total volume of concrete, are divided into two distinct categories-fine and coarse [10].

Sand is an essential ingredient in concrete mixes. Sand obtained people get from natural gravel deposits or crushed rocks can be used as a fine aggregate in concrete production. It is used with coarse aggregates to manufacture structural concrete. Moreover, it may be used alone with cement for making mortars and plastering works. It is not costly because it can be found close to several construction works [12]

Despite the fact that water and cement are mixed together as to form a paste and enable hydration, strange substances in the water that could cause retardation or change the chemical reaction may damage or ruin the concrete [13].

A large number of chemical admixtures are provided in ready-to-use liquid form. They are added to the mix directly during the mixing process or before it. Producers use admixtures mainly to lower the cost of the concrete construction process; to change the features of hardened concrete; to guarantee the quality of concrete during mixing, transporting, placing, and curing; and to deal with some emergencies that may take place during concrete operations. Admixtures are categorized in terms of their function. There are five different categories of chemical admixtures: air-entraining, water-reducing, retarding, accelerating, and plasticizers [10].

2.1.2 Concrete Standards

Concrete standards are of considerable significance when it comes to assessing and testing concrete. Concrete may possess carious features based on the mixture used in creating it. These components are mixed with water to produce concrete that can be used as an essential construction material in buildings. These cement and concrete standards enable laboratories around the world to assess and examine concrete mixtures to guarantee their strength and safety. These standards contribute in identifying the distinct specifications of concrete such as strength, elasticity, hardness, and workability. Concrete standards are instrumental in the evaluation and testing of concrete.

Table 2.1: Specification for Concrete Classes[14].

	Compressive strength	**Slump mm**	**Water absorption (%)**	**Maximum free w/c ration**
B200	200 kg/ cm^2	25 -75	2-5%	0.70%
B250	250 kg/ cm^2	25-100	2- 5%	0.65%
B300	300 kg/ cm^2	75- 25	2 -5%	0.60%

Some mixtures are designed as follows and refers the concrete type to a kilogram cement in one cubic meter of concrete.

Table 2.2: Design details of different types of concrete samples [15].

	w/c ratio	Water kg	Coarse sand kg	Fine sand kg	Cement kg	Gravel kg	Superplasticizer admixture %
B300	0.6	180	797	212	300	900	-
B350	0.43	150	818	214	350	880	4
B400	0.5	200	734	200	400	780	-

2.2 Industrial Waste

Palestine faces the problem of solid waste that Palestine has arouse because of several factors, for example, population growth, lack of material resources significant when it comes to tackling this problem and minimizing the risks, as well as very limited technical expertise for solid waste management in addition suffering for years and years from the Israeli occupation. All of these factors contribute in having faint possibility of addressing this problem. Consequently, solid waste is gathered in random ways and collected in dumps that don't meet environmental health conditions [16].

These dramatically increasing amounts of solid waste are provoking a serious alarm that must be noticed and taken into consideration.

In Palestine, environmental problems related to industrial solid waste (ISW) have increased remarkably in the past few years. Quantity of Industrial waste 131,344 tons/year ((2011) [17]. Figure 2.1 shows status of solid waste generation from different sources in Palestine.

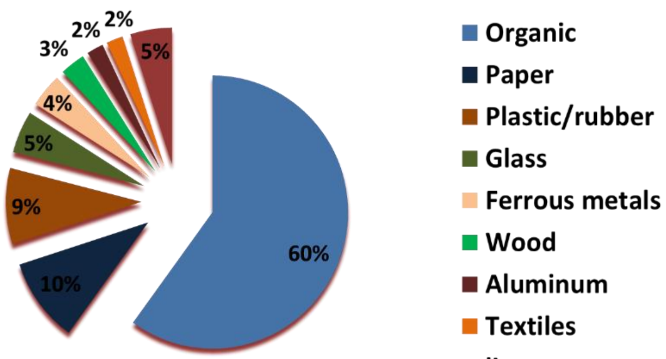

Figure 2.1: the waste composition in Palestine 2011[17].

Hebron District is known for its industrial activities. Quarrying, leather and metallic industries are the most prominent industries in Hebron. Leather industries including leather tanning, shoe factories form around 40% of Hebron's industries while stone cutting factories and quarries are almost 15%, and metallic industries constitute approximately 14% of it [18].

It is clear from the Figure 2.2 shows that Hebron occupies the first place in the production of waste in Palestine due to the diversity of its industries and the large population.

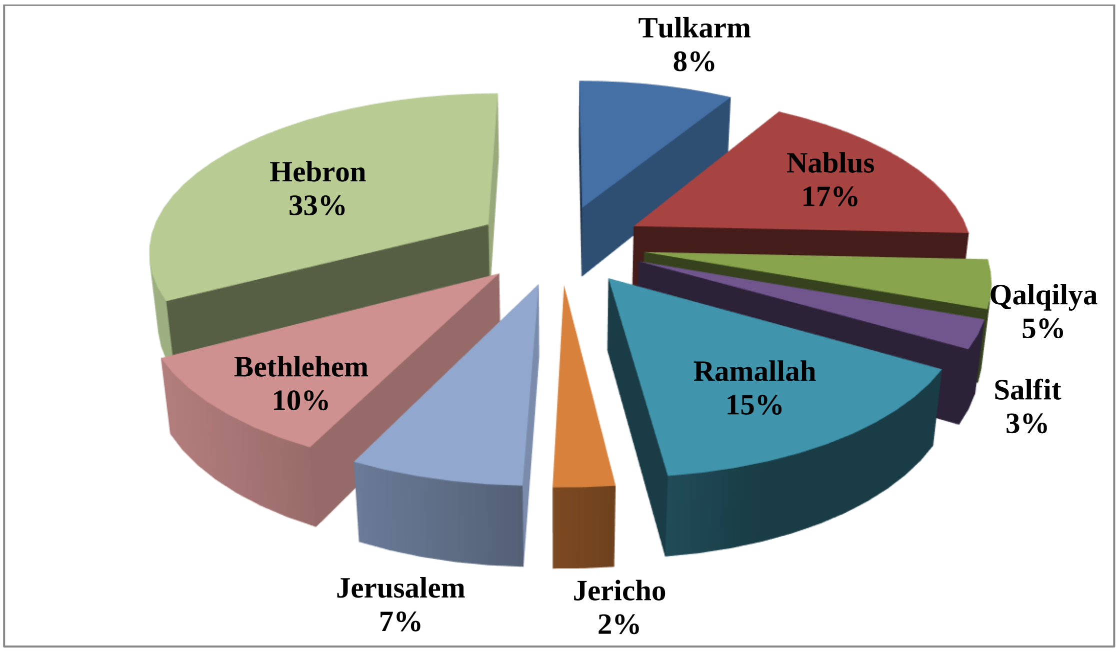

Figure 2.2: Distribution of solid waste generation in the West Bank 2010[19].

2.2.1 Mineral Industrial Waste

Mineral waste can be defined as the 'residues, tailings or other non-valuable material produced after the extraction and processing of material to form mineral products' [20]. Despite the fact that mining and metallurgy are ancient arts, the Industrial Revolution started rapid international demand for minerals which caused waste generation and disposal to be one of the most severe environmental and social challenges of today's industries. Mineral solid waste production alone is tremendously massive. There is no internationally known or adopted classification of mineral wastes. A classification scheme has to consider the economically significant features of the waste, particularly its potential end use and the degree of processing needed [20]. A simple scheme proposed by Harrison et al is shown in Table 2.3, with four descriptive categories.

Table 2.3: Classification of minerals wastes [20].

Group	Description	Example	Potential end uses
Type 1	Unprocessed wastes	quarry scalping's quarry blocks colliery spoil	fill, low grade road stone, armour stone, brick clay
Type 2	Processed wastes – reclaimed mineral	silica sand wastes limestone wastes building stone wastes	silica sand, kaolin, brick clay, mineral filler, a lime, aggregate
Type 3	Processed wastes – added-value products	lead/ zinc wastes pegmatite wastes	fluorite, barite feldspar, rare earths, mica heavy minerals
Type 4	Beneficiated wastes	certain mine wastes	gemstones, high value metals

2 .2.2 Local Industrial Wastes / byproducts

Tannery Sludge (chromium hydroxide $Cr(OH)_3$):

Tannery industries cause serious environmental problems particularly in the respect of polluting organic effluent and hazardous solid waste, which result from leather processing. It is significant that tannery waste that come in the shape of sludge get dealt with in an environmentally appropriate way [21].

Tannery is one of the most prominent industries in Hebron. The tanning process demand a very large amount of chromium and a considerable fraction of this chromium is discharged in addition to the effluent from the industry. The sludge of the tannery can be highly polluting particularly heavy metals [22]. Chromium from wastewater in leather processing is precipitated in an alkaline median (CaO) to produce solid chromium hydroxide $Cr(OH)_3$. Also, can be treated with solid waste powder from stone cutting industry by the adsorption of chromium from wastewater. This process is highly effective; its efficiency can reaches 99% [23]. However, the problem of chromium produced while stone cutting is still unsolved, but it is can't be thrown away as wet solid waste.

Ceramic Wastes

It is a well-known fact that the ceramic industry and processing produces much calcined-clay wastes every year. Such wastes result in having soil, air, and groundwater pollution. Ceramic wastes can be classified in two classes in terms of the source of raw materials. The first category is every fired waste produced by structural ceramic factories that use only red pastes in making their products, like brick, blocks, and roof tiles. The second category is fired waste generated in stoneware ceramic like wall, floor tiles and sanitary ware [24].The ceramics industry includes the following subsectors: wall and floor tiles, sanitary ware, bricks and roof tiles, refractory materials, technical ceramics and ceramic materials for domestic and decoration purposes.

In each category the fired ceramic waste was classified according to the production process. This classification is reported in the following diagram (Figure 2.3)

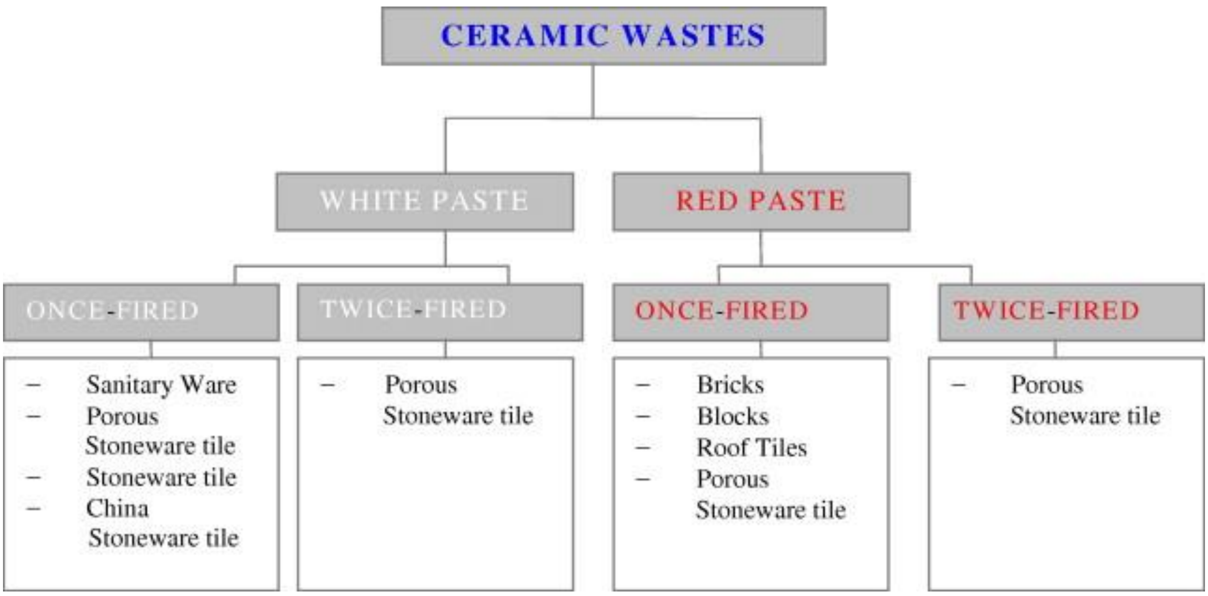

Figure 2.3 :Classification of ceramic wastes by type and production process[25]

Iron Filings:

One of the major environmental issues is the large quantity of waste iron resulting from the industrial sector which is deposited in domestic waste and in landfills. Metals waste materials create serious environmental problems, mainly owing to the inconsistency of the wastes streams. Iron filings are very small pieces of iron that look like a light powder Steel slag, the by-product of steel and iron producing processes [26].

2.3 Solid Waste Management

The primary goal of solid waste management is reducing and eliminating adverse impacts of waste materials on human health and environment to support economic development and superior quality of life. Management of solid waste reduces or eliminates adverse impacts on the environment and human health and supports economic development and improved quality of life. A few processes are involved in effectively managing waste for a municipality. These include monitoring, collection, transport, processing, recycling and disposal.

2.3.2 Waste reduction and reuse

Waste reduction and reuse Waste reduction and reuse of products are both methods of waste prevention. They eliminate the production of waste at the source of usual generation and reduce the demands for large scale treatment and disposal facilities. Methods of waste reduction include manufacturing products with less packaging, encouraging customers to bring their own reusable bags for packaging, encouraging the public to choose reusable products such as cloth napkins and reusable plastic and glass containers, backyard composting and sharing and donating any unwanted items rather than discarding them. [27].

2.3.3 Recycling

Recycling refers to the removal of items from the waste stream to be used as raw materials in the manufacture of new products. Thus, from this definition recycling occurs in three phases: first the waste is sorted, and recyclables collected, the recyclables are used to create raw materials. These raw materials are then used in the production of new products. The sorting of recyclables may be done at the source (i.e. within the household or office) for selective collection by the municipality or to be dropped off by the waste producer at a recycling centers. The pre-sorting at the source requires public participation which may not be forth coming if there are no benefits to be derived. Also, a system of selective collection by the government can be costly. It would require more frequent circulation of trucks within a neighborhood or the importation of more vehicles to facilitate the collection. Another option is to mix the recyclables with the general waste stream for collection and then sorting and recovery of the recyclable materials can be performed by the municipality at a suitable site. [27] .

2.3.4 Waste Collection

Waste Collection Waste from our homes is generally collected by our local authorities through regular waste collection, or by special collections for recycling. Within hot climates such as that of the Caribbean the waste should be collected at least twice a week to control fly breeding, and the harboring of other pests in the community. Other factors to consider when deciding on frequency of collection are the odors caused by decomposition and the accumulated quantities. Descriptions of the main types of collection systems are given in the table below [27].

2.3.5 Treatment & Disposal

Waste treatment techniques seek to transform the waste into a form that is more manageable, reduce the volume or reduce the toxicity of the waste thus making the waste easier to dispose of. Treatment methods are selected based on the composition, quantity, and form of the waste material. Some waste treatment methods being used today include subjecting the waste to extremely high temperatures, dumping on land or land filling and use of biological processes to treat the waste [27].

2.4 Concrete Previous Research

2.4.1 Utilizing Waste in Concrete

2.4.1.1 Aggregate Replacement

Building industry, particularly manufacturing construction materials' process, is a main consumer of the world's resources as well as energy production are considered to be the most significant sources of producing CO2. Concrete is a component which is the second most consumed material in the world, while water is the most used substance in larger amounts. Obviously, around one ton of concrete is utilized by each person in the world annually. When ecological and continual aspects are considered, concrete industry is seen these days as the largest consumer of natural resources and important source of waste. Employing industrial waste materials in concrete reduces the burden of natural resources shortage, overcomes the problem of waste disposal and helps in having alternative method to protect the nature. A lot of industrial wastes are fully or partially used as replacement of coarse aggregate or fine aggregate.

Zainab Z. Ismail studied reusing iron filings in concrete production. Iron filings were partially reused instead of sand. The results of the study indicated that the compressive and flexural strengths of the concrete mixes prepared from iron filings is way higher than plain concrete mixes [26].

In addition, Zainab Z. Ismail analyzed the mechanical properties of concrete made of plastic waste instead of using aggregate. The results proved the existence of a lot of tiny cracks caused due to adding plastic waste in fabiform to concrete mixes which resulted in reducing mechanical features like compressive strength, flexural strength and density[28].

Rafat Siddique conducted a research about the effect of replacing fine aggregate with Class F fly ash on the concrete's mechanical specifications. Tests were carried out to explore characteristics of fresh concrete compressive strength, splitting tensile strength, flexural strength, and modulus of elasticity and stretchiness. The mechanical properties of concrete samples in which ash fly was used were higher than the plain concrete samples. Results of this research indicate that Class F fly ash may be so easily employed in structural concrete [29].

Table 2.4: Concrete and mechanical properties of concrete using industrial waste as an aggregate replacement.

Ref. No.	Year	Waste material	% Replacement	W/C	Fresh density Kg/m^3	Tests	Results
[30]	2011	Copper slag	50%	0.35	2430	Slump in mm/CF	130
						Compressive Strength	47MPa
						Split Tensile Strength	4.126MPa
						Flexural strength*	7.3MPa
[30]	2014	Steel slag	40%	0.55	2410	Slump in mm/CF	13
						Compressive Strength	28.3MPa
						Split Tensile Strength	2.4726MPa

						Flexural strength	6.8MPa
[30]	2014	Waste foundry sand	10%	0.44	2383	Slump in mm/CF	113
						Compressive Strength	33.24MPa
						Split Tensile Strength	2.6126MPa
						Flexural strength*	3.99MPa
[30]	2014	Bottom Ash	10%	0.477	2281	Slump in mm/CF	80 mm
						Compressive Strength	38.81MPa
						Split Tensile Strength	3.2826MPa
						Flexural strength	3.7MPa
[30]	2015	Palm oil clinker	10%	-	-	Slump in mm/CF	-
						Compressive Strength	35.27MPa
						Split Tensile Strength	-
						Flexural strength*	8.22MPa
[30]	2011	Ferrochrome slag	80	0.5	-	Slump in mm/CF	48–60MPa
						Compressive Strength	30.1MPa
						Split Tensile Strength	-

						Flexural strength	-
[31]	2016	E-Plastic (Electronic waste)	10%	0.5	-	Slump in mm/CF	114
						Compressive Strength	44.07 N/mm^2
						Split Tensile Strength	4.8MPa
						Flexural strength*	4.4MPa
[32]	1996	Rubber	25%	0.5	-	Slump in mm/CF	-
						Compressive Strength	19.6MPa
						Split Tensile Strength	-
						Flexural strength	3-5MPa
[33]	2009	Glasses	20%	0.53	2382.9	Slump in mm/CF	50
						Compressive Strength	45.9MPa
						Split Tensile Strength	-
						Flexural strength*	6.55MPa
[34]	2007	Crushed concrete	10%	0.56	2296	Slump in mm/CF625+ 3. 01	52
						Compressive Strength	31MPa

2.4.1.2 Cement Replacement

Among the greenhouse gases, CO_2 contributes about 65% of global warming. The global cement industry contributes about 7% of greenhouse gas emission to the earth's atmosphere. In order to address environmental effects associated with cement manufacturing, there is a need to develop alternative binders to make concrete. Consequently, extensive research is ongoing into the use of cement replacements, using many waste materials and industrial by products.

Yakubu Abba Mahmood used the sawdust in Concrete mixes have been proportioned to have various percentages of cement replacement with sawdust ash (SDA) ranging from 0% to 30% by mass. Performance of the ash–Portland cement mixture has been evaluated with respect to setting time, workability and compressive strength. From the results obtained, 10% replacement of cement with SDA shows good performance giving the desired workability and strength[35].

Zhuet al. studied the usage of limestone and chalk powder as fillers in self-compacting concrete. The results show that both materials can be used in the mixture with modest adjustment of super plasticizers dosage. Generally higher adjustment in the case of chalk powder, the adjustment affected proportionally with the grid size. The compressive strength was 30-40% grater then the conventional self-compacting concert[36].

Dr. G.Vijayakumar studied finely powdered waste glasses are used as a partial replacement of cement in concrete and compared it with conventional concrete. This work examines the possibility of using Glass powder as a partial replacement of cement for new concrete. Glass powder was partially replaced. Glass powder concrete increases the compressive, tensile and flexural strength effectively, when compared with conventional concrete. from the results obtained, it is found that glass powder can be used as cement replacement material up to particle size less than 75µm to prevent alkali silica reaction[37].

One of the greatest potential applications for reusing copper slag is in cement and concrete production. Many researchers have investigated the use of copper slag in the production of cement, mortar and concrete as raw materials for clinker, CaijunShi cement replacement of copper slag, when it is used as a cement replacement the cement, mortar and concrete containing different forms of copper slag have good performance in comparison with ordinary Portland cement having normal and even higher strength[38].

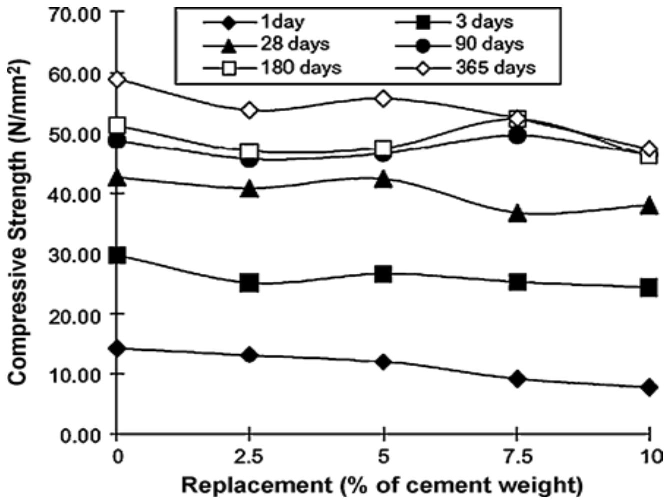

Figure 2.4: Compressive strength of copper slag mortars as a function of replacement level[38].

Agricultural waste material, in this case, coconut shells, which is an environmental pollutant, are collected and burnt in the open air (uncontrolled combustion) for three hours to produce coconut shell ash (CSA), which in turn was used as pozzolana in partial replacement of cement in concrete production. Concrete cubes were produced using various replacement levels of 0, 10, 15, 20, 25 and 30.The results from Utsev, J. T is showed that the densities of concrete cubes for 10 -15% replacement was above 2400Kg/m3 and the compressive strength increased from 12.45N/mm2 at 7days to 31.78N/mm2 at 28 days, Thus, 10 -15% replacement of cement is recommended for both heavy weight and light weight concrete production [39].

Cheah produced a concrete mixture, some of the cement in the mixture was replaced by wood waste ash. The results were affected by many factors such as combustion temperature of wood biomass and the chemical composition of wood, generally at height level of replacement, the mechanical strength of concrete was reduced but at low level of replacement the strength enhanced. The results recommend that 10% replacement to get acceptable strength properties[40].

Table 2.5: Recycling of waste in production of various types of concrete

Admixture	Ref	Year	Source waste	Uses	Additives	Tests	Result	advantages
Gypsum 5%	[41]	1998	gypsum clinker	Construction	*N/A	Compressive strength	740.6 (kg/cm^2)	reduced solubility of alumina and the retardation of the hydration of tricalcium aluminate
Alum %10	[42]	1995	alumina-silicate material' this compound is used by the ceramics industry	Construction works	A superplasticizer of sulphurated, naphthalene formaldehyde	Compressive strength, splitting tensile Slump Density Total scaling	CS=39.9MPa ST=2.7MPa S=170mm D=2345 Kg/m^3 TS= 0.9 Kg/m^3	have excellent potential as a supplementary cementing material for producing high-performance concrete.
Diatomite (30%)	[43]	2012	naturally occurring, soft, siliceous sedimentary rock	agricultural structures	*N/A	Compressive strength, water absorption Density Heat Conductivity	CS=9.18MPa WA=8.58 % D=1880(Kg/m3) HC=1.14kcal/mºC	noise and heat insulation, heat balance, fire-resistance and esthetic purposes

Diatomite (5%)	[45]	2007	naturally occurring, soft, siliceous sedimentary rock	cement mortar	*N/A	Compressive strength Flexural strength water absorption Dry unit weight	CS= 46.02MPa FS= 6.62MPa WA =% 8.67 2208=(Kg/m3)UW	such as higher water demand, but compressive strength higher Portland cement
Ground Granulated Blast Slag 50%	[46]	2015	by product from the blast furnaces used to make iron.	highway structures (particularly bridge parapets)	*N/A	Compressive strength	CS=55(N/mm)	reduce heat of hydration and control early-age cracking
Dolomite powder	[41, 42]	2010	used was obtained from an industrial rock crushing plant	*N/A	polycarboxylate based superplasticizer	Slump test. compressive strength Density	SF =550mm CS= 34MPa D=2420(Kg/m^3)	lower the cost of SCC
Fly ash	[48]	2010	by-product of the combustion of coal	*N/A	polycarboxylate based superplasticizer	Slump test compressive strength Density	SF =645mm CS=38MPa D=2320(Kg/m^3)	lower the cost of SCC

Fly ash and dolomite powder 75%FA + 25%DP	[48]	2010	As mentioned earlier	*N/A	polycarboxylate based superplasticizer	Compressive Strength Slump test Density	CS=36MPa SF=635mm D=2340(Kg/m^3)	It is possible to manufacture self-compacting concrete using fly ash and dolomite powder with acceptable fresh and hardened properties
Silica fume	[49]	2000	by-product of the silicon and ferrosilicon	In marine structures, mortar And hardened concrete	Superplasticizer	Compressive Strength 1.mortar 2.hrdened concrete	CS_1=87MPa CS_2=68MPa	prove the properties of the high strength concrete more than when these materials would be used separately
Silica fume & Pozzolan	[49]	2000	Natural or by-products such as fly ashes from coal-fired	In marine structures	Super plasticizer	compressive strength 1.mortar 2.hrdened concrete	CS_1=110MPa CS_2=82MPa	*N/A
Clay 20%	[50]	2010	fired ceramic	*N/A	nothing	water absorption compressive strength	WA=14% CS=30MPa	minor strength loss possess increase durability performance.

Oxidized chromite ore 5%	[51]	2011	Chromite Industry	*N/A	*N/A	compressive strength Leaching Tests Slump	CS= 29.5MPa LT= <0.01% S=140 mm	gave compressive strength performance similar to that of the reference mixture
Red mud 5%	[51]	2011	by-product of the Bayer process, which is used for the production of alumina from bauxite.	*N/A	*N/A	compressive strength Slump	CS= 30.2MPa S=10.5mm	the percentages of waste materials in concrete mixtures do not affect the workability of concrete.

*N/A= No Data Available

2.4.3 Artificial stone

Many researchers have studied the utilization of some waste/byproducts in order to enhance the characteristics of the produced artificial stone. The main findings of these studies are presented below in table 2.4

Barani et al[52]. Used the waste stone sludge from the granite and marble stone processing factories to produce artificial stones using vibratory compaction. The compressive strength has resulted more than 90MPa with a density less than 2.68 and water absorption less than 0.64.

Yu Lee et al[53]. Manufactured artificial construction slabs from waste glass powder and fine aggregates, with a compressive strength of 148.4MPa and water absorption less than, 02%. Wangrakdiskul studied the use of by-product of crushing limestone plant for producing non-fired wall tiles. The additive has an effect on the bending strength and water absorption, the bending strength was 2.32MPa and water absorption is 3.20%[54].

Table 2.3: Use of waste/ byproduct in artificial stone production.

Ref. No.	Year	Uses	waste / by-products materials	Additives	Tests	Results	Method of preparation
[55]	2003	Artificial stone	Limestone dust	Portland cement	Compressive strength modulus of elasticity	Compressive strength greater than 7MPa	N/A*
[52]	2015	Lightweight artificial	Waste granite and marble stone sludge	Unsaturated polymer resin (orthoptic resin)	Compressive strength, flexural strength, water absorption and tensile strength	Water absorption of less than 0.64, a density less than 2.68, a flexure strength of more than 45MPa, a	Vibratory compaction

						compressive strength of more than 90MPa, and a tensile strength more than 35MPa	
[53]	2008	Artificial stone slab	Waste glass powder and fine granite aggregates	Unsaturated polymer resins	Compressive strength, water absorption, flexural strength	Compressive strength of 148.8MPa, water absorption below 0.02% and flexural strength of 51.1MPa	Vibratory compaction

Chapter Three

Experimental Work

3.1 Methodology

All materials and tests used in this study comply with ASTM standers. A control samples with (10 x 10 x 10) cm dimensions were prepared, each mixture consisted of 732 kg/m^3 sand, 768 kg/m^3 medium aggregate ,329 kg/m^3 fine aggregate, 306 kg/m^3 cement and a W/C (water/cement) ratio of 0.63. These mixtures were cured up to 7and 28 days. Samples with the same dimensions were prepared with same ratios of industrial waste (ceramic, Iron filings , aluminum flings , pottery , red brick).The effect of the replacement of cement by industrial wastes (ceramic, Iron filings, aluminim flings , pottery ,red brick) investigated in this project. The selected mass of industrial wastes in concrete mix were used10% from cement. Test mixtures were prepared and compacted as required by ASTM. The required amounts of medium aggregate, fine aggregate, cement, water, waste materials were weighed. The materials were mixed in accordance with ASTM. The slump of the fresh concrete was determined to ensure that it would be within the value

3.2 Materials and Equipment

- **Materials**

Material used in this project include the followings:

- the cement used in this study was commercial is Composite Portland limestone cement CEM II/A-L 42.5 N, satisfying the requirements of the standard ASTM
- rotem sand passing sieve 100 Parts of the sand were examined and found to possess an especially high level of cleanliness, which is applicable for concret mix
- two sizes of angular aggregates (medium and fine gravel)is gravel breakstone and crushed
- tap water
- industrial waste (ceramic Iron filings aluminim flings pottery red brick) from factory .
- chromium waste from tannery industry.

- **Equipment**

The following apparatus and equipments are used in this project:

Trowel, Iron molds to pour the mixture in certain dimensions (10x10x10) cm, concrete mixing tub, tamping rod, slump cone, slump plate, ruler, concrete scoop, concrete compression machine, oventio dry samples and materials, weight machine and curing tank for concrete specimens

3.3Procedure

In order to achieve the objective of the project, the following steps were followed:

1. Prepare the waste/ byproducts for testing.

- ✓ The ceramic,pottery and red brick waste grinded into fine powder, The powdered sample was then passed through 12 ASTM (1.7 mm).sieve to achieve uniformly graded sample of the powdered waste.
- ✓ Collect Iron filings and the waste sample was then passed through No 40 ASTM (425 microns)sieve to achieve uniformly graded sample of the powdered waste.
- ✓ Collect aluminim flings and the waste sample was then passed through No16 ASTM (1.18 mm)sieve to achieve uniformly graded sample of the powdered waste
- ✓ Collect chromium waste from tannery industry was then passed through No 40 ASTM (425 microns).
- ✓ The mix proportion selected for the study was 1:2:4 (cement: sand: coarse aggregate fine and meduim) in weight basis.
- ✓ The materials were mixed . After mixing, the initial and final setting times for the fresh concrete were determined . To determine the compressive strength and leaching tests for each mixture, three 100 × 100 × 100 mm^3 prisms were cast and tested. The samples were demolded after 24 h after casting and cured in water

2. Test all the other materials (cement, aggregate and sand) to make sure they conform to ASTM specifications.
3. To perform samples with same ratios of wastes/ by-products, cement was mixed with sand, aggregate (medium, fines) and tap water for 10 min manually using a trowel.
4. Test slump, compressive strength, water absorption for the performed samples as detailed below:

- ✓ Slump test was done for the fresh concrete using a standard slump cone, slump plate, tamping rod and a ruler. The slump cone was placed on the slump plate. The cone was filled with fresh concrete in three equal layers. Each layer was tamped for 25 strokes using the tamping rod. The surface was leveled with a trowel. The cone was raised slowly and the slump then was measured with the ruler as the different between the height of the cone and that of specimen.
- ✓ The compressive strength test was performed on the samples at 7 and 28 days, using the compressive strength machine and the results were reported.

- ✓ The water absorption test was carried out after 28 days according to standard tests as follows:

1. The samples were weighted, the mass was recorded as W_1.
2. The samples were immersed in distilled water for 48 hours.
3. Using a clean and dry towel, the surface of the sample was tumble dry, the samples was weighed and the mass was recorded as W_2.

Then the percentage water absorption was obtained from the following equation:

$$\text{Percentage water absorption}(100\%) = {(w_2 - w_1)}/{w_1} \times 100\% \qquad (3.1)$$

5. Data analysis and ranking in charts and tables.

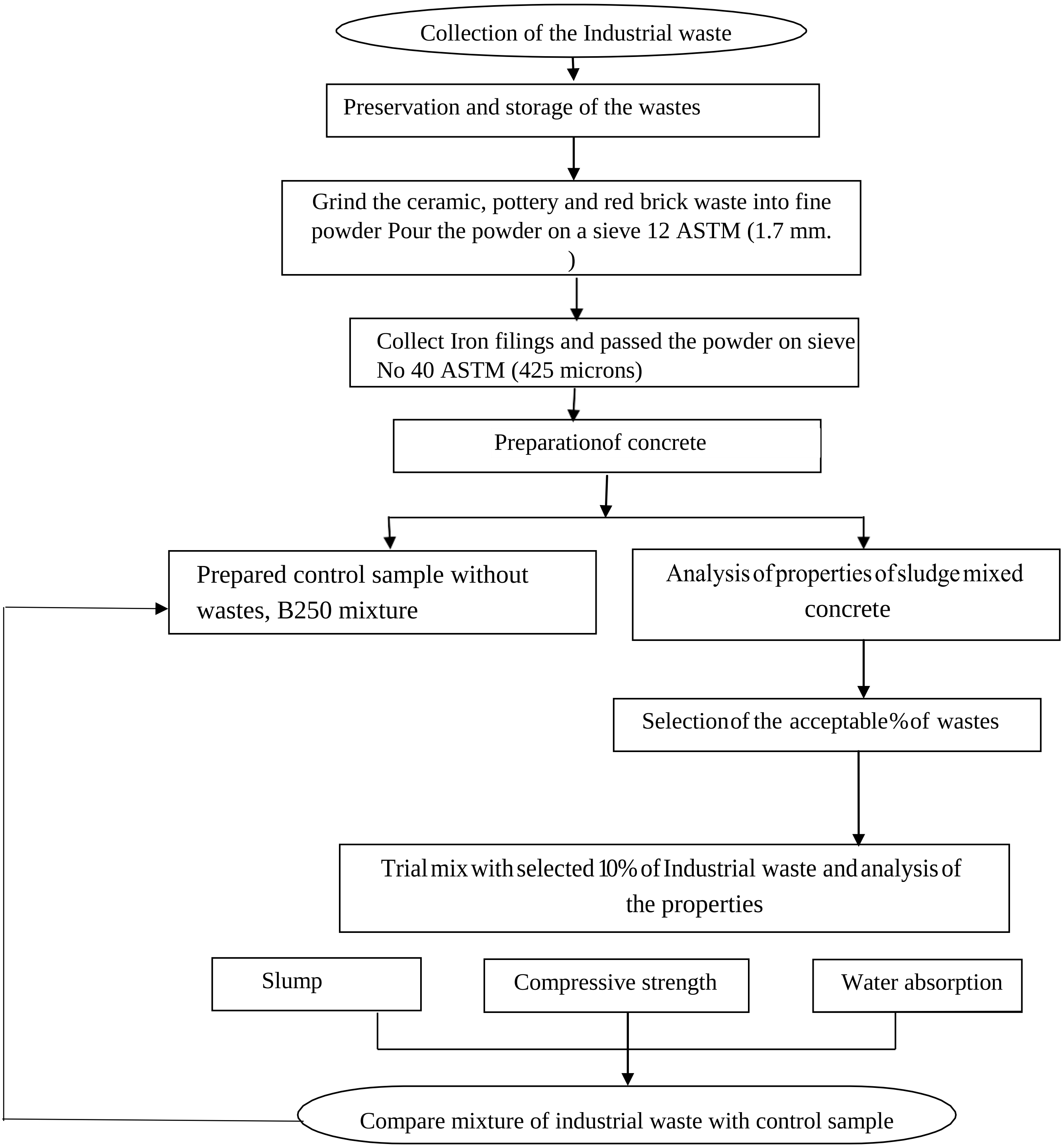

Figure 3.1: The flow diagram of the methodology adopted for the study

3.4 Addition of industrial waste

- **Reference Concrete Mixtures**

The ingredients were mixed according to the mixture which was designed in the building materials laboratory and was designed according to Palestine Standards Institution (PSI),This represents the mixture B250.Each mixture consisted of 732 kg/m3 sand, 768 kg/m3 aggregates medium,fine aggregates 329 kg/m3 cement, water 190 ml and a W/C (water/cement) ratio of 0.62. These mixtures were cured up to 7and 28.

- **Waste Concrete Mixture**

Five waste were selected to investigate the effects of (ceramic (C), Iron filings (IF), aluminim flings (AF) , pottery (P) and red brick (RB) on the properties of concrete. These mixtures are presented in Table 3.1 For all the mixtures, the coarse and fine aggregates were weighed in a dry room condition

Table 3.1: Composition of concrete mixtures

		Materials						
Symbol	**Cement mixes**	**Cement (kg)**	**Fine aggregate (kg)**	**Medium aggregate (kg)**	**Sand (kg)**	**Water tap (mL)**	**Waste (kg)**	**W/C**
(RC)	Reference mix	6.12	6.58	15.36	14.64	3.8	-	0.62
(P)	10%P + 90%RC	7.65	8.225	19.2	18.3	4.75	0.765	0.62
(RB)	10%RB + 90%RC	7.65	8.225	19.2	18.3	4.75	0.765	0.62
(IF)	10%IF + 90%RC	7.65	8.225	19.2	18.3	4.75	0.765	0.62
(AF)	10%AF + 90%RC	7.65	8.225	19.2	18.3	4.75	0.765	0.62
(C)	10%AF + 90%C	7.65	8.225	19.2	18.3	4.75	0.765	0.62

3.5 Results

Compressive strength

The most important property of the concrete is the compressive strength. The compressive strength test results of the cubic casted for each batch of concrete was recorded. As recommended by the American Society for Testing and Materials (ASTM) for structural concrete, a minimum compressive strength of 250 KN. For the lab condition, the 28-day strength targeted was 360 KN to satisfy the strength requirement in the field condition. A graphical presentation of 7 days and 28 days compressive strength are presented in Fig. 3.1,

Table 3.2: Compressive strength KN after 7days

Sample number / **Waste**	**1**	**2**	**3**
conrol sample	221 KN	171 KN	238 KN
ceramic	129 KN	135 KN	140 KN
pottery	125 KN	126 KN	140. KN
red brick	159.59 KN	168 KN	160 KN
iron filings	194 KN	210 KN	200 KN
aluminim flings	81 KN	84.3 KN	80 KN

Table 3.3: Compressive strength KN after 28 days

Sample number / **Waste**	1	2	3
conrol sample	361 KN	369 KN	328.3KN
ceramic	240.9 KN	245.8 KN	250.6 KN
pottery	227 KN	235.78 KN	238.7 KN
red brick	290.6 KN	281.3 KN	270.6 KN
iron filings	321 KN	340.5 KN	281 KN
aluminim flings	130.26 KN	128.4 KN	133.06 KN

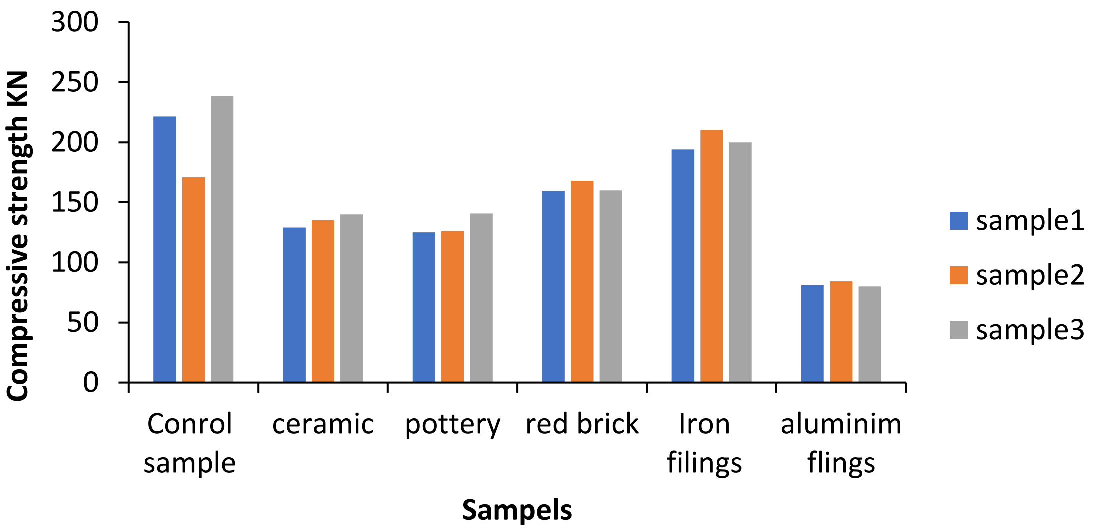

Figure 3.2: Compressive strength KN after 7days.

The Compressive strength KN after 28 days in the figure 3.3 of 10% waste ceramic,red brick ,pottery iron filings and aluminim flings / cement,the standard value of compressive strength KN after 28 days ranges (250-300) KN. As shown in the figure,the waste iron filings providi a value which similar to the standard value,the waste ceramic,red brick and pottery provides a less standard value,so we predict that the granular size affects the compressive strength, the smaller the size the greater the value

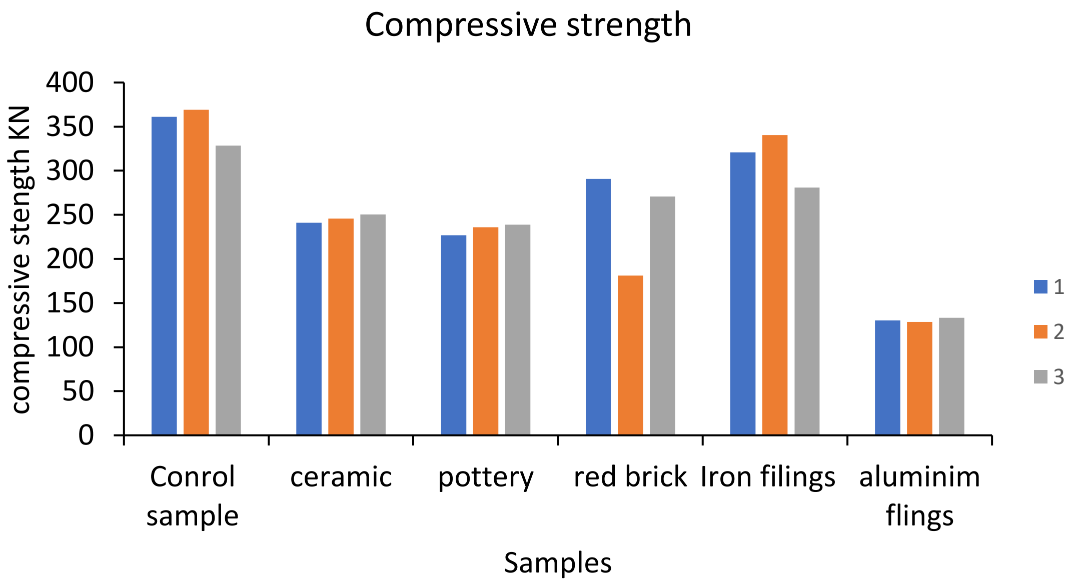

Figure 3.3: Compressive strength KN after 28 days.

Slump Test

A miniature slump test has been developed for the evaluation of the influence of water-reducing admixtures on the workability of neat portland cement pastes. Resulting paste pat areas rather than heights are measured, and the results are expressed as the percentage of water reduction. Relative effects of various admixtures on a portland cement are illustrated, and influences of specific admixtures on different cements are also shown. Effects of different superwater-reducing admixtures and combinations of ordinary and superwater-reducing admixtures are compared. The mini-slump method has also been used for the evaluation of the loss of workability (slump loss) with time for various admixtures and admixture combinations. The simplicity of the method facilitates accurate and effective evaluation of water-reducing admixtures. The results of the slump are given in Table **3.4**

Table 3.4: Ruselt of Slump:

Sample number / Waste	Slump (mm)
conrol sample	80
ceramic	70
pottery	40
red brick	85
iron filings	60
aluminim flings	45

The Slump results are shown in the following Fig. 3.6. of 10 % waste ceramic,red brick and Iron filings/ cement mixed concrete had attained the required slump of 60- 100 mm. pottery and aluminim flings/ cement percentage of 10% provided slump value less than 45 mm.
the first result similar to slump of the control mix (whithout waste) and the standard ASTM. The slump decreased gradually for addition of pottery and aluminim flings.

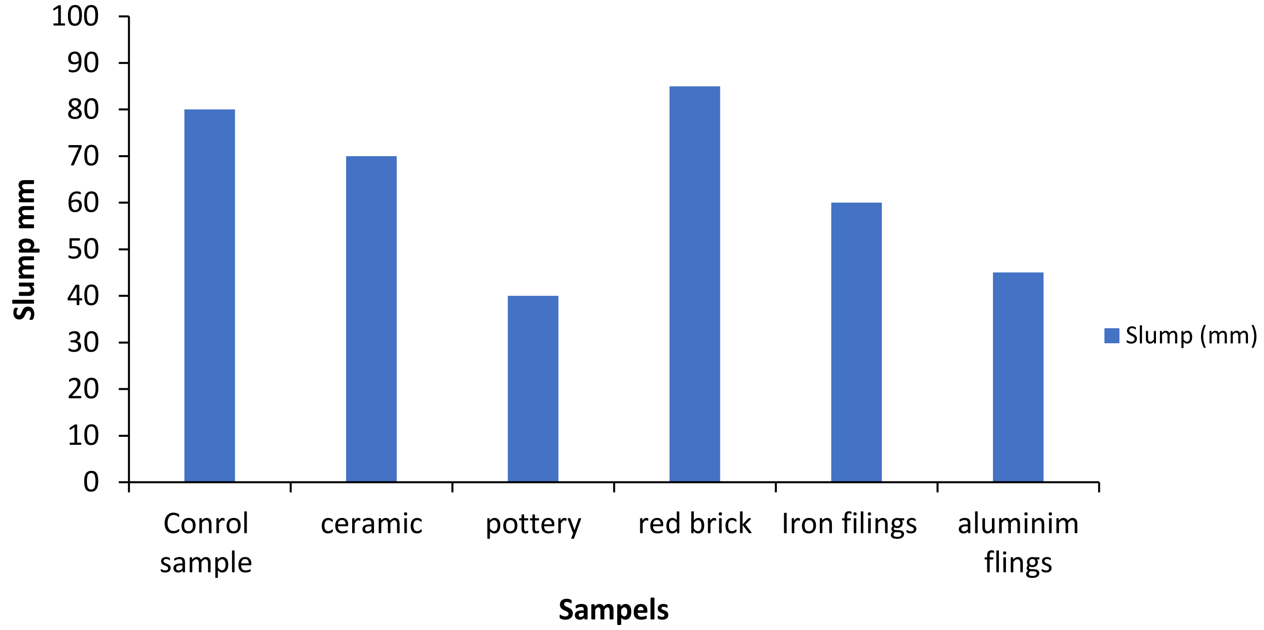

Figure3.4: Slump of different samples of the concrete mixed with 10% wastes (by wt of cement**)**

Water absorption

The pore structure of concrete is known to be of high importance for the durability of the material. A characterisation of this pore structure by means of a simple test is often investigated, in order to find a very simple compliance criterion with respect to concrete durability.

Table 3.5: Ruselt of Water absorption.

Sample number / Waste	Water absorption %
conrol sample	3.5
ceramic	5
pottery	2.6
red brick	3
iron filings	3.75
aluminim flings	6

The water absorption in the figure 3.5 of 10% waste ceramic,red brick ,pottery Iron filings and aluminim flings / cement,Regarding to the water absorption it is noticed that aluminim flings has the highest value,it is also exceeds the allowable the range which is between (1.5-5 %), as we noticed the larger the size, the less the water absorption.

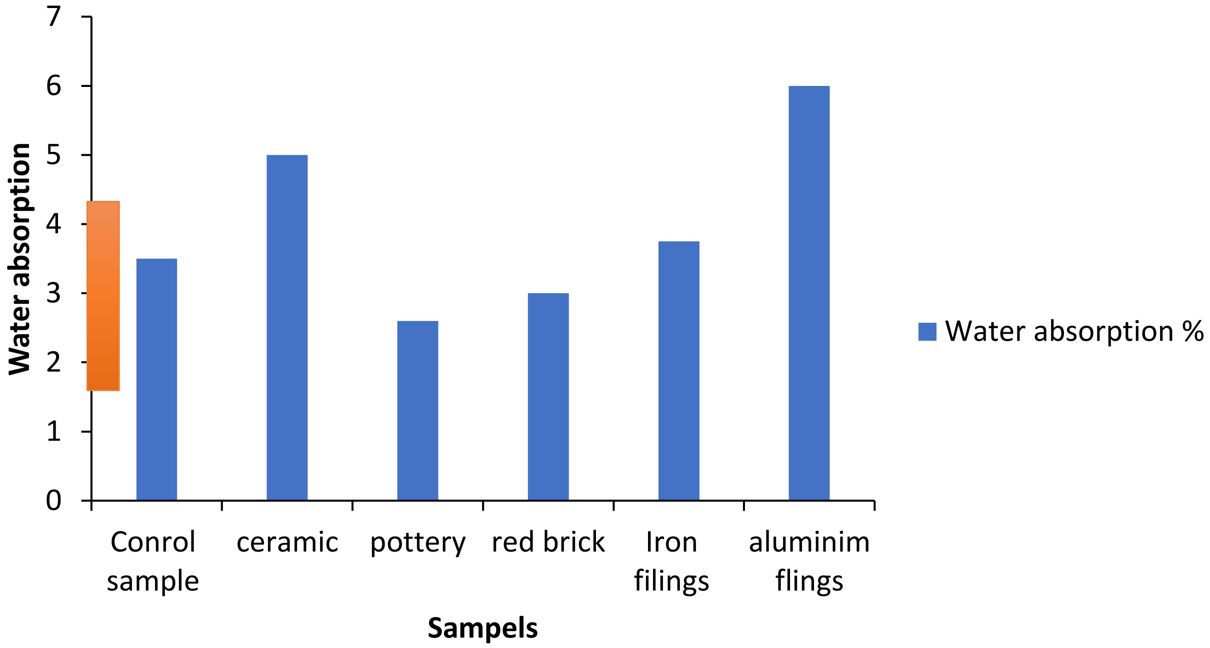

Figure3.5. Water absorption % .

Density

In view of the importance of aggregate density to the mechanical properties of concrete, it is necessary to determine the aggregate density at any point in concrete. Once the aggregate density is known, some mechanical properties of the concrete can be determined based on the theory of micromechanics. the permeable porosity affects the transport properties and durability of concrete. It is connected to many deterioration processes driven by the transport properties of concrete.

Table 3.6 : Density gm/cm^3.

Sample number / Waste	1	2	3
conrol sample	2.41 g/cm^3	2.426 g/cm^3	2.399 g/cm^3
ceramic	2.345 g/cm^3	2.364 g/cm^3	2.404 g/cm^3
pottery	2.3247 g/cm^3	2.329 g/cm^3	2.385 g/cm^3
red brick	2.31 g/cm^3	2.3 g/cm^3	2.385 g/cm^3
iron filings	2.368 g/cm^3	2.33 g/cm^3	2.352 g/cm^3
aluminim flings	2.254 g/cm3	2.21 g/cm^3	2.240 g/cm^3

The density of the waste ceramic,red brick ,pottery and iron filings is nearly the same as the control sample, but the aluminim flings which has low density because the spaces between the granulars are large, so the water absorption increases.

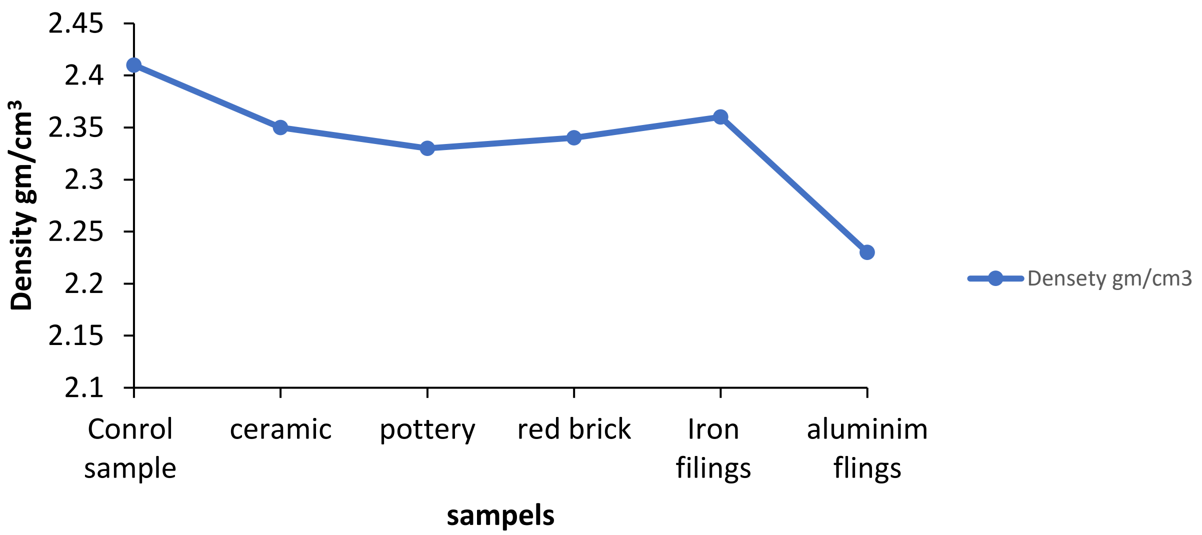

Figure3.6: Density g/ cm^3

Chapter Four

Recycling Chromium Waste from leather Tanning in Concrete

4.1 Introduction

Tanning industries produces large quantities of wastewater, which on direct discharge causes severe environmental pollution. Basic chromium sulphate used in the tanning process is not consumed fully and about 30 problem. Basic chromium used in the tanning process is not consumed fully and about 30-40% of it is washed away to the environment and thus creates severe environmental problem especially to the aquatic system

Over the past few years, these tanneries employed different techniques to manage their wastewater, such as adsorption by marlstone.

Over the past few years, these tanneries employed different techniques to manage their wastewater, such as adsorption by marlstone. Many efforts were made regarding tannery wastewater treatment and management. Natural marl was reported to be very efficient as an adsorbent for chromium (III). Different types of marl were tested along with the effects of contact time, doses and the state of the solid particles. Results showed high adsorption percentage (97%) at 0.003 g yellow marl /ml wastewater after only 3 days. A higher removal percentage was obtained in stirred condition; this also shortened the time required for full removal to about 7 hours .Similarly, stone cutting solid waste was used to treat tanning wastewater. Adsorption was found to be at its highest percentage when stone solids were 5 g/100 ml or higher within just few days.

At the present, the three researchers pulled up their sleeves and designed an ecofriendly efficient integrated wastewater treatment unit that removes chromium tannery wastewater by adsorption on stone cutting solid waste or slaked lime articles, thus eliminating pollution from both industries. Laboratory results proved that this treatment system efficiency is 99%. Moreover, chromium is removed within a 30min process reaction instead of long hour's process using conventional methods. In addition, this sustainable wastewater treatment solution cost three times less than the current solution and saves 50% of treated wastewater for the industry, estimated to 6 cubic meters daily.

However, In Hebron the main limitation on treatment of industrial wastewater came from "Israeli" regulation which imposing huge sums on leather factories interviewing sludge treatment political reasons.

At the present, most sludge are being deported to the "Israeli"

side for money for treatment sludge without taking full advantage of their properties. The sludge should be used as partial or full replacement for Portland cement or aggregate.

In previous studies have been done on exploring the feasibility of using chromite industry waste in concrete mixes [56]. used chromite as an alternative of cement in concrete production;

The compressive strength values of all waste concrete mixtures tend to decrease below the values for the reference concrete mixtures with waste content and the slump values of waste concrete mixtures demonstrated a tendency to decrease below the slump of the reference concrete mixture. Used tannery sludge as a partial replacement of the cement concrete production; the compressive strength of the concrete decreased gradually with the increased amount of sludge addition [57].

Up to our knowledge no study for using chromium waste chromium waste ($Cr(OH)_3$ in concrete mixes then we used these waste in concrete mixes.

This chapter presents the production of concrete 250 by using sludge from treatment tannery wastewater for removing chromium by slaked lime.

4.2 Experimental Methodology

The detailed experimental methodology was presented in chapter three: adding sludge as alternative of cement and aggregate, for various dosages (5%, 10% and 15%) It is based on chromium waste ($Cr(OH)_3$ and Cr_2O_3O) for each type. The workability of mix was determined using slump test. The compressive strength was measured at 7days and 28 days, and water absorption was measured after 28 days according to ASTM standards. Concrete control samples were prepared according to B250 type

4.3 Results and Discussions

The results for utilizing chromium waste ($Cr(OH)_3$ waste are discussed and presented in the following figures that show the effect of using waste replacement of cement and of aggregate on slump ,Compressive strength ,Density and water absorption.

4.3.1 Utilizing Chromium Waste (Cr(OH)3 in Concrete for Partial Replacement of fine aggregate.

This section presents the results obtained for using chromium waste $Cr(OH)_3$ as a replacement of fine aggregate.. The control concrete mix, which consisted of sand (735 kg), fine aggregate (329 kg), medium aggregate (768kg), cement (306 kg), and water (190 kg), resulted in a water concrete ratio of 0.62. The other concrete mixes were made of chromium waste from tannery industry of 5%, 10%, and 15% as a partial replacement for fine aggregate with the same amounts of cement, sand and medium aggregate and the same water-cement ratio as in the control mix. Both types of concrete mixes were cured.

Waste Concrete Mixture

Three groups were selected to investigate the effects of chromium waste from tennary industry (CR) on the properties of concrete. These mixtures are presented in Table 4.1. Three specimens were tested and obtained for every experimental result. For all the mixes, the componants were weighed in a dry room condition.

Table 4.1. Experimental of concrete mix design for partial replacement aggregate.

Materials								
Symbol	**Cement mixes**	**Cement (kg)**	**Fine aggregate (kg)**	**Medium aggregate (kg)**	**Sand (kg)**	**Water tap (mL)**	**Waste (kg)**	**W/C**
RC	Reference mix	6.12	6.58	15.36	14.64	3.8	-	0.62
HAR5	5%+ 95% RC	6.12	6.251	15.36	14.64	3.8	0.33	0.62
HAR10	10%+ 90% RC	6.12	5.922	15.36	14.64	3.8	0.658	0.62
HAR15	15% + 85% RC	6.12	5.593	15.36	14.64	3.8	0.987	0.62

HAR, chromium waste $Cr(OH)_3$ from tennary industry (replacment aggregate), RC reference mix .

- **Effect of Chromium Waste $Cr(OH)_3$ on Compressive Strength**

The results of the compressive strength tests for the waste materials concrete mixes are shown in Figure 4.1 and 4.2 . It was found that at 7 days, the (HAR5) , (HAR10), and (HAR5) concretes had best avarge compressive strength of 220, 221, and 240 KN, respectively, while that of RC (Control sample) concrete was 230 KN.

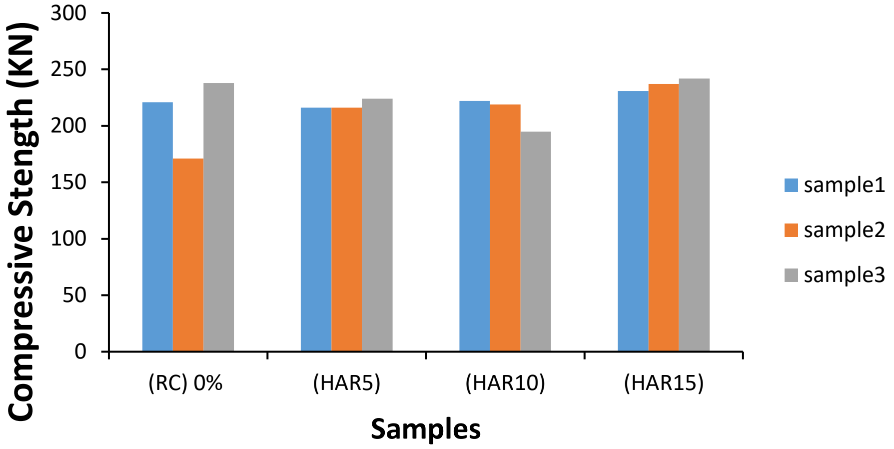

Figure 4.1: Compressive strength for three samples each percentage waste after 7 days

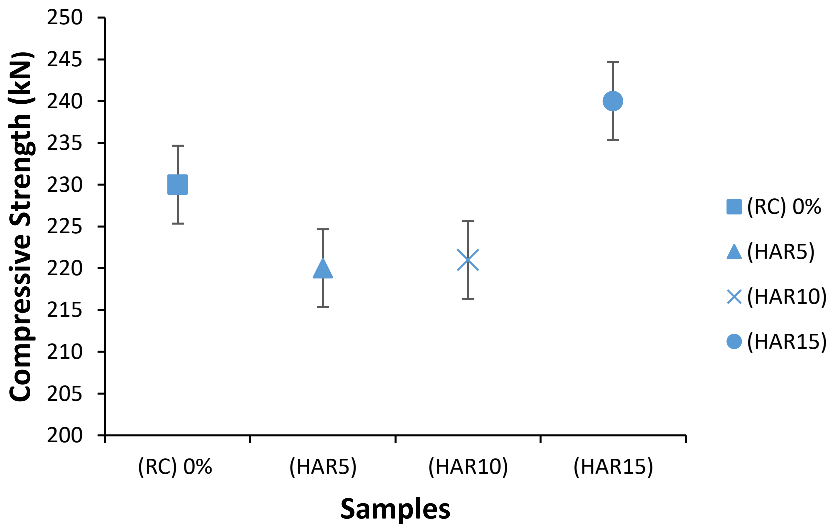

Figure 4.2: Increment ratios in compressive strength after 7days.

The results of the compressive strength tests for the utalizing waste in concrete mixes are shown in Figure 4.3 and 4.4 and. It was found that at 28 days, the (HAR5) , (HAR10), and (HAR5) concretes had avarge compressive strength of 312, 357, and 382 KN, respectively, while that of RC (Control sample) concrete was 365KN.

Figure 4.5 illustrates the increment ratios in compressive strength. According to the test results, the avarge 28-day compressive strength value of 385 KN was obtained from the concrete mix made of 15% waste , which represents an increase in the compressive strength of up to 4.8% as compared to the control mix .However, all the waste concrete mixes showed compressive strength values that are slightly higher than those of the plain mixes, except for the (HAR5) concrete mixes.

The little low compressive strength of the (HAR5) waste in concrete could be attributed to the wrong in work .chromium waste appear to offset this trend at a later stage of hardening and helped to improve the compressive strength at 28 days

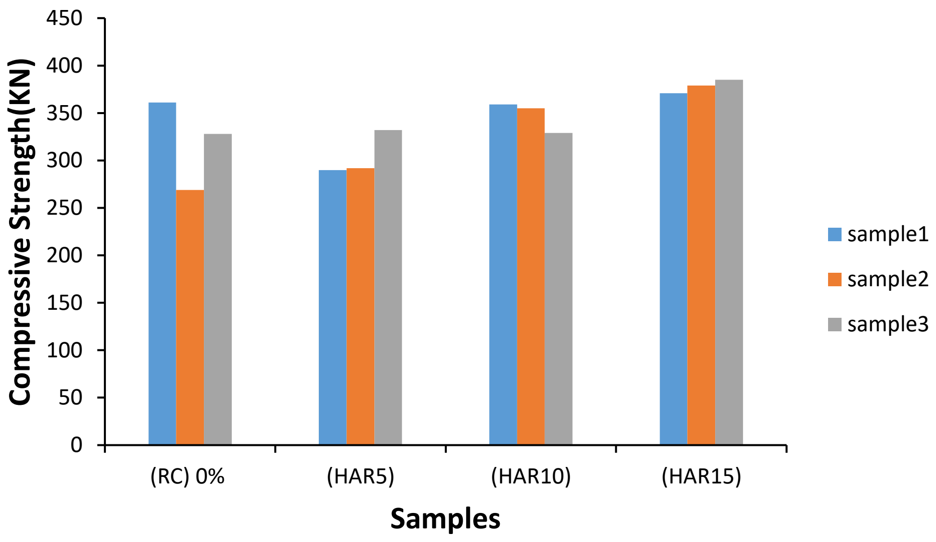

Figure 4.3: Compressive strength for three samples each percentage waste after 28 days

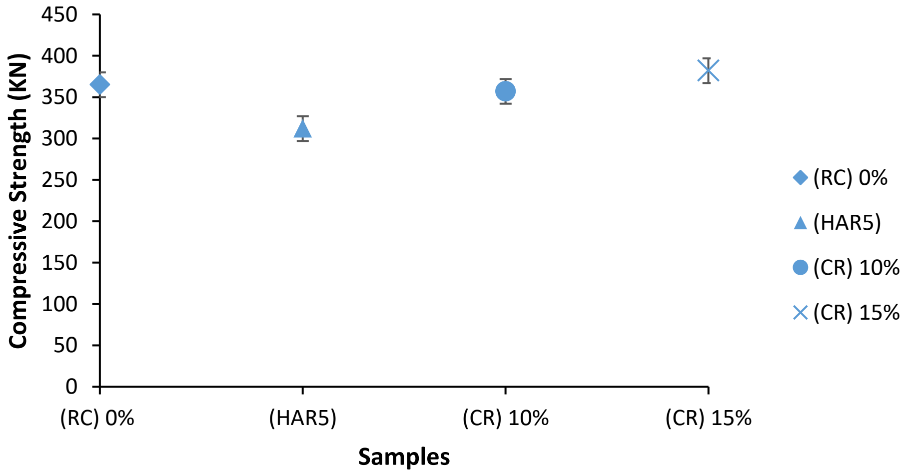

Figure 4.4: Increment ratios in compressive strength after 28 days

- **Effect of Chromium Waste $Cr(OH)_3$ on Workability**

The results of the slump tests are presented in Figure 4.5 and Figure 4.6 shows slump decreases with the increase the content waste material. The slump values were determined to be 80 , 82, 76 and 73 for samples made of 0% 5%, 10%, and 15% waste , respectively. The results demonstrate the tendency of the slump to decrease as the waste ratio increases without 5% of waste is little increase of slump. This decline in the slump values can be related to the absorption of waste to waterwhich results in lesser fluidity of the mixes as well as the reduction of fineness modulus. In spite of the decline in the slump values, the waste glass concrete mixes were considered workable.These results show that the presence of waste materials in concrete mixtures affect the workability of concrete.

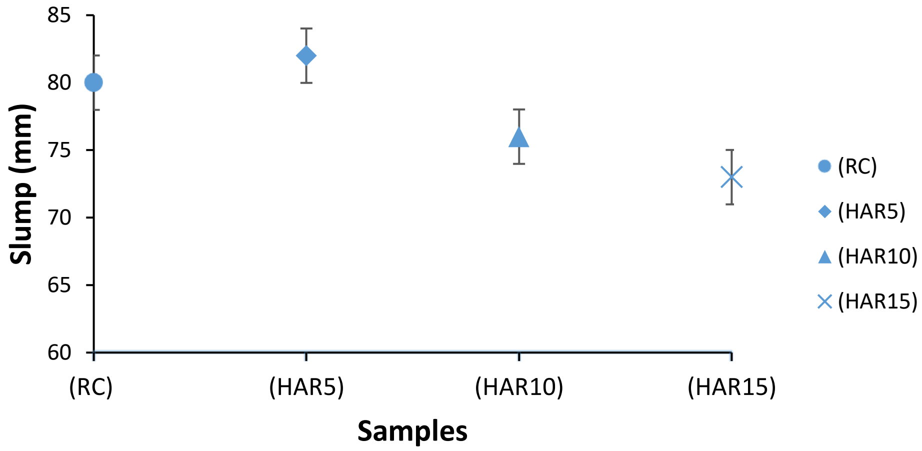

Figure 4.5. Decreasing ratios in the slump.

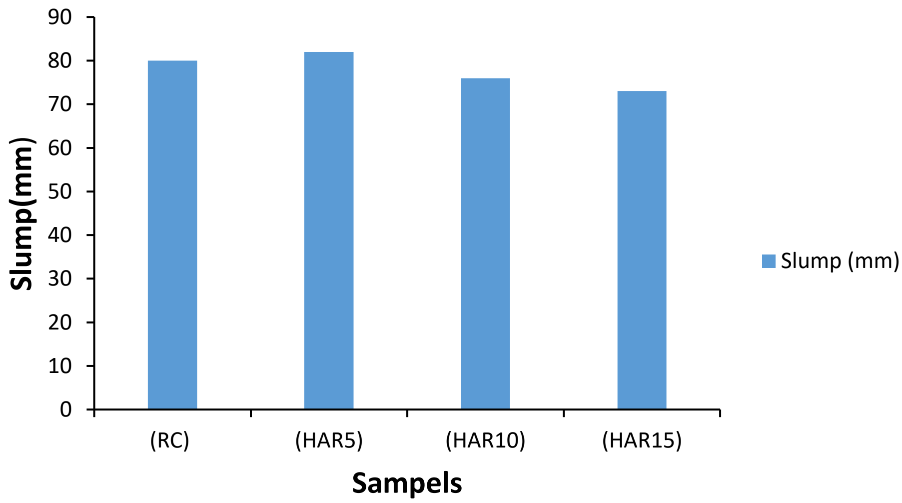

Figure 4.6: Slump of different ratio of chromium waste in concrete mixed

- **Water absorption**

Chromium waste raise the water absorption for concrete B250, the result of water absorption obtained is shown in figure 4.7 and 4.8.

increase water absorption This may be due both to the capability of chromium waste to absorption water (sorptive nature)، The increase in water absorption is also attributed to a increase in the porosity near particle. Leading decrese in concrete density.

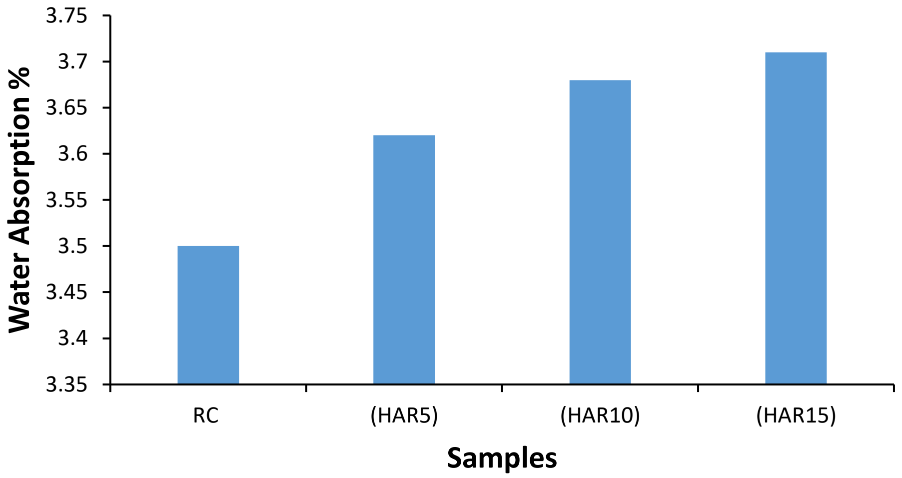

Figure 4.7: Water absorption.

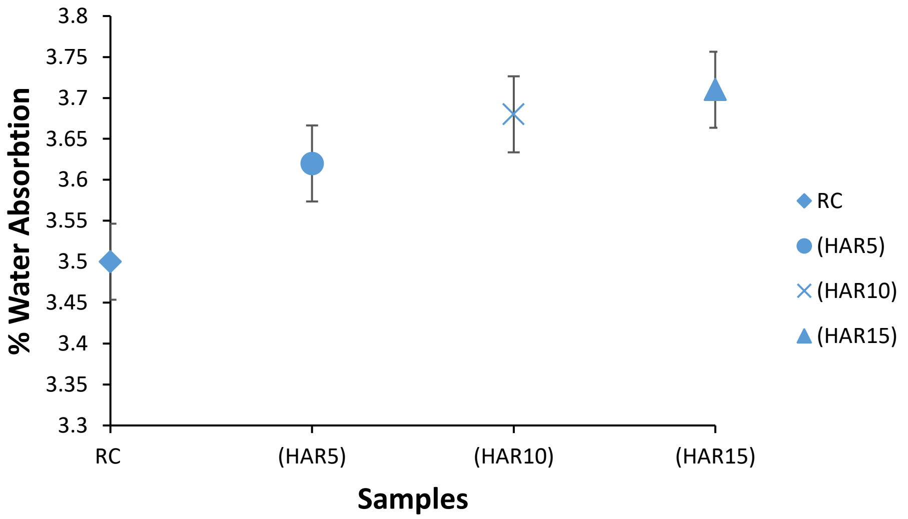

Figure 4.8: Decreasing ratios in Water absorption.

Dry density tests

Figure 4.9 shows the density test results of waste concrete mixes. The decreasing in densities of specimens made of 5%, 10%, and 15% from chromium waste are 2.32 g/cm^3 2.26 g/cm^3, and 2.21 g/cm^3 , respectively, as shown in Figure 4.9: Dry densities of waste concrete mixes.and Figure 4.10 shown the decrease in the density of the waste chromium concrete mixes can be attributed to the specific volume of the waste ,which is lower than that of the fine aggregate . In spite of the decrease in the fresh density values of waste glass concrete mixes, they are still comparable to the control mixes.

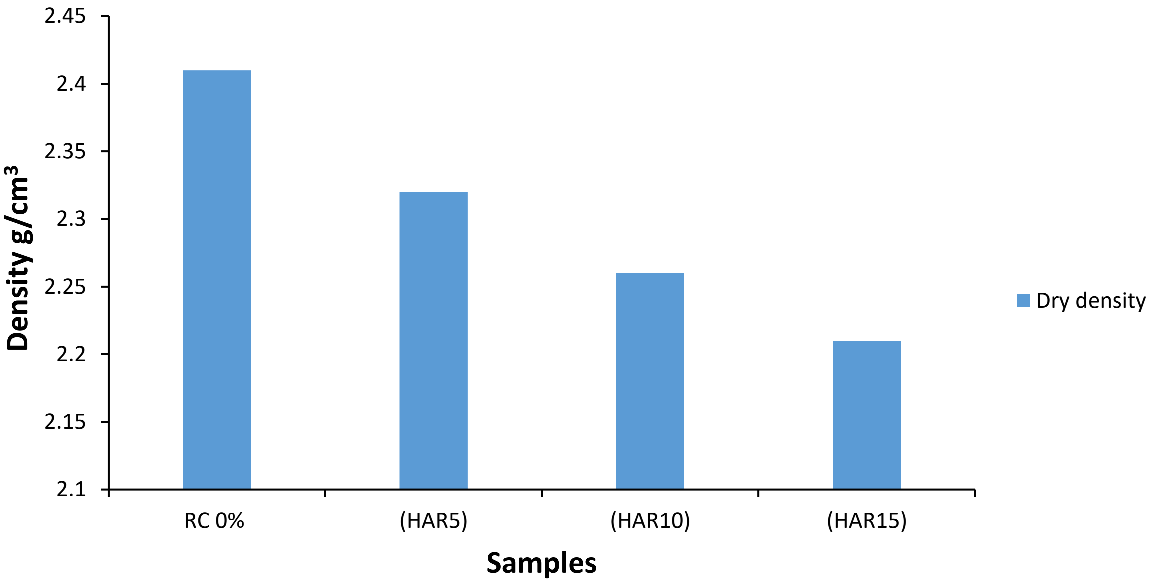

Figure 4.9 Dry densities of waste concrete mixes

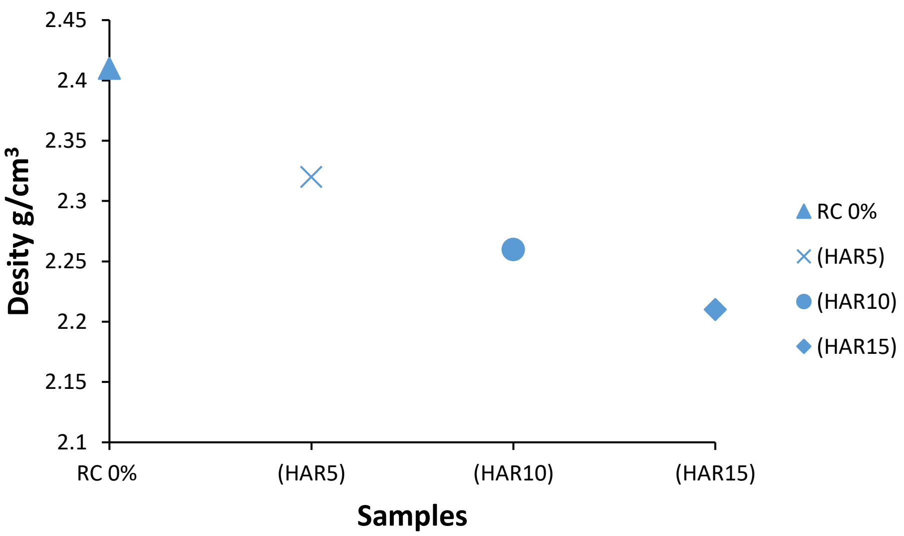

Figure 4.10: Decreasing in dry density

4.3.2 Utilizing Chromium Waste (Cr(OH)3 in Concrete for Partial Replacement of cement.

Three groups were selected to investigate the effects of chromium waste from tennary industry (CR) on the properties of concrete. These mixtures are presented in Table 4.2. Three specimens were tested and obtained for every experimental result. For all the mixes, the componants were weighed in a dry room condition.

Table 4.2. Experimental of concrete mix design for Partial Replacement of cement.

Materials								
Symbol	**Cement mixes**	**Cement (kg)**	**Fine aggregate (kg)**	**Medium aggregate (kg)**	**Sand (kg)**	**Water tap (mL)**	**Waste (kg)**	**W/C**
RC	Reference mix	6.12	6.58	15.36	14.64	4.2	-	0.68
HCR5	5%+ 95% RC	5.81	6.58	15.36	14.64	4.2	0.33	0.68
HCR10	10% + 90% RC	5.508	6.58	15.36	14.64	4.2	0.658	0.68
HCR15	15% + 85% RC	5.202	6.58	15.36	14.64	4.2	0.987	0.68

HCR, chromium waste $Cr(OH)_3$ from tennary industry Partial Replacement of cement.
, RC control mix

- **Effect of Chromium Waste $Cr(OH)_3$ on Compressive Strength**

The results of the compressive strength tests for the waste materials concrete mixes are shown in Figure 4.11 and 4.12 It was found that at 7 days, the (HCR5) , (HCR10), and (HCR15) concretes had avarge compressive strength of 161, 141 and 107 KN, respectively, while that of RC (Control sample) concrete was 168 KN.

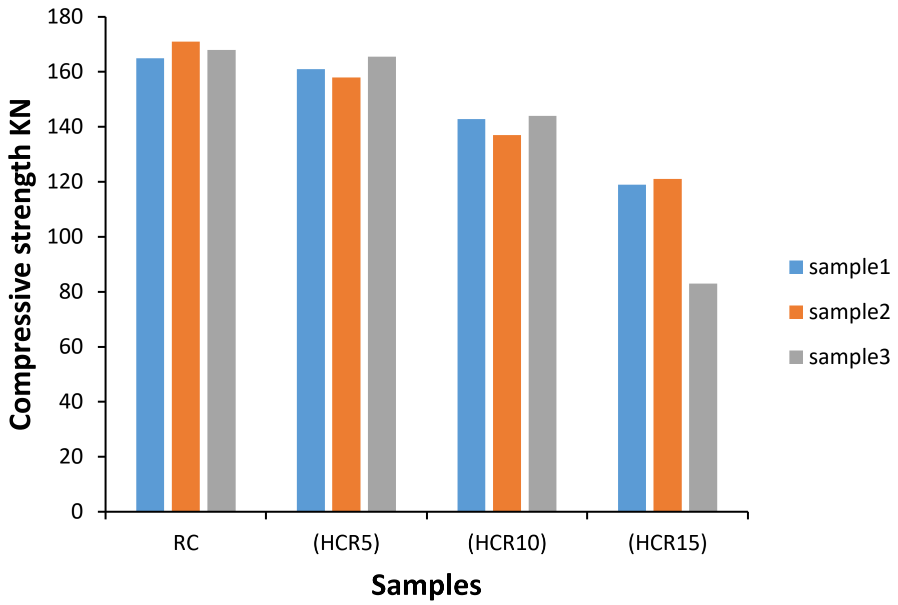

Figure 4.11: Compressive strength for three samples each percentage waste after 7 days

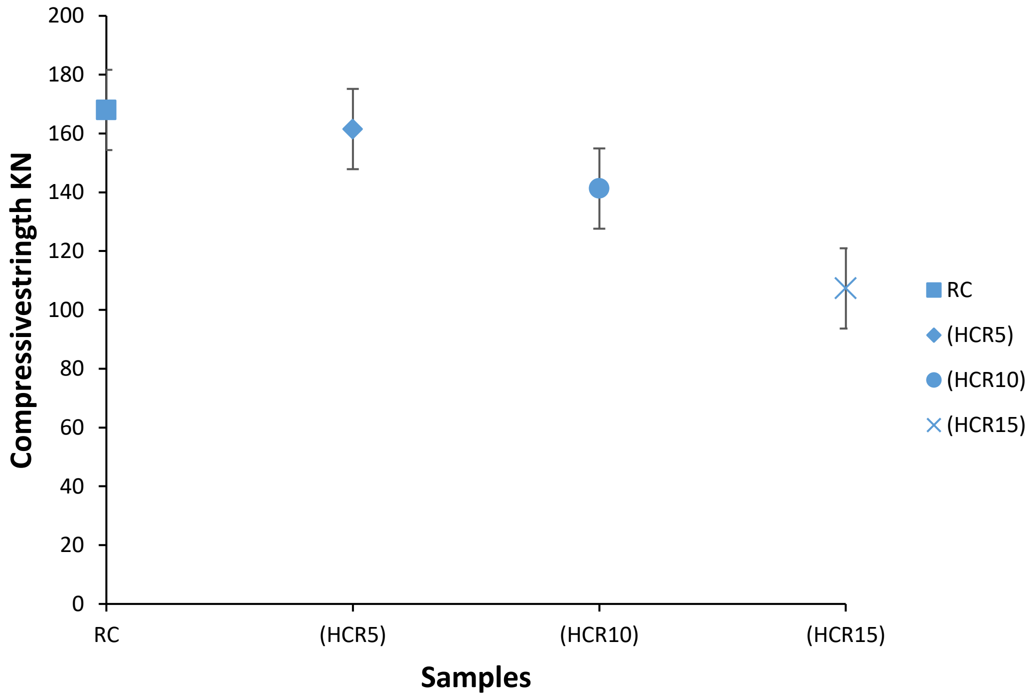

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Figure 4.12: Increment ratios in compressive strength after 7days.

The results of the compressive strength tests for the waste materials concrete mixes are shown in Figure 4.13 and 4.14 It was found that at 28 days, the (HCR5) , (HCR10), and (HCR15) concretes had avarge compressive strength of 206, 181 and 128 KN, respectively, while that of RC (Control sample) concrete was 288 KN. At a higher replacement ratio (15%), the strength of concrete decreased since the amount of cement was greatly reduced**.** These results show that the incorporation of 5% of waste materials did not adversely affect the strength of concrete. An increase in the replacement ratios to 15% of binder, however, decreased the strength of concrete. In addition, the strengths of replacment aggregate were higher than the strengths of replacemnt cement in concrete, although the replacement cement required more water in the concrete mixtures for similar workability**.**

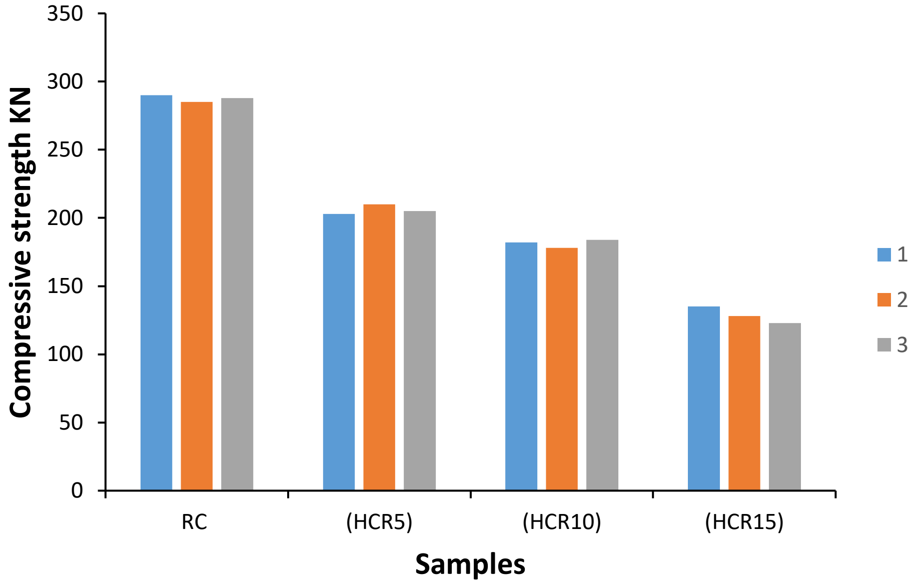

Figure 4.13: Compressive strength for three samples each percentage waste after 28 days

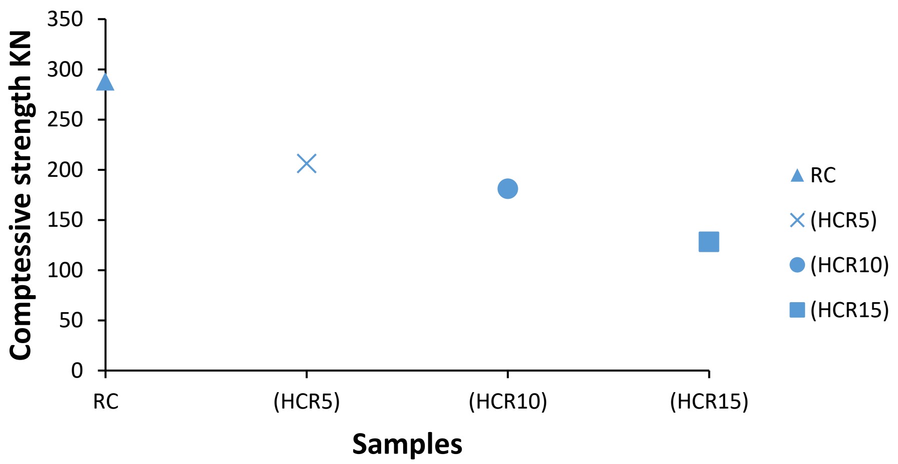

Figure 4.14: Increment ratios in compressive strength after 28days.

- **Effect of Chromium Waste $Cr(OH)_3$ on Workability**

  The results of the slump tests are presented in Figure 4.15 shows slump decreases with the increase the content waste material. The slump values were determined to be 90 , 76, 72 and 60 for samples made of 0% 5%, 10%, and 15% waste , respectively. . This decline in the slump values can be related to the absorption of waste to water which results in lesser fluidity of the mixes as well as the reduction of fineness modulus. These results show that the presence of waste materials in concrete mixtures affect the workability of concrete.

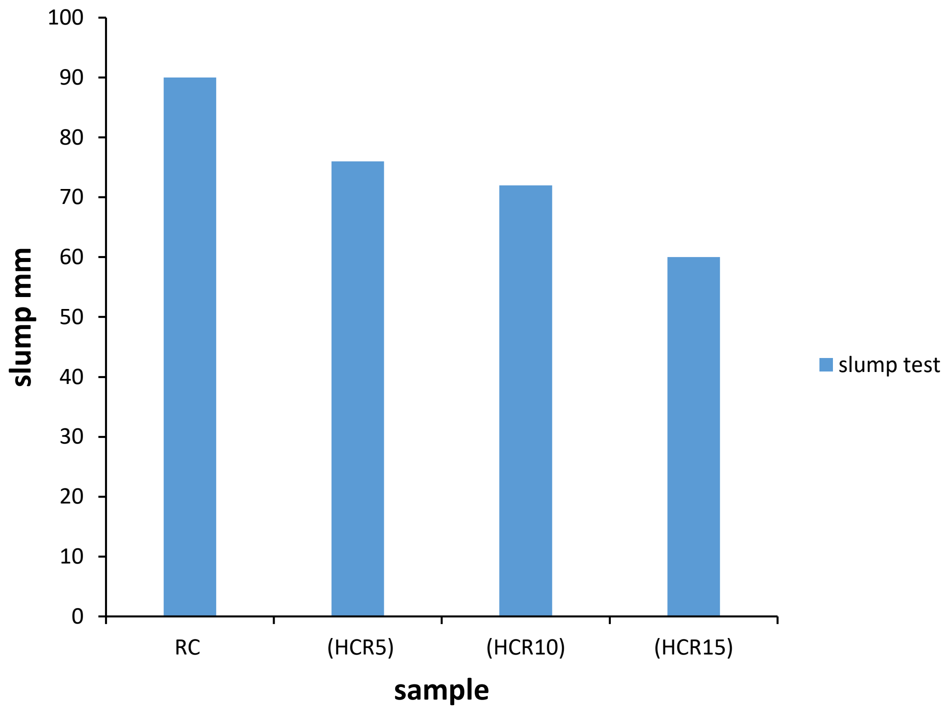

Figure 4.15: Slump of different ratio of chromium waste in concrete mixed

- ## Water absorption

Chromium waste raise the water absorption for concrete B250, the result of water absorption obtained is shown in figure 4.16increase water absorption This may be due both to the capability of chromium waste to absorption water (sorptive nature) ,The increase in water absorption is also attributed to a increase in the porosity near particle. Leading decrese in concrete density.

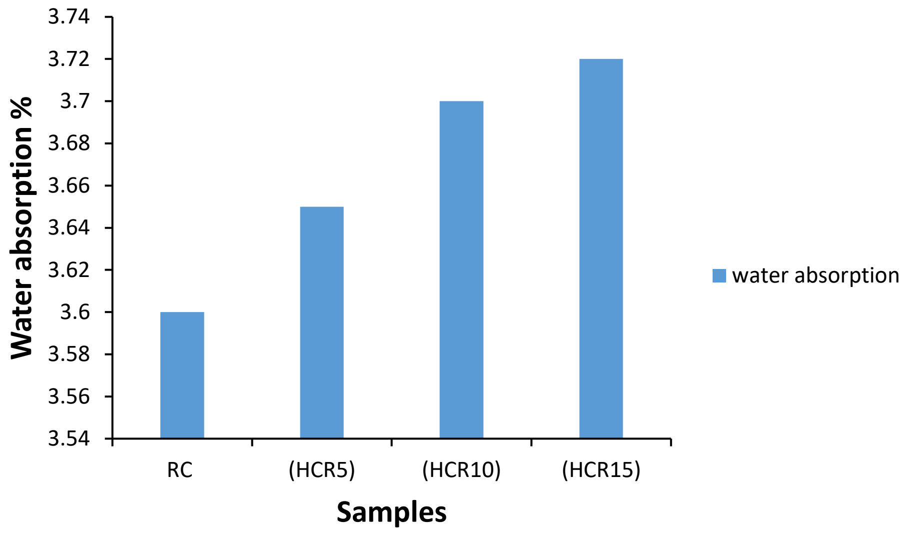

Figure 4.16: Water absorption.

- **Dry density tests**

Figure 4.16 shows the density test results of waste concrete mixes. The decreasing in densities of specimens made of 5%, 10%, and 15% from chromium waste , as shown in Figure 4.17: Dry densities of waste concrete mixes.and Figure 4.17 shown the decrease in the density of the waste chromium concrete mixes . In spite of the decrease in the fresh density values of waste glass concrete mixes, they are still comparable to the control mixes.

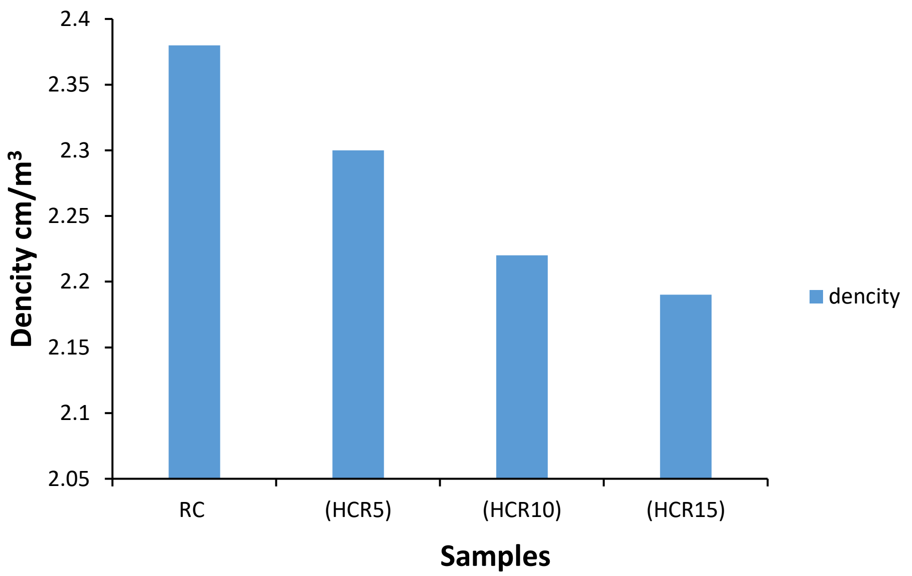

Figure 4.17 Dry densities of waste concrete mixes

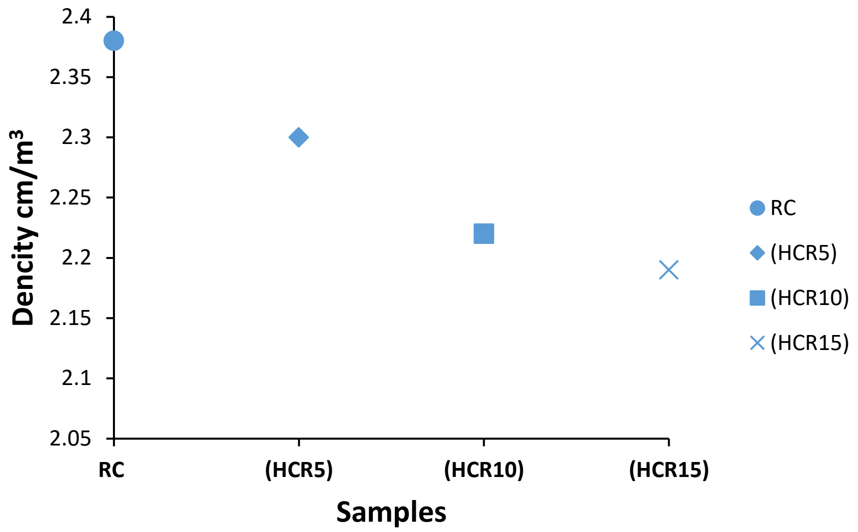

Figure 4.18: Decreasing in dry density

Conclusion

Our results all together showed a strong evidence that industial waste from local industries can be potential additions in producing environmental friendly concrete. Comparison of compressive strength results shown in the previous chapters, indicate that the optimum value was 385، when utilizing 15% , chromium waste Cr(OH) as replacment fine aggregate

In addition to our results, 10% replacment cement of pottery had the optimum value of water absorption 2.6% , followed by red brick both ratios with 3%.

Our study shows promising results of utilizing mineral industrial waste as additives for improving concrete characteristics to enhance the compressive strength as well as some industrial waste to reduce the water absorption ratios. These results are still preliminary and we look forward, by using more sophisticated measuring methods, to achieve better results that can be finally translated into a commercial market. This project will open a new approaches for investees to give more attention on local industrial waste as available resources instead of conception of it as serious problem.

Recommendation

Using $(Cr(OH)_3$ of replacment aggregate significantly improved compressive strength, while using pottery improved water absorption. Therefore, we suggest a future work to test several combinations of these two wastes to develop an environment-friendly concrete.

This study had covered a conventional mixing ratio to produce structural concrete without any chemical admixture. However, the water content has a huge impact on the compressive strength of the concrete.

This study did not include any test of the durability, soundness and permeability the long term of the concrete. The above mentioned tests of the concrete are important to evaluate the performance of the sludge mixed concrete in the long run which might be included in the scope of the future study.

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